Technical Report 15-07

Experimental Evaluation and Design of Unfilled and Concrete-Filled FRP Composite Piles

Task 2 - FRP Composite Pile Driving at the Richmond-Dresden Bridge over the Kennebec River

Final Report – Task 2, January 2014
The overall goal of this project is the experimental evaluation and design of unfilled and concrete-filled FRP composite piles for load-bearing in bridges. This report covers Task 2, FRP Composite Pile Driving at the Richmond-Dresden Bridge over the Kennebec River.

Fiber reinforced polymer (FRP) piles manufactured by Harbor Technologies LLC were driven at the Richmond-Dresden bridge over the Kennebec River (PIN 12674) on August 28, 2013. All piles were 40 feet long with an additional 5 inch steel driving shoe and have an outside diameter of 23.5 inches. Driving was conducted using a Delmag D36---26 diesel hammer. This hammer has a rated energy of 90,560 foot-lbs., a 7930 lb. ram, and a variable fuel setting. The target ultimate load for the piles was 600 kips.

This report documents the pile driving activities including pile analysis and observations. The piles were later pulled and shipped to the University of Maine for further laboratory testing and analysis.
Technical Report

FRP Composite Pile Driving at the Richmond-Dresden Bridge over the Kennebec River

by

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Prepared for: Maine Department of Transportation

Project: Experimental Evaluation and Design of Unfilled and Concrete-Filled FRP Composite Piles

January 30th, 2014

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1. General Driving Information

Fiber reinforced polymer (FRP) piles manufactured by Harbor Technologies LLC were driven at the Richmond-Dresden bridge over the Kennebec River (PIN 12674) on August 28, 2013. All piles were 40 feet long with an additional 5 inch steel driving shoe and have an outside diameter of 23.5 inches. The driving site was located between Pier 5 and Pier 6 of the proposed bridge at approximate station 121+65. A restrike of Piles C and D was conducted on October 11, 2013. The configuration of the piles can be seen in Figure 1.

![Figure 1: Overall Pile Configuration (Looking Upstream)](image)

Pier 5’s soil conditions are characterized by glaciomarine silty clay overlain by alluvium and a depth to bedrock of approximately 15 feet. Pier 6’s soil conditions are characterized by glacial till overlain by marine nearshore deposits and a depth to bedrock of approximately 20 feet. See Appendix A for the initial subsurface investigation information. Two supplementary borings were taken at the driving site on November 20, 2013. The driller’s logs for these supplementary borings are attached in Appendix B. The two logs show refusal at approximately 25 feet with possible medium dense to very dense glacial till (about 5 feet thick) above refusal. This is overlain by soft clay and loose to medium fine sand deposits.

Driving was conducted using a Delmag D36-26 diesel hammer. This hammer has a rated energy of 90,560 foot*lbs, a 7,930 lb ram, and a variable fuel setting. The target ultimate
load for the piles was 600 kips. Driving criteria, based on the use of fuel setting 2 by GZA (8/13/2013), indicated that pile compressive stresses would be less than the specified maximum allowable stress of 12 ksi set by Harbor Technologies.

All Piles were driven using a steel driving shoe designed by Harbor Technologies. Hollow piles were driven with an open shoe as seen in Figure 2. Filled piles were driven with a closed shoe as seen in Figure 3.

![Figure 2: Driving Shoe for Hollow Piles](image1.png)

![Figure 3: Driving Shoe for Filled Piles](image2.png)

All piles were driven using a steel driving cap designed and fabricated by Reed and Reed, Inc. as seen in Figure 4.

![Figure 4: Steel Driving Cap](image3.png)
Pile A was driven with a 6 inch cushion of plywood between the steel cap and pile as seen in Figure 5. All other piles were driven with the steel cap directly touching the top of the pile as seen in Figure 6.

A new driving cap was designed for the restrike to prevent failure at the top of the pile. It can be seen in Figure 7. The restrike was conducted using the same driving hammer.

The layout of the piles after the restrike is shown in Figure 8. The piles achieved maximum penetrations of 21.5 to 23.1 feet below the mud line. The piles were removed following the
restrike and shipped to the University of Maine for testing. Piles B and D arrived on October 15, 2013 which was 4 days after the restrike. However, Piles A and D stayed in the ground approximately 3 weeks longer and were removed on November 6, 2013.

![Figure 8: Pile Layout After Restrike](image)

2. **Pile A**

2.1. Pile Description

Pile A has a 4 ply shell nominally 1/2 inch thick. This pile was completely filled with concrete on August 14, 2013. Class A concrete from MeDOT standard specifications was used.

2.2. Initial Driving

Pile A was driven on fuel setting 3 and stroke of 5 feet for 17 feet (including approximately 8 feet above the mud line). The pile was driven out of vertical alignment and driving was stopped to realign the pile. Pile A was then driven on fuel setting 2 to a penetration depth of 23 feet. Stopping criteria for this pile was 8 blows per inch on fuel
setting 2 with stroke of 6.2 feet. Driving was stopped at a final blow count of 4.5 blows per inch. The reported capacity of Pile A in the field based on the “Case Method” was 850 kips (see Appendix C, page C2). The PDA showed possible damage/separation near end of pile. After analysis of the data, GZA (9/25/2013) found that the dynamic pile testing data was not within reportable limits.

2.3. Restrike

There was no restrike for Pile A.

2.4. Damage

After being extracted, Pile A has a length of 40 feet with an additional 5 inches for the driving shoe. The driving shoe of this pile remained attached.

The bottom end of this pile showed no apparent damage. The bottom of Pile A can be seen in Figure 9.

![Figure 9: Bottom of Pile A](image)

The top of Pile A was damaged during removal. The top 9 inches of concrete cracked and was removed. The damage can be seen in Figure 10
Figure 10: Damage to Top of Pile A

Approximately 7 feet from the top of Pile A there are two gouges that measure 6 inches by 2 inches. These barely cut into the top layer of E-glass fabric reinforcement. The gouges can be seen in Figure 11.

Figure 11: Gouges Near Top of Pile A

There is a group of scrapes located 12 feet from the top of Pile A. This group measures 24 inches by 6 inches. The deepest portions of the group cut 3/4 of the way into the top layer of reinforcement. The scrapes can be seen in Figure 12.
There is also a series of five gouges that measure 7 inches by 2 inches each. These gouges run in the tangential direction of the pile and cut 1/4 of the way into the top layer of reinforcement. These can be seen in Figure 13.

Pile A has a longitudinal scratch that runs the entire length of the pile. The scratch appears to only be cosmetic damage over most of the pile, but the scratch cuts into the reinforcement from 7 to 10 and 21 to 28 feet from the top of the pile. The scratch from 7 feet to 10 feet cuts through 1 ½ layers of reinforcement and the scratch from 21 to 28 feet cuts 3/4 of the way into the top layer of reinforcement. At its largest point, the scratch is about 1/4 inch wide. The scratch can be seen in Figure 14 and Figure 15.
2.5. Testing Plan

Pile A will be tested in four point bending to failure or to the capacity of the test equipment.

