Wood Island Feasibility Study

Part Two: Site Assessment and Recommendations

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Completed for the Town of Kittery, Maine in cooperation with the University of New Hampshire and Appledore Engineering, Inc.

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Preface

The following report is the work of students completed under the guidance and supervision of professional engineers. This report should only be used by the reader for the purpose of conveying general information regarding Wood Island, Kittery, ME. The information in this document is based on several sources regarding the history of the site. These written and photographic sources are cited and credit is given for their reference and use.

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Introduction

The Wood Island Lifesaving Station is a historical icon of the seacoast. It is what makes the island important to the town of Kittery. For this, it is a great concern to keep the structure from slowly deteriorating under the harsh conditions of Portsmouth Harbor winters. This structure is experiencing a lot of rain and snow each year, and damage done to the roof has allowed water penetration to destroy some interior wooden elements. This damage has created unsafe conditions in the Lifesaving Station. Any visitors exploring the structure are in danger of falling through a floor board or slipping on loose wood.

Currently, efforts have been made to close off the structure to visitors. These efforts mainly involved boarding up windows and doors. Unfortunately, these boards have not been able to withstand the harsh wind and rain, as well as visitors, vandals and bird traffic. All of these factors have been able to take down these window and door boards one at a time. Currently, the structure is very much open to the elements and is serving as home for many local birds. These seagulls, as well as other coastal birds, have been further destroying the interior elements.

Figure 1: Boarded side of Lifesaving Station

Figure 2: Damage near openings

Action needs to be taken to end to the visible deterioration and potential dangers. Due to the historical significance, the structure does not fall to ruins under the close watch of the seacoast area. Also, it is extremely important that those visiting Wood Island are safe. The current state of the structure allows for visitors to easily access the inside of the Lifesaving Station, which, as previously mentioned, can be very dangerous. This report is meant to outline some the feasible options to remediate these problems.

The options described include:

- Preservation of the current structure with some improvements meant to stop further damage as well as closing off the dangers of the interior.
- Demolition of the current structure and replacing it with a steel frame mimicking the original dimensions.
- A scale model of the original structure.

These options solve both the on-going deterioration as well as preventing accidents within the structure. Some of the issues faced with these deigns include: asbestos and other “suspect material” abatement required for some construction and any demolition. Another issue is the visibility of a steel frame structure from Kittery and other points in the harbor. Of course, as the site is an island, construction costs and feasibility were of great concern.

Conditions Assessment

Abatement

An important aspect to this project is the presence of "suspect material" within the structure. This is material labeled as potentially dangerous to work near and poses a problem for disposal if the material were to be removed. As the structure was built in a time period that predates concerns for asbestos as well as lead-based products, the building is very likely to house many components containing these materials. OSHA considers any building constructed prior to 1981 to have some sort of suspect material present (Kindley, 2009). Due to this concern, an abatement specialist from Terracon Consultants, Inc. was brought to the island to take a closer look at some of the building materials that had been used.

Figure 3: Piping with suspect asbestos containing material used as insulation

Mr. David Oliver of Terracon, found that there indeed was a good deal of suspect material. His findings can only be considered professional opinion, as no laboratory tests were conducted to prove the existence of asbestos or other material.

One of the most important concerns Mr. Oliver had involved the insulation found on the piping in the boat house (Figure 3). He suspects that this material contains asbestos and would abatement if any type of construction were to occur. Mr. Oliver also stated that it could be dangerous to have out in the open as it is currently. This material would most likely require special removal as well as special landfill disposal procedures and/or costs. Again, this material is deemed suspect only. A laboratory test would need to be conducted to prove it contains asbestos.

Another suspect asbestos-containing material is the roofing shingles. The roof material was replaced sometime in the 1990s, but without proof of particular material that was selected and installed; the shingles will also need to be tested. If the town of Kittery can provide documentation to disprove the existence of asbestos in the material, this test may not be necessary. The investigation also revealed a paper liner which was used throughout the entire structure, including locations from under the siding to between the floor boards and joists (Figure 4). This paper was assumed to be used as insulation, and is suspected to contain asbestos.

