

CAHOON MANSION



ENVELOPE STABILIZATION ASSESSMENT

Entelen Design-Build, LLC. + FFKR Architects

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ASSESSMENT APPROACH AND SUMMARY



Located at 4872 S. Poplar Street in Murray and built at the turn of the century, the Cahoon Mansion is an important representative of the Victorian Eclecticism popular during the period.

The building was nominated to the Nation Register of Historic Places in 1983 and described the building as follows:

"The large brick house sits on a raised sandstone foundation, which holds a full basement story. The brick exterior walls are accented with heavy sandstone lintels and sills. A two-story bowed bay window on the south side is the only feature that interrupts the rectangular massing of the house. Victorian detailing such as scroll brackets and dentils decorates the wide eaves. Hip dormers with fared cheeks provide illumination to the attic story. Other decorative features include clear and frosted leaded glass in some windows and transoms, and a heavy paneled front door framed by a transom and sidelights. The large wrap-around front porch features a wooden balustrade, paired Ionic columns on paneled pedestals, and latticework along the base."

In September 2019, FFKR conducted a thorough review and analysis of the exterior building envelope to identify deficiencies and issues for remediation to stabilize the building. The scope of this report is to document the exterior and weatherproof envelope of the building and does not address any issues with the interior finishes, mechanical or electrical systems, or site or building accessibility. Through a series of on-site investigations, consultation with local specialty craftsmen and careful analysis of the building's existing conditions, FFKR has specifically addressed the following components of the exterior and weatherproof envelope of the building:

- Exterior Brick and Stone Masonry
- Exterior Window and Door Openings
- Decorative Wood Elements
- Roofing & Dormers
- Porches
- Landscaping
- Lighting
- North Addition

ASSESSMENT APPROACH AND SUMMARY



In addition to a description of characteristics and current condition of these items, we have proposed a “Good”, “Better”, “Best” approach for the correction / remediation or further action that should be taken to stabilize the components. As a rule of thumb, the “Good” recommendation would be considered an acceptable means to prevent further deterioration, the implementation of the “Better” recommendations would be an approach similar to a rehabilitation of the building and the implementation of the “Best” approach would be geared towards a full restoration of the historic character of the component. A preliminary budget estimate for each component and each recommendation has been compiled by Entelen Design-Build, LLC and is included in this report.

Overall, the building is in good to fair condition with the areas of most immediate concern being the sandstone foundation, sandstone window sills and the roofing. The continued deterioration of these components is most directly linked to the control of water, both from natural precipitation and landscape irrigation. Implementing the “Good” recommendations in these areas will significantly extend the useful life of the building and provide a stabilization of the components for future restoration work.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 1 – EXTERIOR BRICK AND STONE MASONRY

BRICK FOUNDATION

The exterior of the Cahoon Mansion is predominantly comprised of multi-wythe brick masonry walls on a sandstone foundation base extending to the level of the first-floor line. Prior to our field survey, it was expected that the visible sandstone foundations was constructed using full depth sandstone blocks but further investigation of the building has revealed that the visible sandstone is actually a thin veneer applied over a standard brick foundation. The brick masonry of the building is comprised of two types of fired clay bricks: a high-density reddish orange brick used at the foundation as the structural substrate for the sandstone stone veneer as is visible in the interior basement walls as well as a very smooth, light yellow brick comprising the main body of the building beginning at the main floor line and extending to the roof and chimneys.

The reddish-orange brick foundation will be addressed in two components – the portion exposed to view on the outside of the building and the brick exposed to view on the inside of the basement of the building. The exterior foundation bricks are not consistent in their condition due to varying degrees of exposure and weathering. The bricks covered by the sandstone veneer are expected to be in good condition, as there are no significant indicators of degradation. Note that our analysis is based upon visible observable conditions; no destructive examination, such as removal of sandstone surface materials, has taken

place. We would not recommend such testing at this time. However, there are two locations where the exterior sandstone veneer has deteriorated to the point where the brick foundation has become visible – one on the west of the building by the ADA ramp and one on the south side of the east porch. Both locations exhibit foundation bricks which are significantly weathered and are in poor condition. The foundation is also visible as a row of bricks at grade below the sandstone veneer. This course of bricks is in good condition, but the effects of the adjacent landscaping, irrigation and poor drainage discussed in Section 6 - Landscaping of this report are taking a toll and will contribute to further degradation if the conditions are not corrected.

The brick foundation visible from inside the basement of the building is in much poorer overall condition than the bricks visible at the exterior grade. The interior bricks which are exposed to view in most of the perimeter rooms of the basement have been sandblasted at some point in the history of the building. The sandblasting has removed the hard, outer layer of the fired clay and exposed the much softer interior of the brick. The soft interior has been subject to serious degradation in many locations and is in danger of further erosion.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



The interior walls of the basement also exhibit significant calcification and efflorescence due to water leakage through the foundation wall (see Section 6 - Landscaping). The original plaster wall finish covering the brick in the southeast corner room has begun to fail and delaminate from the brick due to water infiltration. There is also significant efflorescence and calcification on the interior wall inside the kitchenette. This is likely a result of an internal plumbing leak and not likely to be caused by exterior weather infiltration as it is not an exterior wall and there is little evidence of weather damage on the corresponding walls on the floors above.

The only area in the basement which has not been sandblasted is in the coal bin and boiler room. The brick is in good condition in this area except immediately beneath the eastern most coal chute door – which has had a failure in the brick mortar, likely due to water infiltration through the chute door, resulting in the deterioration of the structural integrity of the wall resulting in the loss of a number of bricks. The wall in this location is significantly weakened and appears to only be a double wythe thick. The remaining brick walls should be cleaned with a gentle detergent power wash.



RECOMMENDATIONS:

Good

Implement the remediation recommendations identified in the Landscaping section of this report and clean the exposed exterior bricks and evaluate the need for repointing at grade. Repoint missing mortar at grade with a lime-based mortar.

Better

Clean the exposed brick both inside and outside the building. Care should be taken on the interior brick to prevent further degradation of the bricks. Replace the heavily deteriorated bricks at the porch foundation and below the coal chute door.

Best

Excavate around the perimeter of the foundation wall and evaluate the condition of the below-grade bricks and implement necessary remediation steps to stabilize the foundation – potential steps could include replacement of severely deteriorated bricks, repointing with lime-based mortar and installation of a drainage and protection board on the outside of the exposed foundation walls.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SANDSTONE VENEER FOUNDATION

The exterior sandstone veneer condition varies, ranging from good to fair to poor depending on location. The effects of weathering and past repair efforts have contributed to severe weathering and deterioration of many of the stone blocks. The most significant deterioration has occurred at the base of the building and at the below grade entrances. These areas are severely deteriorated to the point that the sandstone facing is nearly or completely missing.

The most likely contributor to this deterioration is the landscaping and irrigation system. The section on Landscaping will address steps necessary to reduce further deterioration. The bulk of the stone veneer is in good condition with areas of spalling, bedding plane delamination and missing mortar. Past efforts to repoint the missing mortar with Portland cement are evident and have resulted in accelerated deterioration of the stone immediately adjacent to the repointed areas due to the nature of the Portland cement being much harder and more durable than the stone.

RECOMMENDATIONS:

Good

Remove the Portland cement repointing and replace with lime-based mortar. Clean the stone with a mild detergent. Re-tool the spalling areas to help reduce further deterioration.

Better

Apply a penetrating chemical consolidant to help reduce the rate of deterioration. Re-profile the decorative watertable and stone lintels to control the drainage of surface water onto the stone veneer foundation. Install dutchman replacements for severely deteriorated areas of the stone

Best

Replace the severely deteriorated stones with new stone replacements.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS

FIELD BRICK

The yellow field brick comprising the majority of the exterior walls is in remarkably good condition. There are a few areas which exhibit some staining or biological growth due to moisture issues. These issues can be remedied with attention to the roof drainage and reprofiling of the window sills. The historic lime-based flush mortar is mostly intact but there are many areas which need repointing and areas where repointing has improperly occurred that need to be addressed. The areas which have been repointed have been done with a combination of Portland cement and caulk. The Portland cement is much harder than the lime-based original mortar and causes deterioration of the adjacent brick. The areas with caulk pose no risk to the brick, but offer only marginal protection against further deterioration from moisture intrusion because the caulk is cracked and not providing a good seal, and in some locations is channeling surface water drainage into the head or bed joints. The brick seems to have been spared the sandblasting so prevalent inside the building and should continue to protect the building for many years to come. The brick at the east porch cheek walls will be specifically addressed in Section 5 - Porches.

RECOMMENDATIONS:

Good

Remove the Portland cement and caulk repointing. Clean the brick with a mild detergent. Repoint with lime-based mortar.

Better

Apply a penetrating chemical sealer / protectant to improve the weather resistance of the brick.

Best

Not applicable.

STONE LINTELS AND SILLS



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



Each of the windows has a sandstone stone lintel and sill matching the stone veneer foundation. The lintels are of a simple, flat rectangular with a stylized Fleur-de-les carved in the lower center of the face. Some of the lintels at the upper windows have a carved, eased edge at the lowest outside edge. The sills are a rectangular block design with a shaped top to slope away from the window jambs and provide positive drainage off the sill. Neither the lintels over the windows nor the sills were constructed with a drip edge, cut into the underside of the sandstone element. While the lack of a drip channel does not seem to have an affect at the lintels themselves, it may be contributing to the deterioration of the wood window frames, sashes and brickmolds. Beginning at the main floor, the window lintels show signs of mild deterioration but are in good condition. The carved Fleur-de-lis are crisp and sharply defined. There is missing mortar at many of the head joints, but these do not appear to have been repointed with Portland cement. The sills are severely deteriorated and have been completely parged (coated) with Portland cement. The craftsmanship of the parging is quite poor and the sills are now irregular pieces of concrete.

