PRESERVATION TREATMENTS

Many of the maintenance and repair techniques described in this text, if not properly performed, can cause potentially irreversible damage to the character-defining features and historic fabric of a masonry lighthouse. Therefore, if the tasks to be performed are beyond the skills of on-site personnel, they should be carried out by experienced and qualified workmen. A historical architect or building conservator may be required to assess the condition of the masonry and prepare contract documents for its treatment. In Part V., **Beyond Basic Preservation**, examples of treatments that are considered rehabilitation and restoration are illustrated and discussed.

Protection and Stabilization (Mothballing)

Despite their inherent durability, a historic masonry lighthouse that is vacant and receives only minimal routine maintenance is highly vulnerable to decay if not protected and stabilized properly. To properly protect and stabilize a historic masonry lighthouse, a thorough inspection and diagnosis should be performed using the inspection chart in the preceding section as a guide. The results of this inspection can then be used to develop a protection and stabilization plan. The following recommended protection and stabilization guidelines for vacant historic masonry lighthouses are the minimum treatment requirements to prevent any further damage from occurring.

Weatherization

When a masonry lighthouse is mothballed, the exterior envelope should be completely weathertight. When moisture penetrates into masonry walls and foundations, it can be exceedingly detrimental to the masonry. Moisture in a wall or foundation causes various types of damage: it washes away softer lime mortars, expands and cracks surrounding masonry in freezing weather, causes efflorescence (the leaching of salts out of the mortar and masonry units), causes adjacent wood elements to rot, and encourages fungal growth.

Figure 7. Lantern glass with holes and/or cracks should be replaced as soon as possible to minimize water infiltration. If immediate replacement is not feasible, the glass can be temporarily patched.

To prevent moisture penetration, be sure the following moisture infiltration points are weathertight or functioning properly:

- ***Lantern glass:*** Lantern glass, frames, and roofs must be weathertight before mothballing. Refer to the **Lantern** section of this handbook for more information concerning weatherproofing lantern components.

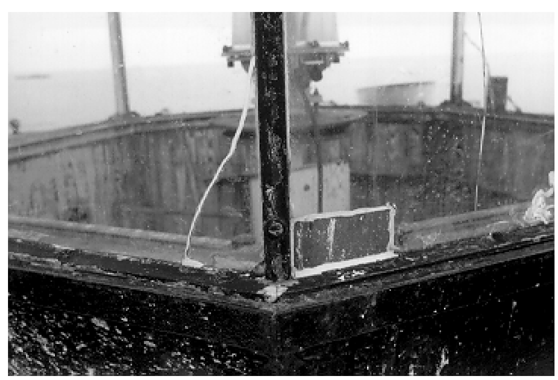

Figure 8. Detail of an acceptable temporary repair to a lantern glass using a piece of painted sheet metal that has been adhered to the glass with a high quality, exterior grade caulk. This type of temporary repair will prevent water from entering the lantern and therefore help avoid further damage. This fix should be considered only as an interim treatment until replacement of the lantern glass.

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Figure 9. View of built-in gutter system on a mansard-style roof; the arrow indicates where a fist-size hole exists. This hole allows water to enter the interior of the lighthouse.

- ***Built-in gutter systems:*** All rainwater gutter systems (lantern roofs, or other tower roof forms) should be cleaned and checked for holes. All holes and non-functioning gutter system components should be repaired. For more information refer to the discussion on roofing in the **Lantern** section of the handbook.
- ***Gallery decks:*** In most masonry lighthouses gallery decks are cast iron, sheet-metal-covered wood, stone, or concrete. These decks are generally laid directly on top of the masonry wall structure. The decking should be sloped away from the lighthouse to shed the water away from the structure. If the decking material is not weathertight, moisture can enter the interior cavity of the masonry wall. See Figure 10 for signs that a gallery deck is failing. Refer to the **Lantern** section of this handbook for more information concerning the weatherproofing of gallery decks.
- ***Door and window frames:*** The joints along the perimeter of door and windows where a wood or metal frame is fitted into a masonry opening should be caulked to prevent moisture from entering the walls. See the **Windows** section of this handbook for the proper caulk for this application.
- ***Loose or eroded mortar joints:*** If pointing between masonry units is loose, cracked, eroded, or is completely missing, moisture will penetrate (see Figure 11). In order to prevent this infiltration, all pointing that is in disrepair must be removed and the affected joints repointed. For more information refer to the discussion on repointing under the **Repair** treatment in this section of the handbook.

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Figure 10. View of underside of gallery deck; the streaks on the stucco indicate that water is passing between the deck plates and possibly entering the masonry wall.

WPTC photo

Figure 11. Detail of severely eroded brick and painting.

- ***Weep and vent holes:*** If the walls have cavities between the interior and exterior walls, weep holes may exist at or near the base of these walls. Weep holes typically range in size from small slits to large brick headers. These holes allow any moisture that has entered the cavity between the walls to drain out. These openings must be kept clear in order to provide sufficient drainage of the cavity. In some instances the walls may have vent holes (larger than weep holes) that allow the movement of air through the cavities or voids. Typically vent holes open into the interior. These openings must be kept clear in order to provide sufficient ventilation (see Figure 12).
- ***Protective coatings:*** Lighthouses were often painted as a protective measure and for identification as a daymark. As part of a

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Figure 12. Typical masonry lighthouse weep hole locations. Each weep hole provides drainage for each individual cavity within the masonry wall.

WPTC photo

Figure 14. Detail of failing paint, a problem which should be addressed during stabilization and protection. In this particular case, spot painting may be all that is required to maintain a weatherproof protective coating.

WPTC photo

Figure 13. Vent hole located in the window well of a brick lighthouse.

WPTC photo

Figure 15. Cracks such these in a sandstone lighthouse should be monitored for movement prior to treatment.

mothballing treatment, the exterior coating should be checked for loose and flaking paint. Any deteriorating areas should be scraped and repainted to match the existing color. Ultimately, as part of a mothballing treatment the entire lighthouse should have all loose and flaking paint removed and a new coating applied according to the manufacturers specifications. If the overall condition of the coating system is sound and there are only a few bare spots, however, the lighthouse can be spot painted to provide a weatherproof coating. Either of these actions will result in a coating system that will require minimal service during the mothballed period. For more information refer to the discussion on repainting under the **Repair** treatment in this section of the handbook.

- ***Open cracks in walls:*** Cracks in exterior masonry walls indicate that movement has occurred, either caused by shrinkage (in the case of stucco) or by settlement or mechanical impact. Cracks should be monitored to determine if movement is still occurring and structural stabilization is necessary before the crack is filled. Refer to the following repair section for more information concerning wall repair.

