NPS Form 10-900-b
(March 1992)

OMB No. 1024-0018

United States Department of the Interior
National Park Service

National Register of Historic Places
Multiple Property Documentation Form

This form is used for documenting multiple property groups relating to one or several historic contexts. See instructions in How to Complete the Multiple Property Documentation Form (National Register Bulletin 16B). Complete each item by entering the requested information. For additional space, use continuation sheets (Form 10-900-a). Use a typewriter, word processor, or computer to complete all items.

_X_ New Submission ____ Amended Submission

A. Name of Multiple Property Listing

Light Stations of the United States

B. Associated Historic Contexts

(Name each associated historic context, identifying theme, geographical area, and chronological period for each.)

Federal Administration of Lighthouses, U.S. Lighthouse Service, 1789-1952
Architecture & Engineering, U.S. Lighthouse Construction Types, Station Components, Regional Adaptations and Variations, 1789 -1949
Evolution of Lighthouse Optics, 1789 -1949
Significant Persons, U.S. Lighthouse Service, 1789 -1952

C. Form Prepared by

name/title Edited and formatted by Candace Clifford, NCSHPO Consultant to the NPS National Maritime Initiative, National Register, History and Education Program.
Based on submissions by Ralph Eshelman under cooperative agreement with U.S. Lighthouse Society, and Ross Holland under cooperative agreement with National Trust for Historic Preservation
Also reviewed, reedited, and reformatted by Ms. Kebby Kelley and Mr. David Reese, Office of Civil Engineering, Environmental Management Division, US Coast Guard Headquarters, and Jennifer Perunko, NCSHPO consultant to the NPS National Maritime Initiative, National Register, History and Education Program.

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date February 23, 1999 & February – July 2002

D. Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this documentation form meets the National Register documentation standards and sets forth requirements for the listing of related properties consistent with the National Register criteria. This submission meets the procedural and professional requirements set forth in 36 CFR Part 60 and the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation. (___ See continuation sheet for additional comments.)

ACTING

Captain, U. S. Coast Guard,
Chief, Office of Civil Engineering
Signature of certifying official

2/22/02
Date

Department of Transportation, U.S. Coast Guard
State or Federal agency and bureau

I hereby certify that this multiple property documentation form has been approved by the National Register as a basis for evaluating related properties for listing in the National Register.

Signature of the Keeper

12/02/02
Date

SHPO Concurrence

Maine:

Signature _____ date 4/2/02

Maryland:

Signature _____ date _____

Virginia:

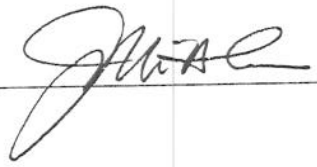
Signature _____ date _____

SHPO Concurrence

Maine:

_____ _____
Signature date

Maryland:



_____ 5-9-02
Signature date

Virginia:

_____ _____
Signature date

E. Statement of Historic Contexts

Introduction

> *The lighthouse and lightship appeal to the interests and better instinct of man because they are symbolic of never-ceasing watchfulness, of steadfast endurance in every exposure, of widespread helpfulness. The building and the keeping of the lights is a picturesque and humanitarian work of the nation.*
>
> George Putnam, Commissioner of Lighthouses, 1910-1935

Of the myriad of cultural resources in the United States, for many people, none have more appeal than lighthouses. Lighthouses conjure up feelings of romance, security, humanity, heroism, and beautiful settings. Some lighthouses have dramatic appeal in connection with notable rescues of shipwreck victims by the lighthouse keeper. Some religious hymns refer to the lighthouse beacon as a symbol of trust, moral direction, and even God. It is not surprising that lighthouses have become icons for humanitarian causes such as the Lighthouse for the Blind. This love of lighthouses and fascination with lighthouse keeping has been described by Dennis Hanson who states:

> *Clearly there is something special about lighthouses that goes far beyond their utilitarian purpose. They are perceived as monuments to the country's maritime past, symbols of man's stormy relationship with the sea, beacons of hope and homecoming. They stand for integrity and reliability. The resourceful lighthouse keeper, who endured the tedium, danger and deprivation of his job with heroic stoicism, has become part of our national folklore ....*[1]

Lighthouses, it seems, have always been favorite destinations for visitors. Throughout the history of the lighthouse service, many visitors camped or picnicked at light stations. Tours of the tower were routinely given upon request. The 1858 Instructions and Directions for Light-House and Light-Vessel Keepers of the United States, Third Edition, specified regulations for admitting visitors in the light tower. It stated,

> *The light-keepers are required to be sober and industrious, and orderly in their families. They are expected to be polite to strangers, in showing the premises at such hours as do not interfere with the proper duties of their office, and may, with the approbation of the inspector, place a placard on a conspicuous part of the premises, specifying the hours when visitors will be admitted, it being expressly understood that visitors shall not be admitted to the lantern-room after sunset. No more than three persons shall have access to the lantern-room at one and the same time during the day; and no stranger visiting the light-house can be permitted to handle any part of the machine apparatus. The light-keepers must not on any pretext, admit persons in a state of intoxication into the lighthouse.*

Today nearly 250 lighthouses are accessible to the public. The more popular sites boast visitation in the hundreds of thousands. Lighthouses have become a popular icon in our culture. They are used as logos for restaurants, television production companies, real estate, newspapers and other periodicals, museums, and other such establishments. The lighthouse motif has been used for the exterior design and interior decor of restaurants, churches, banks, hostelries, and other places of business. Individuals have

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[1]Dennis Hanson, "The Tide Is Turning For Old Beacons Adrift At Land's End," *Smithsonian Magazine* (August 1987).

designed their homes to resemble lighthouses. The lighthouse motif can be found on microbrewery labels, jewelry, calendars, knick-knacks, place mats, napkins, note cards, etc. Miniatures of popular lighthouses are common in souvenir and gift shops. Many towns and counties have incorporated a nearby lighthouse into their official seal; many states include local lighthouses on their license plates. Lighthouses are extremely popular with tourists; local restaurants, motels, inns, bars, and other establishments incorporate lighthouses into their name. A popular television soap opera uses the light from a lighthouse in its introductory title; television commercials often use lighthouses as backdrops to their sales pitch.

PART I: FEDERAL ADMINISTRATIVE HISTORY

Lighthouses transferred to the Federal Government (1789-1820)

Prior to 1789, during the colonial period, each colonial government determined the need for a lighthouse in their colony, financed its construction, and oversaw its operation. Twelve colonial lighthouses remained in the hands of the individual states throughout the period of confederation with additional lighthouses being erected. Colonial lighthouses were usually constructed of wood or rubblestone.

