MILLER CONSTRUCTION, INC.

P.O. BOX 86 ASCUTNEY BLVD WINDSOR, VERMONT 05089-0086
TELEPHONE (802) 674-5525 / FAX (802) 674-5245

TRANSMITTAL

TO: Kristin M. Higgins, PE Project Manager Vermont Agency of Transportation	DATE	PROJECT NO.
	2/24/2014	Barnard ER BRF 0241 (39)

XX WE ENCLOSE THE FOLLOWING: _____ UNDER SEPARATE COVER WE ARE SENDING THE FOLLOWING

COPIES	NUMBER	DESCRIPTION	CODE
1		Pile and Driving Equipment Data Form	H
1		Wave Equation Analysis	H
1		Pile Splice WPS	H
1		Pile Point WPS	H

CODE:

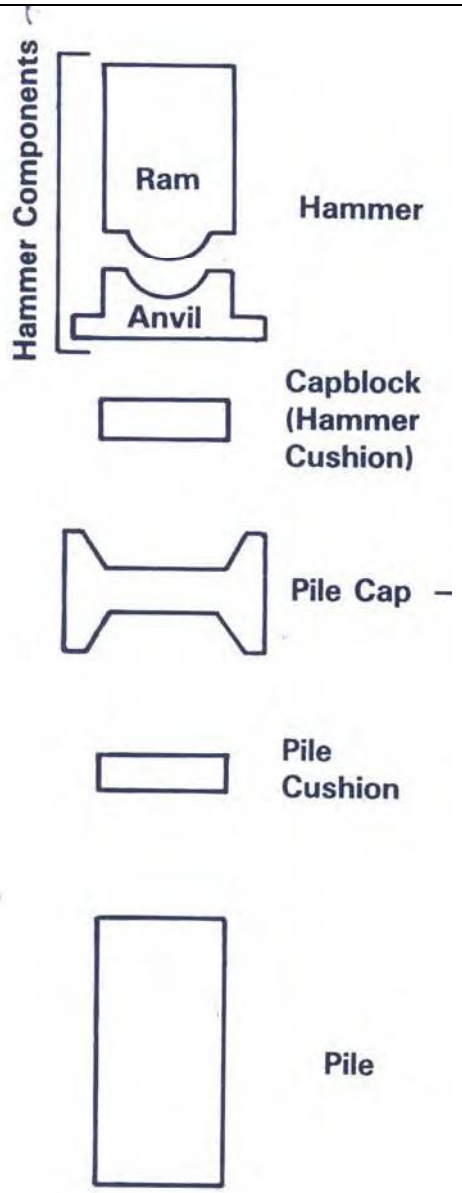
A FOR INITIAL APPROVAL
B FOR FINAL APPROVAL
C APPROVED AS NOTED-RESUBMISSION REQUIRED
D APPROVED AS NOTED-RESUBMISSION NOT REQUIRED
E DISAPPROVED-RESUBMIT
F QUOTATION REQUESTED
G APPROVED
H FOR APPROVAL
I AS REQUESTED OR REQUIRED
J FOR USE IN ERECTION
K LETTER FOLLOWS
L FOR FIELD CHECK
M FOR YOUR USE

BY: Paul [illegible]

Pile and Driving Equipment Data Form

Project Name: Barnard
Project No.: ER BRF 0241 (39)
Route No.: VT 12

Structure Name: Bridge 25 Crossing Locust Creek
Structure No: Bridge 25
Pile Driving Contractor: Miller Construction, Inc.
Foreperson: Ray Estey



Manufacturer: Delmag
Type: Diesel - Open End
Rated Energy (kip-ft): 39.2
Length of Stroke (ft): 11.15
Model: D16-32
Serial No: 408

Modifications: N/A

Material: Alum. and Conbest
Thickness (in): 2 **Area (in^2):** 227
Modulus of Elasticity – E (ksi): 530
Coefficient of Restitution-e: 0.8

Also named:
Helmet
Bonnet
Anvil Block
Drivehead

Weight (lbs): 1900

Cushion material: N/A
Thickness (in): N/A **Area (in^2):** N/A
Modulus of Elasticity – E (ksi): N/A
Coefficient of restitution – e: N/A

Pile Type & Size: HP 12 X 74
Length (in Leads) (ft): 40 - 50
Weight (lb/ft): 74
Wall thickness (in): N/A
Taper: N/A
Cross Sectional Area (in^2): 21.8
Ultimate Axial Pile Capacity (kips): 402
Steel Yield Strength (ksi): 50
Description of Splice: N/A
Tip Treatment Description: Hard Bite Point

Distribution- One copy each to:

☐ **State Structures Engineer**

☐ **State Soils & Foundations Engineer**

☐ **Resident Engineer:**

NOTE: If mandrel is used to drive the pile, please attach separate manufacturer's detail sheet(s), including weight and dimensions.

Submitted by: Paul J. Holloway
Title: Project Manager

Date: 11/18/13

GZA
GeoEnvironmental, Inc.