Moving to the second floor, the lintels are in very good condition. It appears that the roof overhang has provided adequate protection from the elements and the sandstone exhibits little deterioration and the carved Fleur-de-lis are crisp and sharply defined. Just as the lower windows, there are many head joints which need to be repointed, but the overall condition on this level is remarkably good. The



windowsills on this level are also severely deteriorated, but probably due to the inaccessible location, the sills have not received a parge coat of Portland cement. The deterioration is quite prominent and large sections of the sills are either missing or badly spalling with significant bedding plane delamination. Deterioration, such as surface spalling and flaking of the stone, on the south facing stone elements seems to be significantly worse than other exposures, where such deterioration exists.

RECOMMENDATIONS:

Good

Clean the stone lintels and sills with a mild detergent. Repoint missing head joint mortar with lime-based mortar.

Better

Remove the Portland cement parge and re-tool sills with enough material remaining to remove the loose and spalling sections. Apply a penetrating chemical consolidant. Note – Due to the degree of deterioration of the window sills, it is unlikely that these steps will accomplish much in the way of remediation or slowing the rate of deterioration and it is recommended from a cost/benefit basis that the city implement the steps in the Best category.

Best

Replace all window sills with new stone carved to match the original.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



DECORATIVE STONE TRIM

Above the main floor window lintels of the bay window on the south elevation and the east elevation is a decorative sandstone trim. The trim profile is a typical ovolo with an additional step at the upper surface. The trim, like the stone sills, is very weathered and significantly degraded. The ovolo profile is severely deteriorated on the south elevation and has been parged with Portland cement. The parge is poorly executed and the profile has been completely obscured.

RECOMMENDATIONS:

Good

Clean the stone trim with a mild detergent. Repoint missing head joint mortar with lime-based mortar.

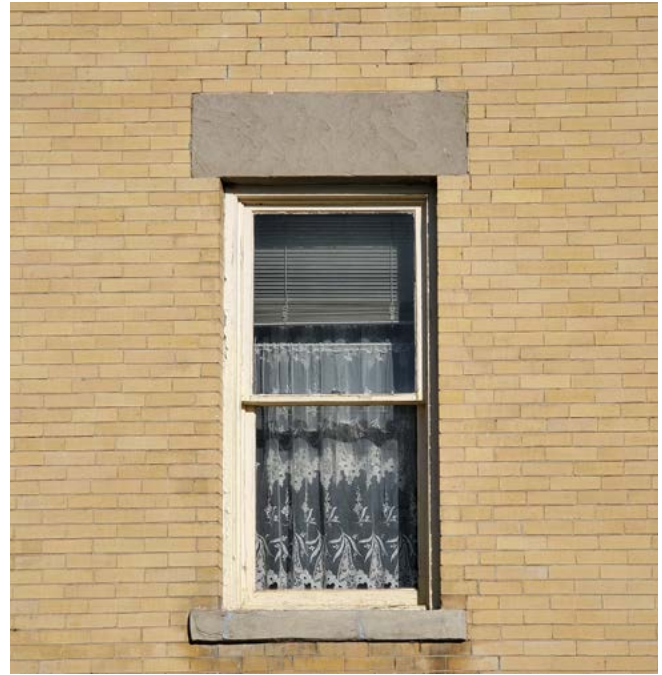
Better

Remove the Portland cement parge and re-tool trim pieces with enough material remaining to remove the loose and spalling sections. Apply a penetrating chemical consolidant. Note – Due to the degree of deterioration of the trim, it is unlikely that these steps will accomplish much in the way of remediation or slowing the rate of deterioration and it is recommended from a cost/benefit basis that the city implement the steps in the Best category.

Best

Replace all decorative stone trim with new stone carved to match the original.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 2 – EXTERIOR WINDOW AND DOOR OPENINGS

OPERABLE WINDOWS

Most of the exterior windows are a simple, vertically oriented, rectangular double hung wood window with one over one single pane lites. The wood brickmold, frames and sashes are in generally fair condition. Multiple coats of paint have been applied to all elements of the brickmold, frames and sashes with little care to maintain the function of the operating ropes and weight mechanism, and most of the windows have effectively been “painted shut”. The ropes and weights are intact in many cases and one can hear the weight move inside the sash when the rope is pulled, while a few windows have had their ropes cut. Still it appears the pulley is functional and it is further assumed that the weight has freely fallen to the bottom of the pocket. The windows appear to be weathertight and little evidence is present of the infiltration of water. The single pane glazing will continue to provide poor thermal performance. Historic photos of the building show what appears to be a window screen applied to the exterior side of the lower operable sash.

RECOMMENDATIONS:

Good

Clean the windows with a mild detergent. Remove loose and flaking paint, repaint brickmold, frames and sashes with a high-quality exterior primer and paint. Thermal performance of the window could be marginally improved by the addition of an exterior applied storm window.

Additional performance could be realized by replacing the vision glass with either a Low-E glass or a more effective spectrally selective glazing such as Vitro (formerly PPG) Solarban 70.

Better

Chemically strip the paint from the inside of the wood frames and sashes. Repair the operating ropes and weight mechanisms to return the functionality of the double-hung mechanism. Repaint the exterior brickmold, frame and sashes with a high-quality exterior primer and paint, stain the interior wood sash and frame. One of the thermal improvements in the “Best” section should be implemented.

Best

Remove the window from the wall, restore the wood frames and replace the window sashes with high-performance insulated glazing units. Rebuild the weight pocket with a larger weight to rebalance the heavier sash. Paint the exterior brickmold, frames and sashes with a high-performance coating system, stain the interior wood sash and frame. Note - depending on the degree of restoration required, an entirely new wood window may be more practical. If so, care should be taken to ensure that the new windows are as near as possible identical replacements of the original. A composite or aluminum clad window will provide a real wood interior and a maintenance free exterior while preserving the historic aesthetic.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS

FIXED DECORATIVE WINDOWS

The large window in the south wall of the main stairwell and the transom window in the on the east elevation are leaded art glass. The window in the stairwell appears to be a replacement window as the art glass pattern of a textured rectangular grid interrupted with clear rounds at the intersections, and detailing is different than the Parlor window and the sash is painted a different color than the adjacent brickmold and other windows. The art glass is also reinforced with interior stiffener rods that are inconsistent with the period of the mansion. The glazing is in good condition. The brickmold and frame exhibit the same degree of paint weathering as the other windows on this elevation. The window is capped with a paneled transom and a smaller art glass window to match.

The Parlor window has a more detailed art glass pattern with an outer border of beveled glass tiles with a similar textured rectangular grid as the stairwell window but with beveled diamonds at the intersections. A round jewel is also present at the right and left of the diamonds. The glazing in this window is also in good condition and the frame has a consistent level of paint failure.

RECOMMENDATIONS:

Good

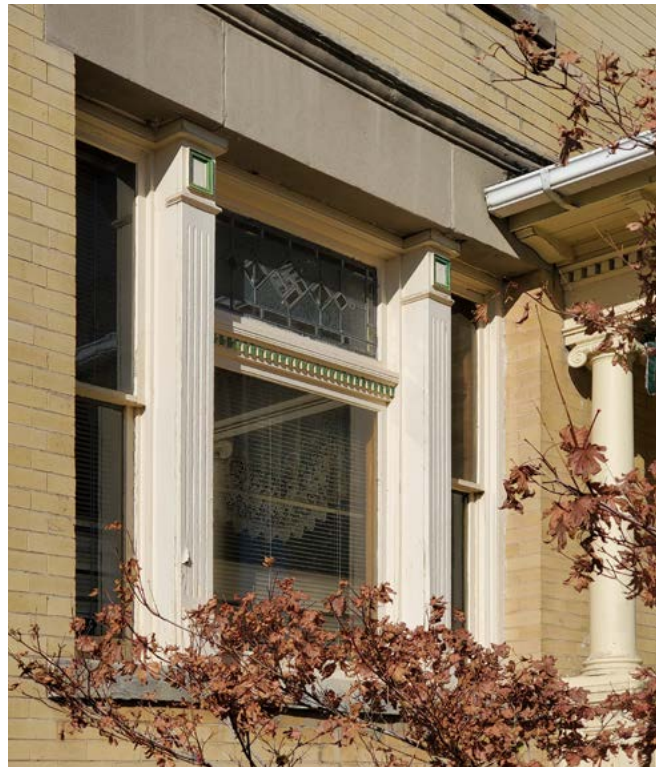
Clean the windows with a mild detergent. Remove loose and flaking paint, repaint brickmold, frames and sashes with a high-quality exterior primer and paint. Thermal improvements to the decorative windows are challenging as any additions to the exterior of the window will obscure the art glass pattern.

Better

Chemically strip the paint from the inside of the wood frames and sashes. Repaint the exterior brickmold, frame and sashes with a high-quality exterior primer and paint, stain the interior wood sash and frame.

Best

Remove the window from the wall, restore the wood frames and replace the window sashes and add a high-performance insulated glazing unit with the art glass as the exterior pane. Paint the exterior brickmold, frames and sashes with a high-performance coating system, stain the interior wood sash and frame. Note – If new windows are installed, they should be capable of accepting an insulated glazing unit with the art glass as the exterior pane to maintain a consistent look to all the windows.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



EXTERIOR DOORS

The mansion has 5 doors to allow access to the interior: 2 in the basement and 3 on the main floor. Only one door – at the northwest corner of the main floor could be considered accessible – and this is only via a wooden ramp system that does not appear to be fully ADA compliant. This ramp will be addressed in greater detail in Section 5 - Porches.

The basement is accessed by wood doors on the west and southeast. These are recessed below grade and have a concrete porch / stair. Neither of the stairwells appears to have provisions for drainage as both landings are full of debris. The doors are both in poor condition due to weather intrusion.

The main floor is accessed through a door at the ramp on the northwest corner, a door on the south elevation into the stairwell and the main door on the east porch. The northwest door is protected by a small porch and is in fair condition. The south door is in fair condition and has suffered greatly from weathering and exposure. The door on the main porch is a large paneled door with a large art glass sidelight and matching transom – curiously, the detailing of the art glass in this door is similar to but does not match the art glass in either of the decorative windows discussed above. The door is in reasonably good condition and appears to be weathertight.

