UFC 4-152-07
14 JULY 2009

UNIFIED FACILITIES CRITERIA (UFC)

DESIGN: SMALL CRAFT BERTHING FACILITIES

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U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated \1\.../1/)

Change No.	Date	Location

1 This UFC supersedes Military Handbook 1025/5, Chapter 2, Dated 30 September 1998.
2 This UFC supersedes UFC 4-152-07N Design: Small Craft Berthing Facilities, Dated 08 June 2005.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Center for Engineering and the Environment (AFCEE) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

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UNIFIED FACILITIES CRITERIA (UFC)
REVISION SUMMARY SHEET

Document: UFC 4-152-07
Superseding: UFC 4-152-07N, dated 8 June 2005

Description of Changes:

- Prepared document in proper UFC format
- Expanded/updated references
- Significantly expanded treatment/discussion of types/classes of small boats and craft
- Deleted section on guest docks
- Expanded discussion on aids to navigation
- Abbreviated discussion on fixed versus floating berthing systems
- Added section on covered versus uncovered berths
- Added section on dead loads
- Considerably reduced discussion on floating pier berthing systems
- Added section on floating dock freeboard and stability
- Expanded discussion on environmental (lateral) loading
- Added section on berthing loads
- Deleted section on design criteria for other sheltered basin structures, i.e. slope stabilization/protection, bulkheads as this can be readily obtained from other references
- Deleted section on design criteria for entrance channel and protective structures as this can be readily obtained from other references as well as being briefly addressed in Section 4-3 of new UFC.
- Expanded discussion on hotel services (utilities)
- Revised section on boat launch hoists and lifts and added new methods currently in use
- Expanded section on launching ramps
- Deleted section on administration building
- Expanded section on dry storage facilities
- Expanded section on boat repair/maintenance
- Deleted section on hardware supply store
- Deleted section on transient housing facilities
- Deleted section on layout of utilities
- Deleted section on perimeter fencing
- Deleted section on signs
- Deleted section on environmental factors and protection
- Deleted section on summary of common design problems
- Overall, made document shorter and more concise, relying on other applicable standards where applicable

Reasons for Changes:

- Previous UFC 4-152-07N, dated 8 June 2005 was merely a UFC cover sheet applied to MIL-HDBK 1025/5 dated 30 September 1988. Therefore, this new UFC 4-152-07 provides current criteria to replace a document over 20 years old.

Impact: There are negligible cost impacts. However, the following benefits should be realized.

- Over the last several years, NAVFAC LANT has been either directly or indirectly involved with numerous small craft basin projects in various stages of development. Current criteria for small craft berthing was not available. This new UFC will provide the criteria which was been found to be lacking.

Non-Unification Issues: None

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CHAPTER 1

INTRODUCTION

1-1 PURPOSE AND SCOPE

This UFC provides general criteria for the design of small craft berthing facilities.

1-2 APPLICABILITY

This UFC applies to all DOD small craft berthing facilities.

1-3 GENERAL BUILDING REQUIREMENTS

All DoD facilities must comply with UFC 1-200-01, *General Building Requirements*. If any conflict occurs between this UFC and UFC 1-200-01, the requirements of UFC 1-200-01 take precedence.

1-4 SAFETY

All DoD facilities must comply with DODINST 6055.1 and applicable Occupational Safety and Health Administration (OSHA) safety and health standards. NOTE: All NAVY projects, must comply with OPNAVINST 5100.23 (series), *Navy Safety and Occupational Health Program Manual*. The most recent publication in this series can be accessed at the NAVFAC Safety web site: www.navfac.navy.mil/safety/pub.htm. If any conflict occurs between this UFC and OPNAVINST 5100.23, the requirements of OPNAVINST 5100.23 take precedence.

1-5 FIRE PROTECTION

All DoD facilities must comply with UFC 3-600-01, *Fire Protection Engineering for Facilities*. If any conflict occurs between this UFC and UFC 3-600-01, the requirements of UFC 3-600-01 take precedence.

1-6 ANTITERRORISM AND PHYSICAL SECURITY

Installations must focus on threats at the first line of defense – the installation perimeter. Antiterrorism and physical security at the waterfront is extremely important for the protection of waterfront assets and to Installation's security. At a minimum, small craft berthing require landside security, pier access control, and identification of restricted area waterways. Coordinate antiterrorism and physical security requirements with Service and Combatant Commander policies and regulations.

Project documents must provide only the minimum amount of information necessary for the installation of all elements required for force protection and must not contain information on force protection methods, philosophy, or information on design threats, as this information is considered sensitive and for official use only. For further guidance, contact the government reviewer.

1-7 REFERENCES

A complete list of references is contained in Appendix A

CHAPTER 2

APPLICABLE CLASSES AND CHARACTERISTICS OF SMALL CRAFT

Small craft berthing facilities will be designed, constructed and operated according to the type of small craft (boats) to be accommodated and the specific needs of those boats. The primary subject of this manual is the berthing of small craft that are owned and operated by the Armed Forces of the United States (U.S). Accordingly, the first portion of this chapter discusses the characteristics of these vessels currently in use. Following is a general overview of the types of vessels accommodated at a typical boating marina, which reflects the recreational segment of small craft operated and berthed in the U.S.

2-1 MILITARY SMALL BOATS AND CRAFT

A summary of the largest branches of the armed forces and the approximate number of small craft they own and operate is presented in Figure 2-1. The distinction between a ship, boat or small craft is subjective and varies between the branches: some distinctions are by use (warship and service craft by the Navy) and others are by length (small boat is defined as less than 65 feet by the Coast Guard). For this document, small craft are those vessels less than 150 ft in length.

Branch of Military Armed Forces	Branch Abbreviation	Number of Vessels
Navy	USN	4,760
Coast Guard	USCG	1,445
Marine Corps	USMC	538
Army	USA	334
Military Sealift Command	MSC	57
Air Force	USAF	36
TOTAL =		7,170

Figure 2-1—Summary of U.S. Military Small Boats and Craft in Use

The types of small craft owned and operated by the armed forces vary according to the mission of each branch. The following section provides an overview of the classes and general characteristics of these small craft. Figure 2-2 summarizes the primary vessel characteristics including length, displacement, and mission for each vessel classification.

Vessel Classification	Ship Class	Number Active	Class Length (ft)	Displacement fully loaded (tons)	Mission
USN					
Small Boats and Service Craft	YTB 760	68	109	356	Provide a variety of services. Includes: patrol training craft (YP), tug boats (YTB), torpedo trials craft (YTT), landing craft, barges, transport boats, personnel boats, harbor patrol boats, work boats, utility boats, floating drydocks, and rigid inflatable boats
	YTB 756	3	109	409	
	YTB 752	1	101	375	
	YTT 9	3	187	1,200	
	YP 654	1	--	--	
	YP 676	27	--	--	
	Various others	4,089	12-192		
USCG					
Small Boats and Craft	Various	1,217	22-58	2-32	Used in harbors (drug interdiction, port security, cable repair, harbors and inland waters, navigation aids, illegal dumping, search and rescue, etc.), in rough surf for rescue, for inland river and lake patrol, as transports, and for firefighting
USMC					
RRC	Rigid Raiding Craft	120	18	--	Perform offensive amphibious operations
CRRC	Zodiak (replacing RRCs)	418	15	2	
USA					
Floating Utility	BC	37	120	760	Perform port terminal operations
	BD	10	140	1630	
	BG	8	120	763	
	BK	7	45	33	
	CHI	1	25	--	
	FB	2	75	64	
	HF	1	65	--	
	J-Boat	4	46	12	
	LT-128	6	128	1,057	
	LT-100	16	107	390	
	PB	10	25	--	
	Q-Boat	1	65	37	
	SLWT	4	--	--	
	ST-65	11	71	122	
	ST-45	2	45	29	
	T-Boat	1	65	--	
	Workboats	47	--	--	
Patrol Ships	ABT	7	190-194	1500-1,900	Perform drug interdiction in the Caribbean Sea

Figure 2-2 U.S. Military Small Craft Characteristics

2-1.1 **U.S. Navy.** The Navy distinguishes between ships, crafts, and boats (SECNAVINST 5030.1L, 22 Jan 93; OPNAVINST 4780.6E, 24 Jan 06). Vessels applicable to this document would be craft and boats. Characteristics and additional information for service craft can be obtained from both the Craft & Boat Support System (CBSS) http://www.boats.dt.navy.mil/ and the Naval Vessel Register (NVR) http://www.nvr.navy.mil/. Characteristics and additional information for boats can also be obtained from the Craft & Boat Support System (CBSS) http://www.boats.dt.navy.mil/ and S9086-TX-STM-010/CH-583R3, NAVAL SHIP'S TECHNICAL MANUAL CHAPTER 583 BOATS AND SMALL CRAFT.

The Navy owns and operates approximately 4,760 small boats and service craft. The Navy classifies these boats according to the type of service they perform. Types include harbor security and escort boats (HSB or sometimes PB), transport boats, work boats (WB), and utility boats (UB).

In 2006, the Navy established the Navy Expeditionary Combat Command (NECC). NECC has become one of the Navy's largest employers of boats as it conducts Explosive Ordnance Disposal, Maritime Expeditionary Security, and Riverine type missions. Types include riverine patrol boats (RPB), riverine assault boats (RAB) and riverine command boats (RCB).

Many of the service craft are non-self-propelled "lighters," or barges (YC, YFN, YON, and YRBM), used for berthing, office, messing, or repair functions or to carry fuel or equipment. Other boats and service craft include: tugboats of various sizes (YTB, YTM, and YTL), training patrol craft (YP), landing craft (LCU, LCM, CM, and PL), torpedo retrievers (TWR, TRB, and TR), floating drydocks (AFDB, AFDL, AFDM, ARD, and ARDM), and rigid inflatable boats (designated RB or RIB). Boats are often out of the water when not in use to increase the vessels' longevity, for storage or for transiting to operational areas.

Figures 2-3 to 2-5 show the dimensional characteristics of Navy Boats and Service Craft as a function of their length, as well as a comparison to guidelines for recreational vessels.

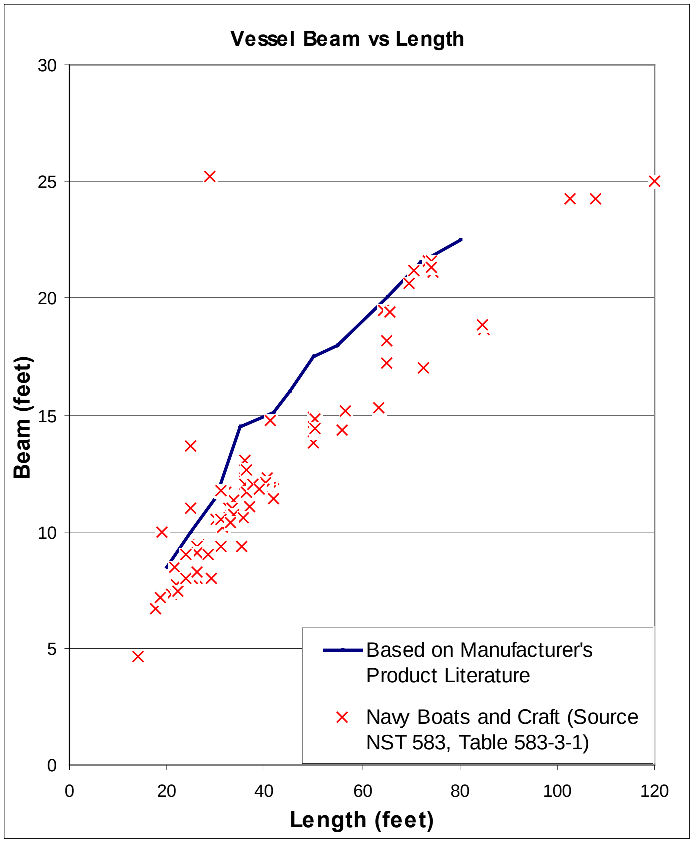


Figure 2-3 Vessel Beam vs Length

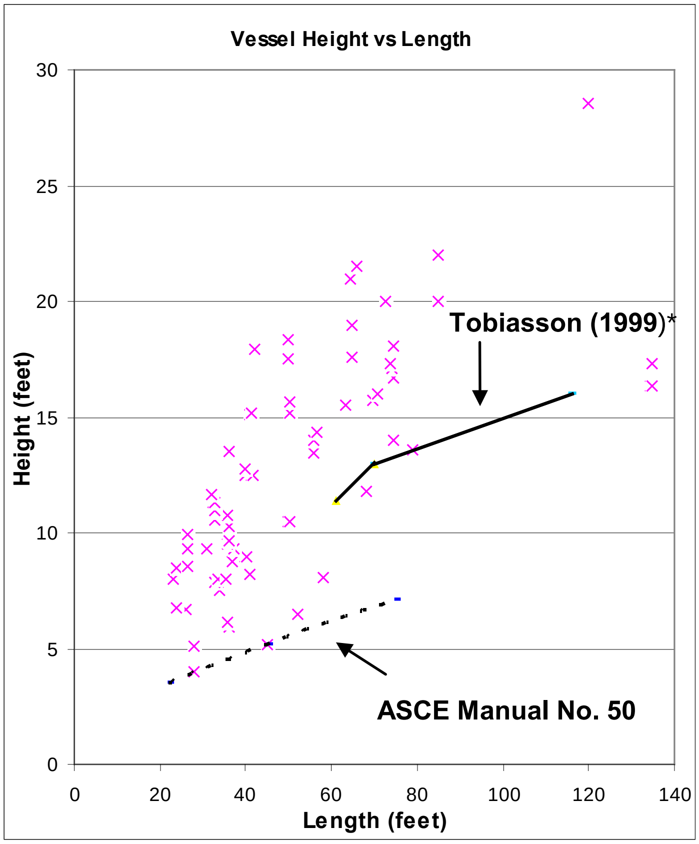


Figure 2-4 Vessel Height vs Length

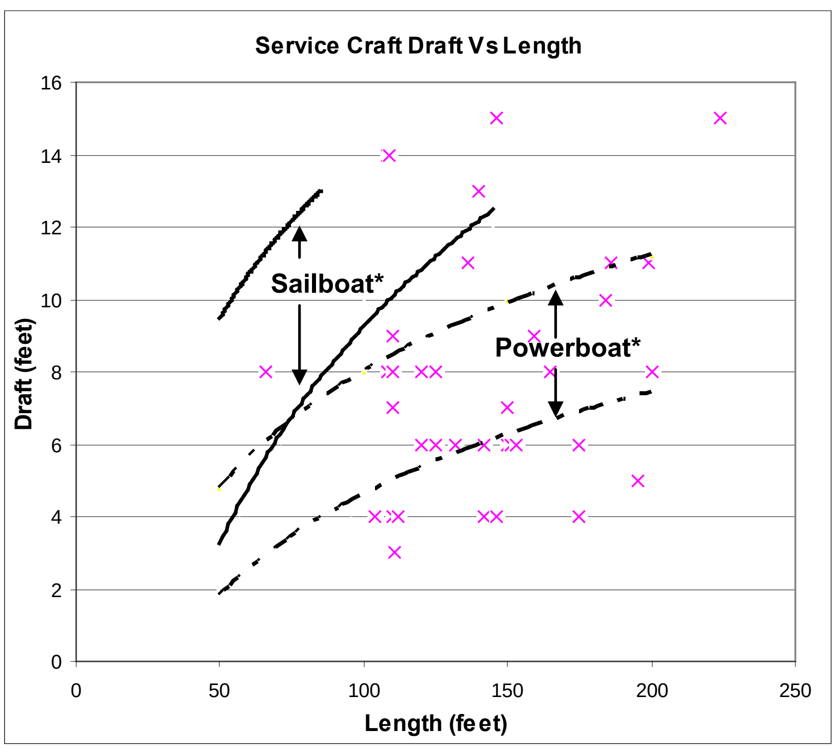


Figure 2-5 Vessel Draft vs Length

2-1.2 **U.S. Coast Guard.** Small boats and craft are used for various harbor duties, search and rescue, rough surf rescues, inland river and lake patrols, transporting equipment, and firefighting. Some of these vessels can be transported by trailer and used on inland waterways.

