PRESERVATION

Tech Notes

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WINDOWS

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Repairing and Upgrading Multi-Light Wooden Mill Windows

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With proper planning, many late 19th and early 20th century wooden mill windows can be repaired and upgraded in performance in a cost-effective manner.

SAWYER MILLS
Dover, New Hampshire

Sawyer Woolen Mills, built between 1864 and 1892 and operated by the Sawyer family, produced uniforms for the Union Navy and, later, high quality worsted cloth and cashmeres. In 1899 Sawyer Mills went bankrupt and was absorbed as one of the eight original mills that formed the American Woolen Company. This national textile giant dominated the domestic woolen industry for half a century and, in 1954, became part of Textron Corporation. The complex consists of 22 interconnected structures, comprising a quarter of a million square feet of space.

Eleven hundred multi-light double-hung wooden windows provided maximum natural light and ventilation for the buildings, while strongly defining the architectural appearance, function and scale of this nineteenth century workplace.

Problem

Architectural planning for the rehabilitation of Sawyer Mills for use as apartments began in mid-1983. The developer recognized early in the planning process the importance of the design characteristics of the original wooden windows and their critical role in preserving the historic character of the mills.

Remarkably, nearly all of the original window sash remained in 1983, having survived more than a century in the harsh New England climate and changing corporate ownership. After undertaking a survey of existing window conditions, and exploring alternative windows in wood, vinyl, and aluminum, the developer was convinced that repair was both feasible and economically realistic. With so many windows involved, thorough planning of the window repair work well in advance of construction was crucial.

Cost, technical capability and window performance were the key considerations in developing the repair approach. The window survey enabled the general contractor to estimate the number of new window sash needed and to form an overall view of the repair work required for sash, frames and sills. To facilitate this aspect of planning, a window and millwork consultant was retained to analyze survey data and to develop shop drawings and specifications for subcontractor's bids.

The general contractor evaluated staff capability to direct and execute such a large task and concluded the job could be done effectively. Fortunately, the general contractor owned a complete, mobile millwork shop managed by a master craftsman and staffed with several highly-skilled tradesmen.

The performance that could be

anticipated from the repaired windows was of paramount concern to the architect and owner. Two hundred twenty-two apartments were planned, each with central heating and air conditioning. Easily operable primary window sash combined with storm window units were essential in order for the complex to be operated economically. To meet the New Hampshire Energy Code, respectable U and R values would have to be achieved from both windows and exterior walls, which were uninsulated.

The window survey concluded that 800 of 1100 windows were considered repairable. Eight different configurations of sash were found, including several sizes of each configuration.

Figure 1. Window repair shop in operation. Photo: Christopher Closs

Solution

Following a close evaluation of typical deterioration problems in a random selection of sash, repair criteria were established. In cases where more than one frame member or where more than two joints were deteriorated beyond repair, the sash was discarded. Salvaged components were used for repair on other units. Muntins were retained if at least half of the grid remained serviceable.

A significant number of window frames and especially sills were found to be in unserviceable condition and required replacement. Some frames had bowed, impairing operability, while many sills were so deeply checked or split that an adequate water-shedding surface could not be recreated. Panning the sills with aluminum was rejected as an alternative to replacement because of the difficulty in achieving a proper flashing detail without further damage to frames and brickmolding.

Several types of interior storm windows were evaluated, including a new style with vinyl frames and Lexan glazing. The type selected was a standard triple track, aluminum, one-light-over-one unit, with special narrow frame profile and a half screen. A key design constraint imposed on the supplier was the requirement that the interior perimeter of the storm window could not visually encroach from behind the glass area of the primary sash, which would create an obtrusive appearance from outside.

The considerable tasks of removing glazing and paint, repairing sash frames, sanding, priming, re-glazing and painting eight hundred windows required organizing the work flow and labor force in a logical sequence (see figure 1). The decision was made to undertake the work on the site and to establish a mobile millwork shop adjacent to the window repair shop so that the former could continuously supply the latter (see figure 2). The shops had to be relocated only once during construction. A key factor making the on-site window repair approach feasible was that the millwork shop's variable workload from window repairs was supplemented by specialty orders from outside contracts, eliminating costly down-time.

