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MaineDOT

Transportation Research Division

Technical Report 12-05

Fiber Reinforced Polymer (FRP) Composite Piles Used on Pier Rehabilitation, Little Diamond Island, Casco Bay, Portland, Maine

October 2012

Technical Report Documentation Page

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16. Abstract (Limit 200 words)

Fiber reinforced polymer (FRP) composite piles were used on a pier rehabilitation project at Little Diamond Island in Casco Bay near Portland Maine. The project was the replacement of an aging wooden pier at the ferry berthing terminal. The FRP piles were installed as fender piles, designed to absorb the kinetic energy of vessels docking at the pier, to prevent damage to vessels and to provide an abrasion resistant surface. The FRP piles were 11.25 inch diameter, 5 ply, hollow piles, having similar properties to wooden piles. The piles also have a heavy duty abrasion resistant sleeve, 0.75 inch thick. There were no significant problems during construction of this project. Using the FRP composite piles required a re-design of the bolting configuration, due in part to the fact that counter-sinking for bolt heads is limited on the hollow FRP composite piles. Despite the increased cost of this installation, the project furthered the Department's understanding of the requirements of using composite piles. In addition, the project will provide an opportunity to observe the performance of composite piles compared to wooden piles.

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Transportation Research Division

Fiber Reinforced Polymer (FRP) Composite Piles Used on Pier Rehabilitation, Little Diamond Island, Casco Bay, Portland, Maine

Project Description

This project highlights one way that fiber reinforced polymer (FRP) composite materials provided a solution when supply problems surfaced with conventional project materials. The project was to replace an aging wooden pier at a ferry berthing terminal at Little Diamond Island in Casco Bay near Portland Maine. The project was a fender system rehabilitation project and was part of an overall Casco Bay timber pier rehabilitation. The project was let to bid in December 2011 for construction in 2012. The ferry service was suspended at the facility from February 27, 2012 until April 22, 2012. The contract allowed for service to be suspended earlier, however due to delays in advertising, award and contractors schedule, the work did not start until Feb 27.The work at this facility had to be completed by April 22, 2012. Casco Bay is a very active harbor. The contractor was required to do all work in such a way as to minimize the impact on of the various harbor activities.

The contractors responsibility consisted of furnishing driving, fitting, and connecting timber piles, and also to furnish and install heavy timber construction including structural framing of wood members with thicknesses of 5" (nominal) or more. A problem arose in that the wooden Greenheart[1] piles normally used for fender piles could not be shipped to the United States to meet the construction schedule. In this project the fender piles were designed to absorb the kinetic energy of a vessel hitting the pier and also to prevent damage.

Due to the existing passenger and freight service to the island it was critical to meet the scheduled construction window in order to minimize impact to the island population and businesses. The fender piles had to be in place for the Casco Bay Island Transit District to commence summer operation. Using temporary piles was ruled out as that would mean interrupting ferry service a second time, in order to replace the temporary piles, causing a second service disruption. The idea of using composite piles, that could be supplied locally, was a solution to this problem; moreover it provided a good opportunity to have a side-by-side comparison of the composite vs. timber piles.

The FRP piles used were 11.25 inch diameter, 5 ply, hollow piles, having similar properties to wooden piles with somewhat greater deflection, (less than 10% greater). The piles also have a heavy duty abrasion resistant sleeve, 0.75 inch thick. Before substituting the composite fender piles for the wooden ones, an engineering analysis was done which considered likely berthing forces, deformation, fixity, and impact elevations. The specifications required a 12 kip-ft energy absorption rating.

"A static analysis was used to determine the energy absorption of a single FRP pile. The energy absorbed by the pile was assumed to be entirely through bending deformations. The pile was modeled as a fixed-

[1] Greenheart (Ocotea rodiaei) is an American tropical hardwood tree that is very resistant to decay and marine organisms. It is durable and does not require chemical preservative treatment. It is used for many marine applications. (http://www.thefreelibrary.com)

pinned beam. Fixity was assumed to be 15 feet below the mud line (EL -31)"[2] The analysis showed that in both energy absorption and maximum reaction the FRP piles were more than sufficient to replace the Greenheart wooden piles.[3]

This project was funded through the American Recovery and Reinvestment Act (ARRA) of 2009. The funding allowed this needed infrastructure project to move forward sooner than it might have otherwise.

Project Location

The project location is shown on the nautical chart below.

