History of the Lighthouse Service and Lighthouse Construction Types

National Archives photo

Figure 1. Assembly of Point No Point Lighthouse caisson at Solomons, Maryland, before being transported to site in Chesapeake Bay.

History of the Lighthouse Service

The U.S. Lighthouse Establishment was created by the First Congress in 1789 to manage the twelve colonial lighthouses now controlled by the federal government and to oversee construction of new lighthouses. Sandy Hook Lighthouse, built in New Jersey in 1764, is the only colonial lighthouse that has survived (Boston Harbor Lighthouse, built in 1716, was rebuilt in 1783-1784). Colonial lighthouses were usually constructed of wood or rubble stone. Between 1789 and 1820 about 40 new lighthouses were built by the Lighthouse Establishment, many using brick and cut stone. Of these, only a few have survived, including Portland Head Lighthouse, Maine, built in 1790 and Cape Henry Lighthouse, Virginia, built in 1792. From 1820 until 1852, Steven Pleasonton, Fifth Auditor of the Treasury, was responsible for lighthouse construction and repairs. Though Pleasonton routinely returned unspent funds to the Treasury, during his tenure approximately 300 lighthouses were built. In 1847 the responsibility for the construction of six lighthouses was granted to the Army Corps of Engineers.

On August 31, 1852, the U.S. Lighthouse Establishment became the U.S. Lighthouse Board, largely as the result of numerous complaints about the state of the U.S. lighthouse system. The nine-member board was composed primarily of Naval and Army engineer officers. The country was divided into 12 new lighthouse districts, each with an inspector responsible for overall construction, maintenance, and purchasing. Over the next five decades several advances in lighthouse construction technology took place, including the development of exposed screwpile lighthouses, skeleton tower lighthouses, wave-swept interlocking stone lighthouses, iron caisson lighthouses, and breakwater lighthouses. Many examples of these

lighthouses exist today. In 1886, the lighthouse districts were increased to 16.

The Lighthouse Board was transferred to the Department of Commerce and Labor on July 1, 1903. On June 17, 1910, the Lighthouse Board became the Bureau of Lighthouses. The number of districts increased to 19. Just before this transition, reinforced concrete lighthouse towers came into use, particularly along the west coast where earthquakes were common. In 1913 the Bureau was assigned to the Department of Commerce when it separated from the Department of Labor. In 1939 the Bureau was abolished and its functions transferred to the U.S. Coast Guard where the responsibility remains today.

At the end of World War II the Coast Guard staffed 468 light stations. Following the war, the Coast Guard embarked on a program of automation. The rationale for this program was 1) to reduce the cost of maintaining lighthouses, 2) to remove personnel from extremely isolated and hazardous locations, and 3) to make billets available for reprogramming. Despite these efforts, the Coast Guard 'manned' 327 lighthouses in 1962. The Coast Guard initiated the Lighthouse Automation and Modernization Program (LAMP) in 1968. LAMP was designed to accelerate and standardize the remaining lighthouses for automation and to standardize the equipment at those previously automated. Over $26 million was spent on LAMP over 20 years; 1989 was the last year for LAMP funding though a few automations were completed as late as fiscal year 1990. LAMP resulted in over 300 billet reductions amounting to savings in excess of $63 million, and recurring savings of about $7 million annually.[1] Every Coast Guard-owned lighthouse in the United States is now automated and unmanned, with the sole exception of Boston Lighthouse. It will continue to be staffed in accordance with Section 221 of the Coast Guard Authorization Act of 1989 (P.L. 101-225). The Coast Guard continues to use the living quarters of several former light stations as housing units for its personnel.

Lighthouse towers themselves have become less valuable to the Coast Guard because, with modern automated beacons, it is more cost effective to construct and maintain an aid to navigation on a steel structure or buoy, rather than inside the lantern of a traditional lighthouse tower. Thus, in many locations, the traditional lighthouse tower has been found to have little value to the U.S. Coast Guard mission, other than to provide a visual aid to mariners during daylight and good weather.[2]

The lighthouse automation process resulted in a loss of practical experience gained by personnel stationed at the lighthouses. The peculiarities and unique needs of the station could no longer be cared for on a daily basis. Experience and traditions were no longer passed on from one keeper to another. Many stations, especially the more remote ones, are seldom visited by Coast Guard personnel, as little as once or twice a year. The lack of simple maintenance such as mopping up condensation on a daily or weekly basis from the inside of the storm pane astragals of the lantern room now result in rust and corrosion. A broken storm pane (window), formerly replaced within a matter of hours, now may result in bird and rodent infestation. Vandalism from lack of on-site supervision and security is an even worse problem.