3. Pile B

3.1. Pile Description

Pile B has an 8 ply shell and is nominally 1 inch thick. This pile has a 4 foot concrete plug at the bottom of the pile. The plug was cast on August 14, 2013 with the same batch of concrete used to fill Pile A.

3.2. Initial Driving

Pile B was driven for 25 feet (including approximately 8 feet above the mud line) on fuel setting 2 and stroke of 4.6 feet. Stopping criteria for this pile was 8 blows per inch at fuel setting 2 and stroke of 8.7 feet. Driving was stopped at 6.8 blows per inch. It was found that this corresponded to a penetration depth of 25.9 feet with 1.3 feet of brooming. The reported capacity of Pile A in the field based on the “Case Method” was 600 kips (see Appendix C, page C3). However, after further analysis GZA (9/25/2013) revised the “Case Method” capacity to 530 kips and calculated a Case Pile Wave Analysis Program (CAPWAP) capacity of 510 kips (30 kips side friction, 480 kips end bearing).

3.3. Restrike

There was no restrike for Pile B.
3.4. Damage

After being extracted, Pile B has a length of 39 feet and 1 inch. The driving shoe of this pile remained attached. The steel shoe is no longer square to the pile and appears to have bent into a concave shape.

The most significant damage to Pile B occurred at the bottom end of the pile. During driving, the plug and driving shoe were forced upwards approximately 1.3 feet. This caused the end of the pile to broom. This can be seen in Figure 16.

Figure 16: Damage at Tip of Pile B

The driving end of the pile sustained a 13 inch longitudinal crack at approximately 38 feet from the top of the pile. This can be seen in Figure 17.

Figure 17: Crack near Tip of Pile B
There is also some damage at the top of the pile. Several circular gouges are located 3-4 feet from the top of the pile. These gouges cut through the top 2 layers of reinforcing. This can be seen in Figure 18. Note that there is a circular hole of the pile purposely made to facilitate extraction.

![Circular Gouges at Top of Pile B](image)

**Figure 18: Circular Gouges at Top of Pile B**

Pile B has noticeable scrapes to the blue gel coat along the length of the pile. These scrapes become more concentrated at the bottom of the pile. It is estimated that these scrapes cover 2-3% of the pile’s surface area. These appear to only be cosmetic damage and should not affect the structural capacity of the pile.

When Pile B was being prepared for flexural testing the concrete plug was cut off. The bottom portion of the plug is mainly sand and coarse aggregate, even though the same concrete used for this plug was used to fill Pile A. The upper 6 inches of the plug resembles chalk and is lightweight. The upper portion of the plug can be broken by hand. The removed concrete can be seen in Figure 19. It is believed that water infiltrated the piles, potentially through the driving shoe, during concrete placement and saturated the concrete preventing it from properly curing. By Inspection, the concrete in the plug did not meet the specified strength. The concrete was also tested with a Schmidt Concrete Test Hammer. This equipment was not calibrated but was verified against concrete with known design strengths at the Advanced Structures and Composites Center. The concrete did not register on the test hammer’s scale, which has a minimum value of 1,450 psi. The removed plug can be seen in Figure 20.
3.5. Testing Plan

Pile B will be cut to a length of 35 feet and tested in four point bending to failure. The end with the concrete plug will be removed before the flexural test.

4. Pile C

4.1. Pile Description

Pile C has an 8 ply shell nominally 1 inch thick. This pile was driven hollow, cleaned out and filled with concrete on October 2, 2013. A restrike was conducted on October 11, 2013.

4.2. Initial Driving

Pile C was driven for 33 feet (including approximately 10 feet above the mud line). At this depth, the PDA showed damage approximately 5 feet from the end of the pile. Driving continued to a penetration depth of 26 feet when the top of the pile failed. The failure can be seen in Figure 21. Stopping criteria for this pile was 11 blows per inch at fuel setting 2 and stroke of 8.5 feet. At failure, the blow count was 2 blows per 1/2 inch. The reported capacity of Pile C in the field based on the “Case Method” was 470 kips (see Appendix C, page C4). After further analysis, GZA (9/25/2013) revised the “Case Method” capacity to 520 kips and calculated a CAPWAP capacity of 470 kips (60 kips side friction, 410 kips end bearing).
4.3. Restrike

The damaged end of this pile was removed to the bottom of the lifting hole seen in Figure 21 (approximately 1 foot). Pile C was cleaned out and filled with MeDOT Class A concrete prior to the restrike. During the cleanout process, the contractor encountered an object approximately 5 feet from the end of the pile that could not be broken or removed. The object was believed to be a boulder, but potentially may have been the detached steel driving shoe. It was initially driven at fuel setting 2 for 4 blows. Then the fuel setting was increased to 3 and the pile was driven 8 more inches. The reported capacity of Pile C in the field based on the “Case Method” was 750 kips (see Appendix D, page D2). After further analysis, GZA (11/13/2013) determined the average “Case Method” capacity to be 731 kips.

4.4. Damage

After being extracted, Pile C has a length of 34 feet and 11 inches. Based on reference marks for monitoring pile driving depths, the bottom 4 feet 6 inches of the pile broke during driving and was not recovered. The rest of this change in length can be attributed to cutting off the damaged portion at the top of the pile after driving. The driving shoe detached during driving, but was recovered.

The bottom of Pile C suffered significant damage from driving. Approximately 4 feet 6 inches of the bottom of the pile broke off during driving. This can be seen in Figure 22.
There are several scrapes about 5 feet from the top of Pile C. The largest is 16 inches by 5 inches. These scrapes cut 3/4 of the way into the top layer of reinforcement. These can be seen in Figure 23.

There is a series of long scratches that run from 15 feet to 30 feet from the top of Pile C. These scratches barely cut into the top layer of reinforcement. They can be seen in Figure 24.
Pile C has an 8 inch gouge approximately 15 feet from the top. This gouge cuts 3/4 of the way into the top layer of reinforcement. It can be seen in Figure 25.

Pile C has a series of 9 gouges that measure approximately 8 to 10 inches long by 1 inch wide. These gouges are located between 15 and 22 feet from the top of the pile. At the deepest point, these gouges cut 3/4 of the way into the top layer of reinforcement. They can be seen in Figure 26 and Figure 27. The similar gouge pictured in Figure 25 is at the same distance from the top of the pile, but on the opposite side.
4.5. Testing Plan

Pile C will be tested in four point bending to failure or to the capacity of the test equipment.

5. Pile D

5.1. Pile Description

Pile D has an 8 ply shell nominally 1 inch thick. This pile was driven hollow. A restrike was conducted on October 11, 2013.

5.2. Initial Driving

Pile D was driven for 35 feet (including approximately 10 feet above the mud line). At this depth, the PDA showed damage 20 feet from the top of the pile. Driving continued to a penetration depth 25.5 feet when the top of the pile failed. The failure can be seen in Figure 28. Stopping criteria for this pile was 11 blows per inch at fuel setting 2 and stroke of 8.5 feet. At failure, the blow count was 2 blows per inch. The reported capacity of Pile D in the field based on the “Case Method” was 600 kips (see Appendix C, page C5). After further analysis, GZA (9/25/2013) revised the “Case Method” capacity to 510 kips and calculated a CAPWAP capacity of 440 kips (60 kips side friction, 380 kips end bearing).
5.3. Restrike

Pile D was driven on fuel setting 2 for 7 inches and showed plugging at a depth of 30 feet. The fuel setting was then increased to 3 and driven for an additional 7 inches. During driving the pile was visibly flexing. The reported capacity of Pile D in the field based on the “Case Method” was 650 kips (see Appendix D, page D3). After further analysis, GZA (11/13/2013) revised the “Case Method” capacity to 460 kips and calculated a CAPWAP capacity of 440 kips (60 kips side friction, 380 kips end bearing).

