A SYSTEMATIC APPROACH TO EVALUATING HISTORICAL WOOD WINDOWS FOR REPAIR AND RESTORATION

By Steven R. Marshall, RRC, CDT, LEED AP, and Catherine Matathia, PE, LEED AP

This article is reprinted from the Proceedings of the 29th RCI International Convention and Trade Show *in 2014 in Anaheim, California.*

ABSTRACT

Historical windows are a key component of the fabric and character of a building. In many cases, the windows are neglected and left to deteriorate. The visible deterioration of historical wood and steel window systems, along with energy concerns, make these windows prime candidates for replacement with modern metal or plastic-based systems. This article provides architects and engineers with an overview of the materials and construction methods of these historical window systems with a primary focus on evaluation and design for their restoration. A methodical evaluation, condition assessment rating system, and repair techniques, including energy-saving weatherization techniques, are discussed.

Renovation and preservation of historical structures create many imposing obstacles for design professionals. Maintaining the structures' historical fabric and character is critical to success, with window restoration playing a major role. Consultants evaluating window assemblies have to fully understand repair techniques used by professional window restoration conservators. In addition to familiarity with historical window constructions and styles of different periods, the consultant must comprehend the types and origins of wood decay, selective wood repair methods, sash stabilization techniques, glazing, and hardware restoration or replacement to properly and effectively evaluate and design the rehabilitation of historical windows. This knowledge helps to restore the windows in a manner that maintains the maximum amount of historical significance of the window assembly and helps protect against unnecessary and/or damaging repairs that might be performed.

COMPILE ARCHITECTURAL AND HISTORICAL INFORMATION

Confirm purpose and history of windows

In order to provide and execute an appropriate repair and/or restoration plan, the original intent and purpose of the windows in the structure should be considered. For example, long runs of fixed, continuous, clerestory windows in a warehouse are presumably to provide adequate lighting rather than ventilation to the interior spaces. Alternatively, casement windows in a residential building circa 1920 function as an aesthetic element and can provide a relatively large amount of fresh air and sunlight to the interior. Additional window factors, including provisions for views of the outside and their contribution to the overall historical significance of the building façade, should also be considered.

Establishing the building's "period of significance" is critically important. The period of significance is often identified by an historical architect or preservationist during a study of the building and is then incorporated into an historical nomination form. It relates to when the building was considered important, based on an historic event, association with a significant person, distinct characteristics of design or construction, or its potential to yield important information. Depending on the treatment selected, all of the building's remaining historical features could be preserved equally, even if they are of different vintages; or the entire structure could be restored to one time period that has been identified to be its period of significance. For example, a building that was originally constructed in the 18th century could have had multiple additions and changes in use, leading it to incorporate wood windows from the 18th, 19th, and 20th centuries, all of which may be historical. Unless one period of the building is identified to be of specific significance, the appropriate approach may be to restore each of the windows to their specific time periods.

Additional research should be performed to determine if some or all of the windows have been replaced and just appear to be original. In some instances, when buildings undergo major renovations during their history, the original windows could have been completely replaced. If original drawings are not available, care should be taken to measure and compare muntin, brick mold, sash rail, and frame profiles for each window throughout the building. Windows that look original may not be when compared to the other windows in the building that may have been salvaged during the major renovation. Typically, the slight changes in

Photos 1 and 2 – An historical photo of the Boston Fire Station, Boston, MA (below) and an historical post card of the Beverly City Hall, Beverly, MA (left) helped identify the appropriate window configurations for these buildings.

the profiles of the sash rails and muntins can differentiate one series of windows from another. It is not uncommon to salvage the existing window frames and only replace the sashes.

Compile Historical Documentation

Gather any available drawings, details, building elevations, and historical photographs. These will assist in determining the original configuration and location of the windows and if any significant changes or alterations have been performed. Sources for this information include building owners, libraries, local historical societies, preservation groups, etc. Useful resources and historical data include the following:

- Original building plans, façade elevations, window schedules, and window and wall details—any information that indicates how the windows were designed or constructed
- Previous reports or photographs that document the windows or building façade
- Knowledge of or records of local practices or what was normally installed by builders at that time and in that region
- Books such as *Traditional Building Details* or historical building codes
- Architectural guide books to identify the style of the building, its vintage, and typical associated window styles

See *Photos 1* and *2*.