[1] "United States Coast Guard Lighthouse Policy Review" (enclosure 7 to Chapter 6 of COMDTINST M11011.9B dated July 27, 1992), pp. 5-6, copy in files of National Maritime Initiative, National Park Service, Washington, D.C.

[2] David Reese and Robert Browning, "Lighthouse Management:: A Balancing Act for the U.S. Coast Guard," *Cultural Resource Management* (June 1997).

NMI photo

Figure 2. Portland Head Light Station, Cape Elizabeth, Maine, one of the few remaining towers built by the Lighthouse Establishment between 1789 and 1820.

Lighthouse Construction Types[3]

Politics, need, cost, location, and geography of the site, as well as technology available at the time of construction influenced lighthouse designs. Before the mid-nineteenth century, lighthouse construction technology required solid rock or other stable foundation soils; onshore towers sometimes proved inadequate to warn of a shoal located offshore. In some locations a lighted buoy or a lightship[4] solved this problem. Riverine and estuarine environments, however, often had unstable muddy and/or sandy bottoms which could not support the heavy masonry towers then in vogue. In areas such as the Chesapeake Bay, Delaware Bay, the Gulf of Mexico, the Mississippi River delta, and the coral reefs of the Florida Keys, the development of newer technology using screwpile, caisson, and skeletal tower lighthouse construction was essential to adequately light these marine hazards.

As technology advanced, stations were improved or even moved to better mark hazards such as offshore shoals. The 95-foot-tall tower at Cape Hatteras Lighthouse (1803), North Carolina, was raised to 150 feet in 1854, and the present 208-foot tall tower replaced it in 1870.[5] The first Thomas Point Shoals Lighthouse (1825), Maryland, was a stone tower built on shore; it was replaced by an offshore screwpile

[3] The following section is from Ralph Eshelman, "American Lighthouse Construction Types," part of the draft Maritime Heritage of the United States National Historic Landmark Theme Context Study for Lighthouses, National Maritime Initiative, National Park Service, 1995.

[4] Lightships are a relatively new type of aid to navigation, first appearing in the U.S. in 1820. None are in operational use today. Lightships, however, played an important role in establishing light stations in locations difficult or impossible for the construction of submarine lighthouse structures.

[5] According to 1989 HABS documentation, the overall height of the structure is 208 feet including the foundation. The height from ground level was recorded at 197 feet.

structure in 1875 to place the aid closer to the navigation channel.[6]

Generally, coastal lighthouses on the low, flat southeastern coast of the United States tended to have tall towers to elevate the lens high enough so the light may be seen many miles at sea; whereas lighthouses on the west coast tended to have short towers built on sea cliffs high enough to project the light many miles at sea. Several light stations on the northeastern coast were also located to take advantage of naturally high elevation sites, such as Block Island Southeast Lighthouse, Rhode Island, and Monhegan Island Lighthouse, Maine. Ironically, the low clouds so characteristic of the west coast caused some station sites at high elevations to be moved to lower altitudes with taller towers in order to get the light below the low cloud levels, but high enough to be visible to ships at sea. The first Point Loma Lighthouse (1855) California tower was only 40 feet tall but was located on a bluff providing a focal plane of 462 feet above the water. It was replaced in 1891 by a 70-foot-high tower built at the base of the bluff with a focal plane of 88 feet above the water.[7]

Lighthouses were made from a variety of materials including wood, stone, brick, reinforced concrete, iron, steel, and even aluminum and fiberglass. Lighthouses were built on land, in the water, on islands, on top of ledges and cliffs, on breakwaters and piers, on caissons, and at least five are on fort walls. Some light towers are stand-alone structures, while others are attached or integral to the keeper's quarters or fog signal building.

The tower served principally as a support for the lantern which housed the optic. The lantern was typically constructed of cast iron; round, square, octagonal, or hexagonal-shaped, and surrounded by a stone or cast-iron gallery. Access to the lantern room was via stone, wood, or cast-iron stairs which either wound around a central column or spiraled along the interior sides of the tower walls.

