

ENGINEERING STUDY of CAPE LOOKOUT LIGHTHOUSE

May 12, 2005

Project No. 0508-01-00-04

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Notice

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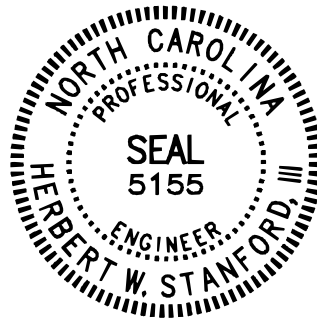


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INTRODUCTION and CONCLUSIONS

This study was undertaken in response to the desire of the Cape Lookout National Seashore (CALO) to open the 1859 Cape Lookout Lighthouse tower to visitors on a more or less routine basis. This study addresses visitor access requirements, structural elements, improved ventilation, lighting, emergency communications, and other measures deemed necessary to fulfill this desire.

It is our conclusion that the tower can be opened to visitor access if certain repairs and modifications are implemented and certain access restrictions are put into place as discussed in the following report Sections. In summary, the repairs and modifications required are as follows:

1. Make minor repairs to and stiffen the existing cast iron stair treads to limit deflection and provide support against repetitive impact loads from foot traffic.
2. Provide additional support of the existing wrought iron stair handrail (Option 1) or replace it entirely (Option 2).
3. Install a new spiral handrail along the inside of the existing stair.
4. Replace the wooden deck and framing of the first landing with non-combustible decking and framing.
5. Replace the stair between the Storage Level and the Watch Level (Note: Level designations are in accordance with U.S. Army Corps of Engineer drawings prepared 1 July 1988). Minor modifications to two sections of the existing structural X-bracing (added in 1988-89) are required, also.
6. Add safety padding, warning paint, and signs to the under edge of the Lantern Level cast iron "platform" due to low headroom clearance (approximately 5'6") and add a lockable, removable panel above the stairs to the Lantern Level to prevent visitor access.

7. Modify one section of existing structural X-bracing (added in 1988-89) at the Watch Level to provide access to the outdoor gallery.
8. Replace the existing ship's hatch that opens to the outdoor gallery with a door more like one used in early in the life of the lighthouse, thus enlarging the access opening.
9. Strengthen and modify, or replace, the existing guardrail around the outside edge of the outdoor gallery.
10. Repair/replace exterior damaged brick, mortar and concrete at the Watch Level and the Lantern Level.
11. Construct new entry deck and stair of noncombustible materials designed to allow for queuing of visitors.
12. Repair/replace existing copper vents and brass vent dampers on the Watch Level to provide for natural ventilation of the tower.
13. Add new lighting, with emergency battery back up, throughout the tower.
14. Add emergency telephone system, with call boxes on each landing and on the Entry and Watch Levels.

In our opinion, these measures can be implemented with a probable cost of construction of \$223,550 and would require approximately 6-8 months construction time.

Other minor items that should be considered, but which are not included in the elements listed above, include:

1. Add locks to all tower windows to prevent their being opened by visitors.
2. Revise the fencing enclosing the Entry Level storage area to provide more space for visitors at the beginning of the stairs.
3. Replace the existing entry door with one that is more historically correct.

Finally, while not of an engineering nature, it is our conclusion that plans to open the tower to visitors must include staffing considerations. It is our opinion that a staff member may be required at the entry to collect a "climbing fee" and to control access to the tower. For safety reasons, a second staff member must be stationed at the Watch Level. Since the Watch Level has constrained head room and the doorway to the gallery will still be relatively small even after modifications, the staff member at this level is absolutely required to monitor access to the outdoor gallery and visitor behavior while there.

