

# 3 PRESERVATION BRIEFS

## Improving Energy Efficiency in Historic Buildings

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The concept of energy conservation in buildings is not new. Throughout history building owners have dealt with changing fuel supplies and the need for efficient use of these fuels. Gone are the days of the cheap and abundant energy of the 1950's. Today with energy resources being depleted and the concern over the effect of greenhouse gases on climate change, owners of historic buildings are seeking ways to make their buildings more energy efficient. These concerns are key components of sustainability — a term that generally refers to the ability to maintain the environmental, social, and economic needs for human existence. The topic of sustainable or “green” building practices is too broad to cover in this brief. Rather, this preservation brief is intended to help property owners, preservation professionals, and stewards of historic buildings make informed decisions when considering energy efficiency improvements to historic buildings.

Sound energy improvement measures must take into consideration not only potential energy savings, but also the protection of the historic property's materials and features. This guidance is provided in accordance with the Secretary of the Interior's Standards for Rehabilitation to ensure that the architectural integrity of the historic property is preserved. Achieving a successful retrofit project must balance the goals of energy efficiency with the least impact to the historic building. Planning must entail a holistic approach that considers the entire building envelope, its systems and components, its site and environment, and a careful evaluation of the effects of the measures undertaken. Treatments common to new construction need to be evaluated carefully before implementing them in historic buildings in order to avoid inappropriate alteration of important architectural features and irreparable damage to historic building materials. This brief targets primarily small-to medium-size historic buildings, both residential and commercial. However, the general decision-making principles outlined here apply to buildings of any size and complexity.

### Inherent Energy Efficient Features of Historic Buildings

Before implementing any energy conservation measures, the existing energy-efficient characteristics of a historic building should be assessed. Buildings are more than the sum of their individual components. The design, materials, type of construction, size, shape, site orientation, surrounding landscape, and climate all play a role in how buildings perform. Historic building construction methods and materials often maximized natural sources of heat, light and ventilation to respond to local climatic conditions. The key to a successful rehabilitation project is to understand and identify the existing energy-efficient aspects of the historic building and how they function, as well as to understand and identify its character-defining features to ensure they are preserved. Whether rehabilitated for a new or continuing use, it is important to utilize the historic building's inherent sustainable qualities as they were intended to ensure that they function effectively together with any new treatments added to further improve energy efficiency.

#### Windows, courtyards, and light wells

Operable windows, interior courtyards, clerestories, skylights, rooftop ventilators, cupolas, and other features that provide natural ventilation and light can reduce energy consumption. Whenever these devices can be used to provide natural ventilation and light, they save energy by reducing the need to use mechanical systems and interior artificial lighting.

Historically, builders dealt with the potential heat loss and gain from windows in a variety of ways depending on the climate. In cold climates where winter heat loss from buildings was the primary consideration before mechanical systems were introduced, windows were limited to those necessary for adequate light and ventilation. In historic buildings where the ratio of glass



*Fig. 1. A decorative, stained glass skylight allows natural daylight into the interior.*

to wall is less than 20%, the potential heat loss through the windows is likely minimal; consequently, they are more energy efficient than most recent construction. In hot climates, numerous windows provided valuable ventilation, while features such as wide roof overhangs, awnings, interior or exterior shutters, venetian blinds, shades, curtains and drapes significantly reduced heat gain through the windows. Historic windows can play an important role in the efficient operation of a building and should be retained.



*Fig. 2. Upper and lower shutters control daylight and provide privacy.*

New architectural styles, beginning with the International Style of the 1920's, brought about an increase in the percentage of glazing in the total building envelope. By the 1950's, with the advent of the glass curtain wall, glazing constituted nearly 100% of a building's exterior walls in many buildings. While many early modern buildings continued to use operable windows as a way to provide natural ventilation, greater reliance on mechanical heating and air conditioning systems eventually reduced the function of exterior glazing to providing light only, particularly in commercial, office, and institutional buildings.



*Fig. 3. Stone walls with substantial mass have high thermal inertia.*

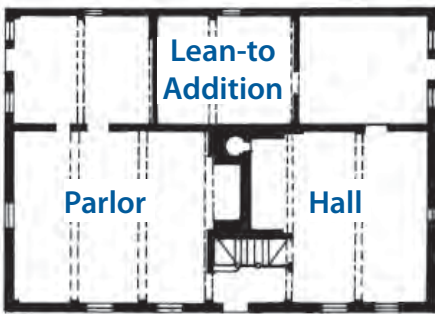
### Walls

Thick masonry walls typical of the late-nineteenth and early-twentieth centuries have inherent thermal characteristics that keep the buildings cooler in the summer and warmer in the winter. Walls with substantial mass have the advantage of high thermal inertia, which reduces the rate of heat transfer through the wall. For instance, a wall with high thermal inertia, subjected to solar radiation for an hour, will absorb the heat at its outside surface, but slowly transfer it to the interior over a period as long as six hours. Conversely, a wall having the equivalent thermal resistance (R-value), but a substantially lower thermal inertia, will transfer the heat in perhaps as little as two hours. Heavy masonry walls also reduce the need for summer cooling. High thermal inertia is the reason many older public and commercial buildings without air conditioning still feel cool during the summer. The heat from the midday sun does not penetrate the buildings until late afternoon and evening, when it is less likely to be occupied or when exterior temperatures have fallen. Heavy masonry walls are also effective in moderating internal temperatures in the winter by dampening the overall peaks of heat gain and loss resulting in a flatter and more tolerable daily cycle. In areas that require cooling during the day and heating at night, masonry walls can help spread out excess heat gain from the day to cover some of the needed heating for the evening and night hours.

### Roofs

Roof construction and design in historic buildings, particularly vernacular buildings, are strongly

influenced by the conditions of the local climate. Wide overhangs that sometimes extend to create porches minimize the heat gain from the sun in warmer climates, while steep, sloping roofs with minimal or no overhang prevail in colder climates to allow for shedding snow and increasing beneficial solar heat gain through the windows. Materials and color also influence the thermal performance of roofs. Metal and light colored roofs, for example, reflect sunlight and thereby reduce the heat gain from solar radiation.



*Fig. 4. A typical New England saltbox features a steeply sloping roof to shed snow and a floor plan organized around a central chimney to conserve heat.*

### Floor Plans

The floor plan of many historic buildings, particularly traditional vernacular ones, was also designed to respond to the local climate. In cold climates, rooms with low ceilings were clustered around central chimneys to share the heat, while small windows with interior shutters reduced drafts and heat loss. In warmer climates, wide central halls with tall ceilings, breezeways, and large porches all maximized air circulation.

### Landscape

Site orientation was another factor considered especially in the location of a historic building on its property. In cold climates, buildings were oriented against northern winds while buildings in warm climates were sited to take advantage of prevailing breezes. Evergreen trees planted on the north side of buildings shielded from winter winds; deciduous trees planted to the south provided summer shade and maximum sun in the winter.



*Fig. 5. The side porches of this house in Charleston, SC, shade the large windows and provide outdoor living spaces that take advantage of sea breezes.*

## Energy Audit

Before implementing any measures to improve the thermal performance of a historic building, an energy audit should be undertaken to evaluate the current energy use of the building and identify deficiencies in the building envelope or mechanical systems. In some areas, the local utility company may offer a free simple audit, however a more in-depth audit should be obtained from a professional energy auditor. The goal of the audit is to establish a baseline of building performance data to serve as a reference point when evaluating the effectiveness of future energy improvements. It is important to hire an independent auditor who does not have financial interests in the results, such as a product vendor.

An energy auditor first documents the current energy use patterns in the building to establish an energy use history. This initial step includes obtaining the billing history from the local utility company over a one- or two-year period, as well as documenting the number of building occupants, how the building is used, and the type of fuel consumed. The location of any existing insulation is recorded and the approximate R-value of various components of the building envelope including walls, ceilings, floors, doors, windows and skylights is calculated. The building envelope is inspected to identify areas of air infiltration and air loss. The type and age of mechanical systems and major appliances are also recorded.

Tools such as a blower door test or infrared thermography are useful to identify specific areas of infiltration, lack of insulation and thermal bridging. Mechanical depressurization along with infrared thermography is extremely useful in identifying locations of air leakage and heat loss followed by the use of tracer smoke to isolate specific air leaks. These tests are often challenging to perform on buildings and must be undertaken by experienced professionals to avoid

misleading or inaccurate results. There are professional standards for audits, those of the Building Performance Institute (BPI) being the most widely used.

The energy auditor then produces a detailed report that documents the findings of the audit and includes specific recommendations for upgrades such as air sealing, adding insulation, general repairs, lighting, and improvements to or replacement of mechanical systems or major appliances. Cost estimates are provided for each of the improvements including the cost of implementation, potential operating cost savings, and, importantly, the anticipated payback period. Armed with this information, historic building owners can start to make informed decisions on how to improve the performance of their buildings. Usually the auditor finds a few locations where there is major air leakage; large “holes” that are unique to a particular building and require equipment to find them. These anomalies are often invisible to the people who use the building on a regular basis. It is important to retest the performance of the building following the implementation of any upgrades undertaken as a result of an energy audit to ensure that the upgrades are performing as expected.

### Prioritizing Energy Upgrades

When implementing energy upgrades, efforts should be concentrated on improvements that will provide the most payback for the money expended and the least compromise to the historic character of the building. Some upgrades recommended in energy audits may not be introduced into a historic building feasibly without damaging historic fabric or altering the appearance of significant features. Removing historic siding and replacing it with new siding to introduce insulation

into the wall cavity of a frame building or replacing repairable historic windows are examples of treatments that should not be undertaken on historic buildings.

A common misconception is that replacing windows alone will result in major energy savings. This argument, often used to sell replacement windows, is simply not true. Although it varies from building to building, the U.S. Department of Energy (DOE) has documented that air loss attributable to windows in most buildings is only about 10% of the total air loss. Studies have shown that window replacement does not pay for itself in energy savings in a reasonable length of time. Moreover, there are ways to improve the performance of historic windows that do not require their replacement. In addition, historic windows can usually be repaired and are, thus, sustainable, while most new windows cannot be repaired, or even recycled, and may wind up in landfills.

When considering energy upgrades, it is imperative to get a clear picture of what an improvement will cost initially and how long it will take to pay back the cost in energy savings. Therefore, the life cycle cost of the improvement must be considered as well as its impact on historic fabric. Reducing infiltration around existing windows and doors, sealing penetrations in the building envelope, and adding insulation — particularly in the attic where it has little impact on historic fabric — can result in significant improvements at relatively little cost. Updating mechanical systems or changing the way in which they are operated can also be cost-effective interventions. For example, installing a more efficient mechanical system alone may pay for itself in ten years.



Fig. 6. (left) A blower door is used to depressurize a building by exhausting air at a rate that allows pressure gages and tracer smoke to measure the amount and location of air leakage. Photo: Robert Cagnetta, Heritage Restoration, Inc.



Fig. 7. (center and right) The left thermal image shows the walls of this building before insulating. After insulation was added, the cooler and, thus darker exterior walls evidence how much the heat loss has been reduced. Photos: EYP Architecture & Engineering.

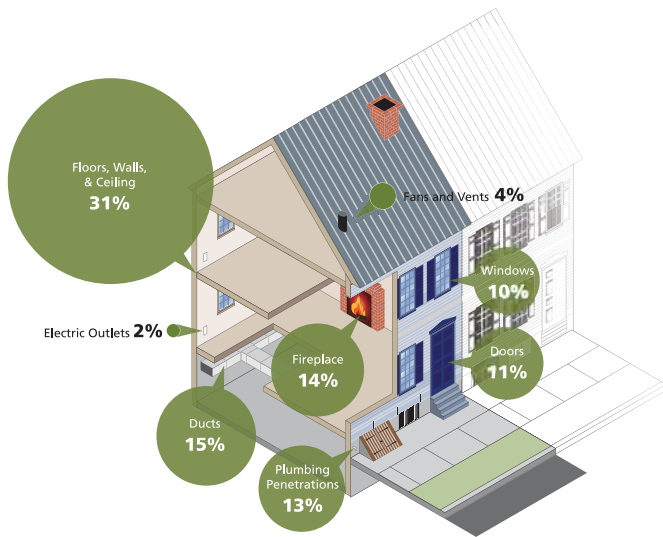


Fig. 8. *Where Air Escapes From a House (by percentage)* – Image based on data from *Energy Savers*, U.S. Department of Energy. Illustration: Blank Space LLC.

## Actions to Improve Energy Efficiency

Reducing energy demands for heating and cooling may be accomplished in two steps. First, implement operational changes and upgrades to mechanical systems and major appliances — measures that do not require making alterations or adding new materials — to ensure that a building functions as efficiently as possible. After all these measures have been implemented, corrective work or treatments, such as weatherization, that require other alterations to the building may be considered.

### Residential Energy Use Intensity by Age

Year Built	KBtu/sq ft/yr
Prior to 1950	74.5
1950 to 1969	66.0
1970 to 1979	59.4
1980 to 1989	51.9
1990 to 1999	48.2
2000 to 2005	44.7

Source: Residential Energy Consumption Survey, 2005

### Establishing Realistic Goals

Energy consumption data gathered by the U.S. Energy Information Administration (see chart) shows that residential buildings built before 1950 (the largest percentage of historic building stock) are about 30 to 40 percent less energy efficient than buildings built after 2000. Using this as a baseline, a 30 to 40 percent upgrade of a historic building's energy performance can be a realistic goal. A 40 percent increase in energy efficiency would of course be a more achievable goal for buildings that have had minimal upgrades since their

original construction, i.e., added insulation, tightening of the exterior envelope, or more efficient mechanical equipment. On the other hand, achieving “net zero” energy goals as it is currently done with some new construction can be a much more difficult challenge to achieve in a historic retrofit. Attempting to reach such a goal with a historic building would most likely result in significant alterations and loss of historic materials. [The data for commercial buildings documents that buildings in 2003 used approximately the same energy as they did before 1920, after reaching their peak in the 1980's.]

### Operational Changes

One of the greatest effects on energy use is user behavior. Once an energy audit has established a baseline for the current energy use in a building, operational changes should be identified to control how and when the building is used to minimize the use of energy-consuming equipment. These changes can range from simple measures such as regular cleaning and maintenance of mechanical equipment to installing sophisticated controls that cycle equipment on and off in specified intervals for maximum performance. The following changes are recommended to reduce heating and cooling costs.

- Install programmable thermostats.
- Close off rooms that are not in use and adjust the temperature in those rooms.
- Do not condition rooms that do not need to be conditioned, thereby reducing the thermal envelope.
- Use insulated shades and curtains to control heat gain and loss through windows.
- Use operable windows, shutters, awnings and vents as originally intended to control temperature and ventilation.
- Take advantage of natural light.
- Install compact fluorescent lights (CFL) and light-emitting diode (LED) lights.
- Install motion sensors and timers for lighting and local ventilation, such as bathroom exhaust fans.
- Reduce “phantom” electricity loads by turning equipment off when not in use.
- Clean and service mechanical equipment regularly.

These measures should be undertaken first to save energy in any existing building and are particularly appropriate for historic buildings because they do not require alterations to historic materials.

### Upgrading Equipment and Appliances

In addition to maximizing the energy efficiency of existing building systems, substantial savings can be achieved through upgrading equipment and appliances. One should still weigh the operational savings against the initial cost of the new equipment, particularly if the existing equipment is not near the end of its life.

Calculator aids that take into account the efficiency of both the existing and new equipment are available



Fig. 9. An energy auditor tests the efficiency of a boiler.

online to assist in determining the payback. Advance planning will allow time to find the most efficient unit, as well as to investigate the availability of any state and federal energy credits. As energy prices continue to rise and technology advances, options such as the installation of a solar hot water heater or geothermal ground source or water source heat pumps are becoming more economically feasible. Recommendations for upgrading equipment and appliances include:

- Upgrade the heating system. It is important to install new furnaces that utilize outside combustion air to reduce air drawn into the building through uncontrolled infiltration. [All furnaces and boilers are now measured by their annual fuel utilization efficiency or AFUE.] Heating equipment is now more efficient and gas furnaces that used to have a 60% (AFUE) rating can now operate at as much as 90 to 97% efficiency.
- Upgrade the air conditioning system.
- Replace the water heater. High-efficiency water heaters use far less energy than earlier models, and high-efficiency tankless water heaters heat water on demand and offer even greater savings. Point of use water heat can also reduce costs and water consumption by reducing the time it takes to draw hot water.
- Upgrade appliances. Energy Star appliances, particularly refrigerators, washing machines and dishwashers can all reduce electricity use and additional indoor heating loads.

### Upgrading Building Components

In addition to operational and mechanical upgrades, it can be possible to upgrade many building components in a manner that will not jeopardize the historic character of the building and can be accomplished at a reasonable cost. The goal of these upgrades is to improve the thermal performance of the building, resulting in even greater energy savings. Retrofit measures to historic buildings should be limited to those that achieve at least reasonable energy savings, at reasonable costs, with the least impact on the character of the building.

The following list includes the most common measures proposed to improve the thermal performance of an existing building; some measures are highly recommended for historic buildings, but others are less beneficial, and can even be harmful to a historic building.

#### Requires Minimal Alteration

- Reduce air leakage.
- Add attic insulation.
- Install storm windows.
- Insulate basements and crawlspaces.
- Seal and insulate ducts and pipes.
- Weather strip doors and add storm doors.
- Add awnings and shading devices where appropriate.

#### Requires More Alteration

- Add interior vestibules.
- Replace windows.
- Add insulation to wood-frame walls.
- Add insulation to masonry walls.
- Install cool roofs and green roofs.

The treatments listed first have less potential to negatively impact the historic fabric of a building. They tend to be less intrusive, are often reversible, and offer the highest potential for energy savings. Undertaking any of the treatments in the second group, however, may pose technical problems and damage to historic building materials and architectural features. Their installation costs may also outweigh the anticipated energy savings and must be evaluated on a case-by-case basis with advice from professionals experienced in historic preservation and building performance.

#### Requires Minimal Alteration

**Reduce air leakage.** Reducing air leakage (infiltration and exfiltration) should be the first priority of a preservation retrofit plan. Leakage of air into a building can account for 5 to 40 percent of space-conditioning costs, which can be one of the largest operational costs for buildings.<sup>1</sup> In addition, unwanted air leakage into and out of the building can lead to occupant comfort issues resulting from drafts. Air infiltration can be especially problematic in historic buildings because it is closely linked to increased moisture movement into building systems.

Air flow into and out of buildings is driven by three primary forces: wind pressure, mechanical pressure and the stack effect. Cold outside air that infiltrates the building through big holes, as well as through loose windows, doors, and cracks in the outer shell of the building, causes the heating system to work harder and consume more energy. In a multi-story building, cold air that enters the building at lower levels, including the basement or crawlspace, will travel up through the building and exit out leaky windows, gaps around windows and the attic as a result of temperature and pressure differential. This pattern of air movement

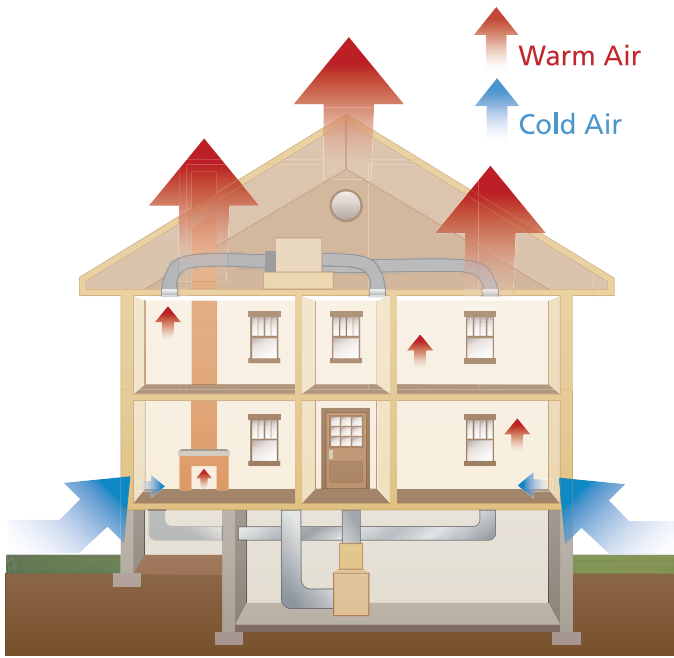


Fig. 10. The pattern of air movement referred to as the “stack effect”.  
Illustration: Blank Space LLC.

is called the “stack effect.” Not only is valuable conditioned air lost, but damaging moisture may also enter the wall cavities and attic spaces. To stop the stack effect, the top and bottom of the exterior walls, inter-floor bypasses, and any existing chases or shafts must be sealed, or “draft proofed.” The use of spray foam sealants in basement and attic cracks is a particularly useful technique for reducing air infiltration.

Adding weatherstripping to doors and windows, sealing open cracks and joints at the base of walls and around windows and doors, sealing off recessed lighting fixtures from above, and sealing the intersection of walls and attic, will substantially reduce air leakage. When using exterior caulk to seal the intersection of siding and doors or windows, do not caulk the underside of clapboards or below windows to allow any liquid water to escape. When infiltration and, consequently, exfiltration are reduced, mechanical ventilation may be necessary to meet occupants’ requirements for fresh air.

**Add attic or roof insulation.** Heat loss and gain caused by increased interior/ exterior temperature differentials primarily due to the stack effect and solar radiation are greatest at the top of a building. Therefore, reducing heat transfer through the roof or attic should be one of the highest priorities in reducing energy consumption. Adding insulation in unoccupied, unfinished attics is not only very effective from an energy-savings perspective, but it is also generally simple to install and causes minimal disruption to historic materials. The U.S. Department of Energy (DOE) provides a recommended R-value chart based on climate zones to help determine the optimal amount of insulation that should be installed in a particular project. Local codes may also have specific insulation requirements. Insulating trap or access doors should not be overlooked. Even though they may be

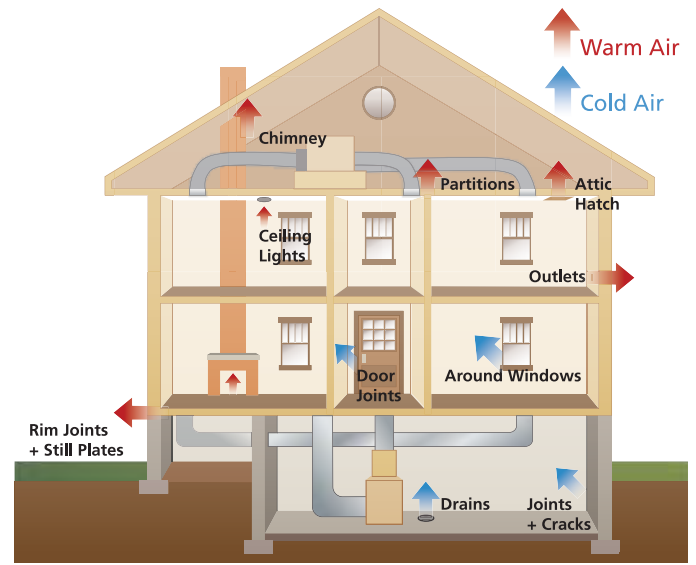


Fig. 11. Air infiltration and exfiltration.  
Illustration: Blank Space LLC.

small, attic doors can be responsible for substantial heat loss and should be addressed as part of any attic insulation project.

### DOE Climate Zone Map

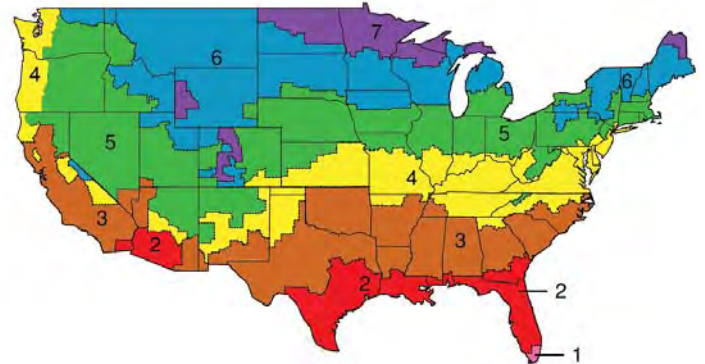


Fig. 12. Recommended energy improvements vary widely based on climate. The information contained in this document is based primarily on the available data for the Northeast and Mid-Atlantic regions.

In unfinished and unheated attics, the insulation material is typically placed between the floor joists using blown-in, batt, or rigid foam insulation. When using fiberglass batts faced with a vapor retarder, the vapor retarder should be face down towards the heated interior. However, the use of a vapor retarder is not necessary in attic applications. If additional batt insulation is being added over existing insulation that is near or above the top of the joists, new un-faced batts should be placed perpendicular to the old ones to cover the top of the joists and reduce thermal bridging through the frame members. In low-pitched roofs, or where installing batt insulation is difficult, a more complete coverage of the attic floor may be achieved by using blown-in insulation. Unfinished attics must be properly ventilated to allow excess heat to escape.

Radiant barriers may be used in attics to reduce thermal radiation across the air space between the roof deck and the attic floor in order to reduce summer heat gain. They are most beneficial in reducing cooling loads in hot climates and consist of a highly reflective sheet or coating, usually aluminum, applied to one or both sides of a flexible material. They are effective only when the foil surface faces an air space, and as long as the surface remains shiny – that is, free from dirt, dust, condensation and oxidation. Radiant barriers should not be installed directly over insulation on the attic floor, as they can act as vapor retarders and trap moisture in the insulation unless they are perforated. Their placement should be ventilated on both sides.

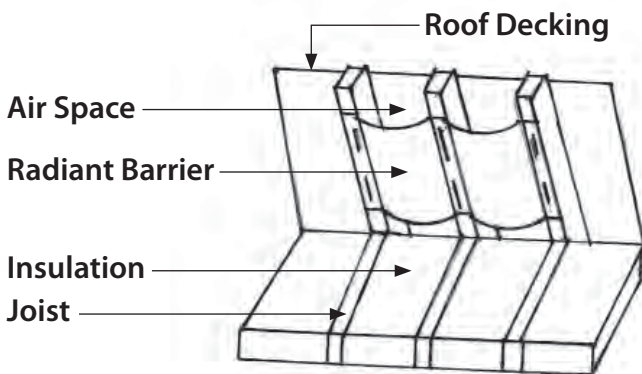


Fig. 13. Sample installation of a radiant barrier.

Insulating the underside of the roof rather than the attic floor increases the volume of the thermal envelope of the building, thus making this treatment inherently less energy efficient. However, when mechanical equipment and/or ductwork are housed in an attic space, placing the insulation under the roof and treating the attic as a conditioned space is strongly recommended. This treatment allows the equipment to operate more efficiently and can prevent moisture-related problems caused by condensation on the mechanical equipment.

When insulation is placed under the roof, all vents in the attic and the intersection between the walls and roof rafters must be sealed. Rigid foam or batt insulation placed between the roof rafters is a common method of insulating the underside of a roof. Open cell spray foam (.5lb/cuft) may sometimes be applied under the roof deck only when there are no gaps in the sheathing which could allow the foam to expand under slates or shingles, preventing the re-use of the roofing material. Also, if roof leaks do occur, they may go undetected until after major damage occurs. Consideration must also be given to the irreversibility of this procedure because the foam enters the pores of the wood. It may be more advisable to install a breathable layer of material that will allow for future removal without leaving a residue.

When total roof replacement is required because of deterioration, installing rigid foam insulation on top of the roof deck before laying the new roofing material

can be simple and effective, particularly on low-pitched or flat roofs. However, the added thickness of the roof caused by installing rigid foam can alter the appearance of projecting eaves, dormers, and other features. If this application would significantly alter the appearance of these features, consider other methods.

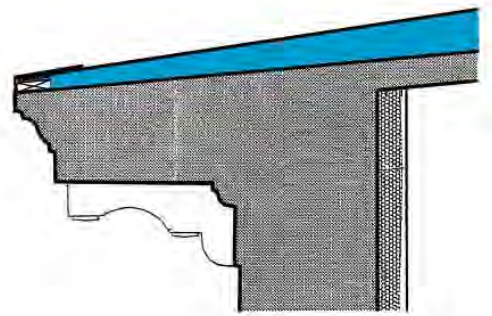


Fig. 14. Sample installation of rigid foam insulation, tapered at the edge to avoid altering the appearance of the roof.

**Install storm windows.** The addition of metal or wood exterior or interior storm windows may be advisable to increase the thermal performance of the windows in ways that weatherstripping and caulking cannot address. A single-glazed storm window may only increase a single-pane window's thermal resistance to R2, however, that is twice as good as a single-glazed window alone. It will make a noticeable contribution to the comfort level of the building occupant, with the added benefit of protecting the historic window from weathering. Using clear, non-tinted, low-e glass in the storm window can further increase the thermal performance of the window assembly without the loss of historic fabric. Studies have shown that the performance of a traditional wood window with the addition of a storm window can approach that of a double-glazed replacement window.<sup>2</sup> Some storm windows are available with insulated low-e glass, offering even higher thermal performance without the loss of the historic window. Furthermore, a storm window avoids the problem of irreparable seal failure on insulated glass units (IGUs) used in modern replacement windows. While the lifespan of the IGU depends both on the quality of the seal and other factors, it is unreasonable to expect more than 25 years. Once the seal fails, the sash itself will usually need to be entirely replaced.

By providing an additional insulating air space and adding a barrier to infiltration, storm windows improve comfort and reduce the potential for condensation on the glass. To be effective and compatible, storm windows must be tight fitting; include a sealing gasket around the glass; align with the meeting rail of the primary sash; match the color of the sash; and be caulked around the frame to reduce infiltration without interfering with any weep holes.

Whether a storm window or the historic window itself, the interior window must be the tighter of the two units to avoid condensation between the windows that can



occur in a cold climate that requires indoor heating. Condensation is a particular concern if it collects on the historic window, as can easily happen with a loose-fitting, storm window. While interior storm windows can be as thermally effective as exterior storm windows, appropriate gaskets must be used to ensure that damage-causing condensation does not form on the inside face of the historic window. Opening or removing the interior storm windows during non-heating months also helps to avoid the negative effects of moisture build-up.



*Fig. 15. Original steel windows were retained and made operable during the rehabilitation of this historic mill complex. Insulated sliding windows were added on the interior to improve energy efficiency.*

For large, steel industrial windows, the addition of interior, insulated sliding glass windows that align with the primary vertical mullions has proven to be a successful treatment that allows the primary window to remain operable.

**Insulate basements and crawlspaces.** The first step in addressing the insulation of basements and crawl spaces is to decide if they are to be part of the conditioned space and, therefore, within the thermal envelope of the building. If these areas are kept outside the thermal envelope of the building and treated as unconditioned areas, insulating between the floor joists on the underside of the subfloor is generally recommended. Alternatively, rigid foam insulation installed over the bottom of the floor joists on the basement or crawlspace side may also be used. All gaps between the unconditioned and conditioned areas of the building, including the band joists, should be air sealed to prevent air infiltration into the upper levels of the building.

If the crawlspace contains mechanical equipment, or if high levels of moist air enter the crawlspace through vents during the summer months, it is advisable to include the crawlspace within the thermal boundary of the building. As in attics, water vapor can condense on ducts and other equipment located in unconditioned basements and crawlspaces. In the past, building codes routinely required that crawlspaces be treated as non-

conditioned spaces and be ventilated. However, this has not proven to be a best practice in all cases. Ventilation through crawlspace vents does not keep the space dry during humid summers. All vents should be sealed and access doors weather-stripped. Rigid foam insulation installed on the interior face of the wall is recommended for basement and crawlspace foundation walls, only after all drainage issues have been addressed. Special attention should be given to ensure that all the joints between the insulation boards are sealed.

A moisture barrier on exposed dirt in a crawlspace is strongly recommended to prevent ground moisture from entering the building envelope. Whenever feasible, pouring a concrete slab over a moisture barrier in crawlspaces or basements with exposed dirt floors should be considered.

**Seal and insulate ducts and pipes.** A surprisingly enormous amount of energy is wasted when heated or cooled air escapes from supply ducts or when hot attic air leaks into air conditioning return ducts. Based on data collected in energy audits, as much as 35 percent of the conditioned air in an average central air conditioning system may escape from the ducts.<sup>3</sup> Care must be taken to completely seal all connections in the duct system and adequately insulate the ducts, especially in unconditioned spaces. This loss of energy is another reason to treat attics, basements and crawlspaces as conditioned spaces. Ducts located in unconditioned spaces should be insulated based on the recommendations for the appropriate climate zone. Hot water pipes and water heaters should be insulated in unconditioned spaces to retain heat, and all water pipes insulated to prevent freezing in cold climates.

**Weather strip doors and add storm doors.** Historic wood doors are often significant features and should always be retained, rather than replaced. While an insulated replacement door may have a higher R-value, doors represent a small area of the total building envelope, and the difference in energy savings after replacement would be insignificant. The doors and frames should, however, have proper maintenance including regular painting, and the addition or renewal of weatherstripping. Storm doors can improve the thermal performance of the historic door in cold climates and may be especially recommended for a door with glazing. The design of the storm door should be compatible with the character of the historic door. A fully glazed storm door with a frame that matches the color of a historic door is often an appropriate choice because it allows for the historic door to remain visible. Storm doors are recommended primarily for residential buildings. They are not appropriate for commercial or industrial buildings. These buildings never had storm doors, because the doors were opened frequently or remained open for long periods. It may also not be appropriate to install a storm door on a highly significant entrance door. In some instances,

the addition of a storm door could add significant heat gain on certain exposures or in hot climates, which could degrade the material or finish of the historic door.

**Add awnings and shading devices.** Awnings and other shading devices can provide a considerable reduction of heat gain through windows and storefronts. Keeping existing awnings, or replacing them if previously removed, is a relatively easy way to enhance the energy performance of a building. Awnings should only be installed when they are compatible with the building type and character. In building types that did not have awnings historically, interior shades, blinds or shutters should be considered instead.

