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MILITARY DESIGN CRITERIA FOR WATERFRONT WOOD STRUCTURES

by

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EXECUTIVE SUMMARY

This document represents a review of national standards used in wood design for application to military waterfront construction. It addresses principally military specifications, which have been listed and summarized, and also includes pertinent references to civilian standards. Military standards covered include Military Handbooks, NAVFAC Standard Specifications, Standard Drawings, and NAVFAC Guide Specifications. Whenever possible, relevant sections from the standards were reproduced or summarized, and annotated.

This document is intended to provide guidance for enhancing current military wood design criteria in waterfront facilities to include engineered wood.

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1 INTRODUCTION

This document represents a review of national standards used in wood design for application to military waterfront construction. It addresses principally military specifications, which have been listed and summarized, and also includes pertinent references to civilian standards. This document is intended to provide guidance for enhancing current military wood design criteria in waterfront facilities to include engineered wood.

2 GLOSSARY OF ORGANIZATIONS

A significant portion of military standards are based on publications by other government or civilian organizations. Acronyms for these organizations are detailed below:

AASHTO	American Association of State Highway and Transportation Officials
AES	Purdue University Agricultural Experiment Station
AF&PA	American Forest and Paper Association (formed in 1993 by combination of AFC, API and NFPA)
AFC	American Forest Council (now part of AF&PA)
AITC	American Institute of Timber Construction
ALSC	American Lumber Standards Committee
APA	American Plywood Association (now EWA)
API	American Paper Institute
AREA	American Railway Engineering Association
ASCE	American Society of Civil Engineers
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute (formerly part of AWPA)
EWA	Engineered Wood Association (formerly APA)
NAVFAC	Naval Facilities Engineering Command
NFPA	National Fire Protection Association
NFPA	National Forest Products Association (now part of AF&PA)
TPI	Truss Plate Institute
USDA	United States Department of Agriculture

3 STANDARDS BY NON-MILITARY ORGANIZATIONS

Each of the above organizations has produced standards that address wood design. The most useful standards published by each organization are as follows:

AASHTO	Standard Specifications for Highway Bridges
AES	Research Bulletins
	No. 714 - Det. of Member Stresses in Wood Trusses with Rigid Joints
	No. 727 - Design of Glued Joints for Wood Trusses and Frames
AF&PA	Standard for Load and Resistance Factor Design (LRFD) for Engineered Wood Construction (joint publication with ASCE)
	National Design Specification (NDS) for Wood Construction
AITC	Timber Construction Manual
APA	Plywood Design Specifications
	Plywood Folded Plates
	Plywood Diaphragm Construction
AREA	Manual for Railway Engineering
ASCE	Standard for Load and Resistance Factor Design (LRFD) for Engineered Wood Construction (joint publication with AF&PA)
AWPA	Book of Standards
	C2 - Lumber, Timbers, Bridge Ties and Mine Ties, Preservative Treatment by Pressure Processes (1992)
	M4 - Care of Preservative-Treated Wood Products (1991)
	M6 - Brands Used on Forest Products (1991)
EWA	Plywood Design Specifications
	Plywood Folded Plates
	Plywood Diaphragm Construction
NFPA	Handbook of Fire Protection
TPI	Design Specifications for Light Metal Plate Connected Wood Trusses
USDA	Wood Handbook

4 MILITARY STANDARDS

The following is a list of applicable military documents. Abstracts for most of them are consequently provided.

MILITARY HANDBOOKS

MIL-HDBK-1000/1A Engineering and Design Criteria and Documentation for Navy Facilities (Jan 97)