2-1.3 **U.S. Army.** The Army's fleet is divided into three sections: the Transportation Corps, the Intelligence and Security (I&S) Command, and the Corps of Engineers (COE). The I&S command operates patrol vessels in the Caribbean sea. The Army Transportation Corps operates lighterage and floating utility vessels. Lighterage are craft used to transport equipment, cargo, and personnel between ships, from ship to-shore, and for operational mission support, and include logistics support vessels, landing craft, and modular powered causeway ferries. Floating utility craft are used to perform port terminal operations and include ocean and harbor tugs, floating cranes, barges, and floating causeways.

The COE operates survey and construction craft, tugs, barges, and other utility craft; these craft are not included in the tables presented herein.

2-1.4 **U.S. Marine Corps.** The Marine Corps operates a large number of watercraft and amphibious craft used during special operations. The watercraft consists of inflatable combat rubber raiding craft (CRRC) and fiberglass rigid raiding craft (RRC). The CRRCs are used for in-port, river, lake, and coastal operations. The RRCs are normally deployed aboard Navy transport dock ships (i.e., LPDs) for transport to the combat area. The CRRCs and RRCs operate exclusively in coastal waters.

2-2 RECREATIONAL BOATS

The two primary types of recreational vessels are power boats and sail boats. Power boats can be further classified by the type of use: sport fishing, racing, waterskiing, cruising, etc. In recent years, recreational boats have been outfitted with more electronics and amenities such as refrigeration, complete living facilities and as a result have increased in length and beam. Slip dimensions in marinas have increased to accommodate these larger vessels. Some military boats are of a similar hull design and may be made by the same manufacturer as recreational power boats. Accordingly, manufacturer's data may be applicable for the design of small craft berthing facilities for military vessels.

Other than for Morale/Recreational Facilities provided by the military, recreational marina berthing guidelines should be carefully considered for applicability when designing for military craft.

CHAPTER 3

SMALL CRAFT HARBOR PLANNING CRITERIA

3-1 BASIN SITING CONSIDERATIONS

3-1.1 **Siting Considerations.** Small craft berthing facilities should be located in a sheltered harbor. The following key considerations apply for planning the location of the facility:

1. Protection from Winds, Waves and Currents
2. Sufficient Land and Water Area
3. Proximity to Operating Area
4. Adequate Water Depths
5. Limited Exposure to Sedimentation and Shoaling
6. Few Potential Environmental Concerns

Additional considerations include waterside access to the area where the small craft fulfill their mission, and convenient landside access for boat crews and support personnel. The most desirable sites are those that require the least amount of excavation, dredging, filling, breakwater construction, disturbance of sensitive habitat and environmental remediation. Since new sites meeting all criteria are rarely found, feasibility studies of alternative sites to compare the pros and cons of each are often required to identify the most attractive site based on an evaluation of combined engineering, environmental and economic considerations.

3-1.1.1 **Wave Protection.** The wave protection for the small craft facility is a function of land mass that surrounds the harbor basin to provide a barrier to the incoming waves. Figure 3-1 shows various configurations of landmass and classifications which make up these types of harbors. The source of waves that must be considered are both wind generated waves and vessel generated waves (or wakes). Wind generated waves can be locally generated short period waves (or chop) and longer period waves that are generated far offshore. Protection from waves is more difficult to provide and is a greater concern for small harbors on the coast that are exposed to long fetches than for harbors on inland waterways. When suitable protection is not provided by surrounding land mass, then some means of constructed wave protection must be considered.

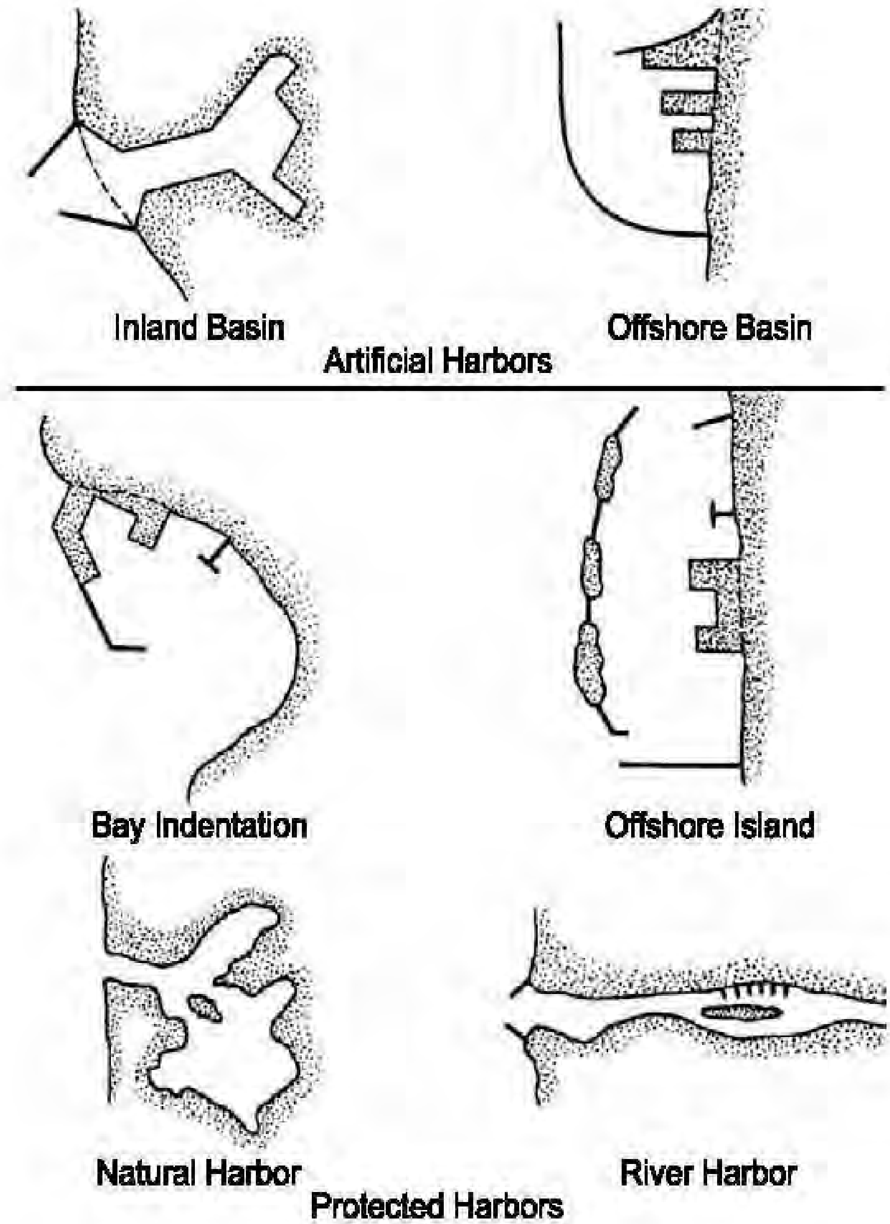


Figure 3-1 Small Craft Harbor Site Classifications

3-1.1.2 **Water Area.** The harbor must be of sufficient area to accommodate the berthing facilities, described further in Chapter 5, as well as to provide space for safe maneuvering. There are existing guidelines for the number of boats that can be accommodated per acre of water area for recreational marinas (*ASCE Manual 50*). Recreational marinas berth relatively large numbers of small craft which leads to large boat/area ratios. In contrast, most military small craft harbors accommodate a much smaller number of craft and the harbor still needs to provide channels and turning areas resulting in smaller boat area ratios than a recreational marina. Figure 3-2 represents a typical layout of a small craft harbor at a DOD installation with associated shore support facilities.

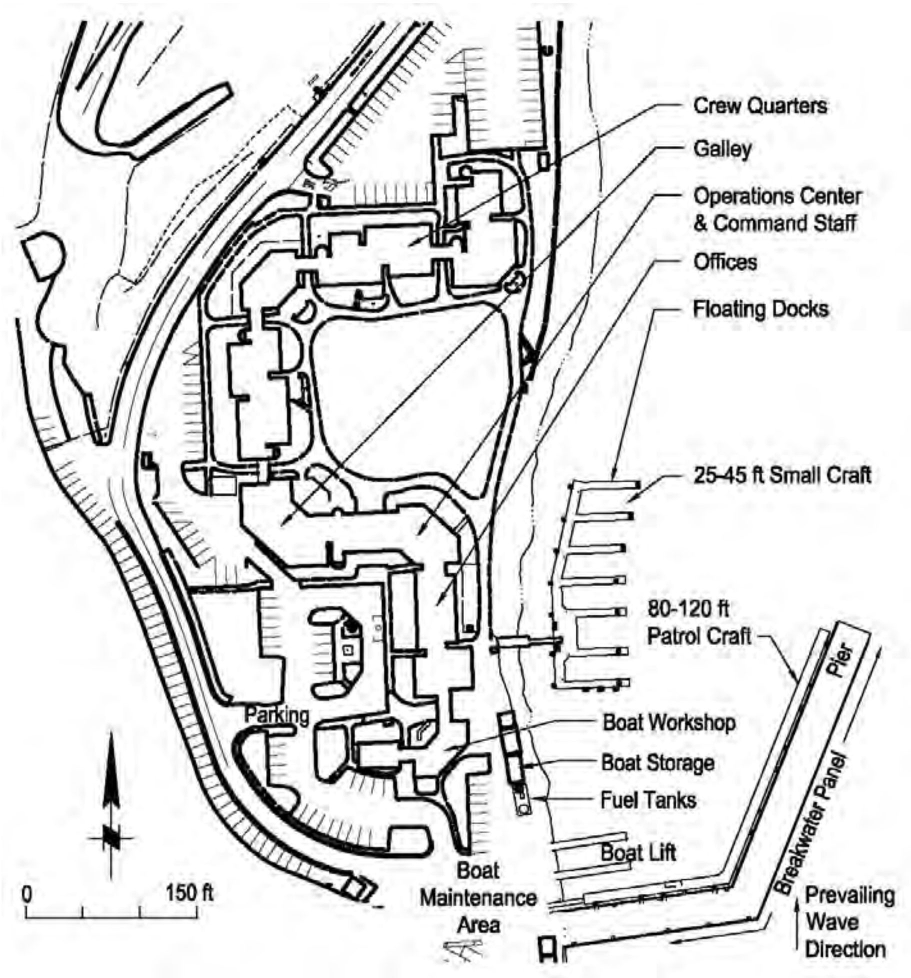


Figure 3-2 Example Military Small Craft Harbor and Shore Facility

3-1.1.3 **Minimum Depths.** In sheltered harbors, the minimum water depth should extend at least 2 ft (.61 m) for a soft harbor bottom, and 3 ft (.91 m) for a hard bottom below the keel of the deepest draft boat at the design low water level. In tidal waters, the design low water level is typically taken as the Mean Lower Low Water (MLLW) tidal datum. In harbors where wave action causes vessel motion and sedimentation reduces water depths over time, additional under keel clearance should be provided.

3-1.1.4 **Location.** The facility should be located as close as practical to the area where the small craft are intended to operate, depending upon the mission of the craft. For security response or search and rescue missions, time from when the vessel leaves the dock to when it arrives on scene can be critical. For vessels that perform longer term patrols of several days, distance from the facility will be less critical. Where the distance from the facility to the area of operation is great, boats can be trailered from the facility to a boat launching facility close to the area of operation.

3-1.1.5 **Dredging.** Most small craft harbors require dredging to maintain water depths at the facility. Harbors located on the coast often have sediment deposited near the entrance (see Figure 3-3) from alongshore sediment transport (or littoral drift);

similarly, harbors on a river often have sediment deposited near the entrance due to sediment transport processes in the river. In addition, suspended sediment can reach far into the harbor as water exchange occurs due to tidal action or river stage fluctuations, and contribute to sediment accumulation within the basin. The extent of this sedimentation can be estimated for a site with the aid of hydraulic models, and the sedimentation rate that will be experienced once a harbor is constructed evaluated for various configurations. Maintenance dredging can be a significant recurring cost due to the environmental concerns that often require disposal of dredged material in distant upland or offshore locations. When considering the minimum required water depth, include over depth to allow for sediment accumulation between maintenance dredging and for a dredging tolerance.

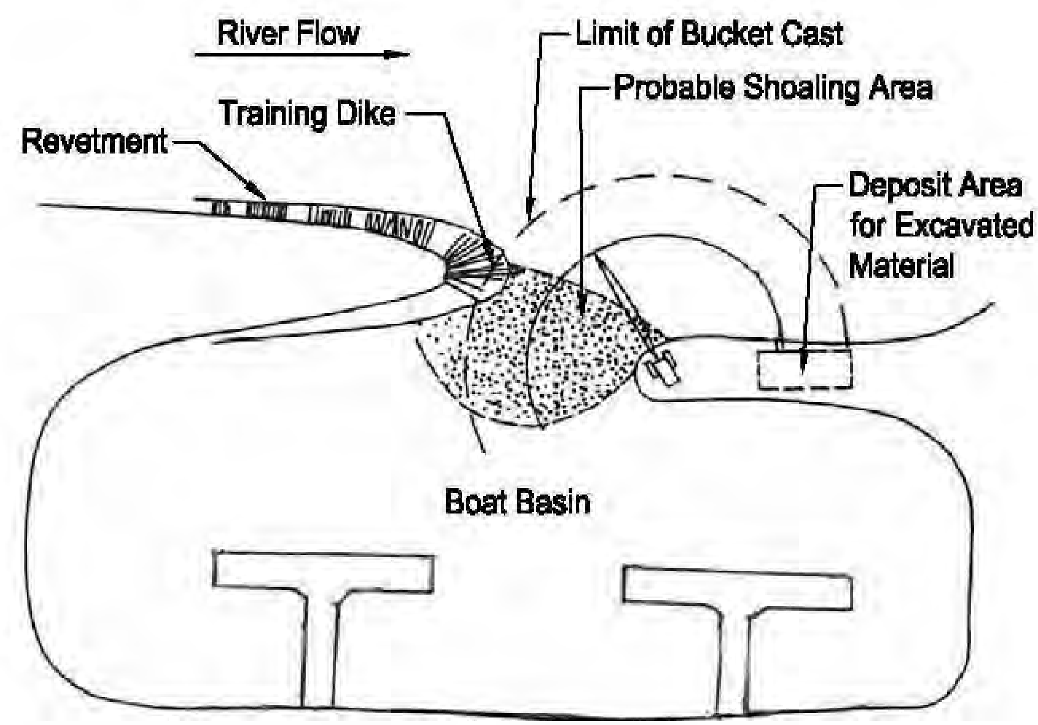


Figure 3-3 Maintenance of Entrance to Off-River Basin with Land-Based Equipment

3-1.2 **Recreational Marina Differences.** There are a number of design guidelines for recreational marinas such as *ASCE Manual 50*. However, there are important considerations in the layout of a recreational marina that would not apply directly to the design of a military harbor, some of these considerations are:

1. Economic Feasibility
2. Number and Dimensions of Vessels
3. Seasonal and Daily Boat Usage Patters
4. Walking Distance to Car

Since most recreational marinas are financed by the fees that the boat owners pay to berth their boats in the harbor, cost efficiencies must be realized to make the fees that boaters pay competitive in the market with other marinas. Therefore, one of the primary objectives of the marina design is to accommodate the maximum number of vessels within the minimum water area.

Boat use by the recreational boater is mostly on an occasional basis that tends to occur at regular times: during daylight hours on weekends and holidays in season. In contrast, military small craft will be utilized by personnel who likely live or regularly work at the small craft facility. The military craft will be utilized according to the mission assigned which will likely be at any time and in any weather. Accordingly, layout of the berthing facility must be done to accommodate the unique function of a military facility.

