Evaluating Prospective Energy Improvements to Historic Multi-Wythe Masonry Walls

APT NYC 2013
Susan L. Knack-Brown, P.E.

With rising energy performance expectations and sustainability goals, there is a growing desire to incorporate thermal insulation, air barriers, and vapor retarders in historic multi-wythe masonry walls. Despite the increasing popularity of these types of energy-related improvements to historic mass masonry walls, these changes should not be made without detailed, quantified analysis of the prospective change to assess the potential for harming the historic masonry and to determine whether the walls are the best place for this energy conservation effort.

Adding insulation to the interior of multi-wythe masonry walls is a disruptive strategy both to occupants and the historic fabric. Because it is invasive, it typically also has longer payback periods than other potential improvements (such as window improvements, adding roof insulation, insulating ducts, etc.). Before committing to this approach, designers should understand how wall improvements fit into the overall building energy strategy and the current wall construction’s thermal and air infiltration performance. Carefully executed whole building energy models, with heat flow modeling of envelope components to account for thermal bridging, can provide the designer and owner with quantifiable feedback from which to evaluate the benefits of incorporating an air barrier and insulation into the existing masonry walls. Designers may find that other energy improvement efforts might be “lower lying fruit” that could yield more significant savings and payback, at lower initial financial costs, and with lesser disruption of historic finishes.

Analyzing the benefits and payback to making energy improvements to multi-wythe masonry walls is just the first step in the process of evaluating suitability. Incorporating an air barrier, insulation, and vapor retarder within the wall system affects the hygrothermal performance of the existing mass masonry walls because these additions limit drying to the interior, and as a result, the walls stay wetter and colder for prolonged periods of time. Insulating the walls also increases the quantity of freeze-thaw cycles the masonry walls undergo during the winter because the walls are not warmed from the interior. These changes can be detrimental to the longer term performance of the wall system if materials are not freeze/thaw durable or materials are moisture sensitive.

Determining the risk of deterioration in comparison to energy performance benefits requires hygrothermal modeling to calculate the transient one-dimensional heat and moisture transport within the wall system and to determine the risk of condensation and moisture accumulation within the proposed wall assembly. Depending upon the wall construction, material testing may also be required, including testing to characterize the freeze-thaw durability and to determine the hygric material properties for model input.

As insulating inhibits drying, it is critical for successful insulation of historic masonry walls that the walls are maintained to prevent excess water entry into the wall system, including water entry through deteriorated masonry, facade projections, or adjacent building features. Successful designs limit bulk water leakage and can be reasonable maintained to prevent future water leakage, by incorporating flashings and other water management features.

Various examples and case studies (on historic stone or brick masonry walls in different states and microclimates) will highlight the steps of the design process, material testing and modeling requirements, and the design of successful energy improvements that balance the addition of insulation on multi-wythe masonry walls with the imperative to not create the conditions that would cause harm to the historic masonry. Examples of investigations of failures of insulated historic masonry walls due to excess water leakage or poor quality masonry will also be presented.
1. **PRESENTATION OUTLINE**

1. **Introduction**
   - Review of presentation outline and learning objectives
   - Brief review of sustainability trends and existing guidelines

2. **Performance Characteristics and Payback Expectations**
   - Review of thermal and energy performance of example wall systems:
     - Uninsulated masonry wall without air barrier (assume multi-wythe brick masonry)
     - Insulated masonry wall with retrofit insulation and air barrier (example systems – spray foam insulation, batt insulation with air barrier)
   - Payback expectations
     - Likely construction costs (assuming interior work only for insulation)
     - Expected energy and cost savings
     - Payback period in comparison to material durability

3. **Potential Consequences**
   - Disruption of historic materials (examples from project showing before and after of interior finish removal)
   - Hygrothermal Changes and Potential Deterioration
     - Changes in freeze/thaw cycling
     - Changes in drying patterns and potential for accumulated moisture in wall system
     - Condensation risk
     - Potential for mold
     - Examples of WUFI models (using case studies from before) and deterioration observed from projects

4. **Steps for Designing (Using example project as case study to illustrate steps)**
   - Initial assessment
   - Proposed project conditions
   - Site survey (existing deterioration, potential sources of bulk-water leakage, general quality of masonry)
   - Estimating improvements and payback
   - Material sampling (interior and exterior masonry)
   - Material testing
     - Masonry quality (ex. for brick – physical properties to grade by ASTM C216, pore characterization (porosimetry), brick maturity (firing temperature, absorption, and strength), initial moisture content)
     - Hygric material property testing (ex. for brick – density and porosity, moisture absorption, equilibrium moisture content, vapor permeability)
   - Modeling (WUFI)
   - Comprehensive façade repairs

5. **Questions**
INTRODUCTION

- Waterproofing and insulating historic buildings can present design challenges.
- Lightweight insulating concrete was used in connection with the replacement of an existing roof at a 6-story Tribeca North Historic District condominium.
- This project demonstrates how a modern material can be integrated effectively at a late 19th-century building.