MIL-HDBK-1001/2	Materials and Building Components (Jul 1987)
MIL-HDBK-1002/1	Structural Engineering - General Requirements (Nov 1987)
MIL-HDBK-1002/2A	Loads (Oct 1996)
MIL-HDBK-1002/5	Timber Structures (Mar 1987)
MIL-HDBK-1002/6	Aluminum Structures, Composite Structures, Structural Plastics, Fiber-Reinforced Composites (Jun 1987)
MIL-HDBK-1008B	Fire Protection for Facilities Engineering Design and Construction (Jun 1997)
MIL-HDBK-1025/1	Piers and Wharves (Jun 1994)
MIL-HDBK-1025/4	Seawalls, Bulkheads, and Quaywalls (Sep 1988)
MIL-HDBK-1025/6	General Criteria for Waterfront Construction (May 1988)
MIL-HDBK-1029/1	Graving Drydocks (Jan 1989)
MIL-HDBK-1029/2	Marine Railways (Jun 1989)
MIL-HDBK-1029/3	Drydocking Facilities Characteristics (Sep 1988)
MIL-HDBK-1104	Maintenance of Waterfront Facilities (Sep 1997, draft)

NAVFAC STANDARD SPECIFICATIONS

NFSS-C39	Standard Aircraft Carrier Mooring Camel (Jun 1991)
NFSS-C46	Standard Submarine Mooring Camel (Nov 1995)
NFSS-C49	Attack Submarine Camel (Jun 1990)

STANDARD DRAWINGS

SD-1281393	Timber Camel With Foam Flotation (Sep 1988)
SD-1404045A/4052	Aircraft Carrier Mooring Camel (Aug 1991)
SD-1404464	Standard Fittings for Waterfront Structures (Mar 1989)
SD-1404667 / 4670	Attack Submarine Camel (Jan 1991)
SD-1404694 / 4725	Brows and Platforms (Sep 1988)
SD-1404943 / 4947	Submarine Mooring Camel General Notes (Jul 1996)

NAVFAC GUIDE SPECIFICATIONS

NFGS-02398	Pier timberwork (Dec 1995)
NFGS-02458B	Timber piles (Jun 1996)
NFGS-02461A	Wood marine piles (Mar 1996)
NFGS-05650A	Railroad track and accessories (Mar 1996)
NFGS-06100W	Rough carpentry (Sep 1996)

5 REVIEW OF MILITARY STANDARDS

5.1 MIL-HDBK-1000/1A Engineering and Design Criteria and Documentation for Navy Facilities (Jan 97)

This document supersedes MIL-HDBK-1000/1 which itself superseded MIL-BUL-34X. This document summarizes all documentation for Navy Facilities related to engineering and design criteria. The following military handbooks, guide specifications, standard drawings, and standard specifications are all listed here.

5.2 MIL-HDBK-1001/2 Materials and Building Components (Jul 87)

Sections of interest from this document:

2.5.1. Permanent Construction: .. "Select finishes, materials and systems for low maintenance and life cycle costs based on 25 years."

2.8. New Materials: The use of new materials is encouraged, but specific policies and procedures must be followed to ensure that the standards and qualities of the Department of the Navy are maintained and enhanced.

2.8.1. Navy Policy: ..."new materials, equipment and methods must be adequately tested and proven by actual performance before adoption. Newly developed materials, equipment and methods not included in NAVFAC guide specifications may be used in limited applications with prior approval by the NAVFACENGCOM Engineering Field Division..."

2.8.2. NAVFAC Procedures: New materials, equipment or methods proposed to NAVFAC must meet the following prerequisites:

a) The item must equal or exceed minimum standards for quality and performance currently included in other criteria
b) The in-place cost of the item must compete with other acceptable products, or the premium cost of the item must result in long term savings in maintenance or operation costs
c) The item must be readily available in quantity and in wide geographical areas
d) The merits of the item must have approved laboratory certification or evidence of satisfactory use under conditions similar to the proposed application
e) Quality control of manufacturing processes and installation techniques must be guaranteed
f) Proposed item must be nonrestrictive enough to admit other available and equally acceptable competition

3.2. Construction systems

3.2.1.1. a) Wood frame: "Wood frame systems are not generally recommended for major or permanent construction projects, although laminated or other structural wood systems can be used for certain building types ..."

3.2.3.1. a) Wood walls: "Exterior walls of wood are not permitted for most major or permanent building types … [they] require constant maintenance, deteriorate rapidly, and offer little fire protection or additional insulation value."