The doors are accessed by concrete steps on the west, south and east elevations. It is suspected that the original stone steps had weathered to the point that they needed replacement and they were replaced with formed concrete. The door for the basement coal chute on the north elevation has deteriorated to the point that it is crumbling and should be replaced.

RECOMMENDATIONS:

Good

Clean the main entry door with a mild detergent. The northwest door should be treated by removing loose and flaking paint, repaint brickmold, frame and leaf with a high-quality exterior primer and paint. The other doors should be replaced with new doors. Replace the coal chute door with a new reproduction.

Better

Main entry door - Prepare the wood for re-staining by thorough sanding. Re-stain the door. Northwest door - chemically strip the paint from the wood brickmold, frame and leaf. Repaint the brickmold, frame and leaf with a high-quality exterior primer and paint.

Best

Not Applicable.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 3 – DECORATIVE WOOD ELEMENTS

WOOD SOFFITS AND FASCIA'S

The roof line of the building is marked by a painted wood dentiled frieze and bracketed soffit and fascia. The wood of the frieze, soffit, fascia and decorative dentils and brackets appear to be in mostly fair condition, except for a few areas directly aligned with the leaking gutters and downspouts, this is particularly problematic in the NE and NW corners of the building. The wood window sills and jambs in the all the dormers are severely deteriorated and should be replaced. The paint is peeling off the wood in most areas around the entire building.

RECOMMENDATIONS:

Good

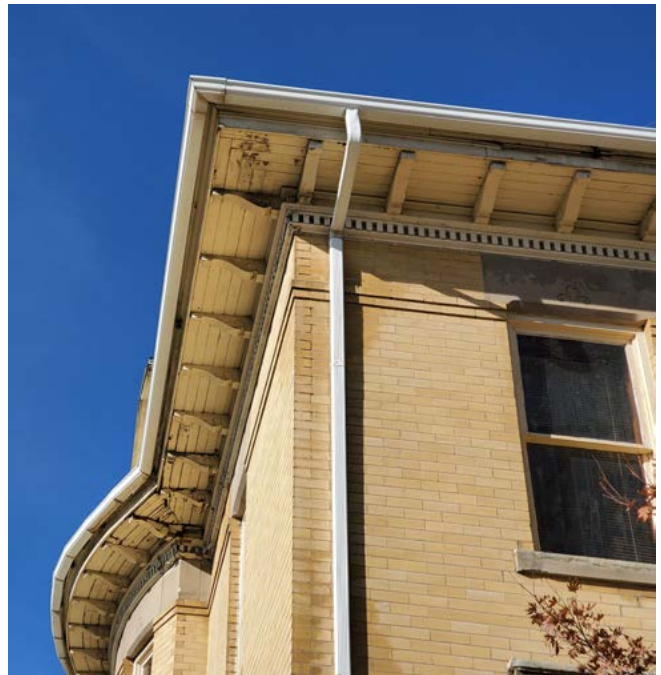
Clean the wood elements with a mild detergent. Scrape the loose and flaking paint. Repair or replace any damaged soffit, brackets or dentils. Repaint the wood with a high-quality exterior primer and paint.

Better

Chemically strip the paint from the wood elements. Repair or replace any damaged soffit, brackets or dentils. Repaint the wood with a high-quality exterior primer and paint.

Best

Not applicable.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 4 – ROOFING AND DORMERS

ROOFING

The current roofing is asphalt shingles with metal flashings. Most of the roof shingles appear to be in poor condition except for the shingles on the dormer addition over the south bay, which are in very poor condition. The shingles in this area have lost all the stone aggregate and are severely curled. There are a number of missing shingles throughout the roof. The roof needs immediate replacement. The historic photos are unclear as to the original roofing material, but it appears to be either wood shingles or slate. Either material is an excellent choice for the replacement of the existing roofing. Budgetary considerations may require the use of asphalt shingles and a traditional 3-tab shingle should be used. An architectural shingle with a decorative shadow-line of either built-up layers or a change in the asphalt aggregate color is not an appropriate approach and should not be used.

At some point in the building's history, an evaporative cooler was installed on the west portion of the roof. The cooler has been removed, but the duct penetrating the roof remains. It is recommended that the duct be removed, the sheathing be patched and prepared for roofing. The historic photos also show a decorative finial on the dormer and roof hips which have all been removed. Consideration could be given to replace these elements with reproductions. The flashings appear to be a mixture of "cut-in" reglet style and surface applied.

Removal of all flashings and replacement with true "cut-in" reglet flashings is recommended as they offer the best performance.

There are a few areas on the roof which require particular attention during the re-roofing process. Areas which either do not receive direct sunlight or which are congested should receive a full application of a peel & stick ice & water shield product. The area on the west side of the building between the historic mansion and the new addition and the areas between the dormers should receive this treatment. It is further recommended that ice & water shield be installed along the eaves, rakes and the valleys of the roof. A full application of an ice & water shield on the entire roof would also significantly improve the performance of the roof.

The original integral gutters have been abandoned and the roof sheathing appears to have been extended to the eave. The extension of the roof sheathing creates a "flattening" of the roof slope at the eave.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



RECOMMENDATIONS:

Good

Remove the existing asphalt shingles and carefully inspect the existing roof sheathing for any deterioration, water damage and signs of the same in the skip sheathing below the plywood or OSB, and replace as necessary. Remove the evaporative cooler ductwork. The roof design has an interesting “flattening” of the roof slope covering the original integral gutter as it approaches the eaves - we recommend a careful evaluation for excess “flattening” which holds or significantly delays water drainage and the reduction of the “flattening” to correct any discovered issues – see the recommendations under the gutter and downspouts category. Install a peel & stick ice & water shield membrane of approximately 18” wide along the roof eaves, on each side of the valleys of all roof intersections, at the sides of the dormers and fully covering the areas which do not receive direct sun. Reroof the building with a traditional 3-tab, asphalt shingle with a 25-year warranty.

Better

Remove the shingles and inspect / repair the roof membrane as above, plus, a full application of the ice & water shield over the entire roof. Install graphite treated wood shingles for a 40 year roof. Install reproductions of the missing finials and widows walk railing.

Best

Re-roof the building with slate for a 75-100 year roof. If this option is selected, it is recommended that a structural evaluation be conducted to determine if the roof framing can support the additional weight of a slate roof. Note: If the historic appearance of a slate roof is deemed important but the cost is prohibitive, there are a number of synthetic slate products which may be investigated for use.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS

GUTTERS AND DOWNSPOUTS

Historic photos of the building depict integral gutters and round downspouts that were likely copper. The integral gutter appears to have been sheathed over and have been replaced with modern, pre-finished aluminum 'K' style gutters and rectangular downspouts, which are not appropriate for the period of the building. The gutters and downspouts appear to be leaking or not draining properly. The leakage is particularly evident in the northeast corner where the brick is significantly stained from repeated wetting. The condition is temporarily exacerbated by leaves and other debris in the gutter blocking the downspouts. The downspouts currently end and drain water immediately adjacent to the building which is contributing to the water damage to the stone veneer foundation. Splash blocks, horizontal downspout extensions or underground piping is highly recommended to direct roof run-off away from the foundation of the building.

RECOMMENDATIONS:

Good

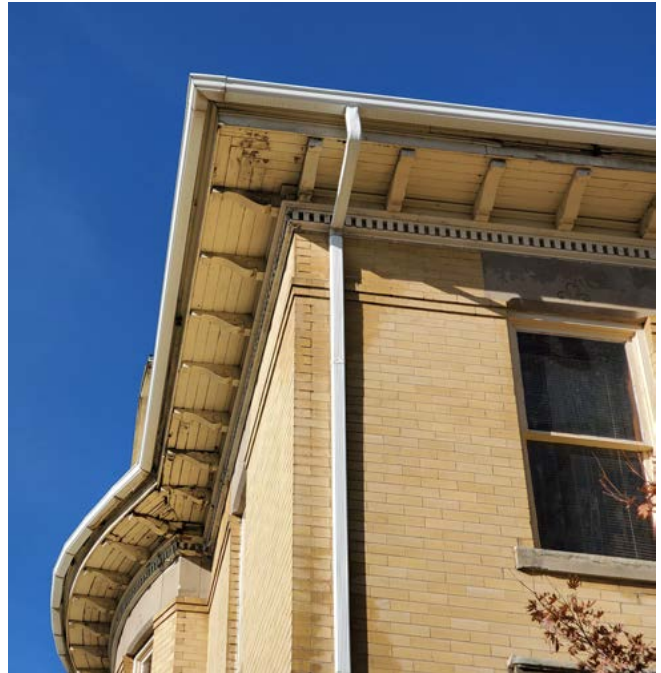
Remove the existing modern gutters and downspouts. Reinstall pre-finished aluminum historic-style half-round gutters and downspouts. Verify that the gutters slope and drain properly and the upper downspouts direct the water directly into the lower gutter system where necessary. Provide downspout extensions to direct roof run-off away from the foundation wall.

Better

Connect the downspouts to an underground piping system to pipe water from the foundation into a French drain system at least 20 feet from the building. Reinstall copper half-round gutters and round downspouts.

Best

Restore the integral gutter at the roof edge by removing the excess roof sheathing and restoring the copper gutter liner. Replace the downspouts with round copper.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



HISTORIC AND MODERN ADDITION DORMERS

Historic photos show that the original building had four dormers, one on each primary elevation. A large dormer was added to the south elevation around the same time the building addition to the north was constructed. The historic dormers have battered walls covered with painted wood shingles and a bracketed soffit and detailed fascia. The dormers all have windows, a single square casement window on the east, south, and west and a double casement window on the north.