Engineers and Scientists

February 19, 2014
File No. 02.0171821.00-C, PC

Mr. Paul Holloway
Miller Construction, Inc.
P.O. Box 86
Windsor, Vermont 05089

249 Vanderbilt Avenue
Norwood
Massachusetts
02062
781-278-3700
FAX 781-278-5701
http://www.gza.com

Re: Wave Equation Analyses
Barnard ER BRF 0241(39) – Abutment 1
Barnard, Vermont

Dear Mr. Holloway:

At your request, GZA GeoEnvironmental, Inc. (GZA) has performed Wave Equation Analyses of Piles (WEAP) for the hammer-pile-soil system proposed on the above referenced project site. These analyses were performed in general accordance with the project specifications. A copy of the completed GRLWEAP outputs are attached and the WEAP inputs are summarized below:

- Hammer- The Delmag D16-32 single acting diesel hammer has a ram weight of 3,520 lbs. and a maximum rated stroke of 11.4 feet, yielding a rated energy of 40,198 ft-lbs. The helmet cushioning material is modeled as 2 inches of aluminum and conbest. The D16-32 is equipped with a ratchet style fuel pump with four settings which limit the ram stroke to 5.3 feet, 7.5 feet, 10.0 feet, and 11.4 feet (open) and yield rated energies of 18,646 ft-lbs, 26,400 ft-lbs, 35,200 ft-lbs., and 40,198 ft-lbs, respectively. The pile type detailed below is modeled with the Delmag D16-32 operating on each of the above fuel settings. No pile cushion material is required for the pile type detailed below.

- Pile - 50-foot long HP 12x74 Grade 50 steel piles are modeled. The cross-sectional area for this pile type is 21.8 square inches. The specified nominal axial resistance of 402 kips is based upon dividing the maximum factored axial pile load of 261.3 kips by a performance factor of 0.65. The maximum allowable driving stresses for Grade 50 steel is 45 ksi (i.e. $0.9f_y$).

- Soil - Based on the subsurface information provided and the anticipated driving conditions, the resistance profile is modeled as 80% end-bearing and 20% skin friction, triangularly distributed along the embedded pile length.

- Analysis Two analyses model the above hammer-pile-soil system:

  1. Variable capacity analysis which develops a driving resistance based on the most efficient hammer stroke. Note that the Delmag D16-32 is modeled operating on each of the four (4) fuel settings for completeness.

Copyright© 2014 GZA GeoEnvironmental, Inc.

2. Constant capacity analysis (i.e., Inspector's Chart) which develops a driving resistance based on a varied hammer stroke.

- Results The results of these analyses are tabulated below:

Nominal Resistance: 402 kips

Pile Hammer	Fuel Setting	Blow Count (bpi)	Ram Stroke (ft)	Compressive Stress (ksi)	Transfer Energy (kip-ft)
Delmag D30-32	1	21 bpi	6.9 ft.	25.4 ksi	11.1 kip-ft
	2	15 bpi	7.6 ft.	27.8 ksi	13.1 kip-ft
	3	11 bpi	8.5 ft.	30.3 ksi	15.3 kip-ft
	Open (4)	9 bpi	9.5 ft.	32.9 ksi	17.8 kip-ft

The results tabulated above indicate that the Delmag D16-32 open-end diesel hammer, operating on fuel setting 2, fuel setting 3, or fuel setting 4 can drive the specified HP12x74 Grade 50 steel piles to a nominal resistance of 402 kips without overstressing the pile section. Fuel setting 1 indicates a penetration resistance that exceeds the allowable Vermont Agency of Transportation (VAOT) specified blow count of 15 blows per inch.

Based on the above results and our experience with these type driving conditions, the preliminary recommended driving resistance is 11 blows per inch with the Delmag D16-32 operating on the fuel setting 3 (rated 10.0 foot ram stroke) and providing a ram stroke of approximately 8.5 feet. The maximum calculated driving stress of 30.3 ksi is within the allowable limits for Grade 50 steel. We recommend that this driving criterion be developed for a minimum of 3 consecutive inches. It is our understanding the driving criterion will be verified with the specified dynamic pile-testing program.

The project documents require that the specified HP12x74 steel piles achieve a minimum penetration of 20 feet (i.e. min. tip elevation +856.0) below the bottom of the pile cap. Our review of the contract boring logs indicate that the installed piles must penetrate an upper stratum of cobbles and weather rock and then penetrate five to ten feet into the lower stratum of weathered broken rock and cobbles to meet the minimum penetration criterion. Our experience with this type of driving condition is that the upper rock stratum may affect the pile alignment and the piles may not be able to develop the minimum penetration criterion if they develop bearing on competent rock in the underlying broken rock and cobble stratum.

If the pile driving system should demonstrate refusal conditions (i.e., sudden increase in ram stroke and penetration resistance), we recommend a refusal criteria of 10 blows per half-inch of pile penetration with the Delmag D16-32 providing a minimum 9.0 foot ram stroke.