ESTABLISH DOCUMENTATION SYSTEM

After compiling the available historical data and researching the building's service history, perform a cursory review of the existing conditions of the façade and windows. This preliminary and limited review will allow for a more accurate window assessment plan to be established. Performing a cursory review of the windows to determine general characteristics including, but not limited to, material type, configuration, operability characteristics, and hardware, will help establish and streamline the documentation system and improve efficiency when performing more rigorous field evaluations.

In addition to the initial review, a unique numbering system for each window or rough opening should be established. The intent of the numbering system is to simplify the documentation process and provide accurate data collection for each window. It also serves as a method to link the various data forms (i.e., photos, window elevation, reports, checklists, and building elevations) together so they can all be accessed through this numbering system. Typically, this alphanumeric window identification should include the single letter representing the referenced building's exterior elevation (i.e., N, S, E, W), floor number, and alphabetical window designation starting from left to right. For example, the window identification number "N3A" would indicate the first window from the left, on the third floor of the building's north elevation. If multiple buildings were involved, the building name or number would precede the identification number. This unique numbering system should be established prior to performing a detailed window survey to reduce potential confusion when the field notes and information are compiled in the office at a later time.

When using the building's original architectural drawings, we strongly recommend comparing them to the building's existing façade prior to developing the numbering system. It is not uncommon for windows to have been enclosed or altered since the building's original construction. Once the actual number of windows is known, then the numbering system can be developed, and modifications can be noted on copies of the elevation drawings for reference in the final report.

Prior to initiating field evaluations, a window designation and condition/defect checklist for each common window type (i.e., wood) should be generated. This list may include, but not be limited to, the following:

- Building name/number
- Window material type
- Window designation number
- Window operability type
- Window glazing type
- Window components and characteristics
- Hardware types
- Defect codes related to materials including wood, glazing putty, paint, etc. Defect codes are typically a numbered rating system, such as a zero to four (0-4), where 0 is "good condition" or "no repairs required," and 4 is "major decay and substantial replacement parts" or "entire window is required." If the window is blocked or concealed in some way, then it should be noted that the unit is not visible (NV) and could not be evaluated.
- Window elevation sketch to show

appearance, dimensions, and location of defects

An example of a window defect checklist for a wood window is referenced in *Figure 1*.

ACCESS METHODS TO EVALUATE WINDOWS

One of the most important aspects of performing window assessments is the field evaluation. After compiling the existing architectural and historical data and establishing a documentation system, field evaluations are performed. Often, the exteriors of windows are not easily accessible due to adjacent buildings, site limitations, or height restrictions. Due to historical window complexities and potentially unique characteristics, it is critical to have "hand reach" access from the interior and exterior of each window to establish accurate restoration methods. There are several access methods that may be utilized to reach difficult areas:

- ***Aerial Lifts*** – Aerial lifts, which generally range in height from 30 to 150 feet, provide access and an observation platform with the ability to articulate to precise locations on the building façade. Note that flat and accessible grounds adjacent to the building are required for the use of an aerial lift.
- ***Swing Staging*** – Swing staging offers a suitable platform for observation and testing but is more suitable for straight vertical drops with a flat building geometry. Roof access is required to set up and move the swing staging, which can have high cost implications and extensive down time.
- ***Ground Observation*** – Ground observation using high-powered binoculars is useful to spot potential problematic areas or simply to verify or acquire quantities of components. High-powered binoculars and vantage points—such as adjacent buildings or roof levels—will help to improve the field data collected.
- ***Rope Access*** – Rope access allows for close-up observation of an elevation when other access (i.e., aerial lifts and swing staging) is too restrictive. Rope access must be performed by a qualified, properly trained person. It is also necessary to provide safety tie-offs and anchor points, which can be limited on historical facilities.