4.4. Wood and Plastics
4.4.1. Wood: use NFGS-06100 Rough Carpentry and NFGS-06200 Finish Carpentry.
4.4.3. Plastic Laminate: " .. [can be used] for architectural woodwork items .."

5.3 MIL-HDBK-1002/1 Structural Engineering, General Requirements (Nov 87)

Scope:
Alternative materials shall provide:

- consistent factor of safety
- fire safety per MIL-HDBK-1008/1

Structures classification:
Class A: bridges, trestles, viaducts and their components
Class B: building-type structures, including portions of piers and wharves
Class C: structures supporting heavy lift cranes, airport runways, storage tanks, ..

5.4 MIL-HDBK-1002/2A Loads (Oct 96)

Supersedes MIL-HDBK-1002/2 Structural Engineering, Loads (Sep 88).
Loads in this MIL-HDBK are for general Class A and B structures. Loads for Class C structures are application specific - e.g. use 1025/1 for Piers and Wharfs.

5.5 MIL-HDBK-1002/5 Timber Structures (Mar 87)

Design standards for:

Structures	
Class A	AASHTO - Standard Specifications for Highway Bridges - for bridges
	AREA - Manual for Railway Engineering - for railway bridges
Class B, C	NFPA - National Design Specification for Wood Construction
	AITC - Timber Construction Manual
Plywood	APA - Plywood Design Specs.
Wood Trusses	TPI

Purdue University AES Research Bulletin No. 714 and 727.

Details of design:	
Stress grade lumber	NFPA standard
Nonstress grade lumber	use "standard" grade or better for blocking, bridging, etc..
Plywood	APA standard, species group 1, 2, or 3
Nondomestic wood	Tropical woods: use strength from supplier (check with tests) and 25% to 33% of strength for allowables
Plywood	Some specs on allowables are included
Preservative treatments	AWPA - Book of Standards

5.6 MIL-HDBK-1002/6 Aluminum Structures, Composite Structures, Structural Plastics, Fiber-Reinforced Composites (Jun 1987)

Section 4: Structural Plastics and Fiber-Reinforced Composites

4.2.1. General: "There is no general design specification for design of thermoplastic or fiberglass reinforced plastic (FRP) components." Some guidance in ASCE Structural Plastics Design Manual and Structural Plastics Selection Manual.

4.2.2. FRP tanks, Ducts, Equipment.

4.2.3. FRP Pultruded Shapes

4.2.4. FRP Panels.

4.2.5. Tension Membranes

4.2.6. Thermoplastics

4.2.7. GFRC Wall Panels

4.2.8. FRC (Fiber Reinforced Concrete)

4.2.9. Polypropylene Fiber Reinforced Slabs on Grade

Appendix B

1. "Apparent stiffness and strength reduce with long duration loads."
2. "Severe environment .. may degrade structural properties.."
3. "Low stiffness and directional properties require special consideration of buckling and deflection .."
4. "Lack of ductility .. requires accurate stress analysis and design to eliminate stress concentrations .."
5. "Low fracture toughness .. requires careful detailing to avoid notches and stress raisers.."
6. "High coefficient of thermal expansion requires careful design to accommodate larger movements or to account for structural consequences of movement restraint."
7. "Few thermoplastics .. can be used .. above 200 F."
8. "Low fire resistance and combustion products that include toxic fumes exclude many plastics .."

9. ".. long term exposure to moisture and weathering usually produces a significant reduction in the strength properties, ductility and toughness."
10. "Movements due to thermal and moisture change and restraint of such movement may induce significant stresses .."

