USCG photo

Figure 1. West Quoddy Head Lighthouse near Lubec, Maine

Historic Lighthouse Preservation:

MASONRY

Brick and stone masonry is the most commonly used building material in lighthouse construction.[1] Because of the harsh conditions associated with the locations of most lighthouses, brick and stone masonry was chosen for its durability. The use of masonry construction ranges from stone foundations of wood frame towers to the brick walls of tall towers (see Figures 2 and 4).

The brick or stone used in lighthouse construction was typically quarried (in the case of stone) or made (in the case of bricks) as close to the site as possible. If the raw materials were not readily available, they would be shipped to the site.

The quality of the materials used for lighthouse construction varied. In some lighthouses soft bricks or stones were used. These materials tended to be susceptible to

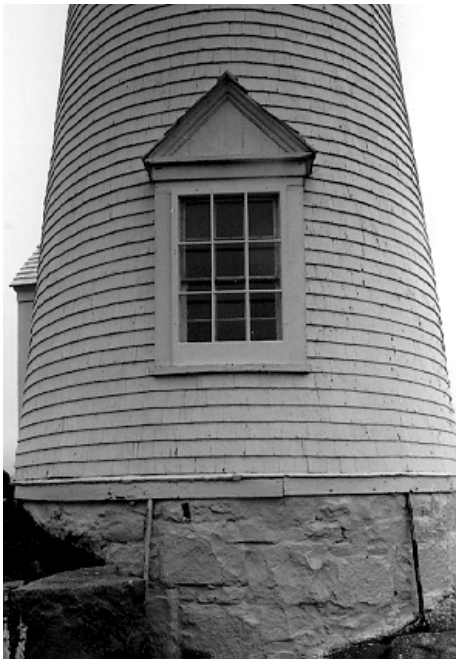

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Figure 2. Stone masonry foundation in a 38-foot-tall wood-frame lighthouse in Maine.

[1]Brick and stone are typically referred to as masonry construction. Because of the similarities in their preservation treatment, brick and stone are being grouped together. Concrete, which is sometimes referred to as masonry, requires different preservation treatment and will be discussed separately.