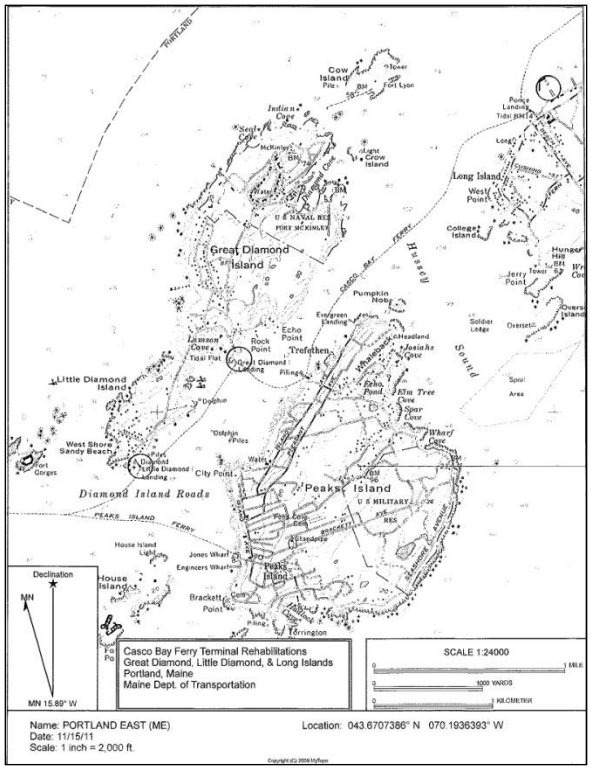

Figure 1 Project Location

[2] Appledore Marine Engineering, Inc
[3] Same as previous.

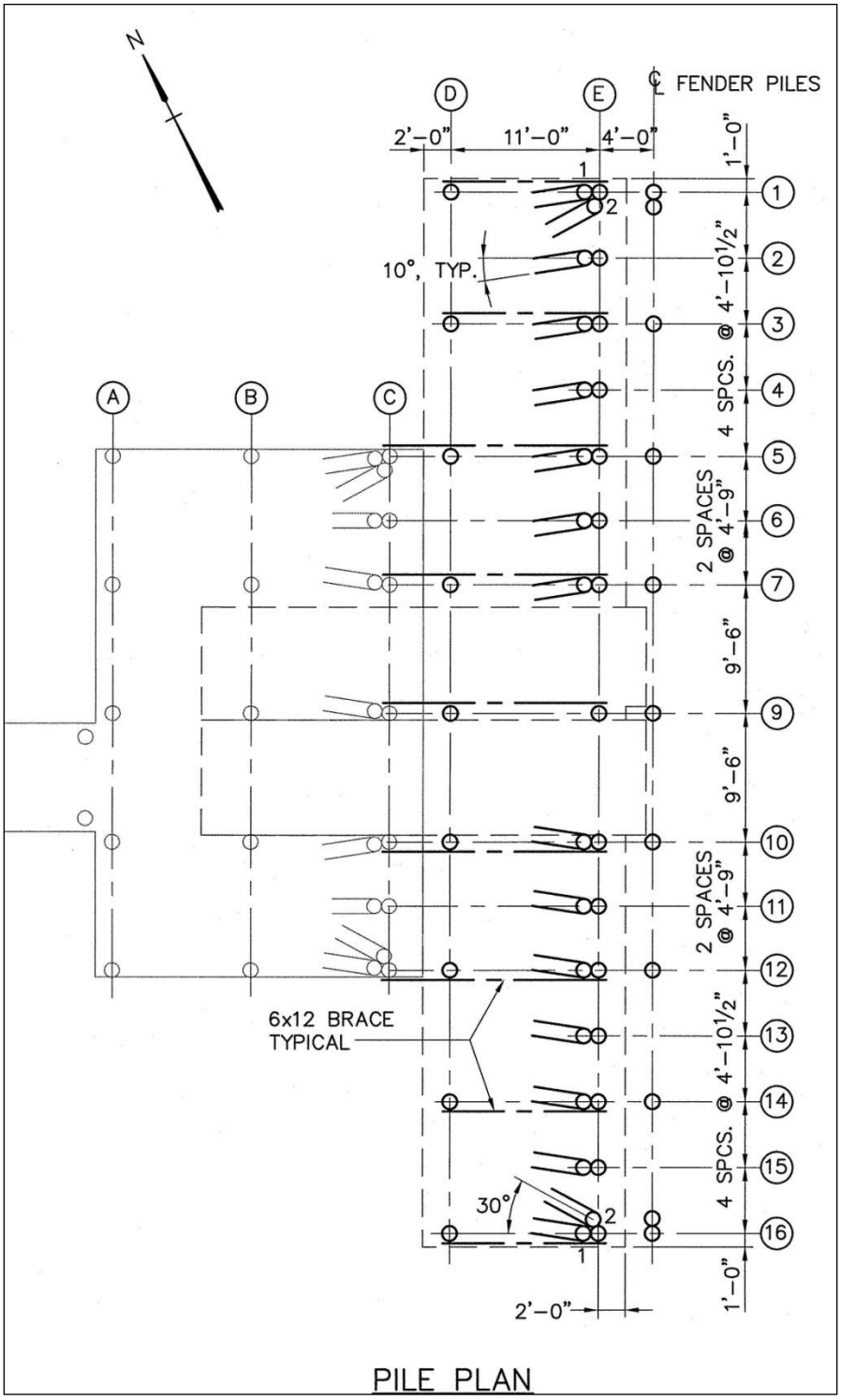
N
D
E
℄ FENDER PILES
2'–0"
11'–0"
4'–0"
1'–0"
10°, TYP.
4 SPCS. @ 4'–10½"
2 SPACES @ 4'–9"
9'–6"
9'–6"
2 SPACES @ 4'–9"
4 SPCS. @ 4'–10½"
1'–0"
A
B
C
6x12 BRACE TYPICAL
30°
2'–0"
PILE PLAN