Figure 4: Paper liner within the floors that has been deemed suspect material

In addition to asbestos, lead paint is suspected to have been applied to the walls within the structure. This paint, as it has been exposed to a good deal of moisture and time, is now chipping off the walls. Although not a hazard unless consumed, the material could require special training for removal. It also could require special disposal. Again, laboratory testing is required before specific remediation or abatement options are considered.

Figure 5: Lead paint chipping off interior walls

Water Infiltration

As this structure is situated on an island, harsh snow and rain are to be expected. The failed roof system over the boat hose portion of the structure, as well as the missing window and door boards meant to close off the building, have left the interior to be exposed to water infiltration. As it is a wooden structure, this has caused much damage to the interior flooring and floor supports. Constant wetting and drying has caused a good deal of the wood to rot. It has rendered some portions of the building un-navigable.

Water can destroy wood for many reasons. One such reason in older structures is lack of or failing trim or flashing elements (Historic Lighthouse Preservation Handbook). This can allow for water to slowly build up in locations. It can deteriorate the wood it is in contact with, and in the Wood Island Lifesaving Station's case, this led to failing surfaces that gave way to the water to infiltrate further and further into the structure. Another important failure mode of wood in wet conditions is fungus, mainly mold, as well as insects (Historic Lighthouse Preservation Handbook).

It is of the upmost importance to the survival of the structure that the water damage be prevented. In addition to closing off the structure to prevent further water infiltration, measures should be considered to dry out the current condition.

Figure 6: Interior damage to wooden elements

Birds

Many structures in the Kittery-Portsmouth area struggle with bird damage. This structure is no different. In fact, as it is open and uninhabited, the structure serves as a seagull nesting area. The birds are breaking through boarded-up openings and creating some of the water infiltration problems previously discussed. It is well known that bird droppings are very acidic and can be very degrading to external surfaces of buildings (Wells, 2007). Many common roofing materials, including asphalt, are very susceptible to this degradation. After which, the material becomes more exposed to UV deterioration (Wells, 2007). This degradation may be a cause of some of the failure being experienced within the roof system.

In addition to damage, the birds' presence is causing an unhealthy situation within the building. On one site visit, several dead birds were found inside the structure. These birds had not made the winter, and their carcasses were most likely providing habitat for unwanted bacteria or potential scavenger creatures. Also, bird droppings are found to spread an array of diseases and in enough volume can be considered hazardous waste (Wells, 2007). This is not a healthy environment for Wood Island visitors or maintenance/construction personnel that might need to access the structure for any improvements.

Figure 7: Bird droppings

Snow and Wind Effects

As the structure is on an island at the edge of Portsmouth Harbor, it experiences a considerable amount of snow and wind. Both are creating a deterioration of the structure that cannot be easily avoided due to the age and condition of the building. The effects of these two components cannot be prevented, but some improvements could slow the process down.

Wind can cause and contribute to the failing of boards placed on windows and doors. It is also the probable cause of the structure's siding deterioration in some exterior wall sections. Wind also has the effect of whipping up and over the roof in such a way that is lifting the damaged roof materials off the structure. These effects are leading to the water infiltration that is deteriorating the interior of the Lifesaving Station. Wind effects have a tendency to make worse what is already damaged.

Snow has been taking a large toll on the structure. In particular, the boat house roof, which has been deteriorated by water infiltration, wind effects and bird droppings, is also suffering from increased snow loads. As the roof fails, the snow has more of a tendency to collect within the failed areas. Within the duration of this investigation, it has been evident the deterioration has increased. The increased damage within this past winter is evident in the photographs below.

Figure 8: Increased damage in March 2009

Figure 9: Damage to roof in July 2008

Analyses Conducted

Abatement Avoidance Options

A complete suspect materials survey and laboratory testing is required to make an appropriate decision regarding abatement options. Mr. Dave Oliver, of Terracon Inc., has indicated that the survey must be in accordance with NESHAP regulations for asbestos materials within buildings for renovation/demolition. The cost estimate to have an inspection performed by a State of Maine licensed asbestos inspector and the paint to be sampled for presence of lead would be approximately $2,800 to $3,500.

