Coastal Engineering Technical Note

PROTECTING TIMBER PILES IN SEAWATER ENVIRONMENTS

PURPOSE: Timber piles are widely used in coastal construction. This note discusses marine organisms that attack timber piles, methods of preservation, and repair options.

BACKGROUND: In coastal construction timber piles are used as structural members for piers, wharves, trestles, jetties, groins, and bulkheads. A twelve-inch diameter untreated timber pile can be completely destroyed in as little as six months by marine borers if located in seawater. Fortunately, effective preservatives that prevent this type of damage are available. Life expectancies of 20 years or more are reasonable for properly treated piles.

MARINE ORGANISMS:

1. Teredo, or ship worms, are long worm-like organisms that attack piles from waterline to midline. The piles interior can be completely destroyed without showing any external damage. Teredo can be found throughout the United States in any brackish water with a salinity over 5 parts per thousand. If the possibility exists for saltwater intrusion at a given site, it is best to use a marine creosote dosage for any pile driven there (see Table 1).

2. *Limnoria tripunctata* (gribbles) are crustacean borers that attack timber piles in the tidal zone. Waves then remove the weakened wood producing a characteristic hourglass shape. Until recently, *Limnoria* was thought to only inhabit warm and moderate waters, up to New York City on the east coast, and Point Conception, California on the west coast. The latest research indicates that the cleanliness of the water is an important factor. As water pollution is reduced, *Limnoria* has been reported as far north as southern New England and Oregon, but the amount of infestation is light north of Norfolk, Virginia on the east coast, and north of Point Conception on the west coast.

3. Pholads are tropical crustaceans found in the Panama Canal and in the tropical Pacific. They have not been found in significant numbers in the continental United States, although they are thought to be present in south Florida. North of Jacksonville their presence is presently disregarded. Pholads are not affected by waterborne salts. Since pholads are usually present in combination with Teredo and *Limnoria*, dual treatments are necessary.

Table 1. Pile Preservative Treatments (in pounds per cubic foot)[a]

Condition and Material	Oilborne Preservatives				Waterborne Salts	
	Creosote	Creosote w/Coal Tar	Creosote w/Petroleum	Pentachlorophenol	Ammoniacal Copper Arsenate (ACA)	Chromated Copper Arsenate (CCA)
COASTAL WATERS						
Teredo Present, No Limnoria						
(Coastal Douglas Fir)	20.0	--	--	--	--	--
(Southern Pine)	20.0	20.0	--	--	--	--
Teredo Present, Limnoria Light						
(Coastal Douglas Fir)	22.0	--	--	--	--	--
(Southern Pine)	25.0	25.0	--	--	--	--
Limnoria Heavy, No Pholads						
(Coastal Douglas Fir)	--	--	--	--	2.50	2.50
(Southern Pine)	--	--	--	--	2.50	2.50
FRESH WATER or ONSHORE						
(Coastal Douglas Fir, Western Hemlock, and Lodgepole Pine)	17.0	17.0	17.0	0.85	1.00	1.00
(Southern, Ponderosa, Jack, and Red Pine)	12.0	12.0	12.0	0.60	0.80	0.80
DUAL TREATMENTS						
Where Teredo, Limnoria, and Pholads are active, or in southern areas where the borer hazard is uncertain (Coastal Douglas Fir, Southern Pine)						
First Treatment	--	--	--	--	1.00	1.00
Second Treatment	20.0	--	--	--	--	--

[a] For detailed information on specifications, see current standards from the American Wood Preservers Association (AWPA) and the American Wood Preservers Bureau (AWPB).

(From NAVFACINST 6250.4B, 1982)

PRESERVATIVES FOR FRESH WATER USES:

In fresh water, piles can be effectively treated with reduced amounts of creosote or waterborne salts (Table 1). In addition, pentachlorophenol, a powerful preservative, may also be used to increase pile life. Pentachlorophenol should not be used in salt or brackish water because it hydrolyzes and breaks down.

PRESERVATIVE TREATMENTS: All of the treatments discussed reduce the strength of the pile. Table 2 lists the reduced values which should be taken into account when designing a structure. Creosote or creosote/coal-tar mixtures are very effective against Teredo; 20 pounds per cubic foot retentions are usually specified in the marine environment. Where *Limnoria* attack is light and Teredo attack is heavy, piles can be protected with the heavier creosote treatments listed in Table 1. Heavier attacks of *Limnoria* are not deterred by creosote, but they can be effectively controlled by waterborne salts.

Ammonical copper arsenate (ACA) is generally applied to Douglas Fir, and chromated copper arsenate (CCA) is generally applied to southern pine. Retentions of 2.5 pounds per cubic foot are sufficient to repel *Limnoria* and Teredo, however, the waterborne salts significantly reduce the strength of the piles.

