



MARINE CONSTRUCTION GUIDE

Fresh Water, Brackish & Salt Water ■ Design Concepts & Specification Guidelines



Docks ■ Piers ■ Bulkheads ■ Pedestrian Walkways ■ Light Vehicular Bridges

SouthernPine.com

FOREWORD

For nearly 20 years, this guide has served the wood products industry, design professionals and marine contractors by providing a comprehensive approach to wood structures built in fresh water, brackish and salt water. Periodic updates to this guide have adequately served users to keep up with changes in the classification of building materials, preservatives, plus fasteners and connectors, as well as construction details.

This new edition focuses on the needs of design professionals and marine contractors, providing the latest guidance for specifying and properly installing pressure-treated Southern Pine products in sensitive and often harsh environments. This comprehensive construction guide addresses several issues:

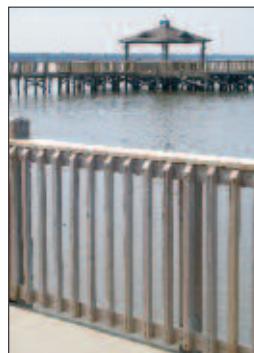
- Changes in wood preservatives and treating industry quality control and inspection agencies.
- Removal of the Commodity (C) Standards for treated wood, replaced with the AWPA Use Category System (UCS) for determining preservatives needed for specific applications. The UCS was developed as a format revision only and was not intended to make significant technical changes.

- Emphasis is placed on using higher grades of lumber: Marine Grade, Seawall Grade, No.1, No.2 Dense and Select grades for structural and appearance considerations.
- New recommendations are included for fasteners and hardware in corrosive environments.
- The impacts of design values for visually graded Southern Pine dimension lumber that became effective June 1, 2013.
- Separate design recommendations are made for fresh water, brackish and salt water applications.

An understanding of the information presented here is important for the successful design and construction of wood structures in marine environments.

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SFPA is a nonprofit trade association that has represented manufacturers of Southern Pine lumber since 1915.

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The information in this publication is based upon design values for visually graded Southern Pine dimension lumber that became effective June 1, 2013.

The Southern Forest Products Association (SFPA) is a nonprofit trade promotional group supported by Southern Pine lumber manufacturers. SFPA neither manufactures, grades, tests, nor treats lumber products.

The primary purpose of this publication is to provide technical information about the use of Southern Pine lumber in marine structures, including piers, docks, bulkheads, pedestrian walkways and light vehicular bridges. The content has been compiled by SFPA as a service to buyers, users, and specifiers of wood building materials. The information is based on other industry sources, including the *Standard Grading Rules for Southern Pine Lumber* published by the Southern Pine Inspection Bureau, the Book of Standards published by the American Wood Protection Association, and the *2012 National Design Specification® for Wood Construction* published by the American Wood Council.

Accordingly, SFPA does not warrant the information in this publication and assumes no liability for damage caused or contributed to by the use of such information.

The design concepts contained herein are illustrative of the engineering and other factors involved in designing and building aquatic and wetland structures with pressure-treated Southern Pine, but are not intended to be used as a substitute for plans and specifications prepared by qualified professionals for individual construction projects.

The conditions under which lumber is used in construction may vary widely, as does the quality of workmanship. Neither SFPA, nor its members, have knowledge of the quality of materials, workmanship or construction methods used on any project and, accordingly, do not warrant the technical data, design or performance of the lumber in completed structures.



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Southern Pine – a Natural Choice for Marine Environments

The use of Southern Pine lumber for marine service includes a wide range of residential and commercial applications such as docks, piers, marinas, bulkheads, boardwalks, as well as pedestrian and light vehicular bridges.

These systems are exposed to especially harsh environmental conditions; therefore, accurate specification of lumber, timbers and fastening hardware is critical to achieve proper performance and serviceability. This guide offers technical information useful to the professional who specifies Southern Pine for these applications.

Industry quality-control standards for the manufacture and preservation of Southern Pine assure long-term performance and

minimize environmental impact. Advances in preservative treatments, modern design and construction techniques, and sustainable forestry management make Southern Pine a cost-effective, ecologically sound and renewable construction material.

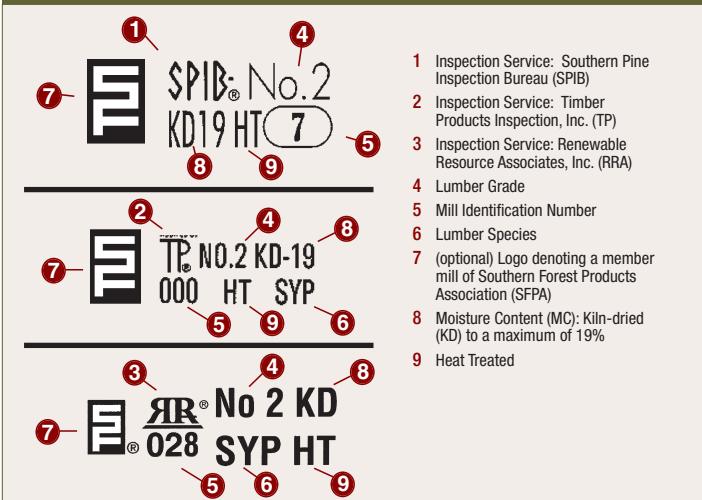
For details on how to select and manage the use of treated wood to achieve best performance while minimizing the potential for adverse environmental impact, refer to *Treated Wood in Aquatic Environments* and its companion document, *Best Management Practices for the use of Treated Wood in Aquatic and Other Sensitive Environments*; download at SouthernPine.com.

Grade Marks and Quality Marks

Southern Pine is recognized by building codes and regulatory agencies for use in construction and must be properly identified. Each piece of lumber must be grade marked by an agency accredited by the American Lumber Standard Committee (ALSC), and manufactured in accordance with Product Standard PS 20 published by the U.S. Department of Commerce. Southern Pine lumber is graded in accordance with the Standard Grading Rules for Southern Pine Lumber published by the Southern Pine Inspection Bureau (SPIB). SPIB, Timber Products Inspection Inc. (TP) and other organizations* are accredited to inspect and grade mark Southern Pine lumber in accordance with SPIB Grading Rules.

The American Wood Protection Association (AWPA) is the standards-writing organization for the U.S. wood treating industry. AWPA's Book of Standards provides consensus-based guidance on methods, preservatives and other technologies that protect wood products. Wood preservatives are accepted for model building code compliance by reference to the AWPA *Book of Standards*, or by Evaluation Reports issued by the ICC-Evaluation Service. Acceptance of a preservative into the AWPA *Book of Standards*, or by ICC evaluation, ensures that properly treated wood products perform satisfactorily for their intended service condition.

Typical Southern Pine Lumber Grade Marks – ink stamp



* Other organizations accredited by ALSC to inspect and grade all or selected Southern Pine products according to SPIB Grading Rules include: California Lumber Inspection Service (CLIS), Northeastern Lumber Manufacturers Association (NELMA), West Coast Lumber Inspection Bureau (WCLIB) and Western Wood Products Association (WWPA).

Southern Pine Lumber Grade Descriptions

The following grade descriptions are based on the *Standard Grading Rules for Southern Pine Lumber*, published by the Southern Pine Inspection Bureau (SPIB). Southern Pine grade descriptions for products not listed below are detailed in the *Southern Pine Use Guide*, available at SouthernPine.com.

Dimension Lumber: 2" to 4" thick, 2" and wider

No.1 – Recommended for construction where high strength, stiffness and good appearance are desired.

No.2 – Recommended for most general construction uses where moderately high design val-

ues are required. Allows well-spaced knots of any quality.

No.1 Dense* – Recommended for construction where high strength, stiffness and good appearance are desired.

No.1 Prime – Recommended where appearance and strength are a consideration. Grade based on No.1 Dimension Lumber except wane and other characteristics that affect appearance are limited.

No.2 Prime – Recommended where appearance and strength are a consideration. Grade based on No.2 Dimension Lumber except wane and other characteristics that affect appearance are limited.

Timbers: 5" x 5" and larger

Select Structural – Recommended where high strength, stiffness and good appearance are desired.

No.1 and No.2 – Similar in appearance to corresponding grades of Dimension Lumber. Recommended for general construction uses.

No.3 – Non-stress rated, but economical for general utility purpose such as bracing, blocking, bulkheading, etc.

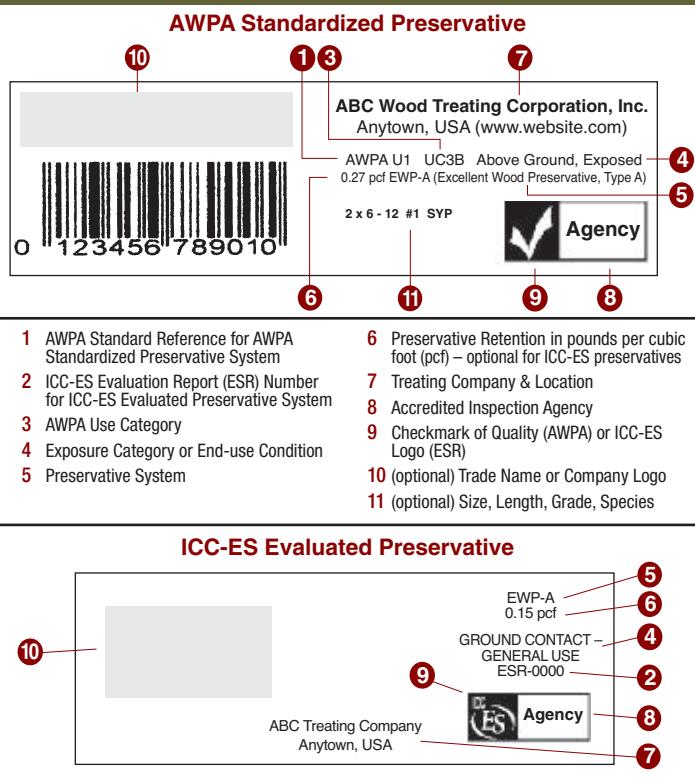
* Most mills do not manufacture all products and make all grade separations. Availability may be limited.

All treated Southern Pine must be identified with a treated quality mark – either plastic end tag or ink stamp – conforming to building code standards. Quality marks identify wood products treated with preservatives standardized by AWPA or evaluated by ICC-ES. Use of such marks provides assurance that:

- the preservative is EPA-approved for the end-use application
- the wood product is treated in compliance with federal law
- the preservative retention and penetration meets the manufacturing specifications
- the pressure-treated wood product has been inspected by a quality-audit program

Whenever practical, boring, machining, trimming or surfacing should be done prior to treatment. Field-cut ends, notches and drilled holes of preservative-treated wood should be treated in accordance with AWPA Standard M4. Refer to the SFPA publication *Pressure-Treated Southern Pine* for more information; download at SouthernPine.com.

Typical Treated Lumber Quality Marks – plastic end tag or ink stamp



Moisture Content Requirements

The moisture content of Southern Pine lumber is an important consideration in marine applications. The majority of in-service problems with heavy timbers and planking have been the result of inadequate drying practices prior to preservative treatment.

Dimension lumber and decking used in marine applications should be kiln-dried to a moisture content range of 19% to 21%. Timbers (5x5 and larger), if specified to be kiln-dried, must be 20% or less and, if specified to be air-dried, must be 23% or less. These moisture content guidelines for untreated Southern Pine originate from the Southern Pine Inspection Bureau (SPIB). One should be aware of these practices in order to develop a working knowledge of the lumber drying process. For further information on end-use requirements, refer to SFPA publication *Southern Pine Use Guide*, available for download at SouthernPine.com.

For decks, handrails, bulkhead sheeting and bulkhead caps, treated lumber can be specified to be Kiln-Dried After Treatment (KDAT). Some lumber treaters Air Dry After Treatment, (ADAT). These processes involve drying lumber to its in-service moisture content of 19% after treatment.

Refer to the SFPA publications *Pressure-Treated Southern Pine* and *Southern Pine Use Guide* for further details; download at SouthernPine.com.



Proper Lumber Storage

Using proper storage techniques is essential to the efficient and economical use of treated lumber. Proper storage also:

- Prevents defects that may result from alternate wetting and drying
- Helps maintain appearance and dimensional stability
- Helps to safeguard against costly callbacks for builders



Design Values

Reference design values for Southern Pine lumber are tabulated in the *Design Values for Wood Construction Supplement of the National Design Specification® (NDS)®* published by the American Wood Council. Reference design values for untreated lumber also apply to lumber pressure treated by an approved process and preservative. As a result, design values that became effective June 1, 2013 also apply to visually graded Southern Pine dimension lumber that is pressure treated.

Reference design values are based on normal load duration under the moisture service conditions specified; they must be multiplied by applicable adjustment factors to determine adjusted design values. Adjustment factors for untreated lumber also apply to pressure-treated lumber with one exception – in Allowable Stress Design applications allowing an increase with the Load Duration Factor, C_D , that factor cannot exceed 1.6 for structural members pressure treated with waterborne preservatives.

As an example, common adjustment factors to consider when sizing pressure-treated members for an exterior application include:

Wet Service Factor, C_M – A reduction required for lumber used under conditions where the moisture content of the wood in service will exceed 19% for an extended period of time, such as for marine structures and uncovered outdoor decks regularly exposed directly to rain or other sources of moisture.

Repetitive Member Factor, C_r – An increase allowed when at least three joists are in contact or spaced not more than 24" on center and are joined by a load distributing element such as decking.

Refer to the SFPA publications *Southern Pine Use Guide* and *Maximum Spans for Southern Pine Joists & Rafters* for more information.

NOTE: Timbers (5x5 and larger) have the same design values for wet and dry uses; design values for timbers are based on green (wet use) conditions.

Job Site Storage

Regardless of where lumber is stored at the job site, a few simple precautions should be observed:

- Lumber should be unloaded in a dry place – not in water or muddy areas.
- Lumber should not be in direct contact with the ground. It should be elevated on stringers to allow air circulation.
- Lumber stored in an open area should be covered with a material that will give protection from the elements, but be porous enough to allow moisture to escape. Polyethylene or similar covers may not allow the passage of moisture.

The builder, building contractor, licensed contractor, erector or erection contractor is responsible for the proper unloading, receiving, storage, handling, installation and bracing of lumber at the job site.

Sizes

Southern Pine sawmills typically produce lumber in two-foot multiples, supplying lengths of 8' to 20'. Some mills produce longer lengths, typically 22' and 24'. Construction designs should consider standard sawmill lengths to utilize full-length lumber and to minimize waste.

Dimension Lumber

Nominal Size (inches)	Actual Size (inches)	thickness x width
2 x 4	1-1/2 x 3-1/2	
2 x 6	1-1/2 x 5-1/2	
2 x 8	1-1/2 x 7-1/4	
2 x 10	1-1/2 x 9-1/4	
2 x 12	1-1/2 x 11-1/4	
3 x 4	2-1/2 x 3-1/2	
3 x 6	2-1/2 x 5-1/2	
3 x 8	2-1/2 x 7-1/4	
3 x 10	2-1/2 x 9-1/4	
3 x 12	2-1/2 x 11-1/4	
4 x 4	3-1/2 x 3-1/2	
4 x 6	3-1/2 x 5-1/2	
4 x 8	3-1/2 x 7-1/4	
4 x 10	3-1/2 x 9-1/4	
4 x 12	3-1/2 x 11-1/4	

Timbers

6 x 6	5-1/2 x 5-1/2
6 x 8	5-1/2 x 7-1/2
8 x 8	7-1/2 x 7-1/2

NOTE: Timber sizes shown above are "dressed" or surfaced on four sides (S4S). Rough timbers can also be specified. Minimum rough sizes are 3/8" scant of nominal sizes, in thickness (inches) and in width (inches), and rough timbers may be 1" oversize if over 2" thick, according to SPIB grading rules; refer to paragraph 121.4 (rough), 123.5 (dressed) and 121.5 (oversize).

- Traditional bulkhead sheeting products are surfaced 2" and 3" nominal dimension lumber (actual thickness 1-1/2" & 2-1/2"). These products are readily available from Southern Pine sawmills and treaters.

Surfacing

Surfacing the lumber to its final configuration (either dimensional size or a specialty pattern) should also be a part of a marine product specification, depending on the final application. According to SPIB grading rules, surfacing options are:

S4S – Surfaced Four Sides

(all four faces)

S2S – Surfaced Two Sides

(two faces on the width)

S1E – Surfaced One Edge

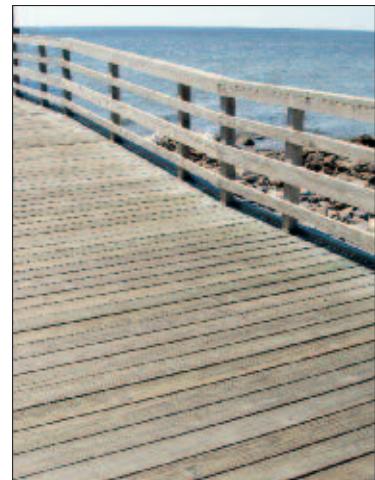
(one edge on the thickness)

S2E – Surfaced Two Edges

(two edges on the thickness)

Proper specification of lumber surfacing often contributes to a cost-effective, well-designed project.

Example: Substructural members 3" and thicker need not always be surfaced on all four sides for optimum service. Rough lumber for stringer applications, surfaced one edge (S1E) or surfaced two edges (S2E) can be used to provide an even surface for installation of decking material.



Profiles & Patterns

Southern Pine lumber for marine construction can be remanufactured into a variety of profiles, including "Sloppy V-T&G," a common pattern used in bulkheading (see illustrations). Simple guidelines involving thickness and tongue length are as follows: If 2"-thick lumber is used, the tongue should be 3/4" long; if 3" or 4"-thick lumber is used, the tongue should be 1" long.

In the case of fabrication during installation, field cuts should be treated in accordance with AWPA Standard M4.

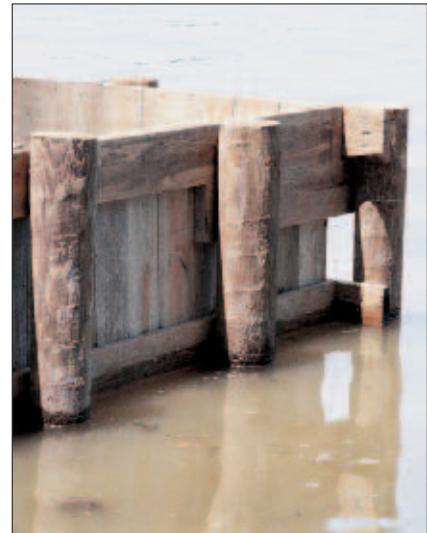
Refer to the SPIB *Standard Grading Rules for Southern Pine Lumber* for more details on surfacing and profile designations, provisions and net product sizes.



"Sloppy V - T & G"



"Square - T & G"



Preservative Treatments – Process and Selection

Pressure-treated Southern Pine is the product of a carefully monitored and controlled process. Preservatives are forced deep into the wood's cells within a closed cylinder while under pressure.

Pressurized treatment of lumber, timbers and piling is the most effective method of protecting wood designated for the marine environment. The pressure process allows deeper penetration of chemical components in the wood and control of retention levels.

The choice of preservative depends on how and where the wood will be used. There are three broad types of wood preservatives used in modern pressure-treating processes:

- **Waterborne Preservatives** are used for residential, commercial, marine, agricultural, recreational, and industrial applications.
- **Creosote** and creosote/coal tar mixtures are used for railroad ties, pilings, timber bridges, utility poles and heavy commercial marine uses.
- **Oilborne Preservatives**, namely Pentachlorophenol, or "Penta," and Copper Naphthenate are used for industrial applications, including utility poles. Penta and copper naphthenate are not recommended for salt water marine construction, especially in immersion or in the splash zone.

Refer to the SFPa publication *Pressure-Treated Southern Pine* for a comprehensive listing of preservatives used for the pressure treatment of Southern Pine materials.

Service Conditions – Use Category System

The American Wood Protection Association's Use Category System (UCS) defines exposure categories that wood products are subjected to in service. The UCS helps users identify the exposure condition for specific products and end-use environments and then specify the acceptable preservatives and retention levels necessary for that application.

The specifier should become familiar with the Service Conditions for Use Category designations to which components will be exposed. Refer to Tables 1 and 2. Commonly used preservatives and retentions for treated Southern Pine by end-use or application and exposure condition are summarized in Tables 2-4, pages 6 and 7.

When purchasing treated Southern Pine under the Use Category System, material orders should include the Service Condition (Tables 1 and 2), specific end-use, preservative and retention level

AWPA Standards

The American Wood Protection Association (AWPA) publishes its *Book of Standards* annually, which lists the proper preservatives and retentions for various service conditions.

The pressure treating industry has established different preservative retention levels for treated lumber, based on intended use.

"Retention levels" refer to the amount of chemical preservative remaining in the wood's cell structure after the pressure process has been completed. Preservative retentions are expressed in pounds of preservative per cubic foot of wood (pcf); the higher the retention level, the harsher the condition to which the wood can be exposed.

Alternative Acceptance

In addition to AWPA Standards, most building code officials will accept treated material with an Evaluation Service Report (ESR) from the International Code Council – Evaluation Service (ICC-ES).

(Tables 2-4), and any special requirements such as pre- or post-treatment preparations, including conditioning and drying.

CCA Approved for Salt Water Use

The use of Chromated Copper Arsenate (CCA) for marine construction, as specified in AWPA Use Category UC5, is approved by the Environmental Protection Agency for certain uses. CCA is allowed for piling and walers in salt water immersion. CCA is also allowed for other framing, stringers and cross-bracing exposed to salt water splash in 2x8 and/or 3x6 and larger nominal dimensions and treated to a minimum of 0.60 pcf.

CCA is not allowed for decking, railings, wall caps and related applications using lumber less than 2x8. Approved alternative preservatives, just as effective as CCA for these applications, are to be used for these components above water.