Figure 2

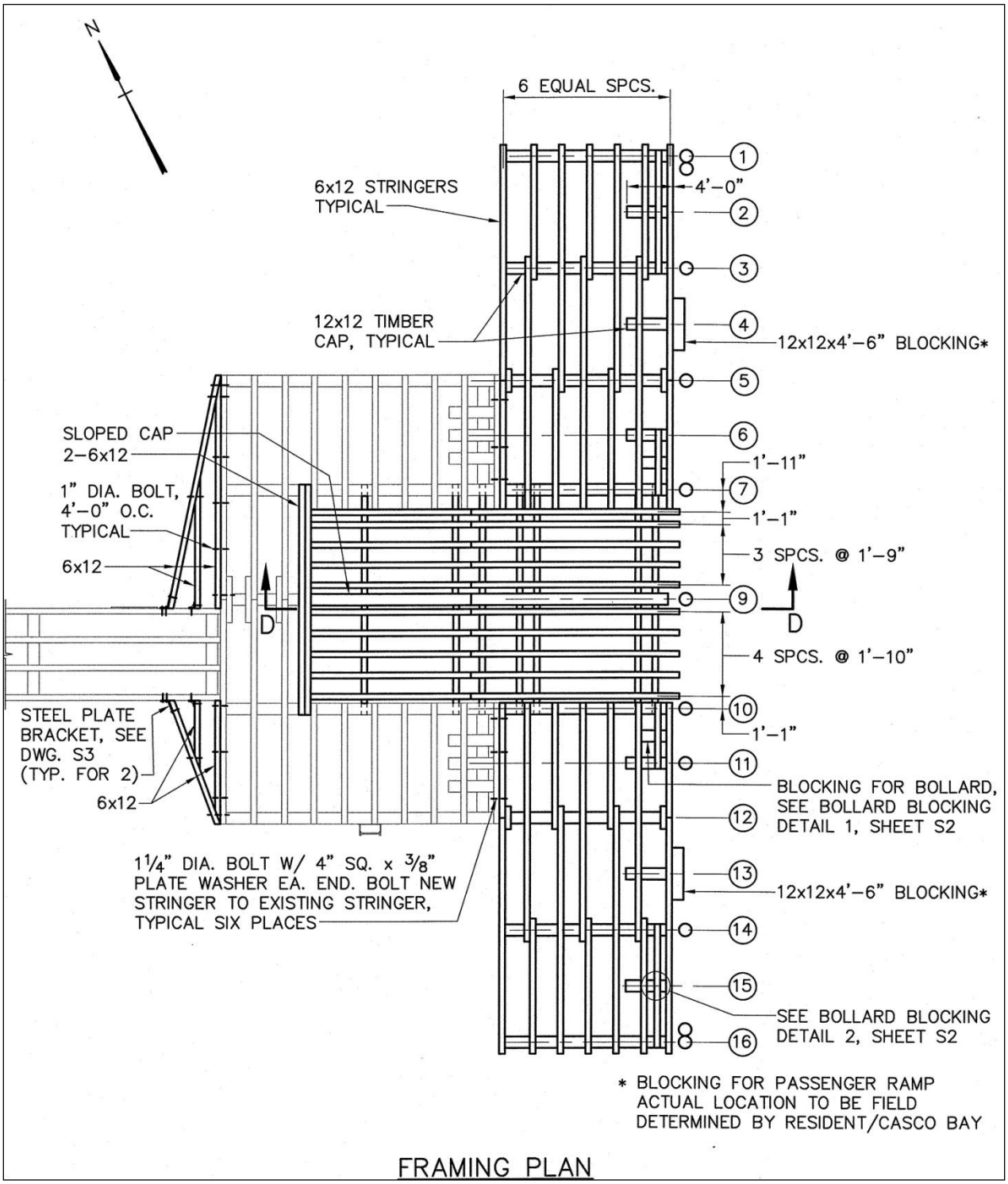
N
6 EQUAL SPCS.
6x12 STRINGERS TYPICAL
12x12 TIMBER CAP, TYPICAL
4'-0"
12x12x4'-6" BLOCKING*
SLOPED CAP 2-6x12
1" DIA. BOLT, 4'-0" O.C. TYPICAL
6x12
1'-11"
1'-1"
3 SPCS. @ 1'-9"
4 SPCS. @ 1'-10"
1'-1"
D
D
STEEL PLATE BRACKET, SEE DWG. S3 (TYP. FOR 2)
6x12
BLOCKING FOR BOLLARD, SEE BOLLARD BLOCKING DETAIL 1, SHEET S2
1¼" DIA. BOLT W/ 4" SQ. x ⅜" PLATE WASHER EA. END. BOLT NEW STRINGER TO EXISTING STRINGER, TYPICAL SIX PLACES
12x12x4'-6" BLOCKING*
SEE BOLLARD BLOCKING DETAIL 2, SHEET S2
1
2
3
4
5
6
7
9
10
11
12
13
14
15
16
* BLOCKING FOR PASSENGER RAMP ACTUAL LOCATION TO BE FIELD DETERMINED BY RESIDENT/CASCO BAY
FRAMING PLAN