If work is required in a space contaminated by suspect materials, workers must be informed of the danger and risks present. Prior to any work, the asbestos suspect materials can be covered to prevent exposure to the workers instead of costly removal. Restrictions for people working in a lead paint environment are less than for those contaminated with asbestos.

Landfilling Options for "Suspect Materials"

Once the survey identifies the types and extent of asbestos and lead paint containments, the materials can be removed appropriately and disposed in hazardous waste receiving landfills. Research has indicated the cheapest asbestos landfills are located in Ohio. Athens County asbestos landfill will accept the materials at a per volume cost of $17.20 per cubic yard. However transport costs by a hazardous waste hauling company could be considerable. Alternatively, Waste Management Turnkey facility in Rochester, NH can take the material at a per weight cost of $75/ton for friable asbestos and $91/ton for non-friable asbestos. Requirements, testing, and other conditions apply for these disposal methods. (Appendix A)

Solutions Considered

Preservation of Current Condition

As mentioned, one of the goals of this report is to recommend ways in which the historic icon can be preserved. This could include either demolition of the structure and construction of some sort of commemorative structure or signage, or it could include a stabilization and preservation of the building's current condition. It is in the best interest of historical preservation to keep a structure as close to its original condition as possible, but may not always be feasible.

This stabilization and preservation option aims mostly to prevent current problems that are the cause for the existing deterioration. The structure's original design and orientation were sufficient enough to keep it standing up to the elements for 100 years. The structural elements that compose the Lifesaving Station have been doing precisely what they were meant to; however, the exterior protection elements are now failing to serve their purpose. Replacement and correction of some failing elements could keep the structure standing still.

An important aspect to preserving the current state of the structure is to block off access to the interior. As mentioned previously, already rotting wooden flooring and beams, as well as suspected asbestos-containing materials and large volumes of bird droppings are creating an extremely unhealthy environment within the building for any visitors or workers. The current use of wooden boards is not working. The findings of this investigation indicate that a sturdier blockade should be put in place. In particular, the south facing walls of the Lifesaving Station are particularly failing. At a minimum it is recommended that the blockades facing south be replaced and made sturdier to withstand the elements. The first floor and basement windows and doors could be blockaded by one of two options investigated in this report. The first option is steel plating. To withstand wind loads, 3/16" thick, A36 steel plating is suggested, at approximately $10 per square foot (calculations found in Appendix A). In places such as the garage-sized doors, once used for boat-launching, this steel could become quite heavy, and reinforcement "piers" from the basement may be necessary during construction to stabilize these blockades. The other option for closing off the lower levels of the structure includes replacing and reinforcing the wooden boards. With the use of ply-wood boards and a 2"x4", vertically-oriented, bracing element placed at foot intervals, these wood-board elements could be much more successful (cost breakdown tables found in Appendix A). These two options could also be used in conjunction with one another. The south-facing structural openings could be replaced with steel plating, and the other less-vulnerable walls could be replaced by ply-wood where needed and reinforced with vertical 2"x4"s.

Another important aspect of this option is the need to close off the upper level windows from both water infiltration and birds, while allowing for ventilation to keep the interior dry. This can be done with the use of louvers. This investigation found specifications for metal louvers that sit in windows, protecting from rain and bird with outward sloping grates and screens. These can be installed as would a window and can be made for different sized windows. An example of an appropriate louver is the E4DS Model produced by Architectural Louvers, as shown here. This particular louver is hurricane-force wind rated as well as water resistant and bird proof. Its approximate cost, including installation is $37 per square foot. This does not include the cost to transport the materials to the island, included in the cost breakdown tables found in Appendix A.