The repair crews consisted of three groups: a millwork shop foreman and assistant; a team of four window repairers (who were trained at the beginning of the project); and a two-person window removal and re-installation crew. Except for the shop foreman, these groups were rotated routinely to avoid monotony and enhance safety, and to build skills within the crews, so that reserves were available in the event of illness or injury. The window consultant and millwork foreman provided skills training for the repair and installation crews and ensured quality control of the repair work.

High quality materials were used in repairing sash and milling new sills and window frames. Canadian eastern white pine, grades #1 and #2, was used exclusively. Canadian #1 white pine was the most cost-effective material that could be procured knot-free and that has proven to wear well in window construction.

Considerable money was saved by re-using original materials wherever possible. All glass from the old sash was carefully removed and stacked for re-use; approximately 60 percent of the original glass was re-used in the repaired sash. Cleaning the glass was labor-intensive and not entirely successful, since some surfaces remained a little cloudy as a result of etching over the years. An effort was made not to mix new glass with the old in repaired sash in order to minimize differential reflectivity outside. Existing sash cord pulleys were removed, cleaned and lubricated, and reinstalled with new sash cord in each window opening. Cast iron counter weights were found in their pockets for the most part, and were also re-used.

Sash Repair Procedure

Original sash were removed from their openings in groups of 20 to 30 units by the installation crew, who carefully checked that both frames and sash were marked with the corresponding window survey number. Once delivered to the repair shop, individual sash were de-glazed, the glass stacked by size, and residual dirt, putty and paint removed from the frames at the first work station (see figure 3). If simple repairs only were needed (e.g., muntin replacement, filling holes or gluing a cracked muntin), they were done and the window sent on for sanding and priming. If more substantial repair was needed, the sash was sent to a work station where milled bars and rails, a whole muntin assembly, or mortise and tenon parts could be fitted. Wherever possible, whole