If you have any questions or require additional information, please contact the undersigned.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

for Michael J. Deery
Geotechnical Engineer

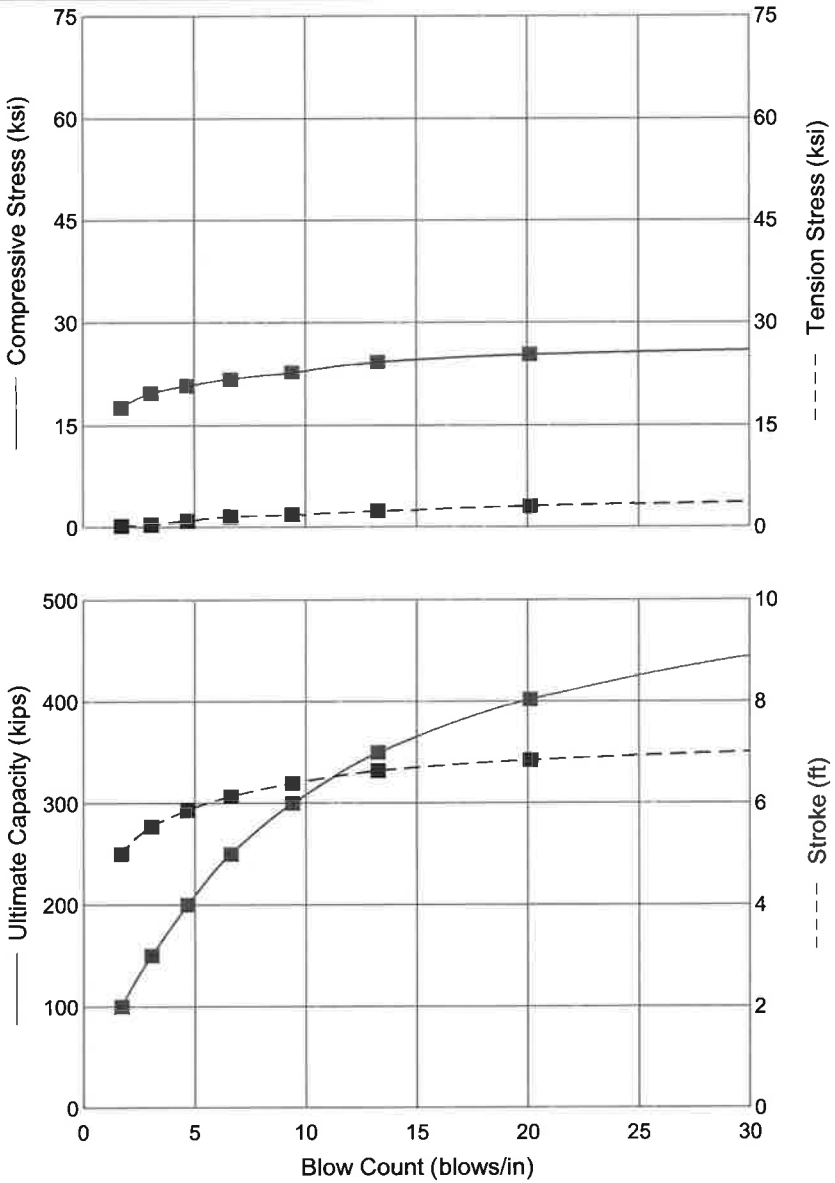
Bradford W. Roberts
Consultant / Reviewer

John E. Regan
Principal

Attachments: Wave Equation Analysis Results

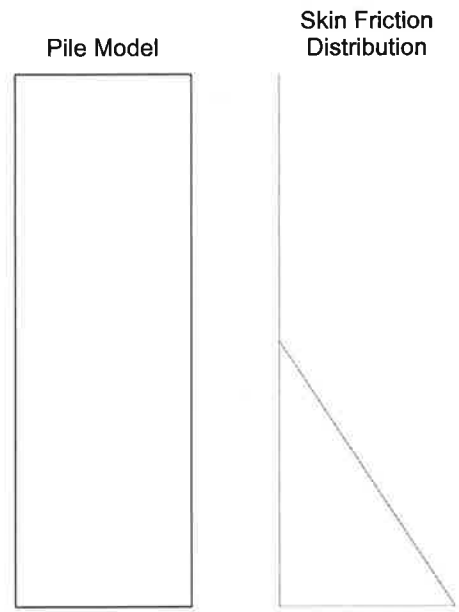
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 1) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010



DELMAG D 16-32

Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1039 (73%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	25.00	ft
Pile Top Area	21.80	in2



Res. Shaft = 20 %
(Proportional)