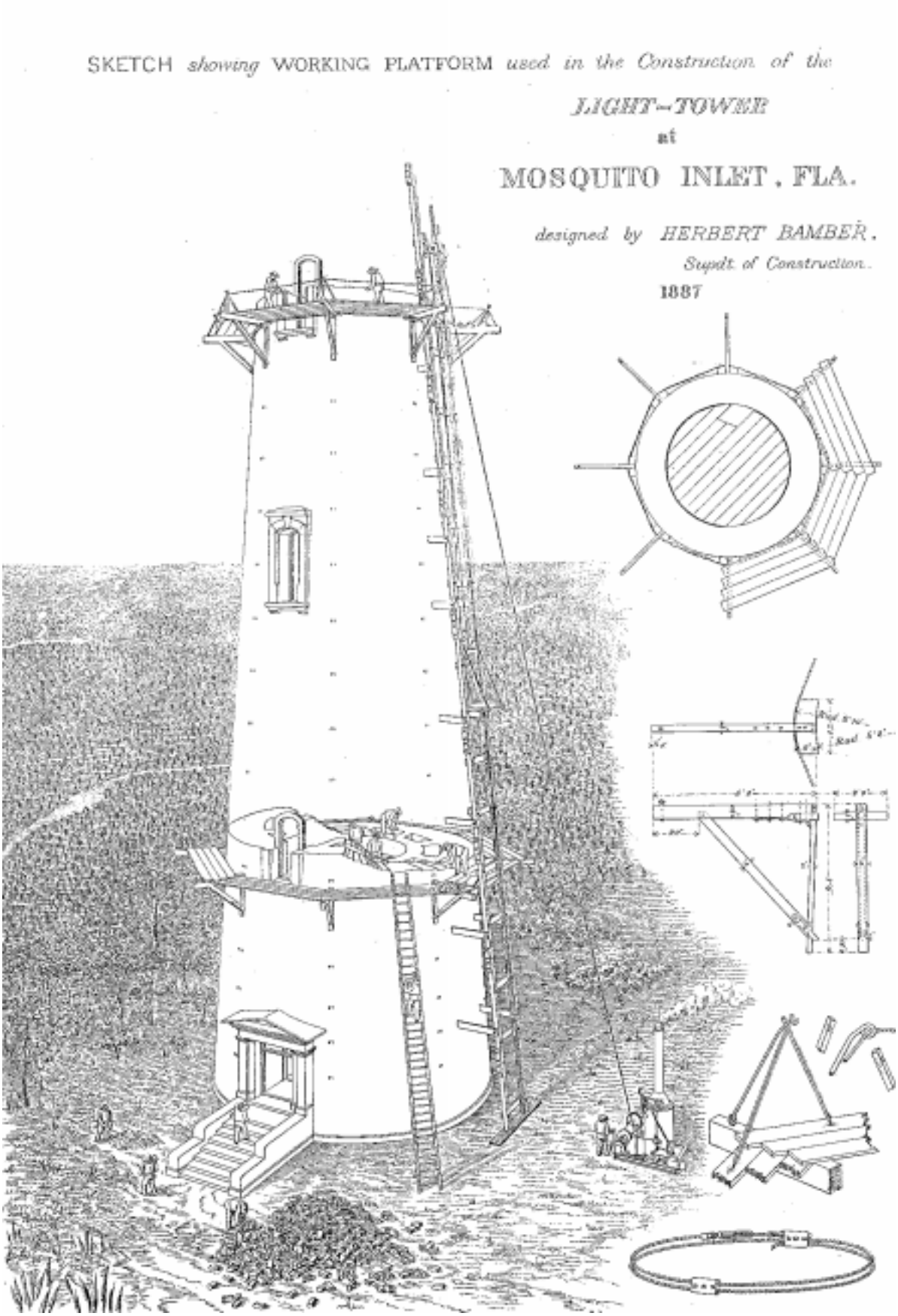

Figure 3. This construction drawing for Mosquito Inlet Lighthouse, Florida, shows the voids or cavities in the walls of tall masonry towers.

accelerated deterioration; therefore they were painted or covered with stucco for protection. This treatment not only provided protection for the lighthouse but also gave the lighthouse a distinct patterning or daymark—characteristics which should be preserved.

In some instances the vulnerable, softer masonry surfaces were not covered with a protective coating, or the protective coating was not maintained and the masonry has since deteriorated. In these cases the protective coating needs to be reinstalled after the required repairs are made, or the masonry may need to be consolidated by a qualified architectural conservator.

Masonry lighthouses are typically constructed in one of two configurations: solid wall or hollow cavity wall. Shorter towers tend to be solid-wall construction because the cross section of wall can be thin enough to support the lantern and interior stairs as well as economical to build. Tall towers are typically constructed with radiating cavities or voids. The exterior of the tower is the frustum of a cone while the interior is typically a cylinder. From the cylinder are radiating walls that tie into the exterior walls and create voids or cavities. The voids in the wall structure save weight while at the same time do not compromise the strength of the wall. The voids are typically vented to encourage air movement through the internal cavities. This ventilation system should be preserved and maintained.

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Figure 4. Brick masonry construction in the 171-foot-tall Pensacola Lighthouse in Florida.

Bender & Associates, Architects

Figure 5. The coating that once protected the soft bricks of this lighthouse was not maintained; the severe deterioration required the replacement of nearly 25,000 bricks.

Masonry features (such as brick cornices and door pediments, stone window architraves) as well as masonry surfaces (modeling, tooling, bonding patterns, joint size, texture, and color) are usually important in defining the historic character of the lighthouse. The character-defining features should be retained during any treatment. While masonry is among the most durable of historic building materials, it is also susceptible to damage by improper maintenance or repair techniques and by harsh or abrasive cleaning methods. Therefore, all treatments should be executed using the gentlest means possible.