TABLE 1: AWPA USE CATEGORY DESIGNATIONS

UC3A	Above Ground, exterior - protected
UC3B	Above Ground, exterior - exposed
UC4A	Exterior, ground or fresh water contact in areas with low risk
UC4B	Exterior, ground or fresh water contact, severe environments, high potential for deterioration
UC4C	Exterior, ground or fresh water contact, very severe conditions or very critical structural components.
UC5A	Salt water exposure – north of San Francisco, CA and Long Island, NY
UC5B	Salt water exposure – south of San Francisco on West Coast, New Jersey through Georgia on East Coast
UC5C	Salt water exposure – south of Georgia, Gulf Coast

TABLE 2: SIMPLIFIED SPECIFICATION GUIDE FOR MARINE APPLICATIONS¹

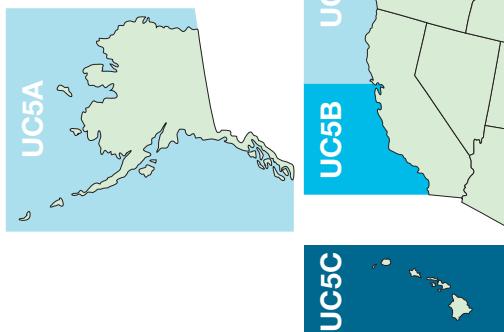
Service Conditions ²	Typical End-Use Applications ²	Commonly-Used Preservative Systems ^{1,3}
Above Ground, Exterior: Protected with coating & rapid water runoff UC3A	Sawn painted/coated lumber	Carbon-based, Borates, Copper Azoles & Quats Micronized Copper Azoles
Above Ground, Exterior: Exposed UC3B	Sawn decking, deck joists & beams (not subject to frequent wetting); deck cross-bracing, railing components & stair stepping; fresh water pier, dock, walkway and boardwalk decking, joists & beams (not subject to frequent wetting)	Copper Azoles & Quats, Carbon-based Micronized Copper Azoles
Ground Contact/ Fresh Water: General Use UC4A Non-critical components	Sawn deck & general-use posts; deck joists & beams (ground contact) & stair stringers; fresh water floating dock platforms; fresh water pier, dock, walkway & boardwalk decking, joists & beams (subject to frequent wetting); fresh water pier cross-bracing; fresh water pier, dock, walkway & boardwalk supports; retaining walls (not critical);	Copper Azoles & Quats Micronized Copper Azoles
	Sawn bulkhead sheeting (fresh water)	CCA, Copper Azoles & Quats Micronized Copper Azoles
Ground Contact/ Fresh Water: Heavy Duty UC4B - Critical components or difficult replacement - High decay potential - Includes salt water splash	Out-of-water salt water splash (above ground); structural support sawn poles & piles	Copper Azoles & Quats, CCA Micronized Copper Azoles
	Retaining walls (critical)	Copper Azoles & Quats Micronized Copper Azoles
	Glulam for bridges	Copper Naphthenate, CCA, Copper Azoles & Quats Micronized Copper Azoles
Ground Contact/ Fresh Water: Extreme Duty UC4C - Critical structural components - Severe environments - Extreme decay potential - Includes salt water splash	Foundation piles; highway bridge, cribbing, piles & structural (critical); out-of-water salt water splash (ground contact); sawn building posts (important structural); sawn poles & piles (critical structural support)	CCA, Creosote Micronized Copper Azoles
Brackish & Salt Water UC5A Northern Waters UC5B Central Waters UC5C Southern Waters	Piling, bulkheads, seawalls, pier cross-bracing	CCA, Creosote

(1) This table provides specification information for only the most common treated marine end-use applications and is not meant to be an all-inclusive reference. There are numerous approved preservatives, but not all of them are suitable or commonly used for a specific marine application. To provide the most practical information possible, only the preservatives that specifiers, users and producers have established as present market leaders for pressure-treated Southern Pine are included in this table. Refer to the American Wood Protection Association (AWPA) 2014 Book of Standards and International Code Council-Evaluation Service (ICC-ES) Evaluation Reports (ESRs) for complete information on all approved preservatives.

(2) Service conditions and end-use applications are based on AWPA Standard U1 (Tables 2-1 and 3-1) and ICC-ES ESRs.

(3) Copper Azoles & Quats includes dissolved and micronized preservative systems; Oilborne includes Penta and CuN.

AWPA Use Categories – Marine Applications



Inland Fresh Water Exposure
UC4A, UC4B and UC4C

Source: AWPA Book of Standards

Use Category requirements for particular zones are based on the presence of specific marine organisms. The degree of hazard posed by these organisms in a specific coastal zone will determine the appropriate preservative loading. This map is only a general guide and should be supplemented with local information where there is doubt concerning the nature of marine borer activity and selection of an appropriate preservative.

FRESHWATER

TABLE 3: PRESERVATIVE SPECIFICATIONS FOR SOUTHERN PINE IN FRESH WATER SERVICE¹

End-Use Commodity	AWPA Use Category (UC) Designation	Minimum Retention Requirements — Pounds per Cubic Foot (pcf)				
		Copper Azole Dispersed (μCA-C)	Copper Azole (CA)	Copper Quat (ACQ) ⁵	Micronized (MCA)	
<i>Piles</i>						
Round	4C	0.80	12.0	0.41	0.33	0.80
Square Sawn & Sheet Pile	4C	0.60	12.0	0.31	0.23	0.60
<i>Glulam Timber</i> ³	4A	0.40	10.0		0.23	0.40
<i>Bulkhead Sheathing, Cross Bracing Split Pile Caps, Stringers, Walers</i>	4A		10.0	0.21	0.23	0.40

(1) Preservatives and retentions listed in Table 3 per American Wood Protection Association (AWPA) 2014 Book of Standards. (2) CCA preservative is not allowed for solid-sawn dimension lumber in fresh water use. (3) Per AITC 109-2007, American Institute of Timber Construction, Standard for Preservative Treatment of Structural Glued Laminated Timber.

BRACKISH & SALT WATER

TABLE 4: PRESERVATIVE SPECIFICATIONS FOR SOUTHERN PINE IN BRACKISH & SALT WATER SERVICE¹

End-Use Commodity	AWPA Use Category (UC) Designation	Minimum Retention Requirements — Pounds per Cubic Foot (pcf)				
		Copper Azole Dispersed (μCA-C)	Copper Azole (CA)	Copper Quat (ACQ) ⁵	Micronized (MCA)	
<i>Piles, round</i>						
New Jersey & San Francisco Bay, North	5A	1.5	16.0			
Mid-Atlantic & San Francisco Bay, South	5B	2.5	20.0			
Florida, Gulf Coast, Puerto Rico, Hawaii	5C	2.5	20.0			
<i>Dual Treatment</i> ⁶						
First treatment	5B-C	1.0				
Second treatment	5B-C		20.0			
<i>Piles, square sawn & sheet pile</i>						
<i>Dual Treatment</i> ⁶	5A-C	2.5	25.0			
First treatment	5A-C	1.5				
Second treatment	5A-C		20.0			
<i>Glulam Timber</i> ³						
<i>Dual Treatment</i> ⁶	5A-C	2.5	25.0			
First treatment	5A-C	1.5				
Second treatment	5A-C		20.0			
<i>Bulkhead Sheathing, Cross Bracing, Walers</i>	5A-C	2.5	20.0			
<i>Split Pile Caps, Stringers</i>	4B-C	0.60	12.0	0.31	0.23	0.60
Salt Water Splash						

(1) Preservatives and retentions listed in Table 4 per American Wood Protection Association (AWPA) 2014 Book of Standards.

(2) In brackish and salt water marine use, CCA treatment is not allowed in nominal dimensions less than 2x8, but is allowed for walers, pile caps, stringers, cross bracing and other framing when 2x8 and/or 3x6 and larger nominal dimensions are treated to a minimum of 0.60 pcf. (3) Per AITC 109-2007, American Institute of Timber Construction, Standard for Preservative Treatment of Structural Glued Laminated Timber. (4) CR and CR-S only. (5) ACQ-B and D only. (6) In certain extreme conditions, where pholads or *Sphaeroma terebrans* are present, dual treatment may be necessary.

Decking Specifications & Installation Guidelines

Boardwalks, piers and floating docks are just a few examples that typically call for treated Southern Pine materials to be used for decking. As with all marine construction, a familiarity with the correct materials and installation techniques is crucial to the long-term performance and longevity of the structure.

Moisture Content & Size Considerations

Because a waterborne preservative system is used, the moisture content and physical dimensions of Southern Pine lumber can vary after treatment. Wood swells in both thickness and width during treatment. For example, a 2x6 at 19% moisture content prior to treatment measures 1-1/2" x 5-1/2". This measurement can increase as much as 1/8" to 1/4" directly after treatment, depending on the density of the wood.

Most treated Southern Pine is delivered to the supplier or job site in a wet condition, usually in excess of 25% moisture content. The actual size of this material (thickness and width) could vary depending on drying time after treatment and ambient temperatures. Accordingly, decking may need to be installed with pieces butted tightly together to avoid excessive gaps as the lumber dries in use. (see chart).

As an alternative, treated Southern Pine lumber can be specified that is redried after treatment. This material can either be kiln-dried after treatment (KDAT) or air-dried after treatment (ADAT); this lumber is designated KDAT or ADAT on the quality mark or end-tag. AWPA Standards specify a moisture content of 19% for all KDAT and ADAT material. Generally, this lumber should be adequately spaced during installation to avoid buckling; refer to Table 5.

Material Selection and Installation

To reduce waste, decking should be specified, ordered and installed in even two-foot lengths (4', 6', 8', etc.). For optimum appearance and performance, the grade of decking material should be specified as No.1 (for 2" nominal thickness). Treated lumber should bear the grade mark of an inspection agency accredited by the American Lumber Standard Committee (ALSC), as well as the treated quality mark indicating the use of preservatives standardized by AWPA or evaluated by ICC-ES.

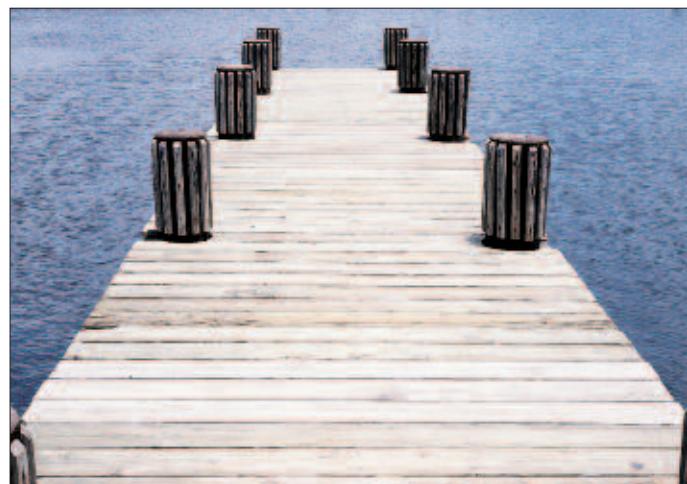


Proper fastening practices and a deck maintenance program are required to ensure stability and optimum performance. To reduce cupping, decking should not exceed 6" in width. Wood preservatives can be specified that include a water-repellent additive that will minimize weather damage (surface checking) to deck surfaces. Color additives are also available. Another option is to seal all decking with a topical water-repellent formulation when construction is completed.

Hot-dipped galvanized screws provide superior holding power for decking. Alternately, stainless steel or hot-dipped galvanized ring or spiral-shank nails can be used. Refer to Decking Selection & Fastening Guidelines, page 25.

TABLE 5: RECOMMENDED SPACING FOR TREATED 2x6 DECKING

Width at Installation	Spacing (min - max)
5-1/2" (wet or dry)	1/8" - 1/4"
5-5/8"(wet)	1/16"- 1/8"
5-3/4"(wet)	Butt boards together
Over 5-3/4" (wet)	Allow drying time prior to installation



Fasteners & Connectors for Use with Treated Wood

The potential for corrosion of hardware in contact with treated wood occurs when metals in the preservative (such as copper) are different from the metals in the hardware (the iron in steel, or aluminum). In a wet environment, these dissimilar metals create a small electrical current that triggers a chemical reaction resulting in galvanic corrosion.

To select proper hardware, the specifier should first consider the end-use application and exposure conditions. In damp or wet exposure, hardware in contact with pressure-treated wood must be corrosion resistant. Hardware includes fasteners (e.g. nails, screws and bolts) and all connectors (e.g. joist hangers, straps, hinges, post anchors and truss plates).

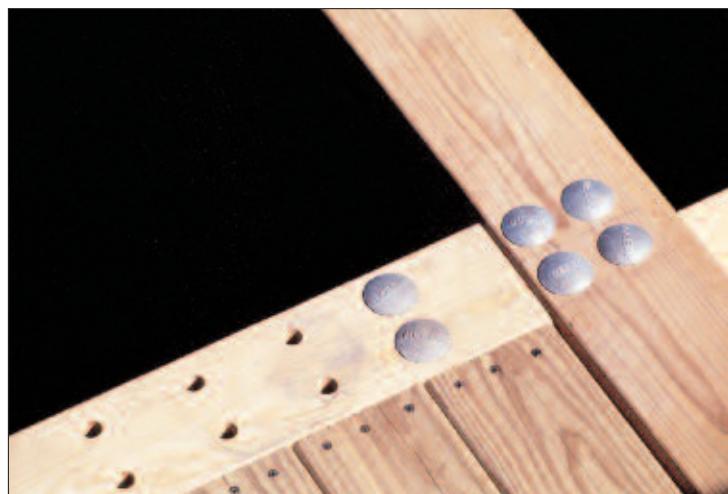
Regardless of exposure condition, fasteners and connectors should be specified in compliance with the hardware manufacturer's recommendations and the building codes for their intended use.

Copper-Based Preservatives

Copper-based preservative formulations include the traditional Chromated Copper Arsenate (CCA) and advanced products such as Copper Azole (CA) or Copper Quat (ACQ or Micronized Copper). CA and ACQ have shown a slightly higher corrosion rate when compared to CCA and Micronized Copper.

In damp or wet environments, hot-dipped galvanized or stainless steel hardware is recommended in contact with wood treated with copper-based preservatives. Hot-dipped galvanized fasteners should meet ASTM A153. Hot-dipped galvanized connectors should meet ASTM A653, Class G185 sheet with 1.85 ounces of zinc coating per square foot minimum.

Type 304 or 316 stainless steel is recommended for maximum corrosion resistance in more severe exterior applications, such as swimming pools or salt water. Stainless steel is also a recommended



option when CA or Copper Quat formulations are specified at retention levels greater than required for Ground Contact.

Standard carbon-steel, aluminum or electro-plated products must not be installed in direct contact with CA or ACQ-treated wood. However, aluminum products may be placed in direct contact with wood treated using micronized copper when used in above ground exterior applications. Electro-plated galvanized metal products

generally have a thinner layer of protection compared to hot-dipped galvanized and are typically not accepted by the building codes for exterior use. Fasteners and connectors used together must be of the same metallic composition to avoid galvanic corrosion (e.g. use hot-dipped nails with hot-dipped joist hangers).

When aluminum or electro-plated hardware must be used in proximity to CA or ACQ treated wood, spacers or physical barriers can protect products, such as flashing or termite shields. Barriers should be non-conductive and remain durable for the intended service life of the application. Suitable barriers may include heavy plastic sheeting, rubber, vinyl, or a high-quality, non-permeable tar bitumen or epoxy.

Hardware coated with proprietary anti-corrosion technologies is also available. Consult individual hardware manufacturers for specifics regarding their performance.



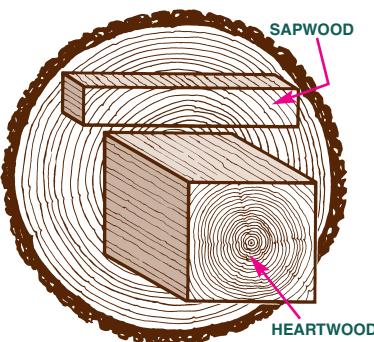
Southern Pine Lumber & the Marine Environment

Lumber Characteristics

An understanding of Southern Pine lumber and its interaction with fresh water, brackish and salt water is important.

Southern Pine lumber is basically composed of sapwood and heartwood cells. Lumber, timbers and piling cut from a log can be 100% sapwood or 100% heartwood, or a combination of both depending on log size, growth conditions and other characteristics.

Sapwood is the living outer portion of the tree composed of elongated cells or tracheids which take an active part in the growth and the movement of water within the tree. Heartwood is the inactive center part of the tree and becomes a repository for resins and extractives. These extractives impart a degree of natural decay resistance. Logs that come from old-growth forests contain higher heartwood concentrations. Logs originating in second-growth stands and pine plantations have faster growth rates and contain more sapwood than heartwood.



Pressure-treating the sapwood portion with preservatives is the most important and effective method of protecting wood and assuring long-term performance. However, the denser heartwood is not able to absorb the preservative; therefore, it is not protected and is more susceptible to marine borer damage and decay.

Wood Decay Factors

The constant or intermittent presence of water in a typical marine setting is the overwhelming factor favoring fungal growth.

Fungi need four criteria to survive: moisture, warm temperature, oxygen and food. The absence of any one of these essentials will interrupt or prevent growth. That's why portions of piers and piles that are constantly underwater do not decay – there's no free oxygen. It's also why protected wood framing, high and dry above the water surface, doesn't decay – there's no water or persistent moisture present.

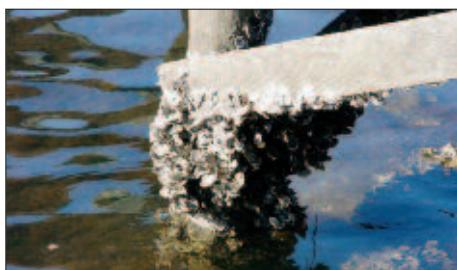
But in areas at or near the waterline, where wood's moisture content remains above 30%, decay is common. The only way it can be prevented is to eliminate the food supply of the fungi. The pres-

sure treating process accomplishes that – the preservative forms a bond with the wood fiber, making it undesirable as a food source for fungi and other organisms.

Marine Borers

Properly treated Southern Pine lumber, timber, and piling is commonly used for submerged salt water applications because it can be sawn with treatable sapwood on all four sides, (refer to "Marine Grade," next page). This is an important consideration in areas of marine borer activity, which are principally brackish and salt water environments.

Marine borers are small invertebrate sea animals that burrow into the wood for food and shelter. They can either be crustaceans, such as gribbles and pill bugs; or mollusks, such as shipworms and pholads. Marine borers are found throughout the world, but most areas have only selected species. The U.S. Southern Atlantic coast and Gulf of Mexico are home to four different types. Consultations with local marine contractors, harbormasters, marina operators and waterfront property owners are some of the best ways to identify what types of borers are prevalent in a particular area.



Pill bugs are mainly limited to brackish water estuaries within inland coastal regions.

Borer damage to wooden marine structures can be prevented, but it requires knowledge of the types of borers present and the use of the proper preservative treatment. For cases of marine borer presence in salt water, Chromated Copper Arsenate (CCA) remains approved for use as the primary preservative treatment to resist shipworms and gribbles. Some types of marine borers are tolerant of preservative treatments, while other types are not. Investigate local conditions and specific marine borer activity and refer to American Wood Protection Association (AWPA) Standards for detailed preservative treatment information.

The wood products industry, preservative manufacturers and the USDA Forest Products Laboratory (FPL) in Madison, Wisconsin, are continuing research involving marine borers. Ongoing FPL research has found that a preservative retention level of 2.5 pcf CCA for marine exposure in sapwood offers long-term performance in salt water where gribbles and shipworms are present, and in brackish water located in temperate regions. In certain extreme conditions, where pholads or *Sphaeroma terebrans* are present, dual treatment may be necessary.

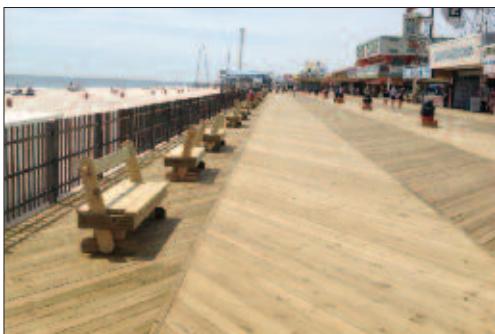


Special Grades for Brackish & Salt Water Service

Marine Grade

In marine construction, the specification of Southern Pine lumber, timbers and piling will vary according to its end use. Higher grades of Southern Pine (No.1, for example) are commonly specified when strength requirements and aesthetics are important. Some producers offer a grade of heart-free face lumber called "Marine Grade," as described in paragraph 508 of the SPIB *Standard Grading Rules for Southern Pine Lumber*.

Marine Grade material requires that all four longitudinal faces must be free of pith and/or heartwood. It can be specified in sizes 1" to 20" thick and 2" to 20" wide in any grade of Dimension Lumber or Timbers.



Typical "Marine Grade" Marks

Marine Grade material is used for pile caps, cross-bracing, walers and other partially submerged or submerged members.



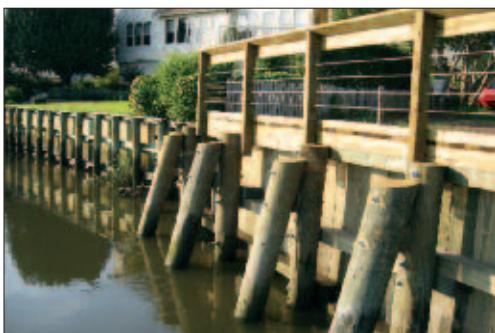
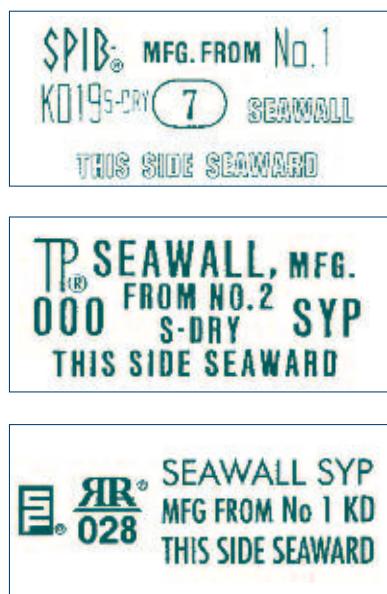
Seawall Grade

"Seawall Grade" material allows heart-free lumber on one wide face and both adjoining edges. The sapwood face must have sapwood at least ½-inch thick, as graded from both ends. The Seawall Grade is described in Paragraph 507 of the SPIB *Standard Grading Rules for Southern Pine Lumber*.