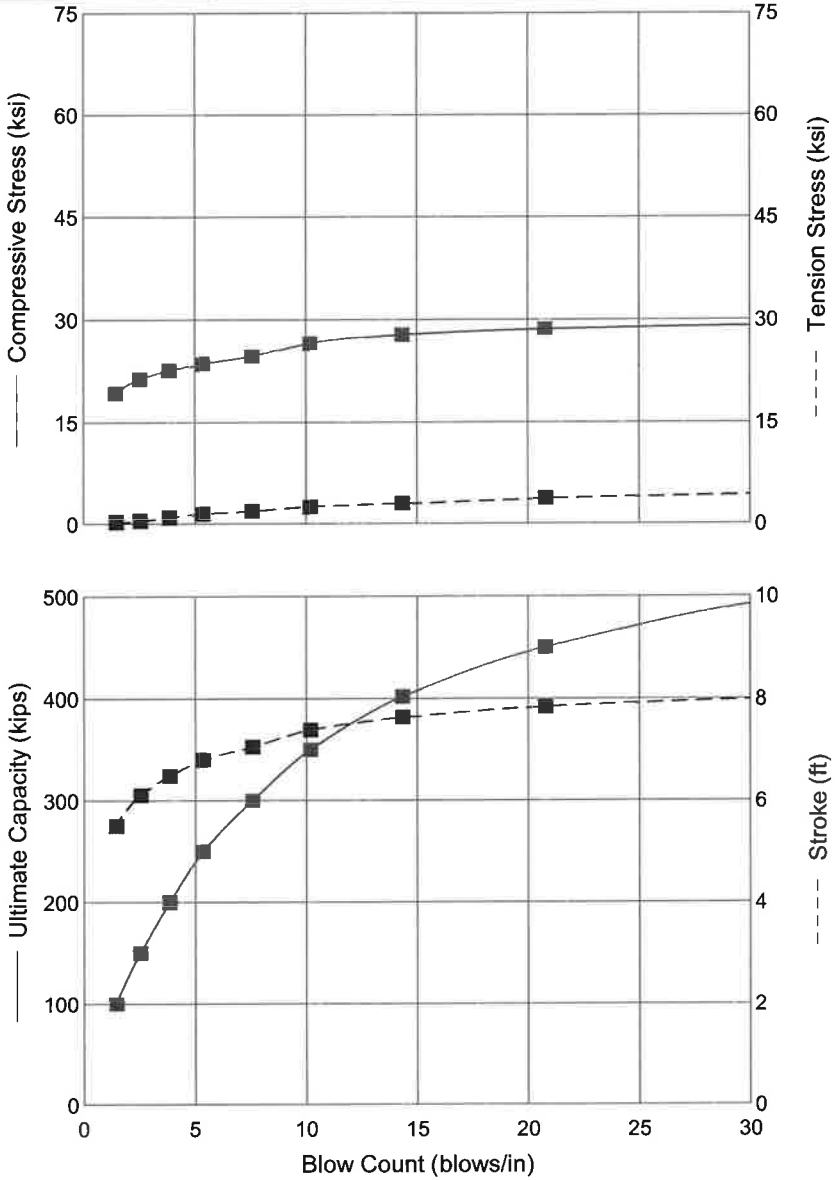
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 1) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	17.50	0.23	1.7	5.01	9.42
150.0	19.60	0.36	3.1	5.55	9.31
200.0	20.75	0.95	4.7	5.87	9.37
250.0	21.69	1.51	6.6	6.14	9.73
300.0	22.70	1.77	9.4	6.40	10.22
350.0	24.23	2.31	13.3	6.64	10.70
402.0	25.36	3.04	20.1	6.85	11.12
450.0	26.06	3.78	31.9	7.03	11.49
500.0	26.61	4.47	59.4	7.19	11.79
600.0	26.84	5.56	9999.0	7.30	11.95

GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 2) 50' HP12x74 VC

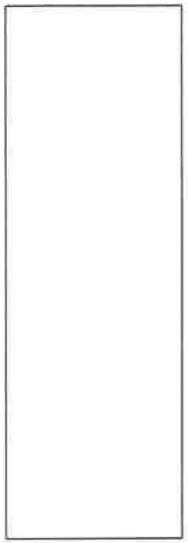
05-Feb-2014
GRLWEAP Version 2010



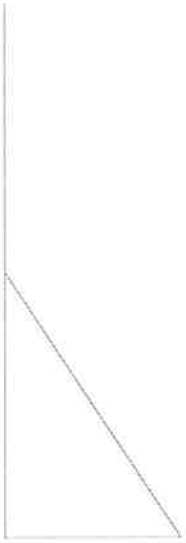
DELMAG D 16-32

Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1154 (81%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	25.00	ft
Pile Top Area	21.80	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 20 %
(Proportional)