Until the adoption of the Fresnel lens in the United States in the 1850s, there was no uniform design for the lantern. Pre-1850s lanterns are rare and are often referred to as "old style" or "bird cage" lanterns because of their bird cage appearance. Selkirk (Salmon River) Lighthouse, New York, built in 1838, retains its bird cage lantern. The "bird cage" lantern on Cape Henry Lighthouse, Virginia, is a reconstruction of one built in 1792. Many pre-1850s light towers had their older lantern removed and new cast-iron lanterns installed when Fresnel lenses were added to a light station; most light stations in the United States were fitted with Fresnel lenses by 1860. In addition to the replacement of the lantern, the tower supporting the lantern was often modified to accommodate the larger lenses.

Fresnel lenses were developed in seven standard sizes, depending on need. The largest first-order lenses were designed for important coastal sites while the sixth order, the smallest, was designed for small harbors and rivers (the seventh size was a third-and-one-half order). The meso radial and hyper radial were two additional lens sizes that were not used in the U.S. with the one exception, Makapuu Light, Hawaii. To accommodate these new lenses the Lighthouse Board designed four pre-made ready-to-assemble cast-iron lanterns for first, second, third, and fourth orders. (The fourth-order lantern could be used to

[6] Robert de Gast, *Lighthouses of Chesapeake Bay* (Baltimore: Johns Hopkins University Press, 1973) p. 79; F. Ross Holland, Jr., *Great American Lighthouses* (Washington D.C., Preservation Press, National Trust for Historic Preservation, 1994), p. 19; and Candace Clifford, *1994 Inventory of Historic Light Stations* (Washington, D.C., History Division National Park Service, 1994), p. 260.

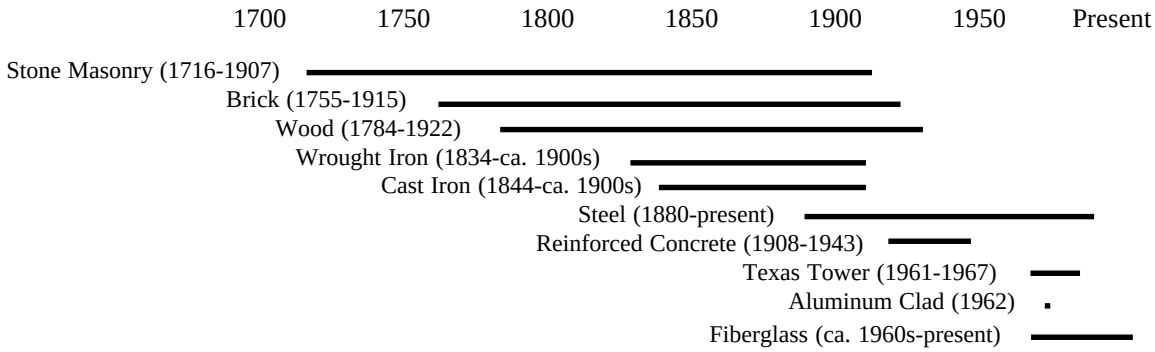
[7] Clifford, pp. 19-20.

accommodate the fourth-, fifth-, and sixth-order Fresnel lenses.) While it was possible to install a smaller order lens in a lantern of a larger order, it was not possible to increase the lens size for a lantern of a lesser order except for the fifth or sixth. Detailed plans for these cast-iron lanterns are available at the National Archives as well as plans for many other lanterns–often the exact plan for the lantern of a specific lighthouse.

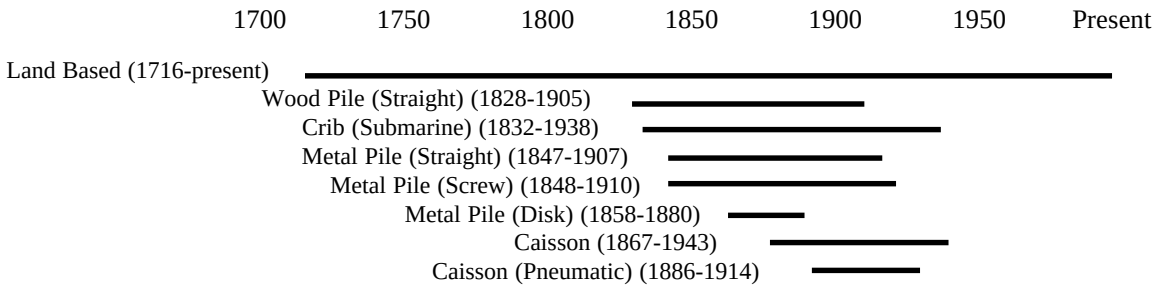
Windows in the tower were positioned to provide daylight onto the stairs. For taller towers, landings were provided at regular intervals. The top landing ended at the watch room where the keeper on duty ensured that the light was functioning properly. The lantern room above was usually reached via a ladder.