Stabilization

When mothballing a masonry lighthouse, all possible structural repairs should be made before the beginning of the

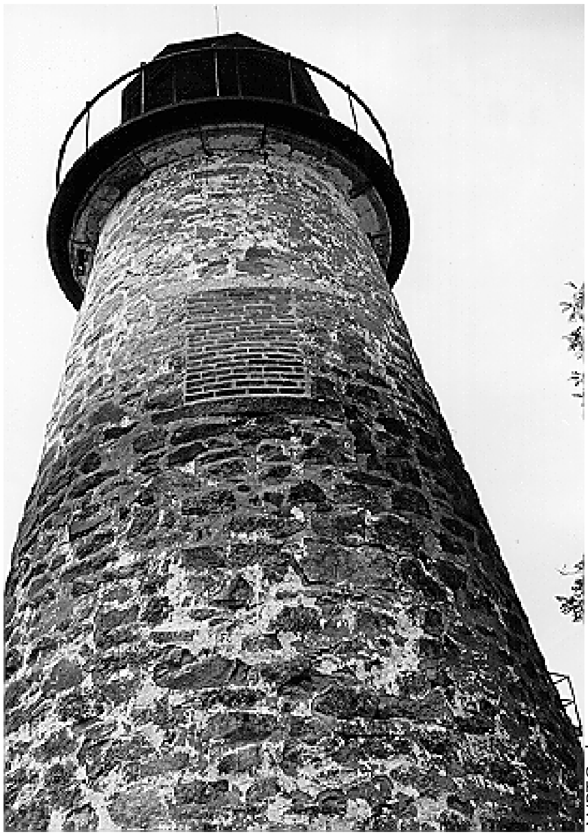

Figure 16. An example of a reversible masonry stabilization treatment for the window opening that has prevented structural deterioration and moisture infiltration.

'mothballed' period. If funds are insufficient to make structural repairs, structural stabilization should be performed as a less expensive temporary alternative. Temporary blocking in of window and door openings and installation of interior or exterior shoring or bracing are all stabilization methods. Figure 16 illustrates a window opening that has been stabilized with brick infill. Brick is a historic stabilization method in stone masonry construction. If this method is used, the mortar employed should be soft enough to not permanently adhere to the historic masonry, thus making the treatment reversible. Other methods of door or window opening stabilization include fitting the opening with a structural wood frame covered with a painted plywood panel that has large louvers to aid in venting the interior of the lighthouse. The stabilization treatment utilized should not permanently damage historic character-defining features and should be easily reversible so that when the budget allows, the structure can be properly repaired.

Ventilation

The most difficult lighthouses to adequately ventilate without resorting to extensive louvering and/or mechanical exhaust fan systems are masonry lighthouses in humid climates. During the summer months masonry lighthouses will need to be ventilated to eliminate stagnate air and damaging condensation on the interior walls and woodwork. In order to achieve this, almost every window opening will need to be fitted with some type of passive louvered ventilation. Installation of window-mounted passive louver systems is covered in the **Windows** section of this handbook. For more information on lighthouse ventilation refer to the **Interiors** section of this handbook.

Fire Protection

Despite the fact that masonry is noncombustible, fire is still a threat to combustible components of masonry lighthouses. The impacts of a fire are devastating and will often cause serious irreversible damage and loss to historic interior fabric. For guidance on these issues, refer to "Fire Prevention and Protection Objectives" under Part V., **Related Activities**.

Repair

Before any preservation repair work is begun, all masonry features that are important in defining the overall historical character of the lighthouse should be identified. These features include brackets, cornices, window architraves, door pediments, steps and pilasters, joint size and tooling and bonding patterns, coatings color and texture. During all repair work measures should be taken to ensure that these features are not damaged.

Once a thorough inspection and diagnoses is performed, using the inspection chart starting on page 5 as a guide, a treatment plan can be developed using the following basic masonry lighthouse preservation guidelines.

Cleaning

The simple act of cleaning painted masonry surfaces can effectively extend the life of the coating as well as effectively enhance the appearance of a historic masonry lighthouse. In some cases where the masonry has not been painted, a deep cleaning of the porous masonry surfaces is needed. This treatment should be used if a buildup of pollution or salts is causing deterioration to the masonry substrate. The following are guidelines for cleaning historic masonry lighthouses:

- Clean masonry only when necessary to halt deterioration or when heavy soiling must be removed to prevent damage to the masonry.
- Carry out masonry surface cleaning tests after it has been determined that such cleaning is necessary. Do not clean masonry merely to improve appearance.
- Clean masonry surfaces with the gentlest method possible, such as using low pressure water and detergents and natural bristle brushes. To select the gentlest method possible, tests should cover a period of time sufficient to determine both the immediate and long-range effects.
- Always allow for thorough drying time of the masonry (months or possibly years) before proceeding with any sealing of the exterior or interior.
- Always neutralize any chemical treatment.
- Do not sandblast brick or stone surfaces using dry or wet grit or other abrasives. These methods of cleaning permanently erode the surface of the material and greatly accelerate deterioration.

WPTC photo

Figure 17. Deeply eroded brick as a result of sandblasting. The white areas are where electrical components were attached to the wall at the time of sandblasting.

- Do not use a cleaning method that involves water or liquid chemical solutions when there is any possibility of freezing temperatures.
- Do not clean with chemical products that will damage masonry, such as using acid on limestone or marble or leaving chemicals on masonry surfaces.
- Do not apply high-pressure water-cleaning methods that will damage historic masonry and the mortar joints.

External Coating Systems

Historically, external coatings were relied upon to protect masonry, such as soft brick or stone, that was susceptible to water infiltration. The external coating was the first line of defense against the elements. Typically the coating was either a paint, stucco, or whitewash/lime mortar wash. As part of preserving the lighthouse, all coatings should be maintained.

Each type of coating protects the lighthouse in a slightly different manner. Paint provides a film over the masonry that prevents water from penetrating. Stucco is a three-layer mortar and sand shell that bonds to the masonry to prevent water from penetrating. Whitewash and lime mortar wash are lime and water based "sacrificial" coatings that protect the lighthouse by slowly deteriorating as they weather.

Lime mortar wash is typically a three-layer coating. The first coat consists of lime, water, and sand; the second, half as much sand; the third, just lime and water. Whitewash is lime and water only. Both of these coatings are meant to be reapplied every three to five years. More information on this coating and its application can be found in the Cape Florida Lighthouse sidebar on page 23.

The key to the preservation of an external coating system, especially a lighthouse coating that is subjected to severe marine environment conditions, is a thorough study of the mechanics of the system. Whether simply touching-up the coating or following through with a complete restoration of the external coatings, it is wise to seek the advice of paint manufacturers' technical representatives.

A thorough study of materials is recommended before starting any coating program. An understanding of the substrate, or base material, must also be had. This can best be achieved by a thorough inspection of both the substrate and the existing coating system. Any areas of deteriorated substrate should be examined and repaired before recoating.

Coatings applied to masonry surfaces should 'breathe', i.e., the coating should allow the transpiration of moisture at the microscopic level. Modern paint coatings are able to do this. A successful coating system for masonry surfaces is an elastomeric acrylic paint system for the exterior surfaces and a breathable acrylic emulsion paint system for the interior surfaces.

All external coatings, especially paints which may date from the 19th and early 20th century, should be tested for lead content. If lead is present, local codes on health, life safety, and environmental requirements must be met.