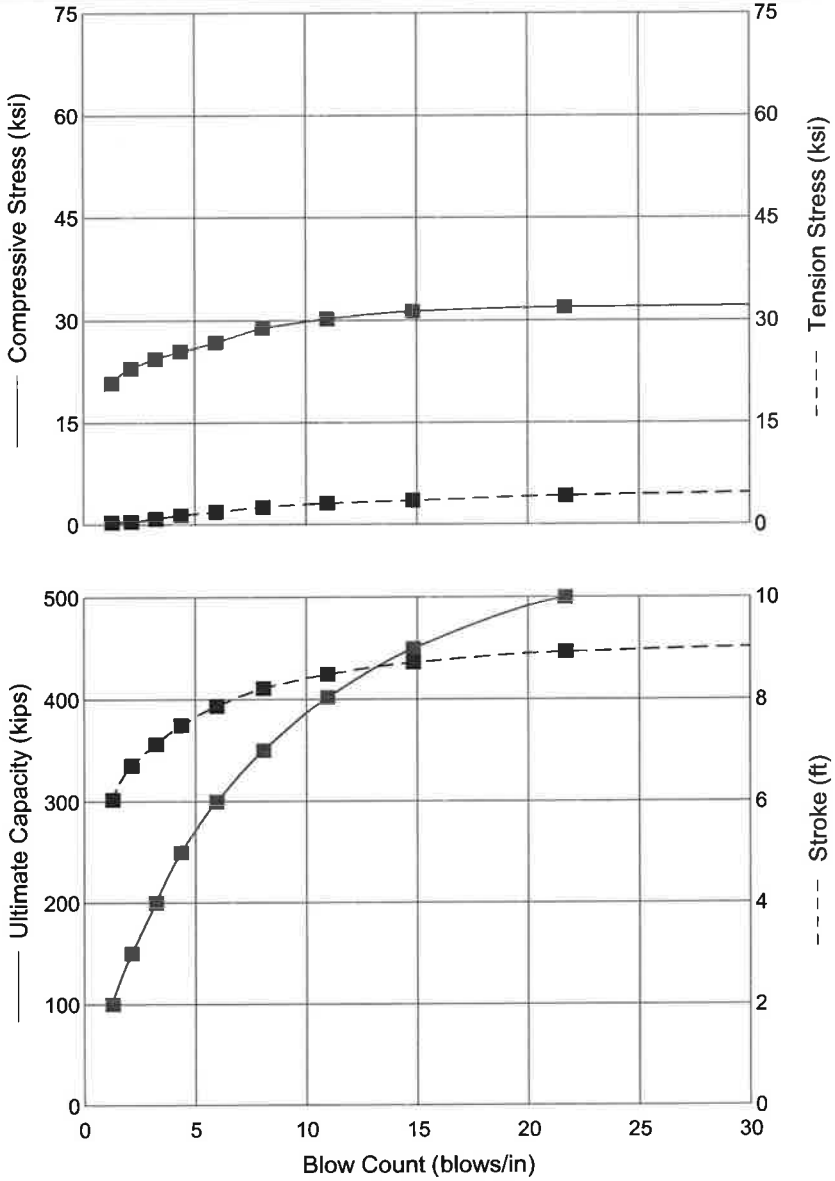
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 2) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	19.13	0.28	1.5	5.50	11.43
150.0	21.26	0.44	2.6	6.11	11.15
200.0	22.50	0.93	3.9	6.48	11.18
250.0	23.52	1.46	5.4	6.80	11.52
300.0	24.61	1.85	7.6	7.06	11.89
350.0	26.52	2.46	10.2	7.39	12.60
402.0	27.79	2.95	14.3	7.63	13.10
450.0	28.62	3.67	20.8	7.84	13.50
500.0	29.19	4.43	33.5	8.01	13.85
600.0	29.66	5.71	183.8	8.22	14.20

GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 3) 50' HP12x74 VC

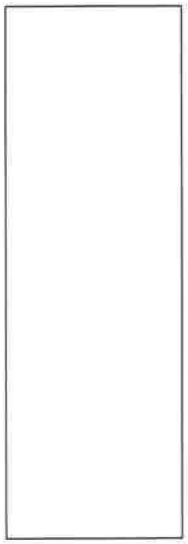
05-Feb-2014
GRLWEAP Version 2010



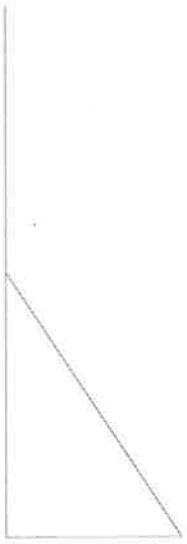
DELMAG D 16-32

Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1283 (90%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	25.00	ft
Pile Top Area	21.80	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 20 %
(Proportional)