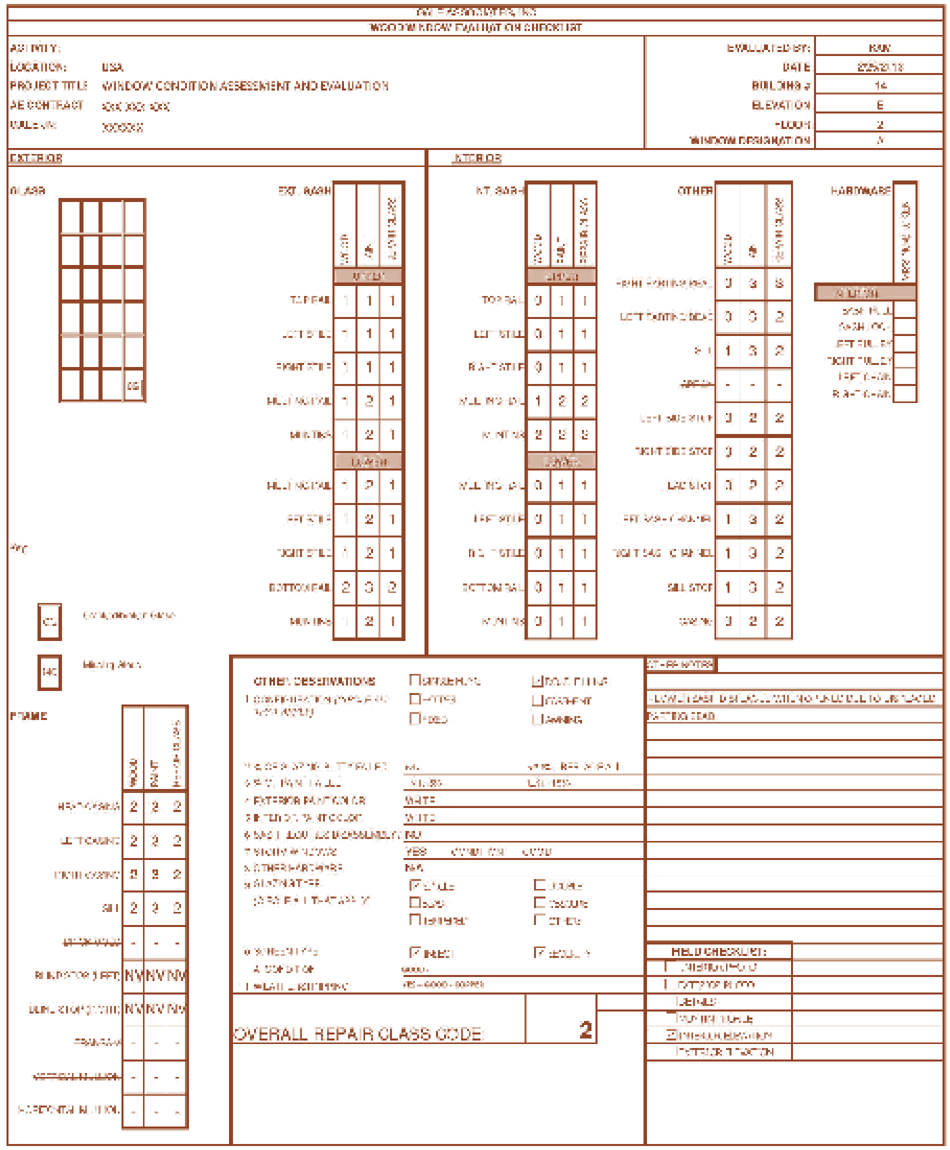

Figure 1 – Window defect checklist.