On August 7, 1789, President George Washington signed the ninth act of the United States Congress which provided that the states turn over their lighthouses, including those under construction and those proposed, to the central government.[2] In creating the U.S. Lighthouse Establishment, aids to navigation would henceforth be the responsibility of the Secretary of the Treasury. The legislation also provided that a lighthouse would be erected at the entrance to the Chesapeake Bay. Cape Henry Lighthouse (1792) and its associated structures was not only the first light station completed by the Federal government, but also its first public works project.

Secretary of the Treasury Alexander Hamilton reviewed contracts and the appointment of keepers before sending these documents to President Washington for his signature. The president sometimes asked pointed questions and often commented on the salaries of each keeper at the individual lighthouses.[3] In 1792 Hamilton turned over the administration of aids to navigation to the Commissioner of Revenue until Albert Gallatin became Secretary of the Treasury. Gallatin kept control of lighthouses for nearly all of his two terms in office when this responsibility went back to the Commissioner of Revenue.[4] The commissioner retained this duty until the office was abolished in 1820. At that time, Stephen Pleasonton, Fifth Auditor of the Treasury, was assigned the responsibilities of the commissioner. The collector of customs assigned to that district did the administration of lighthouses on the local level. Between 1789 and 1820, the Lighthouse Establishment built about 40 new lighthouses; the towers were generally constructed of brick and cut stone.

Lighthouses under the Fifth Auditor of the Treasury (1820-1852)

For 32 years Pleasonton administered the U.S. Lighthouse Establishment. Little technical progress was made during his administration. Once Pleasonton had adopted a way of operation or a technical

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[2] *The Lighthouse Act of 1789*, U.S. Senate Historical Office, 1791, pp. 1-11.

[3] George R. Putnam, *Lighthouses and Lightships of the United States* (Boston and New York: Houghlin Mifflin Co., 1917), pp. 31-33.

[4] Ibid., p. 33.

development, he actively resisted changes or innovations. For example, when he assumed his new responsibilities, lighthouses were lit with the Argand lamp and parabolic reflector. When French scientist Augustin Fresnel invented a lens in 1822 which produced a light infinitely superior to the system used in American lighthouses, Pleasonton refused to adopt the new lens and actively resisted even testing it until forced to do so by Congress in the 1840s. After the highly successful test, the lens was not adopted in this country until the administration of aids to navigation was taken out of Pleasonton's hands and assigned to the Lighthouse Board. His reasons for rejecting Fresnel's lens were that the lens was too expensive and the lamp inside the lens was too complicated for American lighthouse keepers to operate. It is true the lenses were much more expensive, but these lenses paid for themselves within five years with the savings in oil. Moreover, the lenses have a much longer life, and many are still in use in American lighthouses over 125 years after their adoption. Argand lamps and parabolic reflectors were much more fragile, lasting about a tenth as long. Pleasonton was also a close associate of Winslow Lewis who patented and supplied his modified Argand lamp to American lighthouses. This friendship may have played a factor in Pleasanton's reluctance to replace Lewis lamps with Fresnel lenses.[5]

The number of lighthouses and lightships[6] grew dramatically during Pleasonton's reign as General Superintendent of Lighthouses. In 1820, since maritime activities were concentrated in the northeast, 75% of the nation's lighthouses were from Delaware Bay northward.[7] In 1822 there were 70 lighthouses in the country. By 1842 the number had increased to 256 lighthouses and 30 light vessels. Ten years later that number had increased to 331 lighthouses and 42 lightships.

For the last decade or so of his control of lighthouses, Pleasonton was under near-constant attack by shippers, navigators, chambers of commerce, and the Blunt brothers who issued the *American Coast Pilot,* the navigator's bible for sailing in American waters. They complained of the poor quality of America's lighthouses, especially the lights. In 1837 when Congress questioned the need for funding a large number of new lighthouses, a board of navy commissioners was appointed to examine the sites of proposed lighthouses and see if these aids to navigation were really necessary. After careful study, the commissioners recommended dropping 31 of the proposed lighthouses.

In the following year, Congress divided the country into eight districts including two for the Great Lakes. A naval officer assigned to each district examined the condition of current lighthouses as well as selected sites for new ones. The officers found that the condition of lighthouses ranged from good to terrible. Although they reported much faulty construction, an inadequate lighting system, and that many lighthouses were poorly placed, Congress took no immediate action. In 1838 Congress began to give the Army Corps of Engineers an increasing role in selecting the sites, constructing, and lighting lighthouses. An inventory was published and distributed to mariners in the form of an annual *Light List.*

Finally in 1851, complaints regarding the country's system of aids to navigation grew so intense that Congress ordered a sweeping investigation of the country's aids to navigation, and appointed a panel consisting of distinguished military officers and civilian scientists to conduct the investigation. Their investigation was broad and thorough, not only analyzing and criticizing the current state of aids to

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[5] Holland, *America's Lighthouses*, pp. 14-21.

[6] "Lightship" is a term that comes into use after the Lighthouse Board took over aids to navigation. Pleasonton and others always referred to them as "lightboats" or light vessels.

[7] Holland, *America's Lighthouses*, p. 69.

navigation, but also offering detailed recommendations to cure the problems. Surveys of ship's captains who sailed up and down the coasts were conducted. All findings were compiled into a report that made specific recommendations for improvements.[8]

Establishment of the U.S. Lighthouse Board (1852-1910)

Congress immediately passed legislation to establish a Lighthouse Board that was essentially composed of those who had overseen the investigation. The appointment of these experienced, knowledgeable men to the Board attracted others of similar quality to lighthouse duty, both on the board and in district offices. Since the board members were government employees, they could not be paid for this duty. They squeezed their quarterly meetings into their regular jobs. Day-to-day operation of the Board was the responsibility of a naval secretary and an engineer secretary; both officers on detached duty. The country was organized into 12 lighthouse districts, each having an inspector (a naval officer) who was charged with building the lighthouses and seeing that they remained in good condition and that the lens was in operation. After a few years, the inspectors became overloaded with work and an engineer (an army officer) was appointed to each district to tend to the construction and maintenance of lighthouses.

The Lighthouse Board moved quickly. The Board had to deal with new technology, particularly in purchasing and installing new Fresnel lenses and constructing screwpile lighthouses. The Board also had to oversee the construction of the first lighthouses on the west coast. It was a difficult period for the Lighthouse Board, but it methodically went about getting its program started and underway. By the time of the Civil War, all lighthouses had Fresnel lenses.