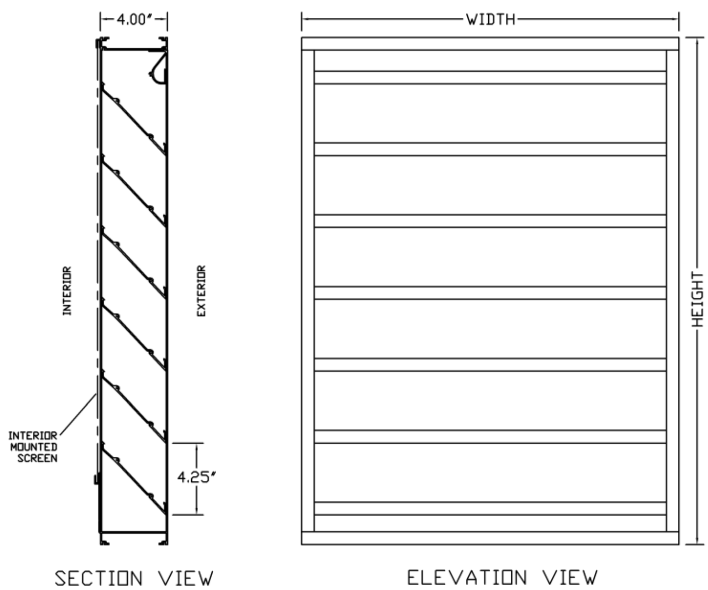

Figure 10: E4DS Model by Architectural Louvers Specification

The louvers and blockades described above will protect the structure against intruders, birds and the elements that are entering from the sides. There is also an extreme danger from above. The roof system is currently failing, in particular, the area of the roof located over the boathouse. There is a notable difference in interior deterioration on the boathouse side when compared to the rest of the building still protected by a roof. This is a depiction of how important a functioning roof is to the Lifesaving Station. This investigation leads to the suggestion of a replacement of the roof.

The costs for the different options are as outline in Table 1: Preservation Cost Analysis. These values assume a $1000 and $200 cost of boat and generator use per day of construction, respectively. They also assume 12.5% engineering and permitting cost, as well as a conservative 25% construction contingency, to allow for unexpected problems and changes. The different options each include: bottom floor barricading of various materials, upper level louver systems, full re-roofing, and limited re-siding of exterior walls. The costs assume all upper level windows will need to be fitted with a louver for maximum venting. Changing the smaller windows to steel plate changed the overall cost by only $2000, so it is found to be slightly conservative to assume all will be louvered. This is likely to change in final design. It also must be noted that these costs do not include any possible abatement. It is uncertain as to whether or not one will be required for these mainly exterior changes, but it is a concern for this construction.

Table 1: Preservation Cost Analysis

Approximate Expected Costs for Preservation Options	
Using All Steel Plating	$104,000
Using All Ply-wood Boards and 2"x4" Reinforcement	$97,500

It can be noted that there is not a significant change in cost when a wood boarding is chosen over steel plating. This can be explained better by detailing the cost breakdown in terms of percentages, as shown in the figure below.

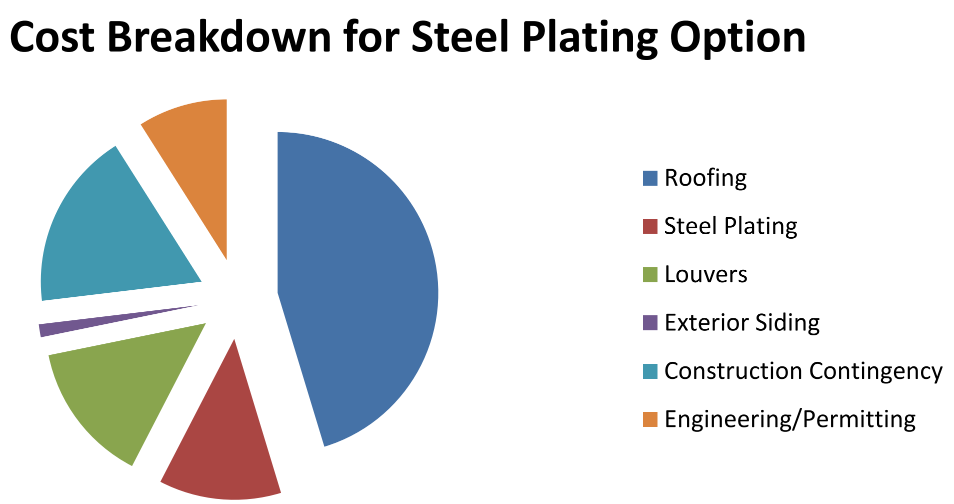

Figure 11: Sample Cost Breakdown for Preservation Options

The above pie chart displays how the costs of each part of this option compare to one another. It becomes obvious how big of a piece of this cost goes towards re-roofing the structure. It should be noted that upon further investigation into preservation of the structure, it may be found that not the entire roof needs to replaced. This cost analysis assumed that all roof surfaces will need replacement.