HISTORICAL WOOD WINDOW CONSTRUCTION

Typically, historical wood windows were manufactured using old-growth wood. Old-growth wood, commonly used until approximately 60 years ago, is significantly more durable than the new-growth wood generally used today. Furthermore, the joints of historical windows are typically mortise and tenon, which is more durable than the com-

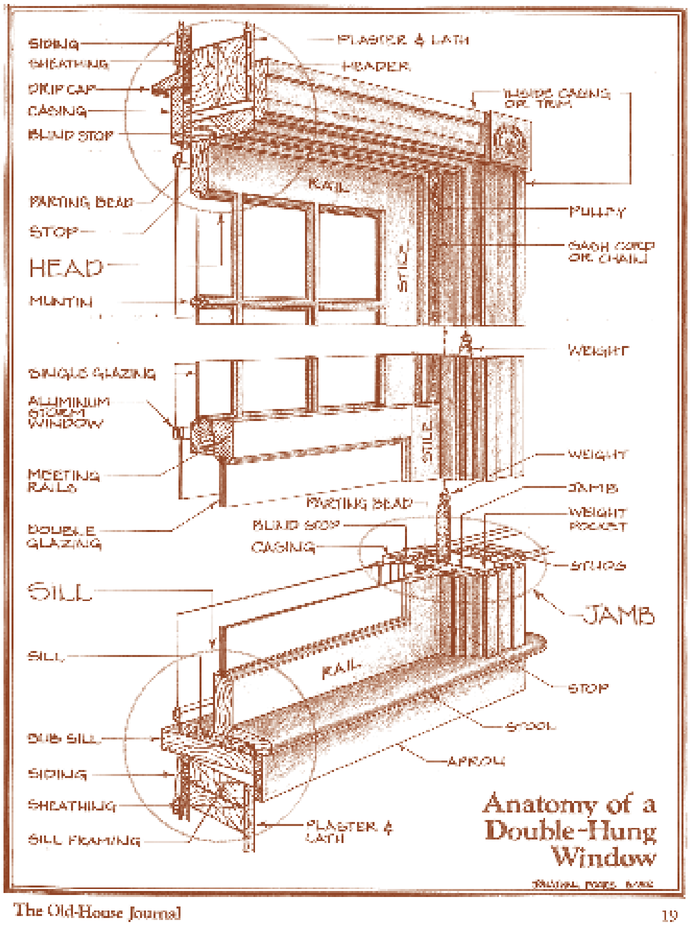

Figure 2 – Anatomy of a double-hung window.

mon mitered and glued joint used today. The material quality of the windows and the ability of these windows to be disassembled are critical factors to achieve a fully restored window, which will result in a reduction of air leakage through the window sashes. Air leakage is the primary cause of thermal loss through an existing wood window, and a common complaint of building occupants with historical wood windows.

In general, wood windows consist of a sash and frame. For the sake of simplicity, the typical components of a double-hung wood window will be described below.

The sash (also known as the operable portion of the window) is typically constructed of side stiles and rails at the top and bottom. The stiles (right/left) and rails (top/bottom) frame and secure the glass, and are typically joined with a mortise and tenon joint with an added fastener in the form of a wood peg or wire nail. The sash stiles and rails are then rabbeted on the exterior face in order to receive glass and glazing putty.

A divided-lite sash is constructed in a similar manner with the addition of bars and muntins. The rails are mortised in order to receive the bars, and the muntins are then installed between the bars. A double-hung sash requires meeting rails at the top of the lower sash and at the bottom of the upper sash. The meeting rails typically have a beveled surface that fits together when the window is closed. For ease of operability, double-hung windows incorporate a parting bead, which is a pressure-fitted piece of wood that sits within the frame groove in order to separate the upper and lower sash when opening and closing the window.

The window sash is set into the frame and held in place with the parting bead and sash stops. The head and jamb section of a window frame are typically constructed of a sash channel, blind stop, and casings. Within this pocket, created by these components, are the sash weights and chords or chains. The bottom rail typically sits over the sill and adjacent to the interior stool. Depending on the existing wall construction of the building, additional decorative trim, molding, and casings may be present. *Figure 2*, taken from *The Old House Journal*, presents the typical "anatomy" of a double-hung window.