The role of the local collectors of custom in connection with lighthouses was slowly declining. In time, all duties regarding aids to navigation were taken from them. The Board demanded that only those who could read were to be appointed as keepers so that they would be able to read their written instructions to them. These instructions were detailed and covered everything possible about the operation of lighthouses, leaving little discretion to the keeper. The Board struggled to eliminate politics from its activities, and slowly the organization became a professional career agency, helped greatly by the Civil Service Reform Acts of 1871 and 1883. Most important, the Board was constantly mindful of advancing technology and took advantage of new types of lighthouses, buoys, or fog signals, as well as improvements in lighthouse optics. Over the next five decades, several advances in lighthouse construction technology took place including the development of the exposed screwpile lighthouses, exoskeleton lighthouses, waveswept interlocking stone lighthouses, iron caisson lighthouses, and breakwater lighthouses.

Several advances in the technology of navigational aids were made during the 1850s. In 1851, an experimental air fog whistle and reed horn was installed at Beavertail Lighthouse at the entrance to Narragansett Bay, Rhode Island. The first installation of this sound signal was powered by a horse-operated treadmill and later by an internal combustion steam engine. Around 1851, mechanically-rung fog bells were introduced. The striking mechanism was governed by a weight attached to a flywheel, and later internally run by clockworks. The strokes of the fog signals were timed deliberately to afford each signal a unique sound characteristic.

In the 1850s, the United States Lighthouse Board prescribed color schemes for the buoys, as well as range lights and day markers; and the buoy system was standardized. Classification systems were also

[8] See also "Report of the Officers Constituting the Lighthouse Board . . . February 6, 1852," *32nd Congress, 1st Session, Senate Executive Document No . 28* (Serial #617), especially pp. 6-18.

developed to mark the nation's waterways. Iron buoys were introduced to replace the more expensive copper-clad wooden buoys; this was noted in an appropriation specifying an iron can buoy for Little Egg Harbor, New Jersey, in 1855. The Lighthouse Board also began printing changes made in aids to navigation as a *Notice to Mariners*.

The U.S. Lighthouse Board was continually trying to improve the quality of navigational aids technology, from fog signals to lighthouse illuminants. Before this period, whale oil was the primary combustible used to fuel the lights; however, it became more expensive as production decreased. Lard oil became popular in the 1850s, and by 1885, kerosene became the principal illuminant for the lighthouses. Because of the volatile nature of kerosene, Congress issued a series of small appropriations for the construction of separate fireproof oil houses at each lighthouse station. Installation of these structures was finally completed about 1918. Lighthouse illuminants were further refined and experiments in other aids to navigation persisted throughout the decades of the 1860s, 1870s, and 1880s.

In the 1870s great improvements in the technology of fog signals were especially helpful on the often foggy northeastern and western coasts.[9] Colonial use of cannon had given way to bells and horns. The bell signal was gradually replaced by three variations of that instrument. The first was an ordinary locomotive whistle, enlarged and modified and blown by steam from a high-pressured tubular boiler. The second was a reed-trumpet, and in 1866 the third variation, a siren-trumpet. Although the fog bell signal was still used for warning vessels over short distances, other fog signals started to supersede the smaller bell signal. Bells were also used on buoys; later whistling buoys were invented by J. M. Courtenay and were first in use in 1876. The first gas-lighted buoy was installed in 1882. The gong buoy was invented in 1923. The number of lightships increased substantially and by 1882, all lightships were constructed of iron or steel.[10]

In 1886, a new technology[11] was being tested in the illumination of the Statue of Liberty: electricity. The electrical lighting of the Statue, under the Lighthouse Board's care from 1886 to 1902, marks the beginning of the "modern age" in lighthouse illumination. In 1900, the Lighthouse Board began converting lighthouses to electric service; however, because of the lack of direct access to power lines, the conversion came about slowly.

In 1889, the "first wireless messages" were sent and received between ship and shore on the East Coast. This exchange occurred between operators aboard the *S.S. Ponce* and at the Navesink Twin Lights, New Jersey. The first actual wireless message, however, had been staged earlier at San Francisco's lightship when one message was sent repeatedly from ship to shore. The advent of the telegraph ushered in a new type of navigational aid which would improve needed communication between ship and lighthouse stations.

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[9] The evolution of fog signals included cannons, bells, ship's whistles, sirens, reed trumpets, diaphone and electronic bells and horns. (Personal communication, Wayne Wheeler, February 24, 1998.)

[10] George Weiss, *The Lighthouse Service: Its History, Activities and Organization* (Baltimore, Maryland: The John Hopkins Press, 1926) p. 15.

[11] Electricity was first used in lighthouses in England and France in 1865. (Personal communication, Wayne Wheeler, February 23, 1998.)

Lighthouses during the Civil War

One of the most trying periods for the Lighthouse Board was the Civil War, mainly because the southern and Gulf coasts were darkened by the Confederates. Lighthouses and other aids to navigation were of greater importance to navigation for the Union forces, since the southerner blockade-runners were familiar with local waters. Lightships suffered also; Confederate naval raiding parties captured these vessels often hiding them from the federal forces, sinking, or burning them.

Most of the damage to the lighthouses was inflicted by contingents of the Confederate army, sometimes on their own initiative, but mostly on orders. Some local citizens took it upon themselves to put a lighthouse out of operation. Often explosives damaged the top of the tower; thus, not only impairing its use as a navigational aid, but also as a spotting tower for federals. On at least one occasion the military dismantled an iron-plate lighthouse, and apparently melted the plates for military purposes.[12]

As the Civil War drew to a close, only a minuscule number of southern lighthouses remained in operation. They were offshore and under the protection of union troops such as Garden Key Lighthouse on Fort Jefferson and Dry Tortugas Key Lighthouse that is within sight of Fort Jefferson, and the tall towers at Carysfort Reef and on Sand Key.[13] As sections of the coasts were brought back under Federal control, commanders of the area would ask the Lighthouse Board to restore the lighthouses and other navigational aids. Though the Board did what it could to get these aids back into service, the actual work done during the war was spotty and mostly temporary. Consequently, after the conflagration was over, the Lighthouse Board had a major task on its hands. Some lighthouses had to be rebuilt, others repaired before they could go back into service, many lightships had to be constructed, and lenses had to be recovered or obtained.[14] Within a couple of years the work was done, with the last few back in operation in the early 1870s.

The Lighthouse Board looked on this tragedy as an opportunity to implement its policy of replacing, where possible, inside light vessels with screwpile lighthouses. A lighthouse was much less expensive to operate than a lightship.[15] The waters of North Carolina and Chesapeake Bay before the war had a number of lightships, and between 1864 and 1868, screwpile lighthouses replaced at least six lightships in North Carolina sounds and at least another five in Chesapeake Bay waters.[16]

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[12] T. Lindsay Baker, *Lighthouses of Texas* (College Station: Texas A&M University Press, 1991) p. 59.

[13] Kevin M. McCarthy, *Florida's Lighthouses* (Gainesville: University of Florida Press, c.1990), pp. 51, 75.

