

CHAPTER 36

PIERS, BULKHEADS AND WATERWAY STRUCTURES

SECTION 3601 GENERAL

The intent of this chapter is to provide minimum standards for the design, construction and maintenance of piers, bulkheads and waterway structures that are not covered by other existing codes or design standards. This chapter exempts farm structures not on public waters, marine terminal or port facilities for berthing, mooring, docking and servicing ships, barges or tug boats which handle cargo of all types including bulks, liquids, fuels and passengers.

The design of piers, bulkheads and waterway structures is essential for the protection of life and property without causing adverse effects to the shoreline. These structures by their very nature result in some modification of physical environment and therefore require minimum design standards. The guidelines in this chapter address minimum standards for foundations, design forces, structural integrity, material selection and utilization, and construction techniques.

SECTION 3602 PERMITS AND APPROVALS

The construction of any pier, bulkhead or waterway structure in public waters or the placement of dredged materials in waters or wetlands, generally requires the owner to obtain permits prior to construction. A permit from the United States Army Corps of Engineers is generally required for all marine construction. In addition to the permit issued by the Corps of Engineers, additional permits may be required from municipal, county or state governments and/or local marine commissions. In cases of structures to be built on lakes operated by an electric utility for the generation of power, a permit from the operating utility may also be required.

SECTION 3603 MINIMUM DESIGN LOADS

3603.1 General. Every structure shall be of sufficient strength to support the imposed dead, live, wind and impact loads without exceeding the allowable stresses prescribed for the various materials elsewhere in this code. Adequate consideration shall be made for forces imposed by earth, water, docking and mooring.

3603.2 Dead loads. The weight of the component parts of a structure shall be used in the design when it will influence the strength of the structural elements.

3603.3 Live loads. Design live loads shall be the greatest load that will probably be imposed on the structure including superimposed loads on retained material which exert horizontal loads on the structure. Where vehicles are allowed, use actual weight of vehicles and wheel loads as specified in the latest

edition of *Standard Specifications for Highway Bridges* of the American Association of State Highway Bridges; of the American Association of State Highway and Transportation Officials. The design load shall be posed at the dock or pier approach where vehicles are allowed. Minimum live loads are:

1. **FIXED PIERS, DOCKS, CATWALKS**—40 pounds per square foot (psf) (1915 Pa) or 300 pounds (1335 N) concentrated load on any area 2 foot (610 mm) square.
2. **FLOATING PIERS, DOCKS, FINGERS**—20 psf or 300 pounds (1335 N) concentrated load on any area 2 feet (610 mm) square. Under dead load, floating piers shall have a minimum of 15 inches (381 mm) freeboard. The pier shall have not more than 6 degrees (0.11 rad) tilt from the horizontal under uniform live loading on one-half of the pier width or under concentrated load of 600 pounds (2669 N) applied on any side.
3. **BULKHEADS, SEAWALLS, REVETMENTS**—Design loads shall be the greatest combinations of loads exerted on the structure. Consideration shall be given to horizontal loads exerted by superimposed loads on the retained earth and by inclined surface slopes.
4. **PUBLIC FISHING PIERS**
 - 4.1. Mean low water line to land—100 psf (4788 Pa).
 - 4.2. Mean low water line to end of pier—50 psf (2304 Pa).

3603.4 Wind loads. As prescribed in Chapter 16.

3603.5 Impact loads. As prescribed in Chapter 16 but not less than 1.25 times the kinetic energy exerted by a striking vessel or vehicle.

3603.6 Water loads. Hydrostatic horizontal pressures along with the equivalent fluid pressure of soil and any surcharge thereon shall be considered. Provide sufficient anchorage against uplift between all components and between the structure and its support of not less than 1.5 times the uplift force. Wave forces shall be determined from wave records where available. Where no wave records are available, the design wave shall be determined from probable wind speed, direction, fetch and water depth which will yield a critical wave. Forces shall then be calculated using current coastal engineering practice.

3603.7 Earth loads. Lateral earth pressures shall be determined by considering the specific soil properties and applying earth pressure theories generally accepted for soil mechanics in engineering practice. Except for simple and inexpensive structures this normally requires the services of specialists in soil mechanics and/or foundations design. Adequate consideration shall be given for the effect of probable varying levels of ground water, tide and flood water. Pressures exerted by the earth shall be checked for dry, saturated and submerged conditions as applicable.