Figure 3

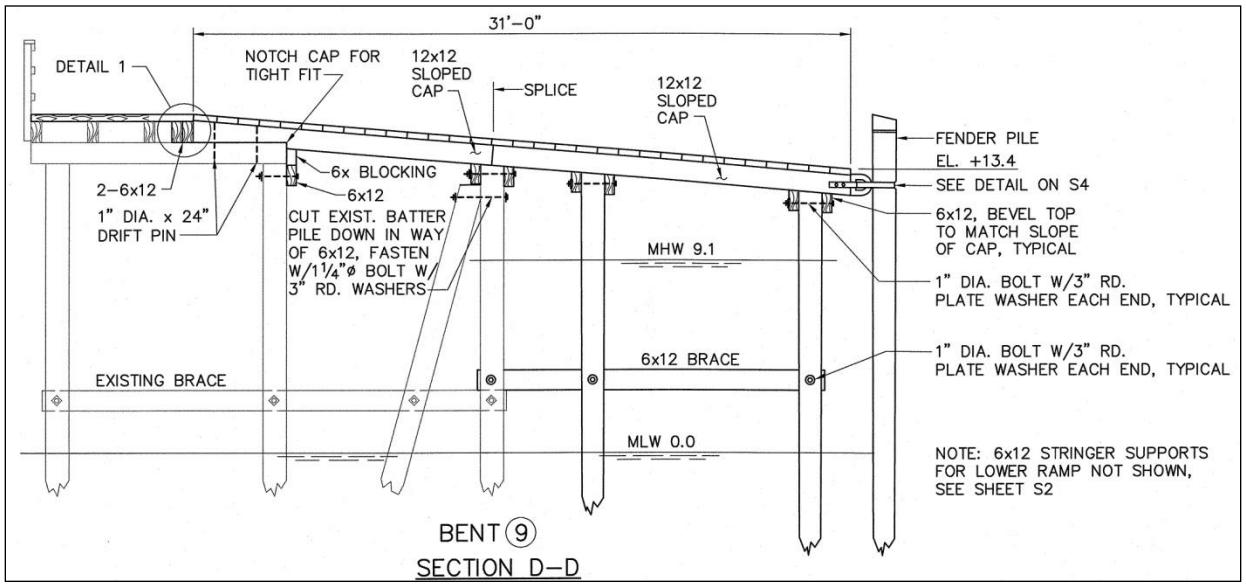

Figure 4 Profile View showing Fender Pile

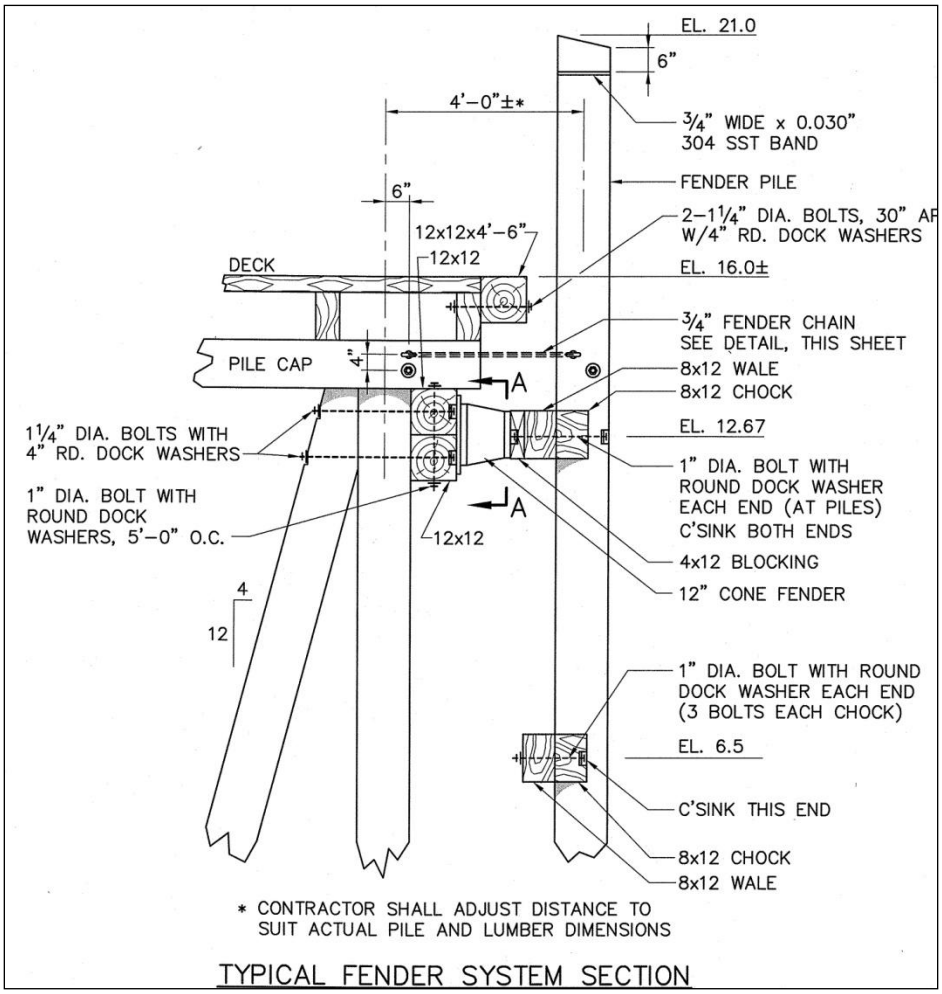

Figure 5

Construction

There were no significant problems during construction of this project. Using the FRP composite piles required a re-design of the bolting configuration, due in part to the fact that counter-sinking for bolt heads is limited on the hollow FRP composite piles. The FRP Pile cross-section plan and bolting design is in Appendix A of this report.

As events played out, some of the composite piles were not ready in time, subsequently temporary piles had to be used in some places. These temporary piles were replaced when the composites were delivered. The construction was extended into May, leading to extra costs born by the contractor; nevertheless most disruptions were minimized.

A YouTube video showing the placement of the piles is located at the following link:
http://youtu.be/ZyBVRQpivXI

Costs

The Little Diamond Island portion of the overall project was bid at around $890,000. The project as-bid required 550 lineal feet of 12 inch diameter Greenheart fender piles at a cost of $22,000. The FRP composite piles cost $4000 more than Greenheart. Despite the increased cost of this installation, the project furthered the Department's understanding of the requirements of using composite piles. In addition, the project will provide an opportunity to observe the performance of composite piles compared to wooden piles.