The intent of this grade provision is to provide suitable material for brackish and salt water marine bulkhead sheeting. Lumber so designated will be clearly marked "This Side Seaward" and can be manufactured in nominal dimensions of 2" to 4" thick and 6" to 14" wide.

The Seawall Grade conforms to service conditions under AWPA Use Category Standards UC5A, 5B, and 5C, Section 6.5.

Typical "Seawall Grade" Marks



Marine Construction Details

Basic Design Guidelines

- Marine construction is a complex process with many variables — it requires extensive knowledge of local conditions and should only be undertaken by qualified professionals. Water level extremes including storm surge, tidal histories, loadings, codes, construction practices, materials and soil analysis all must be considered. Consult licensed design and construction professionals, experienced in the marine environment; review examples of their recent projects. Consider asking reputable contractors for references.
- The proper evaluation of soils is critical to the design and long-term performance of the marine structure. Sandy (granular) soils are usually quite predictable, yet are subject to scour and erosion. Clays (cohesive soils) may not be consistent in a given locale and may vary widely within a single project. Even when viewed by an experienced design professional, soil analysis without the benefit of testing by a qualified soils testing laboratory is only approximate at best. The cost of a local certified soils testing lab is easily offset by the advantages of accurate quality and strength data reports.
- Marine installations using properly specified Southern Pine materials should provide a long service under all anticipated conditions. Materials that do not meet or exceed specifications should be rejected. Alternative materials may offer short-term cost benefits, but short-term savings may deprive the owner of long-term, low-maintenance use.
- Remember that any field cuts may impact the preservative treatment effectiveness. Whenever possible, have cuts such as mortises - the cuts at bottom of sheet piles or radius milling of edges - completed prior to treatment or at least dip or brush these surfaces with copper naphthenate prior to installation, in accordance with AWPA Standard M4.



Engineering & Design Concepts

- Brackish/Salt Water Bulkheads (pp. 18-21)
- Fresh Water Bulkheads with Square Piles (p. 22)
- Fixed Piers (pp. 23-28)
- Commercial/Public Fishing Piers (p. 27)
- Floating Dock Systems (pp. 29-30)
- Pedestrian Walkways (pp. 33-34)
- Light Vehicular Bridges (p. 35)

Site Planning/Design Factor Investigation

Water Levels

- Mean high/high water
- Mean low/low water
- Wave height and run-up
- Possibility of overtopping

Types of soils

- Sands and gravels – good drainage
- Sand/clay mixes – slow drainage
- Clays – poor drainage, moldable

Susceptibility to scour or erosion

Alignment

- Relation to existing shoreline
- Minimize turns or direction changes

Location of permanent structures

- Large trees
- Utilities
- Buildings or other structures

Slope of bank

- Drainage
- Plant watering and inundation

Slope of berm

Backfill materials

- Drainage
- Compaction

Elevation of top of wall

- Minimum two to three feet above high water



Approach to Marine Structure Design Using Wood Products

The proper use of wood products in wet environments is more direct if the designer takes a structured approach. Identifying the project locale to utilize applicable codes, selection of the correct timber grade, and proper use of preservative treatments are primary considerations.

The American Wood Protection Association (AWPA) has adopted a Use Category System (UCS), based on the service conditions for wood rather than on wood commodities. It is designed to reduce confusion among specifiers and consumers. The guidelines listed here embrace the "AWPA Standard U1 (Use Category System)."

Most building codes reference AWPA standards, so the Use Category System has replaced the former Commodity or "C" standards in codes.

Following is a step-by-step design approach for using this publication:

1. What type of project is being constructed?

- Fixed Pier
- Floating Docks
- Bulkhead or Retaining Wall
- Pedestrian or Light Vehicular Bridge

Refer to "Marine Construction Details", page 13. Also, review design details for the selected structure; see pages 19 through 37.

2. What are the applicable Use Categories for the project's location?

Fresh Water - UC4A, UC4B, and UC4C (Inland Waters)

Brackish and Salt Water - UC5A, UC5B, or UC5C (Coastal Waters)

Refer to the map below.

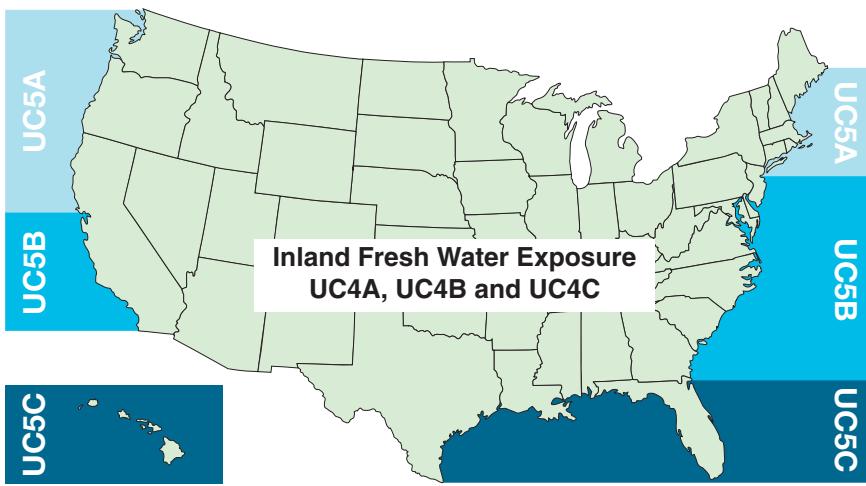
3. Based on the exposure and the structural component requirements, what are the preliminary determinations? Consider:

- Dimension Lumber Sizes and Lengths
- Lumber Grades
- Preservative Retention
- Surface Texture
- Moisture Content

4. Develop basic structural member criteria for use in performing calculations (where necessary), and develop the drawings and technical specifications utilizing one or more of the following sources:

- **Structural Design Values** – Refer to the SFPA publication *Southern Pine Use Guide* for design values for Southern Pine lumber, timbers and other products.
- **Structural Member Sizes** – Check with local lumber suppliers for lumber sizes that are readily available and that will suit the economical needs of your project. Typical "nominal" and "dressed" lumber and timber sizes are listed on page 4.
- **Lumber Grade** – Lumber graded **No.2** is recommended for most general construction uses where moderately high design values are required. For applications where high strength, stiffness and appearance are priorities, lumber graded **No.1** can be used. Where higher strength is needed, **No.1 Dense** may be specified; availability may be limited. For members that will be constantly submerged in brackish or salt water, "**Marine Grade**" lumber provides better resistance to marine borers and should be specified. Consider the specification of "**Seawall Grade**" material as a minimum for retaining wall sheeting.

AWPA Use Categories – Marine Applications



UC4A	Exterior, ground or fresh water contact in areas with low risk
UC4B	Exterior, ground or fresh water contact, severe environments, high potential for deterioration
UC4C	Exterior, ground or fresh water contact, very severe conditions or very critical structural components
UC5A	Salt water exposure – north of San Francisco, CA and Long Island, NY
UC5B	Salt water exposure – south of San Francisco on West Coast, New Jersey through Georgia on East Coast
UC5C	Salt water exposure – south of Georgia, Gulf Coast

Components that are highly visible, and where optimum appearance is desirable (without knots, wane, or other defects), “**No. 1 Prime**” can be specified. Refer to the SFPA publication *Southern Pine Use Guide* for additional details regarding lumber grade descriptions.

- **Moisture Content** – It is generally recommended that treated lumber be Kiln Dried After Treatment (KDAT) to 19% to 21% moisture content (depending on size). For treated timbers (5 inches and larger in thickness) a maximum moisture content of 25% is recommended. Lumber that is not preservatively treated should be dried to 19% moisture content.

- **Surfacing, Profiles and Patterns** – Most readily available lumber

and timbers used for marine construction is generally Surfaced Four Sides (S4S). However, using rough-sawn lumber in some applications may be an economical consideration, particularly for cross-bracing and split-pile caps.

Various profiles are also available. The two most widely used profiles for treated lumber in marine retaining wall construction are Sloppy V - T&G and Square T&G; refer to page 4. These two patterns are primarily used as sheet piling for bulkhead construction projects; typically two, three and four-inch thicknesses are used. Other profiles may be offered; check with local lumber suppliers or mills for availability.

Types of Wood Preservatives

There are three broad classes of preservatives used for the pressure treatment of Southern Pine products:

- **Waterborne** preservatives serve a wide variety of uses, including residential, commercial, marine, agricultural, and industrial applications.
- **Oilborne** preservatives are used primarily for applications such as utility poles, piling, posts, glulam beams, and timbers.

- **Creosote** preservatives, including creosote/coal tar mixtures, protect railroad ties, marine pilings, and utility poles. (Creosote is not recommended for applications where clean appearance and an odor-free environment are priorities).

TABLE 6: WATERBORNE PRESERVATIVES FOR SOUTHERN PINE IN FRESH WATER, BRACKISH & SALT WATER

SERVICE CONDITIONS	WATERBORNE, NON-COPPER	WATERBORNE, COPPER-BASED
Above Ground, Exterior	DCOI+Imidacloprid (EL2) DOT & Polymer Binder Propiconazole-Tebuconazole-Imidacloprid (PTI) Tebuconazole + Imidacloprid (EL)	Alkaline Copper (ACD, ACQ-C, ACQ-D, KDS, KDS-B) Copper Azole (CA-C) Dispersed or Micronized Copper (μ CA-C, MCA) Copper HDO (CX-A) Copper Naphthenate (CuN-W)
Ground Contact or Fresh Water		Alkaline Copper Quat (ACQ-C&D) Alkaline Copper Betaine (KDS, KDS-B) Alkaline Copper + DCOI (ACD) Ammoniacal Copper Quat (ACQ-A&B) Chromated Copper Arsenate (CCA) – <i>timbers & piling only</i> Copper Azole (CA-C) Copper HDO Type A (CX-A) Dispersed Copper Azole (μ CA-C) Micronized Copper Azole (MCA)
Brackish/Salt Water Splash		Ammonical Copper Zinc Arsenate (ACZA) Ammoniacal Copper Quat (ACQ-A&B) Chromated Copper Arsenate (CCA) Alkaline Copper Quat (ACQ-C, ACQ-D) Dispersed Copper Azole (μ CA-C) Micronized Copper Azole (MCA) Alkaline Copper Betaine (KDS, KDS-B) Copper Azole (CA-C) Waterborne Copper Naphthenate (CuN-W) Acid Copper Chromate (ACC)
Brackish/Salt Water Immersion		Ammonical Copper Zinc Arsenate (ACZA) Chromated Copper Arsenate (CCA)

Preservative Specifications

Projects located in brackish or salt water require careful consideration for preservative treatment of the various structural components. Based on each structural member's exposure to environmental conditions, determine the proper preservative treatment and retention level for each member. Develop all specifications for lumber components in chart format; refer to Table 7 below.

See below for guidance in developing your project's final design. Most common preservative treatments call for the use of Chromated

Copper Arsenate (CCA), Copper Azole (CA), or Alkaline Copper Quaternary (ACQ). Careful consideration must be used when selecting the best preservative treatment – depending on the application, exposure to the environment, as well as potential exposure to people and animals.

Though it is a preferred preservative formulation for brackish and salt water use, the preservative CCA is not currently allowed for boards and dimension lumber use.

TABLE 7: SPECIFICATION GUIDE FOR TREATED SOUTHERN PINE IN BRACKISH AND SALT WATER – FIXED PIERS

MEMBER/LOCATION	MEMBER SIZE ¹ (TYPICAL)	LUMBER GRADE	*USE CATEGORY (SEE MAP ON PAGE 13)	SERVICE CONDITIONS/ USE ENVIRONMENT	TYPICAL FASTENERS USED IN SALT WATER ENVIRONMENTS	PRESERVATIVE RETENTION LEVEL & TREATMENT	SURFACE TEXTURE
Timber Piling	Typically 8" to 10" min. tip dia.	ASTM D25 (round piling)	UC5A, UC5B or UC5C	Marine: brackish or salt water. (continuous exposure/immersion)	316 SS or H.D.G. bolts, nuts, washers & nails	2.5 pcf CCA	Round piling
Cross-Bracing	3" x 8"	No.1 Marine Grade No.2	UC5A, UC5B or UC5C	Marine: brackish or salt water. (continuous exposure/immersion)	316 SS all-thread rods or timber bolts w/min. 1/4" thick dock washers or min. 1/4" thick by 3" x 3" cut washers	2.5 pcf CCA	S4S or rough-sawn
Split Pile Cap	3" x 10"	No.1 No.2	UC4B	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. bolts, nuts, washers & hurricane straps / ties	0.60 pcf CCA	S4S or rough-sawn
Stringers, Band Joists, & Blocking	2" x 10" or 3" x 10"	No.1 No.2	UC4B	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. bolts, nuts, washers, nails, & hurricane straps / ties	0.31 pcf CA or 0.60 pcf ACQ ² 0.23 pcf μCA-C, MCA	S4S
Decking	2" x 6"	No.1 or No.1 Prime No.2	UC4B	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. ring-shank nails, or decking screws (SS preferred)	0.31 pcf CA or 0.60 pcf ACQ ² 0.23 pcf μCA-C, MCA	S4S
Handrail Components Upper Rail Lower Rail Rail Cap Pickets Rail Posts	2" x 6" 2" x 6" 2" x 10" 2" x 2" 4" x 6"	No.1 or No.1 Prime No.2	UC4A	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. bolts, nuts, washers, and nails, SS or H.D.G. depending on project exposure and budget	0.31 pcf CA or 0.60 pcf ACQ ² 0.23 pcf μCA-C, MCA	S4S
Roof Components Corner Bracing Header Ceiling Joists Rafters Facia Boards	4" x 6" 4" x 10" 2" x 8" 2" x 6" 2" x 8"	No.1 No.2	UC4A	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. bolts, nuts, washers, nails & hurricane straps/ties, SS or H.D.G. depending on project exposure and budget	0.31 pcf CA or 0.60 pcf ACQ ² 0.23 pcf μCA-C, MCA	S4S
Corner Posts (for roof structure)	6" x 6" 8" x 8" or 10" x 10"	No.1 No.2	UC4A	Marine out of water; salt water splash, not in ground contact	316 SS or H.D.G. bolts, nuts, washers, & nails	0.60 pcf CCA 0.31 pcf CA or 0.60 pcf ACQ ² 0.23 pcf μCA-C, MCA	S4S or rough-sawn
Roof Slats (to support metal roofing)	1" x 4" (minimum)	No.1 No.2	UC2	Marine out of water ³	316 SS or H.D.G. hardware as recommended by metal roofing manufacturers	0.018 pcf PTI 0.019 pcf EL2 (refer to page 14) 0.14 pcf μCA-C 0.15 pcf MCA 0.17 pcf SBX	S4S

1 – Member sizes shown in this column are for reference only. These are based on general rules of thumb for typical residential and light commercial type fixed pier structures. For safety, member sizes should be determined by a licensed professional engineer with experience in the design of this type of structure.

2 – Alkaline Copper Quaternary (ACQ) has been found to be significantly more corrosive than other chemical preservatives when in contact with metal fasteners and structural framing components; and is especially corrosive with aluminum fasteners, framing, and roofing material. Caution should be used when specifying ACQ as the preservative treatment chemical for lumber / timber that is in contact with metal.

3 – Lumber for roof slats to support aluminum roofing could be treated with carbon-based waterborne preservatives (PTI, EL2) Dispersed Copper Azole (μCA-C), Micronized Copper Azole (MCA) or waterborne borates (SBX). Check with metal roofing manufacturer for guidance.

Abbreviations: CCA = Chromated Copper Arsenate. CA = Copper Azole. ACQ = Alkaline Copper Quaternary. μCA-C = Dispersed Copper Azole MCA = Micronized Copper Azole. SS = stainless steel. H.D.G. = hot-dipped galvanized. pcf = pounds of preservative per cubic foot of wood. SBX = Inorganic Boron.

* The Use Category can vary with different members within the same structure. See Table 3: "AWPA Use Category Designations", UC4A through UC5C, (page 6) for applicable Use Category for structure location in the project's location/environment.

Projects located in fresh water environments require less protection from destructive decay mechanisms; therefore, these projects do not require the same level of preservative treatment as those located in brackish and salt water. Members located above the water level and out of the splash zone will have the same level of preservative treatment as shown in Table 7. The same specification process, as de-

scribed above for brackish and salt water, should be used for developing specifications for the materials to be used in fresh water environments. It may be helpful to present the information in chart format; refer to Table 8 below.

Tables 9 and 10 on page 17 may be helpful in developing the final design of a bulkhead project.

TABLE 8: SPECIFICATION GUIDE FOR TREATED SOUTHERN PINE IN FRESH WATER – FIXED PIERS

MEMBER/LOCATION	MEMBER SIZE ¹ (TYPICAL)	LUMBER GRADE	*USE CATEGORY (SEE MAP ON PAGE 13)	SERVICE CONDITIONS/ USE ENVIRONMENT	TYPICAL FASTENERS USED IN FRESH WATER ENVIRONMENTS ³	PRESERVATIVE RETENTION LEVEL & TREATMENT	SURFACE TEXTURE
Timber Piling	Typically 7" to 8" min. tip dia.	ASTM D25 (round), No.1, No.2 Grade (square)	UC4C	Fresh water, (continuous exposure/immersion)	H.D.G. bolts, nuts, washers & nails	0.80 pcf CCA	Round piling or S4S, rough-sawn (square)
Cross-Bracing	2"x or 3"x thickness	No.1 No.2	UC4C	Fresh water, (continuous exposure/immersion)	H.D.G. all-thread rods or timber bolts w/min. 1/4" thick dock washers or min. 1/4" thick by 3" x 3" cut washers	0.60 pcf CCA	S4S or rough-sawn
Split Pile Cap	3" x 10"	No.1 No.2	UC4C	Exterior, ground, or fresh water contact; very severe environment.	H.D.G. bolts, nuts, washers, nails, & hurricane straps / ties	0.60 pcf CCA	S4S or rough-sawn
Stringers, Band Joists & Blocking	2" x 10" or 3" x 10"	No.1 No.2	UC4B	Exterior, ground, or fresh water contact; severe environment.	H.D.G. bolts, nuts, washers, nails, & hurricane straps / ties	0.23 pcf μCA-C, MCA 0.60 pcf CCA 0.31 pcf CA or 0.60 pcf ACQ ²	S4S
Decking	2" x 6"	No.1 or No.1 Prime No.2	UC4A	Exterior, ground, or fresh water contact; low risk environment.	H.D.G. ring-shank nails, or decking screws (SS preferred)	0.14 pcf μCA-C 0.15 pcf MCA 0.15 pcf CA or 0.40 pcf ACQ ²	S4S
Handrail Components Upper Rail Lower Rail Rail Cap Pickets Rail Posts	2" x 6" 2" x 6" 2" x 10" 2" x 2" 4" x 6"	No.1 or No.1 Prime No.2	UC4A	Exterior, ground, or fresh water contact; low risk environment.	H.D.G. bolts, nuts, washers, and nails	0.14 pcf μCA-C 0.15 pcf MCA 0.15 pcf CA or 0.40 pcf ACQ ²	S4S
Roof Components Corner Bracing Header Ceiling Joists Rafters Facia Boards	4" x 6" 4" x 10" 2" x 8" 2" x 6" 2" x 8"	No.1 No.2	UC4A	Exterior, ground, or fresh water contact; low risk environment.	H.D.G. bolts, nuts, washers, nails & hurricane straps/ties	0.14 pcf μCA-C 0.15 pcf MCA 0.15 pcf CA or 0.40 pcf ACQ ²	S4S
Corner Posts (for roof structure)	6" x 6" 8" x 8" or 10" x 10"	No.1 No.2	UC4A	Exterior, ground, or fresh water contact; low risk environment.	H.D.G. bolts, nuts, washers, & nails	0.14 pcf μCA-C 0.15 pcf MCA 0.15 pcf CA or 0.40 pcf ACQ ²	S4S or rough-sawn
Roof Slats (to support metal roofing)	1" x 4" (minimum)	No.1 No.2	UC2	Marine out of water ³	316 SS or H.D.G. hardware as recommended by metal roofing manufacturer	0.05 pcf μCA-C 0.06 pcf MCA 0.018 pcf PTI 0.019 pcf EL2 (refer to page 14) 0.17 pcf SBX	S4S

1 – Member sizes shown in this column are for reference only. These are based on general rules of thumb for typical residential and light commercial type fixed pier structures. For safety, member sizes should be determined by a licensed professional engineer with experience in design of this type of structure.

2 – Alkaline Copper Quaternary (ACQ) has been found to be significantly more corrosive than other chemical preservatives when in contact with metal fasteners and structural framing components; and is especially corrosive with aluminum fasteners, framing, and roofing material. Caution should be used when specifying ACQ as the preservative treatment chemical for lumber / timber that is in contact with metal.

3 – Lumber for roof slats to support aluminum roofing could be treated with carbon-based waterborne preservatives (PTI, EL2) Dispersed Copper Azole (μCA-C), Micronized Copper Azole (MCA) or waterborne borates (SBX). Check with metal roofing manufacturer for guidance.

Fastener note: H.D.G. fasteners are the minimum as recommended for projects in fresh water or mildly brackish water for corrosion resistance; however, at the owner's/developer's discretion, stainless steel (304 or 316) may also be used.