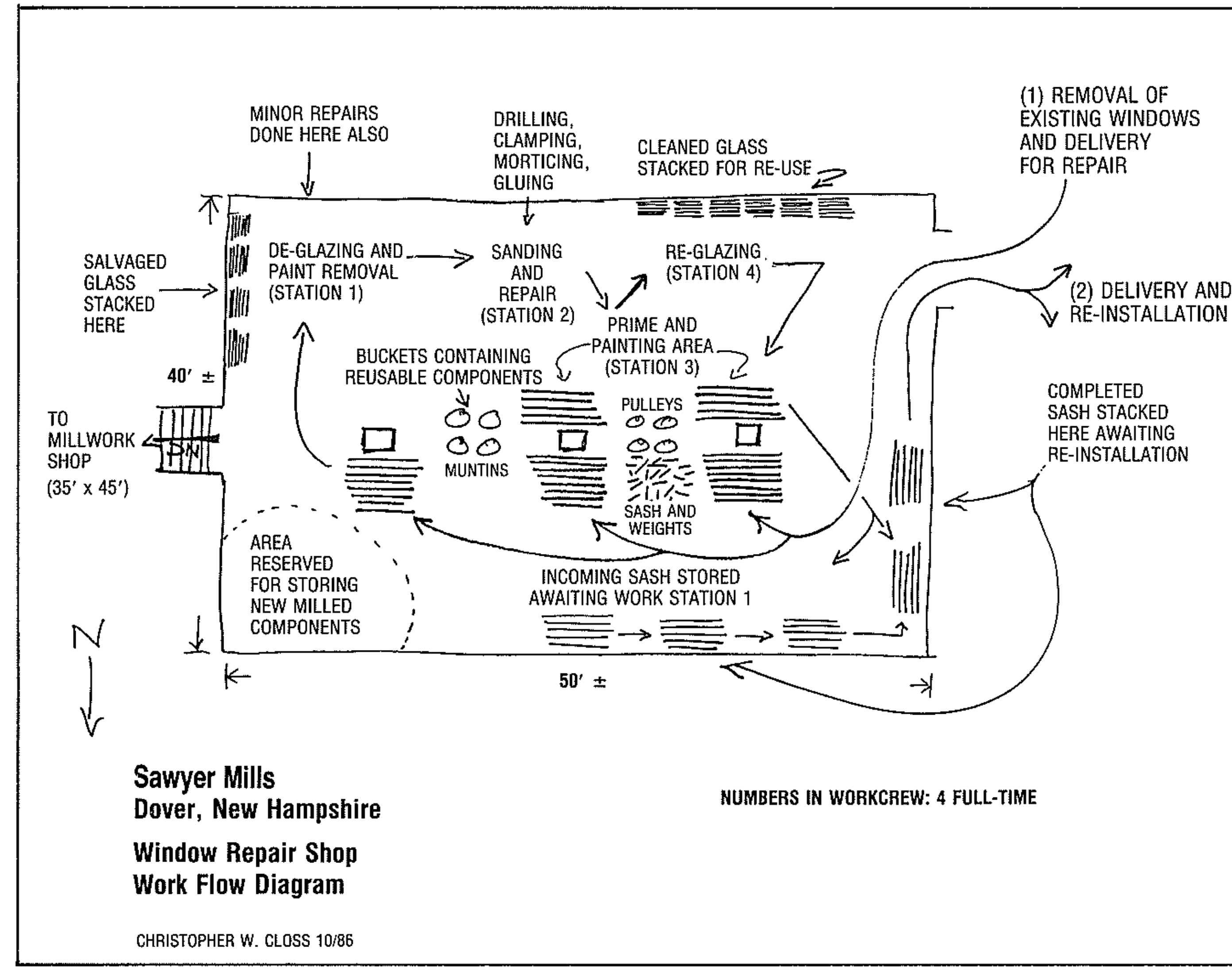


Figure 2. Drawing shows the plan of the window repair shop set up within Sawyer Mill during renovation work. The mobile millwork site was located in a room immediately to the left of the repair shop. Drawing: Christopher Closs

muntins were saved from otherwise deteriorated sash and used for spare parts during repairs, resulting in additional savings in milling costs. The repair shop had 4 full-time employees.

The most typical problem encountered was loose or failed mortise and tenon joints; this was remedied by drilling out the old pegs with a slightly oversize bit and then drawing the sash frame together tightly with pipe clamps (see figure 4). Fluted,

Figure 3. Electric deglazing irons were used to remove hardened putty so glass could be removed and the sash frames repaired. Photo: Christopher Closs

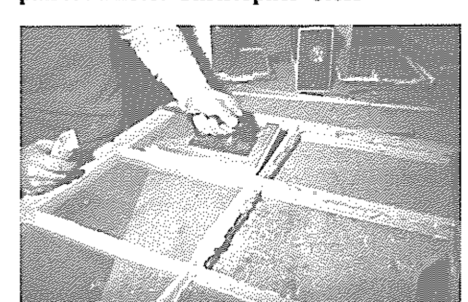
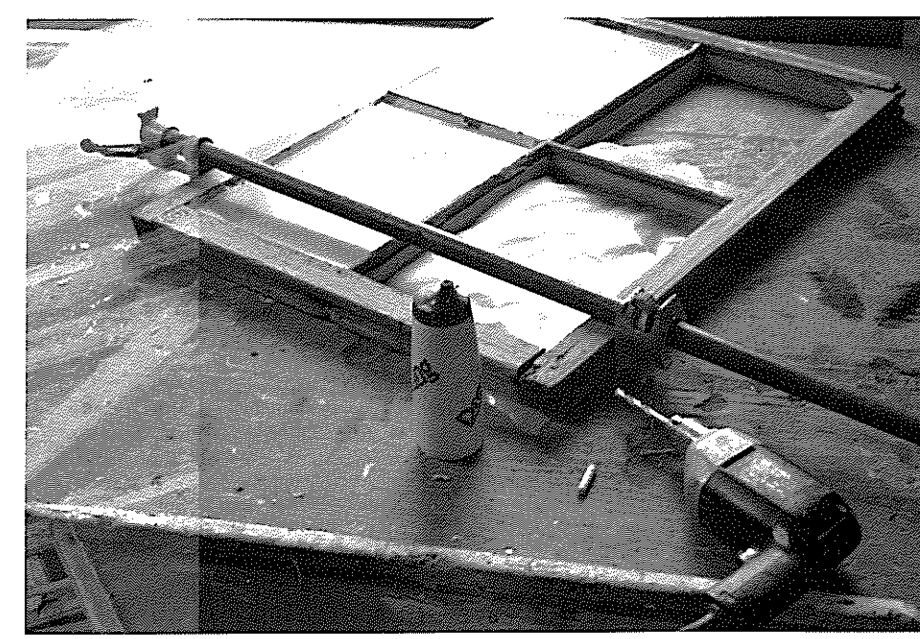