[14] David L. Cipra, "The Confederate States Light House Bureau: A Portrait in Blue and Gray," *The Keeper's Log*, v. VIII, no. 2, pp. 6-13. Cipra, who has been researching confederate lighthouse records in the National Archives, says he found no indication of a confederate policy to put lighthouses out of operation. He thinks local collectors of custom and/or military units took independent action to darken the lighthouses. See p. 9.

[15] Inside lightships were those in bays, harbors, sounds, and rivers. Those lightvessels in the ocean offshore were considered outside lightships.

[16] Some publications containing substantive information on the impact of the Civil War on individual lighthouses or coastal areas are: David Stick, *North Carolina Lighthouses* (Raleigh: North Carolina Department of Cultural Resources, 1988), pp. 53-61; T. Lindsay Baker, *Lighthouses of Texas* (College Station: Texas A&M University Press, 1991), pp. 3-12, 14-15, 19, 30, 59, 73-74; F. R. Holland, Jr., *The Aransas Pass Light Station: A History* (Corpus Christi, TX: Privately printed [Charles C. Butt], 1976), pp. 39-47; F. Ross Holland, Jr., *A History of Cape Hatteras Light Station, Cape Hatteras National Seashore, North Carolina,* Division of History, National Park Service, September 30, 1968, pp. 66-75, and David Cipra, *Lighthouses, Lightships, and the Gulf of Mexico* (Alexandria, VA: Cypress Communications, 1997), pp. 9-23.

Bureau of Lighthouses or the U.S. Lighthouse Service (1910-1939)

Over its 58 years of service, the Lighthouse Board accomplished all it set out to do, and passed on to its successor a first-rate agency, both in terms of personnel and aids to navigation. The Lighthouse Board presided over an enormous increase in numbers of aids. By 1910, there were 11,713 aids to navigation of all types in the country. At this time, the Lighthouse Board had become cumbersome, and Congress wanting to give a civilian aura to the administration of aids to navigation, abolished the Lighthouse Board and created the Bureau of Lighthouses. The legislation authorizing this step referred to the bureau as the Lighthouse Service, and it is better known by that name.[17]

The Lighthouse Board had hired a number of civilians and many of these experienced people took over the roles that the military officers had been playing. Though most of the engineers and inspectors eventually transferred back to military projects, the legislation establishing the new bureau permitted the use of the inspectors and engineers for a two-year transition period. The new commissioner took advantage of the grace period to carefully and methodically select new civilian inspectors for each district; consequently, the change to a completely civilian bureau evolved with a minimum of trauma. Though initially called inspectors, the civilian heads of the districts changed their titles to superintendent.[18] Also at this time, the placement of aids to navigation along rivers had become the responsibility of the Lighthouse Service, and local citizens called lamplighters and lamp attendants tended many of these aids on a part-time basis.

President Taft selected George R. Putnam to head the new bureau, and he had the title, Commissioner of Lighthouses. Putnam had been a longtime employee of the Coast and Geodetic Survey's Washington office. For 25 years Putnam headed the bureau and during his administration, navigational aids saw a substantial increase and new technology, when appropriate, was incorporated into the bureau's work, particularly in the area of electronics. Though the number of aids to navigation increased substantially during Putnam's reign from 11,713 to 24,000, mostly buoys and small lights, arguably two of his most significant achievements were the passage of the Retirement Act for lighthouse personnel in 1918, and the introduction in 1921 of the radiobeacon as an aid to navigation. This new technology permitted a reduction of over 800 employees during Putnam's 25 years as head of the bureau.[19]

In 1912, under Putnam's leadership, a monthly newsletter, called the *Lighthouse Service Bulletin*, was circulated to Lighthouse Bureau employees and contained events of interest and importance, as well as occasional anecdotes and recipes. In the same year, a system of efficiency stars and pennants was established to promote friendly rivalry among lighthouse keepers.

During World War I and the period following, several technological advances contributed to the automation of lighthouses, rendering human occupancy unnecessary. A device for automatically

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The reference to six screwpile lighthouses replacing former lightships in North Carolina can be found in Holland, *America's Lighthouses*, pp. 128-129; Ralph Eshelman, Light Stations of Maryland, Multiple Property National Register Nomination (Maryland Historical Trust, Crownsville, MD, 1996), lists five for Maryland plus Windmill Point in Virginia.

[17] George R. Putnam, *Sentinel of the Coasts: The Log of a Lighthouse Engineer* (New York: W. W. Norton & Co., 1937), p. 119.

[18] Ibid., p. 126.

[19] Ibid., p. 328.

replacing burned-out electric lamps in lighthouses was developed and placed in several light stations in 1916. A bell alarm warning keepers of fluctuations in the burning efficiency of oil-vapor-lamps was developed in 1917. In the same year, the first experimental radiobeacon was installed in a lighthouse. The first automatic radiobeacon in the United States began service in 1928. Radiobeacons are still in use today, although most have recently been decommissioned as improved electronic navigational aids have become available. Radio compasses were also introduced during this period. An automatic time clock for operating electric range lights came into use in 1926, and by 1933, a photo electric-controlled alarm device had been developed to check the operation of the unwatched electric light. A lightship staffed by remote control was equipped by the Lighthouse Bureau in 1934. It included a light, fog signal, and radiobeacon, all controlled by radio signals. A battery-powered buoy that gradually replaced the older acetylene buoys was introduced in 1935. Due to the technological improvements mentioned above, and in particular the radiobeacon direction finder, the United States rose from sixth in shipping safety in 1920 to second in 1935, with only the Netherlands holding a better safety record.[20]

Improvements in the road and highway systems provided better and more rapid means of transportation during the 1920s and 1930s. As a result of the improved roadways, the Lighthouse Bureau was able to better maintain aids to navigation, benefiting the service economically. The extension of electric lines into remote sections of the country provided a reliable power source for operating aids to navigation. By the 1920s and 1930s, the majority of light stations had electric service, reducing the number of staff necessary to operate the station. As ancillary buildings at many stations, especially shore stations, were rendered useless, the makeup of the light station began to change. Over time, many of the lighthouse buildings, such as oil houses, fog signal buildings, and towers, were demolished or removed.

Lighthouses under the U.S. Coast Guard (1939-present)

In 1935, Putnam was followed in the Commissioner's position by a career Lighthouse Service employee, H. D. King, a former district superintendent. But the new commissioner had but four years to serve, for in 1939 the duties of the Bureau of Lighthouses were amalgamated into the operations of the U.S. Coast Guard. Personnel of the former bureau were given the choice of being brought into the Coast Guard through a military position or remaining as civilian employees. About half chose to remain civilians, and about half went the military route.