Additionally, wood windows come in various configurations and operability classifications, including, but not limited to, fixed, awning, casement, pivots, and project in/out windows. These typical types are represented in *Figure 3*.

IN-DEPTH FIELD ASSESSMENT

In order to establish the proper restoration techniques, identification and accurate documentation of defective components are required. As previously noted, the exterior and interior conditions of each window are documented through a specific evaluation process. Certain defective characteristics are more suitably determined from either the interior or exterior of the window. For example, operability should be tested from the interior. Ropes and pulleys of wood windows are reviewed from the interior once exposed in the window pocket. Glazing putty conditions are more easily observed and assessed from the exterior.

A typical assessment plan would include the following: Every accessible window of the building will be evaluated at arm's length on the exterior and interior. Aerial lifts, swing staging, or rope access will be utilized to evaluate windows above the ground level on the exterior. Study team members will complete checklists for each window by sketching the window elevation, measuring the rough opening, sketching significant details, noting all window characteristics and deficiencies, and taking photographic documentation. To maximize the data cataloged, it is recommended that each checklist, sketch, and other notes be completed for the exterior and the interior of every window. Photographic documentation will include an overall photo of each window from the exterior and interior, along with any notable defects or characteristics, such as brick molds, muntins profiles, wood joinery, sash profiles, and hardware.

Document and detect both interior and exterior components for the following:

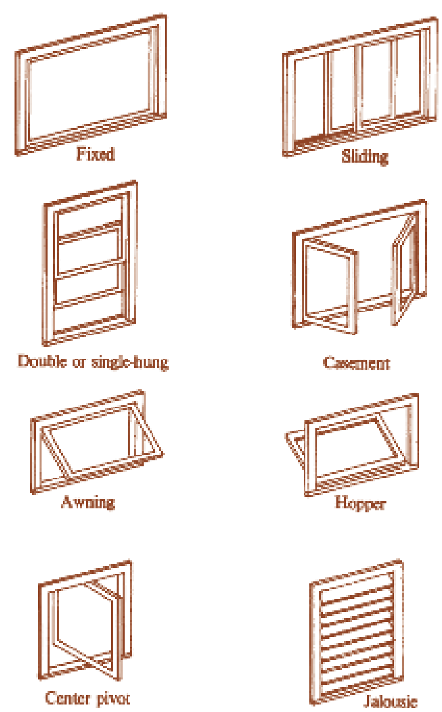

Figure 3 – Typical window types. Note that these diagrams are to show operability types only and do not reflect the typical multi-light glazings and decorative muntins of historical wood windows.

- Wood components
- Hardware
- Paint
- Glazing
- Sealants
- Operability

Documentation on field checklist and window elevation should contain the following:

- Defect numerical rating system
- Defect symbols for repairs (i.e., rotted, checked, or cracked wood; peeled paint; failed sealant; wood gouge; cracked glass)

In the above-mentioned spreadsheet, note that each window component has a level of defect “code” pertaining to each item. For example, the wood of each parting bead may be in satisfactory condition, with no splitting or rotting. However, the parting bead paint may be missing or failed. Therefore, an appropriate restoration technique for this particular component would likely be to salvage the existing parting bead, which will be prepared, primed, and painted for reinstallation.

Glazing putty and paint deterioration can be accurately represented as a percentage or visually shown on the window elevation sketch. Based on the cost of repairs and economies of scale, it is considered reasonable to assume that a 30% or greater failure of a component may warrant complete removal and restoration. For example, glazing putty that is approximately 50% deteriorated is significant enough to call for removal and replacement. This will keep all glazing putties at similar installation periods and help reduce the potential for yearly failures as older putties left in place start to deteriorate. Replacing all provides a more consistent and predictable maintenance schedule.

