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BARRIER SYSTEMS FOR IN-PLACE WOODEN PILING

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by

Thorndyke Roe, Jr.

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U. S. NAVAL CIVIL ENGINEERING LABORATORY
PORT HUENEME, CALIFORNIA

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BARRIER SYSTEMS FOR IN-PLACE WOODEN PILING

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ABSTRACT

This report presents the methods presently in use for the application of barrier systems to increase the service life of wooden piling which has been attacked by marine borers.

INTRODUCTION

Studies which are being or have been carried on to develop systems for increasing the service life of marine piling can be placed in three main categories: improvement of existing preservatives, development of new preservatives, and the use of barrier systems on existing piling. The third category was developed chiefly to increase the service life of piling which had already been attacked by marine boring organisms but which otherwise were still structurally adequate.

Replacement of a damaged bearing pile in an existing wharf is an expensive, time consuming task which is often complicated by the presence of structures and trackage on the decking. Thus, several in-place repair methods for damaged piling have been developed, and installations where these methods have been used are being monitored by this Laboratory.

CURRENT METHODS

Wakeman and Whiteneck[1] described many barrier systems which have been applied to damaged piling and to new piling before driving. They report on the three general methods now used for the application of barriers on in-place wood piling: concrete jacketing, metal jacketing, and plastic jacketing. However, before any system is applied, the structural condition of a pile should be determined. Wooden piling located in areas infested with marine borers should be inspected periodically by a "hard hat" diver. This method is four times as expensive as inspection by a surface crew, but the diver can examine the entire surface of each pile instead of just the upper 10-20%. He is not limited by tidal changes and the data is much more reliable and meaningful.[2] The frequency of inspection would be determined by the ecological conditions in a particular harbor.

Concrete Jackets

In addition to the several systems described by Wakeman and Whiteneck[1], this Laboratory[3] tested three methods and several modifications thereof to determine the most economical method of jacketing timber piles. The method chosen as best as a result of this Laboratory's work used an expendable metal jacket form prepacked with aggregate and cemented with intrusion grout.[3] Costs on various types of concrete jackets have been reported from $4.00 to $15.00 per lineal foot.[1] Concrete jackets have the advantages of strength and durability, and the possible disadvantages of being difficult to apply in certain locations under large wharves, and where numerous cross braces are present.

Metal Jackets

Various corrosion resistant metals have been used for sheathing piling, but the metal now being used almost exclusively is 90:10 copper-nickel alloy.[4] This material is available in 0.020-inch sheet or lock seam joined strip. It is rolled on a mandrel to acquire a set and lowered to a diver who forms it around the pile snugly and attaches it at the overlap with Monel or cupro-nickel anchor fast nails driven on 2-inch centers. Each successive sheath is lapped over the one below. The sheaths extend from approximately 18 inches below the mud line to 18 inches above the mean high water line. Sheaths located in the intertidal zone are now sealed at the top and bottom with Compraband, an asphalt impregnated urethane foam material 1/2 x 3/8-inch in cross section, available in rolls. Two lengths of Compraband are wrapped around the pile, the sheath is then applied, compressing them, and making a watertight seal at both top and bottom. This sealing off of the intertidal zone is important. The water behind the sheath becomes stagnant and any borers still on the pile are killed by the lack of oxygen. Maintenance of the stagnant condition is dependent on the seals preventing the pumping action of the rise and fall of the tides from replacing the stagnant water with oxygenated water. Hunt and Schillmoller[4] reported that cupro-nickel sheathing slowly releases copper ions at its corrosion rate in sea water of 0.0004 to 0.0007 inches per year and that these ions enhance the toxic conditions in the area behind the sheath. Blackening of the inner surfaces by the production of sulfides under anerobic conditions has been reported, but once a black surface has been formed, no further corrosion was noted.

Piling must be scraped to remove fouling before installation of these sheaths in order that a tight fit may be obtained. Installed costs are $7.00 to $9.00 per lineal foot of piling depending on the condition of the piling, accessibility, ease of cleaning, etc. Various commercial and experimental installations have been completed since 1959, and where proper installation procedures were followed, the sheaths are in excellent condition.