3603.8 Erosion. The effects of reasonably predictable erosion and wave-induced scour shall be given ample consideration.

SECTION 3604 ENGINEERED DESIGNS

3604.1 Docks, piers and catwalks. Docks, piers and catwalks used by the public or are intended for use by vehicles shall be designed by a professional engineer or architect.

3604.2 Bulkheads and other type retaining walls. Bulkheads and other types of retaining walls used by the public having an exposed face above the ground or above mean low water of 5 feet (1524 mm) or greater shall be designed by a professional engineer or architect.

3604.3 Ocean-front retaining walls, bulkheads and retaining walls. Ocean-front retaining walls, bulkheads and other types of retaining walls used by the public on the coastline of the ocean or adjacent inlets shall be designed by a professional engineer or architect.

SECTION 3605 MATERIALS

3605.1 General. The quality of materials and fastenings used for load-supporting purposes shall conform to good engineering practices. In areas subject to attack from wood borers such as termites, teredoes or limnoria, the wood used shall be approved wood having natural resistance or shall be pressure treated with a preservative recommended by the American Wood Preservers Association for the specific application. Piling shall comply with applicable provisions of Chapter 18. Wood components shall comply with applicable provisions of Chapter 23. Concrete components shall comply with applicable provisions of Chapter 19. Steel components shall comply with applicable provisions of Chapter 22. In areas of severe corrosion such as salty or brackish waters, all metal components shall be protected by coating, cathodic protection or be oversized accordingly to allow for the specific exposure. Aluminum bulkhead sheets or aluminum bulkhead or dock components shall be of proper alloy to resist corrosive elements in the adjacent water and soil. Galvanized bulkhead components and dock components shall be coated by the "hot dip" process to sufficient cover to provide corrosion protection equal to the degree of exposure of corrosive elements. Masonry used in bulkheads and dock work shall comply with Chapter 21.

SECTION 3606 CONSTRUCTION OF PIERS, DOCKS, CATWALKS AND FLOATING DOCKS

3606.1 Fixed piers. Fixed piers for coastal areas shall be supported by pilings with tip penetrations of not less than 8 feet (2438 mm) dependent on the total applied load. Less penetration is approved only if other means of resisting flotation uplift is provided. Pier support by shallow piling, legs or columns with point bearing on rock shall have provisions for horizontal forces and overturn as well as flotation uplift. Connection between piling or legs to cap beams, stringers, beams and deck shall have sufficient capacity to safely support all applied loads

and provide transfer of load to adjoining members. Maximum spans for pier joists shall be in accordance with the Span Table for Joists and Rafters, as published by the National Forest Products Association or may be designed in accordance with accepted engineering practice.

3606.2 Metal barrel flotation units. The use of metal barrels not specifically designed for use as flotation devices is prohibited.

3606.3 Decomposable flotation units. Floating docks or piers using exposed polystyrene billets (or other foam material) shall be designed for 125 percent of tabulated loads to allow for deterioration from environmental effects.

3606.4 Electrical service. All electrical service to marine structures shall be in accordance with the North Carolina State Building Code, Volume IV-Electrical.

3606.5 Fuel docks. Fuel docks and other marine facilities handling flammable liquids shall comply with the *Flammable and Combustible Liquids Code*, NFPA 30. All fuel installations shall be designed to prevent fuel spillage from entering the water. The fuel docks or floats shall be a separate structure from berths and shall be isolated to the extent that fire or explosion would have minimal opportunity to spread to or from the fuel dock to the berths. Storage tanks for public facilities shall be located a minimum distance of 50 feet (15 240 mm) from the dispenser with a shutoff valve at the tank.

3606.6 Handrails. For walkways, access piers, steps or ranges, personnel handrails or other safety provisions shall be provided along the edges where the vertical drop to the mean low water level or mud line exceeds 6 feet (1829 mm). Edges which have a primary function other than walks or access ways, such as docking frontage and swimming access shall not require railings. Railings shall be designed in accordance with Chapter 16 for balcony railings.