The later addition dormer is much larger than the originals and has three modern double-sash casement windows. These three windows have a wood frame which is proud of the shingle wall and are visually different from the recessed windows in the historic dormers. The walls of this dormer are not battered but are covered with painted wood shingles that match the originals. The soffit and fascia of this dormer are painted plywood and has none of the historic detailing and is completely out of character with the rest of the building. The wood soffit, brackets and fascia's are all in good condition but the paint is peeling and flaking everywhere.

RECOMMENDATIONS:

Good

Clean the dormers with a mild detergent. Scrape the loose and flaking paint. Repair or replace any damaged shingles, soffit, brackets or fascia. Repaint the wood with a high-quality exterior primer and paint.

Better

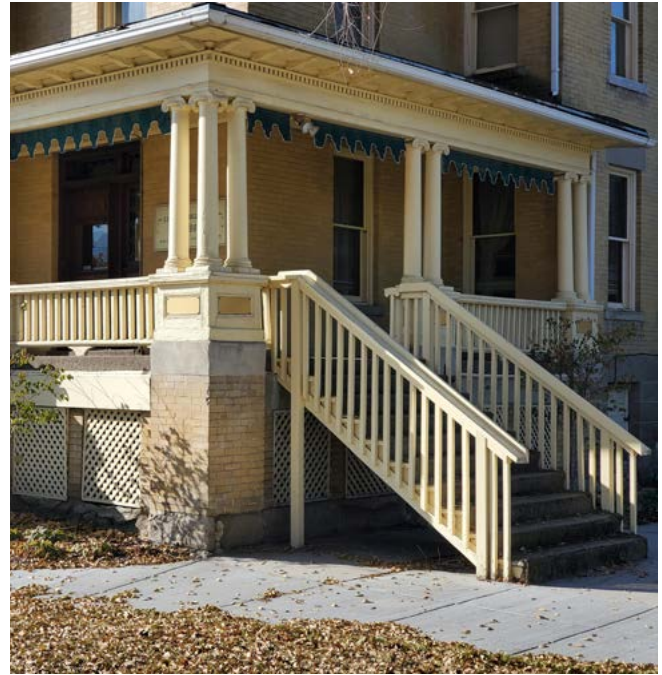
Remove the wood shingles to allow for a better flashing termination in conjunction with re-roofing. Replace the wood shingles. Repair the wood windows. Repaint the wood with a high-quality exterior primer and paint.

Best

Remove the plywood soffit and fascia from the large, modern dormer. Install a bracketed wood soffit and detailed fascia to match the historic dormers. Repaint the wood with a high-quality exterior primer and paint.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 5 – PORCHES

EAST PORCH / MAIN ENTRY

The main entry porch is large and wraps around the NE corner of the building. The entry is marked by stepped, brick masonry cheek walls and the roof is supported by painted columns of the Ionic order resting on a paneled base. A painted, heavy wood railing spans between paneled column bases. The dentiled frieze and bracketed soffit match the detailing at the upper roof. The base of the porch is comprised of brick masonry piers with wood lattice in-fill panels. A base course of the stone veneer foundation runs along the bottom of the piers and beneath the lattice panels. The main entry concrete stair, deck surface and porch flooring are covered with heavily worn outdoor carpeting. An additional painted wood stair leads from the NE corner of the porch to the north. The porch exhibits remarkably little settlement.

Review of historic photos of the building indicate that the main approach has been rebuilt at some time in the past. The brick masonry in the stepped cheek walls appears to have a much wider range of color and texture, a very different joint thickness than the rest of the mansion and the concrete caps are modern replacements for the stone caps shown in the historic photos. The original appearing stone veneer foundation has been parged with Portland cement. The porch has a decorative metal railing that appears to have been installed about the time of the north addition. The porch floor appears to be solid, but the

carpeting is concealing the true state of the wood porch flooring and likely contributing to the degradation of the wood by holding moisture. The paneled bases and the column bases are deteriorating and in need of repair / replacement. The porch is not accessible, and the metal railing is suspected to have been added to help comply with the building code requirement for a handrail.

RECOMMENDATIONS:

Good

Clean the wood and masonry with a mild detergent. Scrape all the painted surfaces to remove peeling and flaking paint. Repair / replace the column bases, paneled bases, soffits, brackets, dentils and other deteriorated decorative wood. Remove the carpeting and repair the porch flooring and wood stair. Repaint the wood with a high-quality exterior primer and paint. Repoint the brick cheek walls as per the recommendation in Section 1.

Better

Repair / replace the deteriorated stone veneer below the lattice panels. Remove the metal handrail. Rebuild the wood stair guardrail to be code compliant.

Best

Replace the concrete masonry cheek wall caps with stone to match the foundation veneer. Replace the foundation veneer with matching stone.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS

WEST PORCH / ACCESSIBLE ENTRY

The west porch is currently serving as the accessible entry to the building. The wood ramp that provides the access is in poor condition and does not appear to fully code compliant. The enclosed porch is a vertical beadboard wall surface between Doric columns with a large window in the south elevation. The small roof is detailed with a dentiled frieze and bracketed soffit matching the main mansion.

The porch is in fair condition with peeling and deteriorating paint at the floor line. The porch is supported by brick masonry piers and painted wood in-fill panels. Particular attention should be paid to the small roof during re-roofing to prevent further water infiltration and degradation.

RECOMMENDATIONS:

Good

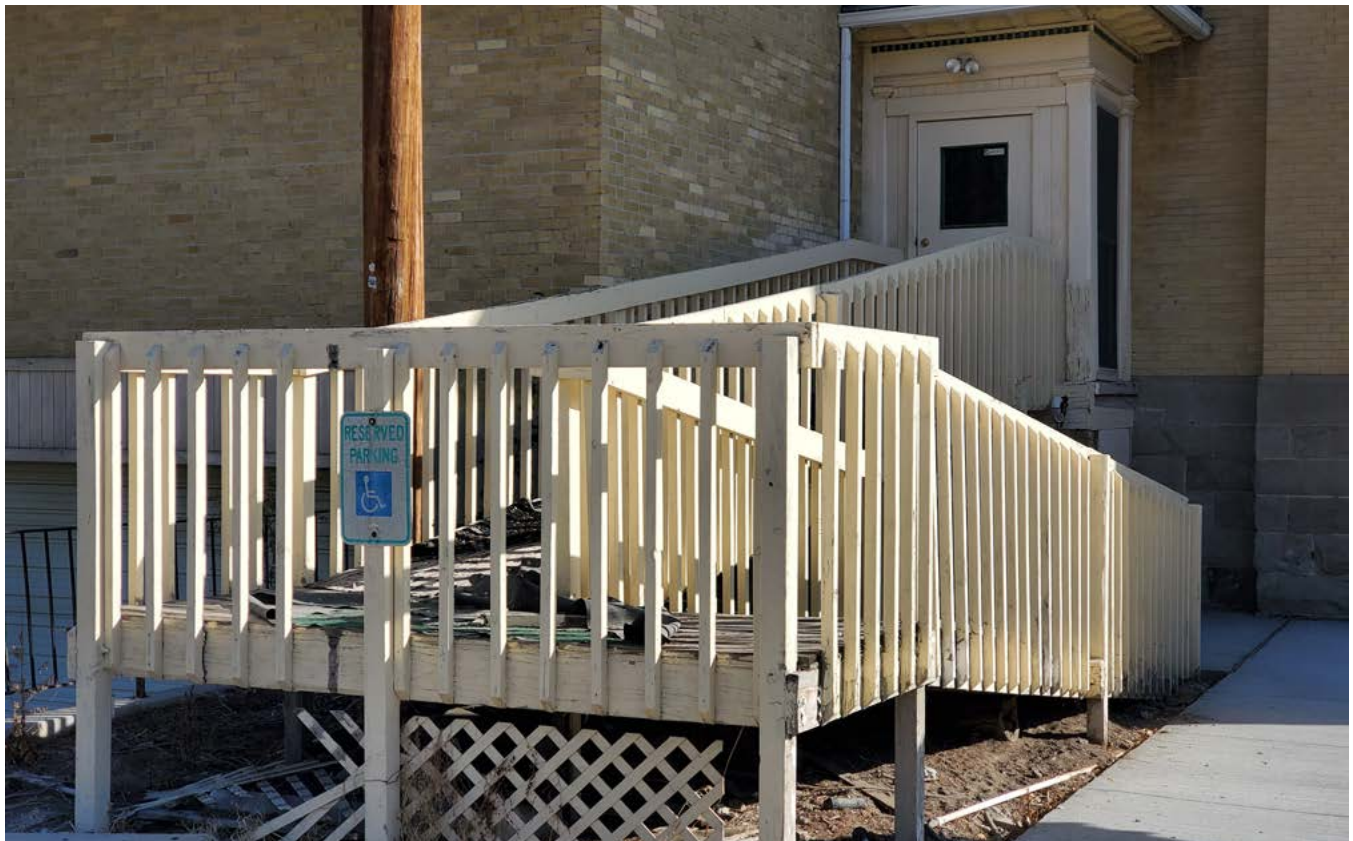
Clean the porch with a mild detergent. Scrape the peeling and flaking paint. Repair / replace any deteriorated wood structure and decorative elements. Repaint the wood with a high-quality exterior primer and paint. Remove the existing wood ramp and rebuild a code compliant ramp that better complements the historic wood railings on the front of the mansion.

Better

Rebuild a code compliant ramp that matches the historic wood railings on the front of the mansion from a more durable material than wood such as powder coated steel or aluminum.

Best

Re-examine the long-term use of the adjacent properties to determine the best location for the accessible entrance. Modify the most likely location for visitor access by adding an accessible ramp that matches the historic railings.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SOUTH ENTRANCE PORCH

The entrance door on the south elevation is accessed via a small concrete porch with a metal guardrail. The porch is covered with the same outdoor carpeting as on the main entry porch. The historic photos of the Mansion do not depict an historic porch at the location of the current concrete porch. The view of the south elevations is oblique in both photos, which makes it impossible to determine if the existing door was an original door or an extension of the windows above.