Lead found in otherwise sound paint layers does not dictate the removal of that paint. In most cases it is far safer and more cost-effective to leave intact paint areas in place. For further information refer to NPS *Preservation Briefs 37: Appropriate Methods of Reducing Lead-Paint Hazards in Historic Housing*.

Follow the manufacturer's specifications for surface preparation and application of paint. This will ensure the coating will perform as designed. For more information on types of masonry paints currently being used in the field, refer to the case study on Point Conception Light Station in Part V., **Beyond Basic Preservation**.

The following guidelines are to be followed when recoating historic masonry lighthouses.

- Before recoating, inspect all painted masonry surfaces to determine whether repainting is necessary. If painting is the determined treatment, a schedule of colors, locations, and quantities should be developed.

- Remove damaged or deteriorated material only to the next sound layer, using the gentlest method possible (e.g., hand scraping) before recoating.
- Recoat surfaces with a system designed for the masonry substrate—brick, stone, or stucco. The system should be designed to 'breathe' so that moisture trapped within the masonry units can escape. This quality is referred to as the permeability of the coating system.
- Use colors that are historically appropriate to the lighthouse or that maintain the character-defining features of the daymark.
- Do not remove any coating that is firmly adhering to, and thus protecting, masonry surfaces.
- Do not use methods of removing coatings which are destructive to masonry, such as sandblasting, application of caustic solutions, or high-pressure water blasting.
- Do not apply coatings such as stucco to masonry that historically has been unpainted or uncoated.

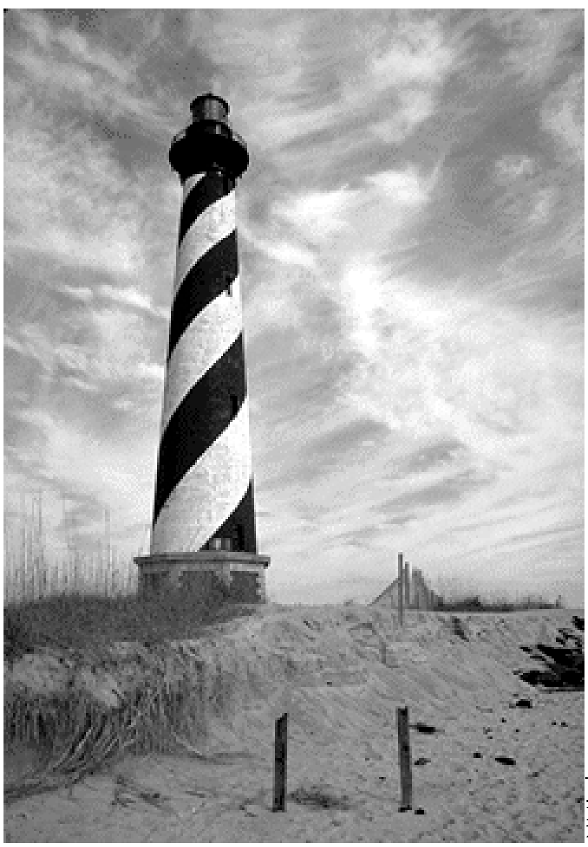
NMI photo

Figure 16. Daymark patterns are a character-defining feature and should be preserved.

- Do not remove historic masonry coatings and leave the underlying layer exposed to the elements.
- Do not apply a sealing type paint to the interior of a lighthouse. This will potentially trap moisture in the wall which will cause the wall to deteriorate.

Repointing

Repointing is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar. Properly done, repointing (also called, somewhat incorrectly, tuck pointing) restores the visual, physical, and structural integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may in fact cause physical damage to the masonry units and the overall structure.

Mortar joints bind together the individual masonry elements of a wall into a structural whole, ensuring a watertight seal. The mortar bed compensates for irregularities in the stones or bricks, which would otherwise lead to uneven stresses and cracking of the masonry unit. The more regular the stone or brick, the thinner the joint can be.

A wall made up of many small units such as brick or stone is both easy to construct and absorbs inevitable slight movements, including variations in temperature, settlement of the building, and vibrations. To absorb these movements, the mortar joints must be somewhat weaker than the masonry units to allow for compressive loading. If a mortar is used which is high in compressive strength (i.e., portland cement), the masonry units become the weakest part of the wall, and slight movements can cause the brick or stone to crack or spall. As mortars become stronger, they tend to become more impermeable to moisture than the masonry units and thus prevent drying through the joints. Moisture movement then is concentrated in the brick or stone, leading to damage of the masonry structure.

Unlike most other parts of a lighthouse, mortar joints are not designed to be permanent, although a good pointing job should last 50 to 100 years. When the time comes to repoint, shortcuts and poor craftsmanship will result in a job that needs to be done soon again or, in the worst case, in a structural failure.

When repointing joints in historic lighthouses, special care must be given to the matching of the strength of the replacement pointing mortar with that of the original pointing mortar. Historically, softer lime-based mortars were used for pointing. If the compressive strength of the original mortar cannot be readily determined, i.e., the lighthouse had been improperly repointed with a hard portland cement based mortar, the mortar should be matched to the compressive strength of the brick on stone. For more information on repointing historic lighthouses refer to NPS *Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings.* These softer mortars were flexible enough to expand and contract with the expansion and contraction of the masonry units which made up the wall structure.

WPTC photo

Figure 19. The use of hard portland cement mortar and sloppy pointing technique have aided in the deterioration of this soft sandstone wall.

Modern portland cement has a higher compressive strength than the lime-based mortars. This quality makes the portland-based cements less flexible than the lime-based mortars; therefore, the pointing tends to resist the expansion and contraction of the softer historic bricks. This resistance will ultimately cause the faces of the bricks to fracture and spall off the body of the brick. In some cases the exterior wythes of brick may shear from the inner core of the wall, resulting in the failure of the outer sections of the wall.

Before repointing, a thorough inspection of the masonry should made to determine the extent of repointing needed. Pointing that

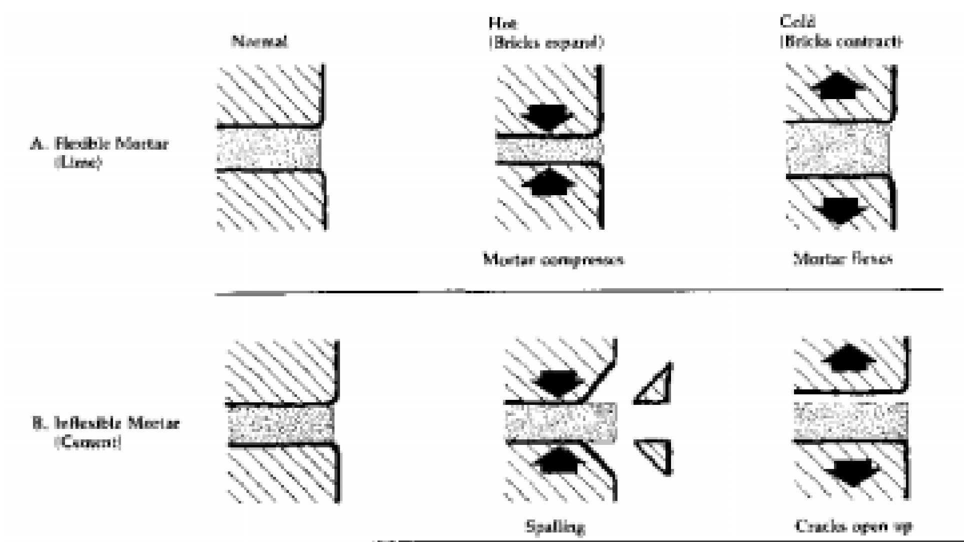

Figure 20. Diagram showing the behavior of lime-based mortar and cement-based mortar during relative temperature changes of the surrounding masonry. (Source: NPS *Preservation Briefs 2*, 1980)

is in need of repair shows signs of deterioration such as disintegrating mortar, cracks in mortar joints, loose bricks, or damp walls. The following are guidelines that should be followed when repointing masonry in historic lighthouses.