3606.7 Maintenance of public structures. The building official shall have the authority to condemn and close to the public any structure which is considered unsafe, and it shall not be used by the public until the deficiencies are corrected. Before the structure is reopened to the public, a certification by a professional engineer or architect shall be required. Each owner shall be responsible for the proper and satisfactory maintenance of any public structure covered by this section. All such structures shall be subject to inspection at any time by the building official.

SECTION 3607 CONSTRUCTION: BULKHEADS, SEAWALLS AND REVETMENTS

3607.1 Bulkheads.

3607.1.1 Bulkheads shall be constructed in a manner to be effective against erosion and provide for adequate bank stabilization. The bulkhead system may consist of either of the following combinations thereof: braced sheet pile walls with tie backs, king piles and horizontal panels, gravity walls, cantilever and counterfort retaining walls. Bulkhead walls shall be constructed to prevent passage of fine mate-

rial through joints or cracks from the fill side to the stream side.

3607.1.2 Local site conditions and performance of bulkheads in service should govern in selection of a system. The potential for erosion and scour at the mud line shall also be investigated, and appropriate compensating features shall be reflected in the construction. Bulkheads shall be terminated by either tying into adjoining structures or by extending the bulkhead line a minimum of 10 feet (3048 mm) in a landward direction at an angle of not less than 45 degrees (0.79 rad) to the shoreline in order to protect against end erosion or flanking by wave action. No structure shall be terminated without regard for end anchorage and stabilization. Sheet pile bulkheads with an exposed vertical height of 4 feet (1219 mm) or greater shall be stabilized at the top by providing adequate anchorage, such as the use of batter piles or tie backs. Anchor blocks for tie backs shall be located landward of the soil wedge formed by the wall and a line projected on an angle of the material being retained. The tie back anchor shall be located no closer than twice the height of the exposed vertical surface of the wall. Sheet pile embedment shall be determined by analysis and design, but shall not be less than the length of the pile exposed above ground. Cantilever and gravity wall bulkheads shall be founded on a firm foundation with special construction given to undermining and progressive instability.

3607.1.3 Where public walkways, steps or ramps run adjacent to bulkheads, personnel handrails or other safety provisions shall be provided along the top of the wall where the vertical drop to the mean low water line or mud line exceeds 6 feet (1829 mm). Handrails shall be designed in accordance with Chapter 16 for balcony railings.

3607.1.4 Wood members used for permanent features shall be not less than 2 inches (51 mm) in nominal thickness. All steel bolts, rods and other hardware shall be hot dipped galvanized or protected with an equivalent system. Bolts, rods and other metal materials shall be no smaller than $\frac{1}{2}$ inch (12.7 mm) in diameter or thickness. Threaded fasteners shall not be tightened directly against wood surfaces but used only in conjunction with standard ogee or flat washers.

3607.1.5 Concrete, steel and cement asbestos bulkheads shall be constructed in a manner to assure adequate performance. Connections shall be designed to resist the full applied load. Adequate attention shall be given to material protection against corrosion and concrete cover for reinforcing steel. Concrete shall have a 28-day minimum compressive strength of 3,000 pounds per square inch (20 685 kPa) and shall be "air-entrained" type concrete.

3607.2 Seawalls. Seawalls may be constructed of concrete or stone rubble mound or other suitable materials. They shall be founded on a firm foundation and may require the use of piling or other suitable support. The face shall be shaped and supported to withstand the full force of the design wave. A provision shall be provided to prevent undermining and progressive instability by installing a sheet pile wall along the toe and/or by placing adequate stone rip rap protection.

3607.3 Revetments.

3607.3.1 Rigid revetments shall be founded on a firm foundation to prevent undermining and progressive instability. Provisions should be made to provide for adequate toe protection by extending the face a minimum of 2 feet (610 mm) below the mud line plus a depth to compensate for known or anticipated scour. Additional protection may be needed in active areas and may consist of sheet piling along the toe and/or stone rip rap. An adequate pattern of weep holes shall be provided in the face to relieve hydrostatic pressure behind the wall. Joints shall be sealed to prevent loss of fines from the protected slope.