RECOMMENDATIONS:

Good

Remove the carpeting and repair any areas of damaged concrete. Scrape the peeling and flaking paint on the metal railing. Repaint the metal railing with a high-quality exterior primer and paint.

Better

Remove and replace the railing with a contemporary design sympathetic to the historic character of the building.

Best

Remove and replace the porch and railing with a scaled down design similar to, but distinguishable from the original main entry porch.



ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SOUTH ELEVATION & BASEMENT ENTRANCE CANOPIES

The entrances to the basement on the south and west elevations have a non-historic decorative metal canopy system. These canopy systems were likely originally installed in the 1960's-1970's and have possibly been replaced at least once. The historic photos of the Mansion do not indicate that the canopies are replacements for lost historic components, but a contemporary addition to the building. The canopies are providing important weather protection of the basement entrances, but detract from the historic aesthetic of the associated facades. The decorative metal supports and light gauge roofing are in fair condition. The canopies have a dark green and white canvas scalloped festoon along the perimeter edge. The canopy on the south entrance is a barrel shaped metal framework covered with a green canvas matching the festoon on the basement entrance canopies.

RECOMMENDATIONS:

Good

Clean canopies with a mild detergent. Apply sealant at the structure attachment locations. Scrape the peeling and flaking paint on the metal structures. Repaint the metal structure with a high-quality exterior primer and paint. Remove the canvas festoons from the basement canopies.

Better

Remove and replace the canopies with a contemporary design sympathetic to the historic character of the building.

Best

Remove and replace the canopies with a canopy design similar to, but distinguishable from the original porches.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 6 – LANDSCAPING

LANDSCAPING ADJACENT TO THE BUILDING

The existing landscape and plantings, while visually appealing, are causing much of the foundation degradation and water infiltration issues. The landscaping is planted immediately adjacent to the building. Bark mulch is overlapping the brick below the stone foundation veneer and piled up to the stone window sills on the south elevation. The irrigation system appears to be spraying water onto the stone foundation veneer, this is especially evident on the north elevation of the historic building where there is a fair amount of moss and other biological growth occurring. The removal of the plantings and bark mulch within 3 feet of the foundation and the installation of a gravel course will help prevent standing water and saturation of the soil against the foundation and greatly improve drainage.

RECOMMENDATIONS:

Good

Remove all plantings and irrigation systems within three feet of the building foundation. Remove all bark mulch. Remove eight inches of soil below the brick band immediately below the stone veneer foundation. Place eight inches of pea gravel to the level of the brick band below the stone veneer foundation. Modify the site irrigation system to prevent from spraying water on the building and within the gravel course.

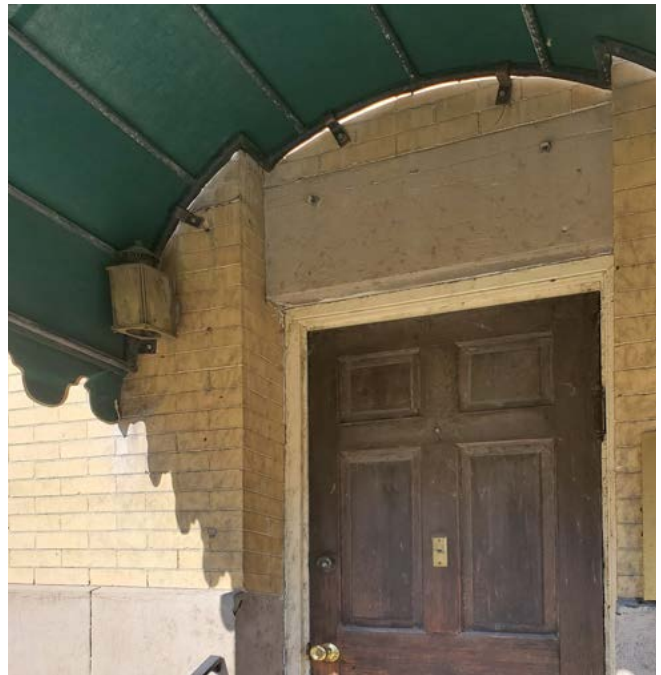
Better

Excavate against the foundation wall and install a drainage mat. Backfill with gravel to the level of the brick band below the stone veneer foundation.

Best

Excavate to the full depth of the foundation and install a perimeter foundation drainage system to pipe water away from the building foundation. Backfill with gravel to the level of the brick band below the stone veneer foundation.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 7 – LIGHTING

BUILDING LIGHTING

The exterior lighting on the building is a mixture of poorly executed reproductions of historic light fixtures located on the ceiling of the historic porch and on the walls at the south and west entrances. The primary fixtures on the main entry porch are simple white glass globes, while the lights at south and basement entrances are brass carriage lights. Motion sensing security flood lights have been installed on the underside of the north beam of the main entrance porch and at the west ramp entrance. The light fixtures are fed in most cases by surface mounted conduit and wire mold.

RECOMMENDATIONS:

Good

Remove the existing light fixtures and replace them with quality period appropriate reproduction fixtures. Remove all abandoned electrical conduit/elements and repair the wall / soffit penetrations.

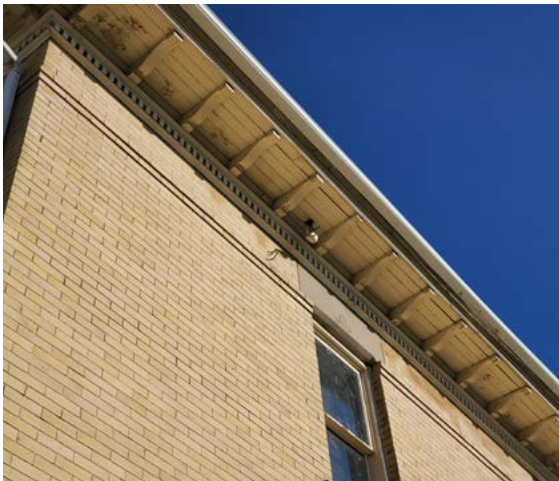
Better

Remove the surface mounted conduit and wire mold feeding the light fixtures and route the new conduit / feeders through the porch soffits.

Best

Not applicable.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 8 – MISCELLANEOUS ITEMS TO REMOVE

There are a number of miscellaneous items attached to the building which should be removed during the work on the stone foundation, brick masonry and soffits. The majority of the items are residual electrical or signage for previous businesses in the Mansion. Beginning on the west façade, the window swamp cooler on the main floor is exhibiting leakage that is damaging the brick and stone. Removal of this cooler should be a high priority. On the southwest corner of the soffit, there is an electrical weatherhead projecting through the soffit that should be removed.

Near the same location at the foundation, there is a residual electrical junction box and surface mounted conduit attached to the window frame that should be removed. Near the south and east entrances are signs for the Murray Mansion Reception Center that should be removed.

At the east end of the south façade are a wire mesh cage and a signage bracket that should also be removed. The residual openings for conduit or fasteners should be filled with materials appropriate to the substrates.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



SECTION 9 – NORTH ADDITION

The addition to the north of the historic mansion appears to have been completed in the 1980's. The brick masonry is a recycled brick which is a reasonable match to the historic brick. The mortar joints are wider than the historic joints and the mortar is a Portland cement-based mortar. The masonry and mortar are in good condition. The high exposed foundation wall is parged with Portland cement and is in good condition. The irrigation system on the north elevation is spraying the wall.

The windows and doors are appropriate for the time of the addition and appear to be in good condition. The roof appears to have been completed with the most recent re-roof of the historic mansion. The shingles are in generally fair condition with a few missing shingles. The gutters and downspouts are pre-finished aluminum K-style with square downspouts. The wood porch on the east elevation is in fair condition with peeling paint and outdoor carpeted treads and risers.

RECOMMENDATIONS:

Clean the masonry with a mild detergent. Adjust the irrigation system to spray away from the building. Re-roof with a 3-tab asphalt shingle. Remove the carpeting from the porch treads and risers, scrape the paint to remove loose paint, repaint with a high-quality exterior primer and paint.

ENVELOPE STABILIZATION ASSESSMENT AND RECOMMENDATIONS



BUDGETARY ESTIMATES

Entelen Design-Build, LLC has prepared preliminary budgetary cost estimates based on the "Good", "Better" and "Best" recommendations. It is important to understand that in many categories, the Good recommendation is the foundation for and a component of the Better or Best recommendation and the estimates regarding cost of the work will reflect that.