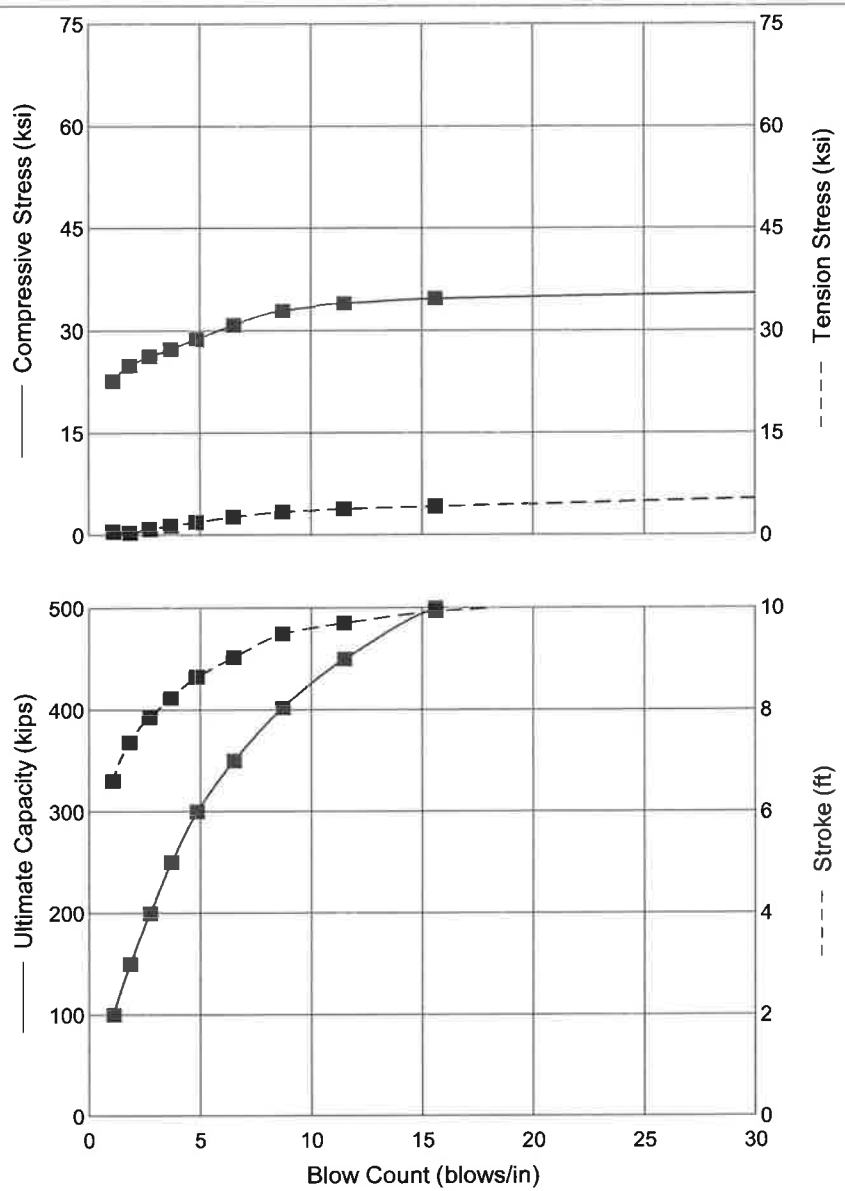
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 3) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	20.78	0.39	1.3	6.04	13.72
150.0	22.94	0.45	2.2	6.71	13.23
200.0	24.31	0.91	3.3	7.13	13.13
250.0	25.40	1.41	4.4	7.50	13.48
300.0	26.76	1.91	6.0	7.87	14.00
350.0	28.82	2.63	8.1	8.22	14.76
402.0	30.25	3.16	11.0	8.50	15.31
450.0	31.32	3.57	14.8	8.73	15.80
500.0	31.94	4.29	21.7	8.94	16.16
600.0	32.68	5.73	61.7	9.27	16.82

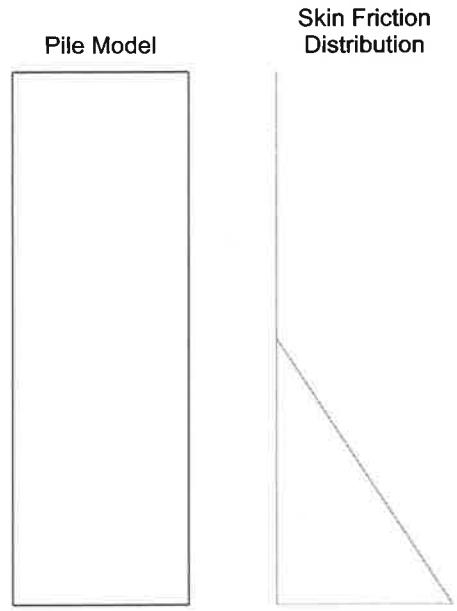
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 4) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010



DELMAG D 16-32

Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	25.00	ft
Pile Top Area	21.80	in2



Res. Shaft = 20 %
(Proportional)

