WHOLE HOUSE CONSIDERATIONS
WHY TODAY'S DECISIONS COMPOUND TOMORROW'S PROBLEMS

Robert Cagnetta, Heritage Restoration, Inc.

Historic buildings are each uniquely built, used, and worn. Property owners, designers, and builders manipulate and upgrade in their own way, where structures evolve and become their own. How we intervene in historic buildings needs to be individually assessed and individually remedied, using a diversity of professional input, so the best solutions are developed. The level of craftsmanship, maintenance, and quality of materials determine the longevity of a building, and many historic buildings have survived the true test of hundreds of years of operation. Modern materials and technologies each have their specific applications, where their application solely depends on the nature of the retrofit, reversibility, and long-term effectiveness. This article reviews and evaluates existing building dynamics, air-flow and moisture, insulation, efficiency retrofits, window and door restoration and replacements, liquid "permanent" coating and synthetic materials, and how they all apply to historic buildings.

Air Flow and Insulation
Historic homes have their own dynamic of airflow and moisture migration. Compounding issues of direct water and air infiltration, as well as a lack of properly designed air and moisture escape routes, make insulation retrofits challenging and potentially hazardous. Various types of insulation each have their advantages and disadvantages in their efficiency as well as their potential for reversibility. Increased efficiency of a house can be achieved through systematic retrofits, where the impact to the building's design and aesthetics can be minimal, and the energy savings and pay back maximized.

A house's envelope is designed to protect the occupants from the elements; each layer provides a specific function. The siding protects the frame. The sheathing makes the frame rigid and holds on the siding. The plaster and trim provide an air seal and clean finish for the interior of the house. Each component has an inherent r-value, or measured heat transfer, that resists the amount of heat loss and gain for the interior. Although when air freely migrates through these elements, it brings in moisture and makes the envelope lose or gain heat. The goal of installing insulation is to reduce the heat transfer. Yet insulation's efficiency becomes compromised with the movement of air, where trapped moisture conducts greater heat transfer and can cause mold and exterior paint failure. To ensure a proper insulation retrofit, a house must first be analyzed for excessive moisture and airflow. Issues such as loose siding, failed flashings, and excessive airflow must be mitigated prior to an insulation retrofit.

Many older homes lack an integrally designed air and moisture escape route, relying on cracks and leaks to exchange air. This air exchange allows a house to expel generated interior moisture, exhaust gases, and enable the building frame to dry out or stay dry.

When considering types of insulation, the primary concerns are:

- The building's overall health
- A planned air and moisture escape route
- Accessibility
- Reversibility
- Effectiveness

Existing conditions and accessibility are primary factors in choosing the type of insulation.[1] The most effective and responsible building efficiency solution is to seal air leaks. Exterior siding, trim and fenestration repairs, and storm windows and doors

[1] A great source for the types of insulation on the market today can be found at the U.S. Department of Energy's website: *http://www.energysavers.gov/your_home/insulation_airsealing/index.cfm/mytopic=11510*

can enhance comfort and keep a building healthy. Once the air seal is complete, the attic is the next place to start, then basements, and then walls. Too many buildings have their walls completed first, where airflow and moisture infiltration continues to cause significant reductions in efficiency and potential serious rot and mold damage.

Projects that reduce or eliminate airflow and moisture migration can seem "unproductive" without visible results, yet they are the essential factor towards a proper insulation retrofit. The walls of a house are typically where occupants feel air flow, so the natural reaction is to fill it. Windows suffer the same finger pointing. The industry created the least-effective solutions of fill and replace, with the reasoning that the most cost-effective solution is the best.

Rigid insulation cut to fit can be used where reversibility is a consideration
Photo courtesy of the author.

All building components and materials have a finite life cycle. All insulation will eventually lose its efficiency or become ineffective through settling, mold, moisture, vermin, or removal by remodeling. Careful consideration must be made toward the project's methodology, longevity and use. Avoid irreversible spray foams, significant changes to the building's air flow and moisture escape routes, and removing historically significant building components for the sake of improving a building's efficiency. Alternate methods of achieving greater efficiency, such as storm windows, reducing air flow, or reversible attic and basement insulation can be more effective. Emphasis should be on air sealing first, then insulation in the attic, basement, and finally walls.

Weather Stripping, Storm Doors and Windows

Air loss is a significant factor to a building's heat loss, where efficiency starts by reducing airflow. Adding storm windows, storm doors, and weather stripping improves air tightness and creates dead air spaces that increase r-values. Storm doors and windows provide a cost-effective, energy-efficient sacrificial layer. Single-glazed or drafty insulated units can be significantly improved by the addition of a storm unit. Storm door and window units are manufactured primarily from wood, aluminum, or fiberglass, while their applications and operations will vary.

A Blower Door Test can determine a house's air loss and overall efficiency.
Photo courtesy of the author.