A wide range of shades, blinds and shutters is available for use in all types of buildings to control heat gain or loss through windows, as well as lighting levels. When properly installed, shades are a simple and cost-effective means of saving energy. Some shade fabrics block only a portion of the light coming in — allowing the use of natural light — while others block all or most of the light. The light-colored or reflective side of the shades should face the window to reduce heat gain. Quilted roller shades feature several layers of fiber batting and sealed edges, and these shades act as both insulation and an air barrier. They control air infiltration more effectively than other soft window treatments. Pleated or cellular shades provide dead air spaces within the cells to add insulation value. These shades, however, do not measurably control air infiltration.

Retractable awnings and interior shades should be kept lowered during the summer to prevent unwanted heat gain, but raised in the winter to take advantage of the heat gain. Interior shades, especially those that have some insulation value, should be lowered at night during the winter months.

Light shelves are architectural devices designed to maximize daylight coming through windows by reflecting it deeper into the building. These horizontal elements are usually mounted on the interior above head height in buildings with high ceilings. Although they can provide energy savings, they are not compatible with most historic buildings. In general, light shelves are most likely to be appropriate in some industrial or modernist-style buildings, or where the historic integrity of interior spaces has been lost and they can be installed without being visible from the exterior.

### Requires More Alteration

**Add interior vestibules.** Vestibules that create a secondary air space or “air lock” are effective in reducing air infiltration when the exterior door is open. Exterior and interior vestibules are common architectural features of many historic buildings and should be retained wherever they exist. Adding an interior vestibule may also be appropriate in some historic buildings. For example, new glazed interior vestibules may be compatible changes to historic commercial and industrial buildings. New exterior vestibules will usually result in too great a change to the character of primary entrances, but may be acceptable in very limited instances, such as at rear entrances. Even in such instances, new vestibules should be compatible with the architectural character of the historic building.

**Replace windows.** Windows are character-defining features of most historic buildings. As discussed previously, the replacement of a historic window with a modern insulated unit is not usually a cost-effective choice. Historic wood windows have a much longer service life than replacement insulated windows, which cannot be easily repaired. Therefore, the sustainable choice is to repair historic windows and upgrade their thermal performance. However, if the historic windows are deteriorated beyond repair, if repair is impractical because of poor design or material performance, or if repair is economically infeasible, then replacement windows may be installed that match the historic windows in size, design, number of panes, muntin profile, color, reflective qualities of the glass, and the same relationship to the window opening.

Other options should also be considered before undertaking complete window replacement. If only the sash is severely deteriorated and the frame is repairable, then only the sash may need to be replaced. If the limited lifespan of insulated glass is not a concern, the new sash can be made to accommodate double glazing.



Fig. 16. Historic vestibules retain conditioned air in the living spaces.

Where the sashes are sound, but improved thermal performance without the use of a storm window is desired, some windows may be retrofitted with insulated glass. If the existing sash is of sufficient thickness, it may be routed to accept insulated, clear low-e glass without extensive loss of historic material or historic character. When insulated glass is added in a new or retrofitted sash, any weights will have to be modified to accommodate the significant extra weight.

### Wall Insulation

Adding wall insulation must be evaluated as part of the overall goal to improve the thermal efficiency of a building and should only be considered after the installation of attic and basement insulation. Can this goal be achieved without the use of wall insulation? Can insulation be added without causing significant loss of historic materials or accelerated deterioration of the wall assembly? Will it be cost effective? These are basic questions that must be answered before a decision is made to insulate the walls and may require professional evaluation.

**Add insulation to wood-frame walls.** Wood is particularly susceptible to damage from high moisture levels; therefore, addressing existing moisture problems before the addition of insulation is essential. Un-insulated historic wood buildings have a higher rate of air infiltration than modern buildings; while this makes older buildings less efficient thermally, it helps dissipate the unwanted moisture and thus keeps building assemblies dry. Climate, building geometry, the condition of the building materials, construction details, and many other factors make it difficult to assess the impact that adding insulation will have on reducing the air flow and, hence, the drying rate in a particular building. For this reason, predicting the impact of adding insulation to wood-frame walls is difficult.

*Insulation Installed in the Wall Cavity:* When sheathing is part of the wall assembly, and after any moisture-related problems have been addressed, adding insulation to the interior cavity of a wood-frame wall may be considered. Adding insulation in a wall where there is no sheathing between the siding and studs is more problematic, however, because moisture entering the wall cavity through cracks and joints by wind-driven rain or capillary action will wet the insulation in contact with the back of the siding.

Installing **blown-in insulation**, either dense-packed cellulose or fiberglass, into the wall cavity causes the least amount of damage to historic materials and finishes when there is access to the cavity walls, and it is therefore a common method of insulating wood-frame walls in existing buildings. In most cases, blowing insulation material into the wall cavity requires access through the exterior or interior wall surfaces. When historic plaster, wood paneling, or other interior historic decorative elements are present, accessing the



AN INTERIOR

Showing Mineral Wool in Floor, and Walls behind Wire Lath.

Fig. 17. Illustration of insulation from the 1889 trade catalog "The Uses of Mineral Wool in Architecture, Car Building and Steam Engineering". Collection Centre Canadien d'Architecture/Canadian Centre for Architecture, Montreal, Canada.

cavity from the exterior is recommended by removing individual siding boards at the top of each wall cavity. In this manner the boards can be reinstalled without unsightly drill holes on the exterior. If the plaster is deteriorated and will require repair, then the wall cavity may be accessed from the interior through holes drilled through non-decorative plaster.

Of the materials available, dense-packed cellulose fiber is most commonly used. Its R-value, ability to absorb and diffuse moisture, impediment to air flow, relatively simple installation, and low cost make it a popular choice. Cellulose insulation from most manufacturers is available in at least two grades that are characterized by the type of fire retardant added to the insulation. The fire retardants are usually: (1) a mix of ammonium sulfate and boric acid or (2) boric acid only (termed "borate only"). The recommended type of cellulose insulation for historic buildings is the "borate only" grade, as cellulose treated with sulfates reacts with moisture in the air and forms sulfuric acid which corrodes many metals.

Optimum conditions for installing insulation inside the wall cavity occur in buildings where either the exterior materials or interior finishes have been lost, or where the materials are deteriorated beyond repair and total replacement is necessary. However, wholesale removal of historic materials either on the exterior or interior face of a historic wall to facilitate insulation is

not recommended. Even when the exterior materials, such as wood siding, could potentially be reinstalled, this method, no matter how carefully executed, usually results in damage to, and loss of historic materials.



Fig. 18. Dense-packed cellulose insulation is being blown in through holes drilled in the sheathing. Once the operation has been completed, the shingles will be reinstalled. Photo: Edward Minch.

If the wall cavity is open, the opportunity to properly install **batt insulation** is available. A tight fit between the insulation and the adjacent building components is critical to the performance of the insulation. Batt insulation must be cut to the exact length of the cavity. A batt that is too short creates air spaces above and beneath the batt, allowing convection. A batt that is too long will bunch up, creating air pockets. Air pockets and convection currents significantly reduce the thermal performance of insulation. Each wall cavity should be completely filled. Unfaced, friction-fit batt insulation fluffed to fill the entire wall cavity is recommended. Any air gaps between the insulation and the framing or other assembly components must be avoided. Batts should be split around wiring, pipes, ducts and other elements in the wall rather than be pushed or compressed around obstacles.

When adding insulation to the sidewalls, the band joist area between floors in multi-story, platform-framed buildings should be included in the sidewall insulation retrofit. The R-value of the insulation installed in the band joist area should be at least equal to the R-value of

### Band Joist

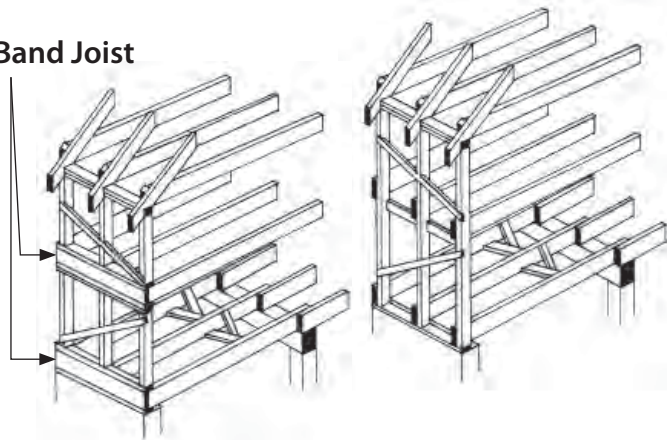


Fig. 19. Platform framing (left) and Balloon framing (right).

the insulation in the adjacent wall cavities. In balloon-framed buildings, the wall cavity is continuous between floors except where fire stops have been inserted.

The use of **spray foam or foamed-in-place insulation** would appear to have great potential for application in historic wood-frame buildings due to their ability to flow into wall cavities and around irregular obstacles. Their high R-value and function as an air barrier make them a tempting choice. However, their use presents several problems. The injected material bonds tightly to historic materials making its removal difficult, especially if it is encased in an existing wall. The pressure caused by the expansion rate of these foams within a wall can also damage historic material, including breaking the plaster keys or cracking existing plaster finishes.

*Insulation Installed on Either Side of the Wall:* Batt, rigid foam board, and spray foam insulation are commonly added to the interior face of walls in existing buildings by furring-out the walls to accommodate the additional thickness. However, this often requires the destruction or alteration of important architectural features, such as cornices, base boards, and window trim, and the removal or covering of plaster or other historic wall finishes. Insulation installed in this manner is only recommended in buildings where interior spaces and features lack architectural distinction or have lost significance due to previous alterations.



Fig. 20. The walls have been furred out inappropriately around the historic window trim creating an appearance the interior never had historically.

Adding rigid foam insulation to the exterior face of wood-frame buildings, while common practice in new construction, is never an appropriate treatment for historic buildings. Exterior installation of the foam boards requires removal of the existing siding and trim to install one or more layers of polyisocyanurate or polystyrene foam panels. Depending on the amount of insulation added for the particular climate, the wall thickness may be dramatically increased by moving

## What about moisture?

The issue of moisture in insulated assemblies is the subject of much debate. While there is no conclusive way to predict all moisture problems, especially in historic buildings, experts seem to agree on a few basic tenants. Exterior materials in insulated buildings become colder in the winter and stay wet longer following a rain event. While the wetness may not pose a problem for robust materials, it may speed the deterioration of some building materials, and lead to more frequent maintenance such as repainting of wood or repointing of masonry. Summer moisture problems are most commonly associated with excessive indoor cooling and the use of interior wall finishes that act as vapor retarders (paint buildup or vinyl wall coverings). Good air-sealing at the ceiling plane usually controls moisture in insulated attics.

Most problems are caused by poor moisture management, poor detailing which does not allow the building to shed water, or inadequate drainage. Therefore, a thorough assessment of the building's ability to keep out unwanted moisture must be done before adding new insulation materials. Refer to Preservation Brief #39:  *Holding the Line: Controlling Unwanted Moisture in Historic Buildings*  for more information. Because of all the uncertainties associated with insulating walls, brick walls in particular, it may be advisable to hire a professional consultant who specializes in the many factors that affect the behavior of moisture in a building and can apply this expertise to the unique characteristics of a particular structure. Sophisticated tools such as computer modeling are useful to predict the performance of building assemblies, but they require interpretation by a skilled practitioner and the results are only as good as the data entered. It is important to remember, there are no reliable prescriptive measures to prevent moisture problems.<sup>4</sup>

**Vapor Retarders (Barriers):** Vapor retardants are commonly used in modern construction to manage the diffusion of moisture into wall cavities and attics. For vapor retardants to work properly, however, they must be continuous, which makes their installation difficult in existing buildings, and therefore generally not recommended. Even in new construction, installation of vapor retardants is not always indicated. Formerly, the recommended treatment was to install a vapor retardant toward the heated side of the wall (toward the interior space in cold climates and toward the exterior in hot climates). DOE now recommends that if moisture moves both to the interior and exterior of a building for significant parts of the year, it is better not to use a vapor retarder at all.<sup>5</sup>

the siding as much as 4 inches out from the sheathing. Even if the historic siding and trim could be removed and reapplied without significant damage, the historic relationship of windows to walls, walls to eaves, and eaves to roof would be altered, which would compromise the architectural integrity and appearance of the historic building.

*Solid Masonry Walls:* As with frame buildings, installing insulation on the interior walls of a historic masonry structure should be avoided when it would involve covering or removing important architectural features and finishes, or when the added thickness would significantly alter the historic character of the interior. The addition of insulation on solid masonry walls in cold climates results in a decreased drying rate, an increased frequency of freeze-thaw cycles, and prolonged periods of warmer and colder temperatures of the masonry. These changes can have a direct effect on the durability of materials.



Fig. 21. The interior face of a brick masonry wall shows damage that resulted from the installation of a vapor retardant (foil facing) and thermal insulation. Photo: Simpson Gumpertz & Heger.

Depending on the type of masonry, exterior masonry walls can absorb a significant amount of water when it rains. Masonry walls dry both toward the exterior and the interior. When insulation is added to the interior side of a masonry wall, the insulation material reduces the drying rate of the wall toward the interior, causing the wall to stay wet for longer periods of time. Depending on the local climate, this could result in damage to the historic masonry, damage to interior finishes, and deterioration of wood or steel structural components

imbedded in the wall. Masonry walls of buildings that are heated during the winter benefit from the transfer of heat from the inside to the outside face of the walls. This thermal transfer protects the exterior face of the wall by reducing the possibility of water freezing in the outer layers of the wall, particularly in cold and wet climates. The addition of insulation on the interior of the wall not only prolongs the drying rate of the exterior masonry wall, but keeps it colder as well, thereby increasing the potential for damage due to freeze-thaw cycles.<sup>6</sup>

Extreme swings in temperature may also have negative effects on a historic masonry wall. The addition of insulation materials to a historic masonry wall decreases its ability to transfer heat; thus, walls tend to stay warm or cold for longer periods of time. In addition, walls exposed to prolonged solar radiation during winter months can also be subject to higher swings in surface temperature during the day. Deleterious effects due to stress caused by expansion and contraction of the building assembly components can result.

Buildings with masonry materials of higher porosity, such as those built with low-fired brick, or certain soft stones, are particularly susceptible to freeze-thaw cycles and must be carefully evaluated prior to adding insulation. Inspection of the masonry in areas that are not heated such as parapets, exposed wing walls, or other parts of the building is particularly important. A noticeable difference in the amount of spalling or sanding of the masonry in these areas could predict that the same type of deterioration will occur throughout the building after the walls are insulated. Brick that was fired at lower temperatures was often used on the inside face of the wall or on secondary elevations. Even masonry walls faced with more robust materials such as granite may have brick, rubble, mortar or other less durable materials as backing.

Spray foams are being used for insulation in many masonry buildings. Their ability to be applied over irregular surfaces, provide good air tightness, and continuity at intersections between, walls, ceilings, floors and window perimeters makes them well suited for use in existing buildings. However, the long-term effects of adding either open- or closed-cell foams to insulate historic masonry walls as well as performance of these products have not been adequately documented. Use of foam insulation in buildings with poor quality masonry or uncontrolled rising damp problems should be avoided.

Periodic monitoring of the condition of insulated masonry walls is strongly recommended regardless of the insulation material added.

**Install cool roofs and green roofs:** Cool roofs and vegetated “green roofs” help to reduce the heat gain from the roof, thereby cooling the building and its environment. Cool roofs include reflective metal roofs,

light-colored or white roofs, and fiberglass shingles that have a coating of reflective crystals. All of these roofing materials reflect the sun’s radiation away from the building, which lessens heat gain, resulting in a reduction of the cooling load. Cool roofs are generally not practical in northern climates where buildings benefit from the added heat gain of a dark-colored roof during colder months. Cool and green roofs are appropriate for use on historic buildings only when they are compatible with their architectural character, such as flat roofs with no visibility. A white-colored roof that is readily visible is not appropriate for historic metal roofs that were traditionally painted a dark color, such as green or iron oxide red. A white reflective roof is most suitable on flat roofed historic buildings. If a historic building has a slate roof, for example, removing the slate to install a metal roof is not a compatible treatment. It is never appropriate to remove a historic roof if the material is in good or repairable condition to install a cool roof. However, if the roof has previously been changed to an asphalt shingle roof, fiberglass shingles with special reflective granules may be an appropriate replacement.



*Fig. 22. Installation of both cool and green roofs in an urban environment.*

A green roof consists of a thin layer of vegetation planted over a waterproofing system or in trays installed on top of an existing flat or slightly sloped roof. Green roofs are primarily beneficial in urban contexts to reduce the heat island effect in cities and to control storm water run-off. A green roof also reduces the cooling load of the building and helps cool the surrounding urban environment, filters air, collects and filters storm water, and can provide urban amenities, including vegetable gardens, for building occupants. The impact of increased

structural loads, added moisture, and potential for leaks must be considered before installing a green roof. A green roof is compatible on a historic building only if the plantings are not visible above the roofline as seen from below.

## Alternative Energy Sources

Although not the focus of this publication, alternative energy sources are dealt with in more detail in *The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings* and other NPS publications.

Devices that utilize solar, geothermal, wind and other sources of energy to help reduce consumption of fossil fuel-generated energy can often be successfully incorporated in historic building retrofits. However, if the alterations or costs required to install these devices do not make their installation economically feasible, buying power generated off site from renewable sources may also be a good alternative. The use of most alternative energy strategies should be pursued only after all other upgrades have been implemented to make the building more energy efficient because their initial installation cost is usually high.

**Solar Energy:** Man has sought to harness the power of solar energy to heat, cool, and illuminate buildings throughout history. Construction techniques and design strategies that utilize building materials and components to collect, store, and release heat from the sun are described as “passive solar design.” As previously discussed, many historic buildings include passive solar features that should be retained and may be enhanced. Compatible additions to historic buildings also offer opportunities to incorporate passive solar features. Active solar devices, such as solar heat collectors and photovoltaic systems, can be added to historic buildings to decrease reliance on grid-source fossil-fuel powered electricity. Incorporating active solar devices in existing buildings is becoming more common as solar collector technology advances. Adding this technology to historic buildings, however, must be done in a manner that has a minimal impact on historic roofing materials and preserves their character by placing them in locations with limited or no visibility, i.e., on flat roofs at a low angle or on a secondary roof slope.

Solar collectors used to heat water can be relatively simple. More complex solar collectors heat a fluid or air that is then pumped through the system to heat or cool interior spaces. Photovoltaic panels (PV) transform solar radiation into electricity. The greatest potential for the use of PV panels in historic buildings is on buildings with large flat roofs, high parapets, or roof configurations that allow solar panels to be installed without being prominently visible. The feasibility of installing solar devices in small commercial and residential buildings will depend on installation costs, conventional energy rates, and available incentives, all of

which will vary with time and location. The same factors apply to the use of solar collectors for heating water, but smaller installations may meet a building's need and the technology has a considerable track record.



Fig. 23. Solar collectors installed in a compatible manner on low sloping sawtooth monitors. Top Photo: Neil Mishalov, Berkeley, CA.

**Geothermal Energy:** The use of the earth's heat is another source of readily-accessible clean energy. The most common systems that utilize this form of energy are geothermal heat pumps, also known as geo-exchange, earth-coupled, ground-source, or water-source heat pumps. Introduced in the late 1940s, geothermal heat pumps rely on heat from the constant temperature of the earth, unlike most other heat pumps which use the outside air temperature as the exchange medium. This makes geothermal heat pumps more efficient than conventional heat pumps because they do not require an electric back-up heat source during prolonged periods of cold weather.

There are many reasons that geothermal heat pumps are well suited for use in historic buildings. They can reduce the amount of energy consumption and emissions considerably, compared to the air exchange systems or electric resistance heating of conventional HVAC systems. They require less equipment space, have fewer moving parts, provide better zone space conditioning, and maintain better internal humidity levels. Geothermal heat pumps are also quieter because they do not require external air compressors. Despite higher installation costs, geothermal systems offer long-term operational savings and adaptability that may make them a worthwhile investment in some historic buildings.

**Wind Energy:** For historic properties in rural areas, where wind power has been utilized historically, installation of a wind mill or turbine may be suitable to the historic setting and cost effective. Before choosing to install wind-powered equipment, the potential benefit and the impact on the historic character of the building, the site and surrounding historic district must be analyzed. In order for the turbines to work effectively, average wind speeds of 10 mph or higher are necessary. This technology may not be practical in more densely-populated areas sheltered from winds or regions where winds are not consistent. In cities with tall buildings, there is potential for installing relatively small rooftop turbines that are not visible from the ground. However, because of the initial cost and size of some turbines, it is generally more practical to purchase wind power from an off-site wind farm through the local utility company.

## Summary

With careful planning, the energy efficiency of historic buildings can be optimized without negatively impacting their historic character and integrity. Measuring the energy performance of buildings after improvements are completed must not be overlooked, as it is the only way to verify that the treatments have had the intended effect. Ongoing monitoring of buildings and their components after alterations to historic building assemblies are completed can prevent irreparable damage to historic materials. This, along with regular maintenance, can ensure the long-term preservation of our historic built environment and the sustainable use of our resources.

## End Notes

<sup>1</sup> John Krigger and Chris Dorsi, "Air Leakage," in *Residential Energy: Cost Savings and Comfort for Existing Buildings*. Helena, Montana: Saturn Resource Management, 2004, p. 73.

<sup>2</sup> *Measured Winter Performance of Storm Windows*. A 2002 study done by Lawrence Berkeley National Labs.

<sup>3</sup> *Midwest Weatherization Best Practices Field Guide*. Prepared for the U.S. Department of Energy Weatherization Assistance Program, May 2007, p. 157.

<sup>4</sup> Adapted from comments provided by William B. Rose, Research Architect, University of Illinois, April 2011.

<sup>5</sup> U.S. Department of Energy, *Insulation Fact Sheet*, DOE/CE-0180, 2008, p.14.

<sup>6</sup> Bradford S. Carpenter, P.E., LEED AP et al., *The Designer's Dilemma: Modern Performance Expectations and Historic Masonry Walls* (paper presented at the RCI 2010 Symposium on Building Envelope Technology, San Antonio, Texas).

## Acknowledgements

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This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. Additional information about the programs of Technical Preservation Services is available on the website at [www.nps.gov/tps](http://www.nps.gov/tps). Comments about this publication should be addressed to: Charles E. Fisher, Technical Preservation Publications Program Manager, Technical Preservation Services, National Park Service, 1201 Eye Street, NW, 6<sup>th</sup> Floor, Washington, DC 20005. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the authors and the National Park Service are appreciated. The photographs used in this publication may not be used to illustrate other publications without permission of the owners. *Cover photograph: Farmhouse with energy efficient historic storm windows.*



# 7 PRESERVATION BRIEFS



## The Preservation of Historic Glazed Architectural Terra-Cotta

de Teel Patterson Tiller

U.S. Department of the Interior National Park Service  
Preservation Assistance Division Technical Preservation Services

Glazed architectural terra-cotta was significant in the development of important architectural idioms in this country—specifically, the “Chicago School,” the High Rise and the Historic or Beaux Arts styles. In fact, glazed architectural terra-cotta is one of the most prevalent masonry building materials found in the urban environment today (Fig. 1). Popular between the late 19th century and the 1930s, glazed architectural terra-cotta offered a modular, varied and relatively inexpensive approach to wall and floor construction. It was particularly adaptable to vigorous and rich ornamental detailing. However, with changing vogues in materials and architectural styles and rising production costs, glazed architectural terra-cotta fell into disfavor and disuse by the mid-20th century.

Today, information on the maintenance, rehabilitation and replacement of glazed architectural terra-cotta is limited, as are sources of new glazed architectural terra-cotta. This report, then, will discuss some of the major deterioration problems that commonly occur in historic glazed architectural terra-cotta, methods of determining the extent of that deterioration and recommendations for the maintenance, repair and replacement of the deteriorated historic material.

### What is Terra-Cotta?

Generically, the broadest definition of terra-cotta refers to a high grade of weathered or aged clay which, when mixed with sand or with pulverized fired clay, can be molded and fired at high temperatures to a hardness and compactness not obtainable with brick. Simply put, terra-cotta is an enriched molded clay brick or block. The word *terra-cotta* is derived from the Latin word *terra-cocta*—literally, “cooked earth.” Terra-cotta clays vary widely in color according to geography and types, ranging from red and brown to white.

Terra-cotta was usually hollow cast in blocks which were open to the back, like boxes, with internal compartment-like stiffeners called webbing (Fig. 2). Webbing substantially strengthened the load-bearing capacity of the hollow terra-cotta block without greatly increasing its weight.

Terra-cotta blocks were often finished with a glaze; that is, a slip glaze (clay wash) or an aqueous solution of metal salts was brushed or sprayed on the air-dried block before firing. Glazing changed the color, imitated different finishes, and produced a relatively impervious surface on the weather face of the final product. The glaze on the terra-cotta unit possessed excellent weathering properties when properly maintained. It had rich color and provided a hard surface that was not easily chipped off. Glazing offered unlimited and fade-resistant colors to the designer. Even today, few building

materials can match the glazes on terra-cotta for the range and, most importantly, the durability of colors.

### Types of Terra-Cotta

Historically there are four types or categories of terra-cotta which have enjoyed wide use in the history of the American building arts: 1) brownstone, 2) fireproof construction, 3) ceramic veneer, and 4) glazed architectural.

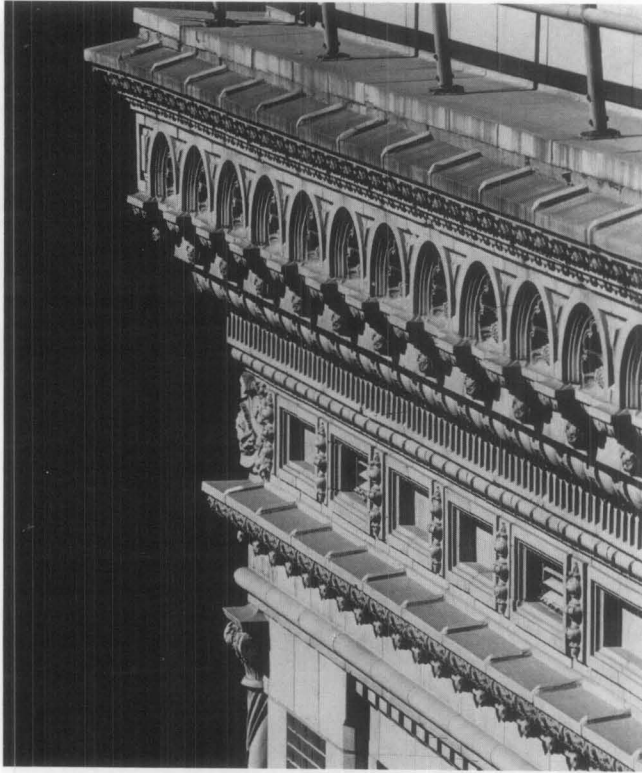
*Brownstone* terra-cotta is the variety of this masonry material used earliest in American buildings (mid- to late 19th century). The brownstone type is a dark red or brown block either glazed (usually a slip glaze) or unglazed. It was hollow cast and was generally used in conjunction with other masonry in imitation of sandstone, brick or real brownstone. It is often found in the architecture of Richard Upjohn, James Renwick, H. H. Richardson and is associated with the Gothic and Romanesque Revival movements through such ornamental detailing as moldings, finials and capitals.

*Fireproof construction* terra-cotta was extensively developed as a direct result of the growth of the High Rise building in America. Inexpensive, lightweight and fireproof, these rough-finished hollow building blocks were ideally suited to span the I-beam members in floor, wall and ceiling construction (Fig. 3). Certain varieties are still in production today, although fireproof construction terra-cotta is no longer widely employed in the building industry.

*Ceramic veneer* was developed during the 1930s and is still used extensively in building construction today. Unlike traditional architectural terra-cotta, ceramic veneer is not hollow cast, but is as its name implies: a veneer of glazed ceramic tile which is ribbed on the back in much the same fashion as bathroom tile. Ceramic veneer is frequently attached to a grid of metal ties which has been anchored to the building.

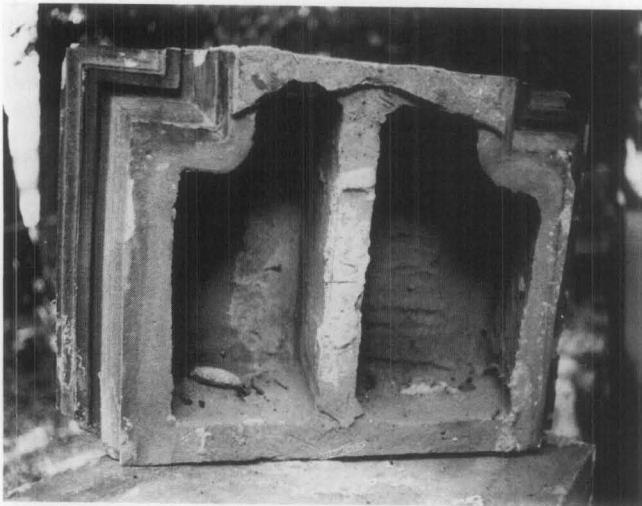
*Glazed architectural* terra-cotta was the most complex development of terra-cotta as a masonry building material in this country. The hollow units were hand cast in molds or carved in clay and heavily glazed (often in imitation of stone) and fired. Sometimes called “architectural ceramics,” glazed architectural terra-cotta was developed and refined throughout the first third of the 20th century and has been closely associated with the architecture of Cass Gilbert, Louis Sullivan, and Daniel H. Burnham, among others. Significant examples in this country include the Woolworth Building (1913) in New York City and the Wrigley Building (1921) in Chicago.

Late 19th and early 20th century advertising promoted the durable, impervious and adaptable nature of glazed archi-



**Figure 1. Terra-Cotta Detailing.** Adaptable to every nuance of color, texture, and modeling, glazed architectural terra-cotta was ideally suited to satisfy the tastes of an eclectic age. Its popularity was, however, short lived; it endured only 30 or 40 years after its introduction as a building material late in the 19th century. (Larry Payne, Houston, Texas)

tectural terra-cotta. It provided for crisp, vigorous modeling of architectural details as the molds were cast directly from clay prototypes without loss of refinement. Glazed architectural terra-cotta could accommodate subtle nuances of modeling, texture and color. Compared to stone, it was easier to handle, quickly set and more affordable to use. Thought to be fireproof and waterproof, it was readily adaptable to structures of almost any height. The cost of molding the clay, glazing and firing the blocks, when compared to carving



**Figure 2. Webbing.** Webbing, or the hollow internal compartment construction of glazed architectural terra-cotta blocks, made them inexpensive to produce, easy to handle and light in construction; these were significant factors in the popularity of the material in the first decades of this century.

stone, represented a considerable savings, especially when casts were used in a modular fashion—that is, repeated over and over again. Maintenance of the fired and glazed surface was easy; it never needed paint and periodic washings restored its original appearance.

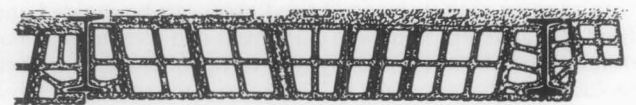
With the passage of time, many of the phenomenal claims of the early proponents of glazed architectural terra-cotta have proven true. There are many examples throughout this country that attest to the durability and permanence of this material. Yet present-day deterioration of other significant glazed architectural terra-cotta resources ultimately belie those claims. Why? Historically, the lack of foresight or understanding about the nature and limitations of the material has, in many instances, allowed serious deterioration problems to occur that are only now becoming apparent.

#### **Characteristics of Glazed Architectural Terra-Cotta as a Building Material**

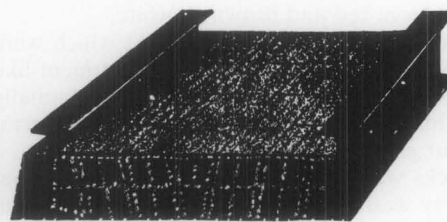
Glazed architectural terra-cotta has many material properties similar to brick or stone. It also has many material properties radically different from those traditional masonry materials. It is those differences which must be considered for a better understanding of some of the material characteristics of glazed architectural terra-cotta when it is used as a building material.

**Difficult to identify:** Glazed architectural terra-cotta probably comprises one of the largest if not the largest constituent material in some of our urban environments today. However, the infinite varieties of glazing have hidden this fact from the casual observer. One of the attractive features of glazed architectural terra-cotta in its time was that it could be finished (glazed) in exact imitation of stone. In fact, many building owners and architects alike are often surprised to discover that what they presumed to be a granite or limestone building is glazed architectural terra-cotta instead.

**Two separate systems:** Historically, glazed architectural terra-cotta has been used in association with two specific and very different types of building systems: as part of a traditional *load-bearing* masonry wall in buildings of modest height, and as a *cladding material* in High Rise construction. As cladding, glazed architectural terra-cotta often utilized an extensive metal anchoring system to attach it or to “hang it” onto a wall framing system or superstructure (Fig. 4). In the first instance the anchoring was limited; in the second, the anchoring was often extensive and complex. Likewise, in the first instance, deterioration has generally been limited. However, where glazed architectural terra-cotta was used as clad-

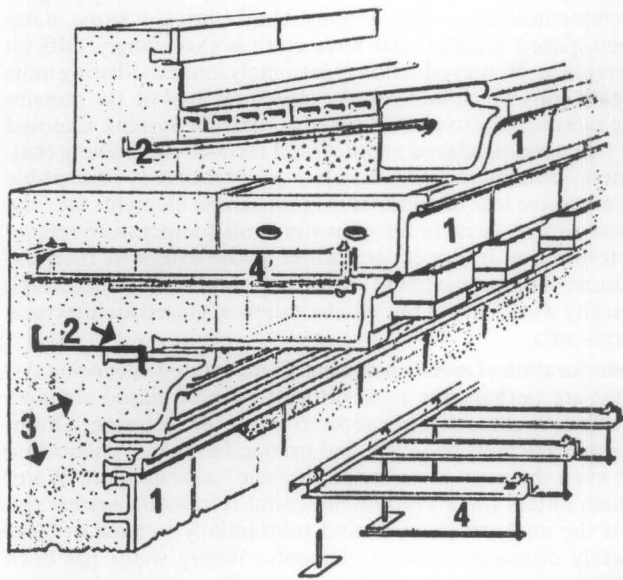


Section Through Typical Arch



Perspective of Typical Arch

**Figure 3. Fireproof construction terra-cotta.** Perspective and section through fireproof construction terra-cotta and I-beam detailing in industrial floor construction. (Detail, “Sweets” Industrial Catalogue of Building Construction, 1906)



**Figure 4. Typical Construction Detail of Glazed Architectural Terra-Cotta Ornament.** Construction detailing was often complex. The terra-cotta units (1) which were laid in mortar were fitted with holes or slots to receive the metal anchors (2) (often called "Z" straps or "light iron") which were often fitted directly to the building frame. Masonry backfill (3) (either brick or poured cement) was laid between the terra-cotta units, with the building frame encasing the metal anchor. Overhanging or protruding elements were further secured by metal dowels or outriggers (4). (Detail, *Architectural Terra Cotta*, Charles E. White, Jr., 1920)

ding, particularly in high rise construction, present-day deterioration and failure are often severe.

