MILLER CONSTRUCTION, INC.

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

TRANSMITTAL

TO: Kristin Higgins Vermont Agency of Transportation	DATE	PROJECT NO.
	3/28/2013	Jamaica ER-BRF 015-1 (23)

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

COPIES	NUMBER	DESCRIPTION	CODE
1		Wave Equation Analyses	H
1		Pile and Driving Equipment Data Form	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 J. Miller

GZA
GeoEnvironmental, Inc.

Engineers and
Scientists

March 27, 2013
File No.02.0171598.00

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

Re: Wave Equation Analyses – Abutment 2
Jamaica ER-BRF 015-1(23)
Jamaica, Vermont

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

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 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- Delmag D16-32 single-acting diesel hammer with a ram weight of 3,530 lbs. and a maximum stroke of 11.4 feet, yielding a rated energy of 40,200 ft-lbs. The Delmag D16-32 is equipped with a ratchet-style fuel pump with 4 settings. The settings are designated to limit the ram stroke to 5.4 feet, 6.4 feet, 8.0 feet, and 11.4 feet (open), yielding rated energies of 19,008 ft-lbs., 22,528 ft-lbs, 28,160 ft-lbs., and 40,200 ft-lbs., respectively. Note the Delmag D16-32 is modeled at fuel setting 3 (i.e., 8.0-foot ram stroke) to limit driving stresses into the pile. The helmet cushioning material is modeled as two-inches of aluminum and conbest. No pile cushion material is required for the pile type detailed below.

- Pile - 25-foot-long HP 12x84 Grade 50 steel piles are modeled. The cross-sectional area for this pile type is 24.6 square inches. The specified ultimate pile capacity (i.e., nominal resistance) is 380 kips. 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 soil profile is modeled and analyzed as 90% end-bearing and 10% skin friction with a 10-foot long triangular distribution in the medium sand and gravel overlaying a rectangular distribution in the underlying weathered bedrock along the lower 5 feet of the pile.

- Analysis Two analyses model each hammer-pile-soil model.

  1. Variable capacity analysis which develops a driving resistance based on the most efficient hammer stroke. Note that thte D16-32 is modeled operating on fuel setting 3 (rated 8.0 foot ram stroke) to limit driving stresses.

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 preliminary analyses are tabulated below:

PILE TYPE	ULTIMATE PILE CAPACITY	BLOW COUNT	STROKE	DRIVING STRESS	HAMMER ENERGY
HP12x84	380 kips	8 bpi	8.2 ft	31.9 ksi	12.9 kip-ft

Notes
1. The maximum allowable driving stress is 45 ksi (i.e., $0.9f_y$) for the Grade 50 HP steel piles.
2. The Delmag D16-32 is modeled operating on fuel setting 3 (8.0 foot rated stroke).

The results of these analyses indicate that the Delmag D16-32 open-end diesel hammer, operating on fuel setting 3 (i.e. rated 8.0 foot ram stroke), can drive the specified HP12x84 Grade 50 steel piles to an ultimate pile capacity of 380 kips without overstressing the pile section. The preliminary recommended driving resistance is 8 blows per inch with the Delmag D16-32 operating on fuel setting 3 and providing a ram stroke of approximately 8.0 feet. We recommend that the above driving criteria be developed for a minimum of 3 consecutive inches. It is our understanding the driving criteria will be verified with the dynamic pile-testing program.

We understand that the modeled specified HP12x84 steel piles to be installed in the Abutment 2 substructure are to be driven to bedrock and develop a minimum pile embedment of 20 feet below the bottom of pile cap elevations (i.e. elevation +721.35). The project specifications require that piles with less than 20 feet embedment will be rock-socketed into the underlying bedrock. All piles installed in the Abutment 1 substructure will be rock socketed into the underlying bedrock.

The borings adjacent to the Abutment 2 substructure indicate that the overburden contains cobbles and boulders which may affect the pile installation in terms of embedment and/or pile location. Given the project requirements, we recommend that the Contractor install the Abutment 2 HP12x84 piles in location with a vibratory hammer. If the piles can be installed to meet the pile embedment and pile location requirements, we recommend installing piles to vibratory refusal and then impact the piles with Delmag D16-32 diesel hammer.