Every building has different levels of air loss, regardless of age, style and quality of construction. According to the US Department of Energy, "air sealing is one of the most significant energy efficiency improvements you can make to your home. Air sealing will not just reduce energy costs; it will also improve your home's comfort and durability." For instance, a $^{1}/_{8}$" gap around a door is a 5" square hole in a wall. A first step is determining the level of air loss and its source(s) is through a blower door test. A proper air sealing strategy can be then be developed. Although with any tightening, a proper air and moisture escape plan may be required, depending on how tight a building becomes.

Storm windows and doors are designed to trap air and increase efficiency. The goal should be to install a unit that operates smoothly, yet has sufficient air sealing methods. Units should have low maximum air-leakage standards and be adjustable for proper conformity to out-of-square openings. Storm windows can be interior or exterior. Interior storm win-

An ineffective storm window installation, allowing excessive air to move through the joints
Photo courtesy of the author.

dows are efficient, since they trap air that comes through the window sashes and the frame, although they make the sash vulnerable to the elements and can cause condensation on the interior of the primary window. Exterior storm windows protect primary sash, can be fixed or on tracks, and can be made from wood, aluminum or fiberglass. Exterior, single-purpose wood storm windows are historically appropriate, although they provide only adequate air sealing and require maintenance. Other options include wood frames with removable glass and screens or wood with aluminum tracks.

Window Restoration and Window Replacement

Restoring, repairing, and weatherstripping existing historic wood windows in combination with the installation of storm windows is the best possible option with regards to authenticity and integrity, repairability, quality, and sustainability. This option will also match the purported energy savings of replacement windows in most cases. However, if replacement is the only option, careful evaluation in needed.

Window replacement inserts (where the window frame is left in place) and replacement assemblies (where the entire frame and sash are replaced) are not all created equal. Window replacements range in cost, quality of construction, and materials, types of finishes, as well as a wide range of balance systems. Selecting window replacements should be based on several important factors, including the longevity, assembly and efficiency. The most important factors in the efficiency of replacement windows are the building's existing conditions and the ability of the old window opening to be properly retrofitted.

The general rule of thumb is you get what you pay for. Replacements should come from a reputable manufacturer with a history. Manufacturer's references for units ten years or more can provide a good litmus test for a unit's ability to be long lasting and efficient. Most replacements cannot be easily repaired and replacement parts are difficult to source. Broken strings and springs require new balances. Broken glass or failed seals requires new sash. Excessive over painting can bind or make units inoperable. Higher-quality windows have warrantees of about 20 years on materials and parts and ten years on labor, and can last for 50 years with proper maintenance and protection. Yet 30% of insulated replacement windows last only about ten years.[2]

The type of replacement window depends on the energy performance of the entire building and expected final aesthetic. The efficiency of replacement window inserts relies on a tight fit, using weather seals and compression for reducing airflow. Yet, modern windows are vulnerable to deterioration since they have a single layer of protection from the elements. Most windows from the mid-19th century forward had protection from shutters and mass-produced storm windows, and continue to survive today. Direct exposure of modern windows makes all products especially vulnerable to environmental variations and abuse. While most replacement windows claim to reduce energy costs, the final analysis largely depends on the extent of air loss from the entire building envelope, not just the windows. If a building is already airtight and the windows *deteriorated beyond repair,* then choose the highest energy upgrades. If the building is loose, don't waste money.

[1] Donald Rypkema, *Economics, Sustainability, and Historic Preservation,* National Trust for Historic Preservation Conference, Portland, OR, 10/1/05.

The materials used to make the window and the method in which the windows are assembled must be of high quality. The American Architectural Manufacturers Association (AAMA) has developed stringent standards where participating manufacturers can apply labels to their windows (*http://www.aamanet.org/*). Also, the National Fenestration Rating Council (NFRC) administers a uniform, independent rating and labeling system for the energy performance of windows, doors, skylights, and attachment products (*http://www.nfrc.org/*).

Existing conditions determine a window replacement's final efficiency and longevity. A building's total air loss and the degree to which windows contribute to that must be ascertained. Another critical consideration is that certain historic window frames do not retrofit well, requiring significant, irreversible alterations for standard thickness units to fit. If the existing opening is racked, bowed, rotting, or out of level within 1/8", the unit will not perform to the factory tested efficiency standards. Also, develop a cost-benefit analysis, since replacement windows can take anywhere from 20-45 years for savings to pay for their costs.

Liquid Siding & Permanent Coatings

There is no such thing as "permanent" anything on an historic building, where most exposed components eventually fail. It is up to the property owner to determine the best course to protect and maintain a building, considering longevity, reversibility and, especially, removing historic components of a building and replacing with new, irreversible products.