**Complexity of deterioration:** Deterioration is, by nature of the design, infinitely complex—particularly when glazed architectural terra-cotta has been used as a cladding material. Deterioration creates a "domino"-like breakdown of the whole system: glazed units, mortar, metal anchors, and masonry backfill. In no other masonry system is material failure potentially so complicated.

**Poor original design:** The root of deterioration in glazed architectural terra-cotta systems often lies in a misapplication of the material. Historically, glazed architectural terra-cotta was viewed as a highly waterproof system needing neither flashing, weep holes nor drips. This supposition, however, has proved to be untrue, as serious water-related failure was evident early in the life of many glazed architectural terra-cotta clad or detailed buildings.

#### Common Deterioration Problems

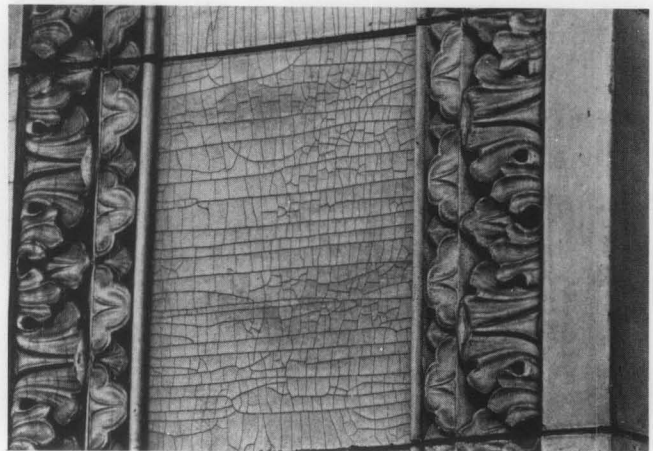
No one case of deterioration in glazed architectural terra-cotta is ever identical to another owing to the infinite number of variations with the material: original manufacture, original installation inconsistencies, number of component parts, ongoing repairs or the various types and sources of deterioration. However, certain general statements may be made on the nature of glazed architectural terra-cotta deterioration.

Material failure can most commonly be attributed to water-related problems. However, less frequent though no less severe causes may include: faulty original craftsmanship, which is often cited but hard to determine; stress-related deterioration; damage caused by later alterations and additions; or inappropriate repairs.

**Water-related deterioration:** As with most building conservation and rehabilitation problems, water is a principal source of deterioration in glazed architectural terra-cotta. Terra-cotta systems are highly susceptible to such complex water-

related deterioration problems as glaze crazing, glaze spalling and material loss, missing masonry units and deteriorated metal anchoring, among others.

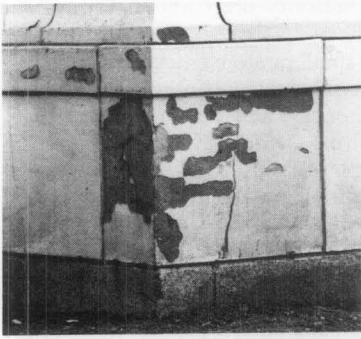
**Crazing**, or the formation of small random cracks in the glaze, is a common form of water-related deterioration in glazed architectural terra-cotta. When the new terra-cotta unit first comes from the kiln after firing, it has shrunken (dried) to its smallest possible size. With the passage of time, however, it expands as it absorbs moisture from the air, a process which may continue for many years. The glaze then goes into tension because it has a lesser capacity for expansion than the porous tile body; it no longer "fits" the expanding unit onto which it was originally fired. If the strength of the glaze is exceeded, it will crack (craze) (Fig. 5). Crazing is a process not unlike the random hairline cracking on the surface of an old oil painting. Both may occur as a normal process in the aging of the material. Unless the cracks visibly extend into the porous tile body beneath the glaze, crazing should not be regarded as highly serious material failure. It does, however, tend to increase the water absorption capability of the glazed architectural terra-cotta unit.



**Figure 5. Crazing.** Water and air-borne moisture entering the glazed architectural terra-cotta causes expansion of the porous clay body which increases its volume. This, in turn, is sufficient to upset the "fit" of the glaze and to make it shatter, commonly called crazing.

**Spalling**, the partial loss of the masonry material itself, is, like crazing, caused by water and is usually a result not only of air-borne water but more commonly of water trapped within the masonry system itself. Trapped water is often caused by poor water detailing in the original design, insufficient maintenance, rising damp or a leaking roof. In most cases, trapped water tends to migrate outward through masonry walls where it eventually evaporates. In glazed architectural terra-cotta, the water is impeded in its journey by the relatively impervious glaze on the surface of the unit which acts as a water barrier. The water is stopped at the glaze until it builds up sufficient pressure (particularly in the presence of widely fluctuating temperatures) to pop off sections of the glaze (glaze spalling) or to cause the wholesale destruction of portions of the glazed architectural terra-cotta unit itself (material spalling).

Glaze spalling may appear as small coin-size blisters where the glaze has ruptured and exposed the porous tile body beneath (Fig. 6). This may occur as several spots on the surface or, in more advanced cases of deterioration, it may result in the wholesale disappearance of the glaze. Spalling of the glaze may also be symptomatic of deterioration (rusting) of the internal metal anchoring system which holds the terra-cotta units together and to the larger building structure. The increase in volume of the metal created by rusting creates increased internal pressures in the terra-cotta unit which, in



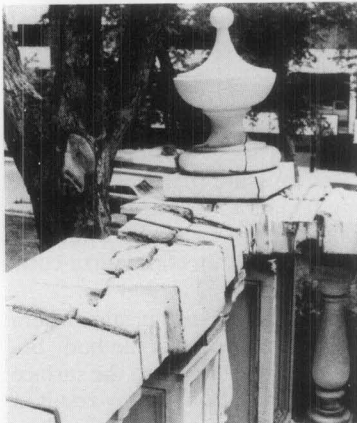
**Figure 6. Glaze Spalling.** Blistering of the glaze, like crazing, is the result of the increase in water in the porous clay body and the subsequent destruction of the glaze as a result of water migration and pressure. Glaze spalling may also be caused by deterioration of metal anchors behind the terra-cotta unit.



**Figure 7. Material Spalling.** Excessive expansion of the porous tile body caused by water and freezing temperatures produces major material spalling, a situation often difficult to repair.

turn, may spall the glaze, or in more extreme cases, cause material spalling.

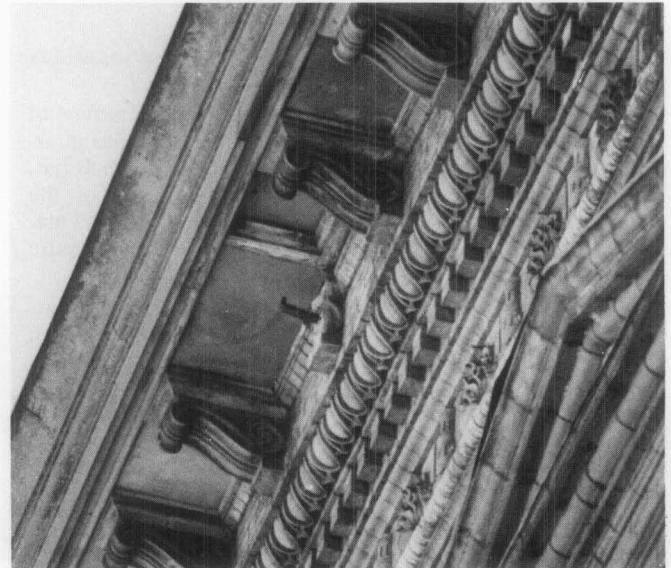
Material spalling is a particularly severe situation. Not only is the visual integrity of the detailing impaired, but a large area of the porous underbody, webbing and metal anchoring is exposed to the destructive effects of further water entry and deterioration (Fig. 7). Both glaze and material spalling must be dealt with as soon as possible.



**Figure 8. Deterioration of Exposed Detailing.** Exposed or freestanding terra-cotta detailing (parapets, urns, balusters, etc.) have traditionally been subject to the most severe vicissitudes of deterioration as a result of freezing temperatures and water. (Colorado State Historic Preservation Office)

**Missing units** is a serious situation which particularly plagues architectural terra-cotta systems. Unlike brick or stone, damaged glazed architectural terra-cotta is exceedingly difficult to replace. New production is extremely limited. Missing units create gaps which increase the structural load on the remaining pieces and also permit water to enter the system. Exposed or freestanding glazed architectural terra-cotta detailing (balusters, urns, parapet walls, etc.) are particularly susceptible to extensive loss of material (Fig. 8). These elements face the most severe vicissitudes of water- and temperature-related deterioration in direct proportion to the extent of their exposure. The replacement of missing units should be a high priority work item in the rehabilitation of glazed architectural terra-cotta.

**Deterioration of metal anchoring:** Deteriorated anchoring systems are perhaps the most difficult form of glazed architectural terra-cotta deterioration to locate or diagnose. Often, the damage must be severe and irreparable before it is noticed on even the most intense "prima facie" examination. Water which enters the glazed architectural terra-cotta system can rust the anchoring system and substantially weaken or completely disintegrate those elements. Where water has been permitted to enter the system, some deterioration has more than likely taken place. Partial deterioration results in staining and material spalling. Total deterioration and the lack of any anchoring system may result in the loosening of the units themselves, threatening the architectural or structural integrity of the building. Recently, falling glazed architectural terra-cotta units have become a serious safety concern to many building owners and municipal governments (Fig. 9). Early detection of failing anchoring systems is exceedingly difficult.



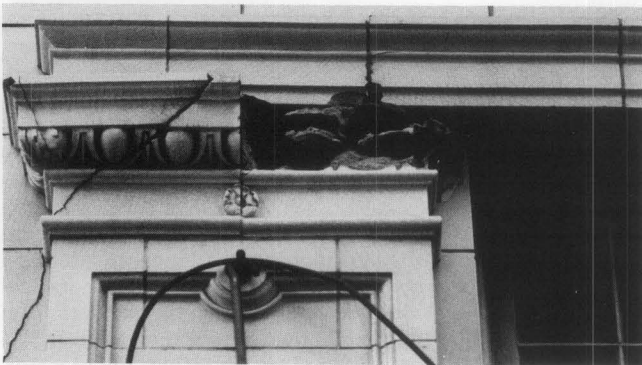
**Figure 9. Deterioration of Metal Anchoring and Masonry Backfill.** Trapped water may deteriorate masonry backfill or rust metal anchoring causing overhanging architectural elements to loosen and drop from the building. This is particularly true when unmaintained roof drainage systems fail and soak the masonry system. Note the exposed metal anchoring.

**Deterioration of mortar and other adjacent materials:** Deteriorated mortar has always been a key to the survival or failure of any masonry system. This is particularly true with glazed architectural terra-cotta. In recognition of the fragile nature of the system, the need for insuring a relatively dry internal system is important. Sound mortar is the "first line" of defense in terra-cotta systems. It is a maintenance "must." Deteriorated mortar joints are a singularly culpable source of water and, therefore, of deterioration. Mortar deterioration may result from improper original craftsmanship or air-

and water-borne pollution. More often, however, lack of ongoing maintenance is mainly responsible. Deteriorated mortar should not be overlooked as a major source of glazed architectural terra-cotta failure.

The deterioration of materials adjoining the glazed architectural terra-cotta (flashing, capping, roofing, caulking around windows and doors) bears significant responsibility in its deterioration. When these adjoining materials fail, largely as a result of lack of maintenance, water-related deterioration results. For instance, it is not uncommon to find wholesale terra-cotta spalling in close proximity to a window or doorway where the caulking has deteriorated.

**Stress-related deterioration:** Stress-related deterioration of glazed architectural terra-cotta frequently occurs in high rise buildings. The evolution of stress relieving details (flexible joints, shelf angles, etc.) occurred late in the development of American building construction. Consequently, most early continuously clad High Rise buildings (c.1900–1920s) had little or no provisions for normal material and building movement in their original design. The development of large stress-related cracks or wholesale material deterioration is often caused by unaccommodated building-frame shortening under load, thermal expansion and contraction of the façade and moisture expansion of the glazed architectural terra-cotta units themselves (Fig. 10). Cracks running through many units or stories or large areas of material deterioration often indicate stress-related problems. This sort of deterioration, in turn, permits significant water entry into the terra-cotta system.



**Figure 10. Structural Cracking.** Structural cracking, whether static (*nonmoving*) or dynamic (*moving or active*), should be caulked to prevent water entry into the glazed architectural terra-cotta system. Note the exposed webbing.

**Inappropriate repairs:** Inappropriate repairs result because using new terra-cotta for replacement of deteriorated or missing glazed architectural terra-cotta has generally been impractical. Repairs, therefore, have traditionally been made in brick or cementitious build ups of numerous materials such as stucco or fiberglass. Some materials are appropriate temporary or permanent replacements, while others are not. (These issues are discussed at a later point in this report.) However, improper anchoring or bonding of the repair work or visual incompatibility of repairs have themselves, with the passage of time, become rehabilitation problems: replacement brick that is pulling free, cement stucco that is cracking and spalling, or a cement or bituminous repairs that are not visually compatible with the original material.

**Alteration damage:** Alteration damage has occurred as a result of the installation of such building additions as signs, screens, marquees or bird proofing. These installations often necessitated the boring of holes or cutting of the glazed architectural terra-cotta to anchor these additions to the building frame beneath. As the anchoring or caulking deteriorated, or as these elements were removed in subsequent renovation

work, these holes have become significant sources of water-related damage to the glazed architectural terra-cotta system.

#### Deterioration Inspection and Analysis

Certain deterioration in glazed architectural terra-cotta may be on the building surface and patently obvious to the casual observer—crazing, spalling, deterioration of mortar joints. Other deterioration may be internal or within the masonry system and hard to determine—deterioration of anchoring, deterioration behind the glaze, crumbling of internal webbing. *Prima facie*, “first inspection,” examination may indicate surface deterioration problems while not revealing others. This demonstrates one of the most frustrating aspects of dealing with deteriorated glazed architectural terra-cotta: that there are two systems or levels of deterioration, one which is visible and the other which is not.

Material failure in glazed architectural terra-cotta is necessarily complex. For this reason, it is generally advised that the examination and repair of this material should be the responsibility of an experienced professional. Few restorationists have experience in the inspection, repair and replacement of glazed architectural terra-cotta. This is certainly never the province of the amateur or the most well-intentioned but inexperienced architect or engineer. There are some methods of internal and external inspection and analysis which are relatively simple to the trained professional. Other methods, however, are expensive, time consuming, and only in the experimental stage at this writing. These all generally preclude the use of anyone but an experienced professional.

**Preliminary cleaning:** Before a terra-cotta building is analyzed for deterioration, it is often advisable, but not always necessary, to clean the surface of the material. This is particularly true when the material has been exposed to the vicissitudes of heavy urban pollution. While most building materials are cleaned for “cosmetic” purposes, the cleaning of glazed architectural terra-cotta for the purpose of inspection and analysis may be advised. Dirt on glazed architectural terra-cotta often hides a multitude of problems. It is only with cleaning that these problems become obvious. Recommended cleaning procedures are covered later in the report.

#### Methods of inspection:

*Prima facie analysis* is the unit by unit, first-hand, external inspection of the glazed architectural terra-cotta building surface. Special note of all visible surface deterioration (staining, crazing, spalling, cracking, etc.) should be made on elevation drawings. Binoculars are often used where cost, height, or inaccessibility prevent easy inspection. However, much deterioration may go unnoticed unless scaffolding or window-washing apparatus is used in a true “hands on” inspection of each unit of the façade.

*Tapping*, a somewhat inexact method of detection of internal deterioration is, nevertheless, the most reliable inspection procedure presently available. Quite simply, tapping is the striking of each unit with a wooden mallet. When struck, an undamaged glazed architectural terra-cotta unit gives a pronounced ring, indicating its sound internal condition. Conversely, deteriorated units (i.e., units which are failing internally) produce a flat, hollow sound. Metal hammers are never to be used, as they may damage the glazed surface of the unit. Extensive experience is the best teacher with this inspection method.

*Infrared scanning* is only in the experimental stage at this time, but its use seems to hold great promise in locating deteriorated internal material in terra-cotta. All materials emit heat—heat which can be measured in terms of infrared light. While infrared light cannot be seen by the human eye, it can be measured by infrared scanning. Infrared photography, a kind of infrared scanning, has been of particular use in detecting sources of heat loss in buildings in recent years.

Broken or loose internal terra-cotta pieces have a less firm attachment to the surrounding firm or attached pieces and, therefore, have different thermal properties, i.e., temperatures. These temperature differences become evident on the infrared scan and may serve as a fair indication of internal material deterioration in terra-cotta.

*Sonic testing* has been successfully used for some time to detect internal cracking of concrete members. In the hands of an experienced operator, there are conditions where it can detect internal failure in glazed architectural terra-cotta. Sonic testing registers the internal configuration of materials by penetrating the material with sound waves and reading the patterns that "bounce back" from the originating source of the sound. Readings at variance with those from undeteriorated material might indicate collapsed webbing or pools of water in the interior of the terra-cotta unit.

*Metal detection* is a nondestructive and generally useful way of locating the position of internal metal anchoring. Metal detectors indicate the presence of metals by electro-magnetic impulses. These impulses are transmitted onto an oscilloscope where they may be seen or they are converted to sound patterns which may be heard by the operator. Original drawings are eminently useful in predicting where internal metal anchoring should be. Metal detectors can confirm that indeed they are still there. Without original drawings, the contractor or architect can still locate the metal anchoring, however. No reading where an anchor would be expected could indicate a missing anchor or one that has seriously deteriorated. The information produced by metal detection is, at best, only rough. However, it is the most viable way of locating the internal metal anchoring without physically removing, thus irreparably damaging, the glazed architectural terra-cotta units themselves.

*Laboratory analysis* may be carried out on samples of removed original material to find glaze absorption, permeability or glaze adhesion, or to evaluate material for porosity. These tests are useful in determining the present material characteristics of the historic glazed architectural terra-cotta and how they may be expected to perform in the future.

#### Maintenance, Repair and Replacement

Deterioration in glazed architectural terra-cotta is, by definition, insidious in that the outward signs of decay do not always indicate the more serious problems within. It is, therefore, of paramount importance that the repair and replacement of deteriorated glazed architectural terra-cotta not be undertaken unless the causes of that deterioration have been determined and repaired. As mentioned before, one of the primary agents of deterioration in glazed architectural terra-cotta is water. Therefore, water-related damage can be repaired only when the sources of that water have been eliminated. Repointing, caulking and replacement of missing masonry pieces are also of primary concern. Where detailing to conduct water in the original design has been insufficient, the installation of new flashing or weep holes might be considered.

Where stress-related or structural problems have caused the deterioration of glazed architectural terra-cotta, the services of a structural engineer should be sought to mitigate these problems. This may include the installation of relieving joints, shelf angles or flexible joints. In any case, stress-related and structural deterioration, like water-related deterioration, must be stopped before effective consolidation or replacement efforts may begin.

**Cleaning:** The successful cleaning of glazed architectural terra-cotta removes excessive soil from the glazed surface without damaging the masonry unit itself. Of the many cleaning materials available, the most widely recommended are water, detergent, and a natural or nylon bristle brush. More

stubborn pollution or fire-related dirt or bird droppings can be cleaned with steam or weak solutions of muriatic or oxalic acid.

*A note of caution:* Any acids, when used in strong enough solutions, may themselves deteriorate mortar and "liberate" salts within the masonry system, producing a situation called efflorescence. For further information on this situation, refer to: "Preservation Briefs 1: The Cleaning and Waterproof Coating of Masonry Buildings," Heritage Conservation and Recreation Service, Department of the Interior, Washington, D.C.

Commercial cleaning solutions may be appropriate but probably are not necessary when water and detergent will suffice. There are, however, certain cleaning techniques for glazed architectural terra-cotta which are definitely *not* recommended and which would damage the surface of the material. These include: all abrasive cleaning measures (especially sandblasting), the use of strong acids (particularly fluoride-based acids), high-pressure water cleaning and the use of metal bristle brushes. All of these techniques will irreparably harm the glaze in one fashion or another and subsequently expose the porous tile body to the damaging effects of water.

It is important to remember that glazed architectural terra-cotta was designed to be cleaned cheaply and easily. This, in fact, was one of its major assets and was much advertised in the selling of the material early in this century.

**Waterproofing:** The covering of crazed glazing (see Fig. 5) with waterproof coatings is the subject of an on-going controversy today. The question involves whether or not the micro-cracks conduct substantial amounts of water into the porous tile body. Tests indicate that the glaze on new unexposed terra-cotta is itself not completely waterproof. Some testing also indicates that most crazing on historic glazed terra-cotta does not substantially increase the flow of moisture into the porous tile body when compared to new material. Excessive and serious crazing is, however, an exception and the coating of those areas on a limited scale may be wholly appropriate.

In an effort to stem water-related deterioration, architects and building owners often erroneously attribute water-related damage to glaze crazing when the source of the deterioration is, in fact, elsewhere: deteriorated caulking, flashing, etc. The waterproof coating of glazed architectural terra-cotta walls may cause problems on its own. Outward migration of water vapor normally occurs through the mortar joints in these systems. The inadvertent sealing of these joints in the whole-sale coating of the wall may exacerbate an already serious situation. Spalling of the glaze, mortar, or porous body will, more than likely, result.

**Repointing:** Repointing of mortar which is severely deteriorated or improperly or infrequently maintained is one of the most useful preservation activities that can be performed on historic glazed architectural terra-cotta buildings. On-going and cyclical repointing guarantees the long life of this material. Repointing should always be carried out with a mortar which has a compressive strength (measured in p.s.i.) *lower* than the adjacent masonry unit. Hard (Portland cement) or coarsely screened mortars may cause point loading and/or prevent the outward migration of the water through the mortar joints, both of which ultimately damage the terra-cotta unit. Repointing with waterproof caulking compounds or similar waterproof materials should never be undertaken because, like waterproof coatings, they impede the normal outward migration of moisture through the masonry joints. Moisture then may build sufficient pressure behind the waterproof caulk and the glaze on the terra-cotta to cause damage to the unit itself.

**Repair of glaze spalling:** Glaze spalling is also a highly culpable source of water-related deterioration in glazed archi-

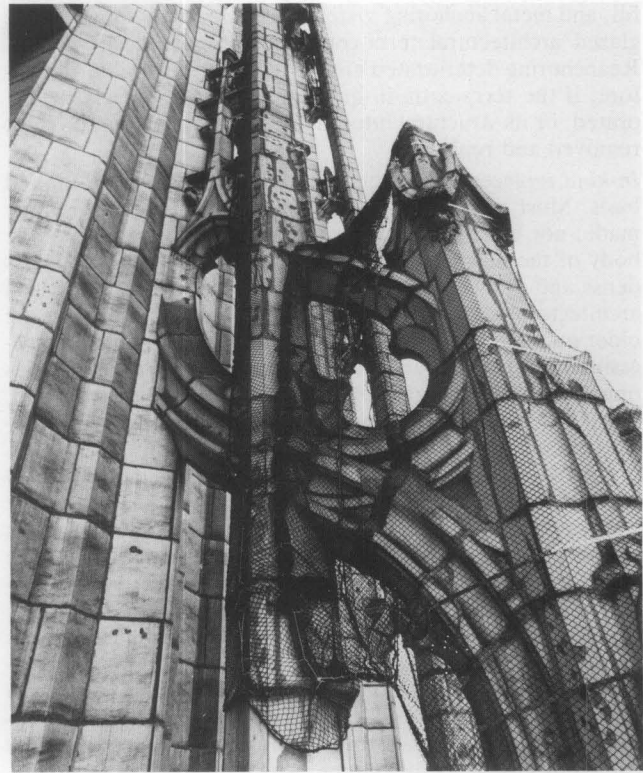
tectural terra-cotta. It is important to coat or seal these blistered areas (see Fig. 6) and to prevent further entry of water into the system by this route. All loose or friable material should be removed. This may be done easily by hand; chisels or similar small tools are most effective. The exposed material is then painted over. At this time, no permanently effective reglazing materials are available. However, there are several acrylic-based proprietary products and masonry paints which can be used effectively to protect these exposed areas, thus preventing the entry of water. These materials are effective for 5 to 7 years and can be reapplied. They also can be tinted to approximate closely the original glaze color.

**Repair of minor material spalling:** Minor material spalling, where visual or cosmetic considerations are negligible, should be treated in a manner similar to glaze spalling damage. That is, areas where small portions of the body and glaze have spalled and which are far removed from close scrutiny (i.e., detailing on entablatures, upper story windows, etc.) are best remedied by painting with a masonry paint or an acrylic-based proprietary product. Units on which material spalling is easily observed (on the street level, door surrounds, etc.), and on which visual integrity is a consideration, may be better replaced. Patching is not appropriate. Stucco-like or cementitious build-ups are difficult to form satisfactorily, safely and compatibly in situ to replace missing pieces of glazed architectural terra-cotta. Cementitious repairs never satisfactorily bond to the original material. The differential expansion coefficients of the two materials (the repair and the original) preclude a safe, effective and long-term attachment.

**Repair of major spalling:** Glazed architectural terra-cotta units, which have spalled severely thereby losing much of their material and structural integrity in the wall, should be replaced. Partial in situ repair will not be long lasting and may, in fact, cause complicated restoration problems at a later date. Appropriate methods of replacement are discussed at a later point in this report.

**Temporary stabilization:** Stabilization measures are necessary when deterioration is so severe as to create a situation where pieces of glazed architectural terra-cotta may fall from the building. This is a particular concern with greatly exposed detailing: cornices, balconies, balustrades, urns, columns, buttresses, etc. Restoration work on these pieces is expensive and often must be carried on over a period of time. Unstable terra-cotta pieces are often removed or destroyed in lieu of such measures. This is particularly true in areas of heavy traffic-related vibrations or in earthquake zones. There are, however, less severe measures which may be employed on a temporary basis. Substantial success has been achieved in securing unstable glazed architectural terra-cotta pieces with metal strapping and nylon net (Fig. 11). While these measures should not be seen as permanent preservation solutions, they do offer temporary alternatives to the wanton destruction of significant glazed architectural terra-cotta detailing in the name of public safety and local code compliance.

**Repair of addition and structural damage:** Holes, sign anchors, slots for channel steel, or structural cracking in the surface of glazed architectural terra-cotta cladding should be permanently sealed with a material that will expand with the normal dynamics of the surrounding material, yet effectively keep water out of the system. Any one of a number of commercially available waterproof caulking compounds would be appropriate for this work. Holes and static (nonmoving) cracks may be caulked with butyl sealants or acrylic latex caulks. For dynamic (moving or active) cracks, the polysulfide caulks are most often used, although others may be safely employed. It is, however, important to remember that these waterproof caulking compounds are not viable repointing materials and should not be used as such.



**Figure 11. Temporary Stabilization Measures.** Falling glazed architectural terra-cotta detailing has become a source of concern, particularly in dense urban areas and locations of high seismic activity. Nylon netting and metal strapping, while not seen as permanent preservation measures, do offer a temporary alternative to the removal of these elements.

**Temporary replacement:** Temporary replacement measures should be implemented when missing units are scheduled to be replaced but work cannot be undertaken immediately. Lengthy delivery time, prorating of work or seasonal considerations may postpone replacement work. Severe deterioration should at least be ameliorated until work can begin. Temporary repointing, removal and saving of undamaged units to be reset later, or the temporary installation of brick infill to retard further deterioration might be considered.

**Removing earlier repairs:** Removing earlier repairs may be necessary when the work has either deteriorated or has become visually incompatible. Cementitious stucco, caulking with black bituminous compounds or brick repair work may become structurally or visually unstable or incompatible and should be removed and properly rehabilitated.

**Replacement of glazed architectural terra-cotta:** Replacement of severely spalled, damaged, or missing glazed architectural terra-cotta elements is always difficult. Certainly, in-kind replacement is advisable, but it has a number of drawbacks. Stone, fiberglass, and precast concrete are also viable choices, but like in-kind replacement, also have their inherent problems.

*Several notes on replacement:* When replacing glazed architectural terra-cotta, all of the original deteriorated material should be completely removed. Half bricks or similar cosmetic replacement techniques are not advised.

—When possible and where applicable, replacement units should be anchored in a manner similar to the original. Both structural and visual compatibility are major considerations when choosing replacement materials.

—Removing and reanchoring damaged glazed architectural terra-cotta is an extremely difficult if not impossible task. The complexity of the interlocking system of masonry units, back-

fill, and metal anchoring system precludes the removal of the glazed architectural terra-cotta unit without destroying it. Reanchoring deteriorated units is likewise impossible. Therefore, if the terra-cotta in question is loose, severely deteriorated, or its structural integrity in serious question, it is best removed and replaced.

*In-kind* replacement is possible today, but only on a limited basis. Most new glazed architectural terra-cotta is machine made, not hand made as the original. Thus, the porous tile body of the new material tends to be more uniform but less dense and often not as durable. The glaze on the new glazed architectural terra-cotta tends to be thinner than that on the older material and subsequently more brittle. Machine processing has also produced a glaze that is uniform in color as opposed to historic glazes which were slightly mottled and, therefore, richer. Visual compatibility is an important consideration when replacing in-kind.

Only a fairly limited inventory of in-kind pieces is presently available for replacement such as plain ashlar blocks and the simpler details such as cappings and sills. When deterioration severely damages the more ornate pieces (urns, cartouche work, balusters, etc.) either expensive hand casting or alternative materials must be sought. There is a tendency today to replace damaged ornamental work with simpler, cheaper and more readily available units. This decision *cannot*, however, be supported, as the removal of this work inevitably diminishes the character and integrity of the building. Another major consideration in choosing in-kind replacement is the question of delivery time, which is often quite lengthy. If new glazed architectural terra-cotta is chosen as a replacement material, the architect or building owner should plan far in advance.

*Stone* may be a suitable replacement material for damaged glazed architectural terra-cotta. Its durability makes it highly appropriate, although the increase in weight over the original hollow units may be of some concern. The fact that historic glazed architectural terra-cotta was glazed in imitation of stone, however, may make the choice of stone as a replacement material a fortuitous one. Metal anchoring may be accommodated easily in the carving. Cost, however, is the major drawback in stone replacement, particularly where rich detailing must be carved to match the original.

*Fiberglass* replacement is a viable alternative, particularly when rich and elaborate ornamentation has to be duplicated. Casting from original intact pieces can produce numerous sharp copies of entablatures, moldings, balusters, voussoirs, etc. Anchoring is easily included in casting.

Significant drawbacks in using fiberglass replacement are color compatibility, fire code violations and poor weathering and aging properties. The appropriate coloring of fiberglass is exceedingly difficult in many instances. Painting is often unsatisfactory, as it discolors at a rate different than that of the historic glazed original. While fiberglass casting is lighter than the original units and, therefore, of great interest in the rehabilitation of buildings in areas of high seismic activity, many fire code requirements cannot be met with the use of this material.

*Precast concrete* units show great promise in replacing glazed architectural terra-cotta at this writing. Precast concrete units can, like fiberglass, replicate nuances of detail in a modular fashion; they can also be cast hollow, use light-weight aggregate and be made to accommodate metal anchoring when necessary. Concrete can be colored or tinted to match the original material with excellent results. It is cost effective and once production is in process, precast concrete can be produced quickly and easily.

Experience shows that it is advisable to use a clear masonry coating on the weather face of the precast concrete units to guarantee the visual compatibility of the new unit, to prevent

moisture absorption, to obtain the proper reflectivity in imitation of the original glaze and to prevent weathering of the unit itself. Precast concrete replacement units are presently enjoying great use in replicating historic glazed architectural terra-cotta and show promise for future rehabilitation programs.

Once the replacement material is selected (new glazed architectural terra-cotta, stone, precast concrete, or fiberglass), it must be reanchored into the masonry system. Original metal anchoring came in numerous designs, materials and coatings ranging from bituminous-coated iron to bronze. While most of these anchors are no longer available, they may be easily replicated in large quantities either in the original material when appropriate or out of more durable and available metals such as stainless steel.

Since the masonry backfill is already in place in the historic building, the new replacement unit with anchoring may simply be fitted into the existing backfill by boring a hole or slot for anchor and bedding the anchor and the unit itself in mortar. When replacing historic glazed architectural terra-cotta which originally employed metal anchoring, it is important to replace that anchoring when replacing the unit. Serious problems may result if anchoring is omitted in restoration when it was used originally. It is erroneous to assume that mortar alone will be sufficient to hold these replacement pieces in place.