5.4. Damage

After being extracted, Pile D has a length of 34 feet and 5 inches. Approximately 2 feet of this change in length can be attributed to cutting off the damaged portion at the top of the pile after driving. The driving shoe of this pile detached and was not recovered.

The bottom of Pile D suffered significant damage from driving. Approximately 4 feet of the pile broke off during driving. This can be seen in Figure 29.
Figure 29: Damage to Bottom of Pile D

A longitudinal crack extends from the damaged end of the pile approximately 43 inches from the bottom of the pile. This can be seen in Figure 30.

Figure 30: Longitudinal Cracking at Bottom of Pile D

There is a large gouge in the side of this pile about 15 feet from the top of the pile. This occurred during the extraction process, when the contractor drove a wedge next to the pile to free it from the surrounding soil. This damage went through the wall, as seen in Figure 31.
Pile D has noticeable scrapes to the blue gel coat along the length of the pile. These scrapes become more concentrated at the bottom of the pile. It is estimated that these scrapes cover 4-5% of the piles surface. These appear to only be cosmetic damage and will not affect the bending capacity of the pile.

5.5. Testing Plan

Pile D will not be tested in four point bending. It will be cut into 3 sections to be tested in axial compression.
References

Appendix A: Original Richmond-Dresden Subsurface Information
**Maine Department of Transportation**

**Project:** Maine Kneeland Bridge #2566

**Location:** Richmond-Dover, Maine

**Boring No.:** BB-RD KR-105

**WIN:** 12674.00

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<th>Driller:</th>
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**Boring Location:** 120-607.1, 12.0 ft RL

| Casing ID/NO: | HW/1W |
| Water Level: | Water Boring - Tidal |
| Hammer Type: | Automatic |
| Motor Load: | Hydraulic |
| Rope & Cable: | 0.6 |

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<th>Definition</th>
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<td>MO = Unclassified Split Sample</td>
<td>Sample No. 24/24 2.00 - 4.00 3/8&quot;/2&quot; WOB/2&quot; WOB</td>
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<td>U = Thin Wall Tube Sample</td>
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| Sample 24/24 2.00 - 4.00 3/8"/2" WOB/2" WOB, \( \text{RQD} = 67\% \) 4 4 12 |

| Sample 24/24 4.00 - 4.36 Would not push, \( \text{RQD} = 67\% \) 4 4 12 |

- **Top:** Brown-gray, wet, loose, Silty clay to medium SAND (Alluvium) 1-2 ft.
- **Bottom:** Gray, wet, Silty CLAY, trace fines sand (Percussive Formation).
- **Gravel:** Gray, very soft, Silty CLAY, trace fines sand (Percussive Formation).

**Remarks:**

1. MaineDOT provided coordinates of test boring locations in NAD83 (96) ME 2000 Wet Zone Coordinate System and ground surface elevations in NAVD94. 2. Bore counts for spoons driven through a disturbed field were not counted. 3. Shelby tubes collected using a CUS sampler. 4. Drilling mud consisting of bentonite and barite weight material was used. 5. PLT = Permeability tested at Field Test at Field Test. 6. UCT = Unit compressive strength from Uniaxial Compressive Strength Test.

- **Top:** Bedrock at 12.5 ft.
- **Middle:** Brown-gray, wet, loose, Silty clay to medium SAND (Alluvium) 1-2 ft.
- **Bottom:** Gray, wet, Silty CLAY, trace fines sand (Percussive Formation).

| Boring No.: | BB-RD KR-105 |

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**Stratification lines represent approximate boundaries between soil types; transitions may be gradual.**

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**Page 1 of 2**
<table>
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<th>Description</th>
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<th>BSFL (%)</th>
<th>NQ</th>
<th>Core Recovery</th>
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**Visual Description and Remarks:**
- Formation: Discontinuities are very close to moderately close, mostly parallel to foliation, subhorizontal to moderately dipping, planar, undulating, rough to very rough, with some quartz veins parallel to foliation, up to 1 inch thick.
- Rock: Mass Quality = Poor.
- Core: Core Tests (in situ):
  - 206.6-208.6: (4.55)
  - 210.6-212.6: (2.65)
  - 214.6-216.6: (2.15) 92% Recovery
  - Filed up 1.4" of R3
- R3: Medium to dark gray, felsic to medium grained, very strong to extremely strong (R7-8), fresh to slightly weathered, strongly foliated, muscovite-pyrophillite-quartz-biotite Schist (Trematic Pond Formation). Discontinuities are close to moderately close, mostly parallel to foliation, subhorizontal to moderately dipping, planar, undulating, rough to very rough, with some quartz veins parallel to foliation, up to 1 inch thick.
- Rock: Mass Quality = Fair.
- Core: Core Tests (in situ):
  - 226.6-228.6: (2.15)
  - 230.6-232.6: (2.30)
  - 234.6-236.6: (2.40)
  - 238.6-240.6: (2.25) 100% Recovery

**Shading:**
- S = Schist
- Q = Quartzite
- B = Biotite
- M = Muscovite

**Laboratory Testing Results:**
- UCST = Peak compressive strength from Uniaxial Compression Strength Test.
- PLT = Peak load index from Point Load Index Test.

**Remarks:**
1. Maine DOT provided coordinates of test boring locations in NAD83 (26) ME 2008 West Zone Coordinate System and ground surface elevations in NAVD88.
2. Bore counts for spots driven through a disturbed field test location cannot be used to determine N-value.
3. Shelby tubes collected using a GUS sampler.
4. Drilling mud consisting of bentonite and ballast weight material was used.
5. PLT = Peak compressive strength estimated from Point Load Index Test. UCST = Peak compressive strength from Uniaxial Compression Strength Test.
Maine Department of Transportation
Project: Maine Kennebec Bridge #2506
Location: Richmond-Dresden, Maine
Boring No.: BB-RDKR-105B
WIN: 12674.00

Driller: Maine Test Boring
Operator: B. Fogg
Datum: NAVD88
Auger ID/DD: -
Sampler: P' Tube

Logged By: M. Hunter
Rig Type: CM-45 Skid on Anchor Stage
Hammer Vol./Foot: -
Core Barrel: NO-2

Date Start/Finish: 12/7-11
Drilling Method: Cased Wash Boring with Mud
Boring Location: 120+59.8, 14.3 E.R.
Casing ID/DD: HW
Core Elevation: -
Water Level: -

Hammer Efficiency Factor: 0.6
Hammer Type: Automatic(1)
Hydraulic (1): -
Rope & Casing(2):

Sample Information

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<td>V6</td>
<td>11.64 - 12.00</td>
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Note 2:
A. WEP = Hydraulic Push
   General based on drill behavior.
   Gravel, wet, Silty CLAY.
   Wash to P to sand coming in clay.