IDENTIFICATION OF HAZARDOUS MATERIALS

It is important to note that historical windows identified for restoration may have received previous repairs or undergone repainting campaigns prior to 1978, when the use of lead paint became prohibited. Therefore, prior to removing the existing paint, the material must be sampled and tested for lead. Often, a full restoration of the existing windows initiates with the abatement of the existing lead paint, which requires stripping the windows down to bare wood. Window sealants and putties could also incorporate hazardous materials, such as asbestos or polychlorinated biphenyls (PCBs), which must also be removed prior to any restorations. It is not necessary to test for the presence of hazardous materials to complete an evaluation. If the primary requirement of the evaluation is to just note the current condition of the windows, then it may not be necessary for hazardous material testing at that time. If budgeting is part of your report, then testing should be performed, since it can significantly increase the cost of the restoration, especially if PCBs are present. PCBs have been known to leach into porous substrates, including wood and masonry. Since testing for these materials will add cost to the initial evaluation, they should be discussed prior to arriving on site. It is recommended that persons trained in sampling and testing be responsible for collecting the materials.

PLANNING FOR REPAIRS

Once the condition assessment of the windows is complete, the designer is in a

Photo 3 – Epoxy repair of checked wood with resin.

Photo 4 –Dutchman repair of wood sash corner.

position to consider the scope of repairs/rehabilitation. Depending on the goal and budget of the project, the scale of repairs may vary from stabilization of the windows to reduce further deterioration, to wholesale restoration of the sashes and frames, to thermal upgrades such as the addition of weatherstripping or storm windows. The levels of repairs for wood windows are best classified by "Technical Preservation Brief 9: The Repair of Historic Wooden Windows," published by the National Park Service (NPS), and are as follows:

- Routine maintenance
- Stabilization
- Splices and parts replacement
- Energy-efficiency improvements through weatherstrippings, interior/exterior storms, and/or double glazing

REPAIR METHODS

While many of the wood windows surveyed could appear to an untrained eye to be in failed condition, the majority of the deterioration may be occurring on the exterior surfaces and be limited to failed sealants, paint coatings, and putties.

The proper repair of wood windows is an involved and intricate process and requires a skilled tradesman. Improper materials and/or repairs can have a detrimental effect on historical window renovations, which can reduce, instead of extend, their service life. Complete restoration of the windows includes the removal of the existing sashes and repair of the existing frames in place. At the sashes, weatherstripping can be replaced or added, defective muntins replaced, damaged wood repaired and repainted, and putties and damaged glazing units replaced. At the frames, parting beads and balances can be replaced, wood components repaired, weatherstripping added, all components repainted, and perimeter sealants replaced. If thermal upgrades are desired, options—including the addition of insulated glazing or a storm window—can be considered. All of these techniques are further described below.

One of the most elementary and critical steps for the stabilization of the existing windows is the maintenance of the paint coatings. Failed paint coatings can result in damage of the wood components, resulting in extensive repairs in order to return the systems to proper operation. Proper repainting of operable units involves removing the existing sashes and painting the frames and sashes separately. Painting the sashes while they are in place can result in a buildup of paint at the frame-to-sash interface, which may cause the sashes to be stuck in place and the windows to be inoperable. In addition, painting would not be able to extend within the sash channel, leaving portions of the wood sash untreated. Proper painting should also consist of scraping off loose or chipped paint to limit the buildup of paint layers. For components that are removable—such as existing sashes—one means of removing paint is via infrared heating. For components that remain in place, such as the frame, chemical strippers are often utilized. Both methods are typically used in combination with hand-scraping and sanding. Note that all paint removal methods need to be done in accordance with proper lead-abatement procedures if lead-based materials have been identified.

Another key component of window stabilization is the replacement of the existing window putties. As previously mentioned, the putties may be a hazardous material and need to be tested prior to the work. If the putties are found to contain asbestos or lead (from being painted over with lead-based paint), abatement of this material is required. The replacement of putties both weatherizes the windows and allows for access to the glazing units to replace any cracked glass pieces. Perimeter sealants should be replaced in a similar method and may also contain lead, asbestos, or PCBs.

In addition to paint and putty replacement, many historical windows may also require additional wood repairs. There are two main types of wood repairs: epoxy and dutchman.