Table 2. Average Mechanical Properties

Flexural Properties					
Type of Treatment	No. of Test Piles	Modulus of Rupture (psi)	Modulus of Elasticity in Flexure (10^6 psi)	Average Absorb Energy in Flexure (in.-lb/cu in.)	Compressive Strength, F_c (psi)
Fir					
Untreated	5	8,394	1.922	6.338	3,346
Creosote	5	6,862	1.584	4.202	a
ACA dual[b]	10	6,111	1.537	3.059	2,714
CCA dual[b]	10	3,844	1.171	3.364	2,333
ACA	5	5,620	1.416	2.078	2,462
Pine					
Untreated	5	8,007	1.942	5.240	a
Creosote	5	5,950	a	a	a
ACA dual[b]	10	4,725	1.568	2.829	a
CCA dual[b]	10	4,167	1.441	2.413	a
ACA	5	5,534	1.538	a	a
CCA	5	5,410	a	a	a

[a]No value is provided because of the large spread in measured values for a small number of samples.

[b]Includes both air-dried and kiln-dried specimens (5 each).

(From CEL, 1979)

To overcome the strength reductions of large waterborne salt applications, dual treatments are recommended to protect against heavy infestations of Teredo and *Limnoria*, as well as pholads. First a waterborne salt is applied at 1 pound per cubic foot retention and allowed to dry. Air drying is thought to reduce strength less than kiln drying (CEL, 1979). This is followed by 20 pounds per cubic foot retention of creosote.

Whether 2.5 pounds per cubic foot of waterborne salts or dual treatment of piles is used for heavy *Limnoria* and Teredo infestation is a matter of economics and strength requirements. Dual treatment is usually the most expensive method. Single treatment with either 2.5 pounds per cubic foot of waterborne salts or 25.0 pounds per cubic foot of creosote is less expensive than dual treatment with 1.0 pound per cubic foot of salts and 20.0 pounds per cubic foot of creosote. In order to determine what is recommended at a particular location it is advisable to consult the American Wood Preservers Institute, local and state agencies and/or local harbor authorities.

If the flexural strength of the piles is important, as in fender systems, creosote treated piles should be used as they are the strongest of the treated piles.

REPAIR OF DAMAGED PILES: For piles already damaged by marine organisms, there are a number of options for repair.

1. The damage piling can be removed and replaced.

2. If the pile cross-sectional loss is 30% or less, flexible polyvinyl chloride(PVC) wraps effectively stop marine borer damage to timber. These wraps not only kill those borers already residing in the wood, but also prevent the entry of new borer recruits. Table 3 indicates that the least expensive preservative and maintenance option for timber bearing piles in all geographical areas is creosoted piling protected by PVC wrap. This assumes, of course, that timely protection of piling occurs. Table 4 compares marine timber fender piling replace costs with PVC wrapping.

3. Heavily damaged piles can be reinforced with concrete. This can be done by placing a nylon jacket around the pile (adding reinforcement as required) and filling the jacket with tremie concrete.

4. A similar method is to enclose the damaged portion of the pile with a fiberglass form, installing the required reinforcement and filling the space between between the form and pile with hydrophilic epoxy (Moffatt and Nichol). These last two methods allow the continued use of the structure while the piles are being repaired.

5. Also, external reinforcement with heavy steel pipe is possible, although the steel would require corrosion protection.

Table 3. Calculated Average Annual Costs of Preservative Treatment and Maintenance Options for 45-foot Marine Timber Piling Other Than Fender in All Geographical Areas *

Location	Preservative Option	Cost ($/Pile/yr) for --		
		Replacement	Encasement Concrete	PVC Wrapping
Tropical Areas	Creosote	436	380	145
	Arsenical Salt	262	292	150
	Dual Treatment	206	223	170
Subtropical Areas	Creosote	393	341	141
	Arsenical Salt	200	232	143
	Dual Treatment	188	199	167
Temperate Areas	Creosote	229	256	131
	Arsenical Salt	171	194	139
	Dual Treatment	181	184	166
Polar Areas	Creosote	141	155	120
	Arsenical Salt	161	149	134
	Dual Treatment	174	170	164

* NCEL Techdata Sheet 87-06

Table 4. Calculated Average Annual Costs of Preservative Treatment and Maintenance Options for Marine Timber Fender Piling (45' in length) in All Geographical Areas

Location	Preservative Option	Cost ($/Pile/yr) for --	
		Pile Replacement	PVC Wrapping
Tropical Areas	Creosote	366	228
	Arsenical Salt	245	213
	Dual Treatment	239	236
Subtropical Areas	Creosote	342	224
	Arsenical Salt	217	208
	Dual Treatment	235	235
Temperate Areas	Creosote	245	213
	Arsenical Salt	209	205
	Dual Treatment	235	235
Polar Areas	Creosote	209	213
	Arsenical Salt	205	205
	Dual Treatment	235	235

* NCEL Techdata Sheet 87-06

ADDITIONAL INFORMATION: Contact AWPI, 1651 Old Meadow Road, McLean, VA 22102 or call (800) 336-0148.

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