ENTELEN DESIGN-BUILD, LLC						
Cahoon Mansion						
Envelope Stabilization Assessment						
		QTY	UNITS	\$/UNIT	Total	
1	Exterior Brick and Stone Masonry					
1	A	Brick Foundation				
		Good			\$6,213	
		Implement Landscape Recommendations in Section 6				
		Clean Exposed Brick	350	sqft	\$3.75	\$1,313
		Repoint Missing Mortar with Lime-Base Mortar	350.00	sqft	\$14.00	\$4,900
		Better			\$10,075	
		Clean Exposed Brick Both Inside and Outside the Building	700.00	sqft	\$3.25	\$2,275
		Replace Heavily deteriorated Brick at the Porch Foundation	312.00	sqft	\$25.00	\$7,800
		Best			\$70,035	
		Excavate Around the Foundation Wall	153.33	cuyd	\$30.00	\$4,600
		Demo of associated exterior Items	1.00	lsum	\$8,500.00	\$8,500
		Possible Remediation Steps for Foundation Wall	1.00	lsum	\$10,075.00	\$10,075
		Repointing Brick	1380.00	sqft	\$14.00	\$19,320
		Install Drainage and Protection Board	1380.00	sqft	\$8.00	\$11,040
		Associated Put Back - Concrete and Reconstruction	1.00	lsum	\$16,500.00	\$16,500
1	B	Sandstone Veneer Foundation				
		Good			\$15,801	
		Remove Portland Cement Repointing and Replace with Lime-Base Mortar	1380.00	sqft	\$4.00	\$5,520
		Clean Stone with Mild Detergent	1380.00	sqft	\$3.25	\$4,485
		Re-Tool the Spalling Areas to Reduce Further Deterioration	414.00	sqft	\$14.00	\$5,796
		Better			\$32,676	
		Cost of Above Good Items	1.00	lsum	\$15,801.00	\$15,801
		Apply a Penetrating Chemical Consolidant to Reduce Deterioration	1380.00	sqft	\$2.75	\$3,795
		Re-profile Decorative Watertable and Stone Lintels to control Drainage of Surface Water.	230.00	lnft	\$26.00	\$5,980
		Install Dutchman Replacements for Severely Deteriorated Areas of Stone	1.00	lsum	\$7,100.00	\$7,100
		Best			\$40,576	
		Cost of Above Better Items - less Dutchmen	1.00	lsum	\$25,576.00	\$25,576
		Replace Severely Deteriorated Stones with New Stone.	15.00	ea	\$1,000.00	\$15,000
1	C	Field brick				
		Good			\$53,820	
		Remove Portland Cement and Caulk repointing.	2760.00	sqft	\$4.00	\$11,040
		Clean Brick with Mild Detergent	5520.00	sqft	\$3.75	\$20,700
		Repoint with Lime-based Mortar	2760.00	sqft	\$8.00	\$22,080
		Better			\$69,000	
		Cost of Above Good Items	1.00	lsum	\$53,820.00	\$53,820
		Apply a Penetrating Chemical Sealer to Protect and Improve Weather Resistance	5520.00	sqft	\$2.75	\$15,180
		Best			\$69,000	
		No new items - Cost is for Better Items Only	1.00	lsum	\$69,000.00	\$69,000
1	D	Stone Lintels and Sills				
		Good			\$4,980	
		Clean Stone Lintels and Sills with Mild Detergent	60.00	ea	\$14.00	\$840
		Repoint missing Head Joint Mortar with Lime-Base Mortar	60.00	ea	\$69.00	\$4,140
		Better			\$8,160	
		Cost of Above Good Items	1.00	lsum	\$4,980.00	\$4,980
		Remove the Portland Cement	60.00	ea	\$25.00	\$1,500
		Apply a Penetrating Chemical Sealer to Protect and Improve Weather Resistance	60.00	ea	\$28.00	\$1,680
		Best			\$59,160	
		Cost of Above Better Items	1.00	lsum	\$8,160.00	\$8,160
		Replace all Window Sills with New Stone carved to match the Original	60.00	ea	\$850.00	\$51,000
1	E	Decorative Stone Trim				
		Good			\$2,490	
		Clean Stone Trim with Mild Detergent	30.00	ea	\$14.00	\$420
		Repoint missing Head Joint Mortar with Lime-Base Mortar	30.00	ea	\$69.00	\$2,070
		Better			\$4,080	
		Cost of Above Good Items	1.00	lsum	\$2,490.00	\$2,490
		Remove the Portland Cement	30.00	ea	\$25.00	\$750
		Apply a Penetrating Chemical Sealer to Protect and Improve Weather Resistance	30.00	ea	\$28.00	\$840
		Best			\$37,080	
		Cost of Above Better Items	1.00	lsum	\$4,080.00	\$4,080
		Replace all Decorative Stone Trim with New Stone carved to match the Original	30.00	ea	\$1,100.00	\$33,000
2	Exterior Window and Door Openings					
2	A	Operable Windows				
		Good			\$37,869	

ENTELEN DESIGN-BUILD, LLC						
		Clean the Windows with a Mild Detergent	834.00	sqft	\$0.65	\$542
		3070 Operable Windows	30.00	ea		
		3050 Operable Windows	8.00	ea		
		2060 Operable Windows	2.00	ea		
		5040 Operable Windows	3.00	ea		
		Remove Loose and Flaking Paint from Window Brickmold, Frames, and Sashes.	43.00	ea	\$140.00	\$6,020
		Repaint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	43.00	ea	\$185.00	\$7,955
		Thermal Improvements will obscure Art Glass Pattern Low-E glass replacement	834.00	sqft	\$28.00	\$23,352
		Better				\$47,217
		Chemically Strip the Paint form the Inside of the Wood Frames and Sashes	43.00	ea	\$165.00	\$7,095
		Repair Operating Ropes and weight Mechanisms	43.00	ea	\$140.00	\$6,020
		Repaint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	43.00	ea	\$125.00	\$5,375
		Stain the Interior Wood Sashes and Frames	43.00	ea	\$125.00	\$5,375
		Thermal Improvements	834.00	sqft	\$28.00	\$23,352
		Best				\$60,547
		Remove the Window from the Wall	43.00	ea	\$105.00	\$4,515
		Restore the Wood Frames	43.00	ea	\$370.00	\$15,910
		Replace the Window Sashes with High Performance insulated Glazing Units	834.00	sqft	\$28.00	\$23,352
		Rebuild Weight Pocket with Larger Weight for Rebalancing	43.00	ea	\$140.00	\$6,020
		Paint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	43.00	ea	\$125.00	\$5,375
		Stain the Interior Wood Sashes and Frames	43.00	ea	\$125.00	\$5,375
		Best - Option				\$37,530
		An Entire New Wood Window with Exterior Aluminum Cladding	834.00	sqft	\$45.00	\$37,530
2	B	Fixed Decorative Windows				
		Good				\$4,328
		Clean the Windows with a Mild Detergent	79.00	sqft	\$0.65	\$51
		3020 Fixed Windows	4.00	ea		
		4070 Fixed Window - Upper Art Glass	1.00	ea		
		3070 Fixed Window - Art Glass	1.00	ea		
		3020 Fixed Window - Art Glass	1.00	ea		
		Remove Loose and Flaking Paint from Window Brickmold, Frames, and Sashes.	7.00	ea	\$110.00	\$770
		Repaint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	7.00	ea	\$185.00	\$1,295
		Thermal Improvements will obscure Art Glass Pattern	79.00	sqft	\$28.00	\$2,212
		Better				\$4,662
		Chemically Strip the Paint form from the Inside of the Wood Frames and Sashes	7.00	ea	\$100.00	\$700
		Repaint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	7.00	ea	\$125.00	\$875
		Stain the Interior Wood Sashes and Frames	7.00	ea	\$125.00	\$875
		Thermal Improvements will obscure Art Glass Pattern	79.00	sqft	\$28.00	\$2,212
		Best				\$14,427
		Remove the Window from the Wall	79.00	sqft	\$105.00	\$8,295
		Restore Wood Frames and Sashes	7.00	ea	\$310.00	\$2,170
		Add High Performance Insulated glazing with Art glass as the Exterior Pane	79.00	sqft	\$28.00	\$2,212
		Paint Window Brickmold, Frames, and Sashes with High Quality Exterior Paint.	7.00	ea	\$125.00	\$875
		Stain the Interior Wood Sashes and Frames	7.00	ea	\$125.00	\$875
2	C	Exterior Doors				
		Good				\$12,831
		Clean the Main Entry Doors with a Mild Detergent	240.0	sqft	\$0.65	\$156
		Remove Loose and Flaking Paint from Northwest Door	1.00	ea	\$175.00	\$175
		Remove Loose and Flaking Paint Brickmold, Frame	4.00	ea	\$175.00	\$700
		Repaint Brickmold, Frame and Leaf with High Exterior Primer and Paint	4.00	ea	\$260.00	\$1,040
		Other Doors Replaced with New Doors	4.00	ea	\$1,775.00	\$7,100
		Replace Coal Chute Frame	2.00	ea	\$405.00	\$810
		Replace Coal Chute Door	2.00	ea	\$1,255.00	\$2,510
		Paint Coal Chute Frame and Door	2.00	ea	\$170.00	\$340
		Better				\$16,025
		Cost of Above Good Items - Less Entry & NW Door Cleaning	1.00	lsum	\$12,500.00	\$12,500
		Main entry Door prepared for Re-Staining by thorough Sanding	240.00	sqft	\$8.50	\$2,040
		Restain Main Entry Door	240.00	sqft	\$4.50	\$1,080
		Northwest Door - Chemically Strip Paint from Wood Brickmold, Frame and Leaf	1.00	ea	\$160.00	\$160
		Northwest Door - Repaint from Wood Brickmold, Frame and Leaf with High Quality Exterior Paint	1.00	ea	\$245.00	\$245
		Best				\$16,025
		No new items - Cost is for Better Items Only	1.00	lsum	\$16,025.00	\$16,025
3	Decorative Wood Elements					
3	A	Wood Soffits and Fascia's				