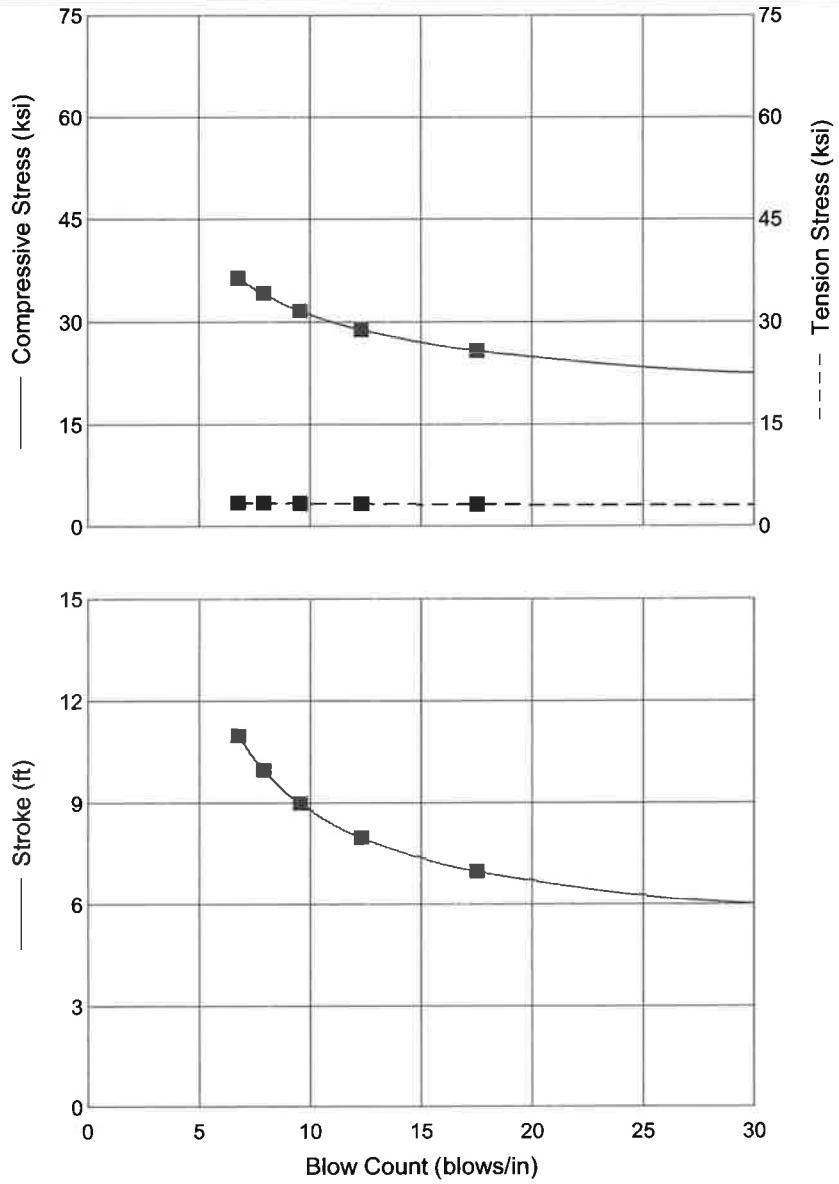
GZA GeoEnvironmental Inc.
Barnard D16-32 (FS 4) 50' HP12x74 VC

05-Feb-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
100.0	22.43	0.53	1.1	6.61	16.16
150.0	24.75	0.36	1.9	7.37	15.55
200.0	26.11	0.89	2.8	7.86	15.36
250.0	27.22	1.37	3.7	8.24	15.58
300.0	28.74	1.89	4.9	8.65	16.10
350.0	30.84	2.65	6.5	9.03	16.84
402.0	32.90	3.38	8.7	9.49	17.81
450.0	33.97	3.80	11.5	9.70	18.22
500.0	34.71	4.17	15.6	9.93	18.70
600.0	35.63	5.68	35.0	10.34	19.54

GZA GeoEnvironmental Inc.
Barnard D16-32 50' HP12x74 CC

06-Feb-2014
GRLWEAP Version 2010

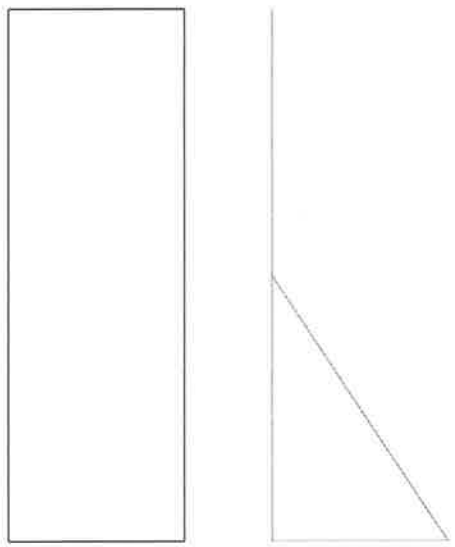


DELMAG D 16-32

Capacity	402.0	kips
Ram Weight	3.52	kips
Efficiency	0.800	
Pressure	1425 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	50.00	ft
Pile Penetration	25.00	ft
Pile Top Area	21.80	in2

Pile Model

Skin Friction Distribution



Res. Shaft = 20 %
(Proportional)

GZA GeoEnvironmental Inc.
Barnard D16-32 50' HP12x74 CC

06-Feb-2014
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
402.0	12.02	1.52	9999.0	3.00	2.97
402.0	15.20	2.47	9999.0	4.00	5.38
402.0	18.66	2.98	150.7	5.00	7.72
402.0	22.42	3.11	31.1	6.00	10.02
402.0	25.81	3.19	17.5	7.00	12.21
402.0	28.90	3.27	12.3	8.00	14.47
402.0	31.65	3.36	9.6	9.00	16.77
402.0	34.19	3.40	7.9	10.00	19.00
402.0	36.43	3.39	6.8	11.00	21.19

WELDING PROCEDURE SPECIFICATION (WPS) Yes ■
PREQUALIFIED _____ QUALIFIED BY TESTING _____
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes ☐