Structure Removal

An estimate for removal of the building was developed by Pickering Marine Inc., a local marine company based in Portsmouth, NH. The contractor estimates demolition and disposal will cost approximately $75,000.00 without abatement. Abatement costs associated with demolition are dependent on results from the suspect materials survey.

If the structure were removed, it would remove the safety hazard that the existing conditions pose to visitors. The station could then be replaced by another structure or the space could be allowed to return to its nature state.

Scale Model Replacement

The final option explored is the demolition and replacement with a scale model replica. The replica envisioned would be to the order of 10-15 feet tall, and could be placed either on the island or at a prominent public location, such as the Kittery Town Hall. As the weather on Wood Island is always a concern, maintenance and general protection of the scale model would be more difficult and perhaps costly. It is recommended that, were this option to be chosen, that the scale model be located within the Town of Kittery to commemorate the structure that stood on Wood Island, and historical plaques would be placed at the original site. These plaques would be very similar to those situated at other locations within in Kittery.

Steel Frame Structure Replacement

Figure 12: Steel Frame Structure Rendering

An option to immortalize the image and semblance of the Wood Island Lifesaving Station is to erect a durable steel frame. The frame would represent the building by matching the original size, shape, and colors. The original building would be demolished and removed completely.

The new foundation for the frame would consist of reinforced concrete columns with reinforcing steel grouted into the island's bedrock. The void caused by the original basement would be filled in with native or other material. The concrete columns would extend above ground and form a stable platform to build the frame.

The frame itself was designed with seven inch structural tubing and sixteen inch wide flange beams. These large sections allow people to clearly see the frame's shape from far distances. The design resists gravity, ice, and wind loads. It also resists vibration cause by lateral loads. Moment connections were used in the design to keep the appearance clean and uncluttered. No cross bracing was added to the design. The frame was designed according to the American Steel Construction Institute Manual.

All steel components would be hot dipped galvanized to prevent corrosion in the extreme ocean exposure. This is the only feasible alternative for a steel structure in the ocean environment. Weathering steel is not appropriate in spraying-salt conditions. The galvanizing process adds a coat of zinc to the metal. The zinc acts as a sacrificial anode to prevent salt spray from attacking the metal structure directly. Galvanizing does not provide permanent protection; eventually the structure will experience corrosion. If there is a chip in the zinc coat, corrosion will occur at that location and salt ions will attack the steel from the inside completely. Depending on the thickness of zinc applied in the galvanizing process, the steel can be protected for several decades. Painting the galvanized steel is an option, however only exotic paints can be used. The galvanized layer can be painted with self etching primer that allows a chemical bond of the paint to the surface.

Loads

Wind loads were determined using ASCE 7-05 for the seacoast region of Maine and New Hampshire. A force distribution was determined using ANSI, the code preceding ASCE because the current standards do not have provisions for force distribution of wind loads on open frame buildings. Snow load was neglected for the design. However, a ½ inch ice load over the entire structure was estimated as the worst case. Dead loads for the trials sections were used: hollow structural square tubing and wide flange sections. The only live loads on the structure were estimated to be caused by birds. These loads were neglected. The seismic loading on the structure was not considered because of the nature of the preliminary design. The peak horizontal accelerations for the area are approximately 15% of gravity. These loads are non catastrophic and it is safe to assume the steel frame would respond well to this level of strong ground motion.