Based on our review of the contract boring logs and our experience with this type of driving condition, the piles are expected to take-up abruptly as they develop end-bearing on competent bedrock. 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 penetration with the Delmag D16-32 operating at a minimum stroke of 8.0 feet.

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

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Michael Deery
Project Engineer

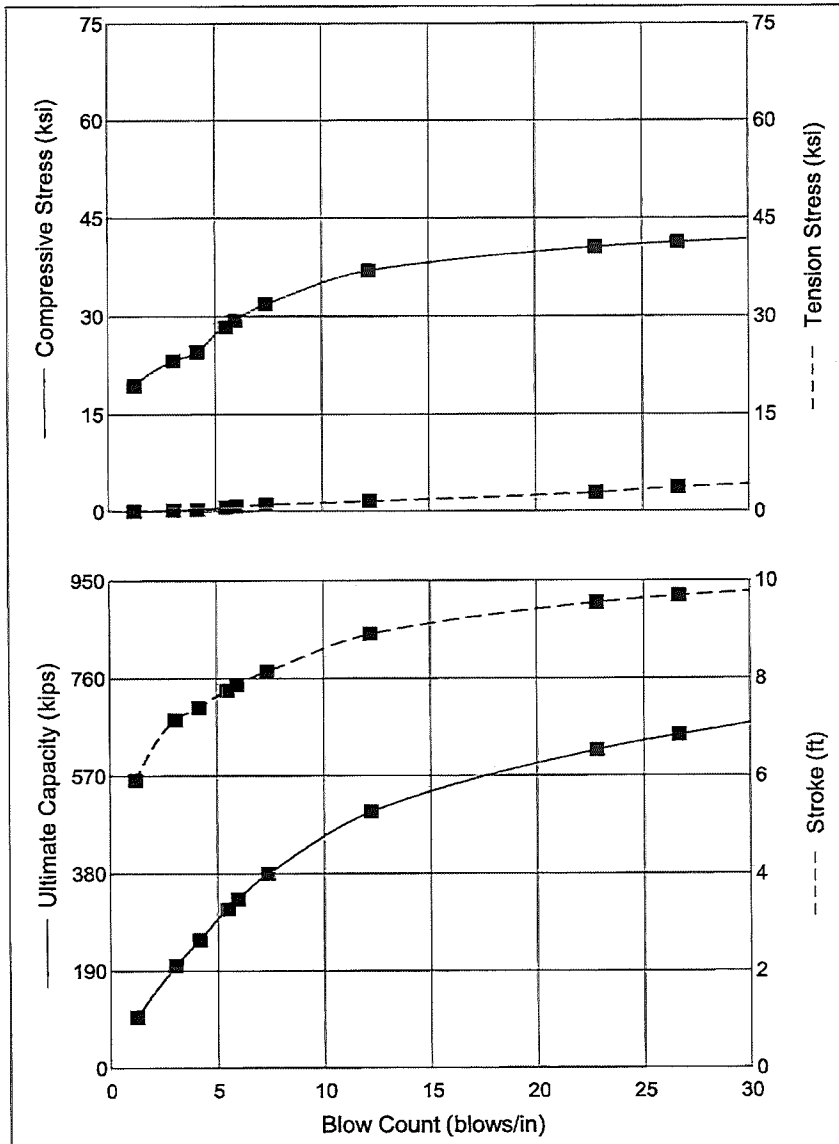
Bradford W. Roberts
Consultant / Reviewer