3-2 BERTHING FACILITY LAYOUT

3-2.1 **Berth Location and Orientation.** Within the harbor, vessels that are more difficult to maneuver, usually the larger craft, should be berthed closer to the entrance to the facility. The boat slips should be oriented such that the boats are heading into the prevailing wind when entering the berth (“upwind slip”). When the slip is oriented at 90 degrees to the wind direction (“cross wind slip”), berthing is more difficult.

3-2.2 **Launch Ramps.** Where trailered craft are used, a launch ramp is a convenient method to launch and retrieve the boat. Further, a launch ramp allows water access at a location for a large number of trailerable boats. If a launch ramp is located at a facility where vessels are also berthed, then the launch ramp should be located with sufficient separation from the berths to avoid vessel traffic conflicts. Adequate area must be provided at the top of the launch ramp to allow maneuvering room for the trailer and tow vehicle to align with the ramp. Most guidelines for recreational launch ramp facilities reflect the need to accommodate high volume usage by the public at peak times. As a result, the parking and maneuvering areas for vehicle traffic on the shore, and courtesy docks for boats waiting to be boarded or to be retrieved from the water, may be scaled back at a military facility. Launch ramp layout and design are discussed in greater detail in Chapter 11.

3-2.3 **Marine Fueling.** Where marine fueling facilities are provided, the fuel tanks should be located on shore and the delivery piping and dispensing equipment should be located on a dedicated pier or dock close to the harbor entrance. The dispenser should be located to minimize the length of fuel piping supported on the pier or dock. The fuel tanks should be located to facilitate fuel delivery truck access.

3-2.4 **Dry Boat Storage, Boat Hoists and Lifts.** When necessary to retrieve small craft from the water to address concerns such as reducing saltwater corrosion or marine fouling on the craft, or avoiding ice on the water body, or to perform maintenance and repair on the vessels, a boat hoist or lift should be provided. The main types of retrieval mechanisms are:

1. Straddle Carrier
2. Fork Lift
3. Hoist-jib Crane
4. Floating Lift

The straddle carrier is the most versatile for the larger vessels (over about 33 ft. (10 m) in length). It requires a set of fixed piers over the water upon which a rubber tired straddle carrier with slings drives to retrieve the craft from the water. Once the carrier has lifted the craft in the slings, it can drive and move the craft overland within a fairly level area with suitable surface and then place the craft within a cradle or stands for storage or for work to be performed.

The fork lift is used primarily for placing and retrieving vessels within a dry storage rack system. It will not accommodate as wide a range of vessels as the straddle carrier and requires greater maneuvering area. Fork lifts with “negative” lift are available to enable launching and retrieving small craft, typically over a bulkhead.

A hoist-jib crane is often the simplest and least costly method of launching and retrieving small craft. It is a fixed crane located on a pier or adjacent to a bulkhead over which it lifts the craft from the water. The boats may have lift points built into the hull for slings that attach to the crane hook, though under hull slings can be used when lift points are not provided. Once the craft is lifted, the crane boom revolves in a horizontal plane and lowers the boat onto an awaiting trailer on the shore which is usually towed to a storage area. This method can be adapted for larger craft by using a mobile crane with a spreader and slings sized for the vessel.

Floating lifts and drive-on dry docking are becoming more common to store boats out of the water, but in a slip. Both systems employ pontoons that submerge to permit a boat to enter or leave the slip. The pontoons are equipped with a cradle to retain the boat as the pontoon is filled with air, its buoyancy increased, and the vessel lifted to its dry storage position.

These methods of retrieval are discussed in greater detail in Chapter 10.

3-2.5 **Boat Repair and Maintenance.** Boat repair and maintenance yards should be located close to the area where craft are retrieved from the water. An enclosed work area or high bay building with an overhead crane is desirable if full service to the craft is to be performed at the facility. This facility is usually located as close to the docks as possible at a military facility. Repair and maintenance facilities are discussed in greater detail in Chapter 9.

3-2.6 **Harbor Administration / Command Center.** At most military facilities, there is a shore side component that coordinates the waterfront operations—often a dispatch or command center. This is typically located to provide visual contact with the berthing area and ready boat crew access to the command center once their mission is completed for any follow up briefings or reports.

3-2.7 **Vehicular Parking.** Vehicle parking for the boat crew should be conveniently located no more than 500 ft from the furthermost berth on the pier or dock. If the craft are to be launched from the land at the facility, parking must include spaces for a tow vehicle with boat trailer.

CHAPTER 4

BERTHING SYSTEM SITING CONSIDERATIONS

4-1 ENVIRONMENTAL

4-1.1 Weather

4-1.1.1 **Precipitation.** Frequency of occurrence and intensity of precipitation should be taken into consideration when siting a facility. They should be evaluated to determine the need for protective structures, such as dock covers, for maintenance activities and may also affect the determination of structure loads. Data on the frequency and intensity of precipitation is readily available from several sources, National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) and United States Geodetic Survey (USGS).

4-1.1.2 **Wind.** Wind is a major factor affecting the design of small craft harbors as it generates waves and loading (pressure) on the berthed craft and structures. The frequency of occurrence of wind direction and speed should be determined. This information is available from the NCDC for most areas around the U.S. If information is not available, data collection should be carried out to determine the wind conditions.

Ideally, berths are oriented upwind to the prevailing wind direction so that vessels enter berths into the wind. If this configuration is impractical then the following configurations may be used in order of priority: downwind and crosswind. The direction of prevailing winds is also to be used to define entrance channel orientation. To the extent possible, vessels should enter the basin upwind. Orienting the entrance with a cross wind condition complicates entrance navigation, and should be avoided to the extent possible.

4-1.1.3 **Fog.** Determine the frequency of occurrence of fog and to the extent possible avoid areas of dense fog. Entrance and interior channels in facilities should be as straight as possible so boaters can more easily follow channel-marking devices.

4-1.1.4 **Ice.** Determine the frequency of occurrence of ice formation in the basin and to the extent possible avoid areas where the basin would become ice locked. If the occurrence of ice in the basin is unavoidable, consider boat removal to dry storage during the winter months. If ice formation in the basin is not heavy, the use of bubblers or current inducers can help to keep the berthing area free of ice. Deflecting booms should be used to protect the berthing area from ice flows when there is no breakwater or other structure to provide protection from drifting ice. A more complete discussion of ice and cold weather impact on small craft berthing facilities is given in *ASCE Manual 50.*

4-1.2 **Water Level Fluctuations**

4-1.2.1 **Astronomical Tides.** Astronomical tides can affect access during low tides, and create strong currents in and around berthing areas. Tidal predictions for most areas are published. *Coastal Engineering Manual II-5-3* provides a comprehensive discussion of astronomical tides and the appropriate tidal datum for waterfront facility design, usually Mean Lower Low Water (MLLW).

4-1.2.2 **Storm Surge.** Storm surge should be incorporated in the determination of the extreme water level fluctuation and can be significant for sites located on large inland lakes and coastal areas with broad, shallow continental margins. *Coastal Engineering Manual II-5*-5 provides a comprehensive discussion of storm surge and the calculation methodology.

4-1.2.3 **Wave Action.** The berthing facility should be sheltered from waves. Consider the prevailing and storm wave directions and select a site with natural sheltering, if possible. For sites exposed to active shipping channels, consider ship wake as well. If natural shelter is not available, limit wave height by means of structures, such as breakwaters or wave attenuators. The berthing area should meet the wave climate criteria shown in Figure 4-1 adapted from *Design Wave Climate in Small Craft Harbors* to provide generally acceptable levels of dock system performance, vessel wear and tear, and comfort for crew that remain on board (or perform vessel maintenance) while at the berth. The criteria requires a smaller wave height for the more frequent events in the 3rd column of table 4-1, and allows a larger wave for infrequent events in the 2nd column (50 yr exceedence—a wave that occurs only once every 50 years on average). Further, the criteria provides subjective latitude by reducing the height of the allowable waves by 25% (multiple by 0.75) to provide an "excellent" climate, or increasing the wave height by 25% to provide a "moderate" climate.

Direction and peak period of significant wave	Significant wave height (H_s) Exceedance	
	50 yrs.	1 yr.
Head seas less than 2 sec	Conditions not likely to occur during this event	Less than 1 ft wave
Head seas greater than 2 sec	Less than 2 ft wave	Less than 1 ft wave
Beam seas less than 2sec	Conditions not likely to occur during this event	Less than 0.5 ft wave
Beam seas greater than 2 sec	Less than 0.8 ft wave	Less than 0.5 ft wave

Note: Criteria for an "excellent" wave climate multiply wave height by 0.75, and for moderate wave climate multiply wave height by 1.25.

Figure 4-1: Criteria for a "good" wave climate in small craft harbors

Wave climate information should be obtained for the berthing area. Determination of wave conditions will depend on the local bathymetry and exposure to the sources of waves noted above. Facilities should be located to provide protection for vessels entering and exiting the facility and avoid beam seas where possible. Wave transformation due to shoaling, refraction and diffraction within the harbor, and the determination of the potential for wave breaking must be considered as well. For further information on wave mechanics see the *Coastal Engineering Manual II*.

4-1.2.4 **Seiche.** Seiche is a phenomenon in harbors typically associated with long period, low amplitude incident waves, in which the basin geometry and incident wave combine to produce a resonant condition with basin wave heights and oscillatory velocities that are significantly greater than those of the incident wave. *Coastal Engineering Manual II-5-6* provides a comprehensive discussion of seiche, calculation methodology, and long waves.

4-1.2.5 **Tsunamis.** Tsunamis are very long period waves generated by an impulsive disturbance that can cause large water level fluctuations and high velocity currents though the source the disturbance may be thousands of miles away. Reports on the probability of occurrence for the tsunamis for many coastal locations have been prepared by the U.S. Army Corps of Engineers (USACE).

4-1.2.6 **River Stage.** For facilities located on rivers, river stage data is required for the determination of water level fluctuations. Flood stage recurrence intervals should be obtained from the stage data but extreme low river stages should be considered as well because of the impact on minimum water depths. *Coastal Engineering Manual II-5-5* and *II-8-6.f* discuss the importance of river stage and the calculation methodology used to determine the extreme water levels.

4-1.3 **Sediment Movement and Shoaling**

4-1.3.1 **Sediment Transport Processes.** Sediment transport and related deposition and erosion occur on open coasts, in tidal inlets, estuaries, harbors, and rivers and play an important role in siting a facility. An understanding of sediment transport process at the site is necessary to determine potential for shoreline erosion, sediment deposition and to address needs for dredging over the lifetime of the facility. *Coastal Engineering Manual III-2*, *III-3* and *IV* provide a comprehensive discussion of sediment transport processes, methods for analysis and sources of coastal data.

4-1.3.2 **Effects of Structures on Sediment Transport.** Structures that interfere with the path of sediment transport typically cause deposition and erosion of sediment around the structure. Potential impacts of a structure can be evaluated through modeling or analysis of historical data. Bypassing trapped sediment, or other forms of sediment renourishment are often needed to maintain the natural sediment supply and avoid adverse impacts.

4-1.3.3 **Sedimentation Within Basins.** Protected basins typically experience sedimentation, which should be determined to estimate maintenance dredging requirements in order to avoid access problems related to reduced water depths in the basin. Regular maintenance dredging of the basin or channel is usually required. Sedimentation within existing basins can be determined from analysis of historical dredging records and/or hydrographic data.

4-1.4 **Regulatory Requirements.** Regulatory requirements relate to navigational, environmental and safety issues. The United States Army Corps of Engineers (USACE) and the United States Environmental Protection Agency (EPA) regulate construction activities and dredging in the navigable waters of the United States and its territories and possessions. Facilities within the coastal zone will often require a state water quality certificate and/or a consistency determination for federal projects in order to comply with the state's Coastal Zone Management Act (CZMA) Plan. *ASCE Manual 50* and *UFC 4-150-06* (Paragraph 5-4) provide a comprehensive discussion of regulatory requirements in the United States.

4-1.5 **Geotechnical Factors**

4-1.5.1 **Geotechnical Investigations.** Geotechnical investigations determine the soil characteristics both physical and chemical, at the site. These investigations should include soil borings and soil testing to determine the engineering properties of the soil necessary for the proposed use and constructability of the project. *Coastal Engineering Manual V-2-14* and *ASCE Manual 50* provide a comprehensive discussion of geotechnical investigations.

4-1.6 **Dredging Projects.** Dredging is often necessary for the construction and maintenance of navigation channels and berthing areas to obtain sufficient water depth. Dredge material must be tested for contaminants to identify proper material handling and disposal methods. *ASCE Manual 50* provides further information on dredging.

4-2 HARBOR ENTRANCE CHANNEL

4-2.1 **Channel Alignment.** Alignment of the harbor entrance channel, outside of the protective breakwater, should consider the initial construction, long-term maintenance, and safe navigation and utilize natural conditions to the extent possible to minimize shoaling and wave penetration into the harbor. Channels are often aligned to provide the shortest path from the harbor to open water or to utilize an existing natural channel. Other considerations include aligning the channel to account for prevailing winds, waves, and currents.

Appropriate channel alignment allows vessels to transit channels upwind or downwind under the prevailing wind direction, and should not expose vessels to beam seas while in the channel. Channel alignment should also consider prevailing currents. The channel alignment may utilize existing currents to help minimize channel shoaling, but must avoid creating hazardous conditions for small craft. Channel stabilizing structures that constrict the channel area may induce higher current conditions for vessels in the channel. High current speeds can be reduced through channel enlargement.

Longshore sediment transport patterns should be considered in determining channel location because of potential impact on maintenance dredging and the shoreline adjacent to channel. If channel stabilizing structures are used, erosion of the downcoast shoreline may result. Sand bypassing around the channel to nourish the eroding shoreline should be planned using the material dredged from the channel, or from a sand trap provided on the up coast side of the channel.

4-2.2 **Channel Width.** Channel width is defined as the clear width at the design depth, and does not include the channel side slope. Channel width is dependent on the expected vessel types and volume of traffic. Minimum channel widths for 2-way traffic should be the greater of:

- 100 ft (30 m);
- 5B, where B= Beam of the largest vessel expected to use the channel;

Additional width may be warranted to provide allowances for:

- Wind, wave and current exposure that affect vessel maneuverability
- Traffic volume

Widening of the channel may be necessary at channel bends or if immediate turns exist inside the entrance channel. In order to improve the wave climate within the harbor, the channel at the breakwater opening may be narrowed to the greater of 75 ft (23 m) or 3B, where B is as defined above. This criteria includes the restriction to one-way traffic at the opening.

4-2.3 **Channel Depth.** The required channel depth at design low water should be determined by combining the following factors:

- Maximum draft of vessels
- Allowance for under keel clearance
- Wave height (as it relates to vessel motions) outside the breakwater

The maximum draft of vessels should be determined for the type of craft to be berthed regularly at the facility. Where this information is unavailable, see Chapter 2 for typical vessel dimensions.

The “squat” of a vessel is the “drawdown” of the vessel when underway in shallow water when compared to the vessel draft at rest. This is generally a concern for larger vessels but not for small craft.

The minimum allowance for under keel clearance should be 2 ft for soft bottoms and 3 ft for hard bottoms. The overdepth applied for the wave motions outside of the breakwater is a minimum of one-half the significant wave height in the channel. These values should be applied to the design low water elevation.

Additionally, where the area outside of the breakwater is exposed to open sea conditions, the channel should be deep enough for the largest vessels to enter at extreme low tide. If the area outside is sheltered from the open sea, then the channel should be deep enough for the largest vessels to enter at the design low tides, excluding the largest vessels from entering at extreme low tide.

Additional overdepth may be provided in areas where a high rate of sedimentation is experienced to permit shoaling and reduce the frequency of maintenance dredging.