Table 2: Loads for Steel Frame Structure

Unfactored Loads ASCE 7-05	
Wind	21.29 lb/lft
Snow	11.13 lb/lft
Dead	41.91 lb/lft
	53.00 lb/lft
Live	Negligible
Seismic	Not considered

Design Loads AISC 2-8 Load Case 4		
Wind	34.06 lb/lft	
Snow	5.57 lb/lft	
Dead	50.29 lb/lft	HSS7x7x1/2
	63.6 lb/lft	W12x53
Live	Negligible	
Seismic	Not considered	

The steel frame was designed with the LRFD method (Load & Resistance Factored Design). The highest design load was determined using Load Case 4.

Structural Analysis

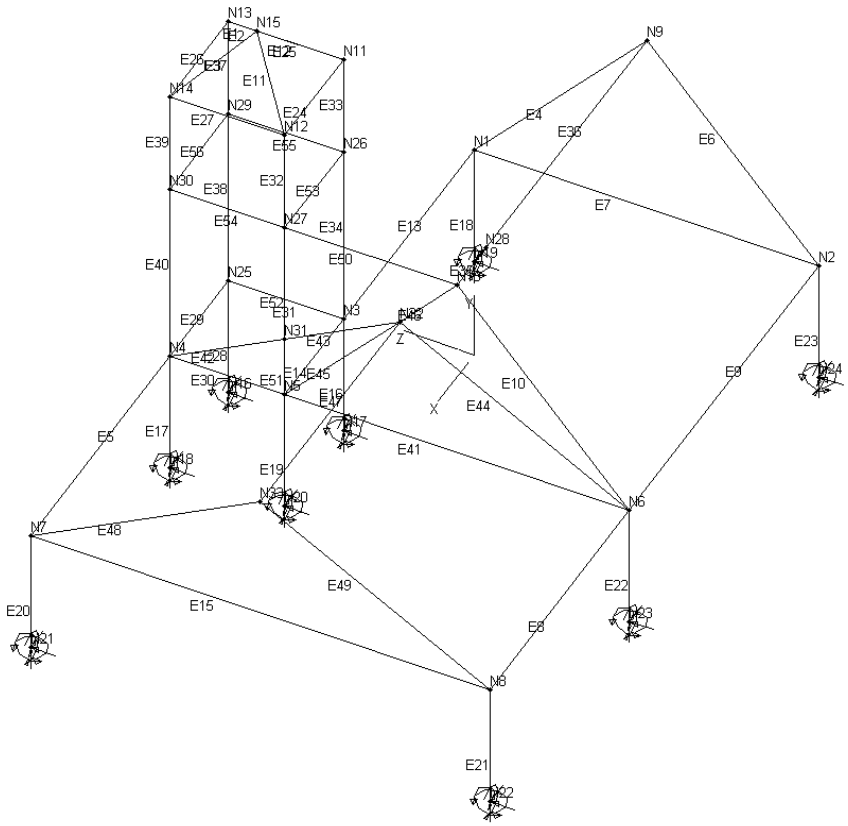

Figure 13: Frame nodes, elements, and fixities

A matrix structural analysis was performed using the program Mastan2. The analysis determined member forces and reactions under design loading of the frame. The analysis was also done to determine the deflections of the structure under maximum loading.

The frame was loaded with uniform distributions of dead and snow loads on every element. The wind analysis was more complicated due to the location and nature of the structure. ANSI stipulated that the worst case wind loads on an open steel frame would be at 10 and 45 degrees in the horizontal plane. It also stated that for analysis, full design load should be applied from one direction, and fifty percent of design load should be applied from the other direction. The purpose of this is not to overdesign the structure. The wind loads were applied as point loads at the connections as stipulated by the code.

A first order linear elastic analysis was done on the frame. The maximum deflection was 8.1 inches at the top of the structure (45 feet above ground level). This is a very large deflection for a steel frame structure. It is possible that the wind analysis is overly conservative. The current analysis may not correctly distribute the wind forces. It may not accurately consider the effects of shielding by landscape and other members. A further analysis is required to confirm that such large deflections could actually be expected on this design.