- Remove deteriorated mortar by carefully hand raking the joints to avoid damaging the masonry.
- Consider leaving the intact portland cement pointing in place because removal may damage the masonry.
- Duplicate the historic mortar in strength, composition, color, and texture. A mortar analysis can be performed by most preservation professionals.
- Duplicate old mortar joints in width and in joint profile.
- Do not remove non-deteriorated mortar from sound joints for purely cosmetic reasons.
- Do not use electric saws and hammers rather than hand tools to remove deteriorated mortar from joints prior to repainting.
- Do not repoint with mortar of high portland-cement content (unless it is the same content of the historic mortar). This can often create a bond that is stronger than the historic material and cause damage resulting from the differing coefficient of expansion and the differing porosity of the material and the mortar.
- Do not repoint with a synthetic caulking compound.

Damaged Masonry Repair

Repair of damaged masonry features can be performed in a variety of ways. Repairing masonry features by patching, piecing in, replacement in kind, or consolidating the masonry using recognized preservation methods is a task best performed by

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Figure 21. Detail of eroded pointing.

WPTC photo

Figure 22. A failing repair made to a stone gallery deck using a simulated stone material. A stone dutchman repair should have been used.

professionals specializing in such work. The following are general guidelines to consider when repairing historic masonry.

- Repair only damaged materials. If possible, limit this type of work to replacement of damaged masonry units only, i.e., isolated removal of a single damaged brick or stone.
- When repairing stone, use traditional dutchman repair techniques as a first choice; consider substitute materials only as a last resort.
- For replacement, use only substitute materials that convey the visual appearance of the surviving parts of the masonry feature and that are physically and chemically compatible.
- Do not apply waterproof, water-repellent, or non-historic coatings such as stucco to masonry as a substitute for repainting and masonry repairs. Coatings are frequently unnecessary, expensive, and may change the appearance of historic masonry as well as accelerate its deterioration.

Stucco

Stucco is an exterior plaster which has historically been used to weatherproof and in some cases decorate masonry lighthouse exteriors. Although stucco is nonstructural, it offers a protective coating and prolongs the life of a lighthouse. Stucco is both convenient and affordable: its ingredients are readily available; it can be readily applied over stone or brick; and it is repairable when cracked or broken.

The choice of materials for the aggregate and binder is critical to match an existing stuccoed surface. Stucco is an inexpensive material that forms a resistant exterior shell to protect *more* costly and vulnerable materials, i.e., soft bricks or stone, in the substrate from exposure and decay; it may considerably prolong the life of a masonry lighthouse by sheltering major components from wear. Also, though stucco application requires a skilled worker, only a minimal amount of specialized equipment is necessary.

Stucco failure is caused by the breakdown of the its water-shedding capacity and the ultimate deterioration of the supporting structure. Poor original materials and techniques, incompatible building materials with different expansion rates, structural settlement, *seismic* movement, and biological growth can all cause cracking or adhesion failure between the stucco and its backing or between individual stucco layers. Lack of proper maintenance increases the likelihood of problems that can lead to the breakdown of the stucco skin.

An aggregate and a binder are the two basic stucco constituents. The aggregate consists of a fine granular substance—such as crushed sea shells, crushed brick and stone, sand, or old mortar—while traditional binders include lime, gypsum, or natural and manmade (portland) cements. In addition, mineral pigments can be added for color and synthetic additives used to further improve the performance of the stucco mixture.

A mechanical key must be created to ensure a strong bond between the stucco and its support. For masonry, either raking out the mortar joints or texturing the masonry surface is usually necessary. Generally, stucco is applied in one to three coats; three-coat work is most common. Layers usually differ slightly in composition, and each coat is scored to provide a key for the next layer.

Although the earliest stuccoes used lime as a binder, by the middle of the 19th century stucco included other elements such as imported natural cement. Gray portland cement stucco, harder and denser than earlier stuccoes, appeared in the 1880s; with the introduction of white portland cement in the early 20th century, a range of tinted stuccoes became available.

The following are guidelines to consider when repairing historic stucco:

Identify, retain, and preserve stucco coatings that are important in defining the overall historic character of the building.

- Determine whether the historic finish coat of stucco was painted, unpainted, or integrally colored.
- When repairing stucco, identify original components of the stucco mix through laboratory analysis to match strength, composition, color, and texture.
- Identify substrate and method of keying stucco to the underlying structure.
- Identify finish trowelling techniques to duplicate the original finish in replacement stucco.
- Do not remove stucco from surfaces that historically featured a stucco finish.
- Do not remove and reapply a major portion of a stucco coating that could be repaired.
- Do not apply paint to stucco that has been historically unpainted or, conversely, remove paint from historically painted stucco.

Maintain:

- Maintain lantern roofs, gutters, and gallery decks to prevent moisture from penetrating walls.
- Remove all plant materials from the base of stuccoed lighthouse walls.
- Survey stucco surfaces for conditions such as biological growth, water or metallic staining, or leaching deposits, which may indicate active water penetration or damage that is masked by the stucco coat.
- Determine the extent of detached stucco by systematically sounding the surface with a wood or acrylic mallet. Areas where stucco layers have delaminated or are no longer keyed to the substrate will produce a characteristic reverberating or hollow sound and should be repaired as outlined below.

Clean stucco only when necessary to halt deterioration. It is difficult to clean most stucco without also removing some of the textured surface. Test cleaning methods in a discreet location before full-scale treatment. The gentlest method should be selected and tested to avoid unnecessary damage.

- Remove soiling and biological growth, such as mold, using a low-pressure water rinse and mild detergent applied with natural fiber brushes. Poultice-applied solvents are probably the most appropriate method for removing graffiti and metallic stains.
- Do not use abrasive cleaning techniques on stuccoed surfaces, which can pit the surface and increase moisture penetration.
- Remove damaged or deteriorated paint from stucco only to the next sound layer using the gentlest method possible, such as hand-scraping or natural bristle brushes.
- Maintain paint coatings by applying a vapor-permeable coating when necessary, matched to existing color.