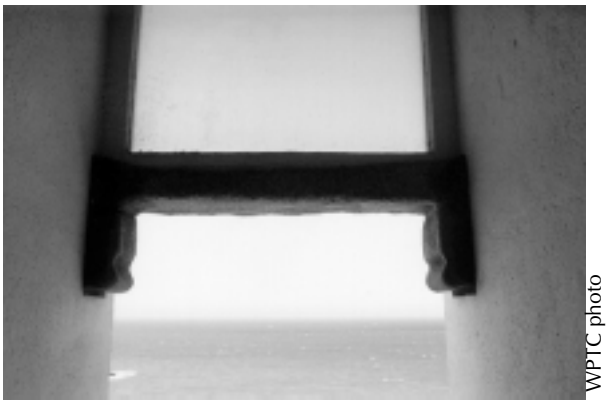

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Figure 6. The once crisp edges of this decorative granite lintel have been eroded by constant high winds and airborne sand.

Why Does Masonry Deteriorate?

Brick and stone are subject to attack by a host of forces. The success of a lighthouse resisting these pressures depends on how well it was designed, constructed, and maintained. A well-built lighthouse may withstand damage indefinitely. Lighthouses with weak foundations and parts that do not shed water or absorb movement, and those made of inferior brick or stone, will deteriorate at an increased rate.

The leading causes of deterioration are

- excessive moisture within the masonry that gives rise to the destructive crystallization action of soluble salts as well as freeze-and-thaw expansion-and-contraction action in northern climates;
- water flowing through walls which can lead to differential settlement, deterioration of adjacent materials (rusting iron anchors or rotting window lintels, for instance), washing out of internal bonding and mortar, and other structural problems;
- inappropriate rehabilitation techniques such as sandblasting; and
- use of mortars that have a high compressive strength, i.e., are harder than the brick or stone.

Secondary factors are

- abrasion by the wind and wind-born solids;
- differential expansion that places internal stresses on the lighthouse when one part responds to thermal stresses more than another or;
- uneven settlement when a lighthouse shifts because of weaknesses in the soil, foundations, or structure;
- mechanical impact caused by accidents, wear and tear by users, or some renovation techniques such as installation of aids to navigation equipment;
- chemical disintegration caused by pollutants in the atmosphere; and
- inadequate ventilation that causes a buildup of moisture on the inside of the tower.
- coating of internal walls with impermeable paint that does not allow moisture to escape.

Inspecting for Masonry Problems

In order to develop an effective treatment plan for masonry problems, an in-depth inspection must be made of the lighthouse and its immediate surroundings. The following chart, derived from *Masonry: How to Care for Historic Brick and Stone* (Mark London, Preservation Press, 1988), is a listing of locations that should be inspected regularly. Associated with these locations are the possible problems to look for during the inspection.

Inspection Chart for Masonry Lighthouses	
THE SITE	
Look For:	*Possible Problems:*
Environment	
Typical climatic conditions, including average temperatures, wind speeds and directions, humidity levels, average snow accumulation, ice, wave action, salt spray, and blown sand	Severe conditions can lead to masonry deterioration, including cracking, spalling, surface erosion, and efflorescence. Masonry lighthouse features can be broken or damaged by the weight of excessive ice build-up or by the impact of violent wave action or wave-carried debris.
Number of freeze-thaw cycles	Severe cycles can produce damage from frost action if moisture is trapped in walls or there is a lack of total structure ventilation. Daily freeze-thaw cycles may also cause excessive condensation build-up within the tower that may promote fungal growth and rot as well as cause iron components such as stairs, landings, and hatches to rust and deteriorate.
Location near sea	Salt in the air can lead to efflorescence forming on the masonry.
Acid rain in the region from nearby industry or from automobile exhaust	Acid rain can cause damage to limestone, marble, sandstone, and concrete.
Proximity to a major road, highway, railroad, or airport	Excessive vibrations can be harmful to mortar joints and other lighthouse parts.
Location in the flood plain of a river, lake, or sea	Prolonged immersion in floodwaters can cause moisture damage to foundations and walls.
Exposed or sheltered locations/elements of a lighthouse	Exposure to the sun and elements affects moisture evaporation and rain penetration. Portions of the lighthouse that do not receive sunlight are susceptible to mildew and other forms of biological attack.