### Summary

Today, many of this country's buildings are constructed of glazed architectural terra-cotta. However, many of these are in a state of serious deterioration and decay. Glazed architectural terra-cotta was, in many ways, the "wonder" material of the American building industry in the late 19th century and during the first decades of the 20th century. New technology and methods of rehabilitation now hold promise for the restoration and rehabilitation of these invaluable and significant resources. Restoration/rehabilitation work on glazed architectural terra-cotta is demanding and will not tolerate half-way measures. Today's preservation work should equal the spirit, attention to detail, pride in workmanship and care which characterized the craftsmanship associated with this widely used, historic masonry material.

### Suggested Further Readings

- "Recipes for Baked Earth." *Progressive Architecture*, (November, 1977).
- McIntyre, W.A. *Investigations into the Durability of Architectural Terra Cotta*. Special Report 12. London: Department of Scientific and Industrial Research, Building Research Station, 1929.
- Prudon, Theodore H.M. "Architectural Terra-Cotta: Analyzing the Deterioration Problems and Restoration Approaches." *Technology and Conservation*, Vol. 3 (Fall, 1978). pp. 30-38.
- Prudon, Theodore H.M. *Terra Cotta as a Building Material, A Bibliography*. Ottawa, Ontario: Association for Preservation Technology, 1976.

The illustrations for this brief not specifically credited are from the files of the Technical Preservation Services Division.

This Preservation Brief was written by de Teel Patterson Tiller, Architectural Historian, Technical Preservation Services Division. Information for this publication was based in part upon interviews and consultation with Theodore H.M. Prudon, The Ehrenkrantz Group, P.C., New York, New York. Additional comments and information were provided by Si A. Bortz, Illinois Institute of Technology Research Institute, Chicago, Illinois, and Jerry G. Stockbridge, Wiss, Janney, Elstner, and Associates, Northbrook, Illinois.

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June 1979.





U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

# Preservation Briefs: 9

## The Repair of Historic Wooden Windows

John H. Myers

The windows on many historic buildings are an important aspect of the architectural character of those buildings. Their design, craftsmanship, or other qualities may make them worthy of preservation. This is self-evident for ornamental windows, but it can be equally true for warehouses or factories where the windows may be the most dominant visual element of an otherwise plain building (see figure 1). Evaluating the significance of these windows and planning for their repair or replacement can be a complex process involving both objective and subjective considerations. The *Secretary of the Interior's Standards for Rehabilitation*, and the accompanying guidelines, call for respecting the significance of original materials and features, repairing and retaining them wherever possible, and when necessary, replacing them in kind. This Brief is based on the issues of significance and repair which are implicit in the standards, but the primary emphasis is on the technical issues of planning for the repair of windows including evaluation of their physical condition, techniques of repair, and design considerations when replacement is necessary.

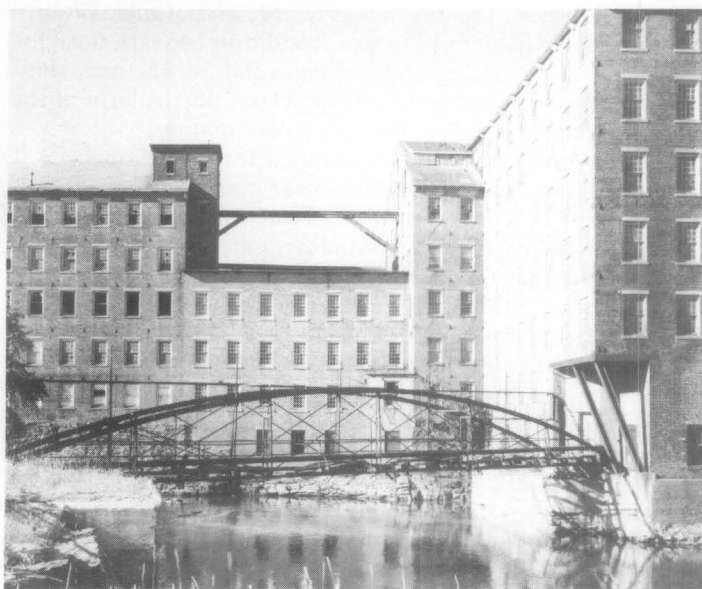


Figure 1. Windows are frequently important visual focal points, especially on simple facades such as this mill building. Replacement of the multi-pane windows here with larger panes could dramatically change the appearance of the building. The areas of missing windows convey the impression of such a change. Photo: John T. Lowe

Much of the technical section presents repair techniques as an instructional guide for the do-it-yourselfer. The information will be useful, however, for the architect, contractor, or developer on large-scale projects. It presents a methodology for approaching the evaluation and repair of existing windows, and considerations for replacement, from which the professional can develop alternatives and specify appropriate materials and procedures.

### Architectural or Historical Significance

Evaluating the architectural or historical significance of windows is the first step in planning for window treatments, and a general understanding of the function and history of windows is vital to making a proper evaluation. As a part of this evaluation, one must consider four basic window functions: admitting light to the interior spaces, providing fresh air and ventilation to the interior, providing a visual link to the outside world, and enhancing the appearance of a building. No single factor can be disregarded when planning window treatments; for example, attempting to conserve energy by closing up or reducing the size of window openings may result in the use of *more* energy by increasing electric lighting loads and decreasing passive solar heat gains.

Historically, the first windows in early American houses were casement windows; that is, they were hinged at the side and opened outward. In the beginning of the eighteenth century single- and double-hung windows were introduced. Subsequently many styles of these vertical sliding sash windows have come to be associated with specific building periods or architectural styles, and this is an important consideration in determining the significance of windows, especially on a local or regional basis. Site-specific, regionally oriented architectural comparisons should be made to determine the significance of windows in question. Although such comparisons may focus on specific window types and their details, the ultimate determination of significance should be made within the context of the whole building, wherein the windows are one architectural element (see figure 2).

After all of the factors have been evaluated, *windows should be considered significant to a building if they:* 1) are original, 2) reflect the original design intent for the building, 3) reflect period or regional styles or building practices, 4) reflect changes to the building resulting from major periods or events, or 5) are examples of exceptional craftsmanship or design. Once this evaluation of significance has been completed, it is possible to pro-

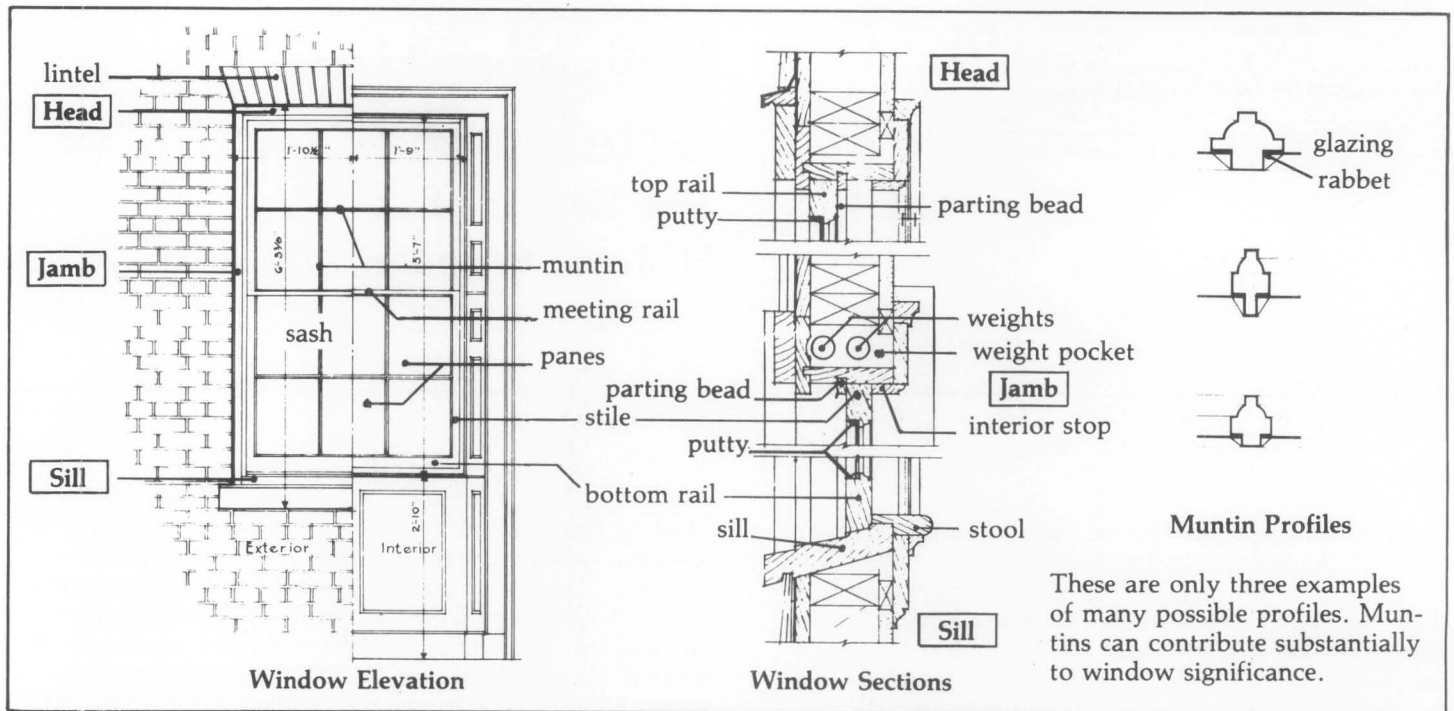


Figure 2. These drawings of window details identify major components, terminology, and installation details for a wooden double-hung window.

ceed with planning appropriate treatments, beginning with an investigation of the physical condition of the windows.

### Physical Evaluation

The key to successful planning for window treatments is a careful evaluation of existing physical conditions on a unit-by-unit basis. A graphic or photographic system may be devised to record existing conditions and illustrate the scope of any necessary repairs. Another effective tool is a window schedule which lists all of the parts of each window unit. Spaces by each part allow notes on existing conditions and repair instructions. When such a schedule is completed, it indicates the precise tasks to be performed in the repair of each unit and becomes a part of the specifications. In any evaluation, one should note at a minimum, 1) window location, 2) condition of the paint, 3) condition of the frame and sill, 4) condition of the sash (rails, stiles and muntins), 5) glazing problems, 6) hardware, and 7) the overall condition of the window (excellent, fair, poor, and so forth).

Many factors such as poor design, moisture, vandalism, insect attack, and lack of maintenance can contribute to window deterioration, but moisture is the primary contributing factor in wooden window decay. All window units should be inspected to see if water is entering around the edges of the frame and, if so, the joints or seams should be caulked to eliminate this danger. The glazing putty should be checked for cracked, loose, or missing sections which allow water to saturate the wood, especially at the joints. The back putty on the interior side of the pane should also be inspected, because it creates a seal which prevents condensation from running down into the joinery. The sill should be examined to insure that it slopes downward away from the building and allows water to drain off. In addition, it may be advisable to cut a dripline along the underside of the sill. This almost invisible treatment will insure proper water run-off, particu-

larly if the bottom of the sill is flat. Any conditions, including poor original design, which permit water to come in contact with the wood or to puddle on the sill must be corrected as they contribute to deterioration of the window.

One clue to the location of areas of excessive moisture is the condition of the paint; therefore, each window should be examined for areas of paint failure. Since excessive moisture is detrimental to the paint bond, areas of paint blistering, cracking, flaking, and peeling usually identify points of water penetration, moisture saturation, and potential deterioration. Failure of the paint should not, however, be mistakenly interpreted as a sign that the wood is in poor condition and hence, irreparable. Wood is frequently in sound physical condition beneath unsightly paint. After noting areas of paint failure, the next step is to inspect the condition of the wood, particularly at the points identified during the paint examination.

Each window should be examined for operational soundness beginning with the lower portions of the frame and sash. Exterior rainwater and interior condensation can flow downward along the window, entering and collecting at points where the flow is blocked. The sill, joints between the sill and jamb, corners of the bottom rails and muntin joints are typical points where water collects and deterioration begins (see figure 3). The operation of the window (continuous opening and closing over the years and seasonal temperature changes) weakens the joints, causing movement and slight separation. This process makes the joints more vulnerable to water which is readily absorbed into the end-grain of the wood. If severe deterioration exists in these areas, it will usually be apparent on visual inspection, but other less severely deteriorated areas of the wood may be tested by two traditional methods using a small ice pick.

An ice pick or an awl may be used to test wood for soundness. The technique is simply to jab the pick into a wetted wood surface at an angle and pry up a small sec-

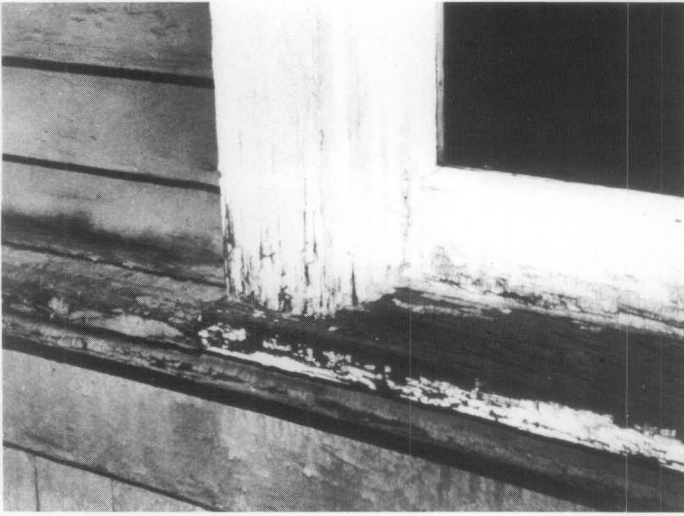


Figure 3. Deterioration of poorly maintained windows usually begins on horizontal surfaces and at joints where water can collect and saturate the wood. The problem areas are clearly indicated by paint failure due to moisture. Photo: Baird M. Smith, AIA

tion of the wood. Sound wood will separate in long fibrous splinters, but decayed wood will lift up in short irregular pieces due to the breakdown of fiber strength.

Another method of testing for soundness consists of pushing a sharp object into the wood, perpendicular to the surface. If deterioration has begun from the hidden side of a member and the core is badly decayed, the visible surface may appear to be sound wood. Pressure on the probe can force it through an apparently sound skin to penetrate deeply into decayed wood. This technique is especially useful for checking sills where visual access to the underside is restricted.

Following the inspection and analysis of the results, the scope of the necessary repairs will be evident and a plan for the rehabilitation can be formulated. Generally the actions necessary to return a window to "like new" condition will fall into three broad categories: 1) routine maintenance procedures, 2) structural stabilization, and 3) parts replacement. These categories will be discussed in the following sections and will be referred to respectively as Repair Class I, Repair Class II, and Repair Class III. Each successive repair class represents an increasing level of difficulty, expense, and work time. Note that most of the points mentioned in Repair Class I are routine maintenance items and should be provided in a regular maintenance program for any building. The neglect of these routine items can contribute to many common window problems.

Before undertaking any of the repairs mentioned in the following sections all sources of moisture penetration should be identified and eliminated, and all existing decay fungi destroyed in order to arrest the deterioration process. Many commercially available fungicides and wood preservatives are toxic, so it is extremely important to follow the manufacturer's recommendations for application, and store all chemical materials away from children and animals. After fungicidal and preservative treatment the windows may be stabilized, retained, and restored with every expectation for a long service life.

### Repair Class I: Routine Maintenance

Repairs to wooden windows are usually labor intensive and relatively uncomplicated. On small scale projects this

allows the do-it-yourselfer to save money by repairing all or part of the windows. On larger projects it presents the opportunity for time and money which might otherwise be spent on the removal and replacement of existing windows, to be spent on repairs, subsequently saving all or part of the material cost of new window units. Regardless of the actual costs, or who performs the work, the evaluation process described earlier will provide the knowledge from which to specify an appropriate work program, establish the work element priorities, and identify the level of skill needed by the labor force.

The routine maintenance required to upgrade a window to "like new" condition normally includes the following steps: 1) some degree of interior and exterior paint removal, 2) removal and repair of sash (including reglazing where necessary), 3) repairs to the frame, 4) weatherstripping and reinstallation of the sash, and 5) repainting. These operations are illustrated for a typical double-hung wooden window (see figures 4a-f), but they may be adapted to other window types and styles as applicable.

Historic windows have usually acquired many layers of paint over time. Removal of excess layers or peeling and flaking paint will facilitate operation of the window and restore the clarity of the original detailing. Some degree of paint removal is also necessary as a first step in the proper surface preparation for subsequent refinishing (if paint color analysis is desired, it should be conducted prior to the onset of the paint removal). There are several safe and effective techniques for removing paint from wood, depending on the amount of paint to be removed. Several techniques such as scraping, chemical stripping, and the use of a hot air gun are discussed in "Preservation Briefs: 10 Paint Removal from Historic Woodwork" (see Additional Reading section at end).

Paint removal should begin on the interior frames, being careful to remove the paint from the interior stop and the parting bead, particularly along the seam where these stops meet the jamb. This can be accomplished by running a utility knife along the length of the seam, breaking the paint bond. It will then be much easier to remove the stop, the parting bead and the sash. The interior stop may be initially loosened from the sash side to avoid visible scarring of the wood and then gradually pried loose using a pair of putty knives, working up and down the stop in small increments (see figure 4b). With the stop removed, the lower or interior sash may be withdrawn. The sash cords should be detached from the sides of the sash and their ends may be pinned with a nail or tied in a knot to prevent them from falling into the weight pocket.

Removal of the upper sash on double-hung units is similar but the parting bead which holds it in place is set into a groove in the center of the stile and is thinner and more delicate than the interior stop. After removing any paint along the seam, the parting bead should be carefully pried out and worked free in the same manner as the interior stop. The upper sash can be removed in the same manner as the lower one and both sash taken to a convenient work area (in order to remove the sash the interior stop and parting bead need only be removed from one side of the window). Window openings can be covered with polyethylene sheets or plywood sheathing while the sash are out for repair.

The sash can be stripped of paint using appropriate techniques, but if any heat treatment is used (see figure 4c), the glass should be removed or protected from the sudden temperature change which can cause breakage. An



Figure 4a. The following series of photographs of the repair of a historic double-hung window use a unit which is structurally sound but has many layers of paint, some cracked and missing putty, slight separation at the joints, broken sash cords, and one cracked pane. Photo: John H. Myers



Figure 4b. After removing paint from the seam between the interior stop and the jamb, the stop can be pried out and gradually worked loose using a pair of putty knives as shown. To avoid visible scarring of the wood, the sash can be raised and the stop pried loose initially from the outer side. Photo: John H. Myers



Figure 4c. Sash can be removed and repaired in a convenient work area. Paint is being removed from this sash with a hot air gun while an asbestos sheet protects the glass from sudden temperature change. Photo: John H. Myers

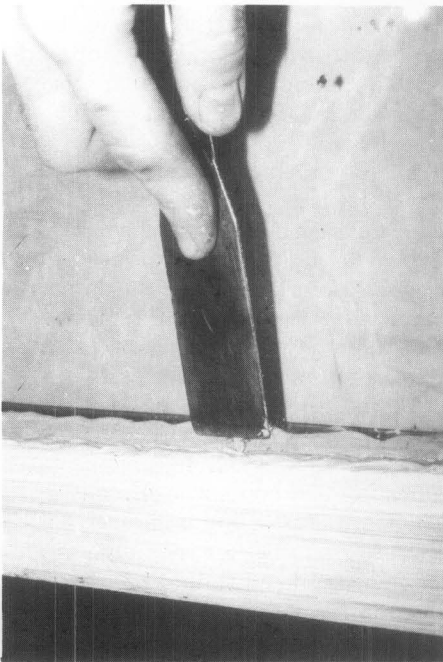


Figure 4d. Reglazing or replacement of the putty requires that the existing putty be removed manually, the glazing points be extracted, the glass removed, and the back putty scraped out. To reglaze, a bed of putty is laid around the perimeter of the rabbet, the pane is pressed into place, glazing points are inserted to hold the pane (shown), and a final seal of putty is beveled around the edge of the glass. Photo: John H. Myers



Figure 4e. A common repair is the replacement of broken sash cords with new cords (shown) or with chains. The weight pocket is often accessible through a removable plate in the jamb, or by removing the interior trim. Photo: John H. Myers



Figure 4f. Following the relatively simple repairs, the window is weathertight, like new in appearance, and serviceable for many years to come. Both the historic material and the detailing and craftsmanship of this original window have been preserved. Photo: John H. Myers

overlay of aluminum foil on gypsum board or asbestos can protect the glass from such rapid temperature change. It is important to protect the glass because it may be historic and often adds character to the window. Deteriorated putty should be removed manually, taking care not to damage the wood along the rabbet. If the glass is to be removed, the glazing points which hold the glass in place can be extracted and the panes numbered and removed for cleaning and reuse in the same openings. With the glass panes out, the remaining putty can be removed and the sash can be sanded, patched, and primed with a preservative primer. Hardened putty in the rabbets may be softened by heating with a soldering iron at the point of removal. Putty remaining on the glass may be softened by soaking the panes in linseed oil, and then removed with less risk of breaking the glass. Before reinstalling the glass, a bead of glazing compound or linseed oil putty should be laid around the rabbet to cushion and seal the glass. Glazing compound should only be used on wood which has been brushed with linseed oil and primed with an oil based primer or paint. The pane is then pressed into place and the glazing points are pushed into the wood around the perimeter of the pane (see figure 4d). The final glazing compound or putty is applied and beveled to complete the seal. The sash can be refinished as desired on the inside and painted on the outside as soon as a "skin" has formed on the putty, usually in 2 or 3 days. Exterior paint should cover the beveled glazing compound or putty and lap over onto the glass slightly to complete a weathertight seal. After the proper curing times have elapsed for paint and putty, the sash will be ready for reinstallation.

While the sash are out of the frame, the condition of the wood in the jamb and sill can be evaluated. Repair and refinishing of the frame may proceed concurrently with repairs to the sash, taking advantage of the curing times for the paints and putty used on the sash. One of the most common work items is the replacement of the sash cords with new rope cords or with chains (see figure 4e). The weight pocket is frequently accessible through a door on the face of the frame near the sill, but if no door exists, the trim on the interior face may be removed for access. Sash weights may be increased for easier window operation by elderly or handicapped persons. Additional repairs to the frame and sash may include consolidation or replacement of deteriorated wood. Techniques for these repairs are discussed in the following sections.

The operations just discussed summarize the efforts necessary to restore a window with minor deterioration to "like new" condition (see figure 4f). The techniques can be applied by an unskilled person with minimal training and experience. To demonstrate the practicality of this approach, and photograph it, a Technical Preservation Services staff member repaired a wooden double-hung, two over two window which had been in service over ninety years. The wood was structurally sound but the window had one broken pane, many layers of paint, broken sash cords and inadequate, worn-out weatherstripping. The staff member found that the frame could be stripped of paint and the sash removed quite easily. Paint, putty and glass removal required about one hour for each sash, and the reglazing of both sash was accomplished in about one hour. Weatherstripping of the sash and frame, replacement of the sash cords and reinstallation of the sash, parting bead, and stop required an hour and a half. These times refer only to individual operations; the entire proc-

ess took several days due to the drying and curing times for putty, primer, and paint, however, work on other window units could have been in progress during these lag times.

## Repair Class II: Stabilization

The preceding description of a window repair job focused on a unit which was operationally sound. Many windows will show some additional degree of physical deterioration, especially in the vulnerable areas mentioned earlier, but even badly damaged windows can be repaired using simple processes. Partially decayed wood can be water-proofed, patched, built-up, or consolidated and then painted to achieve a sound condition, good appearance, and greatly extended life. Three techniques for repairing partially decayed or weathered wood are discussed in this section, and all three can be accomplished using products available at most hardware stores.

One established technique for repairing wood which is split, checked or shows signs of rot, is to: 1) dry the wood, 2) treat decayed areas with a fungicide, 3) water-proof with two or three applications of boiled linseed oil (applications every 24 hours), 4) fill cracks and holes with putty, and 5) after a "skin" forms on the putty, paint the surface. Care should be taken with the use of fungicide which is toxic. Follow the manufacturers' directions and use only on areas which will be painted. When using any technique of building up or patching a flat surface, the finished surface should be sloped slightly to carry water away from the window and not allow it to puddle. Caulking of the joints between the sill and the jamb will help reduce further water penetration.

When sills or other members exhibit surface weathering they may also be built-up using wood putties or home-made mixtures such as sawdust and resorcinol glue, or whitening and varnish. These mixtures can be built up in successive layers, then sanded, primed, and painted. The same caution about proper slope for flat surfaces applies to this technique.

Wood may also be strengthened and stabilized by consolidation, using semi-rigid epoxies which saturate the porous decayed wood and then harden. The surface of the consolidated wood can then be filled with a semi-rigid epoxy patching compound, sanded and painted (see figure 5). Epoxy patching compounds can be used to build up



Figure 5. This illustrates a two-part epoxy patching compound used to fill the surface of a weathered sill and rebuild the missing edge. When the epoxy cures, it can be sanded smooth and painted to achieve a durable and waterproof repair. Photo: John H. Myers

missing sections or decayed ends of members. Profiles can be duplicated using hand molds, which are created by pressing a ball of patching compound over a sound section of the profile which has been rubbed with butcher's wax. This can be a very efficient technique where there are many typical repairs to be done. Technical Preservation Services has published *Epoxies for Wood Repairs in Historic Buildings* (see Additional Reading section at end), which discusses the theory and techniques of epoxy repairs. The process has been widely used and proven in marine applications; and proprietary products are available at hardware and marine supply stores. Although epoxy materials may be comparatively expensive, they hold the promise of being among the most durable and long lasting materials available for wood repair.

Any of the three techniques discussed can stabilize and restore the appearance of the window unit. There are times, however, when the degree of deterioration is so advanced that stabilization is impractical, and the only way to retain some of the original fabric is to replace damaged parts.

### Repair Class III: Splices and Parts Replacement

When parts of the frame or sash are so badly deteriorated that they cannot be stabilized there are methods which permit the retention of some of the existing or original fabric. These methods involve replacing the deteriorated parts with new matching pieces, or splicing new wood into existing members. The techniques require more skill and are more expensive than any of the previously discussed alternatives. It is necessary to remove the sash and/or the affected parts of the frame and have a carpenter or woodworking mill reproduce the damaged or missing parts. Most millwork firms can duplicate parts, such as muntins, bottom rails, or sills, which can then be incorporated into the existing window, but it may be necessary to shop around because there are several factors controlling the practicality of this approach. Some woodworking mills do not like to repair old sash because nails or other foreign objects in the sash can damage expensive knives (which cost far more than their profits on small repair jobs); others do not have cutting knives to duplicate muntin profiles. Some firms prefer to concentrate on larger jobs with more profit potential, and some may not have a craftsman who can duplicate the parts. A little searching should locate a firm which will do the job, and at a reasonable price. If such a firm does not exist locally, there are firms which undertake this kind of repair and ship nationwide. It is possible, however, for the advanced do-it-yourselfer or craftsman with a table saw to duplicate moulding profiles using techniques discussed by Gordie Whittington in "Simplified Methods for Reproducing Wood Mouldings," *Bulletin of the Association for Preservation Technology*, Vol. III, No. 4, 1971, or illustrated more recently in *The Old House*, Time-Life Books, Alexandria, Virginia, 1979.

The repairs discussed in this section involve window frames which may be in very deteriorated condition, possibly requiring removal; therefore, caution is in order. The actual construction of wooden window frames and sash is not complicated. Pegged mortise and tenon units can be disassembled easily, if the units are out of the building. The installation or connection of some frames to the surrounding structure, especially masonry walls, can complicate the work immeasurably, and may even require

dismantling of the wall. It may be useful, therefore, to take the following approach to frame repair: 1) conduct regular maintenance of sound frames to achieve the longest life possible, 2) make necessary repairs in place wherever possible, using stabilization and splicing techniques, and 3) if removal is necessary, thoroughly investigate the structural detailing and seek appropriate professional consultation.

Another alternative may be considered if parts replacement is required, and that is sash replacement. If extensive replacement of parts is necessary and the job becomes prohibitively expensive it may be more practical to purchase new sash which can be installed into the existing frames. Such sash are available as exact custom reproductions, reasonable facsimiles (custom windows with similar profiles), and contemporary wooden sash which are similar in appearance. There are companies which still manufacture high quality wooden sash which would duplicate most historic sash. A few calls to local building suppliers may provide a source of appropriate replacement sash, but if not, check with local historical associations, the state historic preservation office, or preservation related magazines and supply catalogs for information.

If a rehabilitation project has a large number of windows such as a commercial building or an industrial complex, there may be less of a problem arriving at a solution. Once the evaluation of the windows is completed and the scope of the work is known, there may be a potential economy of scale. Woodworking mills may be interested in the work from a large project; new sash in volume may be considerably less expensive per unit; crews can be assembled and trained on site to perform all of the window repairs; and a few extensive repairs can be absorbed (without undue burden) into the total budget for a large number of sound windows. While it may be expensive for the average historic home owner to pay seventy dollars or more for a mill to grind a custom knife to duplicate four or five bad muntins, that cost becomes negligible on large commercial projects which may have several hundred windows.

Most windows should not require the extensive repairs discussed in this section. The ones which do are usually in buildings which have been abandoned for long periods or have totally lacked maintenance for years. It is necessary to thoroughly investigate the alternatives for windows which do require extensive repairs to arrive at a solution which retains historic significance and is also economically feasible. Even for projects requiring repairs identified in this section, if the percentage of parts replacement per window is low, or the number of windows requiring repair is small, repair can still be a cost effective solution.

### Weatherization

A window which is repaired should be made as energy efficient as possible by the use of appropriate weatherstripping to reduce air infiltration. A wide variety of products are available to assist in this task. Felt may be fastened to the top, bottom, and meeting rails, but may have the disadvantage of absorbing and holding moisture, particularly at the bottom rail. Rolled vinyl strips may also be tacked into place in appropriate locations to reduce infiltration. Metal strips or new plastic spring strips may be used on the rails and, if space permits, in

the channels between the sash and jamb. Weatherstripping is a historic treatment, but old weatherstripping (felt) is not likely to perform very satisfactorily. Appropriate contemporary weatherstripping should be considered an integral part of the repair process for windows. The use of sash locks installed on the meeting rail will insure that the sash are kept tightly closed so that the weatherstripping will function more effectively to reduce infiltration. Although such locks will not always be historically accurate, they will usually be viewed as an acceptable contemporary modification in the interest of improved thermal performance.

Many styles of storm windows are available to improve the thermal performance of existing windows. The use of exterior storm windows should be investigated whenever feasible because they are thermally efficient, cost-effective, reversible, and allow the retention of original windows (see "Preservation Briefs: 3"). Storm window frames may be made of wood, aluminum, vinyl, or plastic; however, the use of unfinished aluminum storms should be avoided. The visual impact of storms may be minimized by selecting colors which match existing trim color. Arched top storms are available for windows with special shapes. Although interior storm windows appear to offer an attractive option for achieving double glazing with minimal visual impact, the potential for damaging condensation problems must be addressed. Moisture which becomes trapped between the layers of glazing can condense on the colder, outer prime window, potentially leading to deterioration. The correct approach to using interior storms is to create a seal on the interior storm while allowing some ventilation around the prime window. In actual practice, the creation of such a durable, airtight seal is difficult.

## Window Replacement

Although the retention of original or existing windows is always desirable and this **Brief** is intended to encourage that goal, there is a point when the condition of a window may clearly indicate replacement. The decision process for selecting replacement windows should *not* begin with a survey of contemporary window products which are available as replacements, but should begin with a look at the windows which are being replaced. Attempt to understand the contribution of the window(s) to the appearance of the facade including: 1) the pattern of the openings and their size; 2) proportions of the frame and sash; 3) configuration of window panes; 4) muntin profiles; 5) type of wood; 6) paint color; 7) characteristics of the glass; and 8) associated details such as arched tops, hoods, or other decorative elements. Develop an understanding of how the window reflects the period, style, or regional characteristics of the building, or represents technological development.

Armed with an awareness of the significance of the existing window, begin to search for a replacement which retains as much of the character of the historic window as possible. There are many sources of suitable new windows. Continue looking until an acceptable replacement can be found. Check building supply firms, local woodworking mills, carpenters, preservation oriented magazines, or catalogs or suppliers of old building materials, for product information. Local historical associations and state historic preservation offices may be good sources of

information on products which have been used successfully in preservation projects.

Consider energy efficiency as one of the factors for replacements, but do not let it dominate the issue. Energy conservation is no excuse for the wholesale destruction of historic windows which can be made thermally efficient by historically and aesthetically acceptable means. In fact, a historic wooden window with a high quality storm window added should thermally outperform a new double-glazed metal window which does not have thermal breaks (insulation between the inner and outer frames intended to break the path of heat flow). This occurs because the wood has far better insulating value than the metal, and in addition many historic windows have high ratios of wood to glass, thus reducing the area of highest heat transfer. One measure of heat transfer is the U-value, the number of Btu's per hour transferred through a square foot of material. When comparing thermal performance, the lower the U-value the better the performance. According to *ASHRAE 1977 Fundamentals*, the U-values for single glazed wooden windows range from 0.88 to 0.99. The addition of a storm window should reduce these figures to a range of 0.44 to 0.49. A non-thermal break, double-glazed metal window has a U-value of about 0.6.

## Conclusion

Technical Preservation Services recommends the retention and repair of original windows whenever possible. We believe that the repair and weatherization of existing wooden windows is more practical than most people realize, and that many windows are unfortunately replaced because of a lack of awareness of techniques for evaluation, repair, and weatherization. Wooden windows which are repaired and properly maintained will have greatly extended service lives while contributing to the historic character of the building. Thus, an important element of a building's significance will have been preserved for the future.

## Additional Reading

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# 13 PRESERVATION BRIEFS

## The Repair and Thermal Upgrading of Historic Steel Windows

Sharon C. Park, AIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services



The Secretary of the Interior's "Standards for Rehabilitation" require that where historic windows are individually significant features, or where they contribute to the character of significant facades, their distinguishing visual qualities must not be destroyed. Further, the rehabilitation guidelines recommend against changing the historic appearance of windows through the use of inappropriate designs, materials, finishes, or colors which radically change the sash, depth of reveal, and muntin configuration; the reflectivity and color of the glazing; or the appearance of the frame.