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<td></td>
<td>OPEN</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Visual Description and Remarks

65 x 130 mm vane shear test readings:
V1: 20.2/2.5 ft-lb
V2: 24.0/2.5 ft-lb
Gravel, wet, medium stiff, Silty CLAY (Preamplified Formation).

Bottom of Exploration at 12.00 feet below ground surface.

Remarks:

1. MaineDOT provided coordinates of test boring locations in NAD83 (93) ME 2000 West Zone Coordinates System and ground surface elevations in NAVD88.
2. Supplementary boring to compliment BB-RDKR-10, with field vane shear test data in silty clay soils.
3. Shelly values collected using a CUS sampler.
4. Drilling mud consisting of bentonite and barley weight material was used.
5. Water level readings have been made at times and other conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time readings were made.
### Maine Department of Transportation

**Project:** Maine Kennebec Bridge #2516  
**Location:** Richmond-Dresden, Maine  
**Boring No.:** BB-RDKR-207  
**PIN:** 12674.00

### Sample Information

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Color/Description</th>
<th>Sample Text</th>
<th>Sample Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>WOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24/24</td>
<td>3.0 - 5.0</td>
<td>W1P/W1P/W2P/W2P/2P ---</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>24/24</td>
<td>7.0 - 9.0</td>
<td>W1P/W1P/W1P/W1P</td>
<td>Note 2</td>
</tr>
<tr>
<td>10</td>
<td>24/24</td>
<td>10.0 - 12.0</td>
<td>W1P/W1P/W1P/W1P</td>
<td>Note 2</td>
</tr>
<tr>
<td>10</td>
<td>16/26</td>
<td>12.0 - 13.0</td>
<td>W1P/W1P/W1P</td>
<td>Note 2</td>
</tr>
<tr>
<td>13</td>
<td>60/56</td>
<td>18.3 - 23.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>60/56</td>
<td>23.3 - 26.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Visual Description and Remarks

- Casing sunk into river bottom to 1.6 ft. Gravel and sand in wash to 3.6 ft.
- pH = Casing pushed with drill rig hydraulics.

### Laboratory Testing Results/AASHTO and Unified Class

- **Sample No.** 24/24  
  - Color: Dark Clay, trace fine sand (Presumptive Formation).  
  - Form: Medium stiff, Silty CLAY (Presumptive Formation). Ignition loss 5.6%.
  - V1: 263.5 psi  
  - V2: 653.0 psi  
  - V3: 263.5 psi  
  - V4: 263.5 psi  

### Remarks

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. All samples for spudding driven through a disturbed field vane test location cannot be used to determine N-value.
3. **UCT95:** Peak compressive strength from Uniaxial Compressive Strength Test.

---

Shallow soil lines represent approximate boundaries between soil types. Intersections may be gradual.

*Water level readings have been made in test holes and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.*
**Maine Department of Transportation**

**Project:** Maine Kennebec Bridge 82566  
**Location:** Richmond-Dresden, Maine  
**Boring No.:** BB-RDKR-207  
**PIN:** 12674.00

**Driller:** Maine Ted Borens  
**Elevation (ft):** -23.3  
**Auger ID/DD:** -  
**Operator:** H. Hartwick  
**Datum:** NAVD88  
**Sampler:** 2" Split Spoon

**Logged By:** M. Porte  
**Rig Type:** CME-45 Skid on Anchor Barge  
**Hammer Wt/Fall:** 140/30 SS: 300/15 Csn.

**Date Start/Finish:** 7/20/12  
**Drilling Method:** Case Drill Boring with Water  
**Core Barrel:** NC-2  
**Boring Location:** 120+0.3, 7.9 RLL  
**Casing ID/DD:** BW/NW  
**Water Level:** Water Boring - Tidal

**Hammer Efficiency Factor:** 0.6  
**Hammer Type:** Automatic

---

### Sample Information

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Perc./Rec. (in)</th>
<th>Sample Depth (ft)</th>
<th>Blunt/Flat Strength (psi)</th>
<th>Bedrock Strength (psi)</th>
<th>N-value</th>
<th>Sample Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>1</td>
<td>N/A</td>
<td>25</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>2</td>
<td>N/A</td>
<td>30</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>3</td>
<td>N/A</td>
<td>35</td>
<td>N/A</td>
<td>N/A</td>
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<td>R</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>N/A</td>
<td>40</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>R</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>5</td>
<td>N/A</td>
<td>45</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>R</td>
<td></td>
</tr>
</tbody>
</table>

**Graph Log**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Visual Description and Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.3</td>
<td><strong>Bottom of Exploration at 23.3 feet below ground surface.</strong></td>
</tr>
</tbody>
</table>

---

**Remarks:**

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. Blow counts for spoons driven through a disturbed field vane test location cannot be used to determine N-value.  
3. Vortex = Peak compressive strength from Uniaxial Compressive Strength Test.

---

**Laboratory Testing Results / AASHTO and Unified Class**

Page 2 of 2  
**Boring No.:** BB-RDKR-207
# Maine Department of Transportation

## Soil Exploration Log

**US CUSTOMARY UNITS**

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Sample No.</th>
<th>Penetration in.</th>
<th>Sample Length (in.)</th>
<th>Blow (b)</th>
<th>RQD (%)</th>
<th>Percentum</th>
<th>Length</th>
<th>Casing ID/ID</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>R1</td>
<td>6.6</td>
<td>25.20 - 25.75</td>
<td>63 (H)</td>
<td>53</td>
<td>98</td>
<td>18</td>
<td>25.1</td>
<td>Gray, wet, very dense Silt, some gravel, some fine to coarse sand, traces of clay (Glacial Till). Casing failed at 26 ft; roller cone ahead to 26.9 ft.</td>
</tr>
<tr>
<td>30</td>
<td>R2</td>
<td>40/5</td>
<td>26.60 - 29.02</td>
<td>70 (H)</td>
<td>98</td>
<td>21</td>
<td>15</td>
<td>29.6</td>
<td>Calibrated pulled core barrel. Casing failed on cone at 28.6 ft.</td>
</tr>
<tr>
<td>40</td>
<td>R3</td>
<td>4/4</td>
<td>29.00 - 29.50</td>
<td>70 (H)</td>
<td>98</td>
<td>18</td>
<td>18</td>
<td>29.6</td>
<td>Top of Bedrock at 29.00 ft. Roller cone ahead to 30.7 ft (Elev. -30.1 ft).</td>
</tr>
<tr>
<td>45</td>
<td>R4</td>
<td>62/62</td>
<td>30.00 - 35.17</td>
<td>60 (H)</td>
<td>99</td>
<td>21 (C)</td>
<td>18</td>
<td>35.2</td>
<td>Light gray, fine to medium grained, very strong to extremely strong (R5-R6). Fresh to slightly weathered, slightly altered, phyllicic-plagioclase-SCHIST (Glacial Till). Discontinuities are very close to moderately close, subhorizontal to moderately dipping, planar to irregular, rough with dark grey to black mineral streaks (MxNc).</td>
</tr>
</tbody>
</table>

**Laboratory Testing Results/ AADTHO and Unified Class**

- **Sample Information**
- **Visual Description and Remarks**
- **Graphs**

**Boring No.**: BB-RDKR-106B

1. MaineDOT provided coordinates of test boring locations in NAD83 (90) ME 2000 West Zone Coordinate System and ground surface elevations in NAVD88.
2. Continuation of BB-RDKR-106B, BB-RDKR-105 terminated at 14.0 ft due to broken NW casing.