Photos

Figure 6

Figure 7

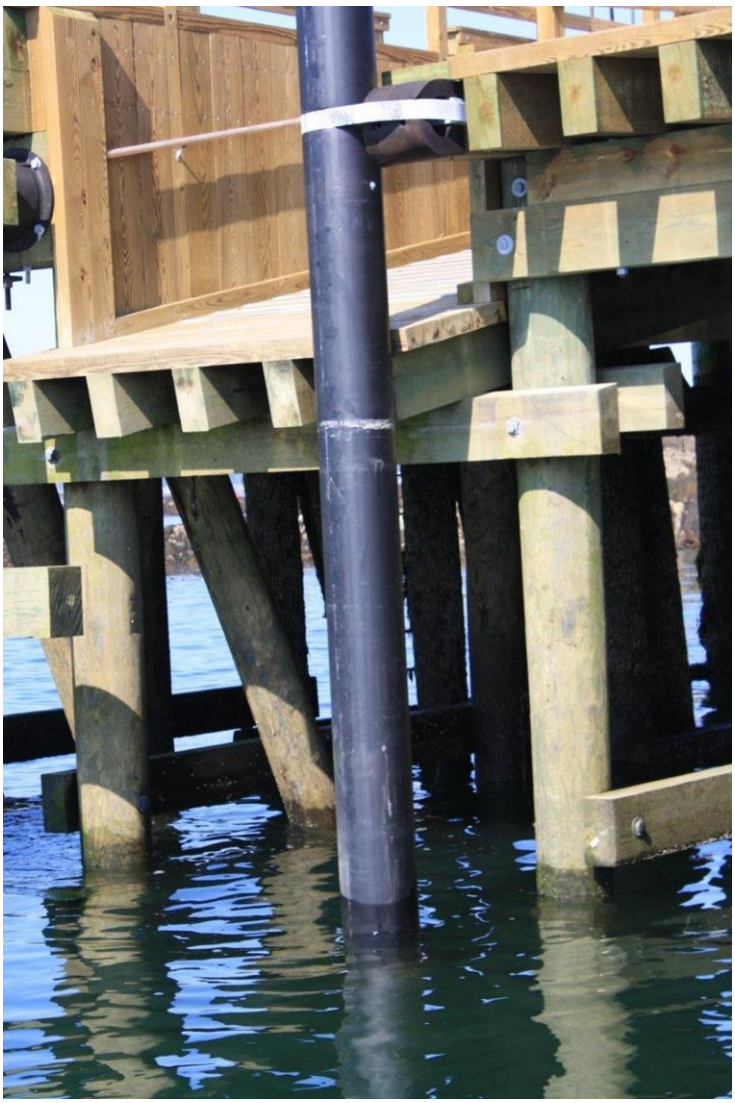

Figure 8

Figure 9

Figure 10

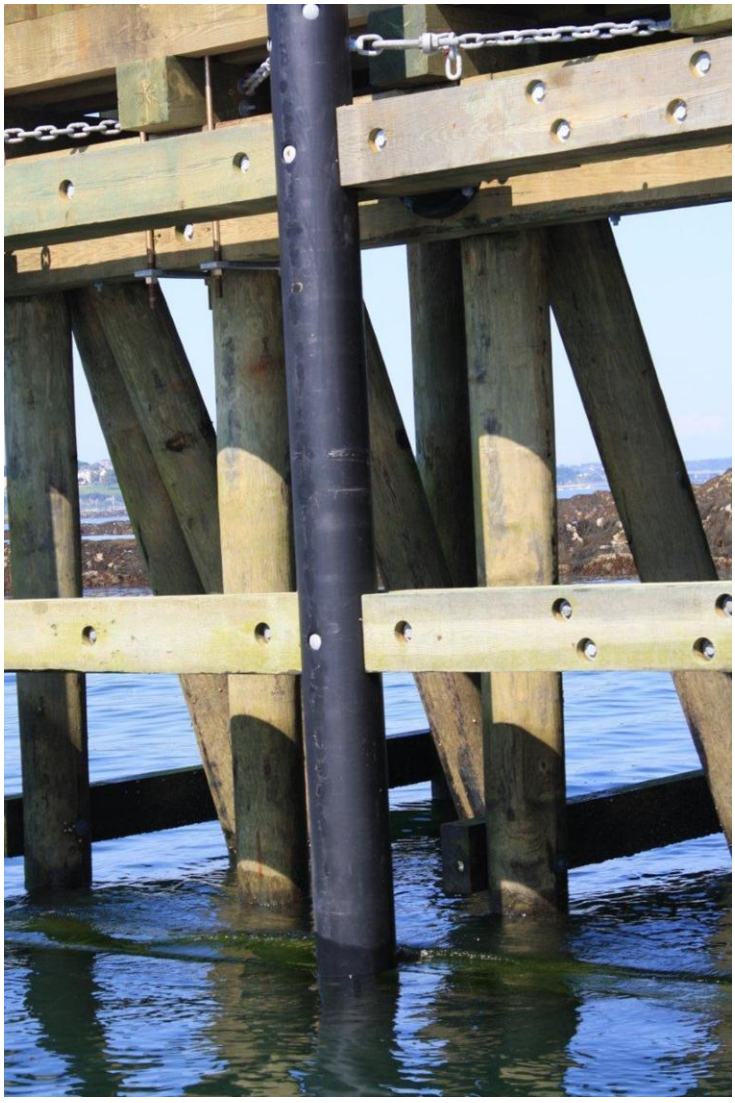

Figure 11

Figure 12

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Photo Credit: Aurele Gorneau II, Maine Department of Transportation
Video Credit: Will Savage, PE, Acorn Engineering, Inc.