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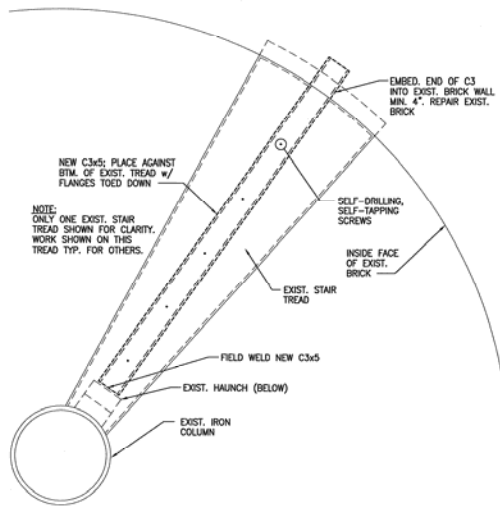
STRUCTURAL ELEMENTS

Overall, the Cape Lookout Light Tower is in good structural condition...the repairs of 1988-89 stabilized the movement of the upper section of the tower. However, to open the tower to routine visitor access, certain repairs and modifications are required due to structural limitations and/or safety considerations, as follows:

Repair and Stiffen Existing Cast Iron Stair Treads

The existing stair treads span approximately 4'-6" between the inside face of the lighthouse wall and a cast iron column located in the center of the lighthouse shaft. They vary in width from approximately 4" at the column, where they bear on a cast iron haunch attached to the column, to approximately 17" at the wall, where their top plates extend into and bear on the wall. The treads have turned-down edges on three sides, which give them the ability to support light foot traffic over the existing span. However, excessive mid-span deflection of the treads is a concern, as is the long-term serviceability of the treads under repeated foot traffic.

One way to reduce mid-span deflection and provide greater resistance to repeated impact loads would be to reinforce the treads with a structural steel member fastened to the bottom of each one. One end of the new member could be welded to the existing haunch and the other embedded into the brick wall. Preliminary analyses indicate that a channel shape, such as a C3x5, could be used as the reinforcing member, as shown in the following figure:



As part of this improvement, the stair "clips" that have been added to the twenty-seven (27) steps immediately below the Storage Level will be removed.

In addition, the two Storage Level stair treads that were cut to allow installation of the light clockwork mechanism should be replaced. The open ends of these two steps represent a safety hazard to visitors.

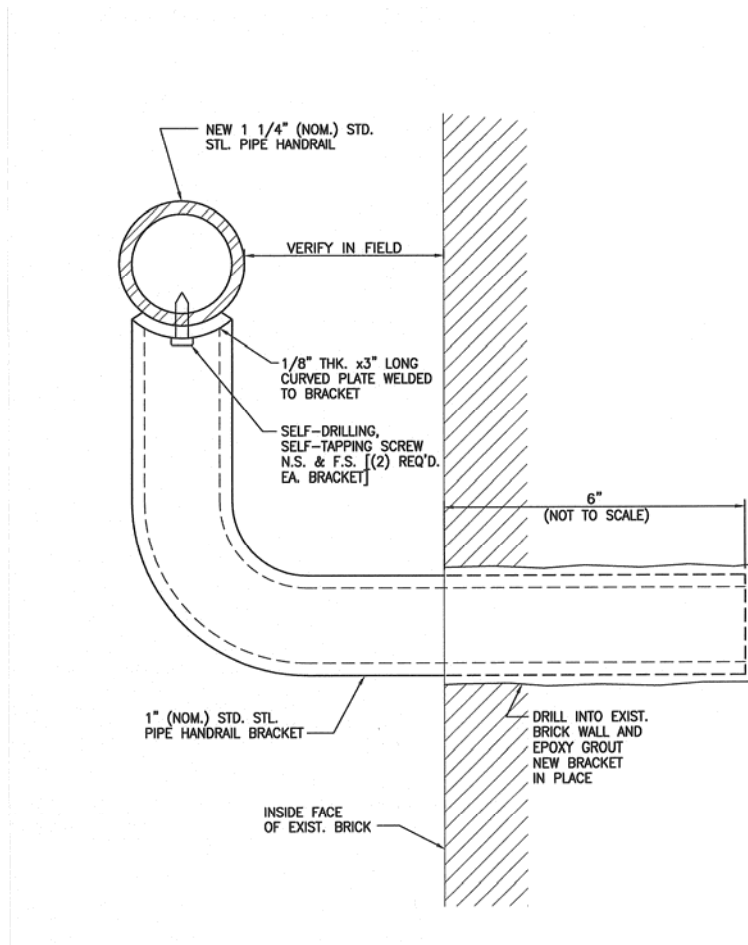
Existing Outer Handrail

The existing outer handrail is constructed of approximately 1" diameter wrought iron solid bar, supported by wrought iron L-shaped anchors inserted in the tower's brick wall. There are two problems with the existing handrail. First, the diameter is much smaller than required by most building codes (1-1/4" minimum). Second, the distance between existing handrail anchors is such that excessive deflection of the handrail can occur under normal use. There are also some anchors that no longer adequately support the handrail because they have worked loose from the masonry into which they are embedded or have corroded away at their base.