Windows are among the most vulnerable features of historic buildings undergoing rehabilitation. This is especially the case with rolled steel windows, which are often mistakenly not deemed worthy of preservation in the conversion of old buildings to new uses. The ease with which they can be replaced and the mistaken assumption that they cannot be made energy efficient except at great expense are factors that typically lead to the decision to remove them. In many cases, however, repair and retrofit of the historic windows are more economical than wholesale replacement, and all too often, replacement units are unlike the originals in design and appearance. If the windows are important in establishing the historic character of the building (see fig. 1), insensitively designed replacement windows may diminish—or destroy—the building's historic character.

This *Brief* identifies various types of historic steel windows that dominated the metal window market from 1890-1950. It then gives criteria for evaluating deterioration and for determining appropriate treatment, ranging from routine maintenance and weatherization to extensive repairs, so that replacement may be avoided where possible.<sup>1</sup> This information applies to do-it-yourself jobs and to large rehabilitations where the volume of work warrants the removal of all window units for complete overhaul by professional contractors.

This *Brief* is not intended to promote the repair of ferrous metal windows in every case, but rather to insure that preservation is always the first consideration in a rehabilitation project. Some windows are not important elements in defining a building's historic character; others are highly significant, but so deteriorated that repair is infeasible. In such cases, the *Brief* offers guidance in evaluating appropriate replacement windows.



*Fig. 1 Often highly distinctive in design and craftsmanship, rolled steel windows play an important role in defining the architectural character of many later nineteenth and early twentieth century buildings. Art Deco, Art Moderne, the International Style, and Post World War II Modernism depended on the slim profiles and streamlined appearance of metal windows for much of their impact. Photo: William G. Johnson.*

<sup>1</sup>The technical information given in this brief is intended for most ferrous (or magnetic) metals, particularly rolled steel. While stainless steel is a ferrous metal, the cleaning and repair techniques outlined here must not be used on it as the finish will be damaged. For information on cleaning stainless steel and non-ferrous metals, such as bronze, Monel, or aluminum, refer to *Metals in America's Historic Buildings* (see bibliography).



## HISTORICAL DEVELOPMENT

Although metal windows were available as early as 1860 from catalogues published by architectural supply firms, they did not become popular until after 1890. Two factors combined to account for the shift from wooden to metal windows about that time. Technology borrowed from the rolling industry permitted the mass production of rolled steel windows. This technology made metal windows cost competitive with conventional wooden windows. In addition, a series of devastating urban fires in Boston, Baltimore, Philadelphia, and San Francisco led to the enactment of strict fire codes for industrial and multi-story commercial and office buildings.

As in the process of making rails for railroads, rolled steel windows were made by passing hot bars of steel through progressively smaller, shaped rollers until the appropriate angled configuration was achieved (see fig. 2). The rolled steel sections, generally  $1/8''$  thick and  $1'' - 1\ 1/2''$  wide, were used for all the components of the windows: sash, frame, and subframe (see fig. 3). With the addition of wire glass, a fire-resistant window resulted. These rolled steel windows are almost exclusively found in masonry or concrete buildings.

A byproduct of the fire-resistant window was the strong metal frame that permitted the installation of larger windows and windows in series. The ability to have expansive amounts of glass and increased ventilation dramatically changed the designs of late 19th and early 20th century industrial and commercial buildings.

The newly available, reasonably priced steel windows soon became popular for more than just their fire-resistant qualities. They were standardized, extremely durable, and easily transported. These qualities led to the use of steel windows in every type of construction, from simple industrial and institutional buildings to luxury commercial and apartment buildings. Casement, double-hung, pivot, projecting, austral, and continuous windows differed in operating and ventilating capacities. Figure 4 outlines the kinds and properties of metal windows available then and now. In addition, the thin profiles of metal windows contributed to the streamlined appearance of the Art Deco, Art Moderne, and International Styles, among others.

The extensive use of rolled steel metal windows continued until after World War II when cheaper, non-corroding aluminum windows became increasingly popular. While aluminum windows dominate the market today, steel windows are still fabricated. Should replacement of original windows become necessary, replacement windows may be available from the manufacturers of some of the earliest steel windows. Before an informed decision can be made whether to repair or replace metal windows, however, the significance of the windows must be determined and their physical condition assessed.

### ROLLING SECTION FROM BAR

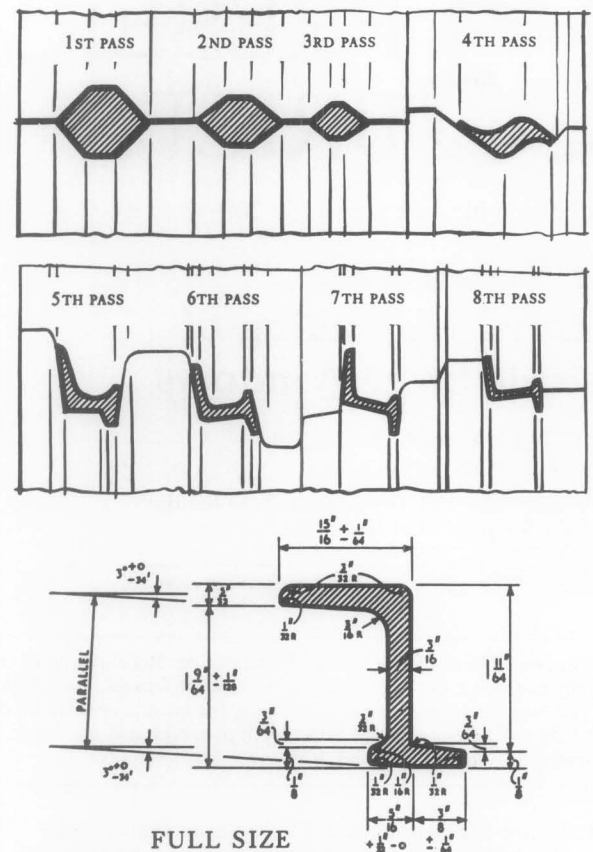


Fig. 2. The process of rolling a steel bar into an angled section is illustrated above. The shape and size of the rolled section will vary slightly depending on the overall strength needed for the window opening and the location of the section in the assembly: subframe, frame, or sash. The  $1/8''$  thickness of the metal section is generally standard. Drawing: *A Metal Window Dictionary*. Used with permission.

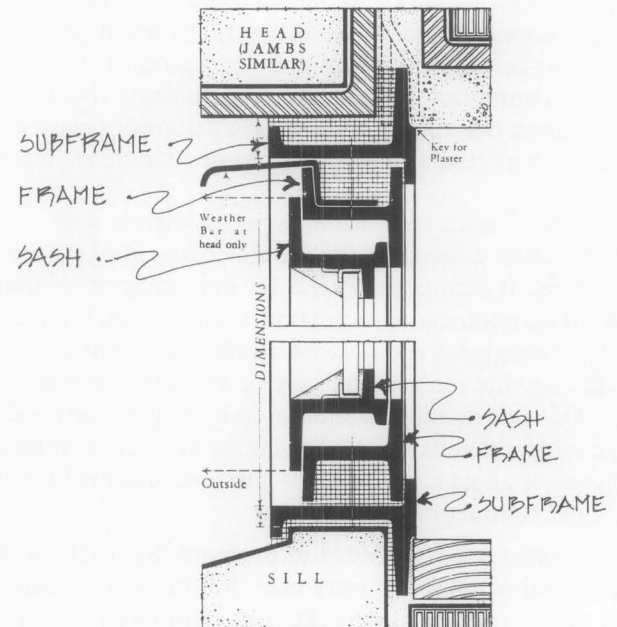


Fig. 3 A typical section through the top and bottom of a metal window shows the three component parts of the window assembly: subframe, frame, and sash. Drawings: Catalogue No. 15, January 1931; International Casement Co, Inc., presently Hope's Architectural Products, Inc., Jamestown, NY. Used with permission.

## EVALUATION

### Historic and Architectural Considerations

An assessment of the significance of the windows should begin with a consideration of their function in relation to the building's historic use and its historic character. Windows that help define the building's historic character should be preserved even if the building is being converted to a new use. For example, projecting steel windows used to introduce light and an effect of spaciousness to a warehouse or industrial plant can be retained in the conversion of such a building to offices or residences.

Other elements in assessing the relative importance of the historic windows include the design of the windows and their relationship to the scale, proportion, detailing and architectural style of the building. While it may be easy to determine the aesthetic value of highly ornamented windows, or to recognize the importance of streamlined windows as an element of a style, less elaborate windows can also provide strong visual interest by their small panes or projecting planes when open, particularly in simple, unadorned industrial buildings (see fig. 5).

One test of the importance of windows to a building is to ask if the overall appearance of the building would be changed noticeably if the windows were to be removed or radically altered. If so, the windows are important in defining the building's historic character, and should be repaired if their physical condition permits.

### Physical Evaluation

Steel window repair should begin with a careful evaluation of the physical condition of each unit. Either drawings or photographs, liberally annotated, may be used to record the location of each window, the type of operability, the condition of all three parts—sash, frame and sub-frame—and the repairs essential to its continued use.

Specifically, the evaluation should include: presence and degree of corrosion; condition of paint; deterioration of the metal sections, including bowing, misalignment of the sash, or bent sections; condition of the glass and glazing compound; presence and condition of all hardware, screws, bolts, and hinges; and condition of the masonry or concrete surrounds, including need for caulking or resetting of improperly sloped sills.

Corrosion, principally rusting in the case of steel windows, is the controlling factor in window repair; therefore, the evaluator should first test for its presence. Corrosion can be light, medium, or heavy, depending on how much the rust has penetrated the metal sections. If the rusting is merely a surface accumulation or flaking, then the corrosion is light. If the rusting has penetrated the metal (indicated by a bubbling texture), but has not caused any structural damage, then the corrosion is medium. If the rust has penetrated deep into the metal, the corrosion is heavy. Heavy corrosion generally results in some form of structural damage, through delamination,

to the metal section, which must then be patched or spliced. A sharp probe or tool, such as an ice pick, can be used to determine the extent of corrosion in the metal. If the probe can penetrate the surface of the metal and brittle strands can be dug out, then a high degree of corrosive deterioration is present.

In addition to corrosion, the condition of the paint, the presence of bowing or misalignment of metal sections, the amount of glass needing replacement, and the condition of the masonry or concrete surrounds must be assessed in the evaluation process. These are key factors in determining whether or not the windows can be repaired in place. The more complete the inventory of existing conditions, the easier it will be to determine whether repair is feasible or whether replacement is warranted.

### Rehabilitation Work Plan

Following inspection and analysis, a plan for the rehabilitation can be formulated. The actions necessary to return windows to an efficient and effective working condition will fall into one or more of the following categories: routine maintenance, repair, and weatherization. The routine maintenance and weatherization measures described here are generally within the range of do-it-yourselfers. Other repairs, both moderate and major, require a professional contractor. Major repairs normally require the removal of the window units to a workshop, but even in the case of moderate repairs, the number of windows involved might warrant the removal of all the deteriorated units to a workshop in order to realize a more economical repair price. Replacement of windows should be considered only as a last resort.

Since moisture is the primary cause of corrosion in steel windows, it is essential that excess moisture be eliminated and that the building be made as weathertight as possible before any other work is undertaken. Moisture can accumulate from cracks in the masonry, from spalling mortar, from leaking gutters, from air conditioning condensation runoff, and from poorly ventilated interior spaces.

Finally, before beginning any work, it is important to be aware of health and safety risks involved. Steel windows have historically been coated with lead paint. The removal of such paint by abrasive methods will produce toxic dust. Therefore, safety goggles, a toxic dust respirator, and protective clothing should be worn. Similar protective measures should be taken when acid compounds are used. Local codes may govern the methods of removing lead paints and proper disposal of toxic residue.

## ROUTINE MAINTENANCE

A preliminary step in the routine maintenance of steel windows is to remove surface dirt and grease in order to ascertain the degree of deterioration, if any. Such minor cleaning can be accomplished using a brush or vacuum followed by wiping with a cloth dampened with mineral spirits or denatured alcohol.

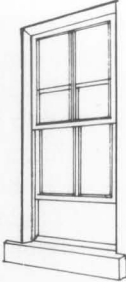
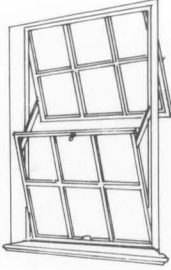
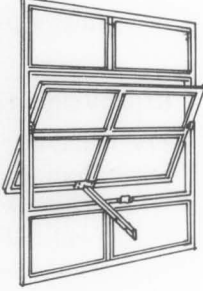
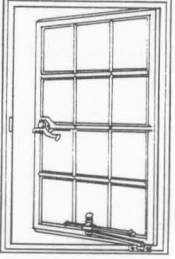
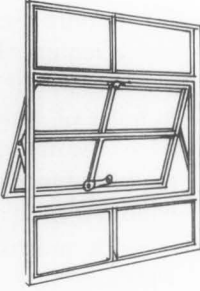

<p><i>Double-hung</i> industrial windows duplicated the look of traditional wooden windows. Metal double-hung windows were early examples of a building product adapted to meet stringent new fire code requirements for manufacturing and high-rise buildings in urban areas. Soon supplanted in industrial buildings by less expensive pivot windows, double-hung metal windows regained popularity in the 1940s for use in speculative suburban housing.</p> 	<p><i>Austral</i> windows were also a product of the 1920s. They combined the appearance of the double-hung window with the increased ventilation and ease of operation of the projected window. (When fully opened, they provided 70% ventilation as compared to 50% ventilation for double-hung windows.) Austral windows were often used in schools, libraries and other public buildings.</p> 
<p><i>Pivot</i> windows were an early type of industrial window that combined inexpensive first cost and low maintenance. Pivot windows became standard for warehouses and power plants where the lack of screens was not a problem. The window shown here is a horizontal pivot. Windows that turned about a vertical axis were also manufactured (often of iron). Such vertical pivots are rare today.</p> 	<p><i>Casement</i> windows adapted the English tradition of using wrought iron casements with leaded cames for residential use. Rolled steel casements (either single, as shown, or paired) were popular in the 1920s for cottage style residences and Gothic style campus architecture. More streamlined casements were popular in the 1930s for institutional and small industrial buildings.</p> 
<p><i>Projecting</i> windows, sometimes called awning or hopper windows, were perfected in the 1920s for industrial and institutional buildings. They were often used in "combination" windows, in which upper panels opened out and lower panels opened in. Since each movable panel projected to one side of the frame only, unlike pivot windows, for example, screens could be introduced.</p> 	<p><i>Continuous</i> windows were almost exclusively used for industrial buildings requiring high overhead lighting. Long runs of clerestory windows operated by mechanical tension rod gears were typical. Long banks of continuous windows were possible because the frames for such windows were often structural elements of the building.</p> 

Fig. 4 Typical rolled steel windows available from 1890 to the present. The various operating and ventilating capacities in combination with the aesthetics of the window style were important considerations in the selection of one window type over another. Drawings: Sharon C. Park, AIA.

If it is determined that the windows are in basically sound condition, the following steps can be taken: 1) removal of light rust, flaking and excessive paint; 2) priming of exposed metal with a rust-inhibiting primer; 3) replacement of cracked or broken glass and glazing compound; 4) replacement of missing screws or fasteners; 5) cleaning and lubrication of hinges; 6) repainting of all steel sections with two coats of finish paint compatible with the primer; and 7) caulking the masonry surrounds with a high quality elastomeric caulk.

Recommended methods for removing light rust include manual and mechanical abrasion or the application of chemicals. Burning off rust with an oxy-acetylene or propane torch, or an inert gas welding gun, should never be attempted because the heat can distort the metal. In addition, such intense heat (often as high as 3800° F) vaporizes the lead in old paint, resulting in highly toxic fumes. Furthermore, such heat will likely result in broken glass. Rust can best be removed using a wire brush, an aluminum oxide sandpaper, or a variety of power tools



Fig. 5 Windows often provide a strong visual element to relatively simple or unadorned industrial or commercial buildings. This design element should be taken into consideration when evaluating the significance of the windows. Photo: Michael Auer.

adapted for abrasive cleaning such as an electric drill with a wire brush or a rotary whip attachment. Adjacent sills and window jambs may need protective shielding.

Rust can also be removed from ferrous metals by using a number of commercially prepared anti-corrosive acid compounds. Effective on light and medium corrosion, these compounds can be purchased either as liquids or gels. Several bases are available, including phosphoric acid, ammonium citrate, oxalic acid and hydrochloric acid. Hydrochloric acid is generally not recommended; it can leave chloride deposits, which cause future corrosion. Phosphoric acid-based compounds do not leave such deposits, and are therefore safer for steel windows. However, any chemical residue should be wiped off with damp cloths, then dried immediately. Industrial blow-dryers work well for thorough drying. The use of running water to remove chemical residue is never recommended because the water may spread the chemicals to adjacent surfaces, and drying of these surfaces may be more difficult. Acid cleaning compounds will stain masonry; therefore plastic sheets should be taped to the edge of the metal sections to protect the masonry surrounds. The same measure should be followed to protect the glazing from etching because of acid contact.

Measures that remove rust will ordinarily remove flaking paint as well. Remaining loose or flaking paint can be removed with a chemical paint remover or with a pneumatic needle scaler or gun, which comes with a series of chisel blades and has proven effective in removing flaking paint from metal windows. Well-bonded paint may serve to protect the metal further from corrosion, and need not be removed unless paint build-up prevents the window from closing tightly. The edges should be feathered by sanding to give a good surface for repainting.

Next, any *bare* metal should be wiped with a cleaning solvent such as denatured alcohol, and dried immediately in preparation for the application of an anti-corrosive primer. Since corrosion can recur very soon after metal has been exposed to the air, the metal should be primed immediately after cleaning. Spot priming may be required periodically as other repairs are undertaken. Anti-corrosive primers generally consist of oil-alkyd based paints rich in zinc or zinc chromate.<sup>2</sup> Red lead is no longer available because of its toxicity. All metal primers, however, are toxic to some degree and should be handled carefully. Two coats of primer are recommended. Manufacturer's recommendations should be followed concerning application of primers.

## REPAIR

### Repair in Place

The maintenance procedures described above will be insufficient when corrosion is extensive, or when metal window sections are misaligned. Medium to heavy corrosion that has not done any structural damage to the metal sections can be removed either by using the chemical cleaning

process described under "Routine Maintenance" or by sandblasting. Since sandblasting can damage the masonry surrounds and crack or cloud the glass, metal or plywood shields should be used to protect these materials. The sandblasting pressure should be low, 80-100 pounds per square inch, and the grit size should be in the range of #10-#45. Glass peening beads (glass pellets) have also been successfully used in cleaning steel sections. While sandblasting equipment comes with various nozzle sizes, pencil-point blasters are most useful because they give the operator more effective control over the direction of the spray. The small aperture of the pencil-point blaster is also useful in removing dried putty from the metal sections that hold the glass. As with any cleaning technique, once the bare metal is exposed to air, it should be primed as soon as possible. This includes the inside rabbeted section of sash where glazing putty has been removed. To reduce the dust, some local codes allow only wet blasting. In this case, the metal must be dried immediately, generally with a blow-drier (a step that the owner should consider when calculating the time and expense involved). Either form of sandblasting metal covered with lead paints produces toxic dust. Proper precautionary measures should be taken against toxic dust and silica particles.

Bent or bowed metal sections may be the result of damage to the window through an impact or corrosive expansion. If the distortion is not too great, it is possible to realign the metal sections without removing the window to a metal fabricator's shop. The glazing is generally removed and pressure is applied to the bent or bowed section. In the case of a muntin, a protective 2 x 4 wooden bracing can be placed behind the bent portion and a wire cable with a winch can apply progressively more pressure over several days until the section is realigned. The 2 x 4 bracing is necessary to distribute the pressure evenly over the damaged section. Sometimes a section, such as the bottom of the frame, will bow out as a result of pressure exerted by corrosion and it is often necessary to cut the metal section to relieve this pressure prior to pressing the section back into shape and making a welded repair.

Once the metal sections have been cleaned of all corrosion and straightened, small holes and uneven areas resulting from rusting should be filled with a patching material and sanded smooth to eliminate pockets where water can accumulate. A patching material of steel fibers and an epoxy binder may be the easiest to apply. This steel-based epoxy is available for industrial steel repair; it can also be found in auto body patching compounds or in plumber's epoxy. As with any product, it is important to follow the manufacturer's instructions for proper use and best results. The traditional patching technique—melting steel welding rods to fill holes in the metal sections—may be difficult to apply in some situations; moreover, the window glass must be removed during the repair process, or it will crack from the expansion of the heated metal sections. After these repairs, glass replacement, hinge lubrication, painting, and other cosmetic repairs can be undertaken as necessary.

<sup>2</sup>Refer to Table IV. Types of Paint Used for Painting Metal in *Metals in America's Historic Buildings*, p. 139. (See bibliography).

To complete the checklist for routine maintenance, cracked glass, deteriorated glazing compound, missing screws, and broken fasteners will have to be replaced; hinges cleaned and lubricated; the metal windows painted, and the masonry surrounds caulked. If the glazing must be replaced, all clips, glazing beads, and other fasteners that hold the glass to the sash should be retained, if possible, although replacements for these parts are still being fabricated. When bedding glass, use only glazing compound formulated for metal windows. To clean the hinges (generally brass or bronze), a cleaning solvent and fine bronze wool should be used. The hinges should then be lubricated with a non-greasy lubricant specially formulated for metals and with an anti-corrosive agent. These lubricants are available in a spray form and should be used periodically on frequently opened windows.

Final painting of the windows with a paint compatible with the anti-corrosive primer should proceed on a dry day. (Paint and primer from the same manufacturer should be used.) Two coats of finish paint are recommended if the sections have been cleaned to bare metal. The paint should overlap the glass slightly to insure weathertightness at that connection. Once the paint dries thoroughly, a flexible exterior caulk can be applied to eliminate air and moisture infiltration where the window and the surrounding masonry meet.

Caulking is generally undertaken after the windows have received at least one coat of finish paint. The perimeter of the masonry surround should be caulked with a flexible elastomeric compound that will adhere well to both metal and masonry. The caulking used should be a type intended for exterior application, have a high tolerance for material movement, be resistant to ultraviolet light, and have a minimum durability of 10 years. Three effective compounds (taking price and other factors into consideration) are polyurethane, vinyl acrylic, and butyl rubber. In selecting a caulking material for a window retrofit, it is important to remember that the caulking compound may be covering other materials in a substrate. In this case, some compounds, such as silicone, may not adhere well. Almost all modern caulking compounds can be painted after curing completely. Many come in a range of colors, which eliminates the need to paint. If colored caulking is used, the windows should have been given two coats of finish paint prior to caulking.

### Repair in Workshop

Damage to windows may be so severe that the window sash and sometimes the frame must be removed for cleaning and extensive rust removal, straightening of bent sections, welding or splicing in of new sections, and reglazing. These major and expensive repairs are reserved for highly significant windows that cannot be replaced; the procedures involved should be carried out only by skilled workmen. (see fig. 6a—6f.)

As part of the orderly removal of windows, each window should be numbered and the parts labelled. The operable metal sash should be dismantled by removing the hinges; the fixed sash and, if necessary, the frame can then be unbolted or unscrewed. (The subframe is usually left in place. Built into the masonry surrounds, it can only be cut out with a torch.) Hardware and hinges should be labelled and stored together.

The two major choices for removing flaking paint and corrosion from severely deteriorated windows are dipping in a chemical bath or sandblasting. Both treatments require removal of the glass. If the windows are to be dipped, a phosphoric acid solution is preferred, as mentioned earlier. While the dip tank method is good for fairly evenly distributed rust, deep set rust may remain after dipping. For that reason, sandblasting is more effective for heavy and uneven corrosion. Both methods leave the metal sections clean of residual paint. As already noted, after cleaning has exposed the metal to the air, it should be primed immediately after drying with an anti-corrosive primer to prevent rust from recurring.

Sections that are seriously bent or bowed must be straightened with heat and applied pressure in a workshop. Structurally weakened sections must be cut out, generally with an oxy-acetylene torch, and replaced with sections welded in place and the welds ground smooth. Finding replacement metal sections, however, may be difficult. While most rolling mills are producing modern sections suitable for total replacement, it may be difficult to find an exact profile match for a splicing repair. The best source of rolled metal sections is from salvaged windows, preferably from the same building. If no salvaged windows are available, two options remain. Either an ornamental metal fabricator can weld flat plates into a built-up section, or a steel plant can mill bar steel into the desired profile.

While the sash and frame are removed for repair, the subframe and masonry surrounds should be inspected. This is also the time to reset sills or to remove corrosion from the subframe, taking care to protect the masonry surrounds from damage.

Missing or broken hardware and hinges should be replaced on all windows that will be operable. Salvaged windows, again, are the best source of replacement parts. If matching parts cannot be found, it may be possible to adapt ready-made items. Such a substitution may require filling existing holes with steel epoxy or with plug welds and tapping in new screw holes. However, if the hardware is a highly significant element of the historic window, it may be worth having reproductions made.

Following are illustrations of the repair and thermal upgrading of the rolled steel windows in a National Historic Landmark (fig. 6). Many of the techniques described above were used during this extensive rehabilitation. The complete range of repair techniques is then summarized in the chart titled *Steps for Cleaning and Repairing Historic Steel Windows* (see fig. 7).

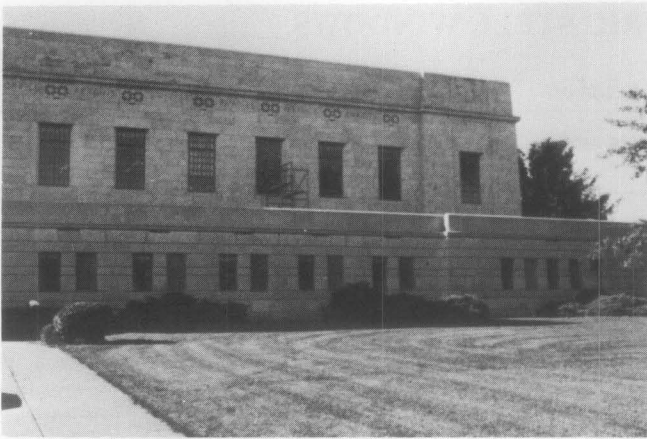


Fig. 6 a. View of the flanking wing of the State Capitol where the rolled steel casement windows are being removed for repair.

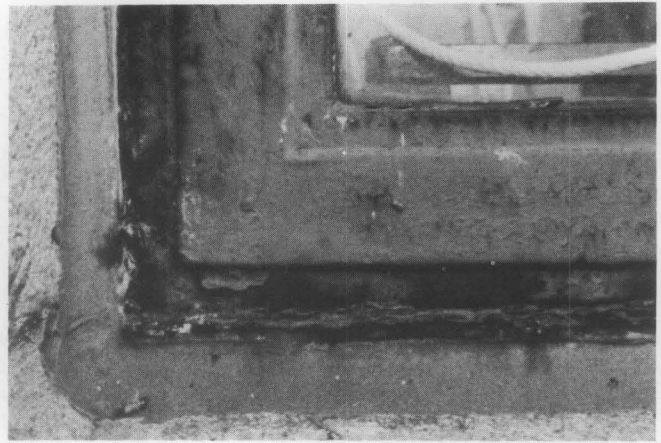


Fig. 6 b. View from the exterior showing the deteriorated condition of the lower corner of a window prior to repair. While the sash was in relatively good condition, the frame behind was rusted to the point of inhibiting operation.

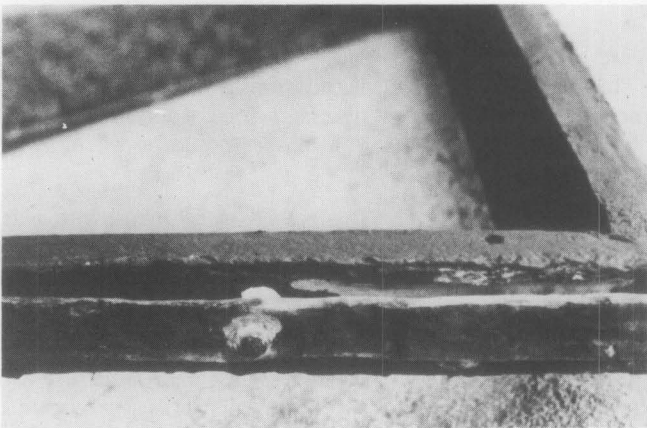


Fig. 6 c. View of the rusted frame which was unscrewed from the subframe and removed from the window opening and taken to a workshop for sandblasting. In some cases, severely deteriorated sections of the frame were replaced with new sections of milled bar steel.



Fig. 6 d. View looking down towards the sill. The subframes appeared very rusted, but were in good condition once debris was vacuumed and surface rust was removed, in place, with chemical compounds. Where necessary, epoxy and steel filler was used to patch depressions in order to make the subframe serviceable again.

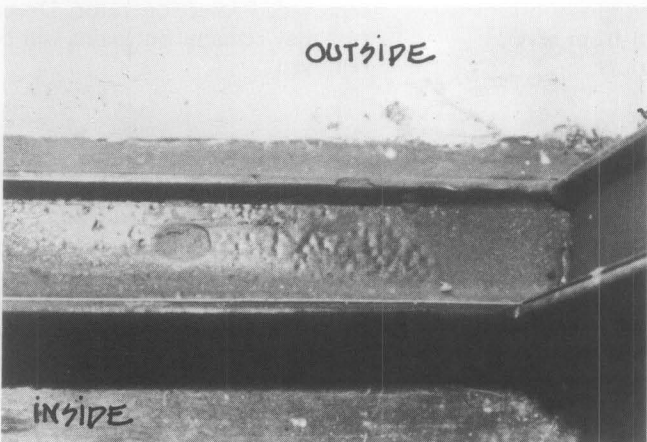


Fig. 6 e. View looking down towards the sill. The cleaned frame was reset in the window opening. The frame was screwed to the refurbished subframe at the jamb and the head only. The screw holes at the sill, which had been the cause of much of the earlier rusting, were infilled. Vinyl weatherstripping was added to the frame.



Fig. 6 f. View from the outside of the completely refurbished window. In addition to the steel repair and the installation of vinyl weatherstripping, the exterior was caulked with polyurethane and the single glass was replaced with individual lights of thermal glass. The repaired and upgraded windows have comparable energy efficiency ratings to new replacement units while retaining the historic steel sash, frames and subframes.

Fig. 6. The repair and thermal upgrading of the historic steel windows at the State Capitol, Lincoln, Nebraska. This early twentieth century building, designed by Bertram Goodhue, is a National Historic Landmark. Photos: All photos in this series were provided by the State Building Division.

## STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
	*(Must be done in a workshop)		
1. Removing dirt and grease from metal	General maintenance and chemical cleaning	Vacuum and bristle brushes to remove dust and dirt; solvents (denatured alcohol, mineral spirits), and clean cloths to remove grease.	Solvents can cause eye and skin irritation. Operator should wear protective gear and work in ventilated area. Solvents should not contact masonry. Do not flush with water.
2. Removing Rust/Corrosion			
Light	Manual and mechanical abrasion	Wire brushes, steel wool, rotary attachments to electric drill, sanding blocks and disks.	Hand sanding will probably be necessary for corners. Safety goggles and masks should be worn.
	Chemical cleaning	Anti-corrosive jellies and liquids (phosphoric acid preferred); clean damp cloths.	Protect glass and metal with plastic sheets attached with tape. Do not flush with water. Work in ventilated area.
Medium	Sandblasting/abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45); glass peening beads. Pencil blaster gives good control.	Removes both paint and rust. Codes should be checked for environmental compliance. Prime exposed metal promptly. Shield glass and masonry. Operator should wear safety gear.
Heavy	*Chemical dip tank	Metal sections dipped into chemical tank (phosphoric acid preferred) from several hours to 24 hours.	Glass and hardware should be removed. Protect operator. Deepset rust may remain, but paint will be removed.
	*Sandblasting/abrasive cleaning	Low pressure (80-100 psi) and small grit (#10-#45).	Excellent for heavy rust. Remove or protect glass. Prime exposed metal promptly. Check codes for environmental compliance. Operator should wear safety gear.
3. Removing flaking paint.	Chemical method	Chemical paint strippers suitable for ferrous metals. Clean cloths.	Protect glass and masonry. Do not flush with water. Have good ventilation and protection for operator.
	Mechanical abrasion	Pneumatic needle gun chisels, sanding disks.	Protect operator; have good ventilation. Well-bonded paint need not be removed if window closes properly.
4. Aligning bent, bowed metal sections	Applied pressure	Wooden frame as a brace for cables and winch mechanism.	Remove glass in affected area. Realignment may take several days.
	*Heat and pressure	Remove to a workshop. Apply heat and pressure to bend back.	Care should be taken that heat does not deform slender sections.