5.7 MIL-HDBK-1008C Fire Protection for Facilities Engineering, Design, and Construction (Jun 97)

Most regulations are for housing, but some affect waterfront directly:

4.12. Waterfront Facilities
4.12.1. Waterfront Facilities Requirements - this section only indicates that fire protection for these facilities should satisfy the requirements in the following documents:

a) NFPA 307 – Construction and Fire Protection of Marine Terminals, Piers, and Wharves
b) NFPA 312 – Fire Protection of Vessels During Construction, Repair and Lay-Up
c) MIL-HDBK-1025/1 Piers and Wharves
d) MIL-HDBK-1025/2 Dockside Utilities for Ship Services
e) MIL-HDBK-1025/6 General Criteria for Waterfront Construction
f) MIL-HDBK-1029/1 Graving Drydocks
g) MIL-HDBK-1029/2 Marine Railways
h) MIL-HDBK-1029/3 Drydocking Facilities Characteristics

5.8 MIL-HDBK-1025/1 Piers and Wharfs (Mar 87, last update Jun 94)

This handbook contains description and design criteria for pier and wharf construction, including auxiliary structures. It is the primary source of guidance for design and construction of Navy waterfront structures. Most of the military handbook is applicable to engineered wood structures. The entire text of pertinent sections is not included because of its length. The main sections are indicated below:

Section 3: Loads
3.1. Dead Loads
3.2. Vertical Live Loads
3.3. Horizontal Loads
3.4. Load Combinations

Section 4: Structural Design

4.1. Types of Construction
4.2. Construction Materials
4.3. Allowable Stresses
4.4. Deck Structure Design
4.5. Substructure Design
4.6. Floating Structures
4.7. Mooring Hardware
4.8. Mooring Dolphins
4.9. Miscellaneous Considerations

Section 5: Fender Systems
5.1. General
5.2. Berthing Energy Determination
5.3. Types of Fender Systems
5.4. Selection and Design of Fender Systems

Section 6: Separators
6.1. Function and Application
6.2. Separator Types
6.3. Loads
6.4. Geometry
6.5. Stability
6.6. Miscellaneous

Section 7: Access Facilities
7.1. General
7.2. Landing Float
7.3. Brow or Gangway
7.4. Brow Platforms
7.5. Walkway or Catwalk
7.6. Ramps
7.7. Utility Booms
7.8. Fuel Loading Arm
7.9. Access Ladders

5.9 MIL-HDBK-1025/4 Seawalls, Bulkheads, and Quaywalls (Sep 88)

2.1. Definitions
2.1.1. Seawall: "A seawall is a soil retaining or armoring structure whose purpose is to defend a shoreline against wave attack. It differs from a breakwater in its capacity as a soil

retention structure. Seawalls are forms of shore protection and are not intended for use as berthing facilities."

2.1.2. Bulkhead: "A bulkhead is a soil retaining wall structure comprised of vertically-spanning sheet piles or other flexural members. Bulkheads derive their stability through mobilization of passive earth pressures between the mud line and embedded tip, and, in most cases, from a lateral restraint system installed between Mean Low Water (MLW) and top of wall. Bulkheads are installed to establish and maintain elevated grades along shorelines in relatively sheltered areas not subjected to appreciable wave attack, and are commonly used as berthing facilities."

2.1.3. Quaywall: "A quaywall is a gravity wall structure having the dual function of providing shore protection against light to moderate wave attack and a berthing face for ships. Its function is similar to a bulkhead but should be chosen when overall height requirements or wave environment severity exceeds the practical capabilities of typical bulkhead constructions. Quaywalls differ from bulkheads and wall-type seawalls in that they do not necessarily retain a soil backfill.

2.2. Selection of type of facility
2.2.1. Bulkheads vs. Seawalls
2.2.2. Bulkheads vs. Quaywalls

3. Seawalls

This section shows types of seawalls (gravity, rubble mound stone revetment, interlocking concrete blocks, stepped face concrete, curved face concrete, combination, filled concrete, etc..). None of them seems to use timber, except perhaps for buried bearing piles.

4. Bulkheads

This section shows types of bulkheads (without relieving platform, with relieving platform and pile anchorage, with relieving platform and deadman anchorage, with relieving platform and batter piles, with double anchor level). Timber can be used for piles (examples K, L in Fig. 14, Fig. 18), fendering (Fig. 25), and also for the wall itself (e.g. tongue and groove, close pile wall in Fig. 27, steel soldier beam and wood lagging in Fig. 28). This would be a good waterfront application for engineered wood.