Look For:	*Possible Problems:*
Terrain	
Soil type—clay, sand, rock	The type of soil influences water drainage around the structure. Excessive water in the soil can cause rising damp, leading to structural problems.
Slope away from lighthouse on all sides	If no slope exists, puddles will form at the base of the lighthouse during heavy rains. This may lead to localized ground saturation and water penetration. Localized ground saturation may cause soil around the lighthouse to shift, possibly resulting in uneven settlement.
Earth covering part of a brick or stone wall or foundation	Moisture accumulation or penetration is possible.
Asphalt or other impervious paving touching the lighthouse foundation (if exposed) or walls	Detrimental water accumulation and rain splash-back onto the walls can result. Splash-back can wash mortar out of the joints as well as saturate the masonry causing premature failure of exterior coatings (if present).
Trees and Vegetation	
Species of trees within 50 feet of lighthouse Elms and some poplars dry up clay soil, possibly leading to foundation failure.	Branches rubbing against a wall or roof Branches may abrade surfaces
Ivy or creepers on walls	Leaves prevent proper drying of the masonry surface. Tendrils from some species can penetrate mortar joints, ultimately leading to erosion of the mortar joints and possibly dislodging the brick or stone.
THE LIGHTHOUSE	
Exterior Walls	
General state of maintenance and repair	A well maintained lighthouse should require fewer major repairs.
Evidence of previous fire or flooding	Such damage may have weakened structure members or caused excessive moisture.
Signs of settlement such as cracks and sloped or wavy mortar joints.	These indicate previous water movement. The resulting cracks can allow water to enter the lighthouse walls.
Construction method—solid or cavity wall	Knowing how a tower wall is constructed will help in analyzing problems and selecting appropriate treatments.

Look For:	*Possible Problems:*
Embedded iron (steel) anchors, structural members, etc.	As iron (steel) rusts, it expands; this expansion can damage the surrounding masonry.
Evidence that parts of the lighthouse were constructed at different times or of different materials	Similar problems with various parts may need different treatments because of different materials.
Weep holes—small holes at the bottom and top of walls	Holes allow ventilation from the air space in a cavity wall. The holes should be clear to allow for ventilation. If missing, they can be added during rehabilitation.
Attached antennas, range finders, auxiliary or replacement lights, etc.	Heavy devices which are cantilevered off the side of the tower wall may cause eccentric loading. If this load is improperly distributed, severe cracking and possible localized failure (i.e., blowout) may result.
Bulges	Bulges indicate that the wall has moved and corrective action may be necessary.
Outer-face bulge	Solid walls tolerate movement less if only the outer face is moving; immediate remedial action may be necessary.
Cracks	Cracks indicate movement has occured within the wall. Small cracks may be patched; large cracks may require reconstruction of the affected area.
Enlarging cracks	Active cracks indicate a continuing problem. The cause must be dealt with before the crack itself is repaired.
Consistent wall plane	A crooked or skewed wall indicates movement has occurred and may still be occurring. This condition should be monitored to determine whether the movement is continuing and the lighthouse is in danger of collapsing.
Windows and Doors	
Straight and square openings	Deformed openings may indicate uneven structure settlement or failure of concealed structural members, i.e., wood lintels.
Sills sloped to shed water; drips under sills to prevent water from running back underneath; caulking	If any of these is inadequate, water can penetrate into the lighthouse wall.
Sealed window and door frames	If caulking is missing or deteriorated around window and door frames, moisture can pentrate into the wall cavity and cause deterioration of the window or door frame as well as of the masonry.