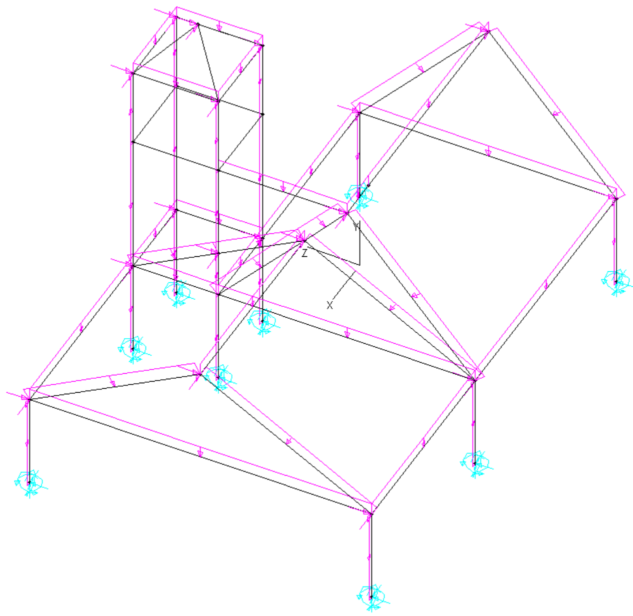

Figure 14: Steel Frame Loading Distribution

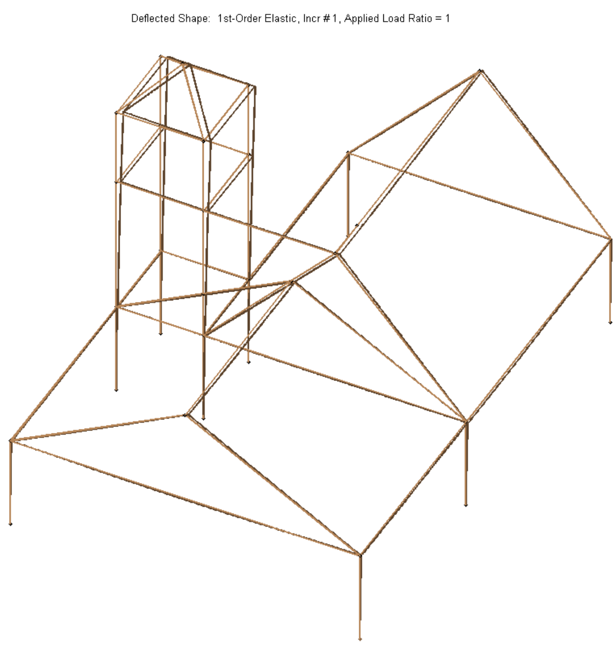

Figure 15: Deflections under Maximum Design Loading

Serviceability

Deflections

According to the American Institute of Steel Construction Manual, H/100 is the maximum permissible interstory drift for a building of height *H*. Therefore the maximum allowable drift is 5.4 inches for the top of the tower. The maximum 8.1 inch deflection estimated by the matrix analysis exceeds this design criterion. If these deflections are in fact the case, they could result in fatigue stresses in the moment connections at each joint. Over time, loading cycles could result in cracking and damage to these connections. Minimizing interstory drift reduces the effects of fatigue. If these movements are undesired or if further analysis relieves unsafe fatigue, the structure could be braced.