During World War II, one of the many war-related jobs of the Coast Guard was to guard the shores of the country. With the help of volunteers and career Coast Guard personnel, the Beach Patrol was formed whose mission was to patrol the shore, guarding against enemy incursion, rescuing victims of German submarine warfare, and retrieving bodies of the dead. The Coast Guard issued directions, that where possible, Coast Guard stations, lifeboat stations, and lighthouse stations be made available to the Beach Patrol. The lifeboat stations were used more often, probably because it was easier to coordinate the lifeboat station activities with the responsibilities of the Beach Patrol. Lighthouses and ancillary structures were also used, especially at stations that had been deactivated. Many were used as spotting stations to view possible enemy land and sea activities. Light towers were also used as temporary radio stations and used portable equipment the height of the tower to improve communication with the unit's beach patrols.[21]

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[20] Holland, Jr., *America's Lighthouses*, p. 204; and Adamson, 1955.

[21] Eleanor C. Bishop, *Prints in the Sand: The U. S. Coast Guard Beach Patrol During World War II* (Missoula: Pictorial Histories Publishing Co., 1989), pp. 30, 33, 38, 41, 56.

During World War II and postwar periods, the Coast Guard continued to develop new technologies. The effectiveness of radio technology, and an increased dependence on it, decreased the role of the lighthouse stations. SHORAN (short-range navigation aids) or LORAN (long-range navigation aids) were installed at stations and stationary towers; large navigational buoys (LNBs) began replacing lightships in the 1970s. In the mid-1960s, the Lighthouse Automation and Modernization Program (LAMP) began further eliminating the need for lighthouse personnel. By the 1960s, fewer than 60 lighthouses had keepers. By 1990, all lighthouses but one were automated.[22]

In May 1980, the U.S. Coast Guard Short Range Aids to Navigation Division of the Office of Navigation was formed. Under this program, 64 Aids to Navigation Teams (ANTS) were assigned across the country. The Aids to Navigation Teams, each of which comprises about 12 people, are responsible for maintaining the active lighthouses in the United States. Each ANT is assigned responsibility for its area's lighthouses, providing periodic preventive maintenance, and responding immediately to lighthouses if any outages or other discrepancies occur. Under this system, a relatively small number of people are able to look after the approximately 300 active lighthouses administrated by the United States Coast Guard today. In recent years, acrylic "Fresnel-like" lenses have been introduced to replace the classic glass Fresnel lenses and airport-type "aero-beacons" used at some lighthouses. These smaller and less expensive lenses, designed like Fresnel lenses, are visually as effective as the old lenses and require less maintenance.

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.[23] With the wholesale automation of lighthouses, secondary structures at light stations for the most part became obsolete and with the departure of personnel, these structures became subject to vandalism and received little maintenance. The Coast Guard soon encountered a rising grassroots concern for the preservation of these old stations and many, mostly local, historical societies, expressed a strong interest in obtaining an old station to preserve and open to public visitation. The Coast Guard began setting up a process for leasing old light stations to local historical groups and other organizations interested in caring for the structures. More recently, the Coast Guard, with the Department of Transportation, has declared lighthouses to be excess property, allowing the General Services Administration to transfer them to organizations better equipped to preserve their historic nature, while retaining access to the navigation signal.

PART II: ARCHITECTURE & ENGINEERING

U.S. Lighthouse Construction Types

The United States has more lighthouses and diverse architectural and engineering types than any other country in the world. Most lighthouses can be categorized by construction method, shape, building material, or foundation types. A lighthouse can also be classified as terrestrial or aquatic, i.e., onshore or offshore. The majority of today's 600 light stations are land based; close to a fourth have foundations

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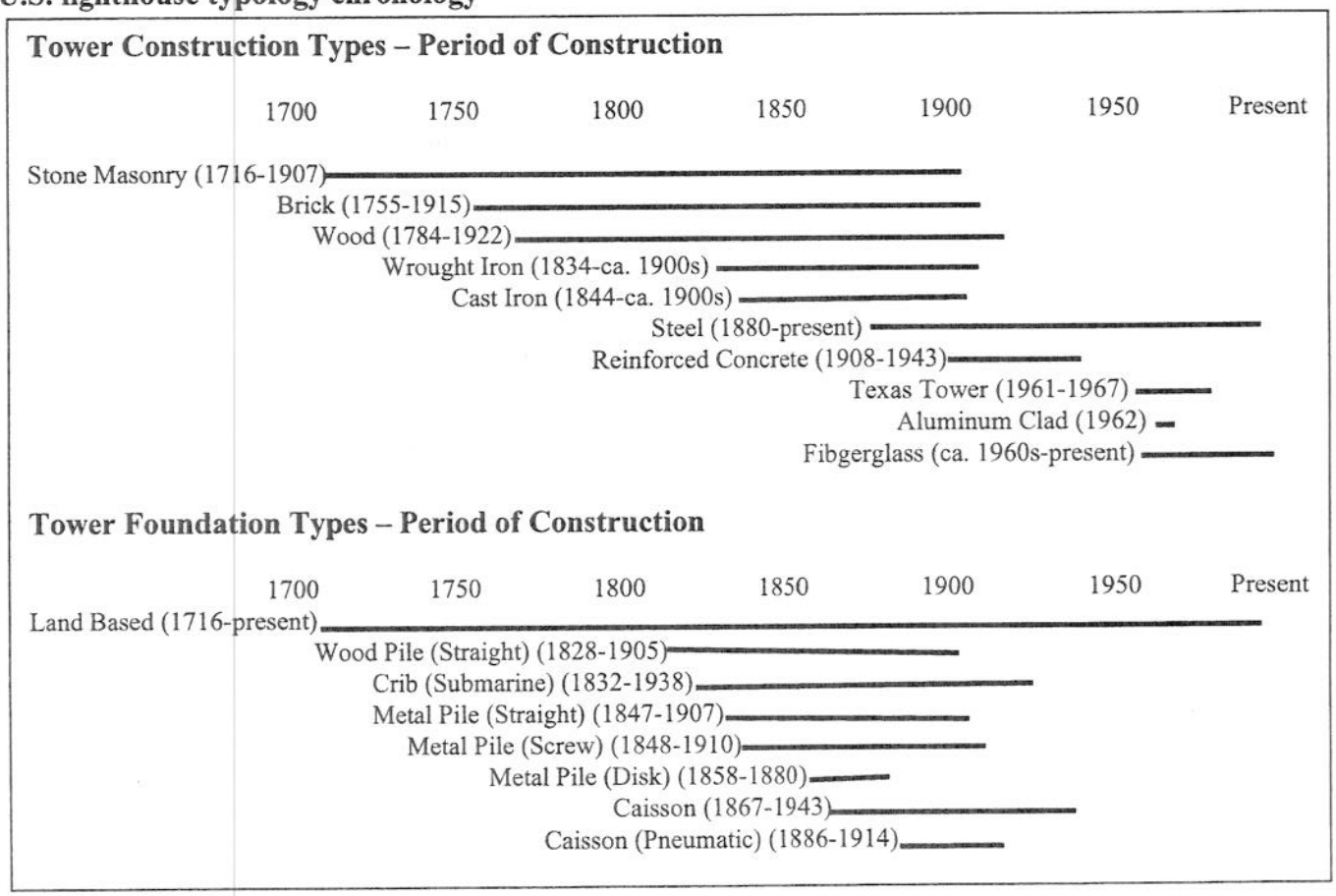
[22] Today the only lighthouse with official keepers is the Boston Harbor Light Station. It will to continue to be staffed per an Act of Congress.