**Shallower**: less represent approximate boundaries between stratigraphic formations may be gradual.

**Water level readings have been made at times and on occasions indicated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.
<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Sample No.</th>
<th>Pen. / Rnd. (in.)</th>
<th>Sample</th>
<th>Depth (ft.)</th>
<th>Bearing (lb. ft.)</th>
<th>Degree</th>
<th>Nk</th>
<th>Grain Size</th>
<th>Remarks</th>
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<tbody>
<tr>
<td>50</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**

1. MaineDOT provided coordinates of test boring locations in NAD83 (96) ME 2000 West Zone Coordinate System and ground surface elevations in NAVD88.
2. Continuation of BB-RDKR-106 BB-RDKR-106 terminated at 14.0 ft due to broken NW casing.
3. CPT<sub>sp</sub>: Peak compressive strength from Uniaxial Compressive Strength Test.

*Shorthand lines represent approximate boundaries between stratigraphic horizons and may be gradual.

*Note: Values listed may include or have been derived from data provided by other sources, as well as values calculated by the Maine DOT.

**Bottom of Exploration at 48.00 feet below ground surface.**
**Maine Department of Transportation**  
**Project:** Maine Kennebec Bridge #2506  
**Location:** Richmond-Dresden, Maine  
**Boring No.:** BB-RDKR-208  
**PIN:** 12674.00

<table>
<thead>
<tr>
<th>Driller:</th>
<th>Maine Test Boring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevatoin (ft):</td>
<td>-0.2</td>
</tr>
<tr>
<td>Auger ID/OD:</td>
<td>-</td>
</tr>
<tr>
<td>Operator:</td>
<td>M. Porter</td>
</tr>
<tr>
<td>Datum:</td>
<td>NAVD88</td>
</tr>
<tr>
<td>Sampler:</td>
<td>2&quot; Split Spoon</td>
</tr>
<tr>
<td>Logged By:</td>
<td>M. Henrick</td>
</tr>
<tr>
<td>Rig Type:</td>
<td>CME-45 Skid on Anchor Barge</td>
</tr>
<tr>
<td>Hammer Wt/Fall:</td>
<td>140 lbs 500' 15 Cariq</td>
</tr>
<tr>
<td>Date Start/Finish:</td>
<td>7/5-6/12</td>
</tr>
<tr>
<td>Drilling Method:</td>
<td>Case Wash Boring with Water</td>
</tr>
<tr>
<td>Core Barrel:</td>
<td>NO-2</td>
</tr>
<tr>
<td>Boring Location:</td>
<td>123°11'8.430 17.2 3.81</td>
</tr>
<tr>
<td>Casing ID/OD:</td>
<td>RWNW</td>
</tr>
<tr>
<td>Water Level:</td>
<td>Water Boring - Tidal</td>
</tr>
</tbody>
</table>

| Hammer Efficiency Factor: | 0.6 |
| Hammer Type: | Automatic |
| Hydraulics: | |
| Rope & Cable: | |

**Sample Information**

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Number</th>
<th>Sample Type</th>
<th>Blasted (ft)</th>
<th>Blasted (m)</th>
<th>Blockage (ft)</th>
<th>Water Content (%)</th>
<th>N-Recovery</th>
<th>N-DRK</th>
<th>Casing Blockage</th>
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<tr>
<td>0</td>
<td>1D</td>
<td>24.6</td>
<td>0.0 - 2.0</td>
<td>3/7/11/9</td>
<td>18</td>
<td>18</td>
<td>IPa</td>
<td>21</td>
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<tr>
<td>1.5</td>
<td>2D</td>
<td>24.6</td>
<td>2.0 - 4.0</td>
<td>3/6/6/9</td>
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<td>14</td>
<td>20</td>
<td>20</td>
<td></td>
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<tr>
<td>5</td>
<td>3D</td>
<td>26.1</td>
<td>5.2 - 7.2</td>
<td>21/17/19/21</td>
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<td>33</td>
<td>27</td>
<td>27</td>
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<tr>
<td>10</td>
<td>4D</td>
<td>26.1</td>
<td>8.0 - 10.0</td>
<td>14/15/17/11</td>
<td>42</td>
<td>42</td>
<td>67</td>
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<tr>
<td>10.2</td>
<td>5D</td>
<td>26.1</td>
<td>10.0 - 12.0</td>
<td>10/31/17/17</td>
<td>19</td>
<td>19</td>
<td>40</td>
<td>40</td>
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</tr>
<tr>
<td>10.9</td>
<td>6D</td>
<td>26.1</td>
<td>12.0 - 13.8</td>
<td>14/85/15/50(3)</td>
<td>99</td>
<td>99</td>
<td>84</td>
<td>84</td>
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</tr>
<tr>
<td>15</td>
<td>R1</td>
<td>48.0</td>
<td>14.0 - 18.0</td>
<td>RQD = 60N%</td>
<td>WOC</td>
<td>24</td>
<td></td>
<td></td>
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<tr>
<td>20</td>
<td>R2</td>
<td>36.1</td>
<td>19.1 - 22.1</td>
<td>RQD = 50N%</td>
<td>OPEN</td>
<td>96</td>
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<td></td>
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<tr>
<td>25</td>
<td>7MD</td>
<td>50.0</td>
<td>23.0 - 23.4</td>
<td>100(5)</td>
<td>38</td>
<td>145</td>
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</tbody>
</table>

**Visual Description and Remarks**

- Gray, wet, medium dense, Silty fine SAND, little organic (bark, roots) (Marine Neuridone Deposits), increasing silt with depth. 
- IPa = Casing pushed with drill rig hydraulics. 
- Blasted: Drilling from 1 to 5 ft. based on drill behavior. 
- Borean and grayish silty, wet, medium dense, fine to medium SAND, some silt, some gravel, trace coarse sand (Marine Neuridone Deposits). 
- Gravel at 4.5 ft, lost water return at 5.0 ft, washed to 5.2 ft. 
- Gravel, fine to coarse SAND, some gravel, little silt, trace clay (Marine Neuridone Deposits). 
- Borean, wet, dense, fine to coarse SAND, some gravel, little silt (Marine Neuridone Deposits). 
- Borean, wet, dense, fine to medium SAND, some gravel, some silt, trace clay (C-terminal). 
- Borean, very dense, fine SAND, some gravel, trace coarse sand, trace clay (C-terminal). 2" gravel less in bottom of sample. 
- Casing refusal at 13.7 ft. on cobble. Fuller washes ahead to 14.8 ft. 
- R1: Pieces of cobble and gravel recovered. 
- R1: Core Timers (microwave). 
- Casing refusal at 19.0 ft, wash ahead to 19.1 ft. 
- Casing refusal at 19.0 ft, wash ahead to 19.1 ft. 
- R2: Boulder 15.0-20.2 ft. Sand in wash 20.2-23.5 ft. 
- R2: Core Timers (microwave). 
- Pull NW casing and advance HW casing and roller bit through boulder to 23.6 ft. Boring stopped upon 21.5 ft. Residence driving NW. 
- Spouter refusal on cobble based on drill behavior.