John E Regan
Principal

MJD/STR:idm
Attachments: Wave Equation Analysis Results

GZA GeoEnvironmental Inc.
Jamaica ER-BRF 015-1(23) D16 HP12x84 vc

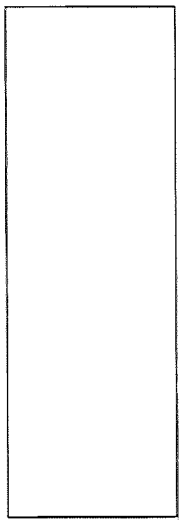
26-Mar-2013
GRLWEAP Version 2010



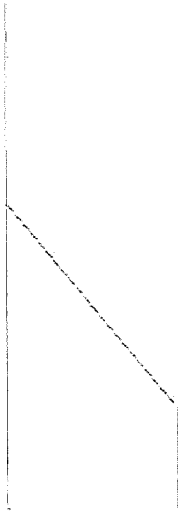
DELMAG D 16-32

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	0.020	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	25.00	ft
Pile Penetration	25.00	ft
Pile Top Area	24.60	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

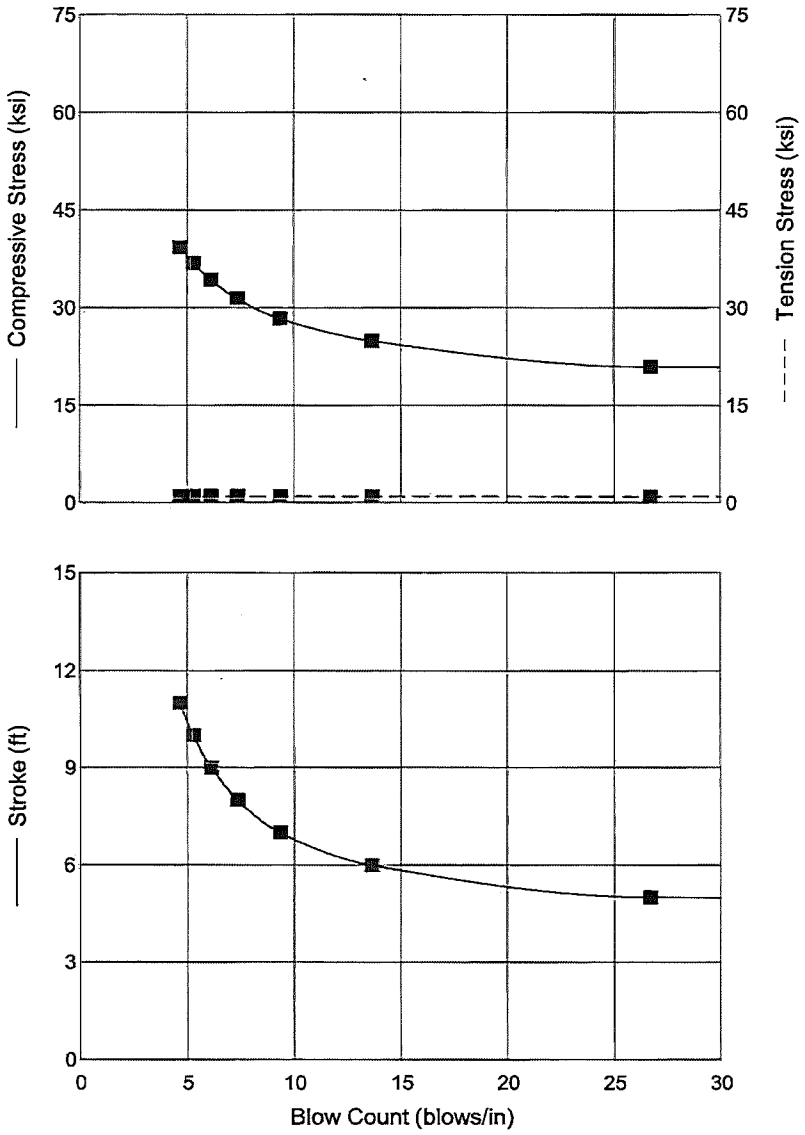
GZA GeoEnvironmental Inc.
Jamaica ER-BRF 015-1(23) D16 HP12x84 vc