BUILDING HISTORY

- Brief description of building typology
- Construction and development by Helen Juilliard for mercantile use circa 1890
- Internal joining of four through-lot buildings
- Twentieth-century use as a self-storage facility and subsequent conversion to condominium

BUILDING USE/CONVERSION AND IMPLICATIONS

- Description of loft-style apartments as typical Tribeca aesthetic
- Construction of light-metal framed penthouse on top of historic masonry building
- Creation of internal courtyard
- Construction of expansive penthouse roof deck

PROJECT IMPETUS

- Prompted by a need to address ongoing moisture infiltration at multiple locations throughout the existing polyiso-insulated roof and deck system.
- Roof-framing and drainage issues created by conversion to condominium and penthouse construction
- Description of lightweight insulating concrete
- Description of existing roof system
- Difficulties in diagnosing moisture infiltration entry points in existing roof and failure of localized repairs
- Required support for replacement roof deck without penetrations
- Code-mandated insulative values
STRUCTURAL DESIGN COMPLICATIONS

- Roof load increase – original building use versus condominium
- Structural engineering review of suitability of lightweight insulating concrete on wood-framed masonry building
- Distribution of load of penthouse roof deck without point loads
- Continuous planters

BENEFITS OF LIGHTWEIGHT INSULATING CONCRETE

- Provides average R-20 insulative value as well as other benefits
- Acoustical benefits
- Re-slope roof using stagger-stepped insulation board to provide adequate drainage

CONSTRUCTION ISSUES

- Protection of apartments below prior to demolition, use of lower membrane as temporary roof
- Maintenance of existing flashings
- Description of installation of lightweight insulative concrete via pump truck
- Concrete surface supports construction-related activities
Introduction
1. Outline typical construction practices of historic buildings in Canada, paying particular attention to the building envelope
2. Discuss energy implications of historic buildings, including energy use intensities of different building types
3. Discuss climate implications, influence of exterior temperature and moisture

Retrofit Challenges with Historic Buildings in Canada
1. Envelope durability problems, particularly with energy retrofit measures
2. Material characteristics and variances
3. Masonry damage related to the exterior environment, freeze-thaw problems

Incorporating a Vented Drying Space
1. Introduce concept and how it differs from typical retrofit approaches
2. Application in field case study
3. Discussion of field monitoring results
   a. wetting and drying cycles during the cold seasons, addressing freeze-thaw implications
   b. wetting and drying cycles during the warm seasons, addressing sun driven moisture
   c. overall moisture removal capabilities
4. Challenges encountered in project

Conclusions
1. Plans for future applications and monitoring
Climate Change: An Increasing Challenge in Stone Material Conservation

Rachel Cusimano, LEED GA, Assoc. AIA
University of Utah College of Architecture + Planning

Session CS12 Insulation and Ventilation for Historic Buildings

Session Chair: Dan M. Worth, AIA FAPT
Mentor: Norman R. Weiss, FAPT
Historic Preservation Program Director: Robert A. Young, FAPT, PE, LEED AP

Student Scholar Bio:

The field of design is ever changing in response to societal concerns, strengths, weaknesses and technologies. Therefore, it poses considerable challenges. Not only am I attracted to these unique dilemmas, I am drawn to the constant adaptation and growth. With a passion for the arts, the environment and humanitarianism, my goal in architectural design is to have a reputable impact on our society. My home town is Las Vegas, Nevada where I obtained my BS in Architecture studies. I have recently graduated with an MA degree from the University of Utah, School of Architecture, with an emphasis on historic preservation. I now currently work for Richard Meier and Partners in New York City. My approaching ambitions include licensure and practice.

Learning Objectives:

1- Understanding of the current environmental/climatic activity
2- Understanding of the changes in stone decay based on current and future climatic activity
3- Understanding of methods of measuring these changes and associated technologies

Paper Overview:

The paper includes research involving environmental/climatic activity across the globe. This section of the research is broken down into 1-pollution associated with climate change 2-chemicals/gases involved 3-expected changes. Stone material decay is introduced in the second section and should relate to the material oriented conference theme. This research involves atmospheric pollution and weathering associated with stone. The third portion of the research includes the changes in stone decay rate now and in the future associated with climatic activity. The fourth section deals with the preservation technology associated with the monitoring systems for the case study research. Some examples of the detection devices analyzed in the paper include and are not limited to a micro-erosion meter, micro-climatic sensor and surface contact temperature sensor. All case study buildings used are historically registered. Conclusions involve the need for technology and advancements in technology, the support of environmental movements associated with preservation and the long-term costs and economic concern.
Outline:

1. **Abstract**
   Introduce the problem that threats to building materials are threats to our heritage and the preservation field.

2. **Current Environmental/Climatic Activity**
   a. Pollution associated with climate change
   b. Chemicals/gases involved with subject
   c. Expected environmental changes

3. **Introduction to Stone Decay**
   a. Results of atmospheric pollution
   b. Atmospheric pollution
      i. Sulfur dioxide
      ii. Blackening, peeling & crust formation
   c. Results of weathering
      i. Sun damage/radiation
      ii. Wind damage
      iii. Water damage
      iv. Contact with moist soil

4. **Changes in Stone Decay**
   a. Present changes
      i. Chemical
      ii. Holistic effects
      iii. Damages
      iv. Repairs
   b. Future changes
      i. Green-house gases
      ii. Color variations
      iii. Organisms

5. **Mitigation efforts: Measurement Technology**
   a. Case Study
      i. St. Paul’s Cathedral; Sir Christopher Wren; 1710

6. **Conclusions**
   a. Environmental support
   b. Technological needs
   c. Long term costs and economic concern