3607.3.2 Flexible revetments may be utilized where foundations will produce minor consolidation and settlement. Adequate provisions shall be made to prevent migration of fine materials through the wall. The face shall not be steeper than one unit horizontal to one unit vertical. Flatter slopes may be needed for stability depending on the construction materials and site conditions. The face may consist of stone rip rap or individual interlocking concrete units or poured concrete. Toe protection provisions shall be provided as discussed for the rigid type. Flexible revetments must be porous enough to allow for water passage and thereby relieve hydrostatic pressure behind the face.

SECTION 3608 CONSTRUCTION OF GROINS AND JETTIES

3608.1 Groins.

3608.1.1 Groins are designed and constructed for the purpose of building or maintaining a protection beach by trapping littoral drift (beach materials) or to retard the recession of an eroding shoreline. The planning and design of a groin/groin system shall be based on wave height, period and direction, characteristics of beach material and beach slope.

3608.1.2 Location. Groins shall extend landward a sufficient distance to prevent flanking.

3608.1.3 Types. Groins shall be either (1) very low, impermeable and nonadjustable or (2) impermeable and adjustable.

3608.1.4 General Specifications. Adjustable groins shall be maintained at elevations in accord with actual beach needs and development of desirable changes of the beach profile, and so as to avoid damage to adjacent beaches. In no case shall the top of such groins be set higher than 2 feet (610 mm) above the beach profile. Impermeable, nonadjustable groins shall not extend seaward beyond the mean low water line, and their top elevation shall not be higher than 6 inches (152 mm) above the beach profile. Considerations of the degree of beach protection to be provided by proposed groins, and the acceptability of such installations, will be based primarily on the following factors: direction and volume of littoral drift; wave force and direction; wind force and direction; land usage; type of bulkhead; type of groin; and spacing and lengths of groins.

A complete coastal engineering study may be required before approval is given to the number, type and length of groins. The design should account for the wave and current forces focused on the beach. The groin/groin system should not adversely modify the littoral drift to the extent to cause severe erosion on the lee side of the structure.

3608.2 Groins and jetties. There is no universal type of groin/groin system or jetty because of the wide variations in conditions at each location. It is incumbent on the owner of a groin or jetty type structure to recognize the legal implications of the coastal structure and to plan, design, construct and maintain the structure accordingly. It is thus prudent to seek the advice of a professional engineer or architect with coastal engineering experience.

SECTION 3609 DEFINITIONS

BASIN, BOAT. A naturally or artificially enclosed or nearly enclosed harbor area for docking and securing small craft.

BULKHEAD. A vertical wall structure designed to retain shoreline material and prevent erosion due to wave activity.

BULKHEAD LINE. The line formed along the shore by the most seaward elements of the bulkhead.

CATWALK. A narrow footway platform extending alongside a structure.

DATUM, PLANE. The horizontal plane to which soundings, ground elevations water surface elevations are referenced.

DOCK. A pier, wharf or platform for the unloading of materials or living beings.

FETCH. The area in which waves are generated having a rather constant direction or speed.

GANGWAY. A narrow footway bridge extending from the shore, usually to a floating structure.

GROIN. A shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore.

GROIN SYSTEM. A series of groins that function to protect a section of shoreline.

JETTY. A structure designed to protect and/or stabilize a navigation entrance.

KING PILE. The primary structural member that supports horizontal panels to form a vertical wall sometimes used in bulkhead or groin construction.

LITTORAL DRIFT. The sedimentary material transported along the shore by waves and currents.

LONGSHORE TRANSPORT. The movement of littoral drift (material) running parallel to the shoreline.

PIER. An elevated deck structure, usually pile supported, extending out into the water from the shore.

PIERHEAD LINE. The limiting line to which any pier or dock structure can extend into the water.

PILE. A cylindrical timber, concrete or metal member embedded into the ground to support or brace a structure.

PILE, SHEET. A pile with a generally slender flat cross section to be embedded into the ground or seabed and meshed or interlocked with like members to form a diaphragm, wall or bulkhead.

REVTMENT. A flexible structure usually constructed of stone or concrete and placed on a bank slope to protect it against erosion by wave and current action.

SEAWALL. A massive structure built along and parallel to a shoreline for the purpose of protecting and stabilizing the shore against erosion resulting from heavy wave activity.

WAVE, DESIGN. A wave that is potentially most damaging to an economically feasible structure, or wave for which a structure is designed.