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Good			\$31,659	
Clean the Wood Elements with a Mild Detergent	1380.00	sqft	\$1.40	\$1,932
Remove Peeling and Flaking Paint - pressure wash	1380.00	sqft	\$1.05	\$1,449
Repair / Replace Damaged Soffit	450.00	sqft	\$16.50	\$7,425
Repair / Replace Damaged Brackets	150.00	ea	\$90.00	\$13,500
Repair / Replace Damaged Dentils	150.00	lnft	\$32.00	\$4,800
Repaint with High Quality Exterior Primer and Paint	1380.00	sqft	\$1.85	\$2,553
Better			\$51,865	
Chemically Strip Paint from Wood Elements	1380.00	sqft	\$3.35	\$4,623
Repaint with High Exterior Primer and Paint	1380.00	sqft	\$1.05	\$1,449
Repair / Replace Damaged Soffit	920.00	sqft	\$16.50	\$15,180
Repair / Replace Damaged Brackets	230.00	ea	\$90.00	\$20,700
Repair / Replace Damaged Dentils	230.00	lnft	\$32.00	\$7,360
Repaint with High Quality Exterior Primer and Paint	1380.00	sqft	\$1.85	\$2,553
Best			\$51,865	
No new items - Cost is for Better Items Only	1.00	lsum	\$51,865.00	\$51,865
4	Roofing & Dormers			
4	A	Roofing		
Good			\$37,273	
Remove Existing Asphalt Shingles	3700.00	sqft	\$1.30	\$4,810
Inspect and Replace Damaged Roof Sheating	1850.00	sqft	\$7.25	\$13,413
Remove Evaporative Cooler Ductwork	1.00	lsum	\$550.00	\$550
Modify Roof "Flattening"	1200.00	sqft	\$7.25	\$8,700
Install Ice & Water Shield - 18" at Roof Eaves at Roof valleys, at Dormers and areas without Direct Sunlight	230.00	lnft	\$4.00	\$920
Reroof Building with 3-Tab Shingle - 25 yr. warranty	3700.00	sqft	\$2.40	\$8,880
Better			\$154,383	
Remove Existing Asphalt Shingles	3700.00	sqft	\$1.30	\$4,810
Inspect and Replace Damaged Roof Sheating	1850.00	sqft	\$7.25	\$13,413
Install Ice & Water Shield - for Entire Roof	3700.00	sqft	\$3.25	\$12,025
Install Graphite treated Wood Shingles - 40 yr roof	3700.00	sqft	\$31.00	\$114,700
Install Reproductions of Missing Finials	9.00	ea	\$215.00	\$1,935
Install Reproductions of Missing Window Walk Railings	50.00	lnft	\$150.00	\$7,500
Best			\$419,683	
Remove Existing Asphalt Shingles	3700.00	sqft	\$1.30	\$4,810
Inspect and Replace Damaged Roof Sheating	1850.00	sqft	\$7.25	\$13,413
Install Ice & Water Shield - for Entire Roof	3700.00	sqft	\$3.25	\$12,025
Re-Roof Building with Slate Shingles - 75 yr roof	3700.00	sqft	\$95.00	\$351,500
Determine if roof structural upgrade is required for Slate Singles.	1.00	lsum	\$28,500.00	\$28,500
Install Reproductions of Missing Finials	9.00	ea	\$215.00	\$1,935
Install Reproductions of Missing Window Walk Railings	50.00	lnft	\$150.00	\$7,500
Option			\$191,383	
Optional Synthetic Shingles				
Remove Existing Asphalt Shingles	3700.00	sqft	\$1.30	\$4,810
Inspect and Replace Damaged Roof Sheating	1850.00	sqft	\$7.25	\$13,413
Install Ice & Water Shield - for Entire Roof	3700.00	sqft	\$3.25	\$12,025
Re-Roof Building with Slate Shingles - 75 yr roof	3700.00	sqft	\$41.00	\$151,700
Install Reproductions of Missing Finials	9.00	ea	\$215.00	\$1,935
Install Reproductions of Missing Window Walk Railings	50.00	lnft	\$150.00	\$7,500
4	B	Gutters and Downspouts		
Good			\$11,663	
Remove the Existing Gutters and Downspouts	430.00	lnft	\$2.75	\$1,183
Reinstall Pre-Finished Aluminum Historic Style Gutters and Downspouts	430.00	lnft	\$22.00	\$9,460
Verify that Gutters and Downspouts Drain Properly	1.00	lsum	\$660.00	\$660
Provide Downspout Extensions - for properly drainage away from building foundation	4.00	ea	\$90.00	\$360
Better			\$38,223	
Cost of Above Good Items	1.00	lsum	\$11,662.50	\$11,663
Connect Downspouts to Underground French Drain System	4.00	ea	\$375.00	\$1,500
Install French Drain System 20' from Building	200.00	lnft	\$35.00	\$7,000
Reinstall Copper Half-Round Gutters and Downspouts	430.00	lnft	\$42.00	\$18,060
Best			\$53,023	
Cost of Above Good Items - Less Aluminum Historic Style Gutters and Downspouts	1.00	lsum	\$28,762.50	\$28,763
Remove Flattened Roof and Restore Integral Gutter	310.00	lnft	\$62.00	\$19,220
Reinstall Copper Rounded Downspouts	120.00	lnft	\$42.00	\$5,040
4	C	Historic and Modern Addition Dormers		
Good			\$13,210	
Clean the Dormers with Mild Detergent	662.00	sqft	\$1.40	\$927
Remove Peeling and Flaking Paint	662.00	sqft	\$1.05	\$695
Repair / Replace Damaged Shingles	220.00	sqft	\$7.00	\$1,540
Repair / Replace Damaged Soffit	84.00	lnft	\$32.00	\$2,688
Repair / Replace Damaged Brackets	48.00	ea	\$90.00	\$4,320
Repair / Replace Damaged Fascia	84.00	lnft	\$32.00	\$2,688
Repaint with High Quality Exterior Primer and Paint	220.00	sqft	\$1.60	\$352
Better			\$17,529	
Cost of Above Good Items - Less Cleaning, Paint Removal and Paint	1.00	lsum	\$11,236.00	\$11,236

ENTELEN DESIGN-BUILD, LLC						
		Remove Wood Shingles	410.00	sqft	\$2.20	\$902
		Install better Flashing Terminations	1.00	lsum	\$1,250.00	\$1,250
		Replace Wood Shingles	410.00	sqft	\$8.50	\$3,485
		Repair Wood Windows			In Section 2A & 2B	
		Repaint with High Quality Exterior Primer and Paint	410.00	sqft	\$1.60	\$656
Best						\$20,323
		Cost of Above Better Items	1.00	lsum	\$17,529.00	\$17,529
		Remove Plywood Soffit and Fascia from Modern Dormer	36.00	lnft	\$9.00	\$324
		Install a Bracketed Wood Soffit - matching historic dormers	36.00	lnft	\$32.00	\$1,152
		Install a Detailed Fascia - matching historic dormers	36.00	lnft	\$27.00	\$972
		Repaint with High Quality Exterior Primer and Paint	216.00	sqft	\$1.60	\$346
5	Porches					
5	A	East Porch / Main Entry				
		Good				\$44,289
		Clean the Wood and Masonry with Mild Detergent	552.00	sqft	\$1.40	\$773
		Remove Peeling and Flaking Paint	2000.00	sqft	\$1.05	\$2,100
		Repair / Replace Column Bases	12.00	ea	\$800.00	\$9,600
		Repair / Replace Paneled Bases	8.00	ea	\$1,300.00	\$10,400
		Repair / Replace Soffit Bases	76.00	lnft	\$78.00	\$5,928
		Repair / Replace Dentils	76.00	lnft	\$27.00	\$2,052
		Repair / Replace Other Decorative Deteriorated Wood	1.00	lsum	\$2,700.00	\$2,700
		Remove Carpeting	552.00	sqft	\$2.15	\$1,187
		Repair Porch Flooring and Stair	1.00	lsum	\$2,650.00	\$2,650
		Repaint with High Quality Exterior Primer and Paint	2000.00	sqft	\$1.60	\$3,200
		Repoint Brick Cheek Walls - per section 1	217.60	sqft	\$17.00	\$3,699
		Better				\$61,555
		Cost of Above Good Items	1.00	lsum	\$44,288.80	\$44,289
		Repair / Replace Deteriorated Stone below the Lattice Panels	76.00	lnft	\$210.00	\$15,960
		Remove Iron Handrail	16.00	lnft	\$16.00	\$256
		Rebuild Wood Stair Guardrail to be Code Compliant	1.00	lsum	\$1,050.00	\$1,050
		Best				\$71,605
		Cost of Above Better Items	1.00	lsum	\$61,554.80	\$61,555
		Replace Concrete Cheek Wall Caps with Stone - matching foundation veneer	6.00	ea	\$625.00	\$3,750
		Replace the Foundation Veneer with Matching Stone	30.00	lnft	\$210.00	\$6,300
5	B	West Porch / Accessible Entry				
		Good - I				\$2,395
		Clean Porch with Mild Detergent	300.00	sqft	\$1.40	\$420
		Remove Peeling and Flaking Paint - pressure wash	500.00	sqft	\$1.05	\$525
		Repair / Replace deteriorated Wood Structure and Decorative Elements	1.00	lsum	\$650.00	\$650
		Repaint with High Quality Exterior Primer and Paint	500.00	sqft	\$1.60	\$800
		Good - II				\$10,350
		Remove Existing Wood Ramp	300.00	sqft	\$6.50	\$1,950
		Build a New Code Compliant Ramp - wood	300.00	sqft	\$35.00	\$8,400
		Better				\$19,350
		Remove Existing Wood Ramp	300.00	sqft	\$6.50	\$1,950
		Build a New Code Compliant Ramp - historical match, with powder coated steel / aluminum	300.00	sqft	\$60.00	\$17,400
		Best				\$20,950
		Remove Existing Wood Ramp	300.00	sqft	\$6.50	\$1,950
		Re-examine / Find best long term location form new ramp, modify visitor access and match historical railings.	1.00	lsum	\$25,000.00	\$19,000
5	C	South Entrance Porch				
		Good				\$826
		Remove Carpeting	40.00	sqft	\$2.15	\$86
		Repair Damaged Concrete	40.00	sqft	\$11.00	\$440
		Remove Pealing and Flaking Paint from Railing	12.00	lnft	\$12.00	\$144
		Repaint Railing with High Quality Exterior Primer and Paint	12.00	lnft	\$13.00	\$156
		Better				\$1,144
		Remove Carpeting	40.00	sqft	\$2.15	\$86
		Repair Damaged Concrete	40.00	sqft	\$11.00	\$440
		Remove Porch Railing	12.00	lnft	\$6.50	\$78
		Install New Contemporary Railing	12.00	lnft	\$45.00	\$540
		Best				\$6,900
		Demo Porch and Railings	40.00	sqft	\$35.00	\$1,400
		Install New Porch similar to Original Main Porch	100.00	sqft	\$55.00	\$5,500
5	D	South Elevation & Basement Entrance Canopies				
		Good				\$2,008
		Clean Canopies with Mild Detergent	120.00	sqft	\$1.40	\$168
		Sealant at Structural Elements	40.00	lnft	\$3.50	\$140
		Remove Peeling and Flaking Paint for Metal Structures	120.00	sqft	\$12.00	\$1,440
		Repaint Metal Structures with High Quality Exterior Primer and Paint	120.00	sqft	\$1.60	\$192
		Remove Canvas Festoons from Basement Canopies	40.00	lnft	\$1.70	\$68
		Better				\$5,658
		Remove Canopies	120.00	sqft	\$2.15	\$258
		New Canopies - Contemporary Design	120.00	sqft	\$45.00	\$5,400
		Best				\$6,858