There are two options available:

Option 1: Ignore the handrail diameter issue and simply repair and enhance the existing handrail. Under this option, the loose or damaged anchors would be replaced and new anchors installed to eliminate the handrail deflection.

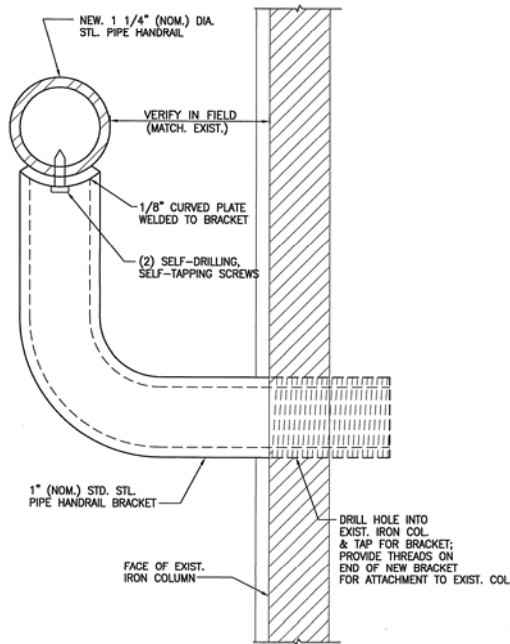
Option 2: We recommend that the handrail be replaced with a 1-1/4" diameter pipe rail with wall anchors as shown in the following figure:



The open ends of the new rail will be closed and turned down so that, visually, the old and new handrails would appear similar.

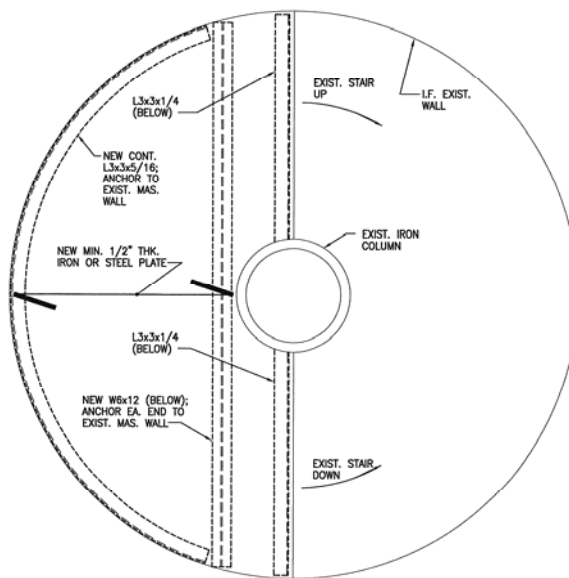
New Inner Handrail

With visitors traveling up and down the stair at the same time, it will be necessary to have handrails on both sides of the stair. This will require fabrication and installation of a spiral shaped handrail that would be "wrapped" around the center column. The handrail should be minimum 1-1/4" in diameter. Attachment of the handrail to the column could be accomplished with steel pipe anchors similar to those embedded in the lighthouse wall except they would be fastened to the column, as shown in the following figure:



Replace Wooden Stair Landing No. 1

In the interest of public safety, all structural components inside the lighthouse should be constructed with non-combustible materials. The first stair landing is currently constructed with wooden joists and decking. These components should be removed and replaced with structural steel joists and either steel plate decking or iron plate decking to match that of the other stair landings within the lighthouse. The following figure illustrates the required improvements to the landing:



Replace Stair between Storage Level and Watch Level

When the upper levels of the lighthouse were reinforced with structural steel X-bracing in the late 1980's, the stair between the Storage Level and the Watch Level had to be removed to accommodate the new work. A new stair was put in its place, one that utilized steel treads that were supported by staggered steel rods. The width of this stair and the way it is constructed render it unsafe for use by the general public.