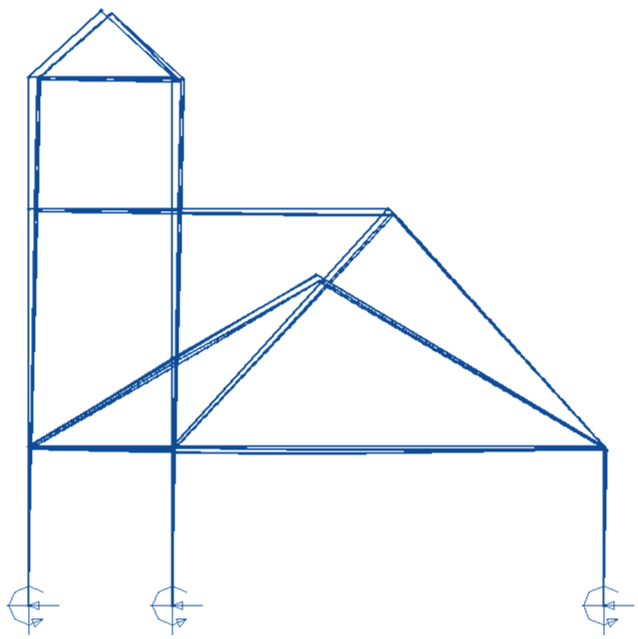

Figure 16: Lateral Deflection under Maximum Design Load

Corrosion

According to service life charts of HDG (Hot Dipped Galvanization) by the American Galvanizers Association (AGA), a 75 micron coat will protect steel structural integrity for 65 years in temperate marine conditions. A 75 micron coat, or 3.0 mils of zinc, is an average thickness. An addition 25 microns would protect the steel for an additional 20 years. These results are based on results from thousands of worldwide locations and heuristic mathematical modeling. At the end of this projected galvanizing lifecycle, red surface oxidation would affect 5% of the steel's structure. This rusty could then be removed and more zinc coating could be painted on in situ with self etching primers.

Cost Analysis

The estimated cost was found using a combination of RS Means, PE oversight, and information provided by vendors. A 25% contingency was incorporated in the analysis. This additional figure could cover transportation and staging costs to the isolated location as well as unforeseen costs. The 2009 cost for demolition of the existing building to construction of the steel frame is estimated to be $302,000.00.

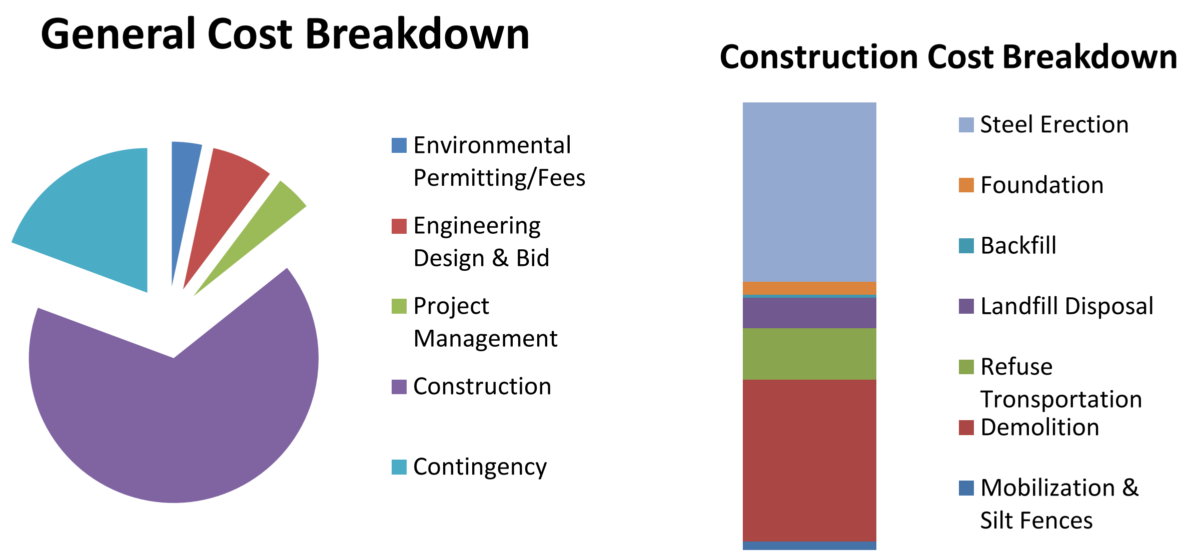

Figure 17: Steel Frame Option Cost Breakdown

Environmental Study Recommended

A study should be done on the effects of the acidity of seagulls waste on the galvanized coating prior to any construction. A demonstrative frame model of the suggested structural elements should be erected on the island. The amount of seagull waste, its chemical properties and its effect on the coated steel should be recorded. Analysis of these results will relieve if damage caused by seagull waste is serious enough to require preventive measures. Options for discouraging birds from landing on the structure include: installation of owl replicas and installation of bird deterrent surfaces along the tops of every member. Acoustic bird deterrent devices are also available on the market. An alternative to discouraging bird habitation is a maintenance program. Cleaning of the structure on a regular basis could protect the zinc coat from corrosion.

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