Repair most stucco by removing damaged material and patching with new stucco that duplicates the old in strength, composition, color, and texture.

- Repair cracks in stuccoed surfaces by raking out the crack and undercutting the edges to provide a mechanical key for new stucco. Cracks are most likely to occur at doors, windows, and where stucco covers joints between dissimilar masonry materials, i.e., brick and stone.
- Do not insert a metal lath over masonry. Attaching the lath will damage the masonry; moisture penetration can cause the metal lath and attachments to corrode.
- Do not apply a stucco patch without remedying the underlying problem.
- Remove incipient spalls or bulges back to sound plaster. Identify and rectify the cause of deterioration before patching.
- Remove previous patches that do not match texture, color, or strength of the original stucco.
- Undercut the repair boundaries to create a dovetail-shaped mechanical bond between the old and new stucco.
- Test new stucco in an inconspicuous location and allow test samples to weather as long as possible, ideally for one year. Matching the original material will probably require a number of test samples.

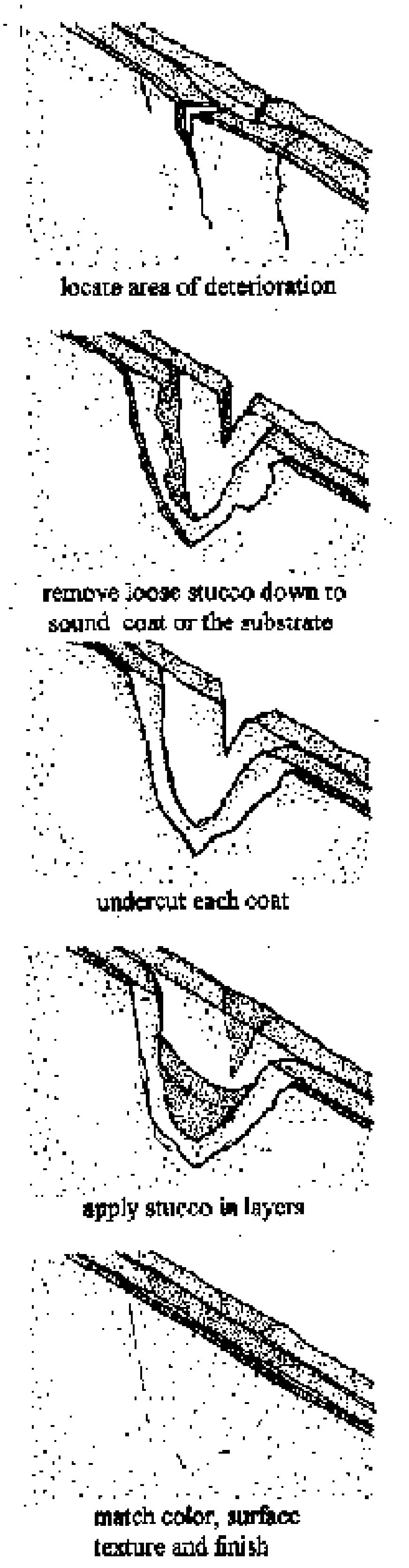


Figure 23. The five basic steps of stucco repair; each layer of stucco must be patched separately. (NPS drawing)

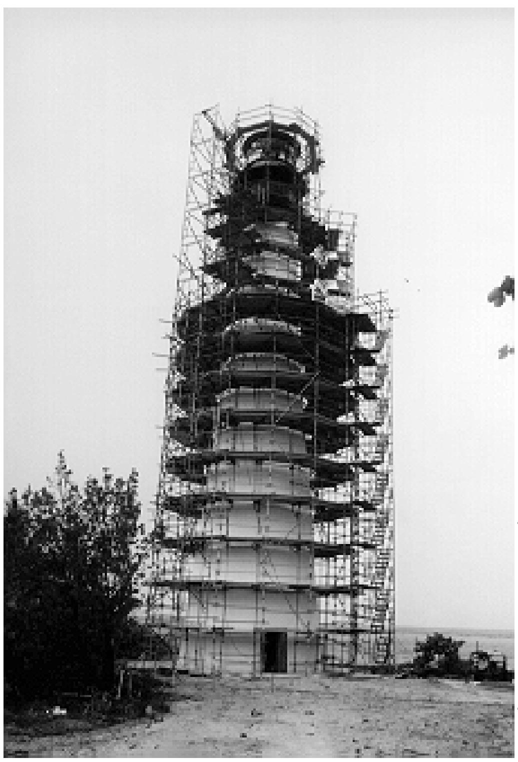
- Do not remove sound stucco or use new stucco which is stronger or denser than the historic material. Doing so will damage underlying masonry as well as alter the appearance.
- Patch stucco rather than replace. It is difficult to match stucco and to conceal patched areas, especially on smooth-finished stucco. A color match may not be critical if the surface was originally painted and will be repainted following repairs.
- Thoroughly wet the substrate before patching to prevent it from drawing moisture out of the stucco too rapidly which could affect the curing time and eventual strength.
- Do not patch cracks with commercial caulking compounds. This type of patch is highly visible because the material has a different texture and sheen than stucco. It also tends to attract dirt and weathers differently.
- Do not apply new stucco when there is danger of frost, or in temperatures below 40° F.
- When applying stucco, provide adequate separation from the ground. Moisture from the ground can rise through the stucco and into the supporting structure.
- Do not apply paint to repair patches before the new stucco has fully cured.
- Do not apply a bonding agent where a mechanical bond is possible. A good mechanical bond is always preferable to reliance on bonding agents. Only substrates that do not offer a good bonding surface may require the use of a bonding agent.
- Prevent new stucco from drying too rapidly during hot weather by shading or repeated misting for 48 to 72 hours.
- Reintegrate detached or delaminated stucco by low pressure injection grouting with fluid mortars or synthetic adhesive materials. These substances must be compatible with the original stucco. This treatment is generally appropriate only for decorative stucco that may be difficult to replicate. The work should be executed under the supervision of a qualified preservation maintenance professional.
- Use chemical consolidants on deteriorated stucco only when deemed necessary by a trained conservator. The need for this type of treatment on most stucco-covered lighthouses is limited. Materials and methods must be tested

before attempting full-scale treatment; different stuccoes may require different consolidation materials for chemical compatibility.

Limited Replacement In kind

If repair by stabilization, consolidation, and conservation proves inadequate, the next level of intervention involves the *limited replacement in kind* of extensively deteriorated or missing *parts* of features when there are surviving prototypes (for example brick cornices and door pediments, stone window architraves, wall structure masonry units). The replacement material needs to match the old both physically and visually, i.e., sandstone for sandstone or dark red, hard-fired brick for dark red, hard-fired brick, etc. Thus, with the exception of hidden structural reinforcement and new mechanical system components, substitute materials are not appropriate in the preservation treatment. Again, it is important that all new material be identified and properly documented for future research.

If prominent features are missing, such as formal stone or brick entry stairs or interior decorative brick or marble floors, then a rehabilitation or restoration treatment may be more appropriate.