[23] Reese, David, and Robert Browning, "Lighthouse Management: A Balancing Act by the U.S. Coast Guard" *CRM*, Vol. 20, No. 8 (National Park Service, July 1997)

built in the water. The major construction types for lighthouse towers are: wooden, masonry, wave-swept interlocking masonry, concrete, cast-iron plate, skeletal, straightpile, screwpile, crib, caisson, and Texas tower. Lighthouses were built on land, in the water, on islands, on top of ledges and cliffs, on breakwaters and piers, and at least five are on fort walls. Some light towers are stand-alone structures, while others are attached or integral to, a keeper's quarters or, in a few cases, a fog signal building. In addition to a light tower, a land-based light station might consist of a keeper's quarters, oil house, fog signal building, workshop, cisterns, privies, landing wharf, boathouse and ways, barn, roads, walks, and fences (for more information, see Part III, Lighthouse Components).

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

U.S. lighthouse typology chronology[24]



[24] This timeline is for United States lighthouses; tower and foundation construction types were sometimes used earlier or later in other countries. The dates are meant only to give relative time, not absolute first and last use of this construction type.

Wooden tower

The earliest lighthouse towers in the original colonies, and subsequently in the United States, were built of wood and/or rubble stone. Of the wooden towers, most were consumed by fire; approximately 11 percent of the historic lighthouse towers in existence today are made of wood.[25]

Masonry tower

Masonry towers were constructed of rubblestone, cut stone (dressed stone), brick, and concrete. Nearly 20 percent of all historic lighthouse towers extant are made of stone and approximately 32 percent are made of brick.[26] 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. The preferred foundation for masonry lighthouses was bedrock, but wooden piles driven into the substrate and topped with timbers and/or rubble stone had to be used in regions such as the coastal plain where bedrock was lacking. Towers of stone and brick were typically built in the form of the frustum of a cone (a conical or pyramidal shape left by cutting off the top portion at a plane parallel to the base). Masonry walls of lighthouses are typically several feet thick at the base and decrease in thickness upward, with heights ranging from 30 feet at Piney Point Lighthouse (1836), Maryland, to the tallest lighthouse in the United States, the Cape Hatteras Lighthouse (1870), North Carolina, at 197 feet.[27] The base of the tower was made thicker to support the ever-increasing weight from above and to make it more stable. Cut or dressed stone, and later brick, permitted construction of taller and stronger towers because the weight could be more evenly distributed.[28] The tapering sides were either conical such as Boston Harbor Lighthouse (1789), Massachusetts, or octagonal such as Sandy Hook Lighthouse (1764), New Jersey, and Cape Henry Lighthouse (1792), Virginia.

Some deteriorated masonry towers on the Great Lakes were encased in steel plates and the void between the steel plates and masonry tower filled with grout. Big Sable Point Lighthouse (1867), Michigan, was encased in 1900; and Cana Island Lighthouse (1869), Wisconsin, encased in 1901.[29]

Tall masonry tower

When the Cape Hatteras Lighthouse (1803) tower was heightened to 150 feet in 1854, it was the first of the "tall tower" lights to be built in the United States (this original tower was replaced by an even taller tower in 1870). During the construction of the Ponce de Leon Inlet Lighthouse (originally Mosquito Inlet) in 1887, Lighthouse District Superintendent of Construction Herbert Bamber invented an adjustable, moveable working platform that increased the efficiency and ease of constructing masonry towers. Individual bricks were left out of the exterior tower wall every 10 feet vertically and

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[25] Robert L. Scheina, "The Evolution of the Lighthouse Tower," in U.S. Lighthouse Service Bicentennial, a U.S. Lighthouse Society Event Souvenir Program (Newport, Rhode Island, September 21-24, 1989), p. 18; and Clifford, p. xvii.

[26] Clifford, p. xvii.

[27] According to 1989 HABS documentation, the overall height of the tower at Cape Hatteras is 208 feet including the foundation. The height from ground level was recorded at 197 feet; and "Cape Henry Light Station," U.S. Coast Guard Records, National Archives, Washington, D.C.

[28] Scheina, pp. 18-19.

[29] Barnes, p. 9.

horizontally so that supports for the platform could be set into the resulting slots. Once the tower was completed, the platform was lowered level by level and the gaps filled with bricks.

Waveswept masonry tower

Subjected to the full fury of the sea, the offshore waveswept masonry tower is built on rocks just above or slightly below the ocean surface. John Smeaton, an Englishman, built the first successful masonry waveswept tower in 1759 at Eddystone Rock, in the English Channel, though a waveswept tower was built in 1157 on the shoal of Meloria, near Livorno, Italy. Smeaton's tower was the first interlocking masonry block tower. Later Smeaton developed (using the Roman idea that by mixing lime putty with a fine volcanic ash, it would harden under water forming possibly the first hydraulic cement) cement that would set up in water. These two inventions revolutionized open sea lighthouse construction and remained the principal method for their construction until concrete and steel came into use. The first masonry waveswept tower to be built in the United States was the 114-foot Minots Ledge Lighthouse (1860), Massachusetts, which replaced a pile-type lighthouse destroyed by a storm. It is considered the "most important engineering work" constructed by the Lighthouse Board and "it ranks, by the engineering difficulties surrounding its erection, and by the skill and science shown in the details of its construction, among the chief of the great sea-rock light-houses of the world." It took five years to complete and cost approximately $300,000 to build.[30]

These waveswept towers were built by interlocking large cut stones together, both horizontally and vertically. This integral intertonguing formed a monolith of great weight which combined with their conical shape diverted the energy of the waves away from the tower enabling them to withstand the heavy pounding of the surf. While most waveswept towers were built with interlocking stone, any lighthouse, regardless of material used in construction, but subject to being waveswept, may be so called.

