

### **Structural Engineering**

There are a number of reasons that a historic building might require structural engineering. Over time, a building may develop structural issues from water infiltration, settling or any number of causes. In many situations a building may have been built with structural deficiencies or changes to the building caused a deficiency. Sometimes there may even be a perception of instability because, for example, the floor is springy or the floors are sloped. A final challenge is that because many historic buildings are not constructed in ways familiar to modern code officials an engineer may be necessary to confirm that the structure can be used for a certain purpose.

Structural engineering is the field of engineering concerned with the capacity of a structure to support or resist different types of loads. There are many specializations of structural engineering so the ideal match is to find a structural engineer who not only specializes in the type of structure being considered but also has a demonstrable record of applying those principles sensitively within a historic context.

### **Guidelines for Working with a Structural Engineer**

- There are many reasons for working with a structural engineer or for a building to require engineering. Historic buildings may have been built with structural deficiencies or develop them over the years or the use of the building may require analysis of its capacity to handle the load demands.
- The preservation philosophy and approach to preservation at the site are critical for the understanding of any engineering work. The approach the organization takes at the site should dictate the repair recommendations.
- Background information is critical to understanding the issues and materials should be prepared in advance of working with the engineer
- It is critical to understand Historic New England's perception of a structural issue from an actual analysis and determination of the perceived need for structural engineering from the actual need for structural engineering. A monitoring program may help identify active movement.
- Most assessments and recommendations should focus on the capacity of the structure to handle current loads and uses as well as any future changes the organization is considering.
- There are many different techniques that can be used to investigate the structural stability or capacity of a structure. These techniques are most commonly categorized as destructive and non-destructive and it is important to be aware and involved in the process.
- It is important to make sure multiple options are thoroughly explored and discussed. Recommendations focusing on traditional repair techniques and reversibility should always be considered and given priority.
- The final product should include the appropriate number of reports and drawings. All drawings or details should be signed and stamped by the engineer.

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### Structural Engineering

#### **Technical Information on Structural Engineering**

##### **Planning a Structural Project**

*There are many reasons for working with a structural engineer or for a building to require engineering. Historic buildings may have been built with structural deficiencies or develop them over the years or the use of the building may require analysis of its capacity to handle the load demands.*

- Any question about the capacity of the structure to safely accommodate visitation of use should be investigated.
- Any change of use will certainly require load calculation provided by a preservation engineer.
- Certain state building codes require frequent or cyclical evaluations of historic house museums by structural engineers to ensure the facility can accommodate its use.

*The preservation philosophy and approach to preservation at the site are critical for the understanding of any engineering work. The approach the organization takes at the site should dictate the repair recommendations.*

- The compatibility of the engineers philosophy towards repair with Historic New England's preservation philosophy is crucial for a successful project
- There is currently no certification process for preservation engineering so emphasis when selecting an engineer should be on education, their stated approach towards preservation engineering and examples of their past work.
- Past work should demonstrate sensitivity to historic fabric and an understanding that there are no stock answers to preservation issues.
- Engineer should be familiar with local building code and exemptions available for historic buildings.

##### **Contracting for Engineering**

*Background information is critical to understanding the issues and materials should be prepared in advance of working with the engineer.*

- Floor plans and elevations
- An understanding of the history and evolution of the building
- Any images showing how the building is constructed – especially images from past construction projects
- A breakdown of the perceived issue:
  - Is it recent or long standing
  - What the concerns with the issue are
  - Any monitoring information gathered
  - Historic and contemporary images of the location or issue in question

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### Structural Engineering

*It is critical to understand Historic New England's perception of a structural issue from an actual analysis and determination of the perceived need for structural engineering from the actual need for structural engineering. A monitoring program may help identify active movement.*

- Example 1: Previous work or renovations have left the structure in a suspect condition because of missing elements or precarious looking cuts.
  - These conditions should be shared with the engineer so that they can determine if the elements are necessary or not.
- Example 2: Previous structural bracing or supports may have been installed for a purpose however if that purpose is undocumented then do not assume it is functional.
  - Structural supports and bracing have sometimes been installed because of perception rather than a need therefore an engineer has not actually calculated the load capabilities of the structure.
  - Start from square one and request the engineer to calculate the load capabilities (see above) without the bracing.
  - Often supports and bracing, specifically those installed in basements, were poorly positioned and not effectively supporting the structure as intended.
- Example 3: The floor is very bouncy, or springy. When staff or visitors enter the room the movement creates a feeling of unease.
  - These conditions should be shared with the engineer so that they can determine if the elements are necessary or not.
  - The structure might be undersized and structurally unstable and therefore repairs or other stabilization might be necessary to support normal operations.
  - The room might be structurally fine but it is only perceived as a structural issue. The decision could be made to stiffen the floor however it should be made understanding the goals and the reason one is undertaking the work.