Abbreviations: CCA = Chromated Copper Arsenate. CA = Copper Azole. ACQ = Alkaline Copper Quaternary. μCA-C = Dispersed Copper Azole MCA = Micronized Copper Azole. SS = stainless steel. H.D.G. = hot-dipped galvanized. pcf = pounds of preservative per cubic foot of wood. SBX = Inorganic Boron

* The Use Category can vary with different members within the same structure. See Table 3: "AWPA Use Category Designations", UC4A through UC5C, (page 6) for applicable Use Category for structure location in the project's location/environment.

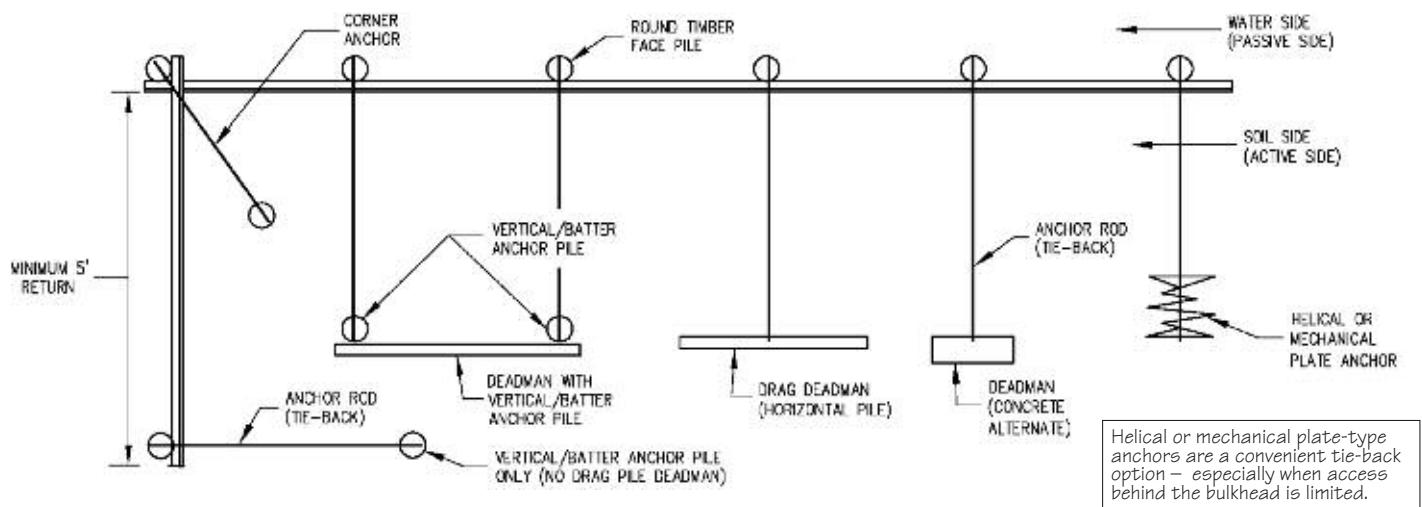
TABLE 9: SPECIFICATION GUIDE FOR TREATED SOUTHERN PINE BULKHEADS – BRACKISH & SALT WATER

MEMBER/LOCATION	MEMBER SIZE ¹ (TYPICAL)	LUMBER GRADE	*USE CATEGORY (SEE MAP ON PAGE 13)	SERVICE CONDITIONS/ USE ENVIRONMENT	TYPICAL FASTENERS USED IN SALT WATER ENVIRONMENTS	PRESERVATIVE RETENTION LEVEL & TREATMENT	SURFACE TEXTURE
Timber Face Piling	Typically 8" to 10" tip dia.	ASTM D25 (Round Piling)	UC5A, UC5B, or UC5C	Marine: Salt or brackish water (continuous exposure/immersion)	In salt and brackish water environments, H.D.G. steel is commonly used for fastening hardware in timber bulkhead construction: through-bolts, nuts, washers, bearing plates, ogee washers, tie-rods, and nails. Extra corrosion resistance and extended service life can be achieved by coating exposed fasteners with coal-tar epoxy after installation.	2.5 pcf CCA	Round piling
Wale Beam	6" x 6"	No.1 Marine Grade No.2	UC5A, UC5B, or UC5C	Marine: Salt or brackish water (continuous exposure/immersion)		2.5 pcf CCA	S4S or rough-sawn
Sheet Piling (sheeting)	3" x 10"	No.1 Marine Grade or Seawall Grade No.2	UC5A, UC5B, or UC5C	Marine: Salt or brackish water (continuous exposure/immersion)		2.5 pcf CCA	Sloppy-V tongue & groove or square tongue & groove
Bulkhead Cap Components: Stringer/Support Rail (front) String/Support Rail (rear) Decking/Cap	2" x 6", 2" x 8", or 3" x 8", 3" x 10", members	No.1 or No.1 Prime No.2	UC4B	Marine out of water; Salt water splash, not in ground contact	Additionally, S.S. (type 316 or 304) fasteners may be used for better corrosion resistance and longer service life. However, S.S. may be cost prohibitive for some owners.	2x6: 0.31pcf CA 0.60 pcf ACQ 2x8 & larger: 0.60 pcf CCA	S4S
1 – Member sizes shown in this column are for reference only. These are based on commonly used member sizes for typical bulkhead structures with 5ft. to 10ft. exposed height. For safety, member sizes should be determined by a licensed professional engineer with experience in the design of this type of structure.							
Abbreviations: CCA = Chromated Copper Arsenate. SS = stainless steel. H.D.G. = hot-dipped galvanized. pcf = pounds of preservative per cubic foot of wood.							
* The Use Category can vary with different members within the same structure. See Table 3: "AWPA Use Category Designations", UC4A through UC5C, (page 6) for applicable Use Category for structure location in the project's location/environment.							

TABLE 10: SPECIFICATION GUIDE FOR TREATED SOUTHERN PINE BULKHEADS – FRESH WATER & RETENTION BASINS

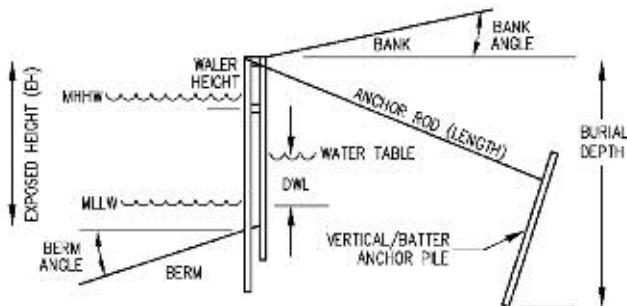
MEMBER/LOCATION	MEMBER SIZE ¹ (TYPICAL)	LUMBER GRADE	*USE CATEGORY (SEE MAP ON PAGE 13)	SERVICE CONDITIONS/ USE ENVIRONMENT	TYPICAL FASTENERS USED IN FRESH WATER ENVIRONMENTS	PRESERVATIVE RETENTION LEVEL & TREATMENT	SURFACE TEXTURE
Timber Face Piling	Typically 8" tip dia.	ASTM D25 (Round Piling)	UC4C	Fresh water (continuous exposure/immersion)	H.D.G. steel is commonly used for fastening hardware in timber bulkhead construction: through-bolts, nuts, washers, bearing plates, ogee washers, tie-rods, and nails. Extra corrosion resistance and extended service life can be achieved by coating exposed fasteners with coal-tar epoxy after installation.	0.80 CCA 0.41 CA	Round piling
	6" x 6" or 8" x 8"	No.1 (Square Piling) No.2				0.60 pcf CCA, 0.60 pcf ACQ, or 0.31 pcf CA	S4S or rough-sawn (square piling)
Wale Beam	4" x 6" 6" x 6" or 8" x 8"	No.1 No.2	UC4C	Fresh water (continuous exposure/immersion)		0.60 pcf CCA, 0.60 pcf ACQ, or 0.31 pcf CA	S4S or rough-sawn
Sheet Piling (sheeting)	3" x 10"	No.1 No.2	UC4C	Fresh water (continuous exposure/immersion)		0.60 pcf CCA, 0.60 pcf ACQ, or 0.31 pcf CA	Sloppy-V tongue & groove or square tongue & groove
Bulkhead Cap Components: Stringer/Support Rail (front) String/Support Rail (rear) Decking/Cap	2" x 6", 2" x 8", or 3" x 8", 3" x 10", members	No.1 or No.1 Prime No.2	UC4A	Exterior, ground or fresh water contact; low risk environment.		0.14 pcf μCA-C 0.15 pcf MCA 0.40 pcf ACQ, or 0.15 pcf CA	S4S
1 – Member sizes shown in this column are for reference only. These are based on commonly used member sizes for typical bulkhead structures with 5ft. to 10ft. exposed height. For safety, member sizes should be determined by a licensed professional engineer with experience in the design of this type of structure.							
Abbreviations: CCA = Chromated Copper Arsenate. CA = Copper Azole. ACQ = Alkaline Copper Quaternary. μCA-C = Dispersed Copper Azole MCA = Micronized Copper Azole. SS = stainless steel. H.D.G. = hot-dipped galvanized. pcf = pounds of preservative per cubic foot of wood.							
* The Use Category can vary with different members within the same structure. See Table 3: "AWPA Use Category Designations", UC4A through UC5C, (page 6) for applicable Use Category for structure location in the project's location/environment.							

BRACKISH/SALT WATER BULKHEADS – USE OF ROUND PILES



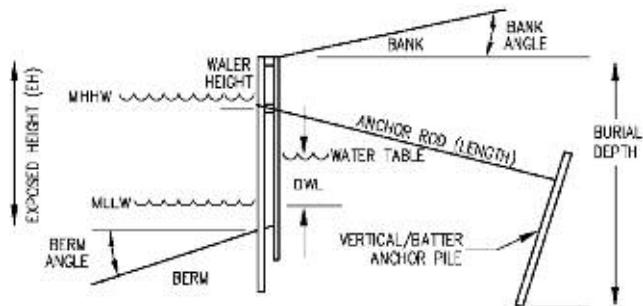
TYPICAL ANCHOR SYSTEM OPTIONS (PLAN VIEW)

[SEE PHOTOS BELOW](#)



Single Anchor at Top for Low Bulkheads

Single anchors located at the top of low exposed height (three feet & less) bulkheads should only be used in residential applications where loads are small and no surcharge is present.



Mid-Height Single Anchor

Mid-height, single-anchor systems are the most common and perhaps most practical anchor systems for exposed heights of four to eight feet. Anchors should always be through-connected to the face pilings.

BULKHEAD ANCHOR SYSTEM OPTIONS (Section Views)

[SEE PHOTOS BELOW](#)

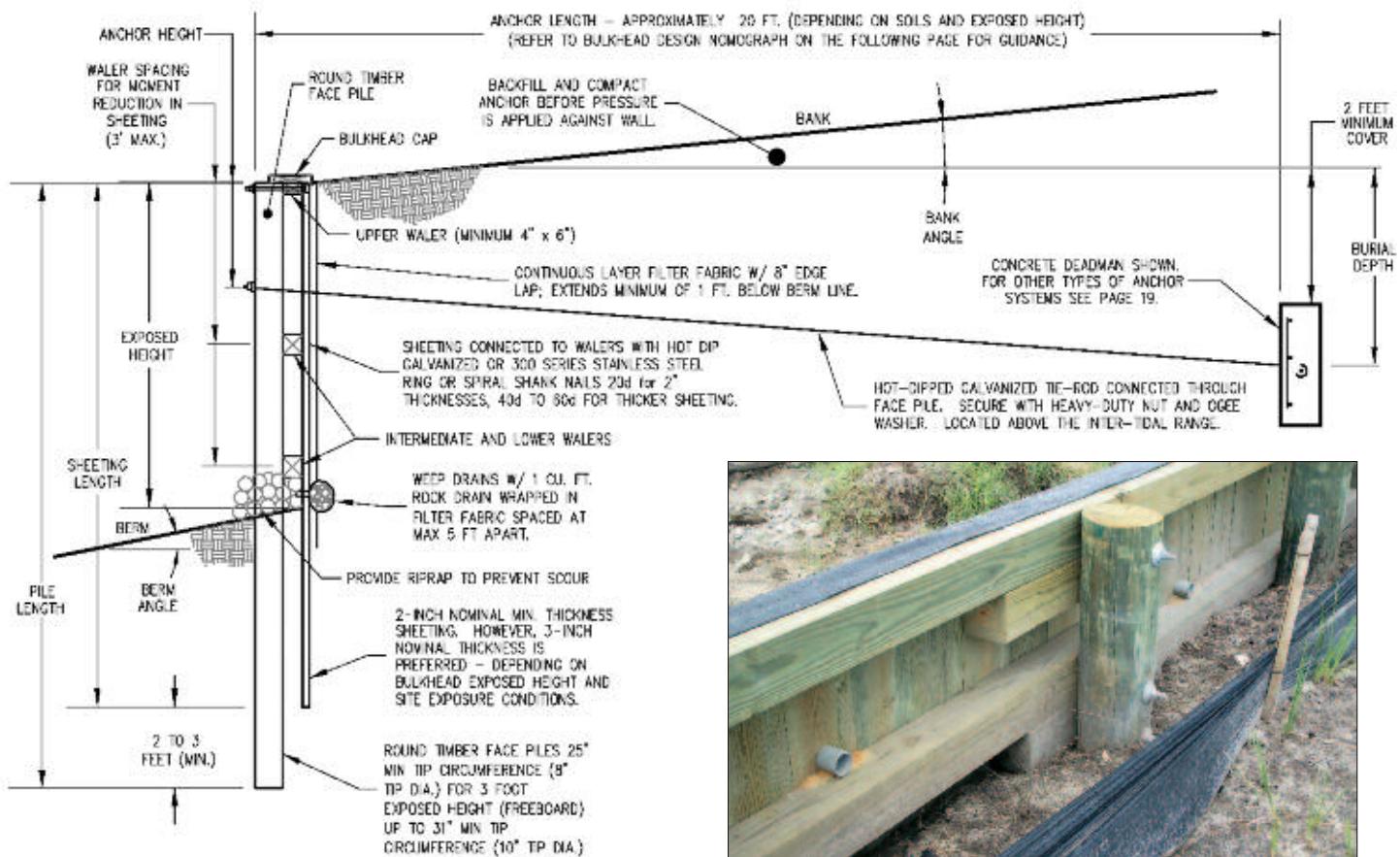
NOTE: Deadman & vertical anchor piles should be located by the design engineer to be behind the failure plane of the active side soil, which is dependent upon soil type and bulkhead exposed height. As a rule of thumb, deadmen and/or anchor piles are

typically located in the range of at least 20 ft. behind the bulkhead – which is approximately twice the exposed height of the bulkhead. This should be verified by a design professional.



TYPICAL SECTION THROUGH BULKHEAD

BRACKISH OR SALT WATER APPLICATION (NO SCALE)



BULKHEAD NOTES (BRACKISH/SALT WATER)

1. All wood should be Marine Grade Southern Pine and should be preservative treated in accordance with American Wood Protection Association (AWPA) Use Category System (UCS) 5A.
2. All face and anchor piles used in construction should be specified using tip circumference (or diameter) in accordance with ASTM D25 standard specifications. Preservative treatment shall be in accordance with AWPA UCS 5A, 5B, or 5C.
3. Wood sheeting (No.1 or No.2 Seawall Grade, No.1 or No.2 Marine Grade) shall be sloppy-V or square tongue and groove. Sloppy-V tongue and groove is the typical profile finish specified for timber bulkhead sheeting. See page 4.
4. All fasteners and the rods should be hot-dipped galvanized per ASTM A-153 with 2 ounces of zinc per square foot or be corrosion resistant (bitumastic coated or 300 series stainless steel).
5. Backfill should be a free draining, clean, granular (sand) material.
6. Minimum 1 1/2" diameter weep holes with filter fabric and gravel filter material (1 cubic foot) should be installed at maximum 5 ft. on center at approximately 6 inches above berm line or at approximately 6 inches above mean low water (MLW). Weep holes in areas of wave action will also require protection at the outlet.
7. Returns (wing walls) must be constructed at the ends of all bulkheads to prevent the possibility of flanking (scour around the end). Also, install riprap at the toe and at the end of the return (wing wall).
8. All cuts, holes, and damage to the surface of treated wood should be protected by field-treatment with copper naphthalate (or equal) in accordance with AWPA P8-11 (or latest issue) and coated with a marine sealant.
9. All treated wood products should be handled & field-fabricated in accordance with AWPA M4-11 (or latest issue) standard for the care of preservative-treated wood products.

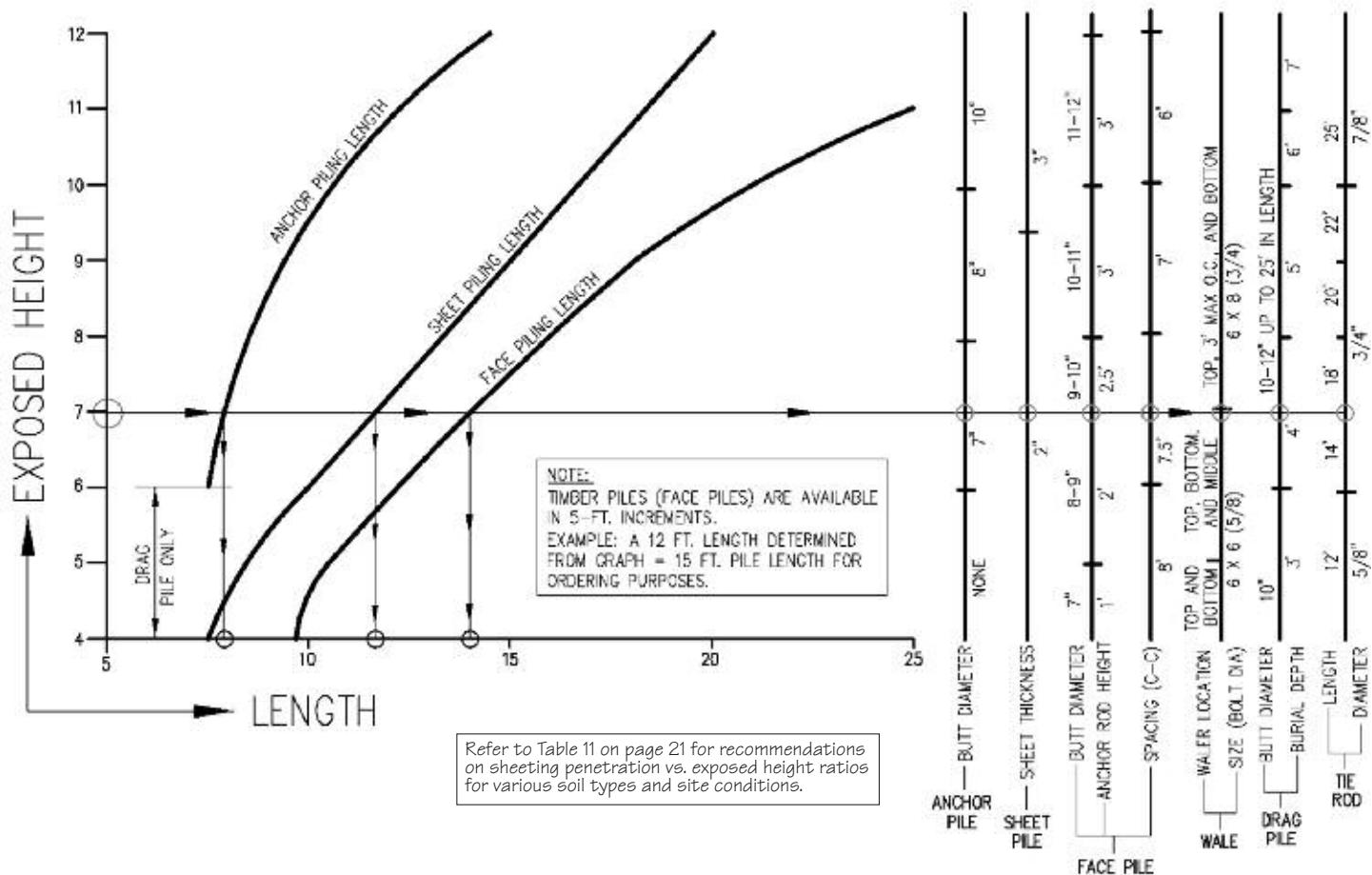


BULKHEAD DESIGN NOMOGRAPH (Flat Berm, Flat Bank, Sandy Soil)

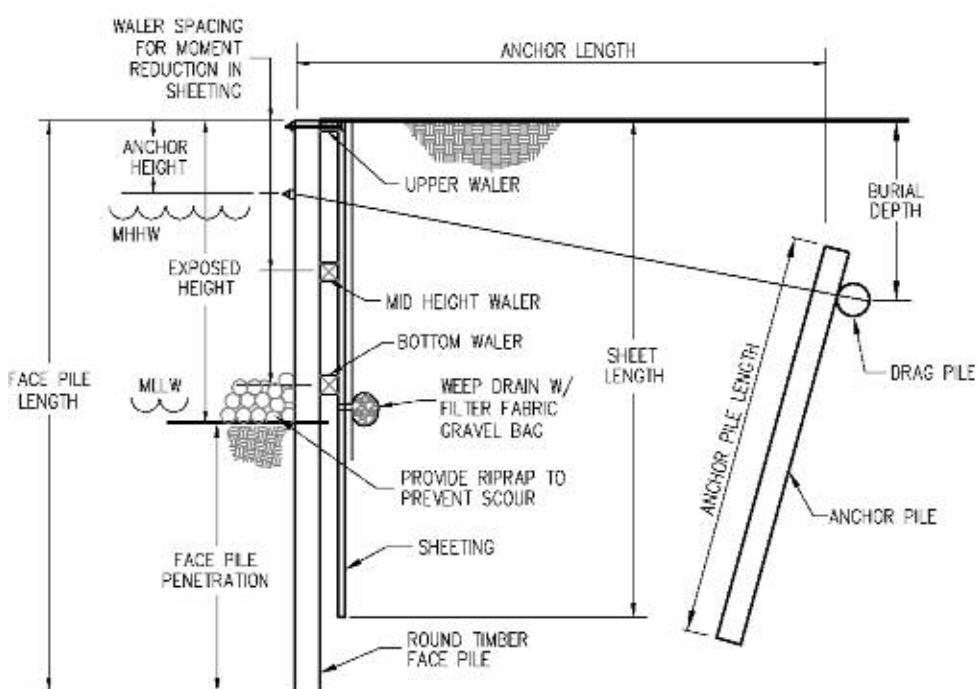
Procedure for use of nomograph:

Draw horizontal line from exposed height of bulkhead across entire width of nomograph as shown in example below.