Bender & Associates, Architects

Figure 24. Cape Florida Lighthouse with scaffolding used during the 1996 restoration. The white coating on the tower is the lime mortar wash applied to help protect the damaged brick and to restore the tower to its 1846 appearance.

SIDEBAR: Brick Replacement and Coating of Cape Florida Lighthouse

The original Cape Florida Lighthouse on Key Biscayne, Florida, was built in 1825 to a height of 65 feet. The tower wall was constructed with a solid brick wall five feet thick at the base and tapering to two feet at the top. The present Cape Florida Lighthouse was constructed around 1846 with a four-feet-thick brick masonry wall at the base. To meet the aid-to-navigation needs, in 1855 the tower's height was raised to 95 feet with a focal plane at 100 feet above sea level. From 1869 until the light was discontinued in 1878, the lighthouse received numerous repairs.

After 1878, the lighthouse began deteriorating because of lack of maintenance. It was restored and the foundation upgraded in 1915 and 1918 respectively. The deterioration was reinitiated when a hurricane in 1926 eroded the tip of the Cape, increasing the vulnerability of the tower to further decay and deterioration. In 1966 when the state of Florida acquired the lighthouse, a four-year renovation effort was instituted for the entire station. During this time a replica of the keepers quarters and a new lantern was constructed.

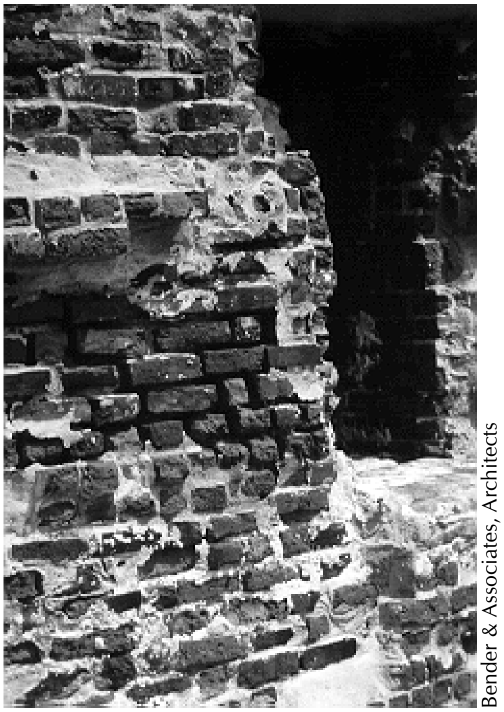


Figure 25. View of the lower portion of the tower showing the more severe deterioration. Note that a large percentage of the first brick wythe is missing or has been removed. The white areas are remains of a portland-cement-based parging applied in the late 1960s in an effort to protect the deteriorating bricks.

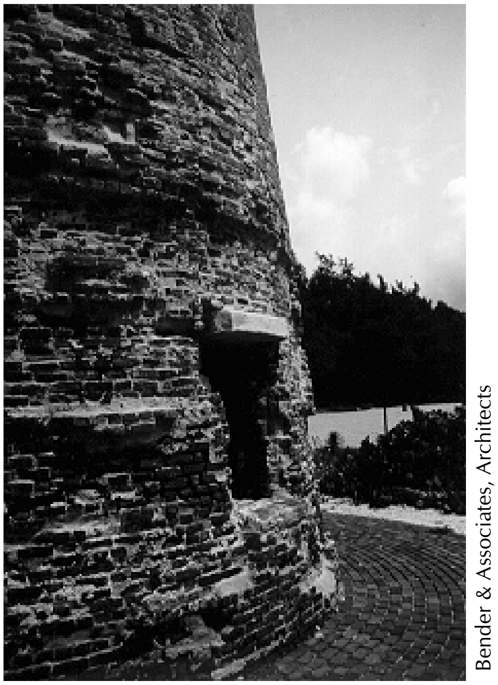


Figure 26. View of the lower tower window; note the depth of the brick deterioration at the window openings. The face of the protruding granite lintel above the window opening represents the face of the original wall.

A condition assessment performed in 1989 stated that the outer brick surface was severely deteriorated with large areas covering approximately 40% of the first brick wythe missing.[2] Two causes contributed to the deterioration of the lighthouse's exterior brick. First, there was the lack of maintenance for the circa-1870-applied mortar wash coating after deactivation of the lighthouse in 1878. Second, the remaining remnants of the exterior mortar wash coating were removed from the brick during the 1960s renovation by sandblasting. Sandblasting is a treatment method that pits the masonry surface, exposing the soft inner core of the bricks, thus accelerating weathering and deterioration. Despite this deterioration the condition assessment determined that the tower was constructed of good quality bricks, and the tower remained structurally sound.

In 1996, the Cape Florida Lighthouse was restored to its 1846 appearance. The severe deterioration of the exterior brick required the replacement of nearly 26,000 bricks. Before installing the replacement bricks, the exterior surface of the lighthouse was stabilized by removing the deteriorated mortar and repointing with a similar mortar mix that was used historically. The mortar used was designed to be compatible with the strength of the extant bricks. The areas of missing bricks were repaired using new replacement hand-molded bricks and masonry anchors. The masonry anchors were placed in holes drilled into the existing bricks and then set with mortar. This treatment helped to tie together the old and new masonry.

To protect the historic bricks from further deterioration, the exterior of the tower was coated with a sacrificial lime mortar wash. Protection of the soft masonry is vital to

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[2] Bert L. Bender, *Architectural and Engineering Report, Cape Florida Light, Key Biscayne, Dade County, Florida*, Key West, Florida, November 1989.

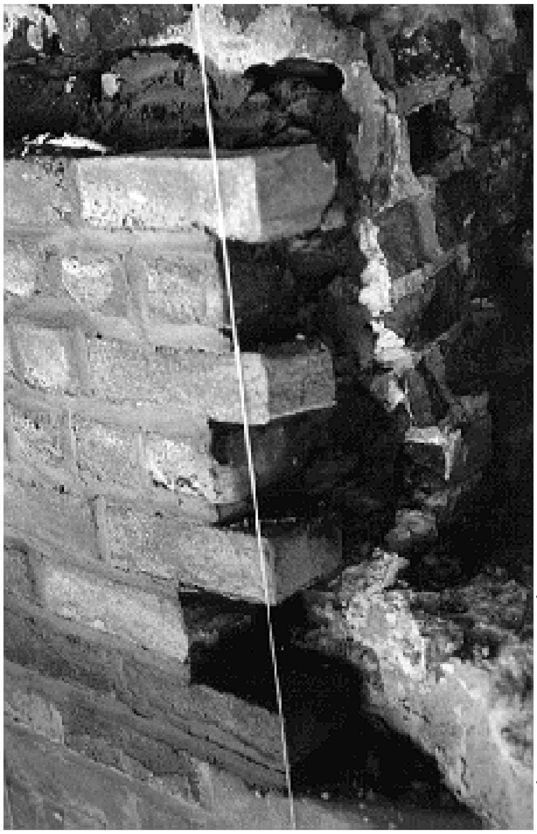

Figure 27. View of repairs being made to the exterior wall. A new brick wythe is being installed where bricks were missing, using mortar that matches the strength of the new and historic bricks. Masonry anchors are used to attach the new wythe to existing wall. The deteriorated mortar joints in the extant wall were repointed with a matching mortar mix.