This stair must be replaced with a wider stair, matching, as nearly as possible, the main cast iron stairs. This can be accomplished as follows:

1. Remove the existing 1" tongue-and-groove partition at the entrance to the Storage Level, back to the center stair column. This effectively opens the entire top of the existing stair for use.
2. Remove the existing decking "pie slice" on the Watch Level through which the current stair is routed.
3. Install a new spiral stair with decreasing width between the two levels. Both new inboard and outboard handrails, as described above, will be required.

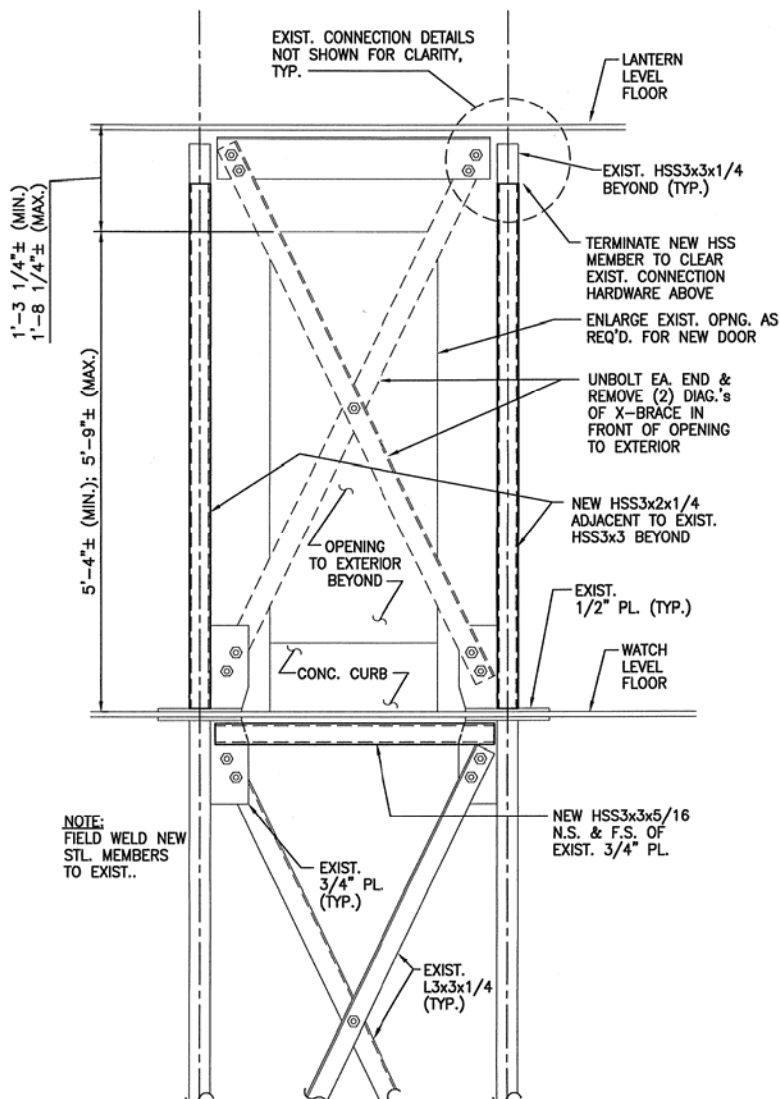
Visitor access to the gallery door is constrained by (1) diagonal X-bracing in sections in the Watch Room and (2) the low head room (approximately 5' 6") under the cast iron lantern platform. We recommend addressing these problems as follows:

1. Two sections of bolted X-bracing will be revised by using a welded connection at the center in lieu of the bolted connection. This will allow the two members to be installed in the same plane, reducing their intrusion into the Watch Room by 5"-6".
2. Add padding, yellow hazard painting, and signs to the outer and under edge of the lantern platform to minimize visitor "head banging".

Modify Structural X-Bracing at Door to Outdoor Gallery

Access to the outdoor gallery from the Watch Level is severely impeded by the X-bracing installed in front of the door opening in the late 1980's.

Our analysis of the X-bracing system around the inside of the upper levels of the lighthouse finds it to be redundant enough to allow removal of the section of bracing at the door opening. The two diagonal angles that block the door opening can simply be unbolted and removed. The vertical members on each side of the opening should then be reinforced and a new horizontal strut constructed just below the Watch Level deck, as shown by the following figure:



Replace Door to Outdoor Gallery

Although the existing ship's hatch that opens to the outdoor gallery appears to be functioning adequately, it is not historically correct and too small for general public use, being only approximately 18" wide and 36" high.