Work Item	Recommended Techniques	Tools, Products and Procedures	Notes
	*(Must be done in a workshop)		
5. Patching depressions	Epoxy and steel filler	Epoxy fillers with high content of steel fibers; plumber's epoxy or autobody patching compound.	Epoxy patches generally are easy to apply, and can be sanded smooth. Patches should be primed.
	Welded patches	Weld in patches using steel rods and oxy-acetylene torch or arc welder.	Prime welded sections after grinding connections smooth.
6. Splicing in new metal sections	*Cut out decayed sections and weld in new or salvaged sections	Torch to cut out bad sections back to 45° joint. Weld in new pieces and grind smooth.	Prime welded sections after grinding connection smooth.
7. Priming metal sections	Brush or spray application	At least one coat of anti-corrosive primer on bare metal. Zinc-rich primers are generally recommended.	Metal should be primed as soon as it is exposed. If cleaned metal will be repaired another day, spot prime to protect exposed metal.
8. Replacing missing screws and bolts	Routine maintenance	Pliers to pull out or shear off rusted heads. Replace screws and bolts with similar ones, readily available.	If new holes have to be tapped into the metal sections, the rusted holes should be cleaned, filled and primed prior to redrilling.
9. Cleaning, lubricating or replacing hinges and other hardware	Routine maintenance, solvent cleaning	Most hinges and closure hardware are bronze. Use solvents (mineral spirits), bronze wool and clean cloths. Spray with non-greasy lubricant containing anti-corrosive agent.	Replacement hinges and fasteners may not match the original exactly. If new holes are necessary, old ones should be filled.
10. Replacing glass and glazing compound	Standard method for application	Pliers and chisels to remove old glass, scrape putty out of glazing rabbet, save all clips and beads for reuse. Use only glazing compound formulated for metal windows.	Heavy gloves and other protective gear needed for the operator. All parts saved should be cleaned prior to reinstallation.
11. Caulking masonry surrounds	Standard method for application	Good quality (10 year or better) elastomeric caulking compound suitable for metal.	The gap between the metal frame and the masonry opening should be caulked; keep weepholes in metal for condensation run-off clear of caulk.
12. Repainting metal windows	Spray or brush	At least 2 coats of paint compatible with the anti-corrosive primer. Paint should lap the glass about 1/8" to form a seal over the glazing compound.	The final coats of paint and the primer should be from the same manufacturer to ensure compatibility. If spraying is used, the glass and masonry should be protected.

Fig. 7. STEPS FOR CLEANING AND REPAIRING HISTORIC STEEL WINDOWS. Compiled by Sharon C. Park, AIA.



## WEATHERIZATION

Historic metal windows are generally not energy efficient; this has often led to their wholesale replacement. Metal windows can, however, be made more energy efficient in several ways, varying in complexity and cost. Caulking around the masonry openings and adding weatherstripping, for example, can be do-it-yourself projects and are important first steps in reducing air infiltration around the windows. They usually have a rapid payback period. Other treatments include applying fixed layers of glazing over the historic windows, adding operable storm windows, or installing thermal glass in place of the existing glass. In combination with caulking and weatherstripping, these treatments can produce energy ratings rivaling those achieved by new units.<sup>3</sup>

### Weatherstripping

The first step in any weatherization program, caulking, has been discussed above under "Routine Maintenance." The second step is the installation of weatherstripping where the operable portion of the sash, often called the ventilator, and the fixed frame come together to reduce perimeter air infiltration (see fig. 8). Four types of weatherstripping appropriate for metal windows are spring-metal, vinyl strips, compressible foam tapes, and sealant beads. The spring-metal, with an integral friction fit mounting clip, is recommended for steel windows in good condition. The clip eliminates the need for an applied glue; the thinness of the material insures a tight closure. The weatherstripping is clipped to the inside channel of the rolled metal section of the fixed frame. To insure against galvanic corrosion between the weatherstripping (often bronze or brass), and the steel window, the window must be painted prior to the installation of the weatherstripping. This weatherstripping is usually applied to the entire perimeter of the window opening, but in some cases, such as casement windows, it may be best to avoid weatherstripping the hinge side. The natural wedging action of the weatherstripping on the three sides of the window often creates an adequate seal.

Vinyl weatherstripping can also be applied to metal windows. Folded into a "V" configuration, the material forms a barrier against the wind. Vinyl weatherstripping is usually glued to the frame, although some brands have an adhesive backing. As the vinyl material and the applied glue are relatively thick, this form of weatherstripping may not be appropriate for all situations.

Compressible foam tape weatherstripping is often best for large windows where there is a slight bending or distortion of the sash. In some very tall windows having closure hardware at the sash mid-point, the thin sections

<sup>3</sup>One measure of energy efficiency is the U-value (the number of BTUs per hour transferred through a square foot of material). The lower the U-value, the better the performance. According to *ASHRAE HANDBOOK-1977 Fundamentals*, the U-value of historic rolled steel sash with single glazing is 1.3. Adding storm windows to the existing units or reglazing with 5/8" insulating glass produces a U-value of .69. These methods of weatherizing historic steel windows compare favorably with rolled steel replacement alternatives: with factory installed 1" insulating glass (.67 U-value); with added thermal-break construction and factory finish coatings (.62 U-value).

of the metal window will bow away from the frame near the top. If the gap is not more than 1/4", foam weatherstripping can normally fill the space. If the gap exceeds this, the window may need to be realigned to close more tightly. The foam weatherstripping comes either with an adhesive or plain back; the latter variety requires application with glue. Compressible foam requires more frequent replacement than either spring-metal or vinyl weatherstripping.

A fourth type of successful weatherstripping involves the use of a caulking or sealant bead and a polyethylene bond breaker tape. After the window frame has been thoroughly cleaned with solvent, permitted to dry, and primed, a neat bead of low modulus (firm setting) caulk, such as silicone, is applied. A bond breaker tape is then applied to the operable sash covering the metal section where contact will occur. The window is then closed until the sealant has set (2-7 days, depending on temperature and humidity). When the window is opened, the bead will have taken the shape of the air infiltration gap and the bond breaker tape can be removed. This weatherstripping method appears to be successful for all types of metal windows with varying degrees of air infiltration.

Since the several types of weatherstripping are appropriate for different circumstances, it may be necessary to use more than one type on any given building. Successful weatherstripping depends upon using the thinnest material adequate to fill the space through which air enters. Weatherstripping that is too thick can spring the hinges, thereby resulting in more gaps.

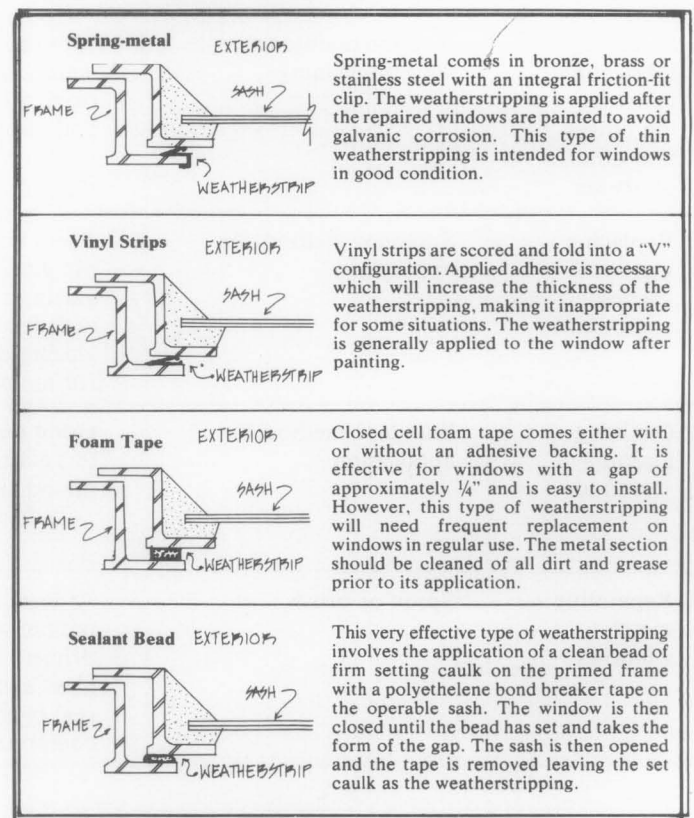


Fig. 8 APPROPRIATE TYPES OF WEATHERSTRIPPING FOR METAL WINDOWS. Weatherstripping is an important part of upgrading the thermal efficiency of historic steel windows. The chart above shows the jamb section of the window with the weatherstripping in place. Drawings: Sharon C. Park, AIA.

## Thermal Glazing

The third weatherization treatment is to install an additional layer of glazing to improve the thermal efficiency of the existing window. The decision to pursue this treatment should proceed from careful analysis. Each of the most common techniques for adding a layer of glazing will effect approximately the same energy savings (approximately double the original insulating value of the windows); therefore, cost and aesthetic considerations usually determine the choice of method. Methods of adding a layer of glazing to improve thermal efficiency include adding a new layer of transparent material to the window; adding a separate storm window; and replacing the single layer of glass in the window with thermal glass.

The least expensive of these options is to install a clear material (usually rigid sheets of acrylic or glass) over the original window. The choice between acrylic and glass is generally based on cost, ability of the window to support the material, and long-term maintenance outlook. If the material is placed over the entire window and secured to the frame, the sash will be inoperable. If the continued use of the window is important (for ventilation or for fire exits), separate panels should be affixed to the sash without obstructing operability (see fig. 9). Glass or acrylic panels set in frames can be attached using magnetized gaskets, interlocking material strips, screws or adhesives. Acrylic panels can be screwed directly to the metal windows, but the holes in the acrylic panels should allow for the expansion and contraction of this material. A compressible gasket between the prime sash and the storm panel can be very effective in establishing a thermal cavity between glazing layers. To avoid condensation, 1/8" cuts in a top corner and diagonally opposite bottom corner of the gasket will provide a vapor bleed, through which moisture can evaporate. (Such cuts, however, reduce thermal performance slightly.) If condensation does occur, however, the panels should be easily removable in order to wipe away moisture before it causes corrosion.

The second method of adding a layer of glazing is to have independent storm windows fabricated. (Pivot and austral windows, however, which project on either side of the window frame when open, cannot easily be fitted with storm windows and remain operational.) The storm window should be compatible with the original sash configuration. For example, in paired casement windows, either specially fabricated storm casement windows or sliding units in which the vertical meeting rail of the slider reflects the configuration of the original window should be installed. The decision to place storm windows on the inside or outside of the window depends on whether the historic window opens in or out, and on the visual impact the addition of storm windows will have on the building. Exterior storm windows, however, can serve another purpose besides saving energy: they add a layer of protection against air pollutants and vandals, although they will partially obscure the prime window. For highly ornamental windows this protection can determine the choice of exterior rather than interior storm windows.

The third method of installing an added layer of glazing is to replace the original single glazing with thermal glass. Except in rare instances in which the original glass is of special interest (as with stained or figured glass), the glass can be replaced if the hinges can tolerate the weight of the additional glass. The rolled metal sections for steel windows are generally from 1" - 1 1/2" thick. Sash of this thickness can normally tolerate thermal glass, which ranges from 3/8" - 5/8". (Metal glazing beads, readily available, are used to reinforce the muntins, which hold the glass.) This treatment leaves the window fully operational while preserving the historic appearance. It is, however, the most expensive of the treatments discussed here. (See fig. 6f).

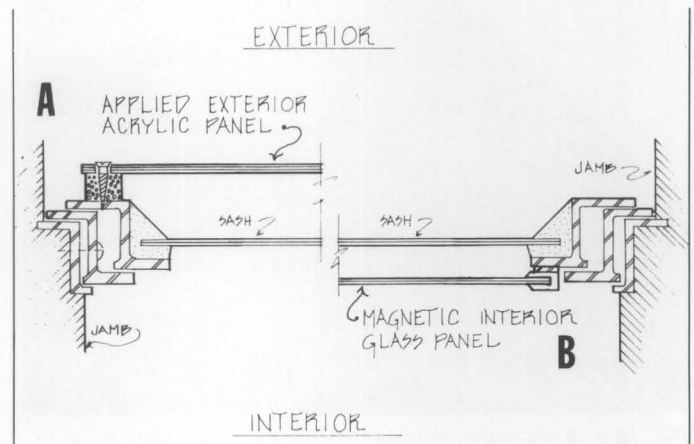


Fig. 9 Two examples of adding a second layer of glazing in order to improve the thermal performance of historic steel windows. Scheme A (showing jamb detail) is of a 1/4" acrylic panel with a closed cell foam gasket attached with self-tapping stainless steel screws directly to the exterior of the outwardly opening sash. Scheme B (showing jamb detail) is of a glass panel in a magnetized frame affixed directly to the interior of the historic steel sash. The choice of using glass or acrylic mounted on the inside or outside will depend on the ability of the window to tolerate additional weight, the location and size of the window, the cost, and the long-term maintenance outlook. Drawing: Sharon C. Park, AIA.

## WINDOW REPLACEMENT

Repair of historic windows is always preferred within a rehabilitation project. Replacement should be considered only as a last resort. However, when the extent of deterioration or the unavailability of replacement sections renders repair impossible, replacement of the entire window may be justified. In the case of significant windows, replacement in kind is essential in order to maintain the historic character of the building. However, for less significant windows, replacement with compatible new windows may be acceptable. In selecting compatible replacement windows, the material, configuration, color, operability, number and size of panes, profile and proportion of metal sections, and reflective quality of the original glass should be duplicated as closely as possible.

A number of metal window manufacturing companies produce rolled steel windows. While stock modern window designs do not share the multi-pane configuration of

historic windows, most of these manufacturers can reproduce the historic configuration if requested, and the cost is not excessive for large orders (see figs. 10a and 10b). Some manufacturers still carry the standard pre-World War II multi-light windows using the traditional 12" x 18" or 14" x 20" glass sizes in industrial, commercial, security, and residential configurations. In addition, many of the modern steel windows have integral weatherstripping, thermal break construction, durable vinyl coatings, insulating glass, and other desirable features.

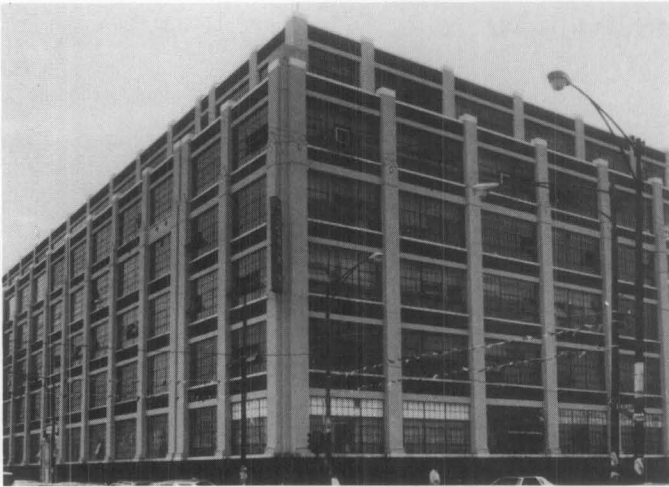


Fig. 10 a. A six-story concrete manufacturing building prior to the replacement of the steel pivot windows. Photo: Charles Parrott.



Fig. 10 b. Close-up view of the new replacement steel windows which matched the multi-lighted originals exactly. Photo: Charles Parrott.

Windows manufactured from other materials generally cannot match the thin profiles of the rolled steel sections. Aluminum, for example, is three times weaker than steel and must be extruded into a box-like configuration that does not reflect the thin historic profiles of most steel windows. Wooden and vinyl replacement windows generally are not fabricated in the industrial style, nor can they reproduce the thin profiles of the rolled steel sections, and consequently are generally not acceptable replacements.

For product information on replacement windows, the owner, architect, or contractor should consult manufacturers' catalogues, building trade journals, or the Steel Window Institute, 1230 Keith Building, Cleveland, Ohio 44115.

## SUMMARY

The National Park Service recommends the retention of significant historic metal windows whenever possible. Such windows, which can be a character-defining feature of a historic building, are too often replaced with inappropriate units that impair rather than complement the overall historic appearance. The repair and thermal upgrading of historic steel windows is more practicable than most people realize. Repaired and properly maintained metal windows have greatly extended service lives. They can be made energy efficient while maintaining their contribution to the historic character of the building.

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This publication has been prepared pursuant to the Economic Recovery Tax Act of 1981, which directs the Secretary of the Interior to certify rehabilitations of historic buildings that are consistent with their historic character; the guidance provided in this brief will assist property owners in complying with the requirements of this law.

*Preservation Briefs: 13* has been developed under the technical editorship of Lee H. Nelson, AIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson at the above address.

# 14 PRESERVATION BRIEFS

## New Exterior Additions to Historic Buildings: Preservation Concerns

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U.S. Department of the Interior

Technical Preservation Services



A new exterior addition to a historic building should be considered in a rehabilitation project only after determining that requirements for the new or adaptive use cannot be successfully met by altering non-significant interior spaces. If the new use cannot be accommodated in this way, then an exterior addition may be an acceptable alternative. Rehabilitation as a treatment “is defined as the act or process of making possible a compatible use for a property through repair, alterations, and *additions* while preserving those portions or features which convey its historical, cultural, or architectural values.”

The topic of new additions, including rooftop additions, to historic buildings comes up frequently, especially as it

relates to rehabilitation projects. It is often discussed and it is the subject of concern, consternation, considerable disagreement and confusion. Can, in certain instances, a historic building be enlarged for a new use without destroying its historic character? And, just what is significant about each particular historic building that should be preserved? Finally, what kind of new construction is appropriate to the historic building?

The vast amount of literature on the subject of additions to historic buildings reflects widespread interest as well as divergence of opinion. New additions have been discussed by historians within a social and political framework; by architects and architectural historians in terms of construction technology and style; and

by urban planners as successful or unsuccessful contextual design. However, within the historic preservation and rehabilitation programs of the National Park Service, the focus on new additions is to ensure that they preserve the character of historic buildings.

Most historic districts or neighborhoods are listed in the National Register of Historic Places for their significance within a particular time frame. This period of significance of historic districts as well as individually-listed properties may sometimes lead to a misunderstanding that inclusion in the National Register may prohibit any physical change outside of a certain historical period—particularly in the form of exterior additions. National Register listing does not mean that a building or district is frozen in time and that no change can be made without compromising the historical significance. It does mean, however, that a new addition to a historic building should preserve its historic character.



Figure 1. The addition to the right with its connecting hyphen is compatible with the Collegiate Gothic-style library. The addition is set back from the front of the library and uses the same materials and a simplified design that references, but does not copy, the historic building. Photo: David Wakely Photography.



Figure 2. The new section on the right is appropriately scaled and reflects the design of the historic Art Deco-style hotel. The apparent separation created by the recessed connector also enables the addition to be viewed as an individual building.

## Guidance on New Additions

To meet Standard 1 of the *Secretary of the Interior's Standards for Rehabilitation*, which states that “a property shall be used for its historic purpose or be placed in a new use that requires minimal change to the defining characteristics of the building and its site and environment,” it must be determined whether a historic building can accommodate a new addition. Before expanding the building’s footprint, consideration should first be given to incorporating changes—such as code upgrades or spatial needs for a new use—within secondary areas of the historic building. However, this is not always possible and, after such an evaluation, the conclusion may be that an addition is required, particularly if it is needed to avoid modifications to character-defining interior spaces. An addition should be designed to be compatible with the historic character of the building and, thus, meet the *Standards for Rehabilitation*. Standards 9 and 10 apply specifically to new additions:

(9) “New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.”

(10) “New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.”

The subject of new additions is important because a new addition to a historic building has the potential to change its historic character as well as to damage and destroy significant historic materials and features. A new addition also has the potential to confuse the public and to make it difficult or impossible to differentiate the old from the new or to recognize what part of the historic building is genuinely historic.

The intent of this Preservation Brief is to provide guidance to owners, architects and developers on how to design a compatible new addition, including a rooftop addition, to a historic building. A new addition to a historic building should preserve the building’s *historic character*. To accomplish this and meet the *Secretary of the Interior's Standards for Rehabilitation*, a new addition should:

- Preserve significant historic materials, features and form;
- Be compatible; and
- Be differentiated from the historic building.

Every historic building is different and each rehabilitation project is unique. Therefore, the guidance offered here is not specific, but general, so that it can be applied to a wide variety of building types and situations. To assist in interpreting this guidance, illustrations of a variety of new additions are provided. Good examples, as well as some that do not meet the Standards, are included to further help explain and clarify what is a compatible new addition that preserves the character of the historic building.



Figure 3. The red and buff-colored parking addition with a rooftop playground is compatible with the early-20th century school as well as with the neighborhood in which it also serves as infill in the urban setting.

### *Preserve Significant Historic Materials, Features and Form*

Attaching a new exterior addition usually involves some degree of material loss to an external wall of a historic building, but it should be minimized. Damaging or destroying significant materials and craftsmanship should be avoided, as much as possible.

Generally speaking, preservation of historic buildings inherently implies minimal change to primary or “public” elevations and, of course, interior features as well. Exterior features that distinguish one historic building or a row of buildings and which can be seen from a public right of way, such as a street or sidewalk, are most likely to be the most significant. These can include many different elements, such as: window patterns, window hoods or shutters; porticoes, entrances and doorways; roof shapes, cornices and decorative moldings; or commercial storefronts with their special detailing, signs and glazing patterns. Beyond a single building, entire blocks of urban or residential structures are often closely related architecturally by their materials, detailing, form and alignment. Because significant materials and features should be preserved, not damaged or hidden, the first place to consider placing a new addition is in a location where the least amount of historic material and character-defining features will be lost. In most cases, this will be on a secondary side or rear elevation.

One way to reduce overall material loss when constructing a new addition is simply to keep the addition smaller in proportion to the size of the historic building. Limiting the size and number of openings between old and new by utilizing existing doors or enlarging windows also helps to minimize loss. An often successful way to accomplish this is to link the addition to the historic building by means of a hyphen or connector. A connector provides a physical link while visually separating the old and new, and the connecting passageway penetrates and removes only a small portion of the historic wall. A new addition that will abut the historic building along an entire elevation or wrap around a side and rear elevation, will likely integrate the historic and the new interiors, and thus result in a high degree of loss of form and exterior walls, as well as significant alteration of interior spaces and features, and will not meet the Standards.



*Figure 4. This glass and brick structure is a harmonious addition set back and connected to the rear of the Colonial Revival-style brick house. Cunningham/Quill Architects. Photos: © Maxwell MacKenzie.*

### *Compatible but Differentiated Design*

In accordance with the Standards, a new addition must preserve the building’s historic character and, in order to do that, it must be differentiated, but compatible, with the historic building. A new addition must retain the essential form and integrity of the historic property. Keeping the addition smaller, limiting the removal of historic materials by linking the addition with a hyphen, and locating the new addition at the rear or on an inconspicuous side elevation of a historic building are techniques discussed previously that can help to accomplish this.

Rather than differentiating between old and new, it might seem more in keeping with the historic character

simply to repeat the historic form, material, features and detailing in a new addition. However, when the new work is highly replicative and indistinguishable from the old in appearance, it may no longer be possible to identify the “real” historic building. Conversely, the treatment of the addition should not be so different that it becomes the primary focus. The difference may be subtle, but it must be clear. A new addition to a historic building should protect those visual qualities that make the building eligible for listing in the National Register of Historic Places.

The National Park Service policy concerning new additions to historic buildings, which was adopted in 1967, is not unique. It is an outgrowth and continuation of a general philosophical approach to change first expressed by John Ruskin in England in the 1850s, formalized by William Morris in the founding of the Society for the Protection of Ancient Buildings in 1877, expanded by the Society in 1924 and, finally, reiterated in the 1964 Venice Charter—a document that continues to be followed by the national committees of the International Council on Monuments and Sites (ICOMOS). The 1967 *Administrative Policies for Historical Areas of the National Park System* direct that “...a modern addition should be readily distinguishable from the older work; however, the new work should be harmonious with the old in scale, proportion, materials, and color. Such additions should be as inconspicuous as

possible from the public view.” As a logical evolution from these Policies specifically for National Park Service-owned historic structures, the 1977 *Secretary of the Interior’s Standards for Rehabilitation*, which may be applied to **all** historic buildings listed in, or eligible for listing in the National Register, also state that “the new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.”

### *Preserve Historic Character*

The goal, of course, is a new addition that preserves the building’s historic character. The historic character of each building may be different, but the methodology of establishing it remains the same. Knowing the uses and functions a building has served over time will assist in making what is essentially a physical evaluation. But, while written and pictorial documentation can provide a framework for establishing the building’s history, to a large extent the historic character is embodied in the physical aspects of the historic building itself—shape, materials, features, craftsmanship, window arrangements, colors, setting and interiors. Thus, it is important to identify the historic character before making decisions about the extent—or limitations—of change that can be made.



Figure 5. This addition (a) is constructed of matching brick and attached by a recessed connector (b) to the 1914 apartment building (c). The design is compatible and the addition is smaller and subordinate to the historic building (d).



Figure 6. A new addition (left) is connected to the garage which separates it from the main block of the c. 1910 former florist shop (right). The addition is traditional in style, yet sufficiently restrained in design to distinguish it from the historic building.

A new addition should always be subordinate to the historic building; it should not compete in size, scale or design with the historic building. An addition that bears no relationship to the proportions and massing of the historic building—in other words, one that overpowers the historic form and changes the scale—will usually compromise the historic character as well. The appropriate size for a new addition varies from building to building; it could never be stated in a square or cubic footage ratio, but the historic building's existing proportions, site and setting can help set some general parameters for enlargement. Although even a small addition that is poorly designed can have an adverse impact, to some extent, there is a predictable relationship between the size of the historic resource and what is an appropriate size for a compatible new addition.

Generally, constructing the new addition on a secondary side or rear elevation—in addition to material preservation—will also preserve the historic character. Not only will the addition be less visible, but because a secondary elevation is usually simpler and less distinctive, the addition will have less of a physical and visual impact on the historic building. Such placement will help to preserve the building's historic form and relationship to its site and setting.

Historic landscape features, including distinctive grade variations, also need to be respected. Any new landscape features, including plants and trees, should be kept at a scale and density that will not interfere with understanding of the historic resource itself. A traditionally landscaped

property should not be covered with large paved areas for parking which would drastically change the character of the site.

Despite the fact that in most cases it is recommended that the new addition be attached to a secondary elevation, sometimes this is not possible. There simply may not be a secondary elevation—some important freestanding buildings have significant materials and features on all sides. A structure or group of structures together with its setting (for example, a college campus) may be of such significance that any new addition would not only damage materials, but alter the buildings' relationship to each other and the setting. An addition attached to a highly-visible elevation of a historic building can radically alter the historic form or obscure features such as a decorative cornice or window ornamentation. Similarly, an addition that fills



Figure 7. A vacant side lot was the only place a new stair tower could be built when this 1903 theater was rehabilitated as a performing arts center. Constructed with matching materials, the stair tower is set back with a recessed connector and, despite its prominent location, it is clearly subordinate and differentiated from the historic theater.





Figure 8. The rehabilitation of this large, early-20th century warehouse (left) into affordable artists' lofts included the addition of a compatible glass and brick elevator/stair tower at the back (right).



Figure 9. A simple, brick stair tower replaced two non-historic additions at the rear of this 1879 school building when it was rehabilitated as a women's and children's shelter. The addition is set back and it is not visible from the front of the school.



Figure 10. The small size and the use of matching materials ensures that the new addition on the left is compatible with the historic Romanesque Revival-style building.

in a planned void on a highly-visible elevation (such as a U-shaped plan or a feature such as a porch) will also alter the historic form and, as a result, change the historic character. Under these circumstances, an addition would have too much of a negative impact on the historic building and it would not meet the Standards. Such situations may best be handled by constructing a separate building in a location where it will not adversely affect the historic structure and its setting.

In other instances, particularly in urban areas, there may be no other place but adjacent to the primary façade to locate an addition needed for the new use. It may be possible to design a lateral addition attached on the side that is compatible with the historic building, even though it is a highly-visible new element. Certain types of historic structures, such as government buildings, metropolitan museums, churches or libraries, may be so massive in size that a relatively large-scale addition may not compromise the historic character, provided, of course, the addition is smaller than the historic building. Occasionally, the visible size of an addition can be reduced by placing some of the spaces or support systems in a part of the structure that is underground. Large new additions may sometimes be successful if they read as a separate volume, rather than as an extension of the historic structure, although the scale, massing and proportions of the addition still need to be compatible with the historic building. However, similar expansion of smaller buildings would be dramatically out of scale. In summary, where any new addition is proposed, correctly assessing the relationship between actual size and relative scale will be a key to preserving the character of the historic building.



Figure 11. The addition to this early-20th century Gothic Revival-style church provides space for offices, a great hall for gatherings and an accessible entrance (left). The stucco finish, metal roof, narrow gables and the Gothic-arched entrance complement the architecture of the historic church. Placing the addition in back where the ground slopes away ensures that it is subordinate and minimizes its impact on the church (below).

## Design Guidance for Compatible New Additions to Historic Buildings

There is no formula or prescription for designing a new addition that meets the Standards. A new addition to a historic building that meets the Standards can be any architectural style—traditional, contemporary or a simplified version of the historic building. However, there must be a balance between differentiation and compatibility in order to maintain the historic character and the identity of the building being enlarged. New additions that too closely resemble the historic building or are in extreme contrast to it fall short of this balance. *Inherent in all of the guidance is the concept that an addition needs to be subordinate to the historic building.*

A new addition **must preserve significant historic materials, features and form, and it must be compatible but differentiated from the historic building.** To achieve this, it is necessary to carefully consider the **placement or location** of the new addition, and its **size, scale and massing** when planning a new addition. To preserve a property's historic character, a new addition must be visually distinguishable from the historic building. This does not mean that the addition and the historic building should be glaringly different in terms of design, materials and other visual qualities. Instead, the new addition should take its design cues from, but not copy, the historic building.



A variety of design techniques can be effective ways to differentiate the new construction from the old, while respecting the architectural qualities and vocabulary of the historic building, including the following:

- Incorporate a simple, recessed, small-scale hyphen to physically separate the old and the new volumes or set the addition back from the wall plane(s) of the historic building.
- Avoid designs that unify the two volumes into a single architectural whole. The new addition may include simplified architectural features that reflect, but do not duplicate, similar features on the historic building. This approach will not impair the existing building's historic character as long as the new structure is subordinate in size and clearly differentiated and distinguishable so that the identity of the historic structure is not lost in a new and larger composition. The historic building must be clearly identifiable and its physical integrity must not be compromised by the new addition.



Figure 12. This 1954 synagogue (left) is accessed through a monumental entrance to the right. The new education wing (far right) added to it features the same vertical elements and color and, even though it is quite large, its smaller scale and height ensure that it is secondary to the historic resource.



Figure 13. A glass and metal structure was constructed in the courtyard as a restaurant when this 1839 building was converted to a hotel. Although such an addition might not be appropriate in a more public location, it is compatible here in the courtyard of this historic building.



Figure 14. This glass addition was erected at the back of an 1895 former brewery during rehabilitation to provide another entrance. The addition is compatible with the plain character of this secondary elevation.

- Use building materials in the same color range or value as those of the historic building. The materials need not be the same as those on the historic building, but they should be harmonious; they should not be so different that they stand out or distract from the historic building. (Even clear glass can be as prominent as a less transparent material. Generally, glass may be most appropriate for small-scale additions, such as an entrance on a secondary elevation or a connector between an addition and the historic building.)
- Base the size, rhythm and alignment of the new addition's window and door openings on those of the historic building.
- Respect the architectural expression of the historic building type. For example, an addition to an institutional building should maintain the architectural character associated with this building type rather than using details and elements typical of residential or other building types.

These techniques are merely examples of ways to differentiate a new addition from the historic building while ensuring that the addition is compatible with it. Other ways of differentiating a new addition from the historic building may be used as long as they maintain the primacy of the historic building. Working within these basic principles still allows for a broad range of architectural expression that can range from stylistic similarity to contemporary distinction. The recommended design approach for an addition is one that neither copies the historic building exactly nor stands in stark contrast to it.

Revising an Incompatible Design for a New Addition to Meet the Standards

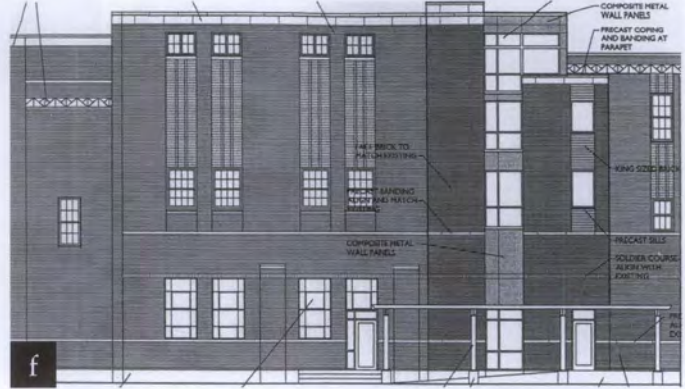
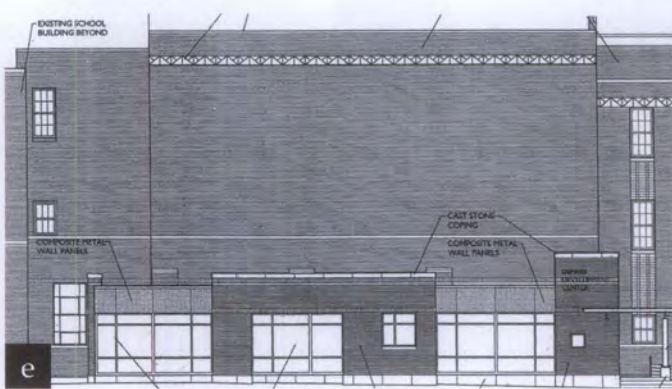
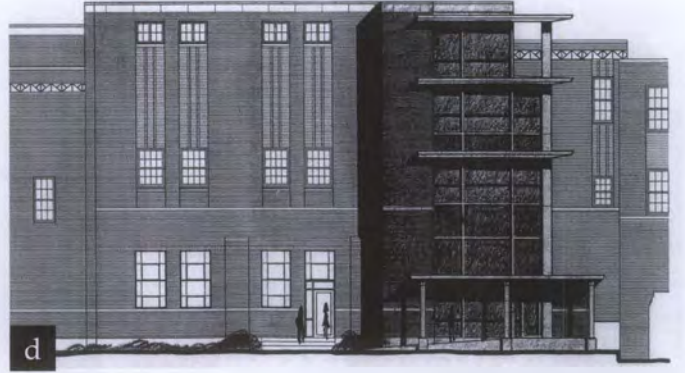
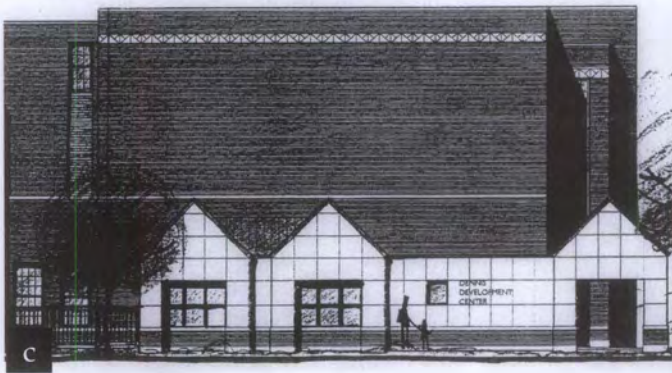


Figure 15. The rehabilitation of a c. 1930 high school auditorium for a clinic and offices proposed two additions: a one-story entrance and reception area on this elevation (a); and a four-story elevator and stair tower on another side (b). The gabled entrance (c) first proposed was not compatible with the flat-roofed auditorium and the design of the proposed stair tower (d) was also incompatible and overwhelmed the historic building. The designs were revised (e-f) resulting in new additions that meet the Standards (g-h).