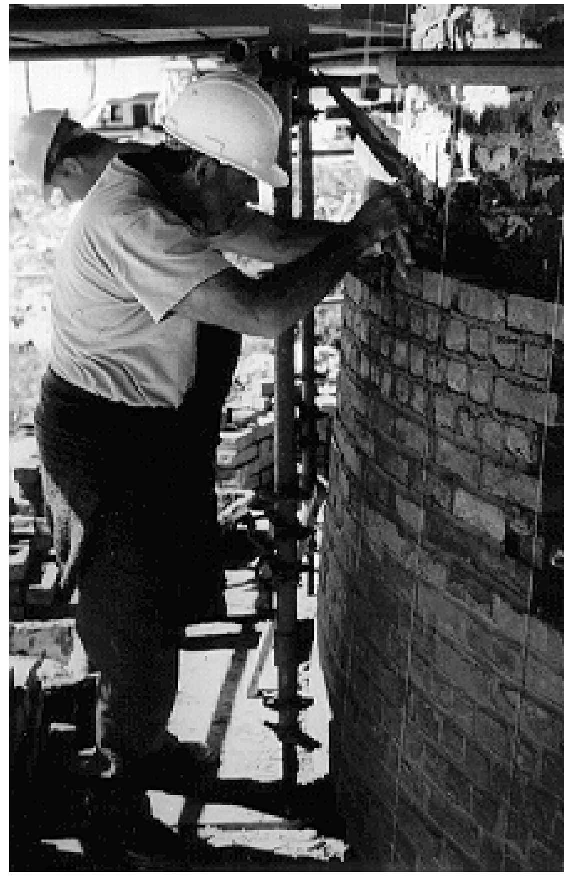

Figure 28. Here a mason is implementing repairs to the exterior wall. The missing bricks were replaced with in-kind materials: the bricks match the historic bricks in size shape and strength. The mortar joint sizes are also being made to match the historic in size, color, and texture, as demonstrated in this photo. The vertical strings over the brickwork define the wall plane, so when the mason places the bricks, they maintain the taper of the conical tower.

maintaining the historic fabric and character of the structure. The sacrificial lime mortar wash is a three-coat system that was applied with natural bristle whitewash brushes. The specification for the lime mortar wash mix was as follows:

3-coat lime mortar wash:

1st - 6 parts lime, 6 parts sand, 1 part portland cement.

2nd - 12 parts lime, 6 parts sand, ½ part portland cement

3rd - 1 finish coat whitewash - water and lime mix (no sand)

This coating system allows the porous brick to 'breathe'; therefore any moisture trapped in the brick can escape. Non-breathable coatings tend to trap moisture in the walls, which can accelerate the deterioration of the masonry. The life expectancy of this coating is approximately ten years in this part of the country.

SIDEBAR: The Building of Minots Ledge Light Station

For many people, their vision of a classic lighthouse is a wave-swept tower. John Smeaton, an Englishman, built the first successful wave-swept tower in 1759 at Eddystone Rock, in the English Channel, made famous by the song *Eddystone Light*. This was the first interlocking-masonry-block lighthouse tower. Later Smeaton developed a 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 just after the turn of the 19th century. Wave-swept towers were built by interlocking large cut stones, both horizontally and vertically. This integral inter-tonguing 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.

Minots Ledge Lighthouse, located on a rock barely visible above the sea near the entrance to Boston Harbor, Massachusetts, is America's

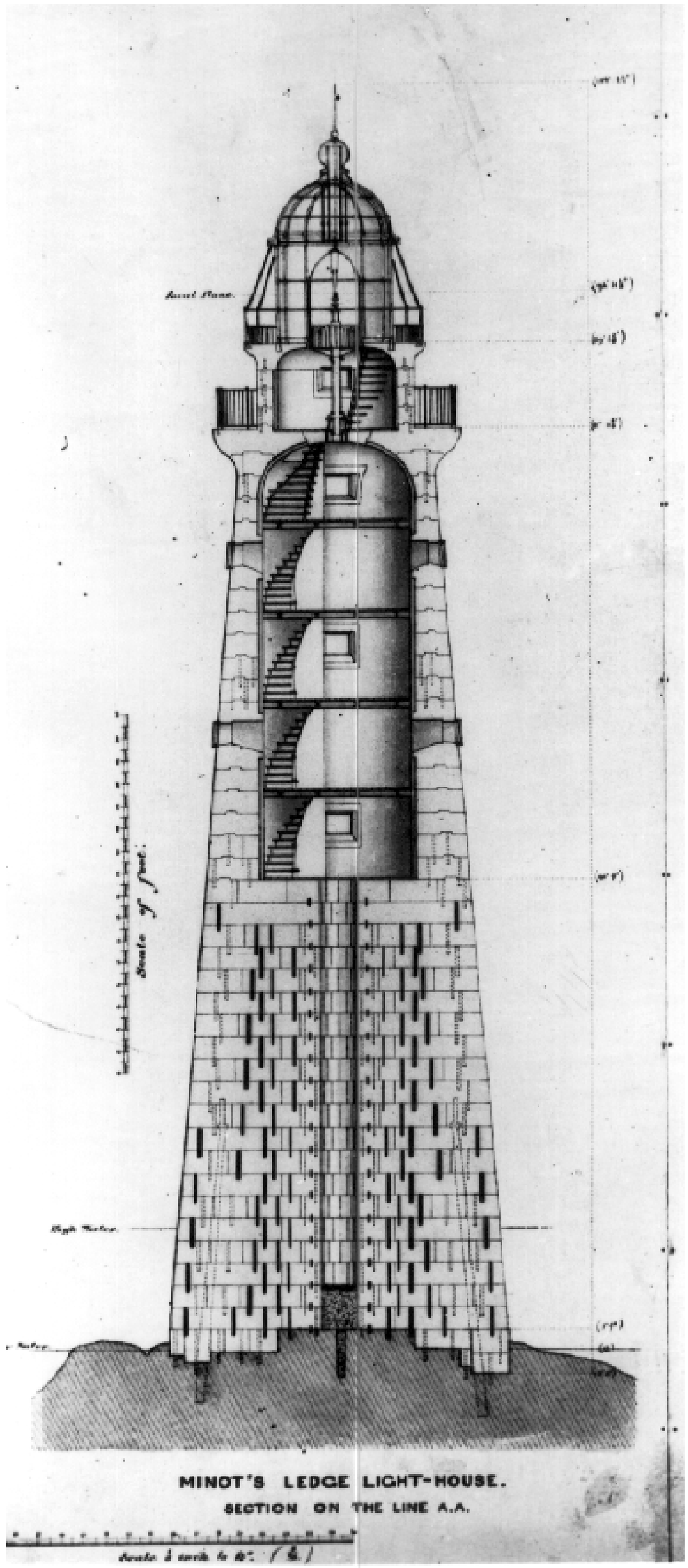

Figure 29. Cross section for 114-foot Minots Ledge Lighthouse.