*Most assessments and recommendations should focus on the capacity of the structure to handle current loads and uses as well as any future changes the organization is considering.*

- There are many exemptions to building code available for historic house museums. The most common is an exemption from meeting a modern standard for load capacity and allowing the engineer to dictate occupancy.
- Do not assume that the engineer will design the project around your goals if they are not clearly articulated.
  - Specifying to assess and provide repair options without discussing the organizations use of the building will not result in helpful information.
- Provide the engineer with practical information such as:
  - Currently tours of no more than 14 people use the space or the barn is used to store the landscape equipment and vehicles.
  - The organization is looking to accommodate a tour group of 15 people on the second floor
  - The organization wants to use a specific room for office space and will require 2 desks and 4 filing cabinets

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### Structural Engineering

*There are many different techniques that can be used to investigate the structural stability or capacity of a structure. These techniques are most commonly categorized as destructive and non-destructive and it is important to be aware and involved in the process.*

- Be sure the scope of work is clear in regards to method of investigative techniques to be used on the site.
- Investigation should start with non-destructive techniques however certain calculations cannot be made without access to the physical structure that may be hidden behind plaster, finished woodwork, etc.
  - Visual Inspection: if you can not access the structure visual inspection might only show the manifestation of suspected structural issues and not the actual issue.
  - Moisture meters: can be used to identify the current moisture content of wood and identify potential problem areas.
  - Resistance drilling: a recommended method for quantifying internal wood conditions. This method does require drilling into the member – a potentially destructive process. It also requires access to the member.
  - Visual grading: recommended method for determining the strength of wood members in situ.
  - Digital radiography: recommended method for identifying hidden construction details.
  - Infrared Thermography: Basic identification of the underlying structure but its value in providing detailed structural information has yet to be proven.
- Destructive techniques should not be implemented without first being approved by team leader and with staff supervising.
  - Depending on the situation it may be appropriate for staff to perform the necessary probe or removal of material.

*It is important to make sure multiple options are thoroughly explored and discussed.*

*Recommendations focusing on traditional repair techniques and reversibility should always be considered and given priority.*

- There are always multiple options to any solution and the engineer should present options representing the different levels of invasiveness and reversibility starting with the effect of doing nothing.
- The consultant should be able to articulate all the options, their pros and cons, their effect on load and a rough estimate for repair so that staff can make an educated decision.
  - It is often helpful to have a trusted contractor review the construction options in order to review the feasibility of the repair and to provide rough estimates for construction.
  - The engineer should emphasize cost effective design solutions
- Traditional repair techniques, in this context, refers to the use of repairing or replacing deteriorated components, in kind, as opposed to the addition of additional braces, supports or other stabilizing techniques.
  - Replacing an undersized beam with a larger beam is not a “traditional repair” as it is not replacing the item in kind and is making a change to the original construction.

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### Structural Engineering

- Engineered solutions to structural issues can sometimes be invasive by necessity and should be evaluated by their reversibility.
  - Reversibility, or the ability to re-treat the component in the future, should be a major part of the decision making process.
    - PPIP approval may be necessary for some solutions, specifically visible solutions.

*The final product should include the appropriate number of reports and drawings. All drawings or details should be signed and stamped by the engineer.*

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### Structural Engineering

#### Technical Specifications

The following is a draft RFP for soliciting structural engineering based on the guidelines presented in the white paper. As not all sections will be pertinent to the project this RFP should be edited for use as appropriate.

#### DRAFT Request for Proposal

##### Project Description

- A. Structural engineering is required for XXXX to determine the existing load capacity.
- B. Site Assessment
  - a. Review existing documentation on history and evolution of the structure and the history of repair. Documentation will be provided, as available, by Project Manager.
  - b. Perform site visit to inspect existing conditions of the visible structural framing.
    - i. Project Manager will be responsible for exposing the structural framing to the extent that is practical.
    - ii. Project Manager must approve any destructive investigation.
  - c. Field measure and document, including digital images keyed by location, the pertinent structural framing and connections.
  - d. Undertake structural analysis calculations to determine current load capacities as defined by PSF and occupant capacity.
  - e. Review goals of Project Manager for future occupancy and use and discuss preliminary ideas on remediation.
  - f. Prepare preliminary report of findings and recommendations for review and comment.
    - i. Engineer should provide at least two options for repair.
    - ii. Engineer should highlight recommendations that emphasize traditional repair techniques, the retention of historic materials and the reversibility of the repair.
    - iii. If repair is not required Engineer will provide documentation as required to satisfy local building department that verifies occupancy.
- C. Structural design
  - a. Prepare design repair details and specifications for the necessary work as outlined in the preliminary report and based on discussions with Project Manager.
  - b. Design details will be stamped as required for permitting and construction.
- D. Construction Monitoring
  - a. Engineer will visit site twice during work to review that repairs are according to specifications.
  - b. Engineer will provide documentation as required by the local building department that verifies occupancy.
- E. Structural Monitoring.
  - a. Engineer will develop a monitoring program appropriate for the situation.
  - b. Monitoring program, if possible, should not be dependent on the engineer for measurement.
  - c. Engineer will develop a report that outlines the goals of the monitoring program, detail the types of monitors, locations for monitoring and measurement protocols.

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### Structural Engineering

- F. All information and resources, digital and hard copy, gathered or produced for this project is the property of Historic New England and should be provided to the organization at the completion of the project.

#### **Deliverables**

- A. Before final report is considered complete a draft shall be reviewed by Historic New England for content and accuracy.
- B. Five bound hard copies of the report should be issued and one copy in PDF format.
- C. Five stamped copies of all drawings and one set in PDF format.
- D. All information and resources, digital and hard copy, gathered or produced for this project is the property of Historic New England and should be provided to the organization at the completion of the project.