4-3 PROTECTIVE STRUCTURES

4-3.1 **Jetties.** Jetties stabilize tidal inlets by confining river and tidal currents, and help provide protection for the entrance channel from waves and shoaling. *Coastal Engineering Manual VI-2* provides a comprehensive discussion of Jetties and their application.

4-3.2 **Breakwaters.** Breakwaters provide protection from wave action. *Coastal Engineering Manual VI-2* and *Planning* and *ASCE Manual 50* provide a comprehensive discussion of breakwaters, their application and design.

4-3.3 **River Current Diverters.** River current diverters provide protection from river currents at an entrance channel and can aid in reducing entrance channel shoaling.

4-3.4 **Bank Protection.** Bank protection stabilizes the berthing basin bank from erosion. *Coastal Engineering Manual VI-2* provides a comprehensive discussion on bank protection systems. Figure 4-2 shows typical structures used for bank or shore protection.

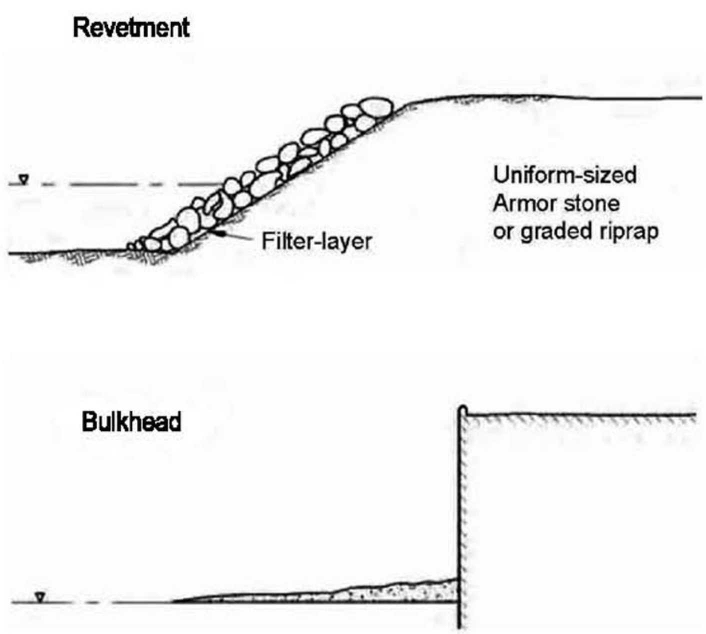


Figure 4-2 Typical Bank Protection Structures

4-3.5 **Wave Attenuators.** Wave attenuators typically consist of floating breakwaters or fixed wave screens and may be used to help protect areas from short period waves (wind waves with a limited fetch, or ship wake). *Coastal Engineering Manual VI-7-5* and *ASCE Manual 50* provide a comprehensive discussion of wave attenuators and their application.

4-4 AIDS TO NAVIGATION

4-4.1 **Purpose.** The U.S. Coast Guard operates and administers the United States Aids to Navigation System. The principal purpose of the Aids to Navigation System is to mark channels and other areas of "safe water." In addition, aids to navigation are used to mark hazards to navigation, wrecks and obstructions. To accomplish this, the Coast Guard establishes, operates, and maintains the system in the Federal Channel and major areas of maritime activity in the U.S. In areas of less activity that serve less mariners, private aids are operated and maintained by private parties upon approval from the Coast Guard. The system utilizes audio, visual, radar, or radio methods to mark safe water for navigation. The U.S. marking system is a predominantly lateral system.

4-4.2 Types of Marks

4-4.2.1 **Lateral.** Lateral marks define the port and starboard sides of a route to be followed, usually the sides of channels. Port marks are green in color and indicate the left side of channels when proceeding in the conventional direction of buoyage (returning from seaward). Marks may consist of beacons, buoys or lights. Beacons have green square daymarks, while buoys are green can or pillar buoys. Green lights of various rhythms are used on port hand marks. Starboard marks are red in color and indicate the right side of channels and consist of the same types of marks as port marks

4-4.2.2 **Isolated Danger.** These marks are erected on, moored over, or placed immediately adjacent to an isolated danger that may be passed on all sides by system users. They are black with one or more broad horizontal red bands and will be equipped with a topmark of two black spheres, one above the other. If lighted, they display a white group flashing two lights with a period of five seconds.

4-4.2.3 **Safe Water Marks.** Safe water marks indicate that there is navigable water all around the mark. Safe water marks have red and white vertical stripes.

4-4.2.4 **Special.** Special marks are not primarily intended to assist safe navigation, but to indicate special areas or features referred to in charts or other nautical publications. They may be used, for example, to mark anchorages, cable or pipeline areas, traffic separation schemes, military exercise zones, ocean data acquisition systems, etc. Special marks are colored solid yellow, and show yellow lights with a slow-flashing rhythm preferred.

4-4.2.5 **Information and Regulatory.** Information and Regulatory Marks are used to alert the mariner to various warnings or regulatory matters. These marks have orange geometric shapes against a white background.

A complete description of the aids to navigation system is described in Commandant Instruction M16500.7

CHAPTER 5

BERTHING SYSTEM LAYOUT

5-1 BERTHING SYSTEM ARRANGEMENTS

When determining the berthing arrangement, berth orientation should take into consideration the local wind and current conditions to facilitate safe berthing and vessel movements. Common berth arrangements are:

- A series of main walks extending perpendicular from the marginal wharf or dock, with finger piers or floats extending at right angles from the main walks on either side
- Larger vessels should be berthed closer to the entrance channel
- Smaller vessels should be berthed closer to the shore
- Launch and haul out facilities should be located away from other marina activities in quiet water
- Fuel service should be located near the entrance channel to facilitate access for larger vessels and separated from the berthing area.
- Seaward orientation to allow quick response

5-2 BERTHING SYSTEM DIMENSIONAL REQUIREMENTS

Figure 5-1 shows typical features and terms of a berthing system for small craft.

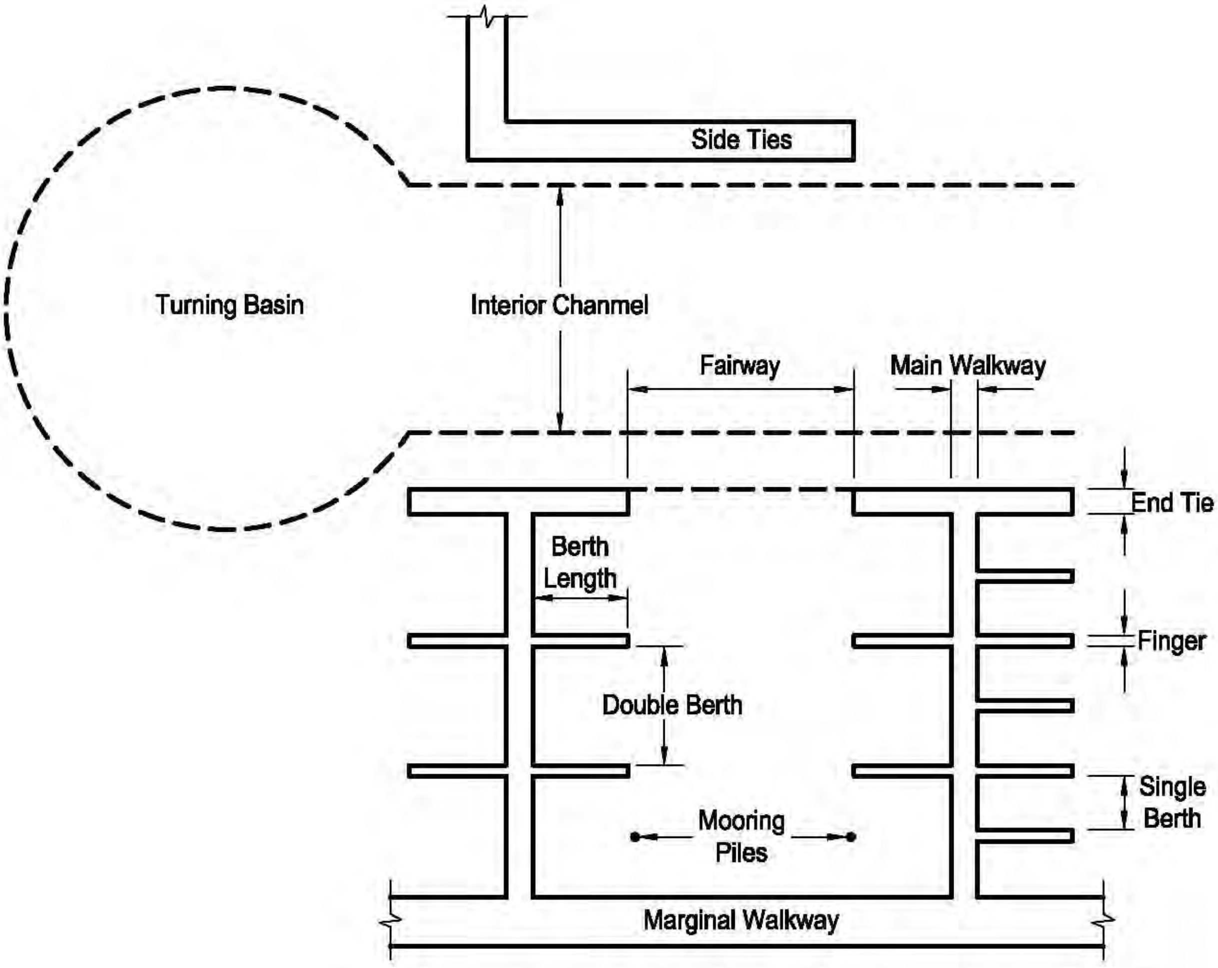


Figure 5-1 Typical Berthing Arrangement

5-2.1 **Interior Channels.** Interior channels connect the entrance channels with the berth fairways.

The minimum clear width of interior channels should be the greater of:

- 1.5 L , where L is the overall length of the longest boat using the channel or
- 75 ft. (23 m)

The preferred width of interior channels should be the greater of:

- 1.75 L, or
- 100 ft. (30 m)

Interior channel depths should be determined using the same considerations as entrance channels. The overdepth allowances for wave height and sedimentation should be included based on the wave and sedimentation patterns within the facility.

Since the minimum interior channel widths in the typical small craft harbor are based on vessel length, turning the vessel within, or at the end of the channel is accommodated without the need for an enlarged turning basin. However, if a situation arises in which a substandard channel width exists, a turning basin should be provided at an appropriate point in the channel; the basin should provide a clear turning circle whose minimum diameter is 1.5 L, where L is as defined above. Where channel currents or winds make turning difficult, this minimum should be increased to 2.0 L.

5-2.2 **Fairways.** Fairways provide vessel access from interior channels to individual berths.

The minimum clear width of fairways should be:

- 1.5 L_b (finger slips), where L_b is the length of the longest berth perpendicular to the fairway where vessel are not allowed to overhang the berth.

- 1.5 L_b (with side/end-ties), where L_b is the length of the longest berth parallel to the fairway where the fairway width does not include the side-tie berth width. A side/end tie is a berth at the end of the main walkway adjacent to the interior channel (See Figure 5-1).

The preferred clear width of fairways should be:

- 1.75 L, where L is the overall length of the longest boat using the fairway.

Fairway depths should be determined using the same considerations as interior channels.

5-2.3 **Berths.** Berth widths should be based on the particulars of the vessels to be berthed. When this information is not available, see Chapter 2 for typical vessel dimensions. The minimum width of a berth should be:

- Double berth: 2 x Beam of the wider vessels served + clearance for environmental conditions, boater experience, and fendering system

- Single Berth: Beam of the widest vessel served + clearance for environmental conditions, user experience, and fendering system

Typical clearances range from 3 ft (.9 m) to 7 ft (2.1 m), being greater for double berths, for longer berths, and where winds and currents make berthing difficult.

Berth depths should be the same as the fairway depth.

5-2.4 **Walkways.** The minimum clear width of main walkways should be 6 ft. (1.8 m). Depending on the need for dock carts passing each other and emergency access and egress, additional width may be necessary. Main walkways on floating docks should also be increased in width if they are not balanced by fingers on both sides. The width defined above is clear width between obstructions on the pier or dock such as cleats, piles, etc. The minimum clear width of marginal walkways is 8 ft. (2.4 m) to allow for increased pedestrian traffic resulting from the connection to main more than one walkway.

Walkway lengths should be limited to 700 feet for main walkways and 1000 ft for marginal walkways in consideration of:

- Walking distance between berths, parking, and restrooms
- Utility size increases due to distance
- Hauling distance for equipment, supplies and gear

5-2.5 **Fingers.** Finger width should support safe pedestrian use. The minimum clear width of the finger should be the greater of:

- 0.1 L, where L is the length of the slip served by the finger or
- 3 ft

The preferred minimum width to enhance stability of the finger is 5 ft.

Finger length should be sufficient to facilitate the loading and unloading of the vessel, and should not be less than 0.8 times the nominal length of the slip. Typically finger lengths are equal to the slip length and to the length of the boat allowed to occupy the berth. Under certain conditions overlength vessels may be permitted to “overhang” the slip into the fairway, but this practice encroaches on the required clear width of the fairway, and places a greater load on the pier or dock.

CHAPTER 6

BERTHING STRUCTURES

6-1 FIXED VS. FLOATING BERTHING SYSTEMS

6-1.1 **Selecting a Fixed or Floating Berthing System.** The selection of a fixed or floating Berthing System is primarily determined by the water level fluctuation at the site. The basis for the selection is the requirement that the fixed pier or float deck elevation match as closely as practical the deck freeboard of vessels that use the pier or float, both to facilitate boarding and to reduce the need for mooring line adjustment.

A secondary consideration is wave height at exposed berths; where waves greater than 2 feet can occur and problems due to floating dock motions would over-ride the benefits provided by the floating dock, a fixed system is preferred.

At sites where a fixed pier exists and the water level fluctuation and wave height criteria for a floating system are met, a floating dock with a variable slope gangway to transition from the pier to the float should be provided.

6-1.1.1 **Fixed systems.** Fixed systems are generally selected where the tidal range for coastal sites or the seasonal water level range for inland rivers or lakes is less than 3 feet. Figure 6-1 shows a typical fixed pier system.

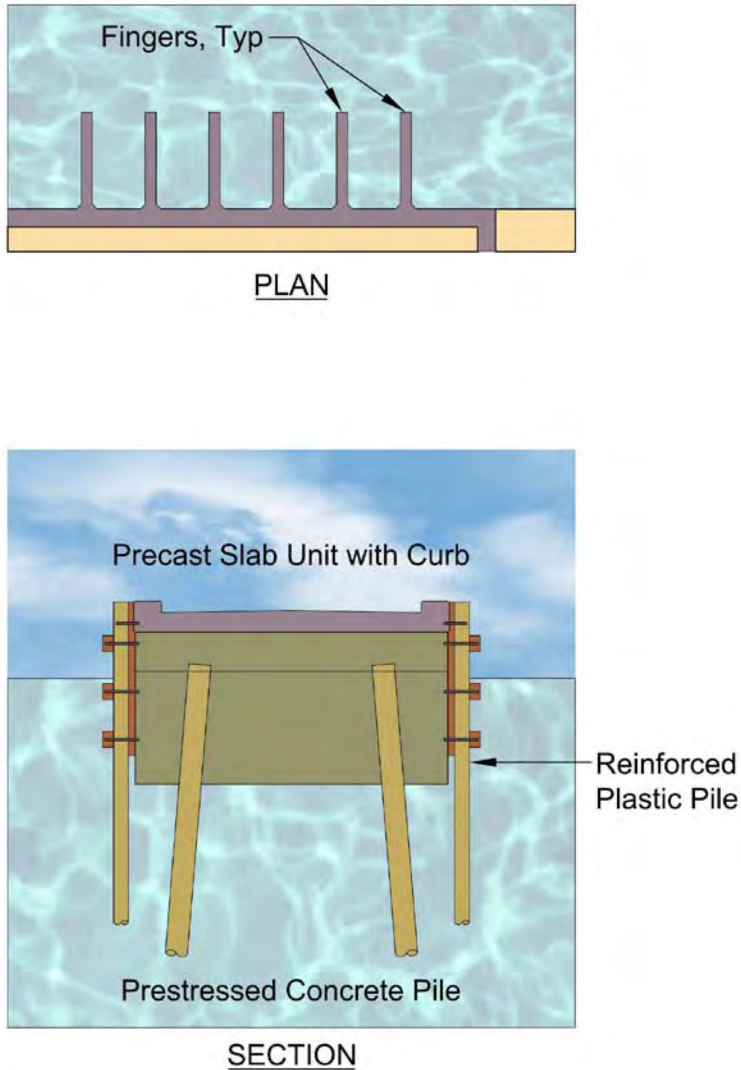


Figure 6-1 Typical Fixed Finger Pier

6-1.1.2 **Floating systems.** Floating systems are generally preferred where the tidal range or seasonal water level range is 3 feet or more. Figure 6-2 shows a typical floating pier system.