National Archives photo

version of Eddystone Lighthouse. The first wave-swept stone tower to be built in the United States, it took five years to complete and cost approximately $300,000 to build. Between 1832 and 1841 over 40 vessels had been lost in the area of Minots Ledge. In 1847 Congress appropriated $20,000 for construction of the first Minots "Rock" Lighthouse—the first iron straight-pile lighthouse built in the United States. The lighthouse consisted of a skeletal wrought-iron pile tower built with one central and eight periphery wrought-iron piles, wedged into holes drilled in the ledge—designed to provoke the least amount of resistance to the sea. Construction equipment was twice swept from the rock during summer storms; workmen were several times swept into the sea by unexpected waves, but none were drowned. The first Minots Ledge Lighthouse, lit on January 1, 1850, was destroyed in a storm on April 16, 1851; both keepers were lost. The piles were found twisted and broken, leaving stubs still wedged in place.

On August 31, 1852, Congress approved the erection of the second and still standing lighthouse on the "Outer Minots rock." This time the design chosen was one of interlocking granite blocks. The plans consisted of a masonry tower in the form of a frustum of a cone, solid for the lower 40 feet of its 114-foot height. Because the ledge was exposed only at low tide and on calm days, the work was very slow. Tides were found to be right only "six times during any one lunation, three at full moon and three at the change." It took three years to prepare the ledge for the first course of granite masonry which was cut and test assembled on nearby Gulf (later called Government) Island, near Cohasset, where the government acquired 7.3 acres of farmland for a staging area for the building of the second lighthouse. Here stone-sheds were erected for the stone cutters and a perfectly flat pavement prepared so the stones once cut could be pre-assembled for correct fitness. Granite from Quincy was chosen as being "finest of grain, toughest and clearest of sap." An iron scaffold was erected on the ledge for the safety of the

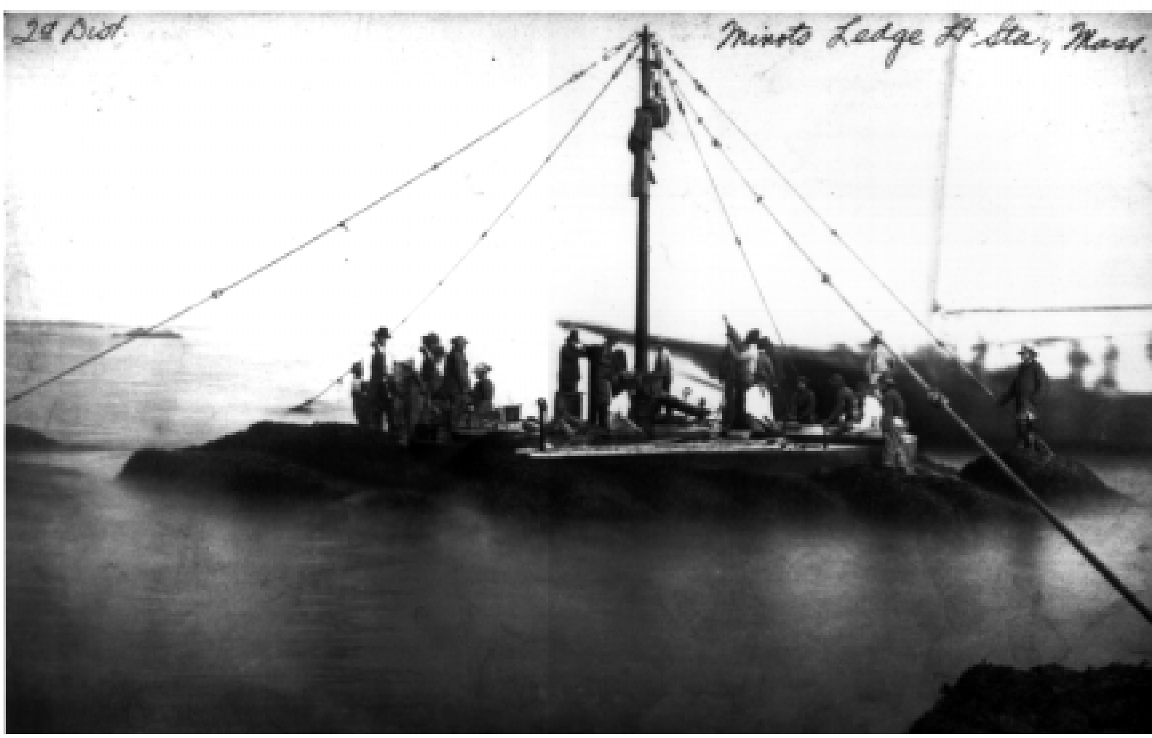

Figure 30. Workers on a calm day, completing the first course of granite block for the foundation of Minots Ledge Lighthouse, 1858

workmen and to facilitate the tedious and difficult operations on the rock. Captain Michael "Neptune" Brennock was hired as lifeguard. He stationed himself in a sloop along side the rock to pick up workmen whom the waves swept from the ledge. Additionally a man was posted to warn the workmen of incoming large waves, hollering out "roller coming!" when necessary.

National Archives photo

Figure 31. Work on Minots Ledge Lighthouse as it progressed just above the entrance level which is visible on the left. The tower below this level was essentially solid.

Permanent iron shafts, about 20 feet high were set in eight of the holes in which the old lighthouse piles had been placed, while the central hole was left open to form a cavity for the base circle of stones—later formed into a 2,200 gallon capacity cistern. Ropes attached to the piles were used by the workman to grasp when waves washed over the ledge. The piles were also used as derricks in laying the stones. This framework was destroyed on January 19, 1857, when the bark *New Empire* struck the ledge during a severe storm and altered the rock surface, necessitating a change in the shape of the foundation stones. New pilings were inserted in the holes, this time 25 feet long. Temporary cofferdams were constructed from sand bags so the foundation stones, which lay more than two feet below low tide, could be cemented to the rock ledge. After much experimentation, it was determined that the mortar should be spread on muslin cloth and wrapped around each stone before it was lowered into place. The mortar was then compressed by the weight of the stone and oozed through the cloth and formed a good adhesion with the rock-surface. Each stone was "dovetailed and doweled to each other in the securest manner" so that the pressure from the impact of the waves tightened instead of weakening the union. Each foundation stone weighted about two tons and was fastened to the rock by 2-inch galvanized wrought-iron bolts. Strap irons attached between the piles kept the stone courses apart until the cement hardened.

The lighthouse was ceremoniously lit August 22, 1860, one day short of five years after beginning construction. But the light was not regularly shown until November 15 when the keepers assumed their official duties. Unlike the first pile structure, the stone wave-swept tower has survived to the present. Minots Ledge Lighthouse is considered the "most important engineering work" constructed by the U.S. Lighthouse Board; "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."