Epoxy repairs consist of using an epoxy resin or paste to fill in cracks, gauges, and rot (after removing the existing rotted wood) to stabilize the wood. Epoxy repairs are often required at sash corners where the joinery has failed. Epoxy repairs require significant preparation of the existing wood and may need several applications of epoxy to completely fill the damaged area. Epoxy requires time to set, and the repairs need to be sculpted and shaved to match the profile of the surrounding wood finishes.

Dutchman repairs involve repairing existing areas of rotted or missing wood with new wood. Ideally, the new wood should match the species of the original wood. If the species of the original wood cannot be matched, the new wood should be mahogany, cedar, or oak in order to be as similar as possible to the density of the original old-growth wood. With a dutchman repair, the area of rotted wood is cut out, and the replacement wood (dutchman) cut to match the opening. The dutchman is set into the opening with a resin. Dutchman repairs are most suitable for large-area repairs. See *Photos 3* and *4*.

Other wood window stabilization repairs include replacing broken or missing hardware, sash lifts (if present), balances, and—in isolated instances—weights. The main factor of these repairs is locating appropriate materials. For example, the original windows are likely to use brass, bronze, and steel for hardware. Balances are typically supported or connected by rope or metal chain and use metal tape pulleys. Most historical weights are brass, but steel is not unusual. Sometimes these replacement materials are difficult to locate and require searching in specialty restoration sites or salvage yards.

Once the window has been stabilized, its performance can be further improved with the addition of weatherstripping to the existing frame and/or sash components. Weatherstripping can be metal, pile type, or neoprene. Sheet metal weatherstripping, which is composed of copper or brass, can sometimes be found in the original window assembly, nailed to the sash along the base and at the meeting rail (two joints through which air leakage can occur). If in good condition, this may be salvageable. If not, it can be replaced in kind, or alternative forms of weatherstripping can be considered. Other commonly used techniques include the addition of metal weatherstripping to the jamb tracks and integral pile weatherstripping set into the sash stops (at the interface of the stop and sash).

While the previously described repairs both stabilize and weatherize the existing wood windows, there are several options for further improvements to the window's thermal performance. The first option, which may be considered the most common and the least invasive (since it does not alter the existing window fabric), is the addition of a storm window. A storm window provides a second seal, which acts like a secondary glazing. The dead space between the window and storm increases thermal resistance for the assembly and reduces air leakage.

Furthermore, a low-emissivity (low-e) glass storm window will provide additional thermal performance to the existing single-glazed unit, making it comparable to a double-glazed replacement system. Storm