Construction documents for the lighthouse that were issued in 1913 show an airlock at this wall opening that extends onto the outdoor gallery deck. On those documents there is one door shown leading from the airlock structure onto the deck and another one shown in the lighthouse wall between the airlock and the Watch Level deck. There is also a window shown in one wall of the airlock.

Construction of an airlock that is a replica of that shown on the existing construction documents can probably be accomplished, but will require ceiling heights and door opening dimensions that are not in accordance with current

building code requirements. Another problem presented by construction of the airlock is that it would essentially block off a portion of the gallery deck and impede movement around the deck.

Due to all these problems, we do not recommend constructing a replica of the 1913 gallery airlock.

The size of the door opening in the lighthouse wall is limited by existing conditions. Unless the existing concrete curb at the base of the opening is modified and/or portions of the existing brick wall are removed, the maximum possible opening size is approximately 25" wide by 48" high. While this opening size does not meet building code requirements, we do not recommend modifying the concrete curb or the brickwork.

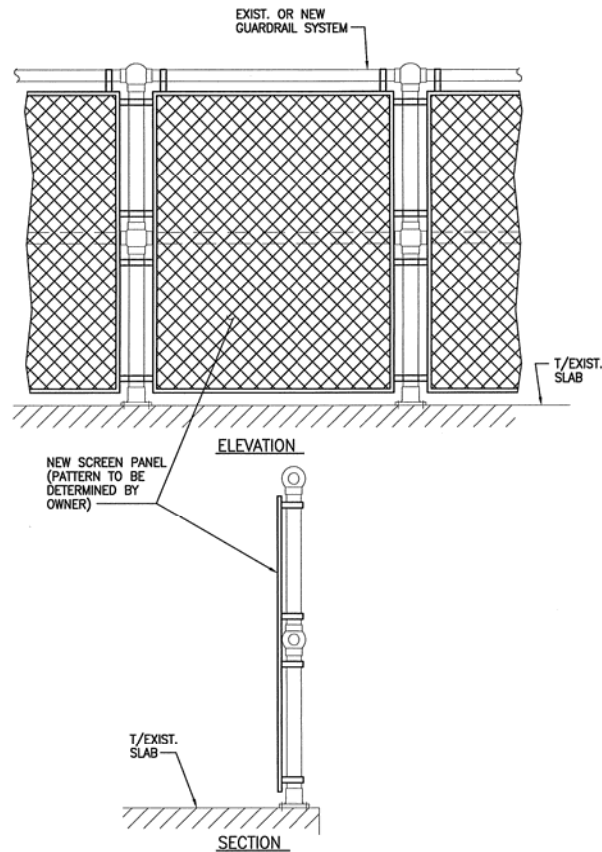
To improve access from the Watch Level to the outdoor gallery, we recommend removing the existing ship's hatch and the miscellaneous construction elements associated with it. A structural steel lintel will be required to support the masonry and existing construction above the opening. Then, a steel door and frame would be installed in the opening. To "trim out" the opening, the existing stainless steel plating would be removed and the brickwork repaired to return it to as near as possible to its 1859 appearance. Hardware for this door must include panic hardware on the exterior so that anyone on the gallery can immediately access the Watch Level and stairs.

Existing Outdoor Gallery Guardrail Modifications

Some of the cast iron posts and rails of the existing guardrail around the outdoor gallery deck are deteriorated to the point of needing replacement. The rest could be cleaned and repainted and remain in use. Any repair of existing guardrail components should be performed in accordance with the "Iron" section of the *Historic Lighthouse Preservation Handbook*, created through cooperative partnership between the National Park Service, the U.S. Coast Guard, and the Department of Defense.

The primary structural concern with the existing guardrail is that each post must be properly anchored to the concrete gallery deck. This concern could be addressed by providing additional anchors at the base of each post.