Figure 4. The basic repair: cleaning sash frame and drilling out pegs to tighten corner joints. Glue purchased in bulk was transferred to squeeze-bottles for ease of application. Oversize bit and new hardwood dowel shown ready for use. Glazing has not yet been completely removed. Photo: Christopher Closs



hardwood cabinet dowels, liberally coated with waterproof glue, were then driven in to secure the joints. To allow for natural movement, the mortise and tenon joints were not glued. In some instances, deteriorated tenons were cut off and bored out, and new tenons installed, using glue to secure the tenons in their seats but not inside the joints. This worked well providing the receiving mortises were sound. If muntins required selective replacement, this was done before clamping. It was critically important to "true" each sash square before re-pinning the corner joints.

Common tools used through this stage of the operation included an electric de-glazing iron, propane torch with both narrow orifice and flame spreader for putty removal, wire brushes and several types of paint scrapers with varying profiles. Standard ¼″ or ⅜″ (chuck size) hand-held electric drills, were used for joint repair.

It was not necessary to remove all the paint from the wood sash frames, but only enough to sand smooth and create a fresh bondable surface to which paint could be successfully applied. In practice, roughly 50-60 percent of the paint was removed.

Once the sash for a complete window were made structurally sound, frames were hand-sanded and fully primed with a shellac-based sealer. Sash were then reglazed in conventional manner and stacked to await final finish with two coats of exterior-grade, oil-based paint (see figure 5). The wood edges of the sash were left unpainted to avoid interfering with hand-planing during fitting in final installation.

Figure 6. Newly milled replacement window frames awaiting installation. Photo: Christopher Closs

Onsite Millwork Shop

All repair and milling of replacement frames, sills, and brickmolds, and components for such special features as the wooden belltower finial and interior louvered office blinds, was performed on-site. The mobile millwork shop was located in a room adjacent to the repair shop and occupied an area 35′ x 45′. The basic equipment of the millwork shop included: 18″ bandsaw, 10″ tablesaw, 36″ lathe, a jointer, 12″ planer, a molder/shaper machine, several routers, and a floor-model drill press with mortising attachments.

Profile gauges were used to create molding machine knives ground specially to match the historic brickmold that trimmed the window openings. Templates were made of the arc of each type of segmental arch window head, so that reproduction of deteriorated features would be precise. Because the white pine stock available was of insufficient dimension to replicate the width of the original arch head, a bandsaw was used to cut segments which were laminated in three pieces to form replacement arched window frame heads. Replacement window sills were laminated similarly.

To maintain production and minimize waste, the millwork shop continuously supplied the repair and re-installation operations with common components such as muntins, bars and rails, frames, sills and brickmold. Approximately one-third of the frames and brickmolding required replacement. Where complete new frames were required, these were produced and assembled by the millwork shop, ready for priming.

Figure 5. Repaired sash primed and awaiting reinstallation. Glass was cleaned of smudges after final installation. Photo: Christopher Closs

Reinstallation and Storm Windows

New matching wood sash, manufactured in Springfield, Massachusetts, were required to fill three hundred openings where the originals were missing or beyond repair (see figure 6). Deliveries of the new sash were scheduled to match the installation capacity of the project crews with the

Figure 7. "Gun carriage" (scaffolding) in use by the window re-installation crew who are preparing to replace missing brickmold with replacement made by the millwork shop. Note saw kerfs used to create arc in molding for use in the window head (same method as used in the original molding). Photo: Christopher Closs

Figure 8. Typical interior aluminum combination storm window unit with insect screen shown at top. Beveled stops around the perimeter were added and the windows were caulked to provide for a good energy seal. Photo: Christopher Closs