In addition to a light tower, a completely equipped light station on land often consisted of a keeper's quarters, oil house, fog-signal building, workshop, water supply, privy, landing wharf, boathouse and ways, barn, roads, walks, and fences. Some regions required special structures to aid in the operation of the lighthouse. The elevated walkway or "catwalk" found on some of the piers of the Great Lakes was necessary for the keeper to get to the light during severe storms when waves washed over the pier or ice made it too dangerous to walk on the pier. These "catwalks" are significant components of this type of light station and contribute to its historic integrity.

Tower Construction Types—Period of Construction



Tower Foundation Types—Period of Construction



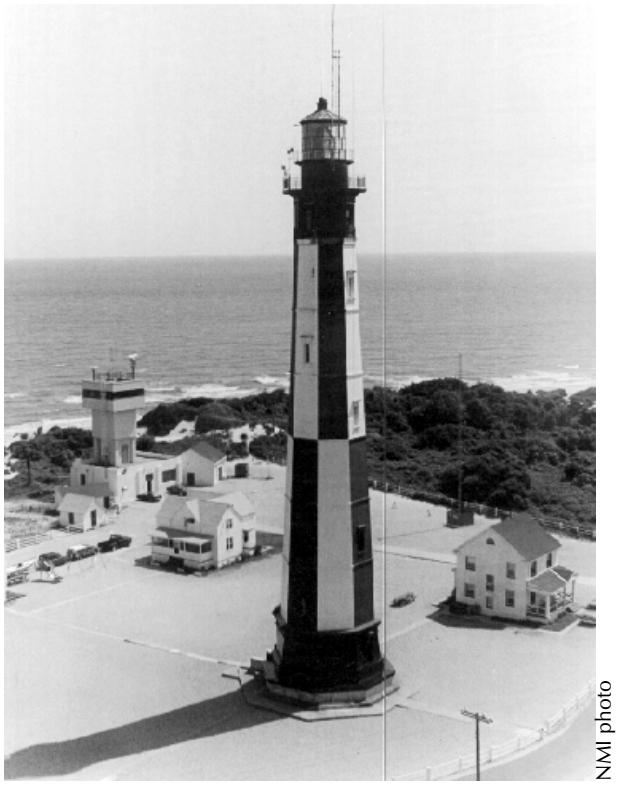
SIDEBAR: Lighthouse Construction Types

Most lighthouses can be categorized by construction method, shape, building material, or foundation types. The lighthouse type can also be classified as terrestrial or aquatic, i.e., onshore or offshore types. The major construction types for historic lighthouses are wooden, masonry, wave-swept, concrete, cast-iron plate, skeletal, straightpile, screwpile, crib, caisson, and Texas tower.

Wooden tower: Most early wooden towers have burned and/or been replaced. Prospect Harbor Lighthouse (1891), Maine, is a good example of a stand-alone, conical wooden light tower. Plymouth/ Gurnet Point Light (1843), Massachusetts is the earliest surviving wooden tower.

NMI photo

Figure 3. Gurnet Point Lighthouse, wooden tower near Plymouth, Massachusetts.



NMI photo

Figure 4. Cape Henry Light Station, cast-iron tower, Fort Story, Virginia.

Masonry tower: Masonry towers were constructed of rubble stone, cut stone (dressed stone), or brick. The oldest standing masonry light tower in the United States is the 85-foot-tall Sandy Hook Lighthouse (1764), New Jersey, built of cut stone. Towers over 150 feet in height are referred to as tall towers. The 208-foot Cape Hatteras Lighthouse (1870), North Carolina, is the tallest lighthouse in the United States.