Look for:	*Possible Problems:*
Foundation	
Uneven settlement	This may cause the leaning tower effect and possibly result in collapse of the lighthouse.
Composition of foundation walls	Stone or brick is more likely than concrete to allow water to infiltrate.
Damp proof course	This will impede rising damp, lessening deterioration of the masonry wall. If work is performed on the wall, the integrity of the damp proof course must be maintained.
Rising damp—discoloration along wall in approximate horizontal line	Could indicate serious foundation or drainage problem.
Interior	
Cracked plaster, signs of patching, stairs and landings askew	These may be signs of lighthouse settlement.
Damp walls, mold or mildew stains on walls, efflorescense, 'bubbling' or blistering plaster, rotting wood	These indicate water infiltration or severe condensation or moisture buildup within the lighthouse.
Masonry Components	
Materials	
Composition, including secondary materials; characteristics—color and color variation; texture—smooth or patterned surfaces	Types of materials indicate the susceptibility to damage and should be matched if the masonry component is repaired or replaced.
Areas of delicate carving or fine moldings such as decorated entry ways or window surrounds	These sections may need special attention or protection during rehabilitation.
Missing or broken bricks or stones	Missing material may allow water penetration, as well as indicate movement of the structure.
Evidence of sandblasting, such as a pitted surface; evidence of erosion, crumbling, flaking, scaling, or spalling	Sandblasting can remove the outer hard-baked protective surface of the brick making the inner softer core vulnerable to moisture penetration. Sandblasted bricks are not only aesthetically displeasing, but may be a point of moisture infiltration as well.
Dirt or stains	Surface stains usually cause few problems other than being unpleasant to look at. Streaking on the surface of the lighthouse tower, however, may be an indicator of deteriorating materials that are not readily visible, such as rust streaks from embedded iron anchors, etc.

Look for:	*Possible Problems:*
Moisture	
Water penetration through joints between masonry and other lighthouse components, through masonry joints or, rarely, through brick or stone units	Moisture can lead to deterioration of the masonry and other parts of the lighthouse.
Staining or white deposits (efflorescence), mold and mildew stains on walls	White deposits are evidence of excessive dampness. Efflorescence on most new or newly repointed walls (new construction 'bloom'), however, is natural and will disappear after normal weathering.
Location and type of salt deposits on surface; or standing water	Deposits can indicate a source of dampness, such as rainwater or ground water, inside the lighthouse materials.
Moisture buildup or condensation on interior window panes	Indicates high moisture levels and poor ventilation.
Coatings	
Applied coating type: stucco, lime mortar wash	Stucco and lime mortar wash are common lighthouse coatings. Applied stucco surfaces should be inspected for cracks that could allow water infiltration. Lime mortar wash or whitewash is considered a sacrficial coating. The lime mortar wash protects the lighthouse masonry by wearing away over time. This coating is meant to be reapplied periodically like paint.
Paint; type of paint	Paints and other coatings are designed with a specific permeability rating. A paint or coating with a low permeability rating may trap moisture and cause masonry to spall or the coating to blister.
Blistering, flaking and peeling paint (interior or exterior), failure of plaster or stucco	These conditions indicate there is an excessive amount of moisture within the masonry substrate. Escaping moisture literally pushes the paint film off the masonry. The amount of moisture transpiration may exceed the permeability of some coatings, therefore even coatings that 'breathe' may fail if the moisture content of the substrate is high enough.
Waterproof or water repellent coating	Such coatings often trap moisture within the masonry.

Look for:	*Possible Problems:*
Mortar Joints	
Type of mortar used during the original construction of the lighthouse—lime based, usually whitish; or portland cement, grayish and very hard	A portland based cement mortar may be too hard for certain masonry bricks and can lead to cracking or other damage of the brick or stone units. Replacement mortar should be compatible with the compressive strength of the masonry units.
Condition of mortar—crumbling, eroded, missing	Crumbling mortar may be an indicator that the original mortar mix was made with salt water or salt water contaminated sand (vs. potable water and clean sand). If this condition exists the lighhouse may require a comprehensive inspection and repointing with a mortar that matches the compressive strength of the brick or stone. Damaged or missing mortar can allow moisture to penetrate; repointing may be required. This condition may also lead to differential settling, eccentric loading, cracking or displacement of masonry, and/or the possible failure of load bearing wall sections.
Broken or chipped edges of brick or stone along joints	Damage may indicate mortar in joint is too hard.
Chimneys and Other Openings	
Boarded or closed openings such as windows, doors, fireplaces, etc.	When removing coverings, personal injury may result from falling debris.
Chimneys, fireplaces, and other types of flues	Different types of soot found in chimneys and other types of flues may cause serious health problems. When inspecting these features of a lighthouse, it is essential to wear personal protective gear such as a respirator, eye protection, and if there is a potential danger of falling debris, a hard hat.