Figure 9. Drawing showing installation of the interior storm window. Drawing: Christopher Closs

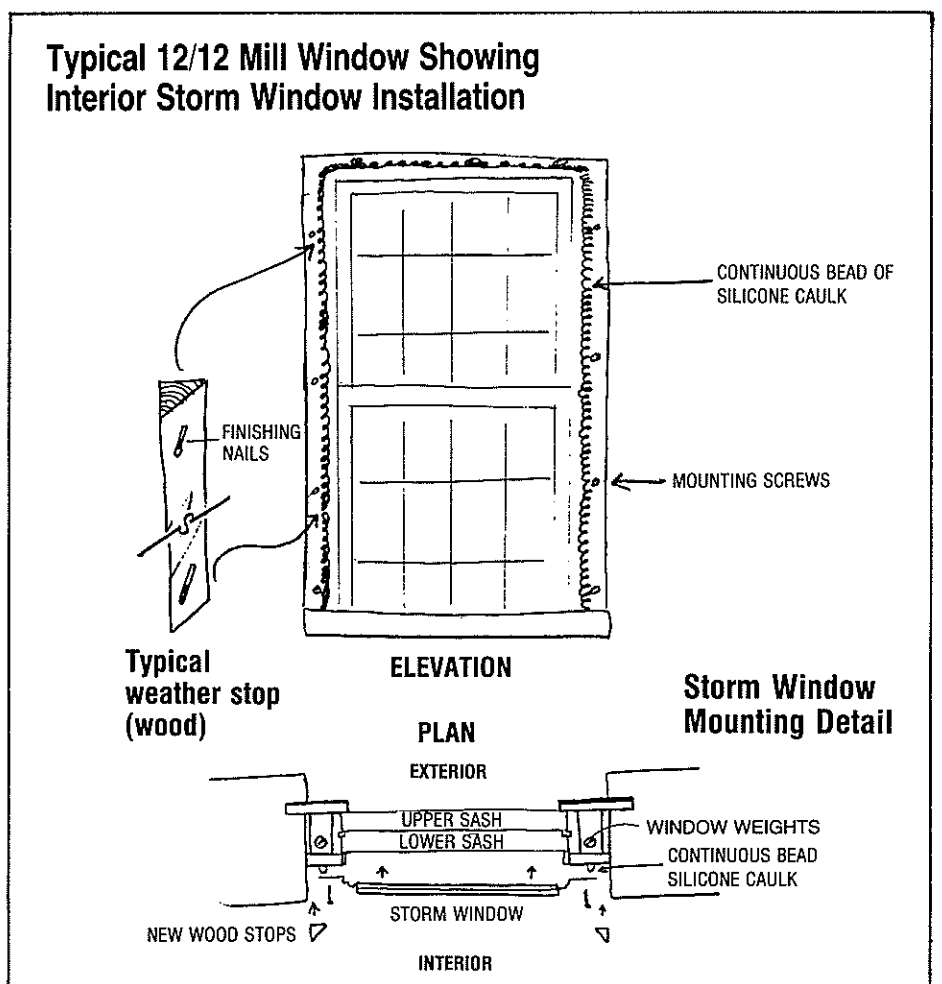
output of the millwork shop. The new sash were delivered pre-primed. A second re-installation crew was trained and put in service during the peak production period in early 1985.

The re-installation crew was responsible for repairing or installing new frames, mounting brickmolds and installing repaired and new sash. Two "gun carriages" were constructed to facilitate frame installation and to ensure safety for the crews (see figure 7). Each carriage served as a cantilevered work platform (if fitted with dolly wheels they would have resembled a naval gun carriage). They permitted the installation crew to work safely on the exterior of the window opening without staging (much of this work had to be done over the river). The carriages had stops on the interior, were counter balanced, and were moved from opening to opening as frame repairs and brickmold work proceeded.

Re-installation of the sash was done in batches of 20 to 30 pairs of sash, which although indexed to the original openings, often required planing of the edges of stiles to achieve smooth operability. For this a handheld, 3½" power planer was employed.