New post and rail construction should replicate the existing guardrail system. However, in order to meet building code requirements for guardrails in public spaces, modifications to the guardrail will be required. The open spaces between guardrail components must be reduced to less than four inches. This can be accomplished in a number of ways, including installing perforated stainless steel screen panels, expanded stainless steel screen panels or "extruded" anodized aluminum screen panels along the inside of the existing guardrail. The following drawing shows one potential solution to the guardrail problems:



Repair Brick, Mortar and Concrete at Watch Level and Lantern Level

Our observations of the exterior surface of the lighthouse wall made from the outdoor gallery deck indicated a number cracked mortar joints and partially displaced brick. Most of this damage can be attributed to the harsh environment and high velocity winds to which the lighthouse is exposed. The severity of the damage and its potential adverse effect on the structural integrity of the lighthouse may have been the primary motivation for developing and installing the X-bracing system around the inside of the upper levels of the lighthouse. This X-bracing appears to be functioning as intended and is providing lateral and torsional support for the upper portion of the lighthouse.

Most of the damage to brick and mortar can be corrected with common masonry repair procedures. Damaged brick should be removed and replaced, and damaged mortar joints replaced or repointed. All masonry repair procedures should be performed in accordance with the "Masonry" section of the *Historic Lighthouse Preservation Handbook*. Consideration should also be given to developing and installing a method to "pin" the multiple brick wythes together and to the vertical members of the X-bracing inside the lighthouse.

The concrete slab of the outdoor gallery deck is in relatively good condition, but is in need of some repair. In some locations, anchors for the posts of an abandoned guardrail have been left exposed and are rusting. These anchors should be removed from the slab and the resulting voids in the concrete should be cleaned and grouted. All cracks in the concrete slab larger than hairline cracks should also be cleaned and grouted.

New Entry Deck and Stair

The existing wooden stair and deck that provides access to the main entry door into the lighthouse is not structurally adequate for public use. It should be removed and replaced with a steel stair and deck structure that has been designed for a Live Load of 100 pounds per square foot and has proper handrail and guardrail systems.

Design of the new deck and stair must address the following criteria:

1. The stair width must be sufficient to support 2-way traffic.
2. The deck should be large enough to allow for a staff member "station" for collecting a "climbing fee" and for the queuing of visitors waiting to enter the tower. For purposes of estimating a cost for this measure, a 20' x 20' deck with 6' 0" wide stairs is assumed.
3. While it is impossible to provide complete handicap access to the existing tower, it may be worthwhile to provide handicap access to the Entry Level, making at least a small part of the tower experience available to the handicapped.
4. Covering the deck to reduce sun exposure and provide some inclement weather protection.

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OTHER CONSIDERATIONS

Aside from structural issues, there are additional improvements that we recommend be made before the tower is opened to routine visitor access:

Lighting

Existing tower lighting consists of four fluorescent fixtures installed near each landing and natural daylighting entering through the windows. Both are inadequate for safe, routine use of the tower stairs. We recommend that new lighting with battery back up be installed throughout the stairs, at the entry, and on the Storage and Watch Levels. These lights would be designed to maintain a minimum lighting level of 10-15 footcandles throughout.

Emergency Communications

While not of an engineering nature, it is our conclusion that plans to open the tower to visitors must include staffing considerations. It is our opinion that a staff member may be required at the entry to collect a "climbing fee" and to control access to the tower. For safety reasons, a second staff member must be stationed at the Watch Level. Since the Watch Level has constrained head room and the doorway to the gallery will still be relatively small even after modifications, the staff member at this level is absolutely required to monitor access to the outdoor gallery and visitor behavior while there.

In addition to staff members being stationed at the Entry and Watch Levels, emergency telephone communications should be available at each landing, the Storage and Watch Levels, and at the Entry for use by visitors and staff in the event of an emergency, medical or otherwise. We recommend the use of boxed handsets with an autodial feature for the stations at the Storage Level and intermediate landings, and full-service

phones connected to the CALO phone system at the Entry and Watch Levels. These autodial phones would be programmed to dial the staffed extension(s) at the Entry and Watch Levels when a handset is lifted from the cradle.

Ventilation

Due to its shear mass and existing natural ventilation, the tower stays at a moderate temperature even during the hottest summer months.