Plastic Jackets[1,5,6]

Although many non-metallic materials have been used for jacketing wooden piles, the material which has had the widest use to date is polyvinyl chloride sheet in thicknesses of 0.020 to 0.060 inches. The system now in use on the west coast is "Pile Gard", a patented process developed by Marine Barriers, Inc., Avalon, California. Several thousand lineal feet of piling have been wrapped at Avalon, California and at the Port of Los Angeles.

The piling must be scraped before wrapping, and a trench must be dug into the mud around the base of the pile so that the wrap can extend below the mud line. On piling which have liquid creosote on their surfaces, a sheet of polyethylene film is applied initially. Prefabricated units consisting of a sheet of PVC with half-round lengths of Apitong wood affixed to their vertical edges are lowered to a "hard hat" diver assisted by a Scuba diver. Each unit is fitted around the pile, the half-round Apitong pieces are placed together, and a ratchet is attached to roll up the excess sheet material to form a tight sheath. Monel or nylon nails are driven through the roll seam to secure the sheath. In some locations, fiberglass reinforced plastic bands are also used to secure the sheath and are attached with Monel or nylon nails. Wherever nylon nails are to be used, holes must be pre-drilled for them. Starting from the one installed at the mud line, each successive sheath is lapped over the one below it. Sheaths applied in the intertidal zone are also sealed at top and bottom with Compraband, as described in the section on Metal Jackets.

PVC jackets have been under test at the Port of Los Angeles for more than ten years with no failures. Cost installed is $5.00 to $6.00 per lineal foot.

PARTIAL BARRIERS

In those harbors where marine borer attack is localized on certain areas of in-place piling, short metal or plastic sheaths can be applied only in those areas. These "bandage" type sheaths should be sealed at top and bottom to maintain stagnant conditions between them and the pile. Piling thus wrapped should be inspected periodically by a diver to determine if attack has shifted to those areas that were left unsheathed.

WHEN TO APPLY BARRIERS

In any discussion of the use of barrier systems for marine piling, the question which always arises is: when should barriers be applied: The generally accepted answer is that they should be applied when inspection by a diver reveals that 10-15% of the cross sectional area of the pile is destroyed because at this stage of deterioration, the pile is still able to carry its design load. Sheathing of piles in-place is expensive, and should not be done until it is needed. By waiting until the pile has been attacked the maximum service life is obtained for the minimum maintenance dollar. Where the cross sectional damage exceeds 15%, and the pile is to be sheathed, the damaged wood should be removed and the area of attack should be filled with a quick-setting hydraulic cement. Where the damage is extensive, vertical reinforcing bars can be installed in predrilled holes before filling the cavity with cement. A plastic or metal sheath can then be applied over the repaired pile. The above repair procedure is not necessary when the pile is to be jacketed with concrete.

Some engineers, when they are first told of barrier systems, suggest that all new piling be jacketed before driving and that all in-place piling be jacketed even if they show no signs of attack.

Concrete jackets (Shotcrete) have been applied on untreated piling before driving and excellent service has been obtained. The Port of Tacoma has piling treated in this manner in service since 1922. The cost of Shotcrete jacketing at Long Beach, California for a marina was $3.00 per lineal foot for 23,756 lineal feet in 1955. However, the installation of piling wrapped with metal or plastic sheaths has not been successful because it is extremely difficult, if not impossible, to prevent damage to the sheaths during the handling and driving operations.

COSTS OF REPLACEMENT OF DAMAGED PILING VS INSTALLATION OF BARRIERS

The average life for a treated pile in Southern California harbors where marine borers are active is 15 years. It can be assumed that under these environmental conditions, a pile will be 10-15% destroyed in 7 years, and will have 8 more years of service life. The average cost of replacement is $500. If the replacement pile gives 15 years of service, then $500 in maintenance costs gives 30 years of service. And if we assume a life of 23 years for a barrier (this is probably a minimum figure), then we can compare maintenance cost of replacement (15 + 15 years) and sheathing with a barrier (7 + 23 years). Figures 1 and 2 show examples of piling driven to the minimum penetration (10 feet) in locations where the water depth is 10 feet and 35 feet at low tide, and the tidal range is 7 feet. The top of each pile is 4 feet above the water at high tide. In every case but one (the high estimate for concrete sheath), the installation of barriers costs less than replacement of a pile.