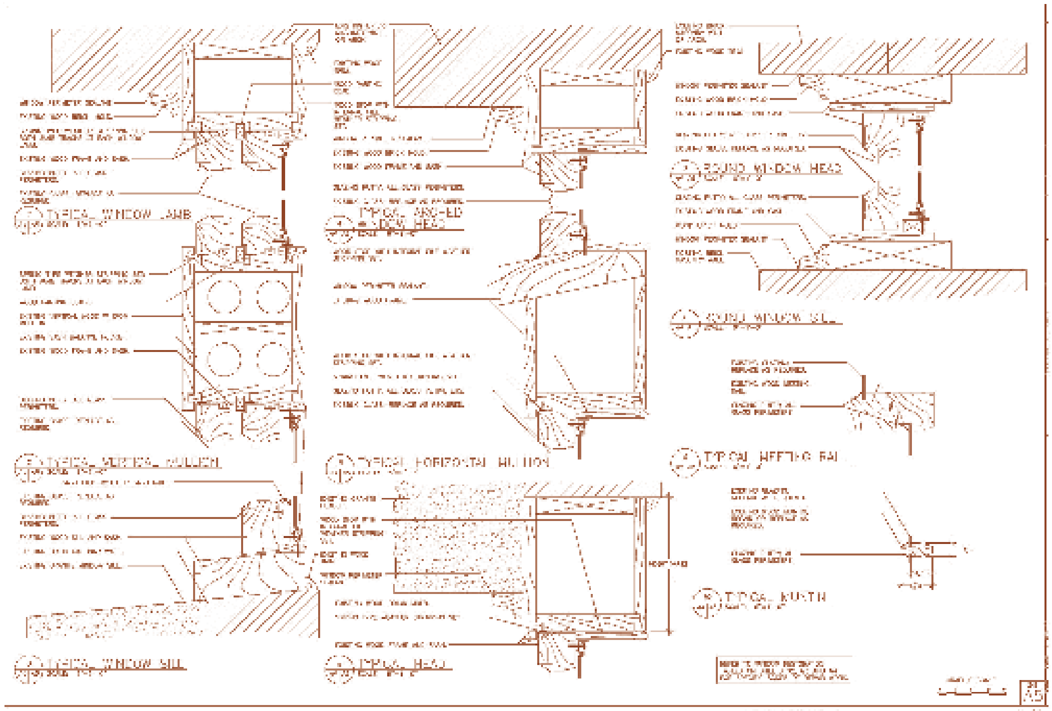

Figure 4 – Wood window restoration details: stabilization repairs at the sash and frame, as well as the addition of weatherstripping and exterior storm windows.

windows can have a metal or wood frame (aluminum is most common) and can be installed on the exterior or interior of the existing window unit. Properly installed storm windows are continuously sealed around the perimeter with weeps left at the bottom to allow air and condensation to escape to limit the potential of condensation between the window and storm. See *Figure 4*.

Another means of thermal improvement of the sash is replacing the existing single glazing with insulated glazing panes. This option is partially dependent on the configuration of the existing sash—whether the current wood is sufficiently thick and durable to accommodate the much thicker and heavier insulated glazing unit in lieu of the original single glazing. For operable sashes, the result of the added glass weight will also likely require the replacement of the existing sash pocket weights to accommodate the heavier sashes.

If the addition of insulated glazing to a window is feasible, there are still several factors that should be considered from both an aesthetic and a performance standpoint. From an aesthetic and historical perspective, it is important to note that the insulated glazing will impact the existing muntin profiles and change shadow lines. The other main consideration is the amount of thermal improvement that can be achieved and if alternate means (such as storm windows) may provide a more feasible option.

CONCLUSION

The restoration of historical wood windows, in lieu of replacement, is both the historically appropriate and sustainable option when repairs or replacement of existing window systems are considered. Too often, the choice to replace existing wood windows is made by those who do not have the appropriate qualifications to both review the conditions of the existing windows and understand that these windows were constructed of quality materials in a manner that facilitates their repair. In many instances, the apparent conditions of the existing wood windows make them an easy target for replacement. However, the actual defects may only be surface-deep and easily repaired by the appropriate tradesman by restoring the condition of the wood components or even thermally improving them with the addition of weatherstripping, storm windows, and/or insulated glazing.

The appropriate repairs and upgrades result in a window unit that, with minimal maintenance,[1] can extend the service life of these windows by up to 30 to 50 years, which would likely exceed the life of new metal or vinyl replacements.

REFERENCES

1. Typical maintenance for wood windows after a wholesale restoration would include painting every five to ten years and replacement of failed sealants and glazing putties.

Steven R. Marshall, RRC, CDT, LEED AP

Steven Marshall is a senior project manager for Gale Associates. He specializes in site investigations, design, administration, and coordination of roof, wall, and window projects. Marshall has extensive experience in evaluation, repair, and replacement of roof, window, curtain wall, storefront, door, and masonry wall projects. He has been responsible for the management of more than 30 historical window projects.

Catherine A. Matathia, PE, LEED AP

Catherine Matathia is a past project engineer for Gale Associates. She specializes in structural engineering and building envelope evaluations and fieldwork for building projects, including investigations, analysis, design, coordination, specifications, and construction administration. She has been responsible for the field evaluation and assessment of historical wood and steel windows at over 30 historical buildings at a National Historic Site. This includes field drawings of window details and "hands-on" assessments of each window component.