5. Quaywalls

This section shows types of quaywalls (steel sheet pile cells, timber crib, concrete caisson, masonry/concrete blocks, cyclopean concrete, gabion, reinforced earth, soil-cement block). The timber crib quaywall is the only one that shows use of timber.

5.10 MIL-HDBK-1025/6 General Criteria for Waterfront Construction (May 88)

Section 2: Piling

2.1.1.1. Capacity as a structural member: "... treat piles as columns having an unbraced length as shown in Figure 1." Alternatively, and for wood piles, assume point of fixity to be about 10 ft below the mud line for soft, cohesive soils, 8 ft for granular and medium cohesive soil, and 5 ft otherwise. The effective length factor K is assumed to be between 0.5 and 0.75. Note: these provisions do not apply if embedment is less than 10 ft into firm material, or 20 ft into soft or loose material.
2.2.1. Untreated timber piles
2.2.2. Treated timber piles
2.2.3. Untreated and treated timber piles

Section 3: Deck and Substructure Framing and Bracing
3.1. Pile caps
3.1.2. Timber (typically preservative-treated Southern Pine and Douglas Fir)
3.2. Deck
3.2.1. Timber: "Do not use creosote treatment on walking surfaces or surfaces which normally will be touched by people (handrails, for example)."

Table 4: Properties of untreated and treated Fir and Pine.

6.1. Evaluation of strength of existing materials
6.1.2. Number of tests required to establish strength of ungraded materials: "The strength of material to be assumed for strength evaluation of the structure shall be the value for which sampling and test indicates to have a 95% probability of being exceeded. Not less than 4 samples shall be tested." The material strength is given as $S = x - t\sigma/2$, where x is the average, σ is the standard deviation, and t varies from 2 to 5 when the samples tested vary from 4 to 25.

Section 7: Deterioration of waterfront structures (case studies).
7.1.3. Timber structures

5.11 MIL-HDBK-1029/1 Graving Drydocks (Jan 89)

Graving drydocks can be made completely out of timber (Figure 4) although this is a temporary application, and for smaller ships (no all-wood drydock was found in MIL-HDBK-1029/3, below). Figures 5 and 6 show ship blocking loads on keel and bilge blocks (up to 149 Kips/ft).

8.2.3. Keel blocks: "Compression is the primary stress, but provision must be made to resist uplift, overturning, and horizontal movements induced by eccentric loads, earthquakes, or accidental impacts... Standard composite [concrete and wood] keel blocks (see Figure 10) are rated at 225 long tons (228610 kg) based on allowable stresses for wet timber in compression perpendicular to the grain taken at 250 psi (1724 kPa) for soft caps. For the standard 6 foot

center-to-center keel block spacing, this rating represents a 37.5 tons per ft (34014 kg/m) ship load." Note: this last conversion does not seem accurate, it should say (123000 kg/m).

8.2.4. Bilge or side blocks: "Bilge or side blocks are timber, built-up, shaped and located according to dimensions indicated in the table of offsets of docking plan of the vessel. These are designed for 250 psi load applied uniformly over the effective bearing area in contact with the hull of the ship. Each block shall be battened adequately for stability, and the resultant load reaction shall fall within the middle one-third of the base dimension of the block on the dock floor." Note: engineered woods with lower elastic moduli may be better suited for blocking since they allow for more local deformations - however, differential deformations between keel (composite) and bilge blocks may have to be addressed.

8.2.5. Types of construction: "Composite blocks shall be built with wood top and bottom layers [6" by 6" white oak timber typ.], and concrete sandwiched in between." (Figure 10).

Figure 14 shows wood bearing block lining used for the caisson gaskets (4.5" by 19" timber lining with center 5" rubber gasket). Note: this design may have been superseded by all-rubber lining.

5.12 MIL-HDBK-1029/2 Marine Railways (Jun 89)

2.2. Principle of operation: "A marine railway, by utilizing the mechanical advantage of the inclined plane and geared hauling machinery, is able to pull the cradle and vessel out of the water with a combination of horizontal and vertical movements."