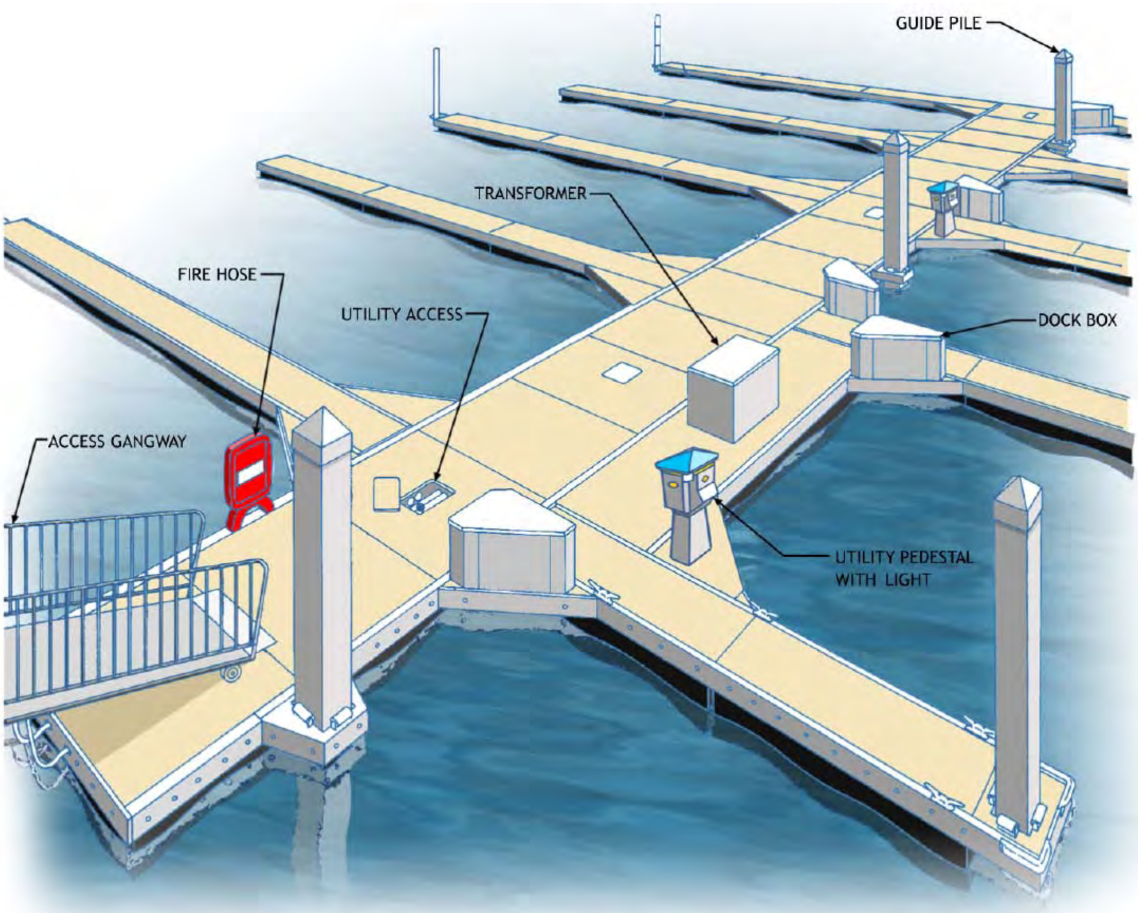


Figure 6-2 Typical Floating Finger Pier System

6-2 COVERED VS. UNCOVERED BERTHS

6-2.1 **Selecting Covered or Uncovered Berths.** Berthing systems are generally uncovered unless adverse weather, in particular precipitation, can be shown to interfere with boat operations, including boarding or essential dockside maintenance. Generally, covers to protect military vessels from exposure to the elements and retard weathering (though common in recreational marinas) are not provided.

Covers for fixed berthing systems are supported on the fixed piers. Covers for floating berthing systems may be supported on the floating dock where wave conditions permit or on fixed pile supports. Berth covers contribute significant additional dead and live loads on the fixed pier or floating dock. Besides the additional dead weight, winds can produce substantial lateral and uplift forces on the dock structure.

Fixed piers or floating docks should not be retrofitted with covers unless the structure (including flotation) was designed for the additional loads produced by the covers, or the berthing structure itself is retrofitted to withstand the additional loads.

6-3 BERTHING SYSTEM LOADING CRITERIA

6-3.1 **Dead Loads.** The dead load should include the self weight of the structure and all permanent attachments such as cleats, fenders, dock boxes, utility pedestals with associated electrical and water lines, fire suppression standpipes and fire lines, light stanchions, power centers, and where fitted, storage lockers, fuel dispensers and fuel lines, sewage pumpout units and sewage lines, etc. The water, fire, fuel and sewage lines should be considered full of liquid. If the berths will be covered, include the superimposed dead load of the cover structure.

The deadload for floating docks should also include the weight of pile guides or anchoring hardware, the superimposed dead load of the gangway reaction on the dock, and an allowance for weight gain due to water absorption in the dock flotation.

6-3.2 **Vertical Live Loads.** The vertical live load may be uniformly distributed or a concentrated point load; both cases should be checked to identify the governing case for design (See Figure 6-3). The restricted access pedestrian application may be used when dock access is controlled and the number of persons on the pier or dock at any one time can be limited to typical recreational marina densities. When it is possible for a large number of persons to congregate on the pier or dock, the unrestricted access pedestrian application should be used. In the case of floating docks, this will impose substantial additional demand on the dock to satisfy freeboard and stability criteria.

APPLICATION	UNIFORMLY DISTRIBUTED LOAD	CONCENTRATED POINT LOAD
Fixed Pier – Pedestrian ▪ Restricted Access ▪ Unrestricted Access Vehicular	 40 psf (8 kPa) 100 psf (20 kPa) Per UFC 4-152-01	 400 lbs at any point on the pier per UFC 4-152-01
Floating Dock – Pedestrian ▪ Restricted Access ▪ Unrestricted Access	25 psf. (5 kPa) 100 psf (20 kPa)	400 lbs at any point on the dock at least 1 ft from the dock edge

Figure 6-3 Vertical Live Loads on Berthing Systems

6-3.3 Floating Dock Freeboard and Stability.

6-3.3.1 **Freeboard.** Floating docks under dead load only should have a minimum freeboard to the deck of 16 inches (40 cm) and a maximum of 24 (60 cm) inches. For a safe and visually pleasing dock system, the deck cross slope on walkways or fingers should not exceed 2% and the freeboard overall should not depart from the average by more than 1 inch (2.5 cm).

Under full live load plus dead load, floating docks should have a minimum freeboard of 10 in (25 cm).

In the event that a uniform live load of 100 psf (20 kPa) is required, additional dead load freeboard of at least 15 in (38 cm) would be needed to meet the fully loaded minimum freeboard of 10 in (25 cm). As a result, the dock may ride too high under dead load only to satisfy functional requirements. If this occurs, consideration may be given to reducing the fully loaded minimum freeboard if the fully loaded condition is a rare occurrence, provided that the stability requirements can still be satisfied.

The dock freeboard and stiffness requirements (to limit deck slopes) may control the structural and flotation design rather than the minimum live loads, and should be checked.

6-3.3.2 **Stability.** The dock should have a minimum freeboard of 2 in (5.1 cm) to the top of the buoyancy pontoon to provide reserve buoyancy under full live load plus dead load. If the buoyancy pontoons provide full flotation to the top of the deck, the minimum dock freeboard noted above is sufficient to satisfy this requirement. If the width of the pontoon varies (pipe pontoons for instance) with submergence, then the minimum freeboard of the pontoon should be increased to provide reserve buoyancy equivalent to the 2 inch (5.1 cm) requirement.

The dock must also be able to withstand overturning forces and return to a normal freeboard and level condition upon removal of any unbalanced forces. Floating dock systems that consist of interconnected walkway and finger docks will generally satisfy this requirement. However, long and narrow dock modules may not, in which case a metacentric method calculation of stability should be performed. A floating dock is stable if under all conditions of loading, the metacenter is located a safe distance above the center of gravity of the structure.

6-3.4 **Environmental Loads.** The principal environmental loads to consider (not all may apply at a particular site):

- Wind, on berthed vessels as well as the pier or dock structure
- Snow and ice due to accumulation on or against the structure
- Floods, surges and tsunamis that produce both extreme water levels and currents
- Floating debris due to impact or accumulation against the structure
- Waves due to locally generated wind waves and boat wake, or swell arriving from offshore storms
- Currents due to tidal and/or river flows
- Seismic, generally of concern on fixed piers only

6-3.4.1. **Wind Load.** Wind load is based on a wind velocity pressure for steady conditions (neglecting gusts) acting on the above water profile of the berthed vessels and dock system

6-3.4.1.1 For wind velocities at various geographical locations consult *UFC 3-310-01.*

6-3.4.1.2 Convert the design wind velocity (in miles per hour) to velocity pressure using Figure 6-4 or other rational method.

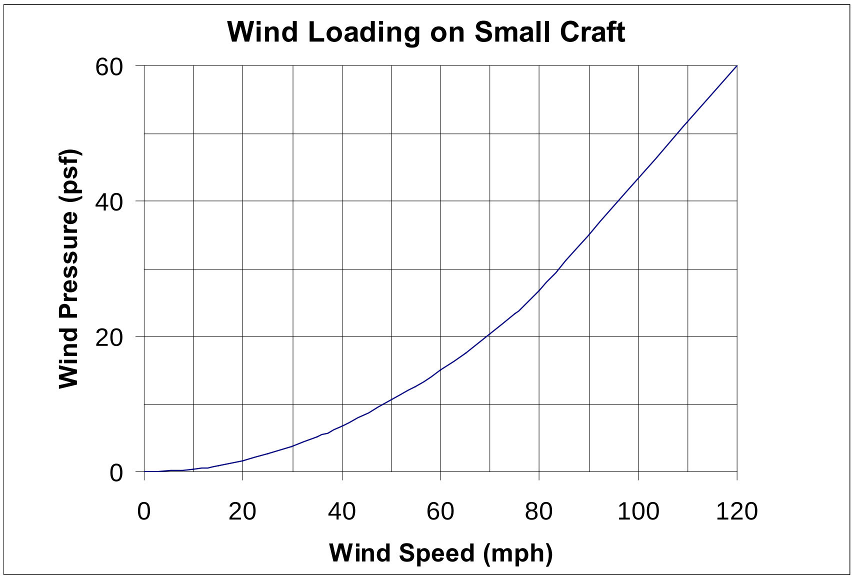
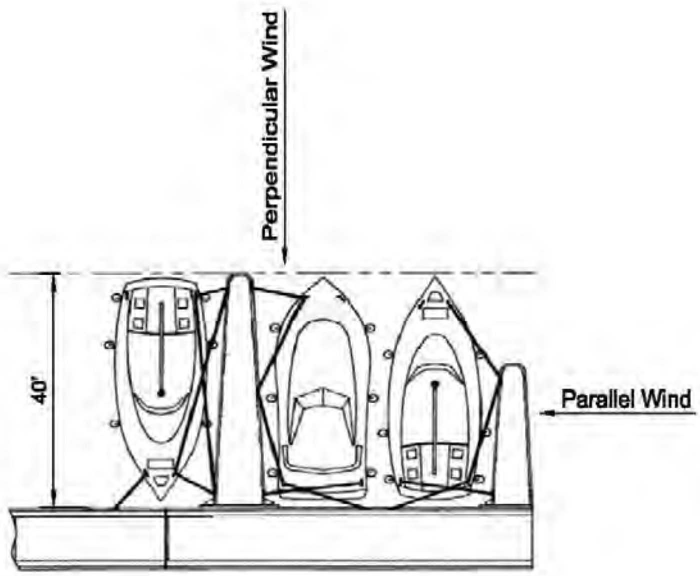


Figure 6-4 Wind Load on Small Craft

6-3.4.1.3 Determine the average profile height for the berthed vessels, generally taken as 15% of the berth length, but other rational method based on the berthed vessel dimensions may be used.

6-3.4.1.4 Compute the wind load, checking both parallel and perpendicular directions to the main axis of the pier or dock. Figure 6-5 shows a sample calculation for total wind load. Assume 100% berth occupancy. For vessels berthed in close proximity to each other, say on either side of a walkway or finger dock, the total force on the structure for each direction should be based on the full wind load applied to the windward (unshielded) vessels, and 20% of the full wind load applied to all leeward (shielded) vessels.



Design Wind Load: 15 PSF

Perpendicular Wind

40' Boats:	**3** Each x 19' Beam x 6.0' Height x 15 PSF	= **5,130 Lbs**
Fingers:	2 Each x 4' Beam x 1.5' Height x 15 PSF	= **180 Lbs**
TOTAL PERPENDICULAR LOAD:		= **5,130 Lbs**

Parallel Wind

40' Boats Unshielded:	1 Each x 40' x 6.0' Height x 15 PSF	= **3,600 Lbs**
40' Boats Shielded:	**2** Each x 40' x 6.0' Height x 3 PSF	= **1,440 Lbs**
Headwalk:	1 Each x 6' x 1.5' Height x 15 PSF	= **135 Lbs**
TOTAL PARALLEL LOAD		= **5,175 Lbs**

Figure 6-5 Sample Calculation for Windloading on a Floating Pier System

In the case where one of the berthed vessels is larger than the rest, the unscreened part of its profile area should be taken into account. Further, when the above water area of the structure is unshielded, the force on the profile area exposed to the wind should be included in the total.

Individual fingers, however, should be designed to accommodate the full wind load on the berthed craft since the presence of a shielding boat cannot be assured.

6-3.4.2 **Snow and Ice.** Snow and ice loads appropriate to the site as spelled out in local building codes should be considered. Vertical snow and ice loads, resulting from precipitation or wind driven spray, can destabilize a floating dock. Non-moving ice formed on the water surface, or ice drifting against a pier or dock can exert tremendous forces and damage the structure unless counter measures are taken to limit ice formation or accumulation. Ice problems and solutions are discussed in the *ASCE Manual 50.*

6-3.4.3 **Currents.** Currents in rivers and tidal areas can produce high loads on piers and docks and the berthed vessels through their underwater profile areas. This condition is at its worst when vessels are berthed perpendicular to the current direction, and least when the vessels are aligned with the current direction. Generally, when the current exceeds 3 ft/sec (1 m/s), it could be a significant factor in design, and a rational method should be used to determine the current forces that include consideration of:

- Peak velocities (speed and direction)
- Drag coefficients to determine velocity pressure
- Underwater profile area

Even moderate current velocities passing under floating docks can produce a downward suction on the leading edge of the dock and cause the edge to submerge unless counter measures are taken to reduce the suction force.