Wave-swept tower: Wave-swept lighthouses were built on low rocks or submarine ledges and constructed of interlocking stones to withstand the fury and power of waves in heavy seas. One of the first wave-swept towers built in the United States was the 114-foot Minot's Ledge Lighthouse (1860) offshore in

Massachusetts, which replaced a pile-type lighthouse that was destroyed by a storm. It was considered the "most important engineering work" constructed by the Lighthouse Board at the time.

Concrete tower: Concrete towers began to replace brick masonry towers at the beginning of the 20th century; a tower of *reinforced concrete* was first used in the United States at the 115-foot-tall Point Arena Lighthouse (1908), California.

Cast-iron-plate tower: Cast iron was lighter than stone or brick, relatively inexpensive, strong, watertight, and had a slow rate of deterioration. The second Cape Henry Lighthouse (1881), Virginia, is the tallest cast-iron-plate tower in the United States at 163 feet. Steel and wrought-iron plate was also sometimes used. This construction type was capable of being dismantled and moved; examples include Cape Canaveral, Florida and Hunting Island, South Carolina.

Skeletal tower: Onshore skeletal towers were built of metal and were typically constructed on concrete foundations. Offshore skeletal towers were also built of metal and typically constructed with straight or screwpile foundations (discussed below). Manitou Island Lighthouse (1861) and Whitefish Point Lighthouse (1861), Michigan, both built from the same plan, are the earliest onshore skeletal towers built in the United States. Like the cast-iron-plate tower, skeletal towers could also be dismantled and moved.

Straightpile: The pile foundation lighthouse utilized the principle of least resistance. Waves would pass through rather than crash against the foundation. This design of lighthouse structure was used offshore, even in wave-swept

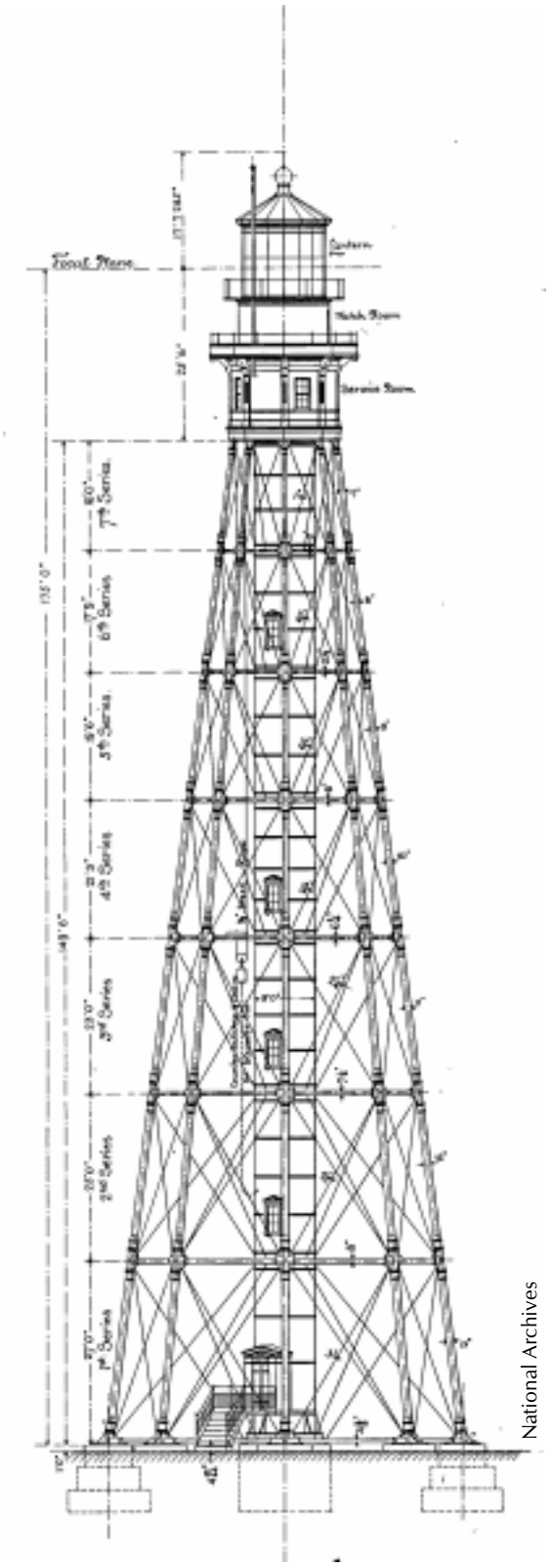


Figure 5. Construction drawing for Cape Charles Lighthouse, Virginia, an onshore skeletal tower.