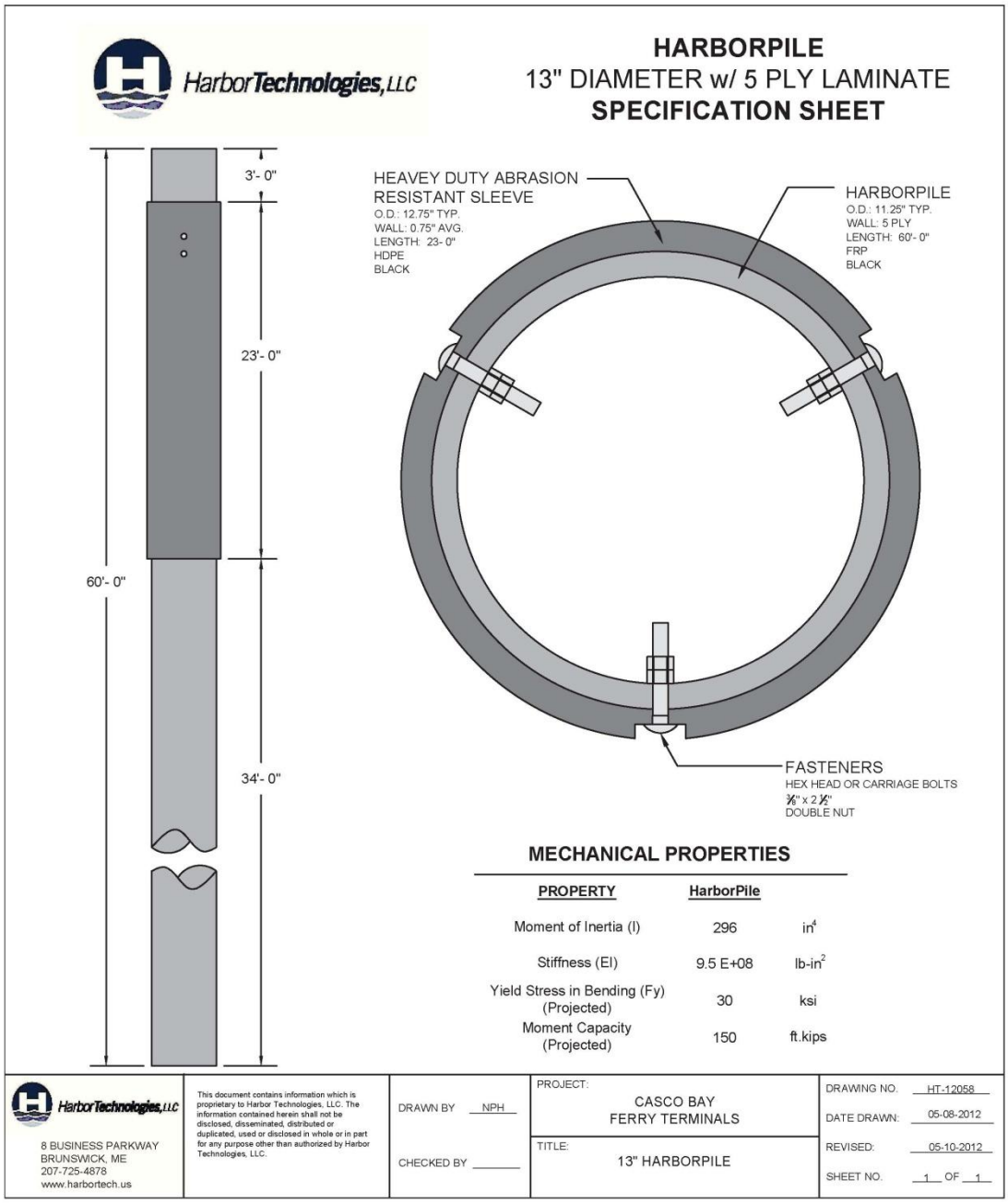

Figure 13. FRP Pile Cross-Section