6-3.4.4 **Hurricanes (Typhoons), Flood Flows and Tsunamis.** Hurricanes, flood flows and tsunamis are similar in that each can produce dramatic water level rises and destructive waves and currents. If the pier or dock cannot reasonably be designed to withstand such extreme conditions, the berthing system must be relocated to a more protected site, or the consequences of catastrophic failure accepted.

6-3.4.5 **Floating Debris.** Debris mats can form against piers or docks on river or reservoir sites and exert significant loads. The structure should be designed for the drag load produced by a debris mat at least 3 ft. thick (or twice the draft of the flotation for floating docks), or the load controlled by installing a fixed or floating debris boom to deflect the debris around the structure.

6-3.4.6 **Seismic.** Seismic loads appropriate to the site as spelled out in local building codes should be considered in the design of fixed piers. Generally, seismic loads are not significant in the design of floating docks, though seismic events may trigger marina basin oscillations, and the resulting current loads and water level fluctuations can be significant, and should be considered.

6-3.4.7 **Waves and Boat Wake.** Wave heights should be limited by locating the berthing system in a sheltered area. If necessary, additional wave protection may be provided by means of a fixed or floating wave attenuator incorporated in the berthing system design. Areas sheltered from wind waves may still be subject to boat wake, since even “no wake” zones may not succeed in preventing passing vessels from generating large wakes.

6-3.4.7.1. When describing the wave climate, the terms significant wave height (H_s) and maximum wave height (H_1) are generally used. Structural designers often use the maximum wave height to size members and connections, while the significant waveheight is used to estimate floating dock motions and cyclic loads for fatigue analyses.

6-3.4.7.2. Generally, when the design wave height exceeds 1 foot, it could be a significant factor in design and a rational method should be used to determine the wave forces that include consideration of:

- Vertical wave load on a floating dock resulting from hogging (and sagging) of the dock.

- Horizontal and vertical wave forces on the submerged portion of a fixed pier (piling and bracing), or on a floating dock pontoon.

6-3.4.7.3 Wave forces are dependent upon the direction of wave approach to the structure. In particular for floating docks, the vertical loads are greatest when the wave approach is parallel to the long axis of the dock, and the horizontal loads are greatest when the wave approach is perpendicular to the long axis. If the direction of wave approach is limited, then the wave loads may also be limited by appropriate orientation of the floating dock.

For larger vessels dynamic mooring forces under the action of waves can be significant and should be considered if the vessel is to remain at its berth during extreme wave conditions.

6-3.4.8 **Anchorage.** Anchorage forces for floating docks are dependent on the type of anchorage, which can take many forms:

- Piles

- Spuds

- Cable/Winch/Anchor

- Chain/ Anchor

- Strut-to-Shore

Cable anchor systems are often utilized when water depths are large, or water level fluctuations are large and bottom slope is shallow, requiring the docks to move horizontally to remain floating. Figure 6-6 shows a cable anchorage system that allows horizontal movement.

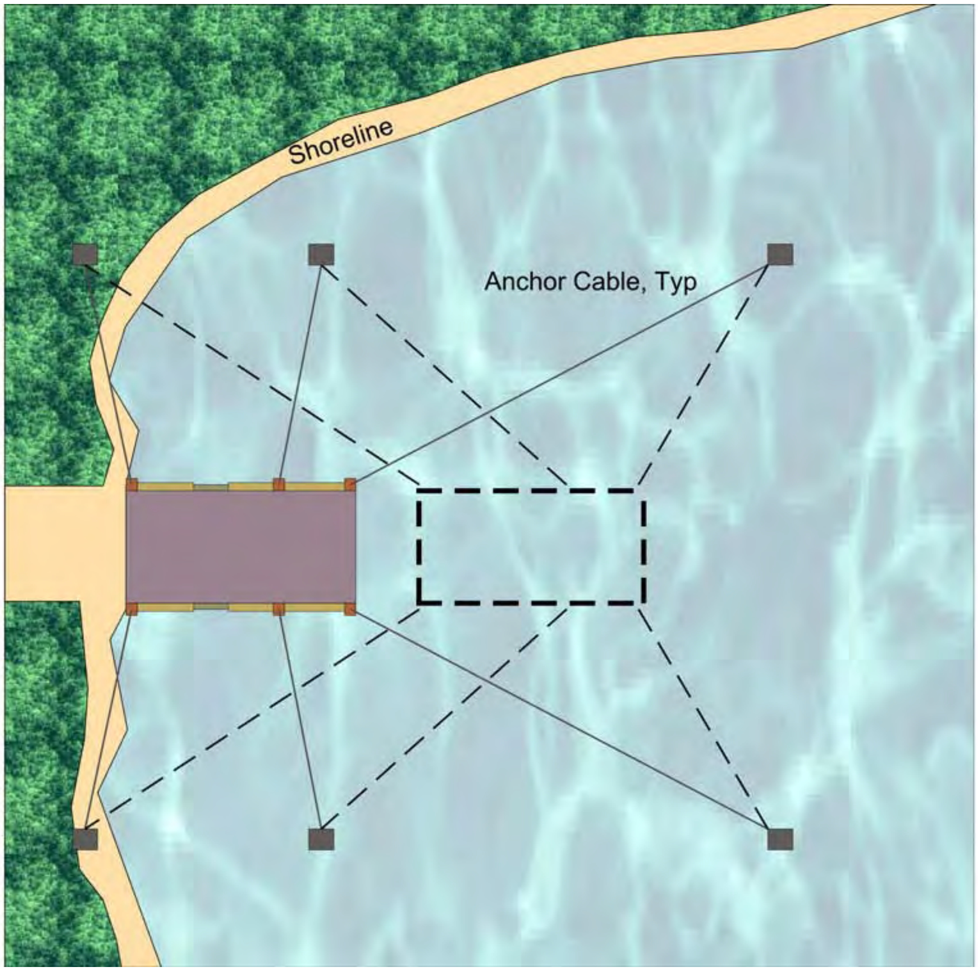


Figure 6-6 Cable Anchorage System

Specific site conditions should determine the most appropriate option, the principal site considerations being water depth, water level fluctuation, exposure to waves and condition of the submarine bed. An additional consideration is the permanence of the floating dock, as some situations require a system that can be relocated, with an anchorage that can be easily removed and reused.

Anchor loads for floating docks are generally determined by the horizontal live loads, which are additive in many cases. Specific site conditions will vary, but generally wind, wave and current loads are combined to get total loads when they can all arrive simultaneously. The type, number, location and size of the anchorage component are critical aspects of floating dock design. Inadequate anchorage is probably the most frequent cause of failure in floating dock systems. A discussion of anchorage design is presented in *ASCE Manual 50.*

6-3.5 **Berthing Loads**

6-3.5.1 **Berthing.** Berthing loads due to vessel impact on a pier or dock result from the kinetic energy of the vessel, which is a function of the design vessel's docking (laden) weight and approach velocity generally taken normal to the dock face. For small craft, no allowance is made for the bumpers typically provided on the dock face. However, deflection of the dock system anchorage for floating docks is generally considered to reduce the impact force.

6-3.5.1.1 The docking weight in lbs (w) of recreational craft may be estimated by $W=12L^2$, where L is the vessel length in feet. For military craft, the weight can be considerably greater, and vessel particulars should be obtained.

6-3.5.1.2 The approach velocity (v) generally varies with the vessel size, but the minimum should be:

- v=0.6 ft/sec for L > 60 ft. (0.2 m/s for L > 18 m)
- v=1.0 ft/sec for L < 60 ft. (0.3 m/s for L < 18 m)

The larger value should also be used regardless of length where adverse wind and current conditions create difficulty for pilots maneuvering into the berth.

6-4 BERTHING SYSTEM TYPICAL CONSTRUCTION

6-4.1 **Fixed Piers.** Fixed Piers may be constructed of many types of materials:

- Steel
- Concrete
- Aluminum
- Combinations of the Above

The basic pier structure consists of piling with caps spanning pairs of piles, and a deck structure spanning between caps. In addition to the basic structure, bumpers, mooring hardware and utility systems (generally power, potable water, fire suppression and communications) are provided. Further, piers may include wastewater reception (pumpout), fuel dispensing and lockers for gear storage. Important safety features include a slip-resistant walking surface, lighting for night operations, guard rails where they do not interfere with vessel berthing requirements, boarding ladders if the deck freeboard exceeds 3 ft (0.9 m) at design low water, and flotation devices for emergency use.

6-4.1.1 Finished Deck Elevation should be a minimum 1 ft (0.3) above design high water, or a height sufficient to prevent deck structure submergence at design high water, including allowance for wave crests, whichever is greater.

6-4.1.2 Provide bow and stern mooring points appropriately located and sized for the berth length.

6-4.1.3 Provide a bumper system able to accommodate vessels with a low rub rail without ‘hanging up’ on any structural components of the pier, for the full range of design water levels, and to accommodate vessels with a high gunwale.

6-4.1.4 For other design requirements, refer to UFC 4-152-01.

6-4.2 **Anchoring Floating Docks.** Floating Docks may be constructed of many types of materials, similar to fixed docks. In addition, plastic and fiberglass materials are finding increased use in floating dock construction. Modular factory fabricated floating dock systems are now in common use. Figure 6-7 shows some typical fabricated floating dock systems. Consideration should be given to using an appropriate commercial product, preferably one with a proven track record over many years of experience. The basic dock structure consists of the flotation pontoon, the structural frame, the deck, and the anchorage. In some proprietary systems the flotation, frame and deck are unitized so that system assembly consists essentially of bolting the modular pontoon units together. The basic dock structure should be finished with all of the appurtenances noted previously for fixed piers.

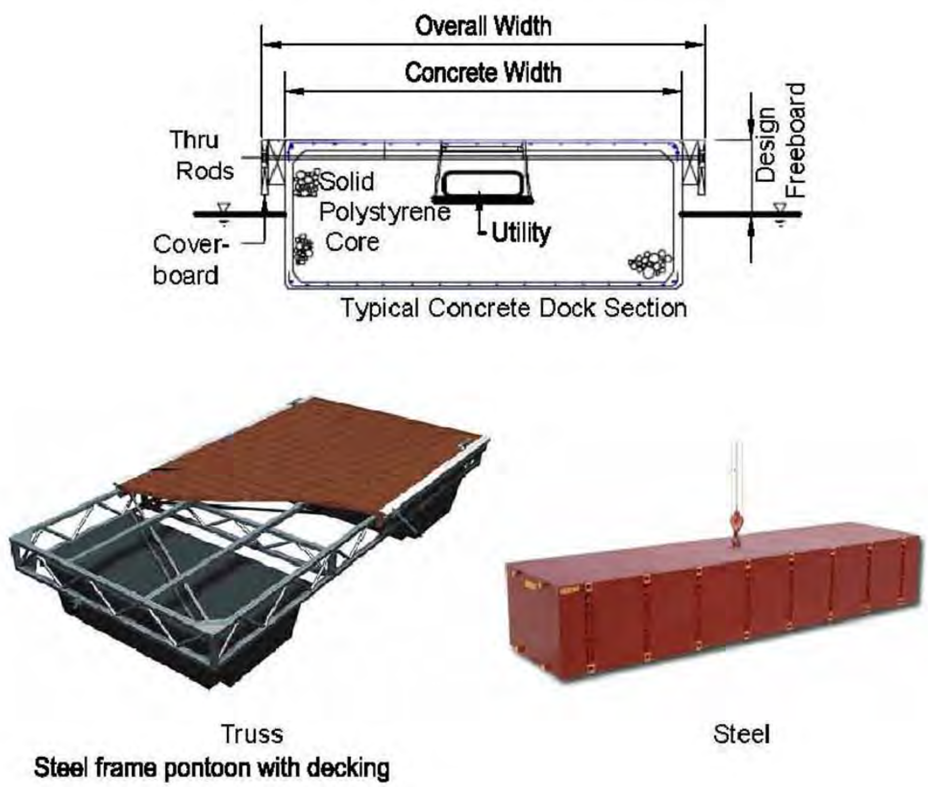


Figure 6-7 Various Types of Floating Docks

6-4.2.1 **Flotation Pontoons.** Flotation pontoons should consist of a foam core completely encapsulated in a protective shell to prevent contact with water or other deleterious elements. The foam generally consists of expanded polystyrene (EPS) closed cell blocks, but other types of foam may be used. Although the foam should be protected by the shell from water contact; certain materials may lose their water-tightness over time. However, a quality foam core will prevent significant loss of buoyancy. This should be acceptable if the maximum water absorption of the EPS core is limited to less than 3% as determined by ASTM Standard C272, Method C, the amount of reground material is limited to less than 10%, and the form core is preformed to the interior configuration of the pontoon as a solid block.

6-4.2.2 **Deck Surface.** Deck surface should withstand prolonged exposure to the elements (sunlight, wetting/drying, freezing/thawing etc., unless the berth is covered), severe abrasion by scuffing and dropped objects, and fatigue due to dock motions and flexing. Further, the surface should be non-skid, and resistant to staining by spills and dirt.

6-4.2.3 **Floating Docks.** Floating docks should be anchored against lateral forces.

6-4.2.3.1 **Cantilever Anchor Piles.** Cantilever anchor piles are simple and the most commonly used anchorage. Generally they are preferred when the water depth at the design high water level is less than 30 ft (9 m). The pile should be high enough so that the dock will not float off the top, so allowance must be made for the dock freeboard and motions due to waves and surge in addition to the extreme high water level. Where piles are used, pile guides should be incorporated in the dock structure. Guides generally consist of collars faced with Ultra High Molecular Weight (UHMW) polyethylene rub blocks, which wear and are replaced periodically. In well protected basins, pile guide rollers may be used in lieu of the rub blocks. The anchor piles are generally prestressed concrete or steel pipe; timber marine piles are rarely specified due to concerns over preservative chemicals used to treat softwood piles, or tropical rain forest protection for the naturally resistant species. In situations where dock loads and water depths exceed the capability of simple cantilever anchor piles, multi-pile dolphins may be considered, with the braced vertical pile serving as the guide pile.

6-4.2.3.2 **Anchor Lines.** Anchor lines are generally used where the dock system is constructed in deep water, or where large water level fluctuations occur. For situations where the extreme wave exposure favors a more compliant anchorage to reduce peak loads, anchor lines are often used as well. The anchor lines consist of wire rope, steel cables or chains. Where the floating dock system requires movement through considerable horizontal distance with water level changes, or where large loads are involved, winch systems are used to adjust line tension and control dock position. In most cases the winches are located on the floating dock and the dead load of the winch and anchor line pull must be factored into the design of the dock floatation. A cable guide should extend a sufficient depth below the winch so that the cable leading away from the dock to the anchors will not interfere with the deepest part of the vessels likely to use the dock. Design of cable anchor systems involves complex non-linear analyses to determine cable behavior and the resultant loads on the ground anchors, particularly as the number of cables increase. Design requirements for mooring systems are described in UFC 4-159-03.

6-5 MOORING FITTINGS AND BUMPERS

6-5.1 **Cleats.** Vessel to pier or dock tie up generally utilizes cleats attached to the structure. Since cleat manufacturers do not specify guaranteed minimum holding strengths, the sizing of cleats and their attachment is largely driven by experience.

6-5.1.1 **Number and Location.** Provide a minimum of 3 equally spaced cleats per berth for vessels over 20 ft (6 m) in length and less than 60 ft (18 m); larger vessels will require additional cleats. Single berths (with a finger dock on each side) should have the minimum number of cleats on each side of the berth; double berths (with a finger dock on only one side of the vessel) should have an additional cleat for each berth on the main walk near the center of the slip. The cleats should be located along the edge of the pier or dock to minimize tripping hazard.