Identification # 1
Revision 0 Date 1/20/14 By J. Ouelette
Authorized by P. Holloway Date 1/20/14
Type—Manual ☐ Semiautomatic ☐
Mechanized ☐ Automatic ☐

Company Name Miller Construction, Inc.
Welding Process(es) SMAW
Supporting PQR No.(s) N/A

JOINT DESIGN USED
Type:
Single ■ Double Weld ☐
Backing: Yes ☐ No ■
Backing Material:
Root Opening _____ Root Face Dimension _____
Groove Angle: 45 Radius (J–U) _____
Back Gouging: Yes ☐ No ■ Method _____

BASE METALS
Material Spec. HP 12 X 74
Type or Grade GR 50
Thickness: Groove 0.68 Fillet 0.75
Diameter (Pipe) _____

FILLER METALS
AWS Specification A5.5
AWS Classification E7018

SHIELDING
Flux X Gas _____
Composition _____
Electrode-Flux (Class) _____ Flow Rate _____
Gas Cup Size _____

PREHEAT
Preheat Temp., Min. 70 F
Interpass Temp., Min. N/A Max. N/A

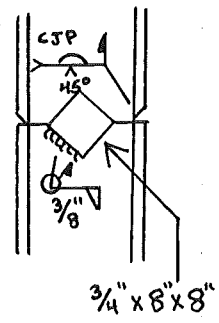
POSITION
Position of Groove: 2G Fillet: 1,2,3,4F
Vertical Progression: Up ■ Down ☐

ELECTRICAL CHARACTERISTICS
Transfer Mode (GMAW) E7018 Short-Circuiting ☐
Globular ☐ Spray ☐
Current: AC ☐ DCEP ■ DCEN ☐ Pulsed ☐
Power Source: CC ☐ CV ☐
Other _____
Tungsten Electrode (GTAW)
Size: N/A
Type: _____

TECHNIQUE
Stringer or Weave Bead: Stringer
Multi-pass or Single Pass (per side) Multi-Pass
Number of Electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

POSTWELD HEAT TREATMENT
Temp. N/A
Time _____

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals		Current		Volts	Travel Speed	Joint Details
		Class	Diam.	Type & Polarity	Amps or Wire Feed Speed			
3 Layers	SMAW	E7018	1/8	DC	132	22/26	As Req.	

Form N-1 (Front)

WELDING PROCEDURE SPECIFICATION (WPS) Yes ■
PREQUALIFIED _____ QUALIFIED BY TESTING _____
or PROCEDURE QUALIFICATION RECORDS (PQR) Yes ☐

Identification # 2
Revision 0 Date 1/20/14 By J. Ouelette
Authorized by P. Holloway Date 1/20/14
Type—Manual ☐ Semiautomatic ☐
Mechanized ☐ Automatic ☐

Company Name Miller Construction, Inc.
Welding Process(es) SMAW
Supporting PQR No.(s) N/A

JOINT DESIGN USED
Type:
Single ■ Double Weld ☐
Backing: Yes ☐ No ■
Backing Material:
Root Opening _____ Root Face Dimension _____
Groove Angle: _____ Radius (J–U) _____
Back Gouging: Yes ☐ No ■ Method _____

BASE METALS
Material Spec. HP 12 X 74
Type or Grade GR 50
Thickness: Groove 0.68 Fillet 0.75
Diameter (Pipe) _____

FILLER METALS
AWS Specification A5.5
AWS Classification E7018

SHIELDING
Flux X Gas _____
Composition _____
Electrode-Flux (Class) _____ Flow Rate _____
Gas Cup Size _____

PREHEAT
Preheat Temp., Min. 70 F
Interpass Temp., Min. N/A Max. N/A

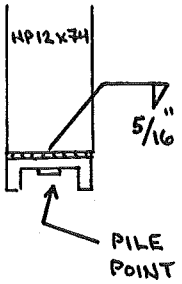
POSITION
Position of Groove: 2G Fillet: _____
Vertical Progression: Up ☐ Down ☐

ELECTRICAL CHARACTERISTICS
E7018
Transfer Mode (GMAW) Short-Circuiting ☐
Globular ☐ Spray ☐
Current: AC ☐ DCEP ■ DCEN ☐ Pulsed ☐
Power Source: CC ☐ CV ☐
Other _____
Tungsten Electrode (GTAW)
Size: N/A
Type: _____

TECHNIQUE
Stringer or Weave Bead: Stringer
Multi-pass or Single Pass (per side) Multi-Pass
Number of Electrodes _____
Electrode Spacing Longitudinal _____
Lateral _____
Angle _____
Contact Tube to Work Distance _____
Peening _____
Interpass Cleaning: _____

POSTWELD HEAT TREATMENT
Temp. N/A
Time _____

WELDING PROCEDURE

Pass or Weld Layer(s)	Process	Filler Metals		Current		Volts	Travel Speed	Joint Details
		Class	Diam.	Type & Polarity	Amps or Wire Feed Speed			
3 Layers	SMAW	E7018	3/16	DC	185	22/26	As Req.	

Form N-1 (Front)