Draw vertical lines from points of intersection on graphs (anchor, sheet, and face piles down to length line).



TYPICAL BULKHEAD TERMINOLOGY (NO SCALE)



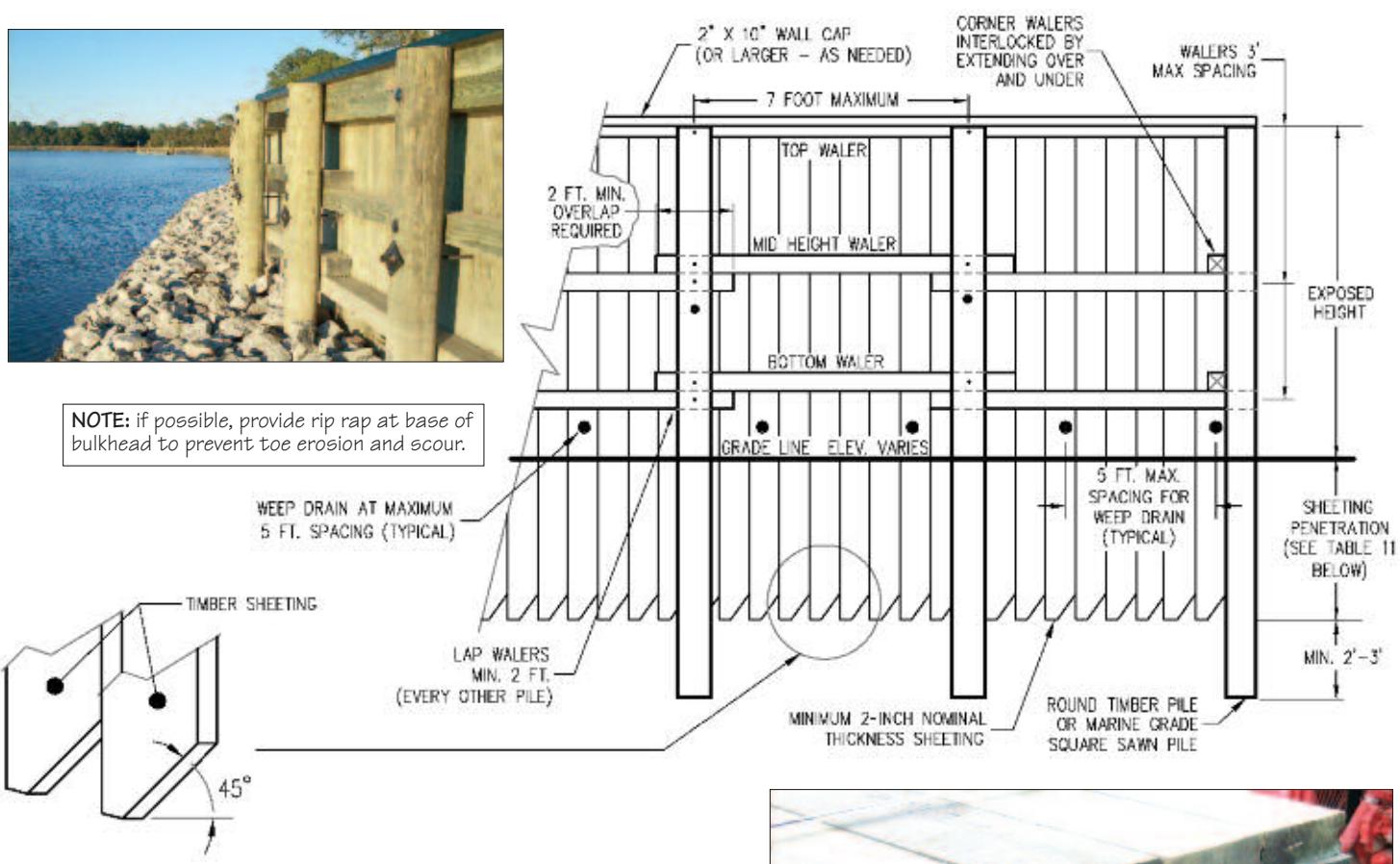
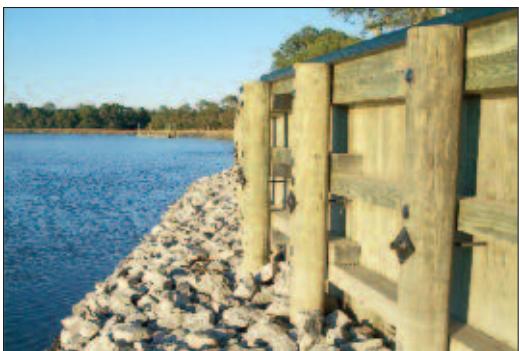
Nomograph Example:

For a 7 ft. exposed height bulkhead in good granular soil with a flat berm angle (0 degree) and a flat bank angle (0 degree) a trial design would yield:

Solution:

Anchor pile length = 8'
 Sheet thickness = 2'
 Sheet pile length = 12'
 Face pile length = 14'
 Anchor pile butt dia = 7"
 Face pile butt dia = 9-10"
 Anchor location = 2.5'
 Anchor spacing = 7.5'
 Waler design
 Top waler 6x8 (3/4 bolts)
 Mid waler 6x8 (3/4 bolts)
 Bottom waler 6x8 (3/4 bolts)
 Drag pile butt dia = 10"
 Drag pile burial depth = 4'
 Tie rod = 3/4" dia. 18' long

TYPICAL ELEVATION – TIMBER BULKHEAD



TYPES OF SHEET PILES

Bulkheads should be as tight and free of cracks as possible. It is recommended that tongue & groove joints (as shown below) be used.



Sheeting note "A": tongue profile should fit loosely in groove
– and tongue needs to be 3/4" long for 2" thick (nominal) sheeting and 1" long for 3" and 4" thick (nominal) sheeting.



TABLE 11: TYPICAL SHEETING PENETRATION
For 2-Inch Thick Lumber (Ratio Of Total Sheet Length To Exposed Height)

Berm Material		
	Clay/Sand Berm	Firm Sand Berm
Bank	0 10 15	0 10 15
0	1.8 2.1 2.4	1.7 1.9 2.5
10	1.9 2.2 2.5	1.7 2.0 2.8
20		1.8 2.2 3.2
		1.6 1.8 2.3

NOTE: assumes no surcharge and adequate anchorage

Example: With a bank angle of 10°, berm angle of 10°, and an exposed height of 5 feet in a sand material, the sheet length would be 5.0' x 2.0 (ratio) = 10 feet.

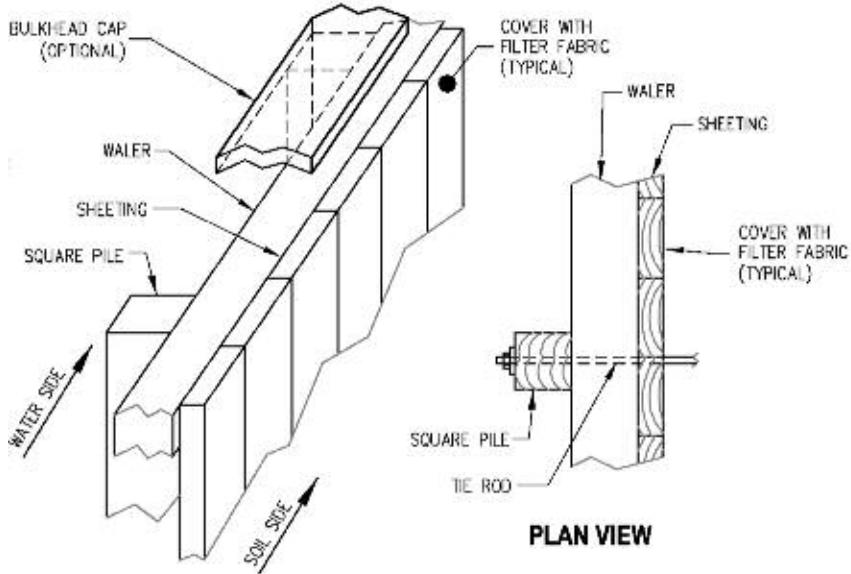
Always cover the back (soil) side with continuous layer of filter fabric. Minimum 8-inch overlap at edges. Filter fabric shall extend a minimum of one foot below the berm line.



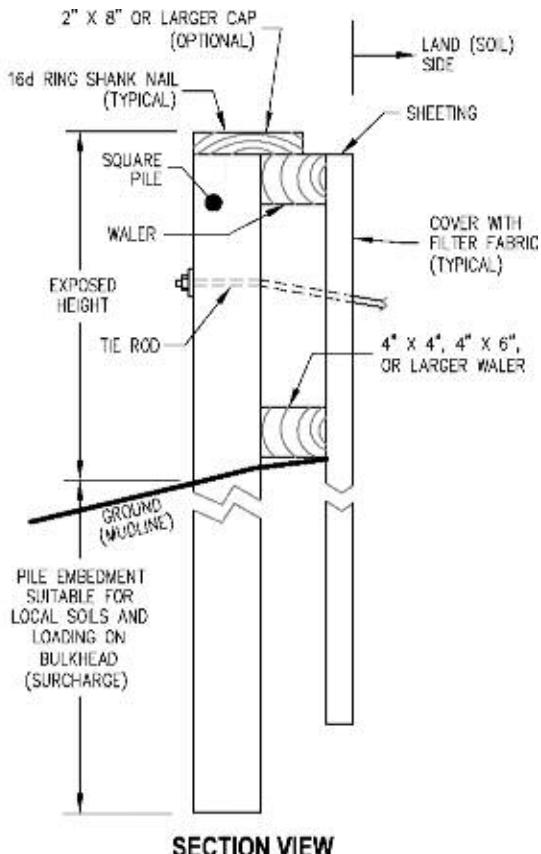
FRESH WATER BULKHEADS & RETENTION BASINS – USE OF SQUARE PILES

Square piles of 6" x 6" and 8" x 8" nominal sizes have been used successfully for many years in fresh water bulkhead applications. Square piles longer than 20 feet in length are available by special order but exposed heights are normally limited to 8 feet and below. The design and placement of walers, face piles, and sheet piles are similar to that for brackish/salt water bulkheads. Modifications to

design should be left to a design professional familiar with local codes and conditions. As in brackish/salt water use, sheeting should be 2" nominal thickness; however, 3" nominal thickness may be required – depending upon site conditions and exposed height. Sheet ing shall also be tongue and groove. Spacing between walers should not exceed 3 feet.



PLAN VIEW



SECTION VIEW

Square piles in brackish/salt water:

Some sections of the country continue to use square piles in brackish/salt water applications. When used in salt water applications, square piles and all other members shall be marine grade lumber treated to brackish/salt water specifications (2.5 CCA).



FIXED PIERS

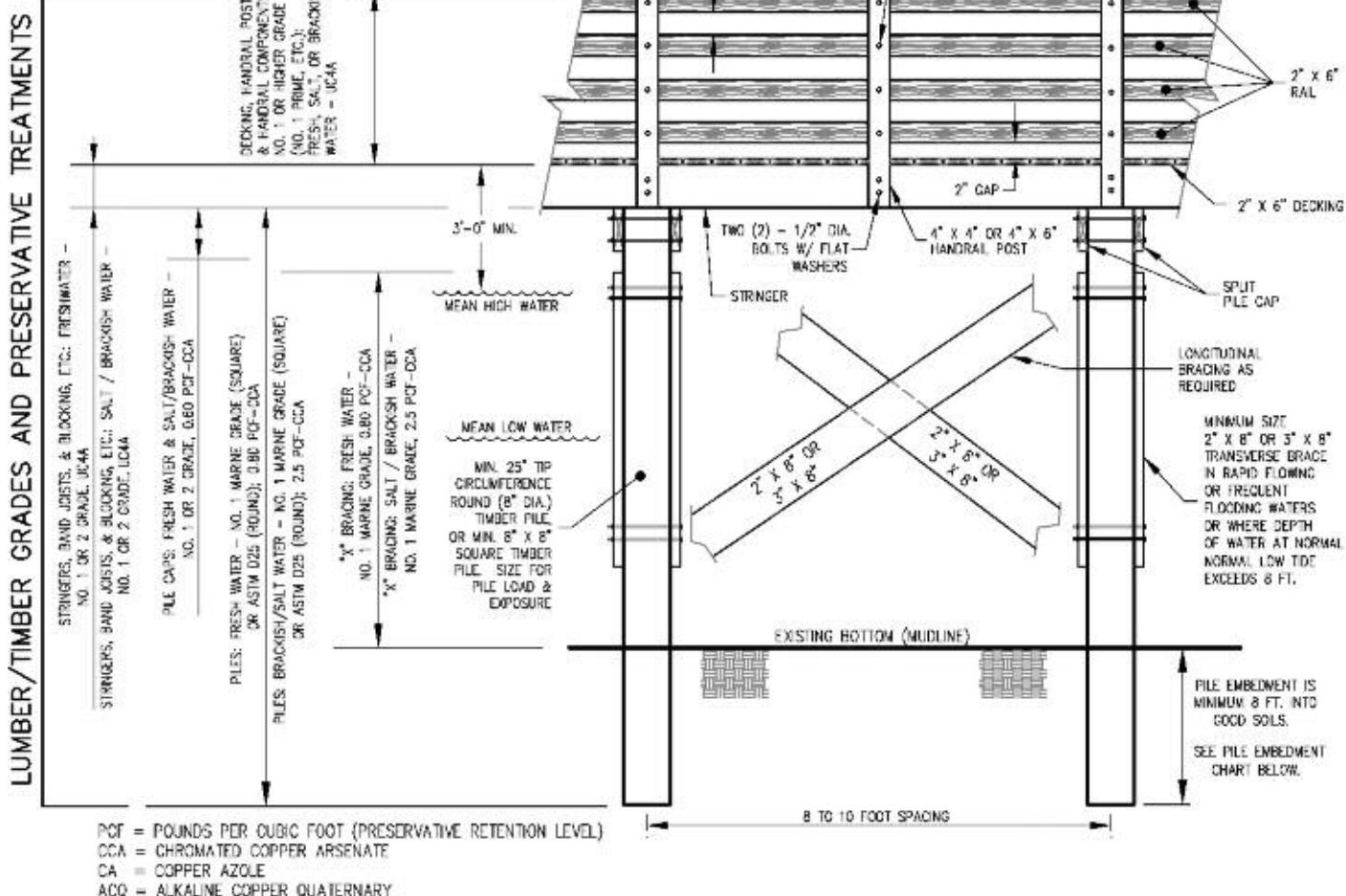
Fixed piers have a long and successful history of providing access to the water for coastal and waterfront property owners. Fixed piers are used for boating access where the active boating period (usually summer) water level fluctuations are minimal (0 to 3 feet). Where the active boating periods exceed three feet in water level change, the choice of boating access structures usually goes to floating dock systems. However, even in floating dock systems, fixed piers are often used to traverse shallow or marsh areas to reach the floating dock system located in deeper waters. See pages 30-31 for typical floating dock design details.

For residential fixed pier systems, a pile span of 8 to 10 feet is common. The normal width of residential piers is four to six feet. Therefore, typical bay (the area between piles and adjacent bays) sizes are 4'x8', 4'x10', 6'x8', and 6'x10'. A suggested minimum vertical live load capacity for residential fixed piers is 50 pounds per square foot (psf) of deck area. Based on this assumption, the chart below will usually give conservative pile embedment values for the common soil types shown.



NOTE: Spacing between intermediate rails/pickets is set at 3-3/4" (max.) in order to comply with International Building Code (IBC) requirement that a 4" sphere shall not be allowed to pass through openings.

TYPICAL PIER ELEVATION



PILE EMBEDMENT CHART

PILE SIZE CIRCUMFERENCE (TIP DIAMETER)	25" (8" tip)	31" (10" tip)	8"x8"
Soil Type	Embedment Depth (Feet)		
Medium Dense Sand	8	8	8
Loose Sand	12	9	10
Medium Stiff Clay	8	8	8
Soft Clay	8	8	8

PILE NOTES

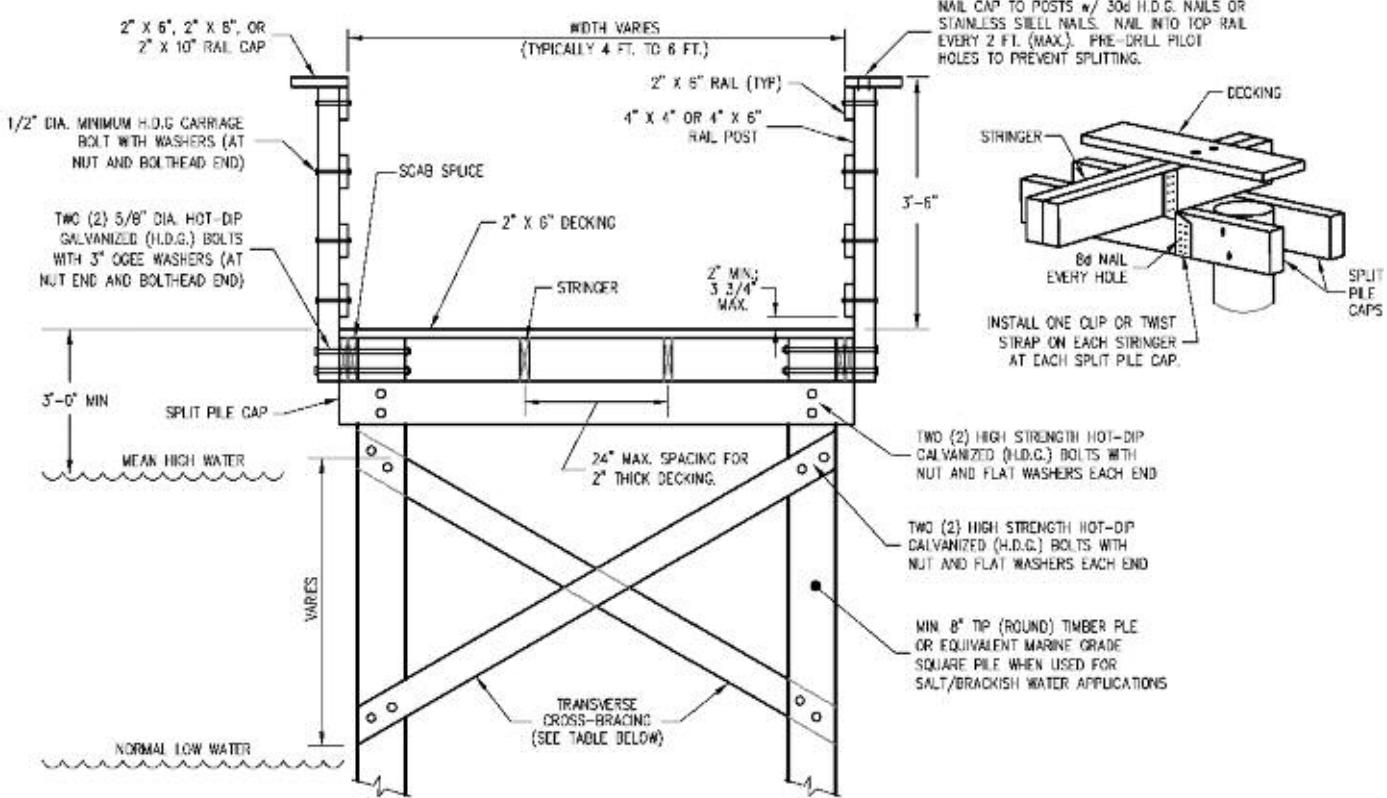
- Specify, order, and install piles for true length. Do not cut long piles or use pile cut-offs for shorter piles. (timber piles available in 5-ft. increments.)
- Piles should be driven to grade, jetting of first two feet of embedment may be allowed to obtain proper alignment.
- Piles should be driven vertical (plumb).

BRACING AND PILE CAPS

Transverse bracing (cross-bracing) of piles is recommended in rapidly-moving or frequently-flooding waters or where depth of water exceeds eight feet. Transverse cross-bracing, when required, is usually 2"x6" or 2"x8" size members for fresh water applications or in sheltered or mild environment exposures – or 3"x8" size members for marine (brackish/salt water) applications or in harsh

environment exposures. 8"x8" square piles (fresh water or brackish/salt water) should always consider transverse cross-bracing because of the lack of lateral strength in 8"x8" piles. The combination of pile caps and the stringer system form the part of the structure that carries the decking live load (assumed 50 psf), plus dead load, to the piles and into the soil.

TYPICAL SECTION THROUGH FIXED PIER



The following chart provides recommendations on the selection of minimum sizes for split pile caps, transverse cross-bracing, stringers, and the sizing of connectors:

FRESH WATER AND/OR SHELTERED, MILD EXPOSURE ENVIRONMENTS

Bay Size (WxL)	Cross-Bracing Size (1, 3) (connectors)	Split Pile Cap Size (connectors)	Stringer Size (2, 3, 5) (connectors)
4'x8'	2"x6" (two (2)-5/8" dia. bolts)	2"x8" (two (2)-5/8" dia. bolts)	2"x8" (toe nail / H.S.)
4'x10'	2"x6" (two (2)-5/8" dia. bolts)	2"x8" (two (2)-3/4" dia. bolts)	2"x8" (toe nail / H.S.)
6'x8'	2"x8" (two (2)-3/4" dia. bolts)	2"x8" (two (2)-5/8" dia. bolts)	2"x8" (toe nail / H.S.)
6'x10'	2"x8" (two (2)-7/8" dia. bolts)	2"x8" (two (2)-3/4" dia. bolts)	2"x8" (toe nail / H.S.)