**Incompatible New Additions to Historic Buildings**

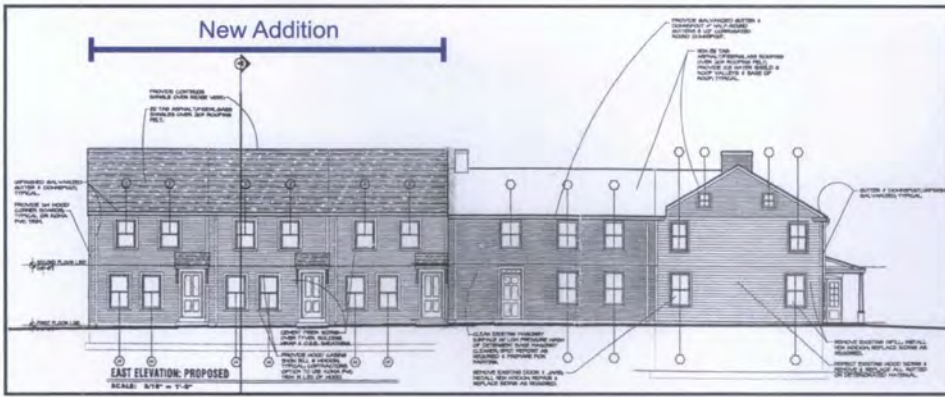


Figure 16. The proposal to add three row houses to the rear ell of this early-19th century residential property doubles its size and does not meet the Standards..



Figure 17. The small addition on the left is starkly different and it is not compatible with the eclectic, late-19th century house.



Figure 18. The expansion of a one- and one-half story historic bungalow (left) with a large two-story rear addition (right) has greatly altered and obscured its distinctive shape and form.



Figure 19. The upper two floors of this early-20th century office building were part of the original design, but were not built. During rehabilitation, the two stories were finally constructed. This treatment does not meet the Standards because the addition has given the building an appearance it never had historically.



Figure 20. The height, as well as the design, of these two-story rooftop additions overwhelms the two-story and the one-story, low-rise historic buildings.



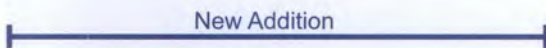
*New Additions in Densely-Built Environments*

In built-up urban areas, locating a new addition on a less visible side or rear elevation may not be possible simply because there is no available space. In this instance, there may be alternative ways to help preserve the historic character. One approach when connecting a new addition to a historic building on a primary elevation is to use a hyphen to separate them. A subtle variation in material, detailing and color may also provide the degree of differentiation necessary to avoid changing the essential proportions and character of the historic building.

A densely-built neighborhood such as a downtown commercial core offers a particular opportunity to design an addition that will have a minimal impact on the historic building. Often the site for such an addition is a vacant lot where another building formerly stood. Treating the addition as a separate or infill building may be the best approach when designing an addition that will have the least impact on the historic building and the district. In these instances there may be no need for a direct visual link to the historic building. Height and setback from the street should generally be consistent with those of the historic building and other surrounding buildings in the district. Thus, in most urban commercial areas the addition should not be set back from the façade of the historic building. A tight urban setting may sometimes even accommodate a larger addition if the primary elevation is designed to give the appearance of being several buildings by breaking up the facade into elements that are consistent with the scale of the historic building and adjacent buildings.



*Figure 21. Both wings of this historic L-shaped building (top), which fronts on two city streets, adjoined vacant lots. A two-story addition was constructed on one lot (above, left) and a six-story addition was built on the other (above, right). Like the historic building, which has two different facades, the compatible new additions are also different and appear to be separate structures rather than part of the historic building.*



*Figure 22. The proposed new addition is compatible with the historic buildings that remain on the block. Its design with multiple storefronts helps break up the mass.*



### Rooftop Additions

The guidance provided on designing a compatible new addition to a historic building applies equally to new rooftop additions. A rooftop addition should preserve the character of a historic building by preserving historic materials, features and form; and it should be compatible but differentiated from the historic building.

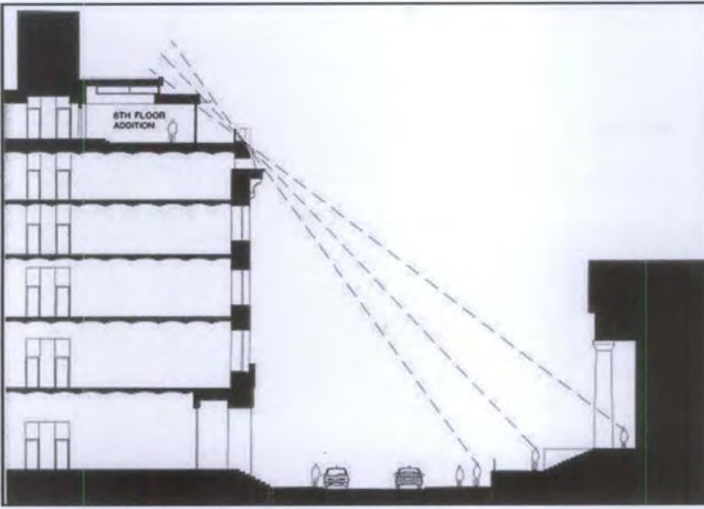
However, there are several other design principles that apply specifically to rooftop additions. Generally, a rooftop addition should not be more than one story in height to minimize its visibility and its impact on the proportion and profile of the historic building. A rooftop addition should almost always be set back at least one full bay from the primary elevation of the building, as well as from the other elevations if the building is free-standing or highly visible.

It is difficult, if not impossible, to minimize the impact of adding an entire new floor to relatively low buildings, such as small-scale residential or commercial structures, even if the new addition is set back from the plane of the façade. Constructing another floor on top of a small, one, two or three-story building is seldom appropriate for buildings of this size as it would measurably alter the building's proportions and profile, and negatively impact its historic character. On the other hand, a rooftop addition on an eight-story building, for example, in a historic district consisting primarily of tall buildings might not affect the historic character because the new construction may blend in with the surrounding buildings and be only minimally visible within the district. A rooftop addition in a densely-built urban area is more likely to be compatible on a building that is adjacent to similarly-sized or taller buildings.

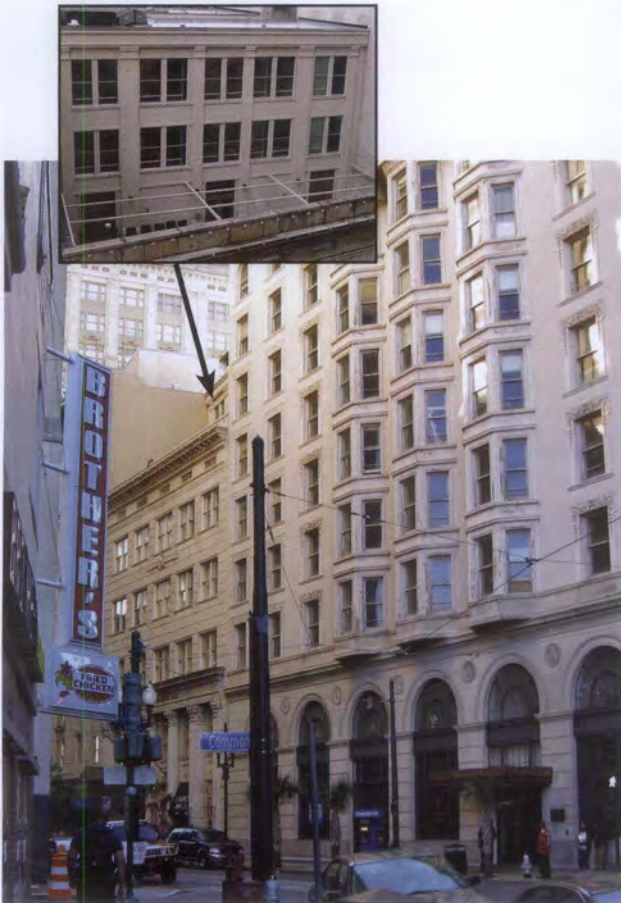
A number of methods may be used to help evaluate the effect of a proposed rooftop addition on a historic building and district, including pedestrian sight lines, three-dimensional schematics and computer-generated design. However, drawings generally do not provide a true "picture" of the appearance and visibility of a proposed rooftop addition. For this reason, it is often necessary to construct a rough, temporary, full-size or skeletal mock up of a portion of the proposed addition, which can then be photographed and evaluated from critical vantage points on surrounding streets.



Figure 23. Colored flags marking the location of a proposed penthouse addition (a) were placed on the roof to help evaluate the impact and visibility of an addition planned for this historic furniture store (b). Based on this evaluation, the addition was constructed as proposed. It is minimally visible and compatible with the 1912 structure (c). The tall parapet wall conceals the addition from the street below (d).



**Figure 24. How to Evaluate a Proposed Rooftop Addition.**  
 A sight-line study (above) only factors in views from directly across the street, which can be very restrictive and does not illustrate the full effect of an addition from other public rights of way. A mock up (above, right) or a mock up enhanced by a computer-generated rendering (below, right) is essential to evaluate the impact of a proposed rooftop addition on the historic building.



**Figure 25.** It was possible to add a compatible, three-story, penthouse addition to the roof of this five-story, historic bank building because the addition is set far back, it is surrounded by taller buildings and a deep parapet conceals almost all of the addition from below.

**Figure 26.** A rooftop addition would have negatively impacted the character of the primary facade (right) of this mid-19th century, four-story structure and the low-rise historic district. However, a third floor was successfully added on the two-story rear portion (below) of the same building with little impact to the building or the district because it blends in with the height of the adjacent building.







Figure 27. Although the new brick stair/elevator tower (left) is not visible from the front (right), it is on a prominent side elevation of this 1890 stone bank. The compatible addition is set back and does not compete with the historic building. Photos: Chadd Gossmann, Aurora Photography, LLC.

## Designing a New Exterior Addition to a Historic Building

This guidance should be applied to help in designing a compatible new addition that that will meet the *Secretary of the Interior's Standards for Rehabilitation*:

- A new addition should be simple and unobtrusive in design, and should be distinguished from the historic building—a recessed connector can help to differentiate the new from the old.
- A new addition should not be highly visible from the public right of way; a rear or other secondary elevation is usually the best location for a new addition.
- The construction materials and the color of the new addition should be harmonious with the historic building materials.
- The new addition should be smaller than the historic building—it should be subordinate in both size and design to the historic building.

The same guidance should be applied when designing a compatible **rooftop** addition, plus the following:

- A rooftop addition is generally not appropriate for a one, two or three-story building—and often is not appropriate for taller buildings.
- A rooftop addition should be minimally visible.
- Generally, a rooftop addition must be set back at least one full bay from the primary elevation of the building, as well as from the other elevations if the building is freestanding or highly visible.
- Generally, a rooftop addition should not be more than one story in height.
- Generally, a rooftop addition is more likely to be compatible on a building that is adjacent to similarly-sized or taller buildings.



Figure 28. A small addition (left) was constructed when this 1880s train station was converted for office use. The paired doors with transoms and arched windows on the compatible addition reflect, but do not replicate, the historic building (right).



Figure 29. This simple glass and brick entrance (left) added to a secondary elevation of a 1920s school building (right) is compatible with the original structure.

## Summary

Because a new exterior addition to a historic building can damage or destroy significant materials and can change the building's character, an addition should be considered only after it has been determined that the new use cannot be met by altering non-significant, or secondary, interior spaces. If the new use cannot be met in this way, then an attached addition may be an acceptable alternative if carefully planned and designed. A new addition to a historic building should be constructed in a manner that preserves significant materials, features and form, and preserves the building's historic character. Finally, an addition should be differentiated from the historic building so that the new work is compatible with—and does not detract from—the historic building, and cannot itself be confused as historic.

## Additional Reading

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*Interpreting the Standards Bulletins (ITS)*. Technical Preservation Services Branch, National Park Service. Online at [www.nps.gov/history/hps/tps/](http://www.nps.gov/history/hps/tps/).

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*The Secretary of the Interior's Standards for Rehabilitation & Illustrated Guidelines for Rehabilitating Historic Buildings*. (Authors: W. Brown Morton, III, Gary L. Hume, Kay D. Weeks, and H. Ward Jandl. Project Directors: Anne E. Grimmer and Kay D. Weeks.) Washington, D.C.: U.S. Department of

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Figure 30. The small addition on the right of this late-19th century commercial structure is clearly secondary and compatible in size, materials and design with the historic building.



Figure 31. An elevator/stair tower was added at the back of this Richardsonian Romanesque-style theater when it was rehabilitated. Rough-cut stone and simple cut-out openings ensure that the addition is compatible and subordinate to the historic building. Photo: Chuck Liddy, AIA.

## Acknowledgements

Anne E. Grimmer, Senior Architectural Historian, Technical Preservation Services Branch, National Park Service, revised *Preservation Brief 14*, written by Kay D. Weeks and first published in 1986. The revised Brief features all new illustrations and contains expanded and updated design guidance on the subject of new additions that has been developed by the Technical Preservation Services Branch since the original publication of the Brief. Several individuals generously contributed their time and expertise to review the revision of this *Preservation Brief*, including: Sharon C. Park, FAIA, Chief, Architectural History and Historic Preservation, Smithsonian Institution; Elizabeth Tune and Karen Brandt, Department of Historic Resources, Commonwealth of Virginia; and Phillip Wisley and David Ferro, Division of Historical Resources, Florida Department of State. The Technical Preservation Services professional staff, in particular Michael J. Auer, Jo Ellen Hensley, Gary Sachau and Rebecca Shiffer, also provided important guidance in the development of this publication. All illustrations are from National Park Service files unless otherwise credited. Front cover image: Detail of new addition shown in Figure 4. Photo: © Maxwell MacKenzie.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended, which directs the Secretary of the Interior to develop and make available information concerning historic properties. The Technical Preservation Services Branch, National Park Service, prepares standards, guidelines and other educational materials on responsible historic preservation treatments for a broad public audience. Additional information about the programs of Technical Preservation Services is available on the website at [www.nps.gov/history/hps/tps](http://www.nps.gov/history/hps/tps). Comments about this publication should be addressed to: Charles E. Fisher, Technical Preservation Publications Program Manager, Technical Preservation Services-2255, National Park Service, 1849 C Street, NW, Washington, DC 20240. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated.

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 Technical Preservation Services  
 National Park Service



# Revising

## **Preservation Brief 14: New Exterior Additions to Historic Buildings: Preservation Concerns**

The topic of new additions, including rooftop additions, to historic buildings comes up frequently, especially as it relates to rehabilitation projects. It is often discussed and it is the subject of concern, consternation, considerable disagreement and confusion. Accordingly, the National Park Service (NPS) published *Preservation Brief 14: New Exterior Additions to Historic Buildings: Preservation Concerns* in 1986 to address this issue. Of course, many aspects of rehabilitation have changed since then, more than thirty years after the 1976 Historic Preservation Tax Incentives program was initiated and more than twenty years after Preservation Brief 14 was first developed. The first years of the tax incentives program were a learning experience for all preservationists, including the NPS. After all — “adaptive use,” “adaptive reuse” or “rehabilitation” — regardless of what it is called, was a relatively new kind of preservation treatment in terms of applying to standards, and, quite different from restoration, the more familiar treatment at that time. In the Secretary of the Interior’s Standards for the Treatment of Historic Properties, restoration is defined as “the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period.” Whereas rehabilitation is defined as “the act or process of making possible a compatible use for a property through repair, alterations, and *additions* (emphasis added) while preserving those portions or features which convey its historical, cultural, or architectural values.”

Although the wording of the Secretary of the Interior’s Standards for Rehabilitation, which govern the administration of the Historic Preservation Tax Incentives program, has been revised somewhat over the years, the actual policy espoused by the Standards has remained the same. Thus, the Standards continue to be applied in the same way to all proposed rehabilitation treatments, including proposed new additions to historic buildings. Standards 9 and 10 specifically address new additions. Standard 9 states: “New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment;” and Standard 10 states: “New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.”

## Reviewing a Proposed Rooftop Addition



The building as it appeared prior to the proposed rehabilitation: Originally constructed in the 19th century, it housed an undertaker's establishment, livery stables and, most recently, a coffee warehouse.



Historical photograph.



The rehabilitation proposal is to recreate the historic appearance, while adding a two-story rooftop penthouse. This did not meet Standards 3 & 9. It would have given the building a false sense of history and adding a two-story rooftop addition to a low-rise building is generally not a compatible treatment.



The NPS conditional approval required that the rooftop addition be reduced to one story and minimally visible from the public right of way. The architect demonstrated that a one-story addition would have minimal visibility by using "animation prints" (on a CD and print outs) showing the building with the proposed rooftop addition from various locations, starting one block away and gradually moving closer until directly in front of the building. Because it is a corner building views were provided from two intersecting streets.



The revised proposal with a one-story rooftop addition that was conditionally approved by the National Park Service.

The Historic Preservation Tax Incentives program has always emphasized that a new exterior addition to a historic building should be considered in a rehabilitation project only after determining that requirements for the new or adaptive use cannot be successfully met by altering non-significant interior spaces. If the new use cannot be accommodated in this way, then an exterior addition may be an acceptable alternative, but it must preserve the character of the historic building. However, what the NPS has learned from thirty years of experience, despite its best efforts to convey what an appropriate new addition to a historic building is, is that it has not always been successful in conveying this to many users of the program.

In September 2006, the Committee on the Federal Historic Rehabilitation Tax Credit Program issued a report to the National Park System Advisory Board, entitled *Federal Historic Rehabilitation Tax Credit Program: Recommendations for Making a Good Program Better*. The report consisted of a number of recommendations to the NPS that it take certain steps to enhance and strengthen the program. One of the recommendations was that the NPS, in consultation with its historic preservation partners, reexamine several, often problematic, issues that are commonly encountered in rehabilitation projects. Not surprisingly, new additions (and related new construction) to historic buildings was one of the issues; the others being windows, interior treatments and modern requirements, and new technologies and materials.

Long aware that it was time to update *Preservation Brief 14* on new additions, the need to follow up on the committee's recommendation prompted the NPS to begin this process. Accordingly, the NPS, as directed, initiated a consultation process with its preservation partners and professionals to seek input on the topic of new additions. Based on

comments and suggestions received through this process, the NPS began to work on developing expanded guidance. The resultant guidance was presented to the public in December 2007, when it was posted on the Technical Preservation Services' website with the heading "Planning Successful Rehabilitation Projects: Applying the Standards to Common Rehabilitation Concerns" as part of the information on the Historic Preservation Tax Incentives program.<sup>1</sup>

The development of this expanded guidance was followed by the revision and publication of *Preservation Brief 14* itself. Although more "how-to" advice has been added to the revised brief, such as evaluating proposed rooftop additions (see sidebar), the NPS policy on new additions presented in the original brief is essentially the same as the revised brief published in 2010. Most of the photographs in the original publication are still good examples in that new additions should be clearly distinguishable from the historic building. However, some of the new additions illustrated in the original brief may not be considered as compatible today; for instance, they may be overly large or perhaps *too* differentiated. Some of the illustrations in the original brief may reflect architectural styles, or other trends, such as greenhouse additions, that have now gone out of fashion but were popular twenty years ago. This is an inevitable result of changing times and tastes and the reason why most publications are updated or revised.

One of the objectives in selecting illustrations for the new brief was to include a representative sample of building types, from single-family and multifamily residential to small, as well as larger-scale commercial, institutional and religious structures, and as many as possible different geographical regions of the country (Figure 2). And, thanks to reduced printing costs, it was now possible to print Preservation Briefs in color! Aside from the obvious fact that a

<sup>1</sup> On the NPS website at: [www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab.htm](http://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab.htm)

color publication is more attractive, color enhances the reader's awareness and ability to understand the point being made by the photograph. The intent in selecting illustrations was also to show new additions that reflected a variety of styles, from more differentiated to more referential to the historic building. An added challenge was to find enough "good" examples of new additions to illustrate. The NPS relies on tax incentives project files, which all too often do not provide good quality photographs for the majority of the illustrations it uses for its educational programs, from publications and web features to professional presentations at conferences.

commercial areas the addition should not be set back from the façade of the historic building."

Another topic that is not included in the brief because it is not an addition is new construction on the site of a historic building or adjacent to a historic property. New construction as it relates to historic buildings may sometimes also be considered infill. It is reviewed in rehabilitation projects from the standpoint of how it impacts the character of the historic building and, when applicable, the historic district in which it is located. The historic property must remain predominant and its historic character must be retained. Generally the same



*A tight urban setting may sometimes accommodate a larger addition if the primary elevation is designed to give the appearance of being several buildings by breaking up the facade into elements that are consistent with the scale of the historic building and adjacent buildings.*



*This new addition, which features a drive-through teller window, to a historic Classical Revival-style bank was designed to appear as a compatible infill structure, rather than an addition to the bank.*



*Historic school buildings are commonly rehabilitated for multi-family housing. This often requires more space and, consequently, new construction, such as the building shown here, which is compatible with the historic school and its site*

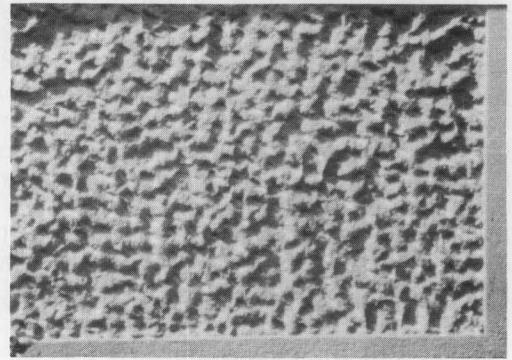
Although often asked about "infill" construction, the NPS does not have specific guidance because this is technically not a rehabilitation issue. However, the revised *Preservation Brief 14* does include a section on new additions in densely built urban environments, which is much the same as infill construction: "A densely-built neighborhood such as a downtown commercial core offers a particular opportunity to design an addition that will have a minimal impact on the historic building. Treating the addition as a separate or infill building may be the best approach when designing an addition that will have the least impact on the historic building and the district. In these instances there may be no need for a direct visual link to the historic building. Height and setback from the street should generally be consistent with those of the historic building and other surrounding buildings in the district. Thus, in most urban

recommendations for compatible new additions apply equally to new construction.

Almost two years have passed since the revised preservation brief was published. All too soon it may be time to update again, but only to refresh the illustrations. The Secretary of the Interior's Standards for Rehabilitation were crafted to stand the test of time. So far they have, and the guidance they provide has not changed. Thus, *Preservation Brief 14* should continue to serve its purpose by providing valuable insight regarding compatible new additions to historic buildings in rehabilitation projects.

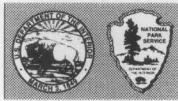
Editor's Note: *Preservation Brief 14: New Exterior Additions to Historic Building: Preservation Concerns* is available in PDF format online at <http://www.nps.gov/tps/how-to-preserve/briefs.htm>. See <http://www.nps.gov/tps/education/sale-pubs.htm> for information on how to obtain printed copies of the brief.

# 17 PRESERVATION BRIEFS



## Architectural Character: Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character

Lee H. Nelson, FAIA



U.S. Department of the Interior  
National Park Service  
Cultural Resources  
Heritage Preservation Services

The Secretary of the Interior's "Standards for Historic Preservation Projects" embody two important goals: 1) the preservation of historic materials and, 2) the preservation of a building's distinguishing character. Every old building is unique, with its own identity and its own distinctive character. Character refers to all those visual aspects and physical features that comprise the appearance of every historic building. Character-defining elements include the overall shape of the building, its materials, craftsmanship, decorative details, interior spaces and features, as well as the various aspects of its site and environment.

The purpose of this Brief is to help the owner or the architect identify those features or elements that give the building its *visual character* and that should be taken into account in order to preserve them to the maximum extent possible.

There are different ways of understanding old buildings. They can be seen as examples of specific building types, which are usually related to a building's function, such as schools, courthouses or churches. Buildings can be studied as examples of using specific materials such as concrete, wood, steel, or limestone. They can also be considered as examples of an historical period, which is often related to a specific architectural style, such as Gothic Revival farmhouses, one-story bungalows, or Art Deco apartment buildings.

There are many other facets of an historic building besides its functional type, its materials or construction or style that contribute to its historic qualities or significance. Some of these qualities are feelings conveyed by the sense of time and place or in buildings associated with events or people. A complete understanding of any property may require documentary research about its style, construction, function, its furnishings or contents; knowledge about the original builder, owners, and later occupants; and knowledge about the evolutionary history of the building. Even though buildings may be of historic, rather than architectural significance, it is their tangible elements that embody its significance for association with specific events or persons and it is those *tangible elements* both on the exterior and interior that should be preserved.

Therefore, the approach taken in this Brief is limited to identifying those visual and tangible aspects of the historic building. While this may aid in the planning process for carrying out any ongoing or new use or restoration of the building, this approach is not a

substitute for developing an understanding about the significance of an historic building and the district in which it is located.

If the various materials, features and spaces that give a building its visual character are not recognized and preserved, then essential aspects of its character may be damaged in the process of change.

A building's character can be irreversibly damaged or changed in many ways, for example, by inappropriate repointing of the brickwork, by removal of a distinctive side porch, by changes to the window sash, by changes to the setting around the building, by changes to the major room arrangements, by the introduction of an atrium, by painting previously unpainted woodwork, etc.

### A Three-Step Process to Identify A Building's Visual Character

This Brief outlines a three-step approach that can be used by anyone to identify those materials, features and spaces that contribute to the visual character of a building. This approach involves first examining the building from afar to understand its overall setting and architectural context; then moving up very close to appreciate its materials and the craftsmanship and surface finishes evident in these materials; and then going into and through the building to perceive those spaces, rooms and details that comprise its interior visual character.

#### Step 1: Identify the Overall Visual Aspects

Identifying the overall visual character of a building is nothing more than looking at its distinguishing physical aspects without focusing on its details. The major contributors to a building's overall character are embodied

in the general aspects of its *setting*; the *shape* of the building; its *roof* and roof features, such as chimneys or cupolas; the various *projections* on the building, such as porches or bay windows; the *recesses* or voids in a building, such as open galleries, arcades, or recessed balconies; the *openings* for windows and doorways; and finally the various exterior *materials* that contribute to the building's character. Step one involves looking at the building from a distance to understand the character of its site and setting, and it involves walking around the building where that is possible. Some buildings will have one or more sides that are more important than the others because they are more highly visible. This does not mean that the rear of the building is of no value whatever but it simply means that it is less important to the overall character. On the other hand, the rear may have an interesting back porch or offer a private garden space or some other aspect that may contribute to the visual character. Such a general approach to looking at the building and site will provide a better understanding of its overall character without having to resort to an infinitely long checklist of its possible features and details. Regardless of whether a building is complicated or relatively plain, it is these broad categories that contribute to an understanding of the overall character rather than the specifics of architectural features such as moldings and their profiles.

### Step 2: Identify the Visual Character at Close Range

Step two involves looking at the building at close range or arm's length, where it is possible to see all the surface qualities of the materials, such as their *color* and *texture*, or surface evidence of craftsmanship or age. In some instances, the visual character is the result of the juxtaposition of materials that are contrastingly different in their color and texture. The surface qualities of the materials may be important because they impart the very sense of craftsmanship and age that distinguishes historic buildings from other buildings. Furthermore, many of these close up qualities can be easily damaged or obscured by work that affects those surfaces. Examples of this could include painting previously unpainted masonry, rotary disk sanding of smooth wood siding to remove paint, abrasive cleaning of tooled stonework, or repointing reddish mortar joints with gray portland cement.

There is an almost infinite variety of surface materials, textures and finishes that are part of a building's character which are fragile and easily lost.

### Step 3: Identify the Visual Character of the Interior Spaces, Features and Finishes

Perceiving the character of interior spaces can be somewhat more difficult than dealing with the exterior.

In part, this is because so much of the exterior can be seen at one time and it is possible to grasp its essential character rather quickly. To understand the interior character, it is necessary to move through the spaces one at a time. While it is not difficult to perceive the character of one individual room, it becomes more difficult to deal with spaces that are interconnected and interrelated. Sometimes, as in office buildings, it is the vestibules or lobbies or corridors that are important to the interior character of the building. With other groups of buildings the visual qualities of the interior are related to the plan of the building, as in a church with its axial plan creating a narrow tunnel-like space which obviously has a different character than an open space like a sports pavilion. Thus the shape of the space may be an essential part of its character. With some buildings it is possible to perceive that there is a visual linkage in a sequence of spaces, as in a hotel, from the lobby to the grand staircase to the ballroom. Closing off the openings between those spaces would change the character from visually linked spaces to a series of closed spaces. For example, in a house that has a front and back parlor linked with an open archway, the two rooms are perceived together, and this visual relationship is part of the character of the building. To close off the open archway would change the character of such a residence.

The importance of interior features and finishes to the character of the building should not be overlooked. In relatively simple rooms, the primary visual aspects may be in features such as fireplace mantels, lighting fixtures or wooden floors. In some rooms, the absolute plainness is the character-defining aspect of the interior. So-called secondary spaces also may be important in their own way, from the standpoint of history or because of the family activities that occurred in those rooms. Such secondary spaces, while perhaps historically significant, are not usually perceived as important to the *visual* character of the building. Thus we do not take them into account in the visual understanding of the building.

### Conclusion

Using this three-step approach, it is possible to conduct a walk through and identify all those elements and features that help define the visual character of the building. In most cases, there are a number of aspects about the exterior and interior that are important to the character of an historic building. The visual emphasis of this brief will make it possible to ascertain those things that should be preserved because their loss or alteration would diminish or destroy aspects of the historic character whether on the outside, or on the inside of the building.





**Overall Visual Character: Shape**

The shape of a building can be an important aspect of its overall visual character. The building illustrated here, for example, has a distinctive horizontal box-like shape with the middle portion of the box projecting up an extra story. This building has other visual aspects that help define its overall character, including the pattern of vertical bands of windows, the decorative horizontal bands which separate the base of the building from the upper floors, the dark brown color of the brick, the large arched entranceway, and the castle-like tower behind the building.



**Overall Visual Character: Shape**

It should not be assumed that only large or unusual buildings have a shape that is distinctive or identifiable. The front wall of this modest commercial building has a simple three-part shape that is the controlling aspect of its overall visual character. It consists of a large center bay with a two story opening that combines the storefront and the windows above. The upward projecting parapet and the decorative stonework also relate to and emphasize its shape. The flanking narrow bays enframe the side windows and the small iron balconies, and the main entrance doorway into the store. Any changes to the center portion of this three-part shape, could drastically affect the visual character of this building. Photo by Emogene A. Bevitt



**Overall Visual Character: Openings**

Window and door openings can be important to the overall visual character of historic buildings. This view shows only part of a much larger building, but the windows clearly help define its character, partly because of their shape and rhythm: the upper floor windows are grouped in a 4,3,4,1,4 rhythm, and the lower floor windows are arranged in a regular 1,1,1,... rhythm. The individual windows are tall, narrow and arched, and they are accented by the different colored arched heads, which are connected where there are multiple windows so that the color contrast is a part of its character. If additional windows were inserted in the gap of the upper floors, the character would be much changed, as it would if the window heads were painted to match the color of the brick walls. Photo by Susan I. Dynes



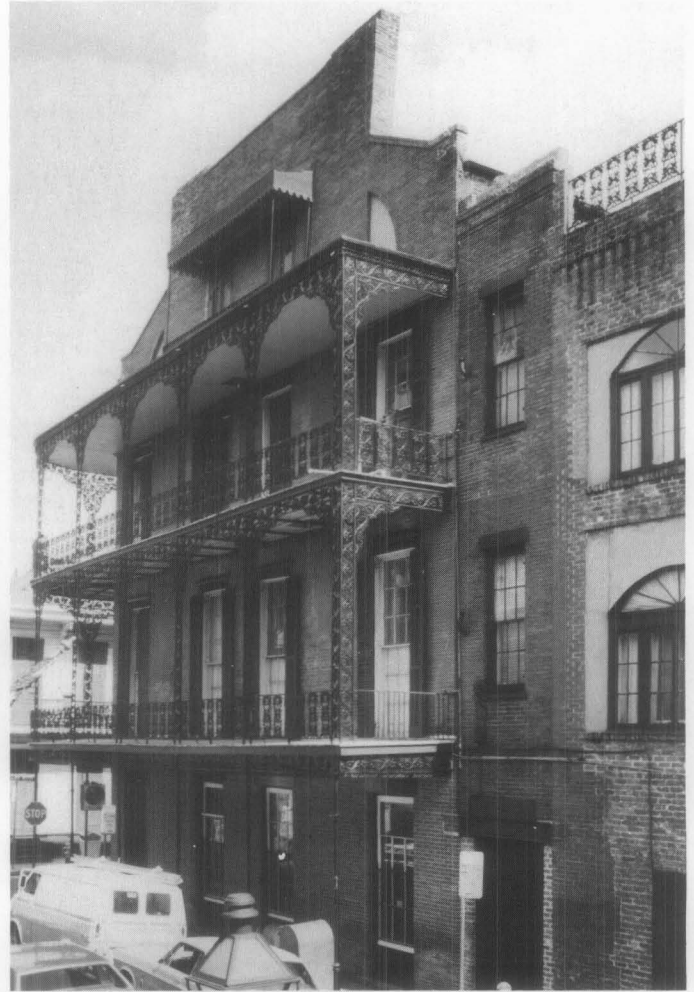
**Overall Visual Character: Openings**

The opening illustrated here dominates the visual character of this building because of its size, shape, location, materials, and craftsmanship. Because of its relation to the generous staircase, this opening places a strong emphasis on the principal entry to the building. Enclosing this arcade-like entry with glass, for example, would materially and visually change the character of the building. Photo by Lee H. Nelson.