National Archives photo

Figure 6. Thomas Point Shoals Lighthouse with screwpile foundation located in Maryland's Chesapeake Bay; shown here in 1885.

USCG photo

Figure 7. Sabine Bank Lighthouse with caisson foundation in Texas.

locations. The earliest surviving straightpile tubular skeletal tower lighthouse is Sombrero Key Lighthouse (1858), Florida.

Screwpile: To increase the holding power of the pile, a screw-like flange was fastened to the bottom of the pile and wound like a screw into the substrate. There are two principal screwpile type lighthouses, 1) low spider-like foundations for rivers, bays, and sounds, and 2) tall offshore coastal towers. Perhaps as many as 100 spider-like screwpile lighthouses were built throughout the Carolina sounds, the Chesapeake Bay, Delaware Bay, along the Gulf of Mexico, and one even at Maumee Bay (1855) on Lake Erie in Ohio. Thomas Point Shoals Lighthouse (1875), Maryland, is the oldest extant, unmoved, spider-like screwpile lighthouse in the United States. The first of the tall skeletal screwpile coastal towers built in the United States was Carysfort Reef Lighthouse (1852), Florida, which still stands. A few offshore screwpile skeletal tower lighthouses built on coral reefs used foot plates or disks to help disperse the weight of the tower. Examples in the Florida Keys include Carysfort Reef Lighthouse (1852), Fowey Rocks Lighthouse (1878), and American Shoal Lighthouse (1880).

Crib: Wooden cribs, constructed onshore, towed to the site, and then filled with stone to sink them in place were a lighthouse foundation type