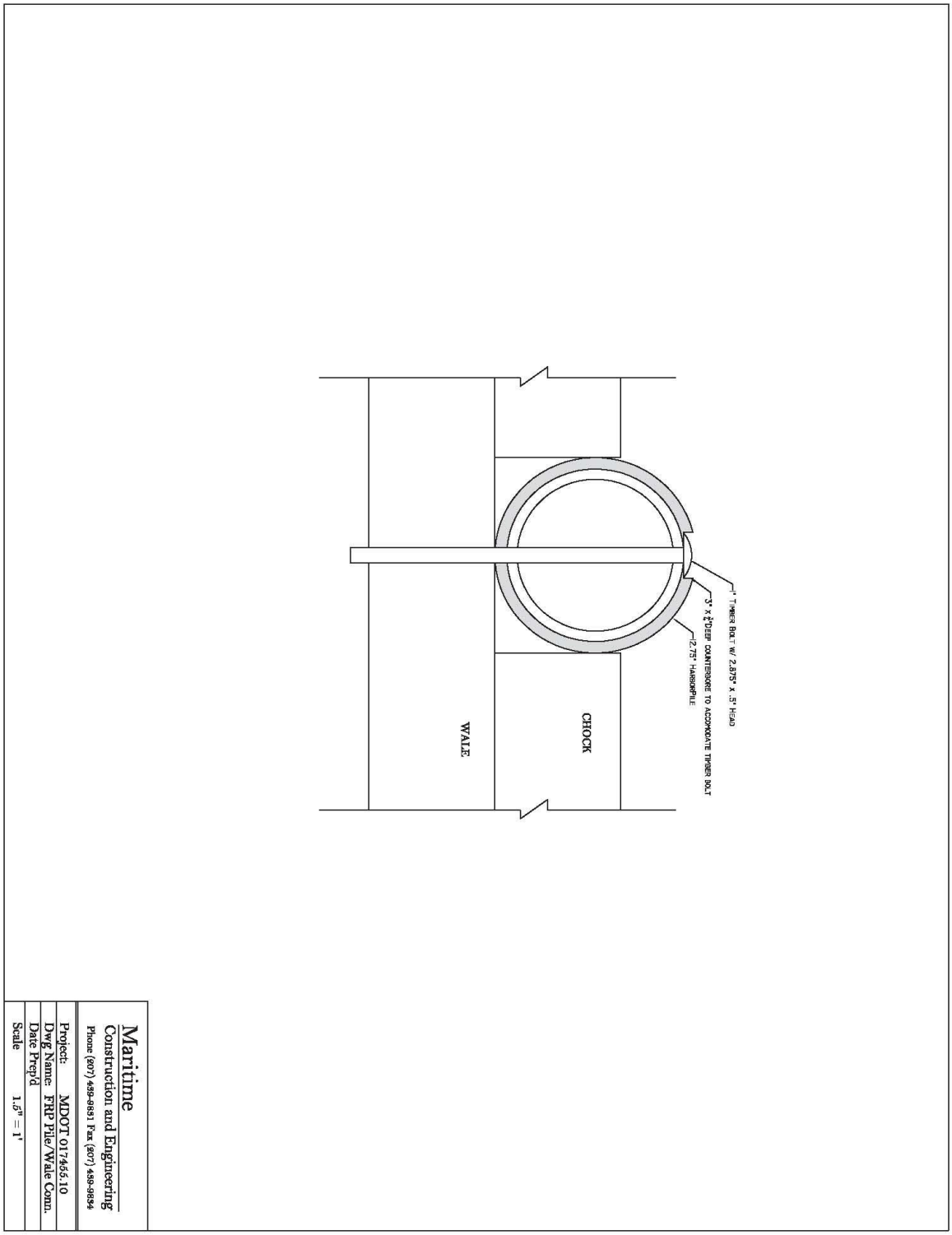

Figure 14. Fender Pile Bolting Plan