**Remains:**

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88). 
2. Below counts for spouts driven through a disturbed field vane test location cannot be used to determine N-value. 
3. P, T, D = Peak compressive strength estimated from Point Load Index Test. 
4. UCS(T, D) = Peak compressive strength from Uniaxial Compressive Strength Test.

**Distribution lines represent approximate boundaries between soil types, transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

**Boring No.:** BB-RDKR-208
### Boring No.: BB-RDKR-208

#### Project: Maine Kennebec Bridge #2306

**Location:** Richmond-Dresden, Maine

**Elevation (ft):** -0.2

**Auger ID/OD:** -

**Boring No.: -**

**PIN:** 12674.00

**Driller:** Maine Test Borings

**Operator:** M. Porter

**Logged By:** M. Henrick

**Datum:** NAVD88

**Rig Type:** CME-45 Skid on Anchor Barge

**Core Barrel:** NQ-2

**Drilling Method:** Cased Wall Boring with Water

**Hammer Efficiency Factor:** 0.6

**Water Level:** Water Boring - Tidal

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Penetration in (in)</th>
<th>Sample Depth (ft)</th>
<th>Blown (ft)</th>
<th>Sample Strength</th>
<th>ROD (%)</th>
<th>Nonconnected</th>
<th>NQ</th>
<th>Crown</th>
<th>Bore</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>R3</td>
<td>28/10</td>
<td>27.6 - 29.9</td>
<td>29.9</td>
<td>ROD = 30%</td>
<td>NQ-2</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>R4</td>
<td>48/41</td>
<td>33.9 - 33.9</td>
<td>33.9</td>
<td>ROD = 30%</td>
<td></td>
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</tr>
<tr>
<td>5.0</td>
<td>R5</td>
<td>54/54</td>
<td>33.9 - 38.4</td>
<td>38.4</td>
<td>ROD = 30%</td>
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</tr>
<tr>
<td>8.0</td>
<td>R6</td>
<td>60/59</td>
<td>38.4 - 43.4</td>
<td>43.4</td>
<td>ROD = 30%</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Description and Remarks:**

- **Sample Information:**
  - **ROD:** RQD = 30%
  - **NQ:** NQ-2
  - **Sample Strength:** ROD = 30%
  - **Nonconnected:**

**Visual Description and Remarks:**

- **Depth:** 0.0 ft
  - **Blown:** 27.6 - 29.9 ft
  - **ROD:** 30%
  - **NQ:** NQ-2

**Mud Log:**

- **SP:** 13,300 psi

- **Visual Description:**
  - **ROD:** 27.6 - 27.8 ft: Cobble
  - **Top of Bedrock:** 28.0 ft
  - **Rock Mass:** Poor
  - **Cores:**
    - **NQ:** 27.6 - 27.8 ft: Medium dark gray (5Gy 4/1), very fine to fine grained, medium weak (R3), moderately weathered, moderately foliated, biotite-quartz SCHIST (Nanibokang Pond Formation). Discontinuities are very close, close, moderately dipping to vertical, planar to rough, tuff. Contact metamorphosed by basin fill below. Rock Mass Quality = Poor

**Laboratory Testing Results:**

- **UCTw:** 4,850 psi
  - **Peak compressive strength from Uniaxial Compressive Strength Test:**
  - **Peak compressive strength estimated from Point Load Index Test:**

**Remarks:**

1. Maine DOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. Blown counts for samples taken through a disturbed field vane test location cannot be used to determine N-value.
3. **PLI:** Peak compressive strength estimated from Point Load Index Test.
4. **UCTw:** Peak compressive strength from Uniaxial Compressive Strength Test.

**Page 2 of 3**

**Boring No.: BB-RDKR-208**
**Maine Department of Transportation**

**Project:** Maine Kenebec Bridge #2516

**Location:** Richmond-Dresden, Maine

**Boring No.:** BB-RDKR-208

**Driller:** Maine Test Boring

**Elevation (ft):** -0.2

**Auger ID/OD:** -

**Operator:** M. Porter

**Datum:** NAVD88

**Sampler:** 2" Split Spoon

**Logged By:** M. Harwick

**Rig Type:** CME-45 Skid on Anchor Barge

**Hammer Wt/Fall:** 140/30 lb: 500 lb

**Date Started/Finished:** 7/5-6/12

**Drilling Method:** Case Wash Boring with Water

**Core Barrel:** NQ-2

**Boring Location:** 12311.6, 17.2 ft Lt

**Casing ID/OD:** DW/NW

**Water Level:** Water Boring - Tidal

**Hammer Efficiency Factor:** 0.6

**Hammer Type:** Automatic

**Hydraulic:** Yes & Cabled

---

### Sample Information

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample No.</th>
<th>Permeability (l/m)</th>
<th>Sample Depth (ft)</th>
<th>Bulk Density (pcf)</th>
<th>Strength (psi)</th>
<th>RQD (%)</th>
<th>Nead</th>
<th>Nogo</th>
<th>Elevation (ft)</th>
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### Visual Description and Remarks

- Visual Description:

  - to integrate, horizontal to vertical with many mineral coatings (Frc). Contains industries of highly altered granitic wallrock (granodiorite).
  - 37.5 - 38.4 ft: Grayish black (N2) to light gray (N7), fine grained, medium weak (R3), moderately weathered, moderately foliated, biotite-quartz GNEISS [Nashunong Pond Formation], contact metamorphosed by basal dike above. Discontinuities are very close to close, planar to irregular, horizontal to steep, light to open, with rusty mineral coating (Frc).
  - Rock Mass Quality = Very Poor
  - RQD Core Times (minutes)
    - 33.0-34.9% (1.20)
    - 34.9-35.9% (1.20)
    - 35.9-36.9% (2.05)
    - 36.9-37.9% (2.05)
    - 37.9-38.9% (2.00) Recovery = 100%
  - Core barrel plugged at 38.4 ft.
  - R: 38.4 - 40.6 ft: Brownish gray (2.5Y) to light gray (N7), fine to coarse grained, weak to strong (R3-R4), moderately weathered, strongly foliated, biotite-quartz GNEISS [Nashunong Pond Formation], hydrothermally altered by basal dike.
  - 40.2 - 40.6 ft: Dark gray, very fine grained very weak (R2), moderately to highly weathered BASSALT [Mount Desert Intrusive]. No discontinuities.
  - 40.6 - 43.4 ft: Medium light gray (5G) to light gray (N7), fine to coarse grained, weak to strong (R3-R4), moderately weathered, strongly foliated, biotite-quartz GNEISS [Nashunong Pond Formation]. Discontinuities are very close to close, planar to irregular to stepped, rough to open. Thin white quartz vein at 38.8 ft, 1/4" thick, steeply dipping. Gneiss up to 1/4" diameter.
  - Rock Mass Quality = Poor
  - Rk Core Times (minutes)
    - 38.4-39.9% (2.53)
    - 39.4-40.4% (2.15)
    - 40.4-41.4% (1.20)
    - 41.4-42.4% (1.40) Recovery = 90%

- Bottom of Exploration at 43.4 feet below ground surface.