2.4. Comparison of Marine Railways, Drydocks, and Graving docks: "A marine railway provides a fast, convenient, and economical method of docking and undocking vessels up to about 5000 tons."

8.1. Cradle Materials: "Most cradle designs have steel frames with wood or steel decking; however, timber cradles may be used for designs of small capacity."

Although not specifically mentioned, it is assumed that the keel and bilge blocks (up to 4 feet in height) would/could be made out of timber.

5.13 MIL-HDBK-1029/3 Drydocking Facilities Characteristics (Sep 88)

1.1. Scope: "This handbook presents drydocking facilities characteristics in tabular and figure form for graving drydocks, marine railways, and lifts. Plans are also presented indicating the locations of drydocking facilities in naval shipyards or other naval shore installations."

Examples of marine railways using wood:

- Annapolis Naval Station - uses wood for cradle, superstructure framing, piles

Examples of marine lifts using wood:

- Patuxent River Naval Air Station marine lifts - timber decks, piles, bracing

Examples of drydocks using wood:

- Charleston Naval Shipyard drydocks no. 3, 4 - use timber piles under concrete
- Hunters Point Naval Shipyard, San Francisco, drydocks no. 5, 6, 7 - timber piles
- Mare Island Naval Shipyard, Vallejo, drydocks no. 2, 3, 4 - timber piles
- Norfolk Naval Shipyard, Portsmouth, drydock no. 1, 2, 3 - timber piles
- Pearl Harbor Naval Shipyard drydock no. 1, 4 - timber piles
- Philadelphia Naval Shipyard drydock no. 1, 2 - timber piles
- Puget Sound Naval Shipyard drydock no. 1 - timber piles

In addition most drydocks use wood for fendering, blocking, and until recently for caisson seat lining. Note that in most cases the timber piles are under the drydock floor and walls, and therefore not accessible.

5.14 MIL-HDBK-1104/3 Maintenance of Waterfront Facilities (Sep 97)

Supersedes MO-104. This is still in draft form. Section dealing with wood and FRP:

3. Materials and Preventive Maintenance

3.1. Wood and Timber - .. "All wood products, including treated wood, must be inspected by agencies certified by the American Lumber Standards Committee (ALSC) and must be properly graded and marked before acceptance. General criteria for accepting wood products are well described in NAVFAC MO-213.2 - A Field Guide for Receipt and Inspection of Treated Wood Products by Installation Personnel."

3.1.1. Wood Deterioration

3.1.2. Preventive Maintenance for Wood and Timber

3.1.2.1. Pressure Treatment - .. "The preservative penetrates the wood from ½ to 4 inches, depending on the type of wood..". "[AWPA] standards govern the treatment processes that must be performed in waterfront areas." Wood preservatives include:

- creosote and creosote-coal tar solutions (these are not resistant to Limnoria Tripunctata)
- oil-borne preservatives such as pentachlorophenol, copper naphtenate, tributyl tin oxide, and copper-8-quinolinolate (these cannot be used for immersed wood).
- water-borne preservatives (toxic metallic salts) such as CCA (chromated copper arsenate), ACZA (ammoniacal copper zinc arsenate), and ACA (ammoniacal copper arsenate) for general use; and ACC (acid copper chromate), CC (ammoniacal copper citrate), and ACQ (ammoniacal copper quat type B) for above the waterline only.

3.5. Synthetic Materials
3.5.1. Fiber Reinforced Plastics
3.5.2. Plastic and Fiberglass Piles

4. Safety and Environmental Compliance
4.3.4. Treated Wood – see section 6.5

6. Repair of Wood and Timber Structures
6.1. General
6.2. References
6.3. Planning the Repairs
6.4. Repair Procedures
6.5. Environmental Concerns – Federal regulations allow the use of treated wood, but local and state regulations have restricted it.
6.6. Quality Assurance Concerns

5.15 NAVFAC Standard Specifications

5.15.1 NFSS-C39 Standard Aircraft Carrier Mooring Camel (Jun 91)

This NFSS is complemented by the standard drawings SD-1404045A / 4052 (see section on Standard Drawings).