Liquid siding (a spray-on coating of resins and polymers) or permanent coatings do not consider a building's life cycle or natural breathing. For centuries, buildings were built and maintained with products that react with moisture and environmental fluctuations and allow alterations or removal of building components for repair. For the past 30 years, products and techniques have been marketed to make reversibility more challenging. Epoxies, ring-shank nails, screws, adhesives and engineered coatings were designed to enhance performance and speed up the building assembly. Yet theses products can be inappropriately applied to historic buildings or applied without consideration of how they will be removed. Owners of historic buildings should seriously consider the reversibility of new treatments and the performance of new products.

Traditional and modern paint finishes fail or wear. They fail from application errors, excessive build-up of finishes, external environmental causes, interior migrating moisture, or direct water infiltration. Finishes reveal problems from failed flashing, poor building envelopes, or rot. Liquid siding or permanent coatings seal envelopes, and despite claims of "breathing," they do not allow excessive moisture to migrate through wood, where it becomes trapped.

The proper use of these building products, which do not need to expel water or migrate moisture, is on metal or in areas where reversibility is not an issue. Wood products are exposed to water, air, and ultra-violet rays, causing expansion and contraction between dissimilar or opposing materials. These areas will always need to expel moisture trapped behind them. Dissimilar or opposing grain products will need to move independently, causing cracks and water infiltration. Permanent finishes do not allow the building to age, are not easily reversible, have not been tested over many decades, and should be used sparingly.

Synthetic Building Products

Synthetic building products have emerged in the market over the last few decades. Depleting resources and lesser-quality wood products have encouraged their mass

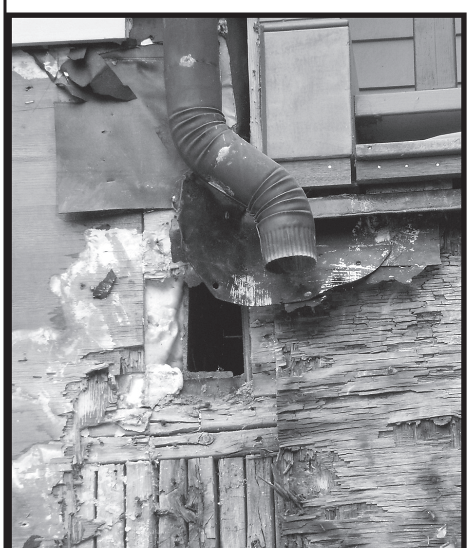
production and use. The use of alternative synthetic building products in historic buildings should be limited, especially where existing original fabric has proven quality and longevity. While "in-kind" limits product selection, there may be instances where alternatives can be properly implemented.

Synthetic building products provide alternatives to traditional wood products. The product materials range from vinyl, to wood pulp and resins, to plastics, to PVC. Many synthetic products provide cost effective alternatives to wood, saving diminishing timber resources by reusing manufacturing waste or recycled materials or by just getting more product from the same source.

Modern synthetic products, plywood, building wraps, peel-and-stick membranes, and sealants can be effective layers of a controlled building envelope. Yet historic and existing buildings are made from solid wood components that require significant expansion and contraction, airflow, and basic breathability. Applying a synthetic material over a wood product can create a situation where components cannot "fail together," thus trapping moisture and concealing underlying water damage, rot, infestation or mold. When a building envelope cannot be layered with the components working together, and water and air are not properly mitigated, synthetic products can trap moisture and mask problems that lie beneath.

Above: *4. Synthetic siding showing some evidence of water infiltration.*

Below: *Trapped moisture behind the synthetic siding rotted the framing and sheathing significantly faster than the siding.*
Photos courtesy of the author.



Moisture, sun, and air are the demise of most wooden building components. Wood, being an organic material, is subject to degradation when alternating wet and dry conditions are present. A general rule of thumb is to keep all wood materials 18" from grade to prevent rot and decay from mold and fungus. Although when it is not possible, alternative synthetic products may be used, such on stair kicks, low mud boards or ground-contact conditions. Otherwise, in-kind wood-to-wood should be used, considering the quality of the wood grain, rot resistance, and back priming.

Conclusion

Historic buildings are each unique. They wear, react to their environment, and are manipulated. Historic building last for a variety reasons: they were well crafted, well maintained, or just plain lucky. Best practices, quality materials, and reversible techniques should honor well-built structures. Design intent, original fabric, and character acquired over time should be recognized through careful analysis and responsible retrofits, where the goal should be to do no harm first, then develop solutions for modern needs.

Robert Cagnetta is the principal of Heritage Restoration, Inc. in Providence, RI, specializing in the care and retrofits of existing and historic buildings. Rob is the current President of the Preservation Trades Network, and sits on various committees and boards that enhance our built environment and provide educational opportunities to professionals, homeowners and our rising, future traditional craftspeople. Rob can be reached at rob@heritagerestoration.net.