---

### Remarks:

1. MaineDOT provided the surveyed location of the test boring referencing Station and Offset relative to the project baseline. Ground surface elevations are based on the North American Vertical Datum of 1988 (NAVD88).
2. Raw counts for spoons driven through a disturbed field vane test location cannot be used to determine N-value.
3. PLT = Peak load strength estimated from Point Load Index Test.
4. UCS = Peak compressive strength from Universal Compressive Strength Test.

---

**Boring No.:** BB-RDKR-208
Appendix B: Driller’s Logs for Supplementary Borings
## MAINE TEST BORINGS

Complete Test Boring Service
18 MACK LANE, HERMON MAINE 04401 • 207-848-7041 • FAX 207-848-7042
www.maintest.com

---

**Reed & Reed**
PO Box 370
Woodwich, ME 04579
Route 97 Bridge • Dresden, ME
Charlie Guerette
cguerette@reed-reed.com

---

**November 20, 2013**

---

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<tr>
<th>Boring #</th>
<th>DR1</th>
<th>Casing: N</th>
<th>Rod: NWJ</th>
<th>Core: NQ2</th>
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Appendix C: Driving Logs for Initial Pile Driving
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<th>Pile ID No.</th>
<th>Date Driven</th>
<th>Section</th>
<th>Measured Lengths (ft)</th>
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**Heave Measurement**
- Date: [Date]
- Elevation: [Elevation (ft)]
- Movement: [Movement (ft)]
- End of Driving: [End of Driving (ft)]
- Total deduced: [Total deduced (ft)]
- Net length: [Net length (ft)]

**Final Inspection**
- Date: [Date]
- Depth (in.)
- Bows (per ft)

**Pile Accepted**
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- 12
- 13
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25

**Remarks**
- Rejected
- Added due to relocated pile
- Added due to broken pile
- Added due to design change
- Deemed due to design change
- Possibly broken
- Completed with follower
- Stopped driving to驍 at [feet]
- Stopped driving at [feet]

**PILE**
- Type: Delmag D36-26
- Size: 24" dia, Pile A 1/2" wall B, C, D 1" wall
- Max. factored load: 600 kip
- Nominal resistance: 600 kip

**PILE NO.**
- A
PILE DRIVING LOG

PROJECT & PIN
Richmond-Dresden - WIN 12674.10 - Pile Item 501.55

LOCATION
Template CL approx 121 + 65 (to be confirmed)

FOUNDATION ID.
Between proposed Pier 5 and Pier 6

GEN. CONTRACTOR
Reed & Reed

PILE CONTRACTOR
Reed & Reed and GZA, Pile Testing Subcontractor

PILE NO. B
Column Location

Heat No. | Pile ID No. | Date Driven | Section | Measured Length (ft) |
--- | --- | --- | --- | --- |
1 | | | BOTTOM | |
2 | | | MIDDLE | |
3 | | | TOP | |

Heave
Measurement
Date Shot | Elevation (ft) | Movement (ft) |
--- | --- | --- |
End of Driving | 0 | 0 |
Final Check | | |

Pile Accepted | Pile Rejected
--- | ---

Final Inspection

Depth (ft) | Blows (per ft) |
--- | --- |
2 | 5 |
3 | 5 |
4 | 5 |
5 | 5 |
6 | 5 |
7 | 5 |
8 | 5 |
9 | 5 |
10 | 5 |
11 | 5 |
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25 | 5 |

PILE:
Type: End Bearing
Friction
Size: 24" dia. Pile A 1/2" wall B, C, D 1" wall
Max. Factor of Load (kN) 90.560
Nominal Resistance (kips) 600
Stopping Criteria 8 bpi at Fuel Setting 2 and 3/8" stroke
Blows for final 6.8

HAMMER:
Type: Delmag D36-26
Field Representative Signature

Remarks:
Replaced 3
Added due to restrained pile 4
Added due to broken pile 5
Added due to design change 6
Deleted due to design change 7
Peaked pile 8
Completed with follower 9
Stopped driving at splice at 3/8" stroke 10
Stopped driving at 3/8" stroke 11

Form 4013 (Regular)
# PILE DRIVING LOG

**Location:** Richmond-Dresden, WIN 12674.10, Pay Item 501.55
**Resident Engr.:** Peter Brown
**Team Geotech:** L. Kruitink

## Project & Pin Information
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<th>C 8/26/13</th>
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</table>

## Foundation Information
- **Foundation Ld.:** Between proposed Pier 5 and Pier 6
- **Pile Contractor:** Reed & Reed
- **Pile & Testing Subcontractor:** Reed & Reed & GZA

## Pile Driving Log Details
### Heave
- **Height:** 1.0” Wall
- **Steel:** Open Shoe

<table>
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<tr>
<th>Heat No.</th>
<th>Pile ID No.</th>
<th>Date Driven</th>
<th>Section</th>
<th>Measured Lengths (ft)</th>
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### Measurement
- **End of Driving:** To Pile Mark, 3’ 10.0” 0.00

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Date Shot</th>
<th>Elevation (ft)</th>
<th>Movement (ft)</th>
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<tr>
<td>Final</td>
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### Deviation from Design:
- **N:** 0
- **S:** 0
- **E:** 0
- **W:** 0

### Final Inspection:
- **Date:**
- **Hours (per ft.):** 2
- **Blows:** 1

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<th>Blows (per ft.)</th>
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**Remarks:**
- Rejected
- Added due to calculated pile
- Added due to broken pile
- Added due to design change
- Detected due to design change
- Possibly broken
- Completed with follower
- Pile top misalignment
- Initial 7.9
- 8.4
- 9.2
- 10.2
- 11.2
- 12.2
- Max. var.
- 1

**Pile:**
- Type: End Bearing
- Size: 24" dia, Pile A 1/2" wall, B, C 1/4" wall
- Max. Factor Load: 85 kips
- Nominal Resistance: 600 kips
- Stopping Criteria: 7 ft at 3/4" 89 kips
- Blows for final: 5/7

**Hammer:**
- Type: Delmag D36-26
- Measured Energy: 90,560 ft-lbs

**Field Representative Signature:** [Signature]

**Pile No.:** C
PILE DRIVING LOG

PROJECT & PIN: Richmond-Dresden
LOCATION: Template CL approx 121 + 65 (to be confirmed)
FOUNDATION I.D.: Between proposed Pier 5 and Pier 6
GEN CONTRACTOR: Reed & Reed
PILE CONTRACTOR: Reed & Reed and GZA, Pile Testing Subcontractor