**Overall Visual Character: Roof and Related Features**

This building has a number of character-defining aspects which include the windows and the decorative stonework, but certainly the roof and its related features are visually important to its overall visual character. The roof is not only highly visible, it has elaborate stone dormers, and it also has decorative metalwork and slatework. The red and black slates of differing sizes and shapes are laid in patterns that extend around the roof of this large and freestanding building. Any changes to this patterned slatework, or to the other roofing details would damage the visual character of the building. Photo by Laurie R. Hammel



**Overall Visual Character: Projections**

A projecting porch or balcony can be very important to the overall visual character of almost any building and to the district in which it is located. Despite the size of this building (3 1/2 stories), and its distinctive roofline profile, and despite the importance of the very large window openings, the lacy wrap-around iron balcony is singularly important to the visual character of this building. It would seriously affect the character to remove the balcony, to enclose it, or to replace it with a balcony lacking the same degree of detail of the original material. Photo by Baird M. Smith



**Overall Visual Character: Roof and Related Features**

On this building, the most important visual aspects of its character are the roof and its related features such as the dormers and chimneys. The roof is important to the visual character because its steepness makes it highly visible, and its prominence is reinforced by the patterned tinwork, the six dormers and the two chimneys. Changes to the roof or its features, such as removal or alterations to the dormers, for example, would certainly change the character of this building. This does not discount the importance of its other aspects, such as the porch, the windows, the brickwork, or its setting; but the roof is clearly crucial to understanding the overall visual character of this building as seen from a distance. Photo by Lee H. Nelson



**Overall Visual Character: Projections**

Since these are row houses, any evaluation of their visual exterior character is necessarily limited to the front and rear walls; and while there are a number of things competing for attention in the front, it is the half round projecting bays with their conical roofs that contribute most prominently to the visual character. Their removal would be a devastating loss to the overall character, but even if preserved, the character could be easily damaged by changes to their color (as seen in the left bay which has been painted a dark color), or changes to their windows, or changes to their tile roofs. Though these houses have other fine features that contribute to the visual character and are worthy of preservation, these half-round bays demonstrate the importance of projecting features on an already rich and complex facade. Because of the repetitive nature of these projecting bays on adjacent row houses, along with the buildings' size, scale, openings, and materials, they also contribute to the overall visual character of the streetscape in the historic district. Any evaluation of the visual character of such a building should take into account the context of this building within the district. Photo by Lee H. Nelson



**Overall Visual Character: Projections**

Many buildings have projecting features such as porches, bay windows, or overhanging roofs, that help define their overall visual character. This projecting porch because of its size and shape, and because it copies the pitch and material of the main roof, is an important contributor to the visual character of this simple farmhouse. The removal or alteration of this porch would drastically alter the character of this building. If the porch were enclosed with wood or glass, or if gingerbread brackets were added to the porch columns, or if the tin roof was replaced with asphalt, or if the porch railing was opened to admit a center stairway, the overall visual character could be seriously damaged. Although this projecting porch is an important feature, almost any other change to this house, such as changes to the window pattern, or changes to the main roof, or changes to the setting, would also change its visual character. Photo by Hugh C. Miller



**Overall Visual Character: Trim**

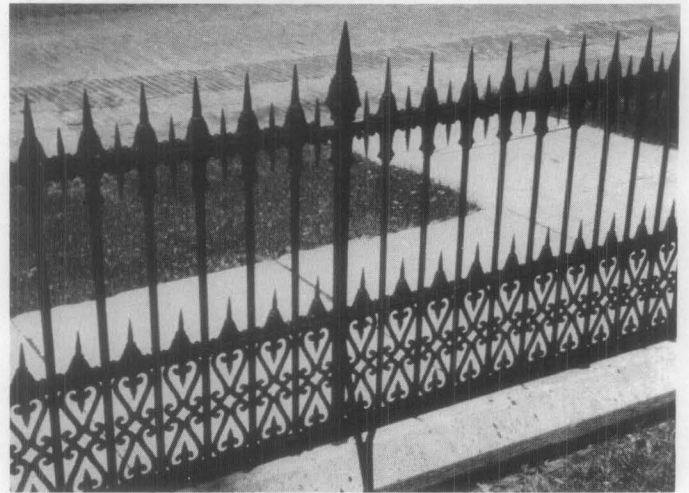
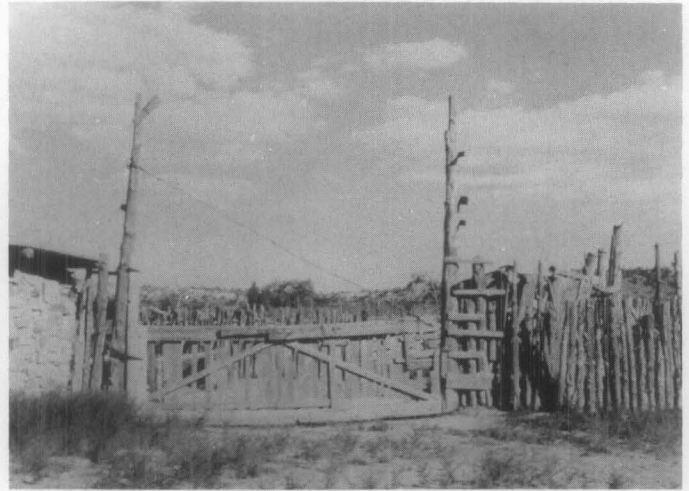
If one were to analyze the overall shape or form of this building, it would be seen that it is a gable-roofed house with dormers and a wrap-around porch. It is similar to many other houses of the period. It is the wooden trim on the eaves and around the porch that gives this building its own identify and its special visual character. Although such wooden trim is vulnerable to the elements, and must be kept painted to prevent deterioration; the loss of this trim would seriously damage the overall visual character of this building, and its loss would obliterate much of the close-up visual character so dependent upon craftsmanship for the moldings, carvings, and the see-through jigsaw work. Photo by Hugh C. Miller



**Overall Visual Character: Setting**

In the process of identifying the overall visual character, the aspect of setting should not be overlooked. Obviously, the setting of urban row houses differs from that of a mansion with a designed landscape. However, there are many instances where the relationship between the building and its place on the streetscape, or its place in the rural environment, in other words its setting, may be an important contributor to its overall character.

In this instance, the corner tower and the arched entryway are important contributors to the visual character of the building itself, but there is also a relationship between the building and the two converging streets that is also an important aspect of this historic building. The curb, sidewalk, fence, and the yard interrelate with each other to establish a setting that is essential to the overall visual character of the historic property. Removing these elements or replacing them with a driveway or parking court would destroy an important visual aspect. Photo by Lee H. Nelson



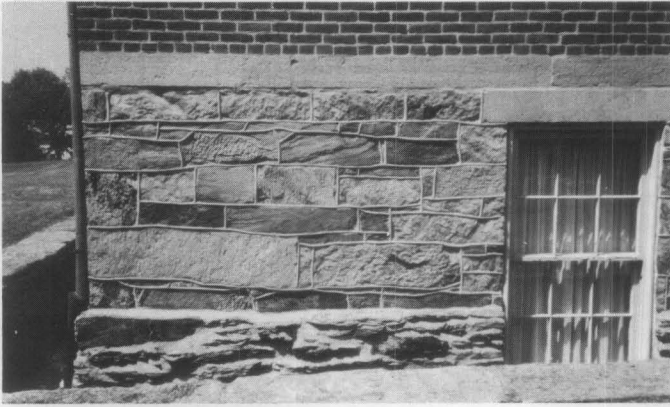
**Overall Visual Character: Setting**

Among the various visual aspects relating to the setting of an historic property are such site features as gardens, walks, fences, etc. This can include their design and materials. There is a dramatic difference in the visual character between these two fence constructions—one utilizing found materials with no particular regard to their uniformity of size or placement, and the other being a product of the machine age utilizing cast iron components assembled into a pattern of precision and regularity. If the corral fence were to be repaired or replaced with lumberyard materials its character would be dramatically compromised. The rhythm and regularity of the cast iron fence is so important to its visual character that its character could be altered by accidental damage or vandalism, if some of the fence top spikes were broken off thus interrupting the rhythm or pattern. Photos by Lee H. Nelson



**Overall Visual Character: Setting**

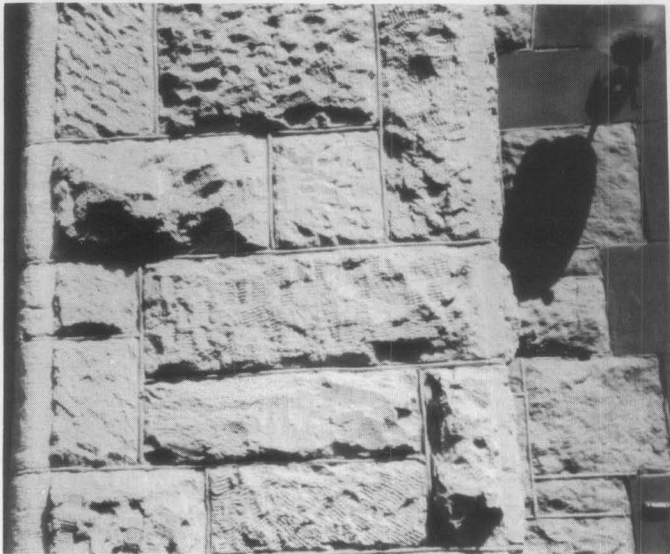
Even architecturally modest buildings frequently will have a setting that contributes to their overall character. In this very urban district, set-backs are the exception, so that the small front yard is something of a luxury, and it is important to the overall character because of its design and materials, which include the iron fence along the sidewalk, the curved walk leading to the porch, and the various plantings. In a district where parking spaces are in great demand, such front yards are sometimes converted to off-street parking, but in this instance, that would essentially destroy its setting and would drastically change the visual character of this historic property. Photo by Lee H. Nelson



#### ***Arm's Length Visual Character: Materials***

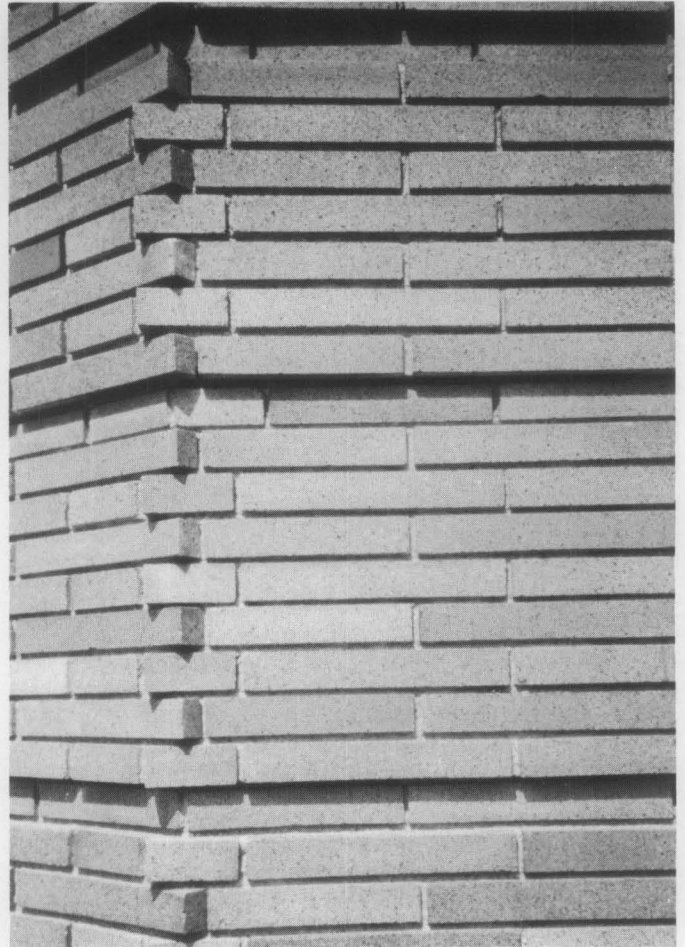
At arm's length, the visual character is most often determined by the surface qualities of the materials and craftsmanship; and while these aspects are often inextricably related, the original choice of materials often plays the dominant role in establishing the close-range character because of the color, texture, or shape of the materials.

In this instance, the variety and arrangement of the materials is important in defining the visual character, starting with the large pieces of broken stone which form the projecting base for the building walls, then changing to a wall of roughly rectangular stones which vary in size, color, and texture, all with accentuated, projecting beads of mortar, then there is a rather precise and narrow band of cut and dressed stones with minimal mortar joints, and finally, the main building walls are composed of bricks, rather uniform in color, with fairly generous mortar joints. It is the juxtaposition and variety of these materials (and of course, the craftsmanship) that is very important to the visual character. Changing the raised mortar joints, for example, would drastically alter the character at arm's length. Photo by Lee H. Nelson



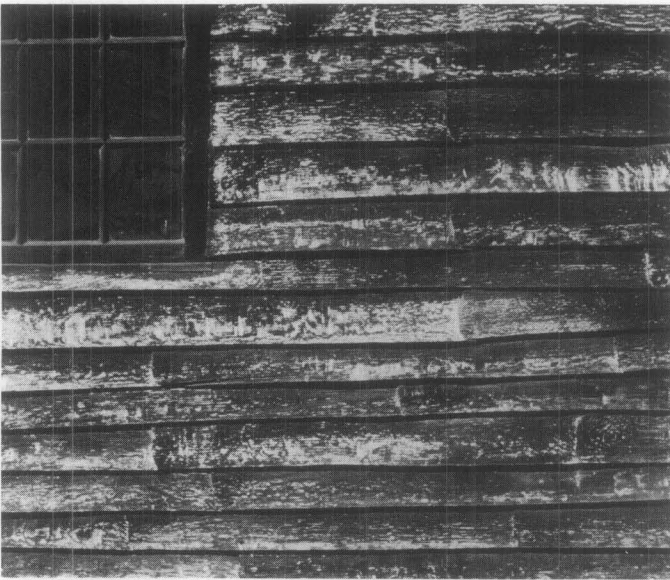
#### ***Arm's Length Visual Character: Craft Details***

There are many instances where craft details dominate the arm's length visual character. As seen here, the craft details are especially noticeable because the stones are all of a uniform color, and they are all squared off, but their surfaces were worked with differing tools and techniques to create a great variety of textures, resulting in a tour-de-force of craft details. This texture is very important at close range. It was a deliberately contrived surface that is an important contributor to the visual character of this building. Photo by Lee H. Nelson



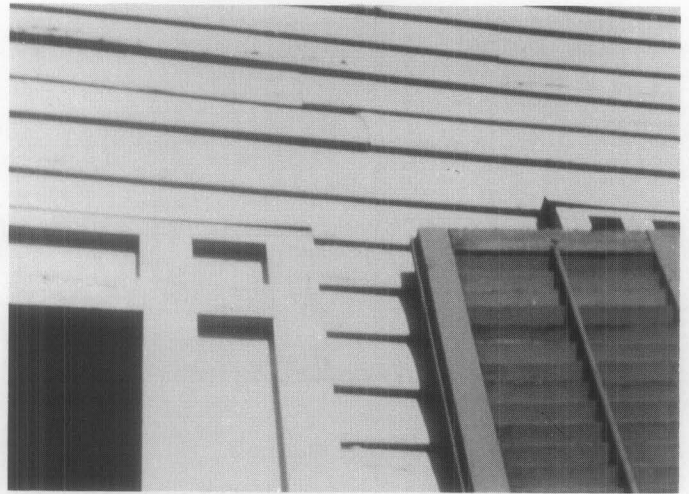
#### ***Arm's Length Visual Character: Craft Details***

The arm's length visual character of this building is a combination of the materials and the craft details. Most of the exterior walls of this building consist of early 20th century Roman brick, precisely made, unusually long bricks, in varying shades of yellow-brown, with a noticeable surface spotting of dark iron pyrites. While this brick is an important contributor to the visual character, the related craft details are perhaps more important, and they consist of: unusually precise coursing of the bricks, almost as though they were laid up using a surveyor's level; a row of recessed bricks every ninth course, creating a shadow pattern on the wall; deeply recessed mortar joints, creating a secondary pattern of shadows; and a toothed effect where the bricks overlap each other at the corner of the building. The cumulative effect of this artisanry is important to the arm's length visual character, and it is evident that it would be difficult to match if it were damaged, and the effect could be easily damaged through insensitive treatments such as painting the brickwork or by careless repointing. Photo by Lee H. Nelson



***Arm's Length Visual Character: Craft Details***

On some buildings, there are subtle aspects of visual character that cannot be perceived from a distance. This is especially true of certain craft details that can be seen only at close range. On this building, it is easily understood that the narrow, unpainted, and weathered clapboards are an important aspect of its overall visual character; but at close range there are a number of subtle but very important craft details that contribute to the handmade quality of this building, and which clearly differentiate it from a building with machine sawn clapboards. The clapboards seen here were split by hand and the bottom edges were not dressed, so that the boards vary in width and thickness, and thus they give a very uneven shadow pattern. Because they were split from oak that is unpainted, there are occasional wavy rays in the wood that stand against the grain. Also noticeable is the fact that the boards are of relatively short lengths, and that they have feather-edged ends that overlap each other, a detail that is very different from butted joints. The occasional large nail heads and the differential silver-gray weathering add to the random quality of the clapboards. All of these qualities contribute to the arm's length visual character. Photo by Lee H. Nelson



***Arm's Length Visual Character: Craft Details***

While hand-split clapboards are distinctive visual elements in their own way, machine-sawn and painted wood siding is equally important to the overall visual character in most other instances. At arm's length, however, the machine sawn siding may not be so distinctive; but there might be other details that add visual character to the wooden building, such as the details of wooden trim and louvered shutters around the windows (as seen here), or similar surface textures on other buildings, such as the saw marks on wall shingles, the joints in leaded glass, decorative tinwork on a rain conductor box, the rough surface of pebble-dash stuccowork, or the pebbly surface of exposed aggregate concrete. Such surfaces can only be seen at arm's length and they add to the visual character of a historic building. Photo by Hugh C. Miller



***Interior Visual Character: Individually Important Spaces***

In assessing the interior visual character of any historic building, it is necessary to ask whether there are spaces that are important to the character of this particular building, whether the building is architecturally rich or modest, or even if it is a simple or utilitarian structure.

The character of the individually important space which is illustrated here is a combination of its size, the twin curving staircases, the massive columns and curving vaulted ceilings, in addition to the quality of the materials in the floor and in the stairs. If the ceiling were to be lowered to provide space for heating ducts, or if the stairways were to be enclosed for code reasons, the shape and character of this space would be damaged, even if there was no permanent physical damage. Such changes can easily destroy the visual character of an individually important interior space. Thus, it is important that the visual aspects of a building's interior character be recognized before planning any changes or alterations. Photo by National Portrait Gallery

**Interior Visual Character: Related Spaces**

Many buildings have interior spaces that are visually or physically related so that, as you move through them, they are perceived not as separate spaces, but as a sequence of related spaces that are important in defining the interior character of the building. The example which is illustrated here consists of three spaces that are visually linked to each other.

The first of these spaces is the vestibule which is of a generous size and unusual in its own right, but more important, it visually relates to the second space which is the main stairhall.

The hallway is the circulation artery for the building, and leads both horizontally and vertically to other rooms and spaces, but especially to the open and inviting stairway.

The stairway is the third part of this sequence of related spaces, and it provides continuing access to the upper floors.

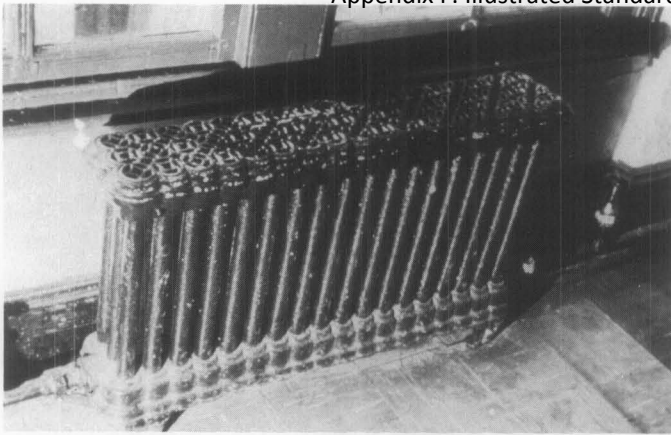
These related spaces are very important in defining the interior character of this building. Almost any change to these spaces, such as installing doors between the vestibule and the hallway, or enclosing the stair would seriously impact their character and the way that character is perceived. Top photo by Mel Chamowitz, others by John Tennant

**Interior Visual Character: Interior Features**

Interior features are three-dimensional building elements or architectural details that are an integral part of the building as opposed to furniture. Interior features are often important in defining the character of an individual room or space. In some instances, an interior feature, like a large and ornamental open stairway may dominate the visual character of an entire building. In other instances, a modest iron stairway (like the one illustrated here) may be an important interior feature, and its preservation would be crucial to preserving the interior character of the building. Such features can also include the obvious things like fireplace mantles, plaster ceiling medallions, or panelling, but they also extend to features like hardware, lighting fixtures, bank tellers cages, decorative elevator doors, etc.

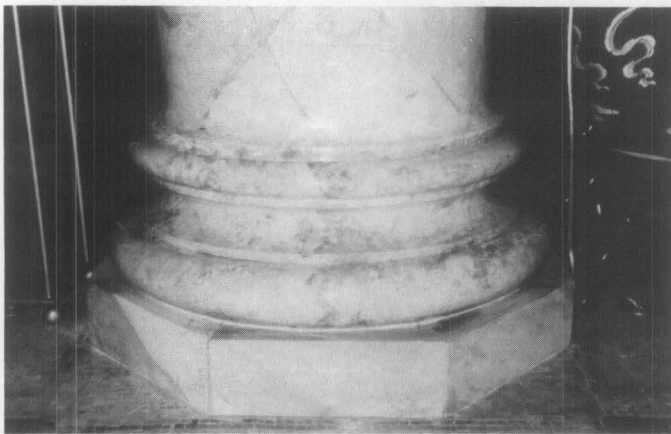
Photo by David W. Look





***Interior Visual Character: Interior Features***

Modern heating or cooling devices usually add little to the interior character of a building; but historically, radiators, for instance, may have contributed to the interior character by virtue of their size or shape, or because of their specially designed bases, piping, and decorative grillage or enclosures. Sometimes they were painted with several colors to highlight their integral, cast-in details. In more recent times, it has been common to overpaint and conceal such distinctive aspects of earlier heating and plumbing devices, so that we seldom have the opportunity to realize how important they can be in defining the character of interior rooms and spaces. For that reason, it is important to identify their character-defining potential, and consider their preservation, retention, or restoration. Photo by David W. Look



***Interior Visual Character: Surface Materials and Finishes***

When identifying the visual character of historic interior spaces one should not overlook the importance of those materials and finishes that comprise the surfaces of walls, floors and ceilings. The surfaces may have evidence of either hand-craft or machine-made products that are important contributors to the visual character, including patterned or inlaid designs in the wood flooring, decorative painting practices such as stenciling, imitation marble or wood grain, wallpapering, tinwork, tile floors, etc.

The example illustrated here involves a combination of real marble at the base of the column, imitation marble patterns on the plaster surface of the column (a practice called scagliola), and a tile floor surface that uses small mosaic tiles arranged to form geometric designs in several different colors. While such decorative materials and finishes may be important in defining the interior visual character of this particular building, it should be remembered that in much more modest buildings, the plainness of surface materials and finishes may be an essential aspect of their historic character. Photo by Lee H. Nelson



***Fragility of A Building's Visual Character***

Some aspects of a building's visual character are fragile and are easily lost. This is true of brickwork, for example, which can be irreversibly damaged with inappropriate cleaning techniques or by insensitive repointing practices. At least two factors are important contributors to the visual character of brickwork, namely the brick itself and the craftsmanship. Between these, there are many more aspects worth noting, such as color range of bricks, size and shape variations, texture, bonding patterns, together with the many variable qualities of the mortar joints, such as color, width of joint and tooling. These qualities could be easily damaged by painting the brick, by raking out the joint with power tools, or repointing with a joint that is too wide. As seen here during the process of repointing, the visual character of this front wall is being dramatically changed from a wall where the bricks predominate, to a wall that is visually dominated by the mortar joints. Photo by Lee H. Nelson



# The Architectural Character Checklist/Questionnaire

Lee H. Nelson, FAIA  
National Park Service

This checklist can be taken to the building and used to identify those aspects that give the building and setting its essential visual qualities and character. This checklist consists of a series of questions that are designed to help in identifying those things that contribute to a building's character. The use of this checklist involves the three-step process of looking for: 1) the overall visual aspects, 2) the visual character at close range, and 3) the visual character of interior spaces, features and finishes.

Because this is a process to identify *architectural character*, it does not address those intangible qualities that give a property or building or its contents its historic significance, instead this checklist is organized on the assumption that historic significance is embodied in those *tangible* aspects that include the building's setting, its form and fabric.

## Step One

### 1. Shape

What is there about the form or shape of the building that gives the building its identity? Is the shape distinctive in relation to the neighboring buildings? Is it simply a low, squat box, or is it a tall, narrow building with a corner tower? Is the shape highly consistent with its neighbors? Is the shape so complicated because of wings, or ells, or differences in height, that its complexity is important to its character? Conversely, is the shape so simple or plain that adding a feature like a porch would change that character? Does the shape convey its historic function as in smoke stacks or silos?

Notes on the Shape or Form of the Building:

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### 2. Roof and Roof Features

Does the roof shape or its steep (or shallow) slope contribute to the building's character? Does the fact that the roof is highly visible (or not visible at all) contribute to the architectural identity of the building? Are certain roof features important to the profile of the building against the sky or its background, such as cupolas, multiple chimneys, dormers, cresting, or weathervanes? Are the roofing materials or their colors or their patterns (such as patterned slates) more noticeable than the shape or slope of the roof?

Notes on the Roof and Roof Features:

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### 3. Openings

Is there a rhythm or pattern to the arrangement of windows or other openings in the walls; like the rhythm of windows in a factory building, or a three-part window in the front bay of a house; or is there a noticeable relationship between the width of the window openings and the wall space between the window openings? Are there distinctive openings, like a large arched entranceway, or decorative window lintels that accentuate the importance of the window openings, or unusually shaped windows, or patterned window sash, like small panes of glass in the windows or doors, that are important to the character? Is the plainness of the window openings such that adding shutters or gingerbread trim would radically change its character? Is there a hierarchy of facades that make the front windows more important than the side windows? What about those walls where the absence of windows establishes its own character?

Notes on the Openings:

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### 4. Projections

Are there parts of the building that are character-defining because they project from the walls of the building like porches, cornices, bay windows, or balconies? Are there turrets, or widely overhanging eaves, projecting pediments or chimneys?

Notes on the Projections:

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### 5. Trim and Secondary Features

Does the trim around the windows or doors contribute to the character of the building? Is there other trim on the walls or around the projections that, because of its decoration or color or patterning contributes to the character of the building? Are there secondary features such as shutters, decorative gables, railings, or exterior wall panels?

Notes on the Trim and Secondary Features:

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### 6. Materials

Do the materials or combination of materials contribute to the overall character of the building as seen from a distance because of their color or patterning, such as broken faced stone, scalloped wall shingling, rounded rock foundation walls, boards and battens, or textured stucco?

Notes on the Materials:

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### 7. Setting

What are the aspects of the setting that are important to the visual character? For example, is the alignment of buildings along a city street and their relationship to the sidewalk the essential aspect of its setting? Or, conversely, is the essential character dependent upon the tree plantings and out buildings which surround the farmhouse? Is the front yard important to the setting of the modest house? Is the specific site important to the setting such as being on a hilltop, along a river, or, is the building placed on the site in such a way to enhance its setting? Is there a special relationship to the adjoining streets and other buildings? Is there a view? Is there fencing, planting, terracing, walkways or any other landscape aspects that contribute to the setting?

Notes on the Setting:

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## Appendix F. Illustrated Standards, Preservation Briefs, and Bulletins Step Two

### 8. Materials at Close Range

Are there one or more materials that have an inherent texture that contributes to the close range character, such as stucco, exposed aggregate concrete, or brick textured with vertical grooves? Or materials with inherent colors such as smooth orange-colored brick with dark spots of iron pyrites, or prominently veined stone, or green serpentine stone? Are there combinations of materials, used in juxtaposition, such as several different kinds of stone, combinations of stone and brick, dressed stones for window lintels used in conjunction with rough stones for the wall? Has the choice of materials or the combinations of materials contributed to the character?

Notes on the Materials at Close Range:

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### 9. Craft Details

Is there high quality brickwork with narrow mortar joints? Is there hand-tooled or patterned stonework? Do the walls exhibit carefully struck vertical mortar joints and recessed horizontal joints? Is the wall shinglework laid up in patterns or does it retain evidence of the circular saw marks or can the grain of the wood be seen through the semi-transparent stain? Are there hand split or hand-dressed clapboards, or machine smooth beveled siding, or wood rusticated to look like stone, or Art Deco zigzag designs executed in stucco?

Almost any evidence of craft details, whether handmade or machinemade, will contribute to the character of a building because it is a manifestation of the materials, of the times in which the work was done, and of the tools and processes that were used. It further reflects the effects of time, of maintenance (and/or neglect) that the building has received over the years. All of these aspects are a part of the surface qualities that are seen only at close range.

Notes on the Craft Details:

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## Step Three

### 10. Individual Spaces

Are there individual rooms or spaces that are important to this building because of their size, height, proportion, configuration, or function, like the center hallway in a house, or the bank lobby, or the school auditorium, or the ballroom in a hotel, or a courtroom in a county courthouse?

Notes on the Individual Spaces:

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### 11. Related Spaces and Sequences of Spaces

Are there adjoining rooms that are visually and physically related with large doorways or open archways so that they are perceived as related rooms as opposed to separate rooms? Is there an important sequence of spaces that are related to each other, such as the sequence from the entry way to the lobby to the stairway and to the upper balcony as in a theatre; or the sequence in a residence from the entry vestibule to the hallway to the front parlor, and on through the sliding doors to the back parlor; or the sequence in an office building from the entry vestibule to the lobby to the bank of elevators?

Notes on the Related Spaces and Sequences of Spaces:

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### 12. Interior Features

Are there interior features that help define the character of the building, such as fireplace mantels, stairways and balustrades, arched openings, interior shutters, inglenooks, cornices, ceiling medallions, light fixtures, balconies, doors,

windows, hardware, wainscoting, panelling, trim, church pews, courtroom bars, teller cages, waiting room benches?

Notes on the Interior Features:

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### 13. Surface Finishes and Materials

Are there surface finishes and materials that can affect the design, the color or the texture of the interior? Are there materials and finishes or craft practices that contribute to the interior character, such as wooden parquet floors, checkerboard marble floors, pressed metal ceilings, fine hardwoods, grained doors or marblized surfaces, or polychrome painted surfaces, or stencilling, or wallpaper that is important to the historic character? Are there surface finishes and materials that, because of their plainness, are imparting the essential character of the interior such as hard or bright, shiny wall surfaces of plaster or glass or metal?

Notes on the Surface Finishes and Materials:

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### 14. Exposed Structure

Are there spaces where the exposed structural elements define the interior character such as the exposed posts, beams, and trusses in a church or train shed or factory? Are there rooms with decorative ceiling beams (non-structural) in bungalows, or exposed vigas in adobe buildings?

Notes on the Exposed Structure:

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This concludes the three-step process of identifying the visual aspects of historic buildings and is intended as an aid in preserving their character and other distinguishing qualities. It is not intended as a means of understanding the significance of historical properties or districts, nor of the events or people associated with them. That can only be done through other kinds of research and investigation.

This Preservation Brief was originally developed as a slide talk/methodology in 1982 to discuss the use of the Secretary of the Interior's Standards for Rehabilitation in relation to preserving historic character; and it was amplified and modified in succeeding years to help guide preservation decisionmaking, initially for maintenance personnel in the National Park Service. A number of people contributed to the evolution of the ideas presented here. Special thanks go to Emogene Bevitt and Gary Hume, primarily for the many and frequent discussions relating to this approach in its evolutionary stages; to Mark Fram, Ontario Heritage Foundation, Toronto, for suggesting several additions to the Checklist; and more recently, to my co-workers, both in Washington and in our regional offices, especially Ward Jandl, Sara Blumenthal, Charles Fisher, Sharon Park, AIA, Jean Travers, Camille Martone, Susan Dynes, Michael Auer, Anne Grimmer, Kay Weeks, Betsy Chittenden, Patrick Andrus, Carol Shull, Hugh Miller, FAIA, Jerry Rogers, Paul Alley, David Look, AIA, Margaret Pepin-Donat, Bonnie Halda, Keith Everett, Thomas Keohan, the Preservation Services Division, Mid-Atlantic Region, and several reviewers in state preservation offices, especially Ann Haaker, Illinois; and Stan Graves, AIA, Texas; for providing very critical and constructive review of the manuscript.

This publication has been prepared pursuant to the National Historic Preservation Act of 1966, as amended. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, P.O. Box 37127, Washington, D.C. 20013-7127. This publication is not copyrighted and can be reproduced without penalty. Normal procedures for credit to the author and the National Park Service are appreciated.