BRACKISH/SALT WATER AND/OR HARSH EXPOSURE ENVIRONMENTS

Bay Size (WxL)	Cross-Bracing Size (1, 4) (connectors)	Split Pile Cap Size (connectors)	Stringer Size (2, 4, 5) (connectors)
4'x8'	3"x6" (two (2)-3/4" dia. bolts)	2"x8" (two (2)-3/4" dia. bolts)	2"x8" (toe nail / H.S.)
4'x10'	3"x8" (two (2)-3/4" dia. bolts)	3"x8" (two (2)-3/4" dia. bolts)	2"x8" (toe nail / H.S.)
6'x8'	3"x8" (two (2)-3/4" dia. bolts)	3"x8" (two (2)-3/4" dia. bolts)	2"x8" (toe nail / H.S.)
6'x10'	3"x8" (two (2)-1" dia. bolts)	3"x10" (two (2)-1" dia. bolts)	2"x8" (toe nail / H.S.)

1. Use ogee washers on bolt head side with 4"x4"x1/4" cut washer or ogee washer on nut side.
2. Toe-nail stringers to split pile caps with 2-16d ring-shank nails and use hurricane straps (H.S.) in addition to toe-nailing in hurricane-prone, flood-prone, or tornado-prone areas.
3. Hot-dipped galvanized (H.D.G.) fasteners recommended in fresh/mildly brackish water. Coat exposed fasteners with coal-tar epoxy for added protection.
4. Use minimum hot-dipped galvanized (H.D.G.) fasteners in brackish/salt water. Coat exposed fasteners with coal-tar epoxy for added protection. Stainless steel (SS) type 316 strongly recommended for salt water exposure applications – especially for fasteners located in the intertidal zone.
5. 3" nominal thickness members may be used if added durability / longevity is desired.

DECKING SELECTION AND FASTENING GUIDELINES

The most obvious visual features of a completed fixed pier are the deck and the handrails. The higher lumber grades: No.1 and No.1 Prime give excellent structural performance with minimal visual imperfections. Nails or decking screws that are carefully aligned and properly installed create a complimentary, pleasing pattern. Pre-drilling pilot holes for nails or screws helps to prevent splitting.

Decking 1-1/2" in thickness should be fastened to the stringers with at least two (2) 3-1/4" ring-shank or spiral-shank nails (12d), or multi-purpose decking screws. All fasteners should be hot-dipped galvanized (H.D.G.), or stainless steel (300 series), or shall be specially coated for use with treated lumber.

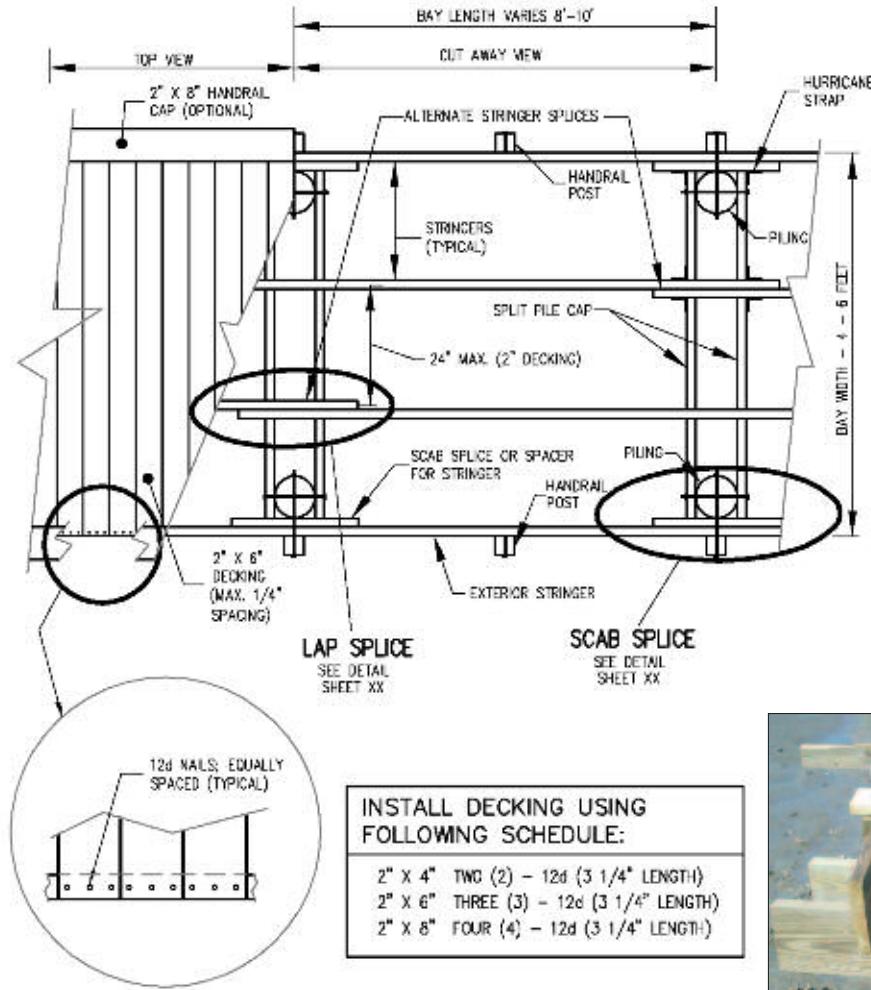
NOTE: Alkaline Copper Quaternary (ACQ) and Copper Azole (CA) used in the preservative treatment of lumber are corrosive to metal. Therefore, it is very important to use ceramic-coated, stainless steel, or other nails or screws specifically recommended for contact with these preservatives.

If splitting occurs, pre-drill pilot holes of nails 1/16" less than the nail (or screw) shaft diameter. The deck boards are put under very severe stress caused by the cyclic wetting and re-drying of the material. Restraining the natural tendency to crook, bow, cup, or twist with good nail/screw penetration into the stringer is very important in assuring that the lumber remains flat.

Nails/screws should be inspected at least yearly to check that they have not worked loose or pulled out. Reset as needed.

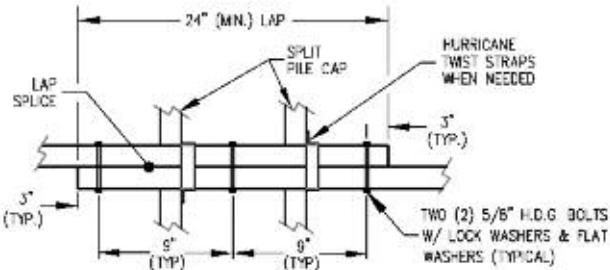


TYPICAL FIXED PIER FRAMING PLAN



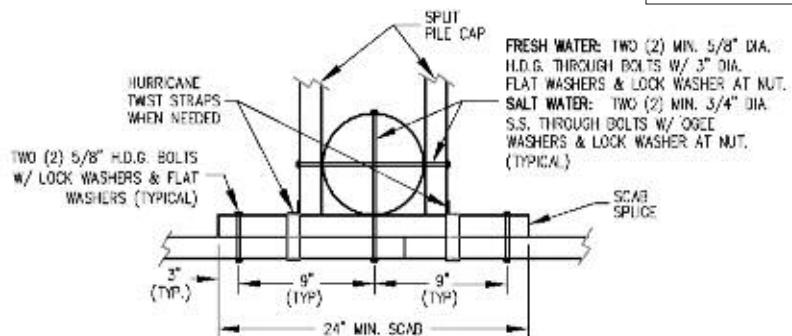
PIER DETAILS – STRINGER SPLICES

Timber sizes are market sensitive and often the pile spacing is dictated by the available lumber sizes for stringers. It is usually more economical to use a ten-foot pile spacing if the longer stringer material is available. This also reduces the number of piles and the number of splices which join adjacent stringers and carry the load over the pile caps to adjacent bays. Splices must occur over pile caps. As far as practical, splices should be alternated so that two adjacent splices do not occur over the same pile cap.



LAP SPICE DETAIL (PLAN VIEW)

NOTE: stainless steel (S.S.) fasteners and hurricane straps are highly recommended in brackish and salt water environments.



SCAB SPICE DETAIL (PLAN VIEW)

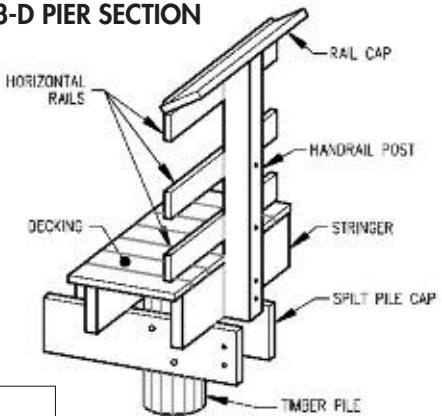
NOTES:

The spacing between decking members should be chosen to prevent a gap, which could hinder handicap access in case of shrinkage. (See decking notes, page 8.)

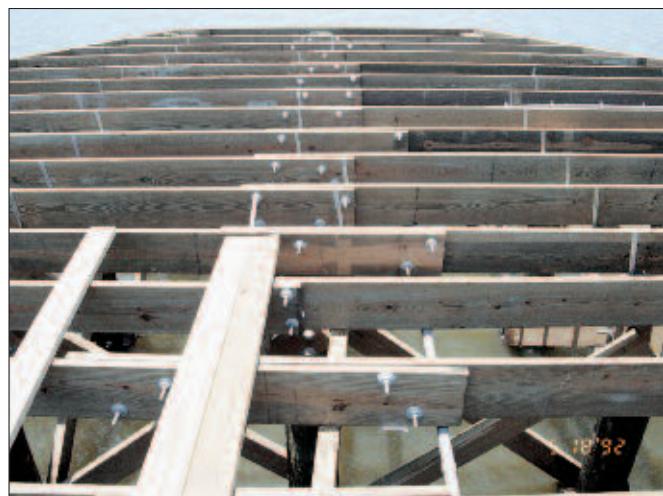
If H.D.G. fasteners/straps are used for marine (brackish and salt water) environment, hardware should be oversized due to the harshness of the corrosive marine environment. Hurricane straps are recommended for securing stringers to the split pile caps. Refer to lower left photo on page 12.

As in all marine construction, fasteners should be hot-dipped galvanized (H.D.G.) after fabrication and coated with coal-tar epoxy after installation – or should be stainless steel (type 304 or type 316).

3-D PIER SECTION



Stainless steel cables can be used for handrails instead of 2"x6" wooden rails. Follow cable rail system manufacturer guidelines for proper installation.



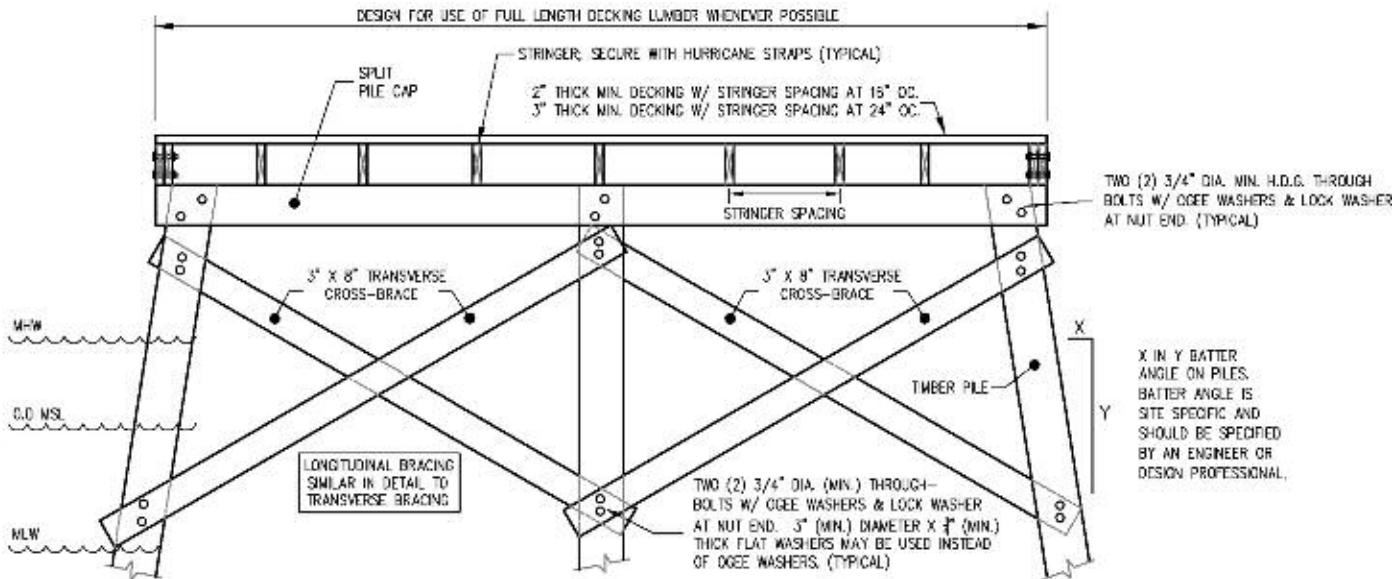
COMMERCIAL / PUBLIC FISHING PIERS

Fishing piers, whether commercial or public, are characterized by heavier construction and more involved design than the residential fixed pier. Deck surfaces are wider and bays are sometimes longer than a residential pier and have heavier timbers used for these larger spans. This type of pier usually provides for handicap access by providing handrails and other features designed for physically challenged use – as required by the Americans with Disabilities Act (ADA). Because the location of most commercial / public fishing piers is often in rougher, deeper waters, outer piles on this type of pier are often battered. Both longitudinal and transverse cross-braces are used because of stronger wave and current forces. Embedment of the piles and design of this bracing are site specific and should be left to a design professional. Features such as benches, tables and sinks as well as shelters are often built in as part of the structure.

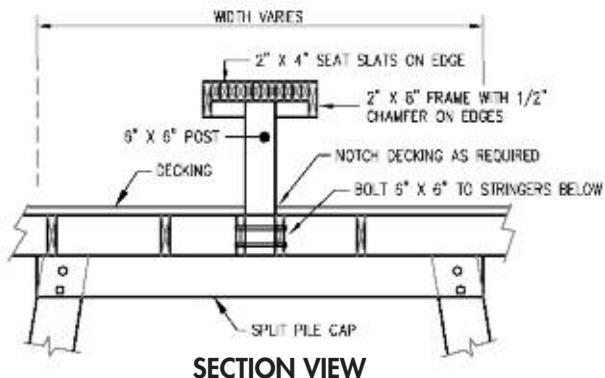
TYPICAL SECTION THROUGH FISHING PIER

No handrails shown here for clarity (see page 29 for handrail details)

NOTE: 316 stainless steel (S.S.) fasteners (hardware) are highly recommended for projects located in brackish/salt water environments, especially in the intertidal splash zone. H.D.G. may be used for projects located in fresh water environments.



BUILT-IN BENCH – FISHING PIER

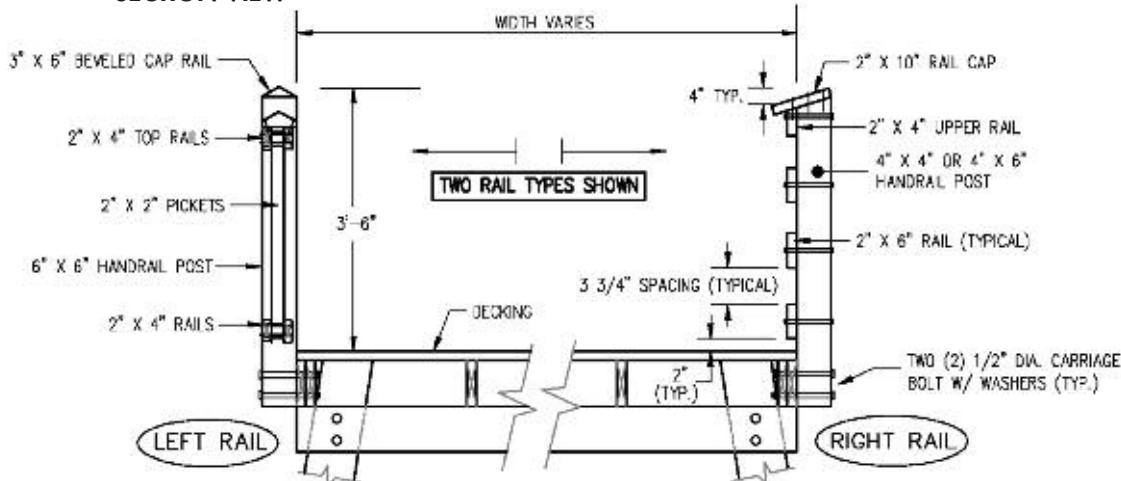


FISHING PIER – HANDRAIL DETAILS

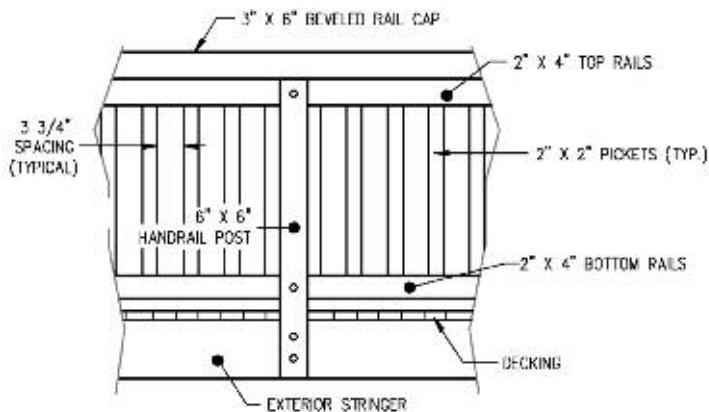
Handrails provide safety for users and make the fixed pier more secure for children, senior citizens, and the physically challenged. Horizontal rails are added at the top and as required at intermediate middle areas and bottom to secure activities (walking, fishing, etc.) along the deck space. Maximum spacing on a 4"x4" or 4"x6" post is five feet. Top and intermediate rails are typically 2"x4"

or 2"x6" size members, nailed with 2-16D ring-shank or spiral-shank nails – or – secured with 1/2" dia. carriage bolts w/flat washer and lock washer at nut end. Depending on exposure and owner preference, H.D.G. or S.S. may be used; however, S.S. will provide longer service life and better corrosion resistance.

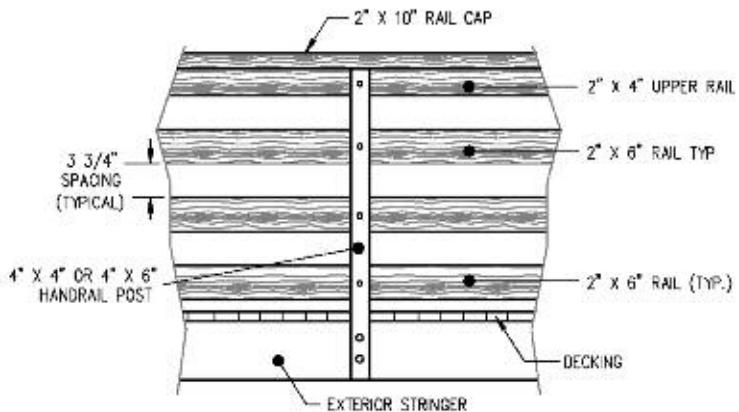
SECTION VIEW



ELEVATION VIEW – LEFT RAIL



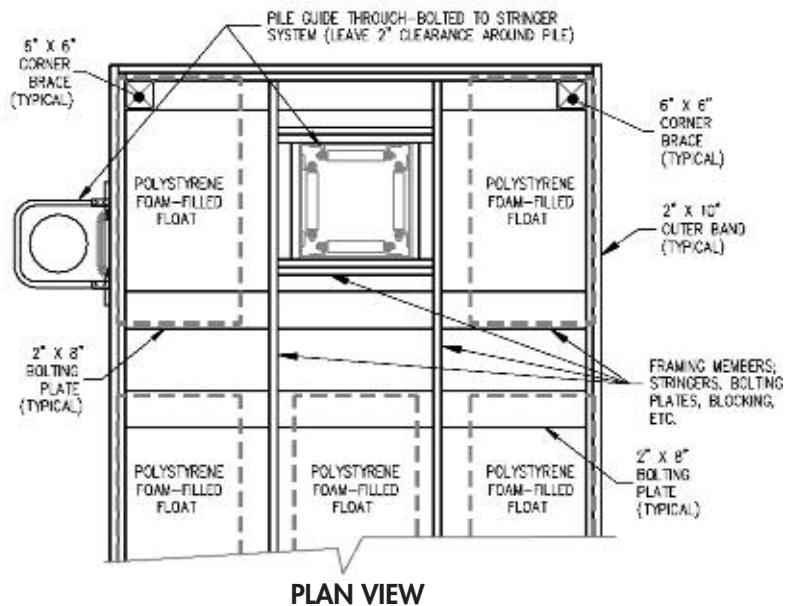
ELEVATION VIEW – RIGHT RAIL



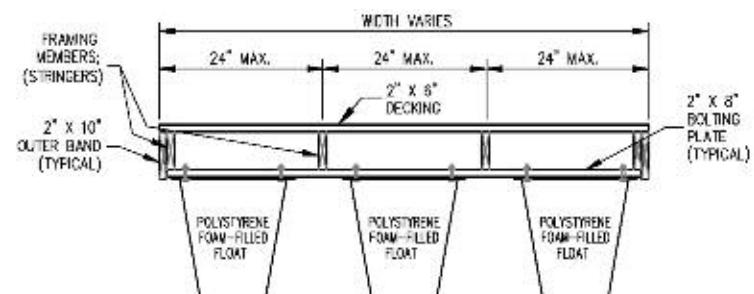
FLOATING DOCKS

The use of treated Southern Pine in floating docks has been proven in both public and private applications. The pleasing appearance of the treated timber, long service life, the ease of repair, and resistance to impact damage make Southern Pine an attractive choice for commercial and residential floating dock builders. Floating docks are typically anchored using 4-roller internal pile guides or single-roller external hoop pile guides – as shown on this sheet. Floatation units, typically ranging in size from 2'x4' to 5'x5', are

attached to the stringer system with bolts through 2"x8" timber bolting plates. In order to set proper pile heights, embedment depth into supporting soil, and overall pile lengths, the designer must be familiar with local soil conditions, water levels, and tidal actions in the area where the floating dock system is being installed. Consideration of abnormal water levels associated with storm surge is also critical.