PILE NO. D
Column-Location

Heat No. | Pile ID No. | Date Driven | Section | Measured Lengths (ft) |
---|---|---|---|---|
| 1 | 8' | | BOTTOM | Approx. Grnd Surf. El. |
| 2 | 8' | | | Initial Top El. |
| 3 | 8' | | | Length Of Pile |
| 4 | 8' | | | Tip El. |
| 5 | 8' | | | Cut-off El. |
| 6 | 8' | | | Initial Pay Length |
| 7 | 8' | | | Net Change In Tip El. |
| 8 | 8' | | | Final Top El. |
| 9 | 8' | | | Final Pay Length |
| 10 | 8' | | | Final Length |

Heave | Measurement | Date Shot | Elevation (ft) | Movement (ft) |
---|---|---|---|---|
| | Total length | | | |
| | Length deducted | | | |
| | Total length deducted | | | |

End of Driving | TOPORE | 33' | 0.00 |

MARK ON PILE | |

Final Check (Necessary to redo) | Yes | No |

Redrive Blows Per Inch: | | |

Deviation from design location: | N | S | E | W |

Final Inspection: | Date | Pile Accepted | Pile Rejected |
---|---|---|---|

Depth (ft) | Blows (per ft.) | Depth (ft) | Blows (per ft.) | Depth (ft) | Blows (per ft.) | Depth (ft) | Blows (per ft.) | Depth (ft) | Blows (per ft.) |
---|---|---|---|---|---|---|---|---|---|
1 | 26 | 1 | 51 | 76 |
2 | 27 | 1 | 52 | 77 |
3 | 28 | 1 | 53 | 78 |
4 | 29 | 1 | 54 | 79 |
5 | 30 | 1 | 55 | 80 |
6 | 31 | 1 | 56 | 81 |
7 | 32 | 1 | 57 | 82 |
8 | 33 | 1 | 58 | 83 |
9 | 34 | 1 | 59 | 84 |
10 | 35 | 1 | 60 | 85 |
11 | 36 | 1 | 61 | 86 |
12 | 37 | 1 | 62 | 87 |
13 | 38 | 1 | 63 | 88 |
14 | 39 | 1 | 64 | 89 |
15 | 40 | 1 | 65 | 90 |
16 | 41 | 1 | 66 | 91 |
17 | 42 | 1 | 67 | 92 |
18 | 43 | 1 | 68 | 93 |
19 | 44 | 1 | 69 | 94 |
20 | 45 | 1 | 70 | 95 |
21 | 46 | 1 | 71 | 96 |
22 | 47 | 1 | 72 | 97 |
23 | 48 | 1 | 73 | 98 |
24 | 49 | 1 | 74 | 99 |
25 | 50 | 1 | 75 | 100 |

PILE: Type: End Bearing | Friction
Size: 24" dia. | 12" wall
Max. Tapped Load: 90,560 lbs
Nominal Resistance: 600 kip
Blows for final 7

HAMMER: Type: Delmag D34-26
Measuring Energy: 90,560 lbs
Field Representative: 

Notes: Top Crushing with these final blows.

Form 4013 (Regular)
Appendix D: Driving Logs for Pile Restrikes
### PILE DRIVING LOG

**Column Location**: 3

**Date**: 10/11/2013

**Project & Pin**: Richmond-Dresden, WD 12674.30, Pay Item 591.51

**Location**: Template C, approx. 121 + 65 (to be confirmed)

**Foundation L/D**: Between proposed Pier 5 and Pier 6

**General Contractor**: Reed & Reed

**Pile Contractor**: Reed & Reed and OCA, Pile Testing Subcontractor

**Resident Engineer**: Peter Brown

**Team Geotech**: L. Kusinski

**Inspector**: G. W. Pile Cushioning, A. Steel Cap

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<td>TOP</td>
<td>36' - 37'</td>
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**Reece Name to receive**: Yes

**Required Bows Per Inch**: 4 Bows at Fuel Setting 2 Then

**Final Inspection**: Date

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<th>Depth (ft)</th>
<th>Blows (per ft)</th>
<th>Depth (ft)</th>
<th>Blows (per ft)</th>
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</table>

**Remarks**:

- [ ] Rejected
- [ ] Added due to water table
- [ ] Added due to broken pile
- [ ] Added due to design change
- [ ] Omitted due to design change
- [ ] Pile broke
- [ ] Completed with follower
- [ ] Stepped driving at 1 ft
- [ ] Stepped driving at 2 ft

**Pile**: End Bearing

<table>
<thead>
<tr>
<th>Type</th>
<th>Hammer</th>
<th>Size</th>
<th>Nominal Resistance</th>
<th>Driving Criteria</th>
<th>Field Representative Signature</th>
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<tr>
<td>Type D136-26</td>
<td>24&quot; dia. Pile A 1/2&quot; wall, B, C 1&quot; wall</td>
<td>600 kip</td>
<td>bpsi at Fuel Setting 2 and 1 stroke</td>
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** blows for final drive**: 4

** Notes**: Field Representative Signature
# PILE DRIVING LOG

**Project & PIN:** Richmond-Dresden  
**WIN 1126794.30 Pay Item 501.95**

**Location:** Template Cl, approx 121 + 65 (to be confirmed)

**Foundation ID:** Between proposed Pier 3 and Pier 6

**General Contractor:** Reed & Reed

**Pile Contractor:** Reed & Reed and GZA, Pile Testing Subcontractor

**Resident Engineer (R.E.):** Peter Brown

**Team Geotechnical Inspector:** L. Kresinski

**Pile No.:** D

**Column Location:**

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<th>Measured Lengths (ft)</th>
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<td>Tip El.</td>
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<td>Cut-off 6 - 10'</td>
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<td>Net Change to Top El.</td>
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<td>Final Tip El.</td>
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<td>Final Pay Length</td>
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</table>

**Reave:**

- Shoe (Plywood Cushion) + Steel Cap
- Top

**Measurement:**

- Date Shot
- Elevation (ft)
- Movement (in)
- Length Deducted

**End of Driving:**

- Date: 10/11/13
- Elevation (ft): 0.00
- Movement (in): 0.00
- Length Deducted (ft):
- Total Deducted (ft):

**Final Check:**

- Date Shot
- Elevation (ft)
- Movement (in)
- Length Deducted
- Net Length

**NOTICE TO REORDER:**

- Yes
- No

**Redrive Blows Per Inch:**

**Final Inspection:**

- Date
- Pile Accepted
- Pile Rejected

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<th>Depth (ft)</th>
<th>Blows (per ft)</th>
<th>Depth (ft)</th>
<th>Blows (per ft)</th>
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**Remarks:**

- # Rejected
- # Added due to undrilled pile
- # Added due to broken pile
- # Added to design change
- Deficient due to design change
- Possibly broken
- Completed with followers
- # Stopped driving to splice at...
- # Stopped driving at...

**Pile:**

- End Bearing
- Friction
- D31-12' wall B, C, D wall

**Hammer:**

- Type: D31-38
- Field Representative Signature

**Messmastic:**

- Nominal Resistance: 600 kips
- Stopping Criteria: bhp at Fuel Setting 2 and 10" stroke

**Blows for Final:**

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<th>Avg.</th>
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Form 4013 (Regular)