6-5.1.2 **Size.** Piers or docks required to hold vessels under extreme wind and wave conditions should receive a rational analysis of peak mooring loads, and an attempt made to obtain data from manufacturers on maximum cleat capacities in order to size the cleats. Generally, however, the following sizes have proven adequate for most situations:

Berth Length L – ft. (m)	Cleat Size – in. (cm)
L< 40 (12)	10 (25)
40 ≤ L < 60 (18)	15 (38)
60 ≤ L < 80 (24)	18 (46)
L ≥ 80	24 (61)

6-5.1.3 **Attachment.** Attach cleats with a minimum of two through bolts into the structural frame of the pier or dock. Plate washers should be used to distribute cleat pull out forces without crushing the structural support. Bolt heads should be recessed into the cleat so lines do not chafe on them; the recess should be filled to prevent water ponding and corrosion.

6-5.2 **Bumpers.** Vessels and piers or docks need protection from each other because of impact and chafing. Hardware used to fasten the various types of bumpers to the pier or dock structural frame should have all exposed heads on the berth face recessed to prevent hull damage. The solutions described below are considered part of the pier or dock, and would be in addition to the portable fenders typically deployed on the vessel itself.

6-5.2.1 **Horizontal Rub Rails.** Generally a continuous recycled plastic lumber, rub rail running the full length of the berth is attached wherever a vessel can contact the pier or dock. Additional protection may be provided by means of a continuous vinyl bumper strip attached to the top edge of the rub rail, largely to reduce marring of the vessel hull, but also to provide some cushioning.

6-5.2.2 **Vertical Rub Strakes.** Generally rub strakes extend below the deck to contact the lowest vessel rub rail at design low water, and prevent the rail from 'hanging up' on the horizontal member at the face of the dock or pier. The top of the rub strakes should extend above the deck far enough to contact the highest vessel rub rail at design high water for the same purpose. Rub strakes are generally fitted to fixed piers as the freeboard variations tend to be greater and the hull rub rail problem arises more often than with floating docks, whose freeboard remains relatively constant. If the berthed vessels are not fitted with rub rails, rub strakes should be avoided on floating docks in particular.

6-5.2.2.1 Rub strakes should be placed at 1/3 points on the berths, starting at the outer end and omitting the strake on the inner end: Do not omit strakes for continuous side tie berthing. Generally, recessed horizontal rub rails are still used between the strakes.

6-5.2.2.2 Rub strakes should be attached to the structural frame of the pier or dock. Generally, the vessel (due to hull curvature) will lay up against only 2 strakes, and vessel loads are applied to the structure at the level of the vessel rub rail rather than the dock frame, creating a torsional load on the frame.

6-5.2.2.3 Vertical rub strakes may also be fitted with vinyl bumper strips attached on the berth face, similar to the horizontal rub rail.

6-6 ACCESS PIERS AND GANGWAYS

6-6.1 **Accessing Fixed Piers.** Access to a fixed pier berthing system is relatively straight forward, and may be provided by an extension of the berthing system main walkway. For situations where the elevation of the point of access on the shoreline bulkhead or landing is greater than the deck elevation on the fixed pier, a ramp should be provided that conforms to code requirements.

6-6.2 **Accessing Floating Docks.** Access to a floating dock system typically requires a hinged gangway with a variable slope ramp to span between the fixed access point on shore and the floating dock. Design Criteria for the variable slope gangway ramp are discussed in *DBW Layout and Design Guidelines*.

6-6.2.1 **Gangway Ramp Upper Support.** The upper end of the gangway ramp should be supported on the shoreline bulkhead, or on a fixed pier to provide access to a floating dock system that is located a considerable distance from shore. The support should be in the form of a "hinge" that accommodates the vertical swing of the gangway in response to changing water level as well as the horizontal sway in response to floating dock drift.

6-6.2.2 **Gangway Ramp Lower Support.** The lower end of the gangway ramp should be supported on the floating dock, which must be provided with additional flotation to offset the superimposed dead load of the ramp plus 50% of the live load reaction and maintain the required dock dead load freeboard. The remaining 50% of the live load reaction is distributed to the dock system flotation by the dock structure on demand. Experience has shown that providing sufficient flotation for 100% of the live load results in excessive dead load freeboard. The ramp support on the dock consists of HDPE skidplates or rollers to carry the loads and reduce wear on the deck as the ramp adjusts to changing water levels.

6-6.2.3 **Gangway Ramp Structure.** The gangway ramp construction may be of steel or aluminum, with aluminum being the most common because of weight savings. Standardized factory designed aluminum ramps are now in common use to cover a wide range of load requirements, widths and lengths.

6-6.2.3.1 The ramp should have a minimum of 3 ft (0.9 m) clear width.

6-6.2.3.2 The maximum slope at design low water should be 3 (horizontal) to 1 (vertical). The length of the ramp should be the minimum to achieve the slope requirement at design low water. Generally gangway lengths greater than 80 ft are not used; either steeper slopes (2.5 to 1 absolute maximum) or special stair-ramp structures that convert to stair steps at steeper slopes may be used instead.

6-6.2.3.3 The vertical live load on the ramp should be a minimum of 50 psf (10 kPa) if dock access is restricted; use 100 psf (20 kPa) if dock access is unrestricted or public assembly use is permitted.

6-6.2.3.4 The ramps should have guardrails and handrails on both sides in conformance with occupational safety requirements, and an aggressively non-slip walking surface when dry or wet. Raised treads placed transversely are sometimes used for this purpose, but are a potential tripping hazard and are not the preferred solution.

6-6.2.3.5 Generally ramps also support utility feeders for the dock systems, and the added dead load of the utility lines must be considered.

CHAPTER 7

HOTEL SERVICES (UTILITIES)

7-1 POTABLE WATER

Potable water service is typically provided to individual berths by means of a ¾" hose bibb mounted next to the berth. The hose bibb is supplied by a line on the main walkway. Water demand is estimated to be about 25 gallons (95 L) per berth per day. When potable water is supplied from the public mains system it should be in accordance with the requirements of the local water authority. Piping should be non-corrodible and ultraviolet-stabilized. Flexible hose shall be used when making dock-to-shore connections to allow movements. Rigid lines may be used on piers and docks with the consideration of the expansion and contraction of the material, special consideration of line flexibility should be taken on floating dock systems.

7-2 SEWAGE AND OILY WASTEWATER

7-2.1 **Holding Tanks.** Pumpout facilities should be provided for the emptying of sewage holding tanks to meet the requirements of the local wastewater authority for proper disposal of sewage. Typical small craft sewage pumpout facilities consist of a central pump station with a flex hose that can vacuum out the vessel's holding tank contents by means of a flex hose connection between the pumpout hydrant on the dock and the holding tank fitting on the vessel. Pumpout hydrants may be located at intervals throughout the marina so boats can be serviced at their berths, or located on a "public" dock for vessels to pull-up for service. Pumpout facilities are typically rated about 40 gals/min (150 L/min). The pumpout facility should include a water hose bibb to permit flushing of the holding tank; the hose bibb should be marked "non-potable water". If the pumpout station is located near a fueling station, allow space sufficient between the two facilities so that vessels may utilize either facility without interfering with the operation of the other.

7-2.2 **Pump Station.** The pumpout station is connected to a landside sewer system via force main with a sewage pump.

The sewage pump is typically rated at about 40 gals/min and is a peristaltic or diaphragm type of pump, to reduce clogging from solids being pumped.

7-2.3 **Bilges.** Bilge water if contaminated with oil should be collected and disposed to the oily Waste system. Some marinas now offer bilge water pumpout facilities separate from the sewage pumpout to receive and treat oily wastes.

7-3 ELECTRICAL

Electrical service is provided to individual berths for vessel usage by means of weatherproof receptacles, mounted on a locker box (as with potable water) or with lighting in pedestals. Electrical service is commonly provided at 120/240 vac single phase or 208 vac 3 phase, at currents of 20-100 amps, typically. *ASCE Manual 50* provides a detailed discussion of small craft berthing facility electrical systems.

7-4 COMMUNICATION

Communication systems include an intercommunication system, such as a public address or paging system with speakers located within easy hearing distance of every berth. Telephone service, though not commonly provided at Naval facilities, may be provided at each slip if desired, often located with lighting and electrical service in one pedestal. Fiber optic and high speed internet service can be included as well. Typically, the service provided installs the required equipment in raceways and cabinets provided for that purpose. *ASCE Manual 50* provides a detailed discussion of small craft berthing facility telephone service.

7-5 FUEL

Marine fueling stations are often provided in small craft berthing facilities and shall comply with the requirements of NFPA 30A, “Motor Fuel Dispensing Facilities and Repair Garages", unless it is anticipated that some berthing facilities will not be constructed on government property. If berthing facilities will be constructed on private property, then comply with the requirements of the authority having jurisdiction. Determine the fueling requirements (types of fueling, fill rate and quantity) for the classes of vessels to be berthed. Fueling systems should be separated from the berths and landside facilities by required fire separation distances in accordance with UFC 3-600-01. The fueling station is typically located near the harbor entrance in an area that is protected from waves and is often near the sewage pumpout station. The adjacent land area must be suitable for fuel storage tanks and accessible for fuel delivery vehicles and fire fighting equipment. Provide spill containment equipment as required by the local environmental authority.

7-6 LIGHTING

Waterfront areas consist of a defined perimeter (landside and waterside), restricted area, entry control facilities at the entrance into the waterfront area, access control points located at each pier, and pedestrian access control points along the perimeter. In waterfront areas, utilize high mast lighting to reduce the number of poles minimizing obstructions to waterfront operations and maintaining clear paths for equipment and vehicles. Provide full cutoff or fully shielded fixtures mounted in the horizontal plane to limit direct and reflected glare. Lamps should be metal halide (MH) to improve color rendering and nighttime visibility. Refer to UFC 4-152-01 for Pier and Wharf operational lighting requirements and UFC 3-530-01 for lighting design. Note, in some regions, white light sources may interfere with the marine environment. Coordinate marine issues with the local environmental authority.

7-7 FIRE FIGHTING

Fire protection should be provided through appropriate design and placement of firefighting equipment on the piers and docks in accordance with the *Fire Protection Standard for Marinas and Boatyards NFPA 303,* and *UFC 3-600-01*. If any conflict occurs between this UFC, the *NFPA 303* and *UFC 3-600-01*, the requirements of *UFC 3-600-01* take precedence.

All firefighting equipment shall comply with the requirements of NFPA 303 and UFC 3-600-01. Firefighting equipment includes, but is not be limited to:

- Portable chemical extinguishers placed at 200 ft (60 m) intervals along each main walkway housed in cabinets painted red.
- Fire-alarm boxes placed at convenient locations on or near piers.
- Fire hydrants or stand pipes located along the shoreline near where the dock/berthing slip meets the shoreline.

Firefighting equipment should be maintained and inspected in accordance with UFC 3-600-02.

7-8 LOCKER BOXES

Locker boxes provide a place for gear storage on the pier or dock, convenient to the berth. They are typically made of sheet metal, or fiberglass. Locker boxes are typically located in the knee brace of floating dock systems or other similar out-of-the-traveled-way place.

CHAPTER 8

DRY STORAGE FACILITIES

8-1 DESCRIPTION

Dry storage of small craft is the practice of removing the craft from the water until it is placed in service. Dry storage of boats is performed using two common methods: trailer storage in a yard (yard storage) and rack storage (drystack).

8-2 YARD STORAGE

The most common method of dry storage is storage on trailers within a yard area. In this method, boats are kept on trailers that allow them to be transported on the road (Figure 8-1 shows typical yard storage).

Figure 8-1, Yard Dry Storage

Once the boat is loaded onto the trailer, the trailer is kept in a designated spot within the yard—which is usually paved and enclosed with a locked security fence. The boat gains access to the water either by a ramp, or crane. For the ramp, the boat and trailer are towed, by a vehicle, down the ramp into the water until the trailer is submerged and the boat floats freely, whereupon, the trailer is usually returned to the dry storage yard until the boat is to be retrieved from the water, when the process is reversed. Utilizing a crane, the boat and trailer are towed to the crane location, which is usually close by on a pier or bulkhead adjacent to the water. (Figure 8-2 shows a typical crane). The boat is fitted with a wire rope sling that attaches to fittings on the boat and then to a single pick up point that the crane hook lifts the boat from the trailer. Once the boat is lifted free of the trailer, the crane swivels about a vertical axis to place the boat out above the water, and then it lowers the boat into the water. Again, the trailer is returned to the dry storage yard until the boat returns and the process is reversed.

Figure 8-2, Small Craft Crane Access (Jib-boom)

8-2.1 **Characteristics.** The general characteristics of yard dry storage are summarized as follows:

- Vessel stored on trailer
- Launched from ramp or crane
- Vessels < 35 ft in length
- Vessel density: 50-80 vessels/acre

8-2.2 **Advantages.** The primary advantages of yard storage are:

- Less costly
- Low height
- Can be performed by boat operator
- Provides destructive weather (hurricanes, deep freeze) haven

8-2.3 **Disadvantages.** The disadvantages of yard storage are:

- Requires greater land area
- Requires time to launch/retrieve vessel

8-3 DRY STACK STORAGE

Figure 8-3, Drystack (rack) Storage

8-3.1 **Characteristics.** The general characteristics of dry stack (rack) storage are summarized as follows:

Vessel Weight:	< 6 tons
Vessel Length	< 35 ft
Rack levels	4-5 Max.
Vessel Density	392 vessels/acre

8-3.2 **Advantages.** The primary advantages of rack storage are:

- Reduced land area required to store a given number of small craft
- Craft are kept dry when not in use, reducing deterioration
- Increased security

8-3.3 **Disadvantages.** The disadvantages of stack storage are:

- Requires trained operator to retrieve and launch the vessel
- Requires landside facility
- Vessel is not immediately ready in the water
- High structure can be objectionable in view corridors
- Heavy structure loads require suitable foundation conditions

8-3.4 **Covered Storage.** The storage rack can be located inside a building, usually a metal building, to provide protection from the weather. The building will usually require sprinklers for fire protection in accordance with NFPA 303. Because these storage facilities are often higher than 35 ft, they can be objectionable from a visual perspective along the waterfront.

8-4 APPLICABILITY

Dry storage provides increased security and increased service life of the vessels, as well as reduced maintenance, due to storage out of the water and out of the weather, if covered storage is used. However, yard storage is most probably the preferred method for military facilities.

As discussed above, the primary reason for constructing a stack storage system is to fit as many small craft as possible into a small area—typically done in areas of high real estate values in dense urban settings. This would rarely be the case at most military facilities due to the small number of small craft that need to be accommodated. Further, the advance notice required to launch vessels, may not lend itself to the operational needs of the small craft. For these reason, dry stack storage is generally suited for recreational vessels in urban areas or areas of inclement weather. Several publications provide additional guidance for dry stack storage *ASCE Manual 50*.

CHAPTER 9

BOAT REPAIR/MAINTENANCE

9-1 GENERAL

Repair and maintenance are required by all small craft during their service life. The location of the facility for repair and maintenance is often determined by the mission of the craft, and the availability of a standby craft to replace the ready boat while it undergoes repair/maintenance. The repair/maintenance facility can be located either at the same facility (onsite), or at a ship yard or another facility (offsite).

9-1.1 **Onsite.** Typically, at least minor maintenance and repair to deck equipment will be performed onsite, usually at the craft moorings, including replacement of broken fittings and tasks that can be performed with hand tools. More involved work can be performed onsite if the facility has a haul out and shoreside repair facilities to perform the work.

9-1.2 **Offsite.** Where onsite facilities do not exist, or do not have the capability to perform the required work, the maintenance and repair work will have to be performed offsite. Offsite facilities can either be boat yards that specialize in small craft repair including hull repair and coatings, or may be facilities that perform general work such as a machine shop or engine repair shop. In regions with large port and marine activities, boat/ship yards are generally available to work on small craft.

9-2 MAINTENANCE SCOPE

9-2.1 **Hull.** Repair and maintenance of the hull requires that either the vessel be hauled out of the water or the work be performed by a diver.

9-2.2 **Deck.** Most minor replacement of deck fittings and equipment (cleats, rails, antenna, etc) can be performed at the slip. For more extensive work, the vessel will usually be removed from the water and placed on land on stands or taken to a dry dock where overhead cranes can lift heavier equipment and where there is access to welding and other power equipment.