Therefore, it is our opinion that a new, mechanical ventilation system is not required. However, we do recommend that the existing natural ventilation system be improved, as follows:

1. Increase the size of the existing door transfer louver at the Entry Level, which serves as the ventilation inlet, to at least 4 square feet. This can be easily accomplished by modifying the existing door or installing a new door (see Item 3, below).
2. Repair the existing vents and vent dampers at the Watch Level and keep them open to serve as ventilation outlets. Of the five outlets, four need copper ducting repairs and new caps and all five need their vent dampers repaired.

Other minor items that should be considered, but which are not included in this report, include:

1. Adding locks to all tower windows to prevent their being opened by visitors;
2. Revising the fencing enclosing the Entry Level storage area to provide more space for visitors at the bottom of the stairs; and
3. Replacing the existing entry door with a more historically correct one.

Finally, while the modifications recommended in this report will allow routine visitor access, the number of visitors in the tower should be limited to make stair transit and outdoor gallery access comfortable and safe. We recommend that, at least initially, no more than 30 people be allowed in the tower at one time, with, perhaps, no more than 10 on the outdoor gallery.

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PROBABLE COST OF CONSTRUCTION

Following are our opinions of probable cost for the various elements discussed in this report. It must be understood that Stanford White Associates has no control over costs or the price of labor, equipment or materials, contractors' methods of determining bid prices, competitive bidding, market or negotiating conditions. Therefore, Stanford White Associates cannot warrant the accuracy of these cost opinions with regard to actual construction cost.

It should also be noted that these opinions do not include any expenses necessary to identify, evaluate, handle or dispose of hazardous materials (asbestos, lead paint, etc.). Hazardous materials may exist where there is no reason to believe they could or should be present, therefore a detailed evaluation of hazardous materials should be made prior to performing any of the repairs or new work described above.

Due to its location, access to the Lighthouse is only by water, increasing the logistical costs imposed on the contractor(s). Therefore a "Conditions Factor" has been added to attempt to define these increased logistical costs. Finally, a "Contingency" factor has been applied in the cost opinion inasmuch as: 1) not every miscellaneous construction cost will be included on a schematic line item cost opinion; and 2) the rehabilitation of an existing structure requires that certain assumptions be made regarding existing conditions that may not be reasonably verifiable prior to the actual construction/renovation process.

Item	Probable Cost of Construction
Make minor repairs to and stiffen the existing cast iron stair treads to limit deflection and provide support against repetitive impact loads from foot traffic.	\$12,000

Provide additional support of the existing wrought iron stair handrail (Option 1) or replace it entirely (Option 2).	Option 1: \$5,000 Option 2:\$12,000
Install a new spiral handrail along the inside of the existing stair.	\$15,000
Replace the wooden deck and framing of the first landing with non-combustible decking and framing.	\$5,000
Replace the stair between the Storage Level and the Watch Level. Minor modifications to two sections of the existing structural X-bracing (added in 1988-89) are required, also.	\$12,500
Add safety padding, warning paint, and signs to the under edge of the Lantern Level cast iron "platform" due to low headroom clearance and add a lockable, removable panel above the stairs to the Lantern Level to prevent visitor access.	\$500
Modify one section of existing structural X-bracing at the Watch Level to provide access to the outdoor gallery.	\$1,000
Replace the existing ship's hatch that opens to the outdoor gallery with a door more like one used in early in the life of the lighthouse, thus enlarging the access opening.	\$6,000
Strengthen and modify, or replace, the existing guardrail around the outside edge of the outdoor gallery.	\$6,000
Repair/replace exterior damaged brick, mortar and concrete at the Watch Level and the Lantern Level.	\$8,000
Construct new entry deck and stair of noncombustible materials and designed to allow for queuing of visitors.	\$40,000
Repair/replace existing copper vents and brass vent dampers on the Watch Level to provide for natural ventilation of the tower.	\$2,500
Add new lighting, with emergency battery back up, throughout the tower.	\$18,000
Add emergency telephone system, with handsets on each landing and on the Entry and Watch Levels.	\$6,000

SubTotal	\$147,500*
Conditions Factor (20%)	\$ 29,500
Subtotal	\$177,000
Contingency (15%)	\$ 26,550
Total Construction	\$203,550
Design Fees (10%)	\$ 20,000
Grand Total	\$223,550

*Based on stair handrail Option 2