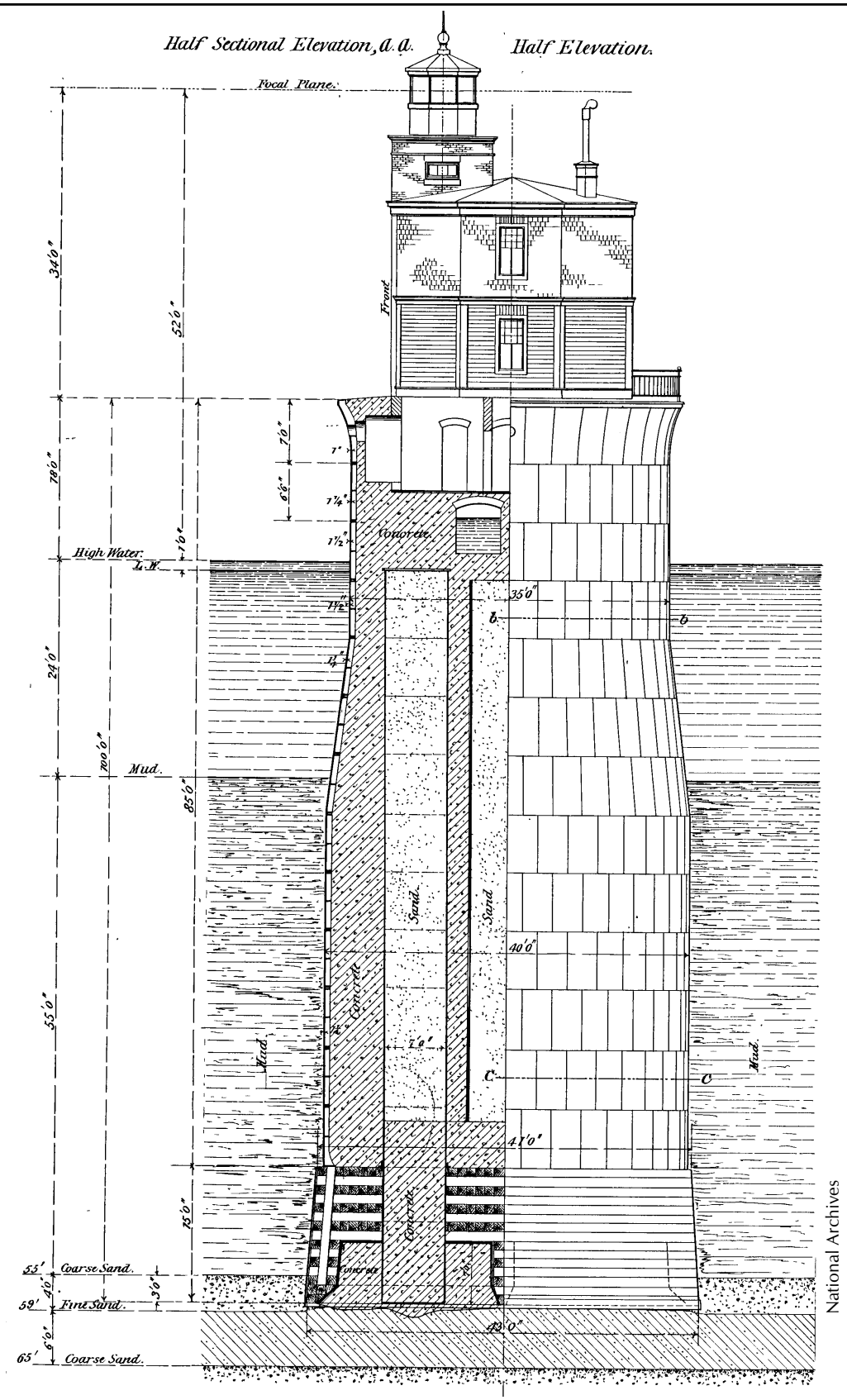


Figure 8. Construction drawing detailing the caisson foundation for Baltimore Lighthouse in Maryland's Chesapeake Bay.

USCG photo

Figure 9. Chesapeake Light Station, Texas tower at entrance to Chesapeake Bay.

used extensively in the Great Lakes, usually to replace lightships. Once settled and leveled, the cribs were capped with concrete or some other masonry upon which the lighthouse structure was constructed. Perhaps the two most significant crib foundation lighthouses are the 93-foot Spectacle Reef Lighthouse (1874) on Lake Huron, Michigan, located 10½ miles from the closest land; and the 110-foot Stannard Rock Lighthouse (1882) on Lake Superior, Michigan, located 23 miles from the nearest land. Crib foundations were best suited for hardrock bottoms typically found in the Great Lakes.

Caisson: Caisson foundations were best suited for unconsolidated bottoms composed of sand or mud. The caisson lighthouse type used a large cast-iron cylinder, which was sunk on the bottom and filled with rock and concrete to form a foundation. The caisson foundation was sturdier and better able to withstand heavy stress than the pile foundation lighthouses, so it is not surprising that caisson lighthouses were built in areas where moving ice was a hazard. The Craighill Channel Lower Front Range Lighthouse (1873), Maryland, is an early surviving example. Where bottoms were harder, contained rocks, and/or needed greater depth of penetration into the substrate, the pneumatic process was used. The substrate within the caisson was removed and the caisson allowed to sink further into the bottom. Eleven pneumatic caisson lighthouses were built in the United States. The Sabine Bank Lighthouse (1905), Texas, is the most exposed, located 15 miles offshore in the Gulf of Mexico—the only successful caisson south of the Chesapeake Bay.[6]

Texas Tower Type: A relatively recent technological development in lighthouse construction was the Texas tower type which replaced exposed lightships offshore. These so-called Texas towers were adaptations modeled on the offshore oil drilling platforms first employed off the Texas coast. The first Texas tower lighthouse in the United States was the Buzzards Bay Light, located in Buzzards Bay, Massachusetts, and commissioned on November 1, 1961. It has been extinguished and may be dismantled. A total of six Texas tower lighthouses have been constructed.

[6] The caisson type lighthouse, though superior to the screwpile lighthouse type as far as stability is concerned—especially in northern locations where ice flow conditions exist, did not prove satisfactory for offshore ocean locations because of severe bottom scouring. In the late 1880s, a 54-foot-diameter pneumatic caisson foundation with a tall steel light tower was sunk off Diamond Shoals, thirteen miles off the shore from Cape Hatteras, North Carolina. But water currents scoured the site and tilted it out of level. The contractors gave up in disgust as did the Lighthouse Board after a few more unsuccessful attempts. (Wayne C. Wheeler, "Diamond Shoal Lighthouse: The Lighthouse That Never Was," *Keeper's Log* (1988) 4(3):24-29.)