The installation of the aluminum interior storms occurred after the primary windows were in place (see figure 8). Installation of the storm windows was monitored carefully to ensure that aluminum frames were set in a continuous bead of silicone caulk to provide a tight weather seal. This was made easier by the absence of decorative casing on all of the windows; storms were simply screwed fast to the flat, three-inch weight pocket covers (see figure 9). A new beveled 1" wooden strip was applied around the outside perimeter of the weight pocket covers and the heads, and caulked forming an uninterrupted seal with the brick masonry wall. Weight pockets were not insulated since the counterweights remained operable.

To reduce the chances of moisture being entrapped between the storm unit and the primary window, the repaired wooden sash were fitted somewhat loosely, thus allowing for adequate venting. In practice, this approach worked well. The first units installed were checked during the winter of 1984 and exhibited no excess moisture or frost build-up.



Evaluation

In an energy-conscious era, this project shows that the repair of historic wooden windows in mill buildings can be cost-effective and energy-efficient with proper planning. The following measures need to be considered in the design solution:

1) Proper and detailed survey evaluation is made of the existing window stock

2) Repair procedures are designed and integrated into the overall schedule and work flow of the rehabilitation project

3) Skilled and semi-skilled personnel are available, and provisions are made for any necessary training

4) Modern methods for upgrading the energy performance of existing windows are integrated into the design.

The rehabilitation of the original wooden windows at Sawyer Mills was successful in meeting historic preservation standards, aesthetic considerations and window performance objectives. Seventy-three percent of the original windows were preserved. The actual costs only slightly exceeded the original budget allowance of $440 per opening, excluding the new storm windows. The thermal performance of the windows was upgraded and ease of operability restored for the new residential use; both were accomplished with little difficulty and at minimum cost. Moreover, the introduction of interior storm windows was an entirely reversible solution that caused no change or alteration to historic material and was expected to reduce maintenance cleaning costs.

PROJECT DATA

Property:
Sawyer Mills
Dover, New Hampshire

Owner:
Sawyer – Bellamy Mill Associates
Dover, New Hampshire

Project Duration: 1983-1985

Architects:
Keyes Associates
Providence, Rhode Island

Paul Mirski, AIA
Enfield, New Hampshire

Preservation Consultant:
Christopher W. Closs, MNRP
Closs Planners, Inc.
Concord, New Hampshire

Window/Millwork Consultant:
Arthur L. Pepperman II
Heritage Preservation, Inc.
Laconia, New Hampshire

General Contractor:
Bonnie Brae Construction
East Waterboro, Maine

Project Costs:
The rehabilitation of Sawyer Mill cost approximately $12,000,000. The window work cost about $616,000, or an average of $555 per window including the $90 per window cost for the fabrication and installation of the interior storm windows.

800 Windows (Sash Repair)

Sash repair	$300 per window
Sill and frame work (repair & replacement)	$100
New wooden brick molding	$20
Reinstallation	$50
Painting (included in overall painting contract)	
Total	$470 per window

300 Windows (Sash Replacement)

Sash Replacement	$250 per window
All other costs the same as the repair work	
Total	$420 per window

Miscellaneous Window Cost: $15,000

1100 Interior Storms
Fabrication and Installation $90 per window.

Materials:
Grade #1 and #2 eastern white pine (Canadian)
DAP Glazing Compound

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This and many of the PRESERVATION TECH NOTES on windows are included in "The Window Handbook: Successful Strategies for Rehabilitating Windows in Historic Buildings," a joint publication of the Preservation Assistance Division, National Park Service, and the Center for Architectural Conservation, Georgia Institute of Technology. For information write to the Center for Architectural Conservation, P.O. Box 93402, Atlanta, Georgia 30377.

PRESERVATION TECH NOTES are designed to provide practical information on practices and innovative techniques for successfully maintaining and preserving cultural resources. All techniques and practices described herein conform to established National Park Service policies, procedures, and standards. This Tech Note was prepared pursuant to the National Historic Preservation Act Amendments of 1980 which directs the Secretary of the Interior to develop and make available to government agencies and individuals information concerning professional methods and techniques for the preservation of historic properties.

Comments on the usefulness of this information are welcomed and should be addressed to PRESERVATION TECH NOTES, Preservation Assistance Division–424, National Park Service, P.O. Box 37127, Washington, D.C. 20013-7127.

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