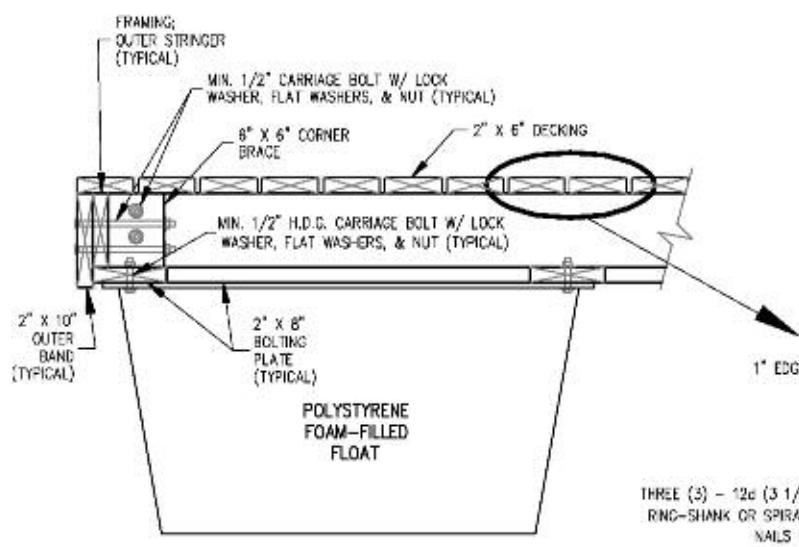


PLAN VIEW

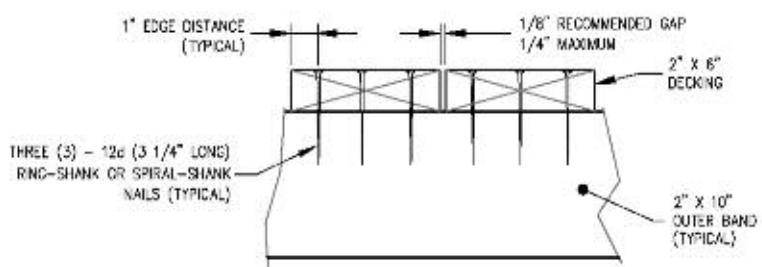


END VIEW

NOTE: Decking used on floating docks should be treated with the same type of preservative and to the same retention level as allowed for decking and handrail components used on fixed piers (UC4A Use Category for fresh water applications and UC4B Use Category for salt water applications).



DOCK SECTION DETAIL

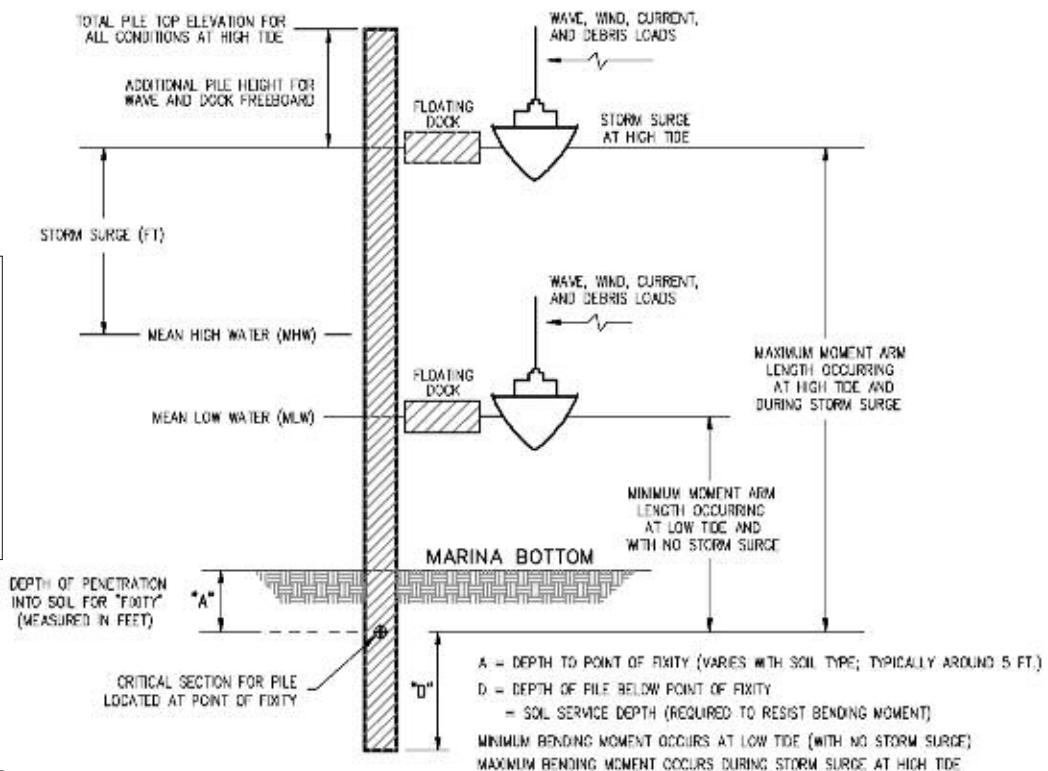


DECKING ATTACHMENT DETAIL

TYPICAL FLOATING DOCK FRAMING DETAILS

DESIGN CONSIDERATIONS FOR FLOATING DOCK PILES

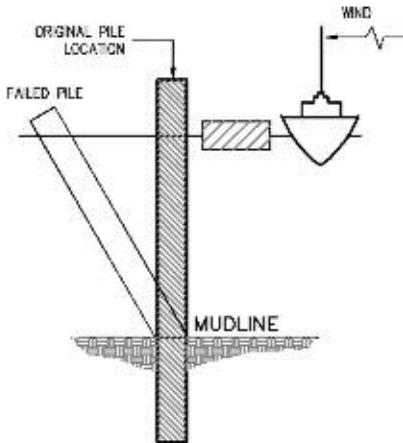
NOTE: The point of fixity for the piling into the soil is typically estimated at approximately 5 ft. below the marina bottom. However, in cases where very poor soils are present, it will be necessary for a design professional to evaluate the soils and determine the depth of penetration of the piling into competent material to provide adequate lateral bearing support for the piling.



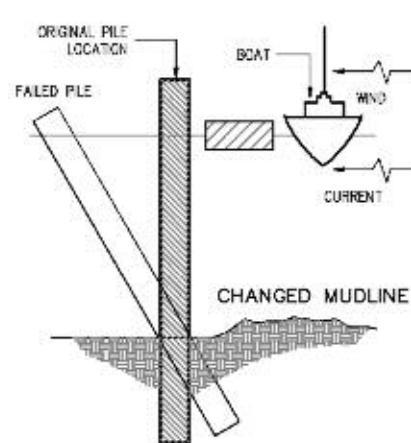
DESIGN REFERENCE STANDARDS

AGENCY	NUMBER	DESCRIPTION
ASTM	D25	Pile classifications and sizes
ASTM	D2555	Strength values
ASTM	D2899	Strength values and factors, wet round timber piles
ASTM	D245	allowable properties for visually graded lumber
ASTM	D4022	Sealing of pile cut-offs (coal-tar roof cement)
AWPA	U1	Preservative-treatment for piles
AWPA	M4	Care of preservative-treated wood products
FEMA	55	Coastal construction manual
FHWA	1P-84-11	Handbook on design of piles
AFPA	NDS (latest)	National Design Standards – adjustment factors for Southern Pine Piles

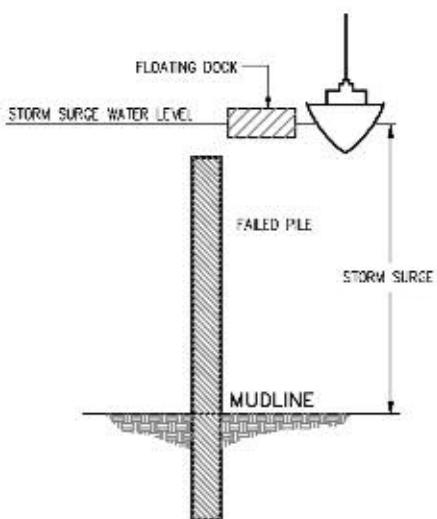
PILE FAILURE MODES



PILE FAILS IN BENDING (BREAKS)
(pile cross-section size too small)



PILE FAILS WITH SOIL
(not enough penetration)



STORM SURGE RAISES WATER LEVEL
(pile too short & dock floats over top)

Practical Marine Use Considerations

MATERIALS (LUMBER, FASTENERS)

- ▶ Use properly treated Southern Pine lumber bearing the quality mark of an approved inspection agency. **A**
- ▶ For salt water environments, use round pilings to limit heartwood exposure.
- ▶ Square-sawn piling can be used in fresh water environments.
- ▶ Use tiebacks of sufficient size. Undersized tiebacks often fail or bite into the pile face.
- ▶ Use hot-dipped galvanized or stainless steel fasteners to resist corrosion and extend service life of the structure. **B**
- ▶ Use clean, granular fill which is free-draining and has good bearing strength.

**A****B**

DESIGN

- ▶ Provide tiebacks, even on bulkheads with low exposed height (3 to 4 feet). Size the tiebacks to handle loads and harshness of the marine environment. **C**
- ▶ Provide weepholes at 6", on-center, with rock drains. If sprinkler system is used on landward side, provide proper drainage to take excess water away from the structure.
- ▶ A sufficient number of piles, adequately penetrated, as well as proper water orientation, contribute to a long service life. **D**
- ▶ Inadequate piles, undersized walers and undersized tieback rods may result in bulkhead alignment problems.
- ▶ Proper overlap of walers at piles and proper orientation of walers to provide greatest bending resistance are essential.
- ▶ Adequate piling, anchor sizes, walers and the use of ogee washers combine to resist forces and provide structures with a long service life.
- ▶ Ogee washers, spike grids and adequately sized lumber and piling are examples of good engineering and design.
- ▶ Disabled access piers must comply with federal ADA regulations. Alternating the height of the fishing pier handrails and installing a nearby roofed structure for shade are helpful for children, the handicapped and senior citizens. Slant the fishing pier handrails to provide convenient armrests. **E**

**C****D****E**

CONSTRUCTION METHODS

- ▶ Overlap walers two feet at each joint and interlock ends at returns. **F**
- ▶ Provide bulkhead toe protection to prevent erosion and loss of embedment.
- ▶ Spacers are often used to maintain the proper alignment of stringers with handrails.
- ▶ Overlap splices and hurricane straps to keep fixed pier structures in place during high winds and storm wave forces. **G**
- ▶ Preferably, sheet piles should be driven to grade, and jetting of sheet piles should only be done in sandy soils, under professional supervision.
- ▶ Weep holes, geotextile fabric and graded rock filter bags help the bulkhead adjust to varying soil and groundwater conditions.

**F****G**

Walkway & Light Vehicular Bridges – Construction Details

- Walkway construction in wetlands and other environmentally sensitive areas is a complex process with many variables requiring extensive knowledge of local conditions. This should only be undertaken by qualified professionals.
- Considerations should be given to natural surroundings and aesthetics, loadings, codes and construction practices, materials and soil analysis. Do not hesitate to seek out experienced design professionals and look at examples of their work. Use only licensed, experienced contractors. Ask for pictures and references. Visit past projects and talk to recent customers.
- The proper evaluation of soils is critical to design and performance of the walkway structure. Sandy (granular) soils are usually quite predictable and yet are subject to scour and erosion. Clays (cohesive soils) may not be consistent in a given area and may vary widely within a single project. Even when viewed by an experienced design professional, soil analysis without benefit of testing by a qualified soil testing laboratory is approximate at best. The relatively low cost of a local certified testing lab is easily offset by the advantages of accurate quality and strength data.
- Properly specified Southern Pine lumber should give long performance under all anticipated conditions. Materials that do not meet or exceed specifications should be rejected. Substitute materials may appear to offer short-term benefits, but such savings may translate into higher maintenance and repair costs for the owner.
- Lumber is supplied in increments of two feet. To avoid unnecessary cutoff and waste, designs should be developed to utilize the full length. Remember that any field cuts damage the preservative effectiveness of treatment. Whenever possible, have cuts such as mortises or radius milling of edges completed prior to treatment or at least dip or brush these surfaces with copper naphthenate prior to installation (AWPA Standard M4).

In Harmony with the Ecosystem

Elevated walkways are an excellent alternative to wetland filling and the associated negative environmental impacts. Meandering elevated walkways through forests, wildlife sanctuaries and nature preserves offer pedestrians and cyclists opportunities to view environmentally sensitive areas from a new perspective, while minimizing impact on the ecosystem. Timber walkways adapt and blend into sensitive surroundings because of their versatility, flexibility and relative ease of construction.

Pedestrian bridges and walkways also lend themselves to an aesthetically pleasing park or recreation area when used over retention ponds, drainage ditches or naturally occurring wetlands. In downtown development projects, timber provides excellent pathways for sightseeing and walking through historical areas, especially when situated near the waterfront.

Design Concepts and Engineering For:

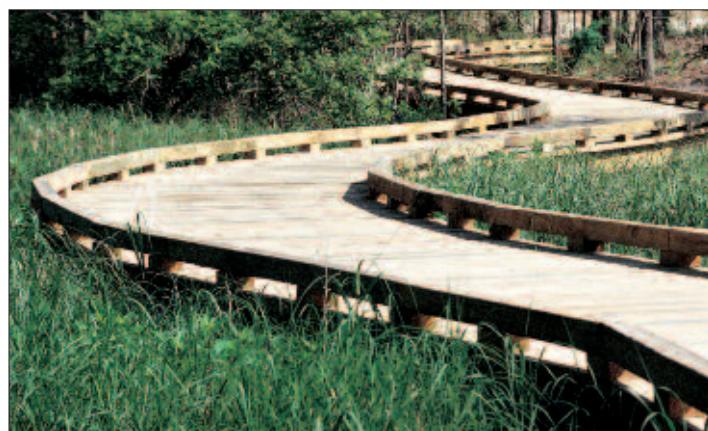
- Pedestrian Walkways (pp. 32-34)
- Light Vehicular Bridges (p. 35)

For use in:

- Wildlife and nature preserves
- Wetland areas
- Recreational parks and playgrounds
- Residential developments
- Golf courses

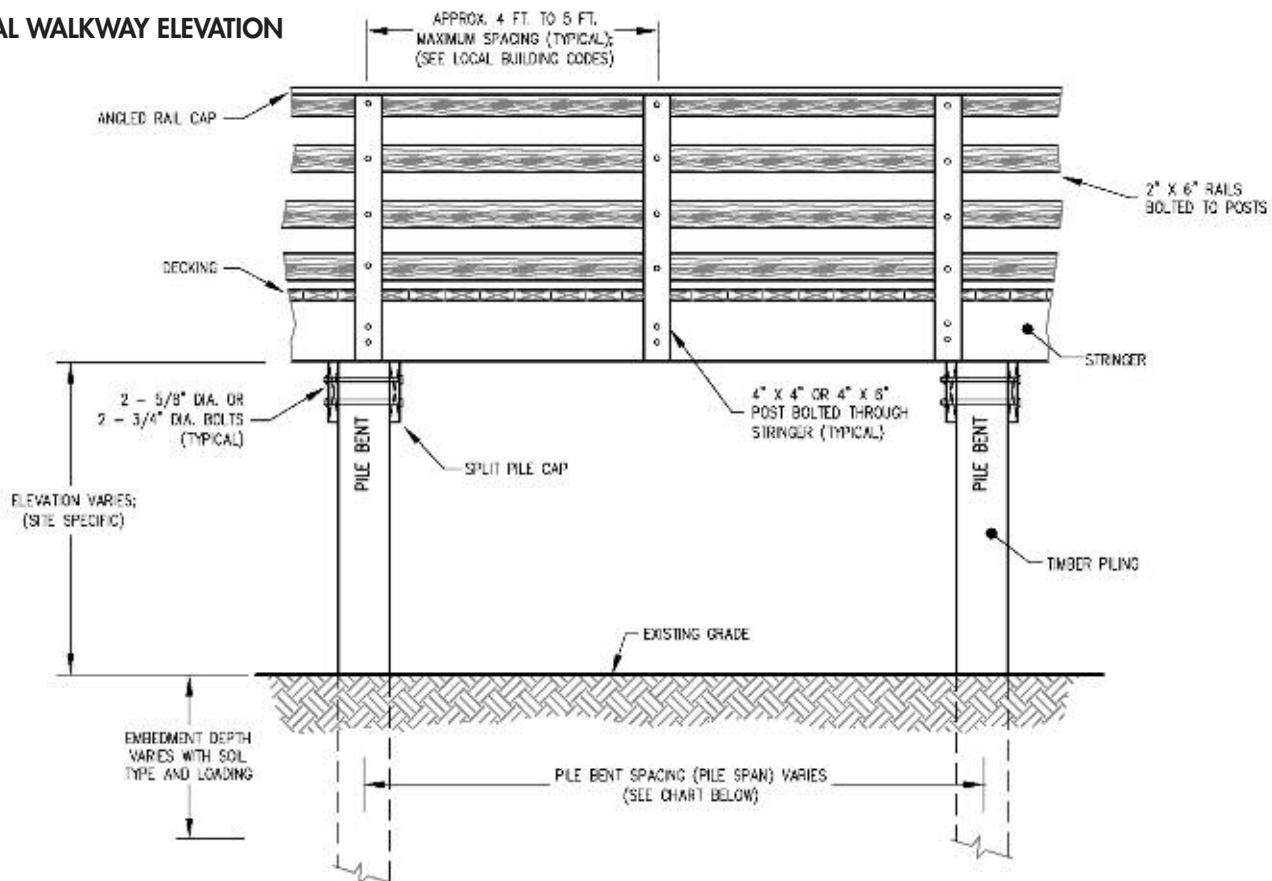
Site Planning and Design Factors:

- Natural Surroundings and Site Conditions
 - Desirable trees and flora*
 - Natural streams, ponds*
 - Wildlife sensitivity*
 - Flow with natural terrain*
- Structural Aspects
 - Expected loading and use*
 - Elevation above ground*
 - High winds or flood zone*
 - Soil conditions*
- Americans with Disabilities Act (ADA)
 - Proper width of deck*
 - Minimal slope*
 - Required rest areas*
 - Smooth transitions*



WALKWAY DESIGN DETAILS

TYPICAL WALKWAY ELEVATION



NOTES:

1. See chart below for general guidance and sizing information for stringer size and split pile cap member size.
2. For optimum appearance, all lumber should be No.1 grade or better Southern Pine. Refer to SFPA publications Pressure-Treated Southern Pine and the Southern Pine Use Guide for additional information on lumber grade and size descriptions.
3. See page 34 for typical details, cross-section, and plan view.
4. Use ogee washers on bolt head end with 4"x4"x1/4" cut washer or ogee washer and lock washer on nut end.
5. Toe-nail interior stringers to pile caps with two (2) 16d ring-shank nails and use hurricane straps for projects located in creeks/riars with fast currents, an din flood-prone and hurricane-prone areas.
6. Refer to the SPIB Standard Grading Rules for Southern Pine Lumber for more details on surfacing designations, provisions, and net product sizes.