Concrete tower

In 1824 Joseph Asplin was granted a patent for a superior cement which resembled Portland Stone. I. C. Johnson discovered in 1844 the high temperature process of forming Portland Cement clinker. In 1872 Johnson was granted a patent for Improvements in the Manufacture of Portland and Other Cements. The mass production of Portland Cement was made possible by the introduction of the rotary kiln in 1877. Concrete towers began to replace the brick masonry towers in Scotland in the late 19th century and in the United States at the beginning of the 20th century. Use of reinforced concrete in the United States dates from 1860 when S. T. Fowler obtained a patent for a reinforced concrete wall. Concrete did not become generally accepted, however, until the introduction of the horizontal rotary kiln, developed by Ernest L. Ransome in 1880. This type of kiln allowed for the production of cheaper, more uniform and reliable cement. Reinforced concrete became an accepted building method during the 1890s; the first use of reinforced concrete in a lighthouse in the United States was at Tillamook Rock Lighthouse (1881), Oregon, when the original iron roof was replaced with a flat reinforced concrete slab in 1898. The first lighthouse tower constructed of reinforced concrete in the United States was the 115-foot-tall Point Arena Lighthouse (1908), California. The earthquake hazards of the West Coast prompted the

[30] Hague and Christie, p. 12; Ebbe Almqvist and Kenneth Sutton-Jones, "Milestones in Lighthouse Engineering," (no reference), p. 16; and Quote from Arnold Burges Johnson, *The Modern Light-house Service* (Washington, D.C., Government Printing Office, 1890), pp. 30-31.

construction of many reinforced concrete lighthouses in California and Alaska.[31] Unlike the tapered brick and stone towers, reinforced concrete towers typically are cylindrical.

The Navassa Island Lighthouse (1917), Windward Passage, West Indies, at 162-feet in height, was the tallest reinforced concrete tower when built. The newest reinforced concrete lighthouse in the United States is Oak Island Light, North Carolina (ca. 1958). This 155-foot silo-type tower was built using slipforms. The three wide horizontal daymark color bands were incorporated into the concrete so that the tower never needs to be painted.[32]

The first combination of a reinforced concrete tower on a reinforced unprotected concrete pier was built at the Brandywine Shoal Lighthouse (1914), New Jersey. The pier is cylindrical, 35 feet in diameter, weighs 225 tons, and rests in eight feet of water on top of 74 pine piles which were jetted into the shoal within one foot of the bottom. The pier was built on shore, floated to the site, and sunk into position in a manner very similar to cast-iron caisson construction discussed later. Where it differs, however, is that the pier is secured to the wooden piles by 12 precast reinforced concrete piles, each weighing 4 tons passing through sleeves on the outer shell of the pier. This is the first use of precast concrete in the United States. Some modern lighthouses are now made of prestressed-precast rings which are stacked and post-tensioned.[33]

Cast-iron tower

Approximately 20 percent of the historic lighthouse towers extant in the United States are made of iron, however, this percentage includes screwpile and skeletal towers.[34] Cast iron was lighter than stone or brick, relatively inexpensive, capable of being shaped, watertight, and had a slow rate of deterioration.

The first cast-iron lighthouse was an octagonal tower built at Swansea, England, in 1803. The earliest surviving cast-iron lighthouse is believed to be the 1834 slender hollow octagonal lantern built on the south pier of Mayport, Cumberland, England. The first cast-iron lighthouse in the New World was designed by Alexander Gorden, built in England and erected in Jamaica in 1840. This round lighthouse tower built at Morant Point, still stands. Gorden designed at least 10 similar lighthouse structures. The United States was quick to follow Gordens concept when in 1844 it built a cast-iron tower on Long Island Head, Boston Harbor (this tower was replaced by a brick tower in 1900).[35] Another early iron lighthouse was begun in 1847 and completed in 1850 when Captain William H. Swift of the U.S. Topographic Bureau, recommended an iron pile structure for Minots Ledge, an offshore waveswept ledge. The Minots Ledge lighthouse was built with one central and eight periphery 10-inch diameter wrought-iron piles wedged in 5-foot-deep holes drilled into the ledge. Swift recommended this design

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[31] Hague and Christie, p. 107; Belle Isle North East Lighthouse, Newfoundland, Canada, built in 1905, is possibly the first reinforced concrete lighthouse in North America; see Alfie Yip and Ross Anderson, *Canadas Flying Buttress Style Lights*, unidentified Canadian publication.

[32] Clifford, pp. 9, 25, and 337; and Barnes, p. 12.

[33] George R. Putnam, *Lighthouses and Lightships of the United States* (Boston, Houghton Mifflin Company, 1933), pp. 84-85; and Barnes, pp. 11 and 13.

[34] Clifford, p. xvii.

[35] Hague and Christie, pp. 104-105; Patrick Barnes, The Development of Lighthouse Structures, unpublished manuscript, USCG, Cleveland, Ohio, no date, p. 6., copy at National Maritime Initiative Office, National Park Service, Washington, D.C.; and Clifford, p. 149.

because he felt the piles would provide less resistance to the waves than a stone tower. But 15 months later the lighthouse was destroyed in a severe storm. Nevertheless iron lighthouses continued to be built.

Cast-iron-plate tower

Cast-iron plates were prefabricated offsite, numbered, and easily assembled into towers on site. The cast-iron plates were either segments of a cone or a flat surface, depending on the design chosen. The plates have flanges on all four sides which were fastened together by bolts. The interior of the tower was often lined with brick for added stability and insulation. Cast-iron-plate towers were similar to masonry towers in external physical appearance; from the outside, both the Hunting Island Lighthouse (1875), South Carolina, and the second Cape Henry Lighthouse (1881), Virginia, resemble masonry structures. In areas where shifting and eroding beaches were present, cast-iron-plate towers were designed so they could be disassembled and re-erected as needed. Cape Canaveral Lighthouse (1868), Florida, and Hunting Island Lighthouse (1875), South Carolina, are examples of this design - both having been successfully moved.

By varying the size of the plates and number of courses, lighthouses of different heights and dimensions could be made. Architectural features such as door and window openings were cast into the integral part of a plate so when fastened together an attractive, uniform pediment or hood could be produced.[36] This same design was used to build the cast iron cylinders which formed the upper foundation of caisson lighthouses.

Skeletal tower

Skeletal tubular iron towers consisting of a central vertical stairway cylinder and four to eight slanting structural skeletal peripheral columns were especially adapted to locations where a relatively light pile structure was required in mud, sand, swamp, or coral. This type of lighthouse structure was also prefabricated offsite and easily assembled on site.[37]

Some skeletal tubular lighthouses were constructed on foundations not requiring piles. These were usually terrestrial tubular skeletal towers built on rock or sand and made of cast iron or steel. Skeletal towers were often standardized. The most common form was four-legged tapered towers with diagonal bracing available in 10-, 20-, 30-, and 40-foot heights. Skeletal towers built offshore typically used straight or screwpile foundations and are discussed later. Cape Charles Lighthouse (1895), Virginia, is the tallest skeletal lighthouse tower in the United States and at 191 feet is only 17 feet shorter than the brick tower at Cape Hatteras.