9-2.3 **Engine.** Similar to deck work, minor engine work can be performed on the vessel. There is an increased use of outboard engines on small craft under approximately 35 feet in length. This allows quick replacement of the engine if a spare is on hand, for more involved maintenance or repair of the affected engine either on site or at a specialized repair shop.

9-3 MAINTENANCE PROGRAM

All vessels require routine maintenance in order to reduce emergency break downs and required repair. This is particularly true for vessels moored in saltwater where the vessel and its equipment are subject to corrosion when not in use. Maintenance of the vessel is often performed by the boat crew to some extent and greater maintenance tasks are performed by specialized personnel, either on staff at the facility or provided by outside contract services.

9-3.1 **In-House Workforce.** For facilities with larger staff and vessels that perform continuous operations it is preferable to have skilled workers on staff dedicated to performing the maintenance and repair of the small craft equipment (deck, hull and engines). This allows the most control and flexibility to perform the work according to the schedule of the operational needs of the small craft. A scheduled maintenance program should be established in accordance with those established by the manufacturer of the engine, hull and various other equipment (radio, radar, etc.) on the vessel. Having the permanent staff to perform this work will usually increase operating costs which can be compared to costs paid for such work that is contracted out, if such records are available, to see if such staff is cost effective.

9-3.2 **Contract Services.** In larger cities, or where there is a large boating community, there may be skilled maintenance and repair facilities close by that can perform work fairly readily. For scheduled maintenance, skilled personnel often from the manufacturer's staff or trained by the manufacturer can be scheduled in advance to perform the work onsite. For facilities with fewer small craft or multiple standby craft, this may reduce costs or allow a smaller workforce without the requisite skills to perform the maintenance and repair of the vessels.

9-4 FACILITIES

9-4.1 **On Dock.** For minor repair and maintenance, much of the routine maintenance can be performed with the vessel berthed at the dock.

9-4.2 **Covered Mooring.** Where extensive maintenance must be performed on the berthed vessel at the dock by onsite personnel, the cost of a covered mooring may be warranted. In areas of inclement weather (rain, snow, wind) this allows greater time in which the staff can perform this work.

9-4.3 **Haul Out.** If a haul out facility (see Chapter 10) is provided at the facility, the small craft can be transferred to the shore where more extensive maintenance and repair can be performed. Generally, this includes work on the hull or work that requires use of a crane, welding or other powered tools to perform the necessary repairs or maintenance. A straddle type carrier provides the greatest flexibility and speed for retrieving vessels (see Figure 9-1) and is commonly used.

Figure 9-1, Vessel Haul out Facility for Straddle Carrier

9-4.4 **Yard Maintenance.** The vessel can be placed on a trailer or stands in the yard to allow access to the hull for needed repairs. This can be in the outdoors for work that does not require containment. Environmental considerations often require that, depending on the work being performed, that the vessel be fully contained for the work, such as if sand blasting or painting is being performed.

9-4.5 **Enclosed Shop.** An enclosed work shop building provides a facility in which all necessary repairs and maintenance could be performed. Such a building should be furnished with ventilation and filtration to allow painting and sandblasting to be performed, an overhead crane rail for lifting of the engine or similar heavy equipment, and a full supply of power tools including welding capabilities. The building should often be sized to allow a straddle carrier entry to place the vessel on stands or a cradle within the shop. Figure 9-2 shows a typical enclosed shop building.

Figure 9-2, Enclosed Shop Building, with Straddle Carrier

CHAPTER 10

BOAT LAUNCH HOISTS AND LIFTS

10 -1 GENERAL

The ability to remove small craft from the water is essential for any type of major repair or maintenance at a small craft facility. Further, the ability to launch small craft greatly increases the capacity of the facility and the flexibility to operate a greater number of small craft than accommodated at limited spaces on the floating docks or fixed piers. Because of these reasons, most dedicated small craft harbors have some provision to launch small craft. Various systems have been developed over time and the number of such types of systems has varied as technologies and vessel types change.

10-2 FIXED SYSTEMS

Fixed systems typically utilize a lift that is in a set position to retrieve the vessel from the water. Once the vessel is removed from the water, it is transferred to a trailer to be transported and kept at the storage location, or repair facility. Alternatively, if the vessel is the only vessel at the facility, or it is a dedicated system, the vessel will remain on the lift until it is to be placed in service again.

10-2.1 **Jib Boom.** This is the most common type of retrieval system and is comprised of a crane mast that rotates about a vertical axis. The hoist is mounted on a trolley on a fixed arm (jib boom) that is swung over the boat in the water. The boat is fit with a wire rope sling that attaches to fittings on the boat. A crane hook then attaches to a pickup point on the wire rope sling to lift the boat out of the water. Once the boat is lifted above the top of the seawall, the crane rotates about its axis to place the boat onto a waiting trailer. Once the boat is loaded onto the trailer, the trailer is kept in a dry storage yard until the boat is to be placed in service, when the process is reversed.

10-2.2 **Marine Railway.** A marine railway is a set of fixed rails that ramp down from the shore into the water. The rails are typically supported on piles within the water. A cradle with wheels is hauled by a cable and winch system mounted on the railway and runs into the water, sufficiently deep, such that the vessel can float over the cradle. The vessel is lashed to the risers on the cradle and the cradle is winched up the railway to haul the vessel out of the water. Once on shore, the wheeled cradle can be transferred to a rail siding; multiple work bays can be supported by a single inclined railway. This system is best suited to larger vessels and it requires a significant amount of land area. As such, it is not considered practical for most small craft facilities.

10-2.3 **Elevator Lift.** This method consists of a platform that is raised and lowered into the water by a number of synchronized winches mounted on dolphins along the sides of the platform. A cradle with wheels – similar to the marine railway described previously – is located on the platform when it is lowered into the water sufficiently deep such that the vessel can float over the cradle and platform to then be raised out of the water. The platform is fitted with rails that continue to the shore upon which the cradle and vessel are transported once it is out of the water. This system has been developed by the Syncrolift Corp and is best suited to larger vessels.

For small craft, a similar system is used that utilizes a fork lift mounted to a fixed vertical mast that operates similar to a mobile forklift with “negative” lift and is becoming more common. The forklift rotates about the mast to place the forks in the water, or over land where a mobile forklift can access the vessel. This system is more effective for stacked storage in that a conventional forklift can also store and retrieve the vessels.

10-3 MOVEABLE SYSTEMS

10-3.1 **Straddle Carrier.** This is probably the most versatile and cost effective system for small craft retrieval. The system is comprised of a self propelled carrier frame that drives over the water on a set of two fixed piers. The carrier frame supports a set of slings that is lowered into the water between the piers to a depth sufficient to allow the vessel to position itself over the slings. Then the slings are lifted out of the water by lifting mechanisms within the carrier frame. Once out of the water, the carrier drives off the piers and can maneuver to any location with its wheels that can be steered.

10-3.2 **Crane Lift.** This type of haulout can utilized a dedicated fixed crane or a rubber tire boom crane, or similar mobile crane. The crane supports a lifting frame fit with slings that is lowered into the water similar to the straddle carrier described previously. Once the vessel is lifted from the water, the crane swivels to place the boat on an awaiting trailer, or for a limited number of vessels, could place them onto stands within the arc swing of the crane.

10-3.3 **Forklift.** This method utilizes a forklift with “negative” lift. The forklift is positioned at a vertical bulkhead (marginal wharf) where it lowers the forks below the keel depth of the awaiting vessel. The vessel is placed over the forks and the forklift lifts the vessel out of the water. This method is rapid and has the advantage of being able to move the vessel to a storage location on land and to raise the vessel onto a storage rack.

10-3.4 **Trailer.** Various trailer methods are used to retrieve and launch vessels into the water. Trailers are utilized with jib booms, crane lifts or launch ramps, discussed in the following section. This is the most common method of moving vessels.

10-3.5 **Floating Lift.** Floating boat lifts use buoyancy chambers to raise small craft out of the water much like a floating dry dock. The typical floating lift is permanently installed in a single berth and is configured for the vessel that uses that berth. The boat is stored out of (but over) the water with minimal additional load on the dock system. This type of system is used increasingly by the Navy, with capacities up to 13,000 lb.

10-3.6 **Drive On Dock.** The drive on dock is a shallow freeboard platform that floats a few inches above the water surface. Vessels approach the platform from the water and “drive up” onto the platform at low speed. The platform is constructed of multiple plastic blocks that are pinned together to form a flexible platform that yields to the hull when it drives up, sufficient to avoid damage to the hull. The “Jetdock” System (Moose Boats, Inc.) is a drive on dock system currently in use.

CHAPTER 11

LAUNCHING RAMPS

11-1 GENERAL REQUIREMENTS – WATER AREA

11-1.1 **Fairway.** The Basin or other waterway into which a launching ramp extends should meet the following requirements:

11-1.1.1 Minimum water depth 4 ft (1.2 m) at design low water.

11-1.1.2 Minimum bottom width greater than the combined width of the launch ramp and boarding floats.

11-1.1.3 Minimum length of 50 ft beyond the toe of the ramp, and absolutely clear of obstructions and/or navigation hazards.

11-1.1.4 Mark with navigational aids in accordance with the Waterway Marker System rules per USCG (COMDTINST 16500 series) which identify the proper color and locations of channel markers.

11-1.2 **Launch Ramp.** The launch ramp should meet the following requirements:

11-1.2.1 **Ramp Slope.** Slope between 12% and 15%. Few trailered boats can be launched with slopes flatter than 12% without submerging the wheel hubs of the tow vehicle, which is to be avoided. The slope should be uniform over the entire length of the ramp.

11-1.2.2 **Ramp Toe.** The ramp should extend down to an elevation a minimum of 3 ft (0.9 m) below design low water. The toe of the ramp should be provided with a wheel stop to prevent trailers from backing off the end of the ramp.

11-1.2.3 **Ramp Head.** The ramp should extend up to an elevation 1 ft (0.3 m) minimum above design high water. In addition, the head of the ramp should be provided with a 20 ft (6.1 m) long vertical curve to provide a smooth transition between the steeper ramp slope and the flat slope of the apron/turnaround area.

11-1.2.4 **Ramp Finish.** Ramp surface should be constructed of reinforced concrete, either cast-in-place or pre-cast panels, or a combination of both, and provided with a V-groove surface finish to maximize traction. Typical launch ramp finish details are described in *Layout and Design Guidelines for Marina Berthing Facilities (DBW)*.

11-1.2.5 **Ramp Width.** Standard launching ramp lane width is 15 ft (4.5 m) when 2 or more lanes are provided. When a single lane is provided, the width should be 20 ft. (6.1 m). The number of lanes will be determined by the demand and the site specific conditions. One launching lane should handle up to 25 launch/retrievals (round trips) per day. The total width of the ramp structure is obtained by adding the width of the required number of lanes and boarding floats.

11-1.3 **Boarding Floats and Platforms.** The launch ramp should be fitted with a boarding float (or platform) along the side of the lane (minimum one per lane) meeting the following requirements:

11-1.3.1 **Float Width.** Minimum clear float width is 6 ft. (1.8 m). In cases where guide piles are located inside the boarding float frame on one side, provide a minimum clear distance of 4 ft to the opposite side of the float. Where the guide piles are located in the center of the float, provide a minimum clear distance of 3 ft. (0.9 m) to each side of the float.

11-1.3.2 **Float Length.** Provide a minimum of 50 ft. (15.2 m) in the water (measured from the water line at design low water). Articulated boarding floats are often used to accommodate changes in water level, however, the portion of the boarding float that remains permanently in the water should not be articulated, but be continuous, to enhance stability.

11-1.3.3 **Float Live Load.** Where access is restricted, floats should be designed for a minimum uniform live load of 20 psf 4.1 (kPa); where access is not restricted, the minimum uniform live load should be 40 psf 8.2 (kPa). The floats should also be designed for a live point load of 650 lbs. applied at any point on the float deck not less than 12 in. (0.3 m) from the edge of the float.

11-1.3.4 **Float Freeboard.** Freeboard under dead load only should be between 14 in. (35 cm) and 20 in. (51 cm); the float deck should be level within the following tolerances:

Difference in Freeboard Transverse Direction – 1 in. (2.5 cm) maximum

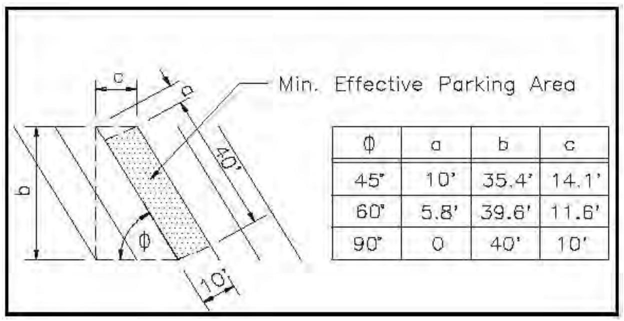
11-1.3.5 **Other Requirements.** See the discussion for floating docks in Section 6 for other requirements pertaining to floating dock design and construction.

11-1.3.6 **Non-Floating Boarding Platforms.** Non floating boarding platforms generally consist of movable wedge shaped scaffolds that rest on the launching ramp and remain in-place by self weight. Typically constructed of steel, with retractable wheels and fitted with hitches, they may be towed to position on the ramp in response to changing water levels. These are used at sites where water levels do not change rapidly, or where winter conditions dictate removal of the boarding platform to reduce risk of ice damage. Other types of boarding systems are described in the *Layout, Design and Construction Handbook for Small Craft Berthing Facilities*.

11-1.4 **Shoreside Support Facilities.**

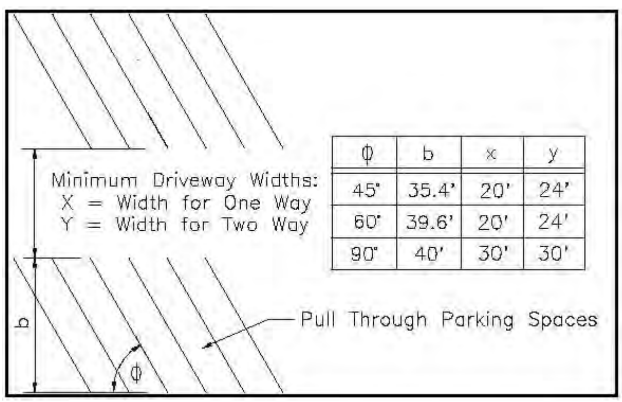
11-1.4.1 **Trailer Maneuvering.** Provide sufficient area at the head of the ramp for trailer maneuvering; typically an area 50 ft x 50 ft (15.2 m x 15.2 m) will be sufficient.

11-1.4.2 **Trailer Parking.** Provide sufficient parking to meet the expected demand for car-trailer spaces; pull through parking spaces should be utilized where practical. See Figure 11-1 for layout of car-trailer parking space and maximum driveway dimensions.



ϕ	a	b	c
45°	10'	35.4'	14.1'
60°	5.8'	39.6'	11.6'
90°	0	40'	10'

A.



ϕ	b	x	y
45°	35.4'	20'	24'
60°	39.6'	20'	24'
90°	40'	30'	30'

B.

Figure 11-1 Car/Trailer Parking Layout

11-1.4.3 **Boat Washdown.** Provide a fresh water boat/engine washdown area for launching facilities in salt water areas. Capture runoff from the washdown area in a separator and direct to wastewater collection system. Locate washdown area away from the head of the ramp to minimize interference with launching and retrieval operations.

11-1.4.4 **Power Lines.** Overhead power lines should not be permitted to cross the launch ramp or its maneuvering or parking area unless minimum overhead clearances prescribed by the authority having jurisdiction are met.

11-1.4.5 **Lighting.** High level lighting for the launching and retrieval area may be required to support night time operations. Avoid glare that can interfere with navigation.

APPENDIX A REFERENCES

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