5.15.2 NFSS-C46 Standard Submarine Mooring Camel (Nov 95)

This NFSS is complemented by the standard drawings SD-1404943 / 4947 (see section on Standard Drawings).

These drawings require 12 by 12 inches timber, 30 to 36 feet long, Douglas Fir or Southern Pine, undressed, treated to 2.5 pcf retention, SPIB /WWPA specifications.

5.15.3 NFSS-C49 Attack Submarine Camel (Jun 90)

This NFSS is complemented by the standard drawings SD-1404667/4670 (see section on Standard Drawings).

This camel is made out of steel pipes (24 and 30 inches in diameter, 0.375 inches wall thickness), but could conceivably be built out of engineered wood.

5.16 Standard Drawings

The following standard drawings are up to date and support the three NFSS documents in the previous section:

- SD-1404045A / 4052 Aircraft Carrier Mooring Camel (Aug 1991)
- SD-1404667 / 4670 Attack Submarine Camel (Jan 1991)
- SD-1404943 / 4947 Submarine Mooring Camel General Notes (Jul 1996)

The following standard drawings have not been updated and have not been used for years (i.e. are considered obsolete), but are still applicable:

- SD-1281393 Timber Camel With Foam Flotation (Sep 1988)
- SD-1404464 Standard Fittings for Waterfront Structures (Mar 1989)
- SD-1404694 / 4725 Brows and Platforms (Sep 1988)

5.16.1 Aircraft Carrier Mooring Camel (Aug 91)

These include the following drawings:

- SD-1404045A Title Sheet
- SD-1404046A General Arrangement Plan
- SD-1404047A Standard Camel Module Plan and Details
- SD-1404048A Camel Module Details
- SD-1404049A Camel Module Details
- SD-1404050A Fender Details
- SD-1404051 Floatation Chamber Plans
- SD-1404052 Floatation Chamber Section and Detail

5.16.2 Attack Submarine Mooring Camel (Jan 91)

These include the following drawings:

- SD-1404667 General Arrangement
- SD-1404668 Plan, Elevation and Section
- SD-1404669 Catwalk Details

- SD-1404670 Miscellaneous Fitting Details

A modified deep draft submarine camel that uses plastic timber instead of wood has already been used by the Public Works Center, Naval Submarine Base Pearl Harbor, Hawaii (see Appendix A).

5.16.3 Submarine Mooring Camel General Notes (Jan 91)

These include the following drawings:

- SD-1404943 General Notes and List of Materials
- SD-1404944 Camel Plan
- SD-1404945 Elevation and Section
- SD-1404946 Details
- SD-1404947 Details

5.17 NAVFAC Guide Specifications

5.17.1 NFGS-02398 Pier Timberwork (Dec 95)

Supersedes NFGS-02491 which itself superseded NFGS-02891.
All NFGS are short documents that provide guidelines to prepare contract specifications. The complete text of each NFGS should be reviewed to insure that no guideline needs revision to accommodate engineered wood.

5.17.2 NFGS-02458B Timber Piles (Jun 96)

Supersedes NFGS-0261.

5.17.3 NFGS-02461A Wood Marine Piles (Mar 96)

Supersedes NFGS-02483.

5.17.4 NFGS-05650A Railroad Track and Accessories (Mar 96)

Supersedes NFGS-02452.

5.17.5 NFGS-06100W Rough Carpentry (Sep 96)

6 SUMMARY

This document addressed military specifications, which have been listed and summarized, and also includes pertinent references to civilian standards. It includes military handbooks, guide specifications, standard specifications, and standard drawings. This document is intended to provide guidance for enhancing current military wood design criteria in waterfront facilities to include engineered wood.

APPENDIX A

PLASTIC TIMBER DEEP DRAFT SUBMARINE CAMEL

The attached drawings show an adaptation of a standard submarine camel that includes plastic timber in lieu of wood. It is expected that a similar drawing can be produced using engineered wood.

Figure A-1. Plastic Timber Deep Draft Submarine Camel, S-1.

Figure A-2. Plastic Timber Deep Draft Submarine Camel, S-2.