Iron proved popular for construction of range lights (pairs of lights that when viewed in a line from a vessel signifies the vessel is within the navigable channel) and breakwater lighthouses (lights established at the ends of protective breakwaters to harbors and waterways) which required small and lightweight structures so as to not stress a small lightweight foundation, yet strong enough to withstand the impact of waves and resultant vibrations. The keepers' quarters were often detached and located onshore, as most breakwater lights were built at port towns. The Great Lakes has the largest number of breakwater

[36] J. G. Barnard, Lighthouse Engineering as Displayed at the Centennial Exhibition, American Society of Civil Engineering Transactions, volume 8, 1879, p. 70.

[37] Almqvist and Sutton-Jones, p. 17; and Scheina, p. 22.

lighthouses in the United States.[38] There are at least two "bottle shaped" cast-iron/boiler plate breakwater lighthouses: South Buffalo North Side Lighthouse (1903) and Buffalo North Breakwater South End Lighthouse (1903), both in New York.[39]

Non-cast-iron tower

It is not always clear whether lighthouses are made of cast iron, wrought iron, or steel. Steel was used in place of iron for skeletal structures as early as 1880 but iron was more common until just before the turn of the century. After 1900 iron was used only in special situations. For example, to take advantage of iron's superior corrosion resistance, iron plates were placed over a steel frame at the St. Joseph North Pier Inner Lighthouse (1907), Michigan; and corrugated iron was placed over a wooden structure at Grand Haven South Pier Entrance Light Station fog signal building (1922), Michigan. Cast-iron lanterns continued to be used even on steel structures up into the 1930s. Steel towers have lapped, riveted, or welded joints. The 1833 Buffalo Lighthouse in New York is built with internal cast-iron supports but non-cast-iron external plates.[40] Gravelly Shoal Lighthouse (1939), Michigan, is a steel-plate tower. At least one dressed stone light was sheathed in iron plate, Destruction Island Lighthouse, (1891), Washington.[41] It was gradually accepted that the cast-iron lighthouses, though cheaper to build than masonry, were not as structurally sound for exposed sites, but rather more acceptable for secured headlands and harbor locations. Steel on the other hand, has greater tension and residual strength than iron making it better for slender truss and frame members resulting in lighter designs. Ductile steel when used as a reinforcement also allowed the use of concrete which lacked tensile properties. Los Angeles Harbor (1913), California, is a steel frame structure with concrete plaster infilled walls.[42]

Foundation Types

Many of the earliest lighthouses in the colonies and the United States were built on natural rock outcrops. Other early lighthouses were built upon sandy soil lying almost at sea level and built on foundations of wood timbers and planks. With the advent of pile-driving technology closely spaced wooden piling also supported such foundations. This grillage was usually placed within an excavation deep enough to keep the wood below the water table. Of the 40 or so brick tower lighthouses constructed in the South between 1820 and 1852 at least 25 were destroyed when eroding foundations caused them to fall down or blow over in storms.

Offshore lighthouses were generally more expensive to build because of exposure to storms, currents, and wave action and because of the high costs of transporting materials and workers to the site. But, their strategic placement afforded better marking of offshore shoals, reefs, rocks, and channels. Many of the first offshore lighthouses replaced light vessels and buoys.

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[38] Scheina, p. 23.

[39] Clifford, pp. 229 and 252.

[40] Barnes, p. 10; Clifford, pp. 174, 201 and 228.

[41] Clifford, p. 327.

[42] John Naish, *Seamarks: Their History and Development* (London, Stanford Maritime, 1985), p. 129; and Barnes, pp. 10 and 13.

In the Great Lakes region, cribs of fastened timbers built in a box-like fashion were floated to a site and filled with stone and/or concrete. Sometimes a steel shell containing cells was built around the wood crib that then was pumped full of concrete and positioned on the bottom. Interlocking steel sheet piling filled with stone and capped with a concrete slab has been used to form foundations in areas where ice is prevalent.
Metal screwpiles were used to form the foundation of many lighthouses built on sandy or muddy bottoms. The helicoidal or screw-like cast-iron flange at the end of the metal pile was augured into the bottom increasing the bearing power of the pile as well as its anchoring properties. Yet lighthouses built with these foundations were found to be vulnerable to ice floes. In areas such as the Florida Keys, where the bottom is soft coral rock, disc pile foundation lighthouses were built. Wrought iron piles were driven through a cast-iron or semi-steel disc that rested on the sea floor until a shoulder on the pile prevented further penetration. The disc diffuses the weight of the tower more evenly over the bottom. In coral reef areas where sand is also prevalent, a cast-steel screw was fitted to the end of the pile to give it more anchoring ability. Cofferdams were used generally in shallow waters where it was not necessary to deeply penetrate the natural bottom. The cofferdam enabled the water inside the dam to be pumped out and the foundation built in the dry.

In areas prone to ice flows, caissons were employed as lighthouse foundations. Caissons were made of fastened cast-iron plates forming a hollow cylinder. At the bottom of the cylinder is fastened a wooden crib. The assemblage is allowed to settle to the bottom and sinks under its own weight as rock and concrete fills the cylinder. Where deeper penetration into the bottom is required, sediments are excavated from the bottom of the crib allowing the assemblage to sink deeper. This later technique is referred to as pneumatic because of the air pressure required to keep water from entering into the assemblage.

Finally, a few lighthouses have been built on breakwaters composed of large quarry rock. Los Angeles Harbor Lighthouse (1913), California, is an example of a breakwater foundation lighthouse. Many of these foundation types are more fully discussed below.[43]

Pile foundation

A Quaker and wealthy Liverpool merchant, John Phillips, erected a lighthouse on Smalls Rock in 1773, in the British Channel off the west coast of Wales. Instead of hiring an engineer to design the structure, he chose a musical instrument maker, Henry Whiteside, who built the lighthouse on piles rather than using the methods for a conventional masonry tower. Phillips' choice and Whiteside's design were to prove revolutionary. Construction began in June 1775 and, when finished, the lighthouse consisted of nine oak posts each 24 inches in diameter and 40 feet in length with a small two-story octagonal wooden cabin built on top. The first floor was where the keepers lived and the top floor housed the light. It stood for 85 years, but more importantly proved the principle of least resistance since waves would tend to pass through as opposed to crash against a foundation built in waveswept locations.[44]

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[43] *Aids to Navigation 1945*, pp. 312-326.

[44] Layne Bergin, "Screwpile Lighthouses: From Britain to the Bay," *The Keeper's Log* (Summer, 1987), p. 11.