Walkway Width	Pile Span		50 psf		100 psf	
	8 ft.	10 ft.	8 ft.	10 ft.	8 ft.	10 ft.
4 ft.	<u>2x6</u> 2x6	<u>2x8</u> 2x8	<u>2x8</u> 2x8	<u>2x10</u> 2x10		
5 ft.	<u>2x6</u> 2x8	<u>2x8</u> 2x8	<u>2x8</u> 2x8	<u>2x10</u> 2x10		
6 ft.	<u>2x6</u> 2x10	<u>2x8</u> 2x10	<u>2x8</u> 2x10	<u>2x10</u> 2x12		

Minimum Stringer Size (Inches)
Minimum Pile Cap Size (Inches)

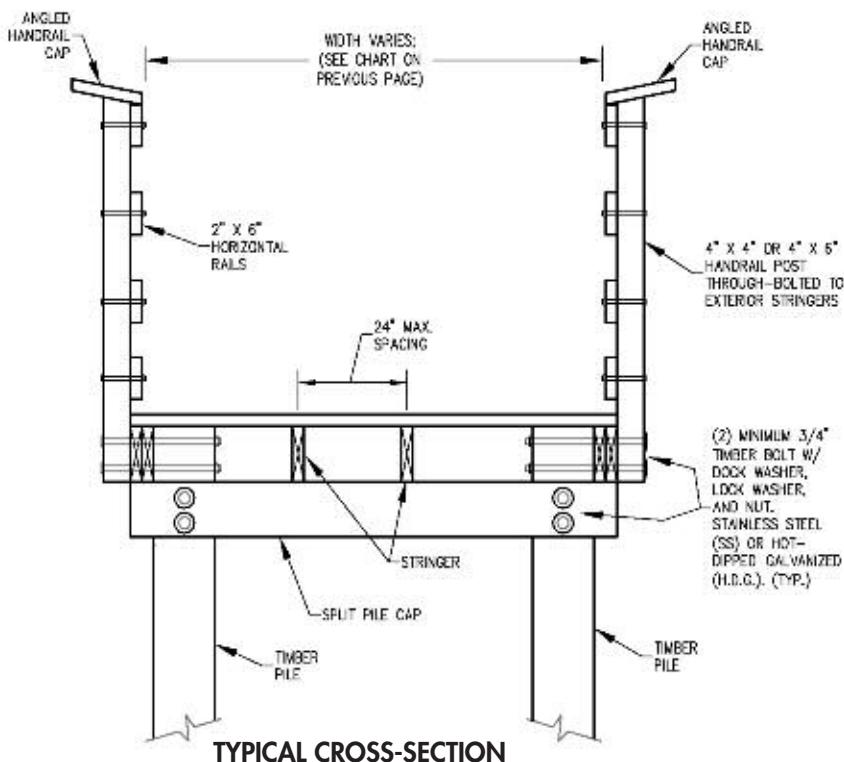
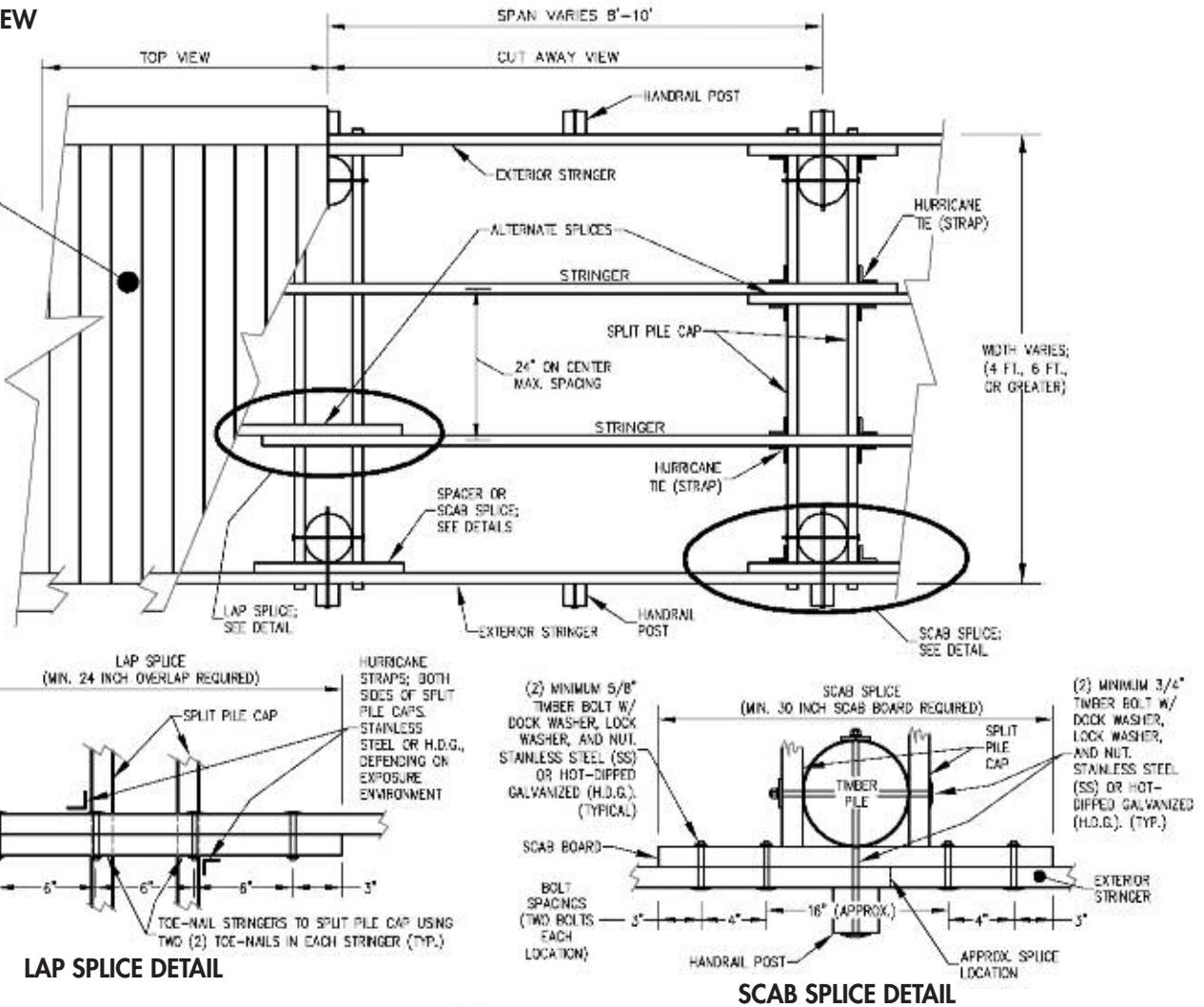


NOTE: This chart is intended for reference in making initial approximate estimates on stringer and split pile cap size selection. All structural design should be performed by a licensed engineer or design professional.

WALKWAY FRAMING DETAILS

TYPICAL PLAN VIEW

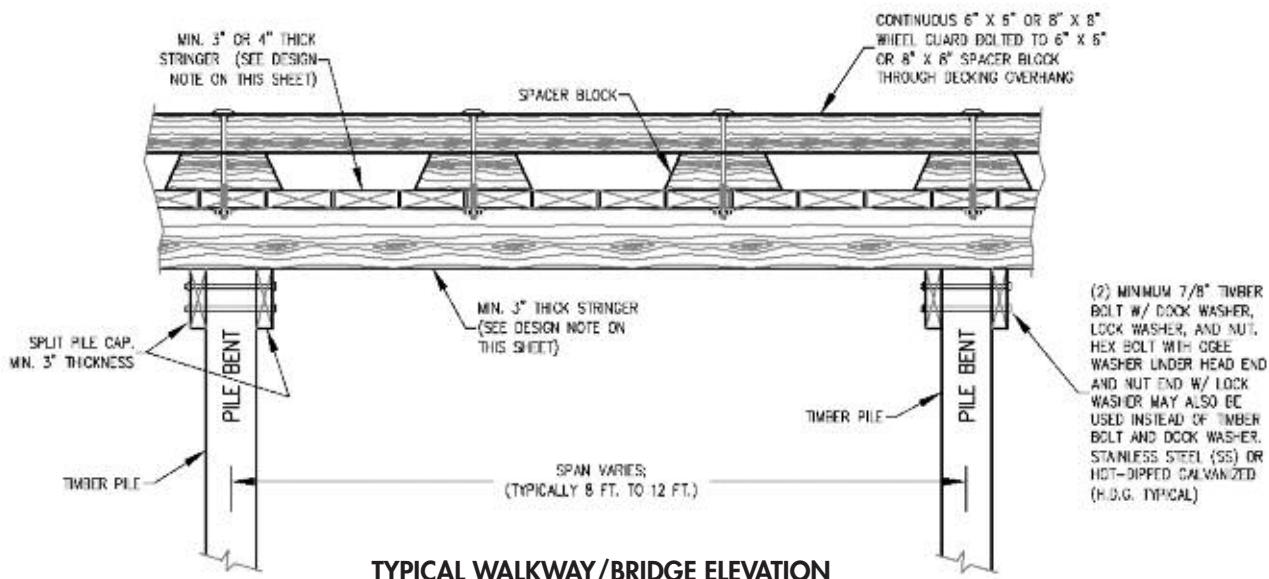
Designer should use caution in selection of fasteners. For best corrosion resistance, stainless steel (SS) type 304 or 316 are highly recommended for brackish and salt water environments.



NOTES:

1. One of the most aesthetically important aspects of a walkway is the handrail system. The handrails provide necessary safety and offer an eye-pleasing look when designed properly.
 2. An installation practice is to use stainless steel screws to fasten decking into stringers. This allows for easy removal of deck boards for maintenance and replacement.
 3. See chart on page 33 for dimensions of walkways and approximate sizing of structural members.
 4. Angled rail cap, as shown on typical cross-section view on this page, allows for comfortable leaning or sightseeing and also sheds water better.
 5. Lumber sizes and pile spacing can often be dictated by lumber availability. It is usually more economical to use 10 ft. spacing between pile bents if the longer stringer material is available. For stability, stringers should always span across two spans.
- Example: If 10 ft. pile bent spacing is used, 20 ft. long stringers would be required to cover two spans (i.e., connecting 3 pile bents).
6. Scab splices must occur over pile caps. When possible, lap splices should be alternated so that two adjacent splices do not occur over the same pile cap.

LIGHT VEHICULAR BRIDGE APPLICATIONS – GOLF CART & PEDESTRIAN BRIDGES

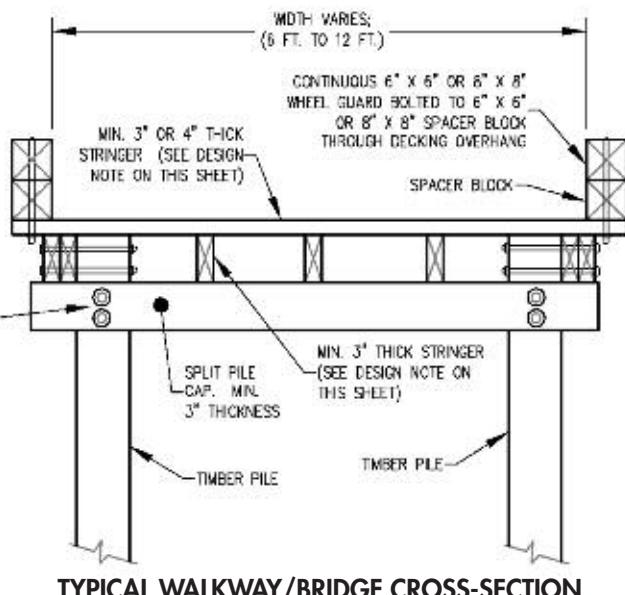


Design NOTES:

1. The loading for each individual bridge should be determined by the designer. Loads should be used as a basis for engineering design of each individual structure.
2. Stringer size, support pile diameter and length, and split pile cap member sizes should be determined by a design professional based on loading, site and soil conditions, and pile bent spacing (spans).
3. The guard rail shown on this sheet is standard for golf cart bridges, offering the safety of the wheel guard and uninterrupted views of the surroundings and water body being crossed. Also see previous sheets for other guardrail options.
4. When heavy-use conditions are anticipated, minimum 3" decking material is recommended.
5. If it is desirable to prevent vehicles of a certain size from using the bridge, install a bollard post (or two bollards set at a maximum allowable vehicle width).

Specification NOTES:

1. All wood should be Southern Pine and should be preservatively treated in accordance with American Wood Protection Association (AWPA) Use Category Standard UC4 or UC5.
2. Support piles used in construction should be specified using tip circumference (diameter) in accordance with ASTM O25. Preservative treatment shall be in accordance with AWPA Use Category Standards (UC4C, UC5A, UC5B, or UC5C).
3. All fasteners and tie-rods should be hot-dipped galvanized (H.D.G.) per ASTM A-153 for protection against corrosion. Also, coat H.D.G. fasteners with coal-tar epoxy to extend service life. For a higher level of corrosion protection and extended service life, use stainless steel (S.S.) 300 series steel for fasteners.
4. All cuts, holes, and damage to the surface of treated wood should be protected by field-treatment meeting AWPA standard M4 (latest issue).
5. All treated wood products should be handled and field-fabricated in accordance with AWPA M4 – standard for the care of preservative-treated wood products.
6. For further information on fresh and brackish/salt water specifications, consult the AWPA Book of Standards and Sources listed on the back cover of this guide.



GLUED LAMINATED TIMBER FOR DOCKS, PIERS & BRIDGES

Structural glued laminated timber (glulam) is a popular construction material for above-water dock and pier decks, pedestrian bridges and walkways. For more than sixty years, architects, engineers, designers and contractors have been specifying pressure-treated Southern Pine glulam beams for their high strength, natural beauty, dimensional stability, and its availability in a wide range of sizes and shapes.

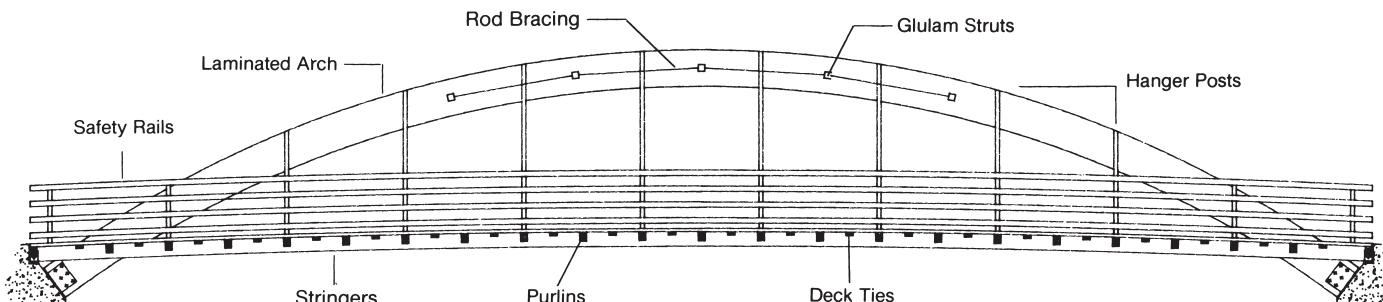
Complete information regarding the pressure treatment of glulam materials is available in the Technical Note 5580, Preservative Treatment of Glued Laminated Timber, published by APA – The Engineered Wood Association. Additional information can be found in the SFPA publication, Pressure-Treated Southern Pine.

For site-specific designs and specifications, contact the manufacturers of glued laminated timbers listed in the online Product Locator at SouthernPine.com.



Old Salem Covered Bridge; Winston-Salem, North Carolina
(courtesy of Blue Ridge Timberwrights)

Arch Suspension Bridge



Courtesy of Enwood Structures, Inc. Morrisville, NC



For further information about structural glued laminated timber, contact the American Institute of Timber Construction (AITC), wwwAITC-glulam.org, 503/639-0651, and APA – The Engineered Wood Association, www.apawood.org, 253/565-6500.

Glossary

AWPA - Founded in 1904, the American Wood Protection Association (AWPA) is a non-profit organization which is responsible for promulgating voluntary wood preservation standards. AWPA Standards are developed by its technical committees in an open, consensus-based process, are universally specified for wood preservation in the USA, and are recognized worldwide. AWPA Standards help ensure that treated wood products perform satisfactorily for their intended use. They are recognized and used by most, if not all, specifiers of treated wood products, as well as by local, state and federal governments. Visit www.awpa.com.

Bulkhead - An earth-retaining structure. It retains earth on one side and is usually partially surrounded by or submerged in water on the other side. Bulkheads, in the context of this guide, are timber structures consisting of timber sheet piling, wale beams, face piling, and in some cases tie-back anchors.

Galvanized Steel - Steel that has been coated with zinc to improve its corrosion resistance. For use in marine construction projects, hot-dipped galvanizing (H.D.G.) is the process by which steel is coated. H.D.G. steel does offer good corrosion resistance in fresh water and slightly brackish water environments; however, it will eventually corrode if exposed to these harsh conditions.

Heartwood - The center of the tree; It is usually darker in color when viewed from the cross-section of the tree trunk and will be more dense than the surrounding sap wood. Due to the hardness of the heartwood, it will not accept the preservative treatment chemical very well; therefore, this portion of the piece remains somewhat unprotected from marine borer attack.

ICC - International Code Council. This is a professional membership association dedicated to providing its members and building industry professionals with tools necessary to ensure the public's safety in the "built" environment.

Lumber Grades - A designation made to a piece of lumber based upon the visual and mechanical inspection of individual pieces for structural and appearance properties. Typical grades used in most marine construction are: No.1, No.1 Dense, No.2, Marine Grade and Seawall Grade.

Marine Borers - Organisms that consume wood and will ultimately destroy the portion of the wooden structure that is located within the intertidal zone. The most common marine borers in salt and brackish water are shipworms (*teredos*) and gribbles (*limnoria*).

Marine Grade lumber - Can be any grade of Southern Pine lumber, except that all four faces must be free of pith and/or heartwood. Marine Grade lumber is typically specified as "No.1 Marine Grade."

Riprap - Stone or other aggregate such as granite or limestone. Can be composed of concrete rubble from the demolition of concrete structures. It is often placed to form a protective layer or facing to prevent erosion and scour along a shoreline or embankment.

Salinity - The saltiness or dissolved salt content of a body of water is what determines which preservative treatment should be used and the grade of lumber required for a particular project.

Saline In Water: (ppm = parts per million)
Fresh Water – official salt concentration limits in US drinking water = 1,000 ppm
Brackish Water – “mildly brackish” = 1,000 to 5,000 ppm
Brackish Water – “moderately brackish” = 5,000 to 15,000 ppm
Brackish Water – “heavily brackish” = 15,000 to 35,000 ppm
Sea Water = 30,000 to 50,000 ppm (normally approximately 35,000 ppm)

"Moderately" and "heavily" brackish waters should receive similar wood preservative treatment as salt water. It is recommended that designers/owners have salinity tests performed on the water at the project locale if uncertainty exists of the site's salinity range.

Salt water splash zone - That portion of a marine structure located above mean high, but is still subject to frequent wetting from wave action and/or wind-blown water (salt water splash). The conditions in this zone of exposure support intermittent degradation by marine organisms. Corrosion of metal fasteners in this zone is also usually severe. Members in the salt water splash zone typical include: piling, walers, framing, stringers, and cross-bracing.

Sapwood - The outermost wood layer of a tree; it is the "living wood" in the growing tree. The softer sapwood is able to accept preservative treatment more readily than the heartwood; therefore, will provide better resistance to decay and marine borer attack.

Seawall Grade lumber - Can be of any grade of Southern Pine dimension lumber (2" through 4" nominal thickness; 6" through 14" nominal width). One wide face and both edges must be free of pith and/or heartwood and the sapwood face shall have sapwood at least 1/2 inch thick as graded from both ends. Seawall Grade lumber is typically specified as "No.1 Seawall Grade." The Seawall Grade lumber should be stamped with a grade-mark indicating "This Side Seaward."

Sheet Pile (Bulkhead Sheeting) - Used in the construction of bulkheads as the main earth-retaining component. Sheet piling ranges in size from 2x6 for light-duty bulkheads with low exposed heights to 3x8, 3x10, 4x8 or 4x10 for more heavy-duty bulkheads with higher exposed heights and harsh site condition exposure. Sheet piling in salt water environments should always be "No.1 Seawall Grade" or "No.1 Marine Grade" and treated to 2.5 (pcf) CCA. Sheet piling is typically specified with a "Sloppy V-Tongue & Groove" or "Square Tongue & Groove" edge profile.

Sloppy V – T&G - This sheeting provides a loose-fitting groove especially useful in driving or jetting sheets into different soil conditions (clay, sandy clays or similar-type soils).

Stainless Steel - An alloy that contains chromium, nickel, and/or manganese. Stainless steel has very good corrosion resistance properties due to the high levels of chromium and nickel/manganese. The two most common alloys of stainless steel used in marine construction are Type 304 and Type 316. Both are used in marine construction for hardware, straps, plates, ties, bolts, nuts, washers, and screws. However, 316 stainless steel provides the best corrosion resistance in salt water.

Waler (wale beam) - A horizontal structural beam used in the construction of a bulkhead, which carries the load that is transferred to the sheet piling from the retained soil to the face piling (support piling in the front of the bulkhead structure). Wale beams in brackish and salt water environments should always be "No.1 Marine Grade" and treated to 2.5 pounds per cubic foot (pcf) CCA.

Wood preservative - A chemical formulation that is forced deep into the wood fibers, typically through the process of placing lumber inside a pressurized chamber and introducing the chemical and pulling a vacuum. Commonly used formulations for preservative treatment of Southern Pine products, as discussed in this guide, include: Chromated Copper Arsenate (CCA), Copper Azole (CA), and Alkaline Copper Quaternary (ACQ). Designers should check with local suppliers for the latest approved wood preservatives in the project area.

ADDITIONAL RESOURCES

The Southern Forest Products Association offers a wide variety of helpful publications for design-build professionals. The titles listed below are available online in PDF. Visit [SouthernPine.com](#) to download and to see a listing of all publications.

Pressure-Treated Southern Pine

Wood preservative systems, industry standards, specification guidelines and examples, applications

Southern Pine Use Guide

grade descriptions, design values, applications, specification guidelines

Southern Pine Maximum Spans for Joists and Rafters

span tables, design criteria

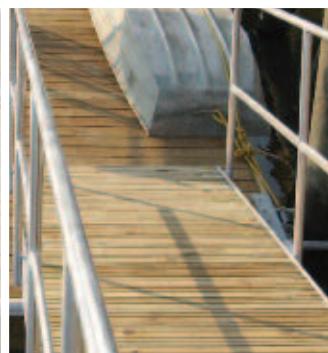
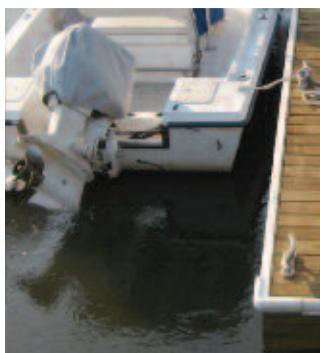
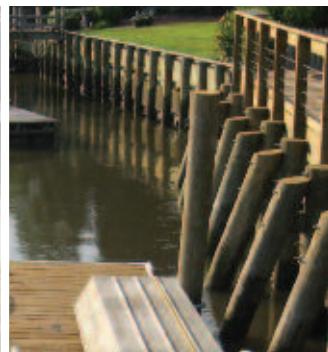
The following two titles can also be downloaded from the Publications page of [SouthernPine.com](#):

Treated Wood in Aquatic Environments

a specification and environmental guide to selecting, installing and managing wood preservation systems in aquatic and wetland environments

Best Management Practices

for the use of wood in aquatic and wetland environments



Online PRODUCT LOCATOR

Sourcing Southern Pine products?

Visit the online Product Locator at
SouthernPine.com

to find SFPA member producers.

SOURCES OF TREATED WOOD PRODUCT INFORMATION

American Wood Council [awc.org](#)

American Wood Protection Association [awpa.com](#)

Creosote Council [creosotecouncil.org](#)

ICC Evaluation Service [icc-es.org](#)

North American Wood Pole Council [woodpoles.org](#)

Southern Forest Products Association [southernpine.com](#)

Southern Pressure Treaters' Association [spta.org](#)

Western Wood Preservers Institute [wwpinstitute.org](#)

Wood Preservation Canada [woodpreservation.ca](#)

Wood Preservative Science Council [woodpreservativescience.com](#)



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