CONCLUSIONS

It is concluded that:

1. Optimum life can be obtained from bearing piling by periodic inspection by a "hard hat" diver and installation of barrier systems on those piling which have lost 10-15% of their cross sectional area because of marine borer attack.

2. Of the three methods in use today and which perform well, concrete jacketing is the most difficult and plastic jacketing the least difficult to apply. Metal jackets are much less difficult to install than concrete jackets, but more difficult to install than plastic jackets.

3. Sheaths applied to the intertidal zone must be sealed at both top and bottom to maintain stagnant conditions in the envelope.

4. Where marine borer attack is localized in one area on piling, "bandage" sheaths may be applied to those areas. Unsheathed areas, however, should be inspected periodically to guard against a shift of attack to these areas.

5. All three sheathing methods require care and thoroughness in application.

6. A properly applied sheath should add twenty years and more service life to a bearing pile which has lost 10-15% of its cross sectional area.

RECOMMENDATIONS

It is recommended that:

1. Barrier systems be considered to prolong the service life of in-place wooden piling where submarine inspection reveals significant amount of marine borer attack has occurred.

2. The Laboratory continue to monitor existing and future barrier installations.

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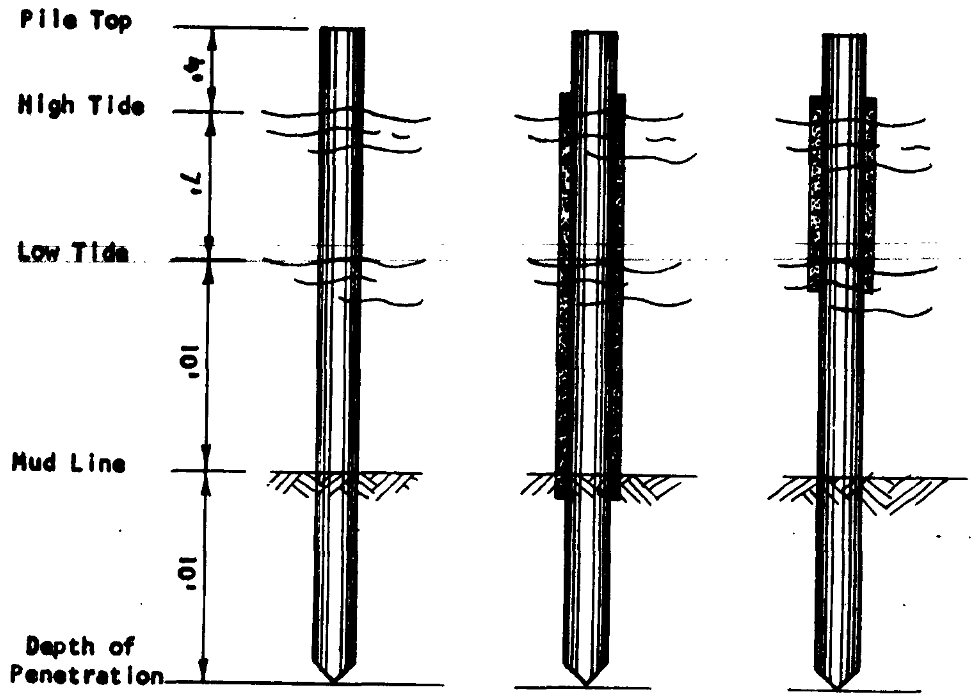
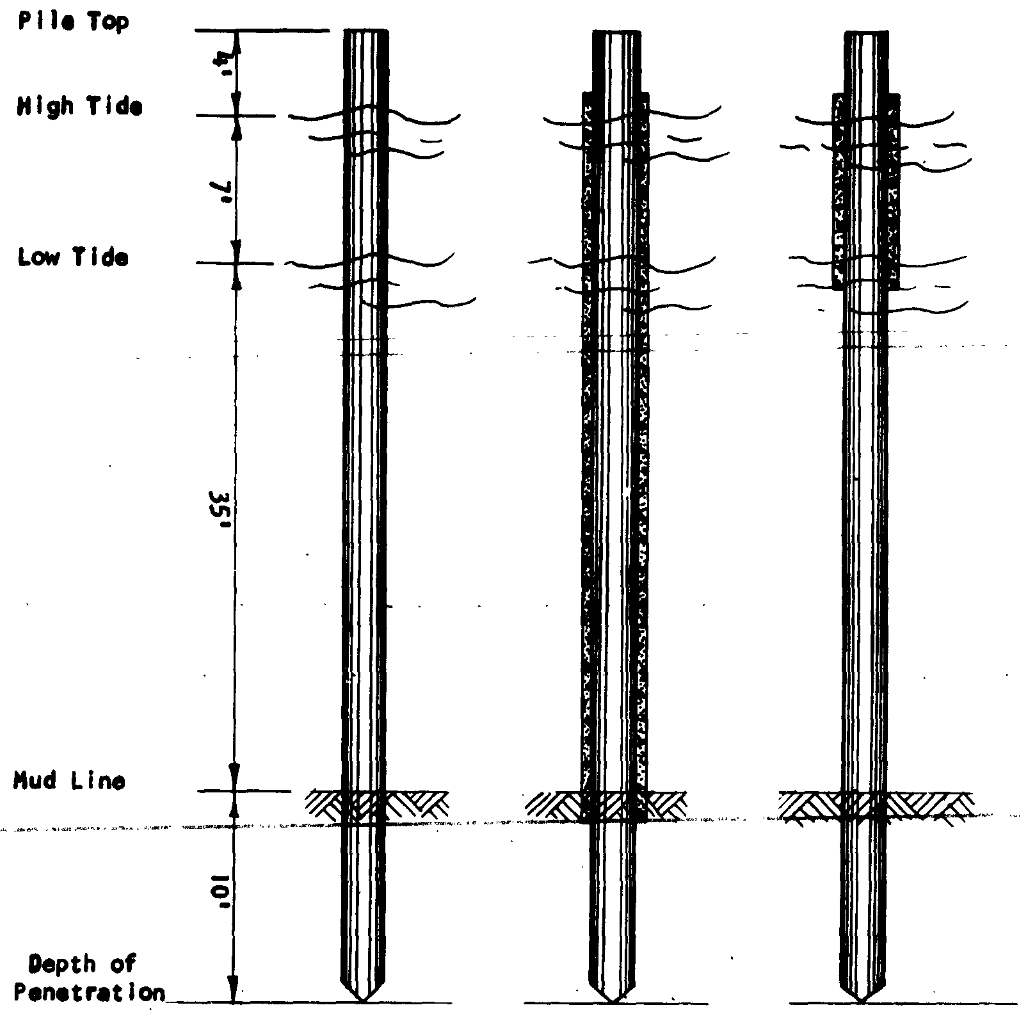


Replacement with pressure treated pile: $500

Full barrier, 2' below mud line to 1' above high tide (20 lineal feet)
Concrete: $80 - $280
Metal: $140 - $180 (90:10 CuNi)
Plastic: $100 - $120 (PVC)

Partial barrier (10 lineal feet)
Concrete: $40 - $140
Metal: $70 - $90 (90:10 CuNi)
Plastic: $50 - $60 (PVC)

Figure 1. Cost comparison of replacement of damaged piling vs installation of barriers (water depth 10' at low tide).



Replacement with pressure treated pile: $500

Full barrier, 2' below mud line to 1' above high tide (45 lineal feet)
Concrete: $180 - $630
Metal: $315 - $405 (90:10 CuNi)
Plastic: $225 - $270 (PVC)

Partial barrier (10 lineal feet)
Concrete: $40 - $140
Metal: $70 - $90 (90:10 CuNi)
Plastic: $50 - $60 (PVC)

(15 lineal feet)
Concrete: $60 - $210
Metal: $105 - $135 (90:10 CuNi)
Plastic: $75 - $90 (PVC)

Figure 2. Cost comparison of replacement of damaged piling vs installation of barriers (water depth 35' at low tide).