26-Mar-2013
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	19.40	0.07	1.2	5.91	13.85
200.0	23.25	0.21	3.0	7.15	12.70
250.0	24.57	0.33	4.1	7.40	12.41
310.0	28.32	0.66	5.5	7.75	12.59
330.0	29.34	0.83	6.0	7.87	12.70
380.0	31.89	1.12	7.4	8.15	12.88
500.0	36.98	1.63	12.2	8.91	13.98
620.0	40.55	2.95	22.8	9.55	15.18
650.0	41.30	3.75	26.7	9.69	15.45
700.0	42.34	4.74	34.7	9.88	15.81

GZA GeoEnvironmental Inc.
Jamaica ER-BRF 015-1(23) D16 HP12x84 vc

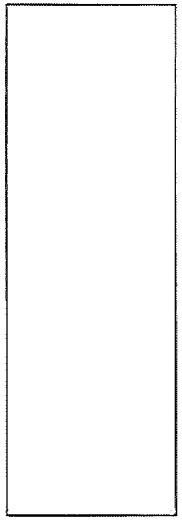
26-Mar-2013
GRLWEAP Version 2010



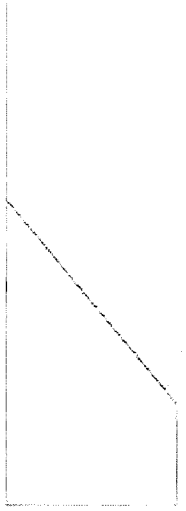
DELMAG D 16-32

Capacity	380.0	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	0.020	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	25.00	ft
Pile Penetration	25.00	ft
Pile Top Area	24.60	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 10 %
(Proportional)

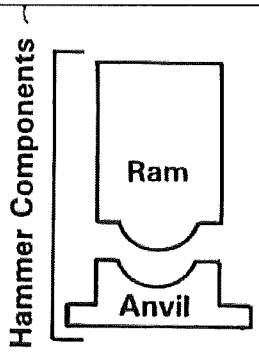
GZA GeoEnvironmental Inc. 26-Mar-2013
Jamaica ER-BRF 015-1(23) D16 HP12x84 vc GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count blows/in	Stroke ft	Energy kips-ft
380.0	12.31	0.59	9999.0	3.00	2.09
380.0	16.42	0.95	815.2	4.00	4.05
380.0	20.93	1.02	26.7	5.00	6.25
380.0	24.96	1.05	13.6	6.00	8.40
380.0	28.39	1.07	9.3	7.00	10.62
380.0	31.44	1.08	7.3	8.00	12.78
380.0	34.32	1.08	6.1	9.00	14.95
380.0	36.84	1.08	5.3	10.00	17.11
380.0	39.26	1.09	4.7	11.00	19.32

Pile and Driving Equipment Data Form

Project Name: Jamaica
Project No.: ER-BRF 015-1 (23)
Route No.: VT RTE 30

Structure Name: Bridge No. 30
Structure No: Bridge No. 30
Pile Driving Contractor: Miller Construction, Inc.
Foreperson: Raymond Estey



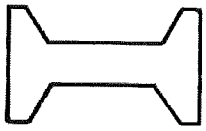
Hammer

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

Capblock (Hammer Cushion)

Material: Alum. and Conbest
Thickness (in): 2 | **Area (in²):** 227
Modulus of Elasticity – E (ksi): 530
Coefficient of Restitution-e: 0.8



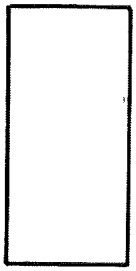
Pile Cap

Also named:
Helmet
Bonnet
Anvil Block
Drivehead

Weight (lbs): 1900

Pile Cushion

Cushion material: N/A
Thickness (in): N/A **Area (in²):** N/A
Modulus of Elasticity – E (ksi): N/A
Coefficient of restitution – e: N/A



Pile

Pile Type & Size: HP 12 X 84
Length (in Leads) (ft): 40 - 50
Weight (lb/ft): 84
Wall thickness (in): N/A
Taper: N/A
Cross Sectional Area (in²): 24.6
Ultimate Axial Pile Capacity (kips): 380
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: Eric J. Murphy
Title: General Manager

Date: 3/27/13