ENTELEN DESIGN-BUILD, LLC						
		Remove Canopies	120.00	sqft	\$2.15	\$258
		New Canopies - similar or Original Porch	120.00	sqft	\$55.00	\$6,600
6	Landscaping					
6	A	Landscaping Adjacent to the Building				
		Good				\$4,417
		Remove Plantings and Irrigation within 3' of Building Foundation	490.00	sqft	\$4.50	\$2,205
		Remove Bark Mulch	490.00	sqft	\$1.25	\$613
		Remove 8" of Soil below Brick Band	13.50	cuyd	\$50.00	\$675
		Place 8" of Pea gravel to level of Brick Band	13.50	cuyd	\$40.00	\$540
		Maintain/Adjust Irrigation to Prevent Building Spray	1.00	lsum	\$385.00	\$385
		Better				\$19,809
		Remove Plantings and Irrigation within 3' of Building Foundation	490.00	sqft	\$4.50	\$2,205
		Remove Bark Mulch	490.00	sqft	\$1.25	\$613
		Excavation to Install Drainage Mat	120.31	cuyd	\$33.00	\$3,970
		Install Foundation Drainage Mat	978.00	sqft	\$8.00	\$7,824
		Install Gravel up to Brick Band	120.31	cuyd	\$40.00	\$4,813
		Maintain/Adjust Irrigation to Prevent Building Spray	1.00	lsum	\$385.00	\$385
		Best				\$27,633
		Remove Plantings and Irrigation within 3' of Building Foundation	490.00	sqft	\$4.50	\$2,205
		Remove Bark Mulch	490.00	sqft	\$1.25	\$613
		Excavation to Install Drainage Mat	120.31	cuyd	\$33.00	\$3,970
		Install Foundation Drainage Mat	1630.00	sqft	\$8.00	\$13,040
		Install Perimeter Foundation Pipe Drainage System	163.00	lnft	\$16.00	\$2,608
		Install Gravel up to Brick Band	120.31	cuyd	\$40.00	\$4,813
		Maintain/Adjust Irrigation to Prevent Building Spray	1.00	lsum	\$385.00	\$385
7	Lighting					
7	A	Lighting				
		Good				\$5,294
		Remove Existing Exterior Light Fixtures	8.00	ea	\$29.00	\$232
		New Exterior Light Fixtures - Period Appropriate Reproductions	8.00	ea	\$500.00	\$4,000
		Remove Abandoned Electrical Conduit	180.00	lnft	\$1.40	\$252
		Repair Soffit and Walls at Removed Conduit	180.00	lnft	\$4.50	\$810
		Better				\$7,274
		Remove Existing Exterior Light Fixtures	8.00	ea	\$29.00	\$232
		New Exterior Light Fixtures - Period Appropriate Reproductions	8.00	ea	\$500.00	\$4,000
		Remove Electrical Conduit	180.00	lnft	\$1.40	\$252
		Repair Soffit and Walls at Removed Conduit	180.00	lnft	\$4.50	\$810
		New Conduit run through Porch Soffits	180.00	lnft	\$11.00	\$1,980
		Best				\$7,274
		No new items - Cost is for Better Items Only	1.00	lsum	\$7,274.00	\$7,274
8	North Addition					
8	A	North Addition				
		Good, Better, & Best				\$14,549
		Clean Masonry with Mild Detergent	2600.00	sqft	\$2.45	\$6,370
		Adjust Irrigation System Spray	1.00	lsum	\$260.00	\$260
		Re-Roof w 3 Tab Asphalt Shingle	2640.00	sqft	\$2.40	\$6,336
		Remove Carpet from Porch Treads and Risers	110.00	sqft	\$2.15	\$237
		Remove Loose Paint - (pressure wash)	310.00	sqft	\$1.05	\$326
		Repaint with High Exterior Primer and Paint	310.00	sqft	\$1.60	\$496
		Wood Repairs	1.00	lsum	\$750.00	\$525
Totals						
		Good	1.00	lsum		\$313,869
		Better	1.00	lsum		\$583,233
		Best	1.00	lsum		\$1,067,512

ANNOTATED PHOTOGRAPHS

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Photo courtesy Steve Cornell – SHPO

Location of Modern
Dormer Addition



Photo courtesy Steve Cornell – SHPO













- Mortar Re-pointing
- Stone Degradation
- Water Damage





- Mortar Re-pointing
- Stone Degradation
- Water Damage



Mortar Re-pointing

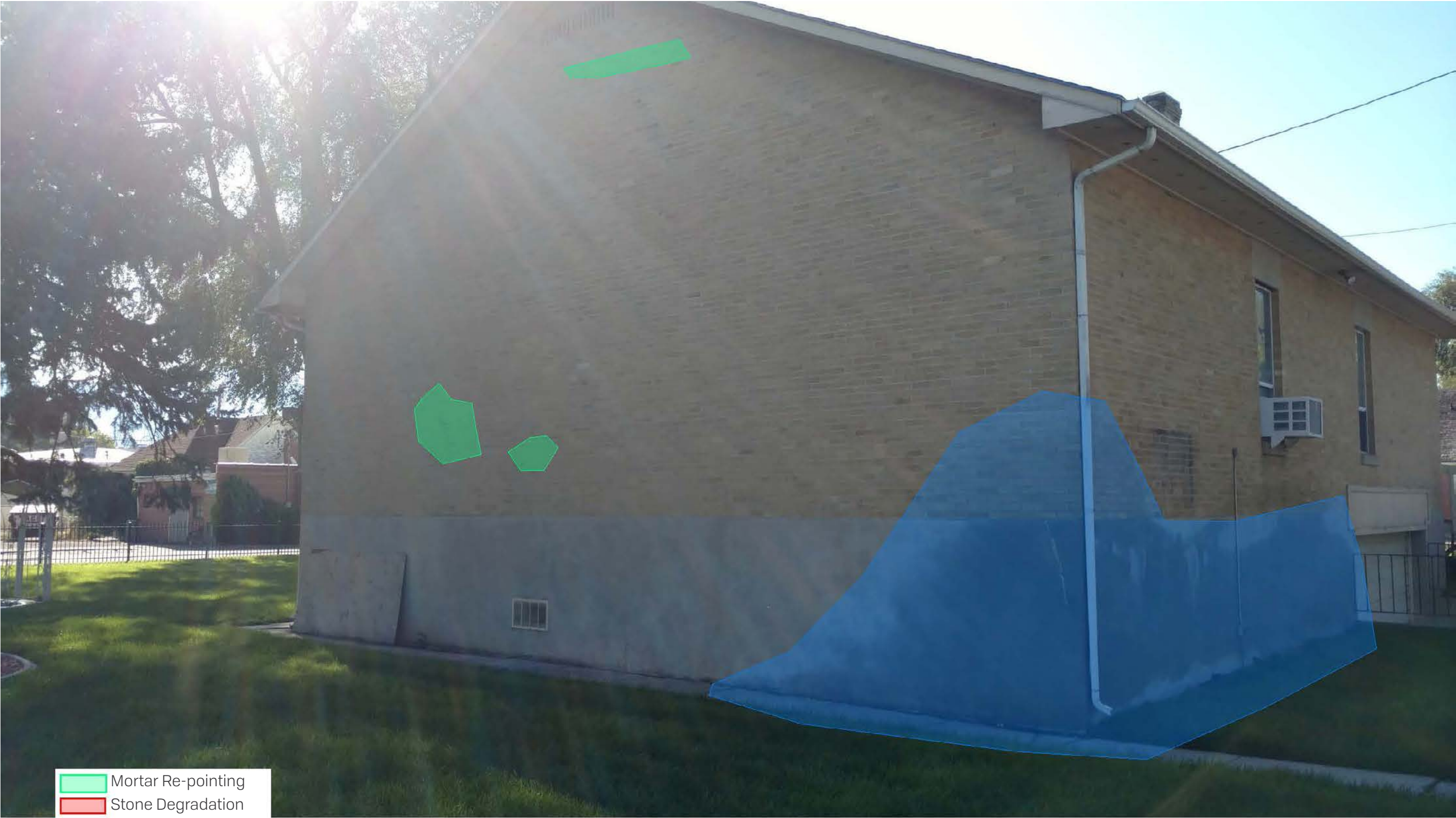
Stone Degradation

Water Damage









- Mortar Re-pointing
- Stone Degradation
- Water Damage



- Mortar Re-pointing
- Stone Degradation
- Water Damage





Mortar Re-pointing

Stone Degradation

Water Damage



- █ Mortar Re-pointing
- █ Stone Degradation
- █ Water Damage

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- APPENDIX B NATIONAL PARK SERVICE PRESERVATION BRIEF - ASSESSING CLEANING AND WATER - REPELLENT TREATMENTS FOR HISTORIC MASONRY BUILDINGS
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Technical Preservation Services

National Park Service
U.S. Department of the Interior



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Some of the web versions of the Preservation Briefs differ somewhat from the printed versions. Many illustrations are new and in color; Captions are simplified and some complex charts are omitted. To order hard copies of the Briefs, see [Printed Publications](#).

PRESERVATION BRIEFS

2

Repointing Mortar Joints in Historic Masonry Buildings

Robert C. Mack, FAIA, and John P. Speweik

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Soft mortar for repointing. Photo: John P. Speweik.

Masonry—brick, stone, terra-cotta, and concrete block—is found on nearly every historic building. Structures with all-masonry exteriors come to mind immediately, but most other buildings at least have masonry foundations or chimneys. Although generally considered "permanent," masonry is subject to deterioration, especially at the mortar joints. Repointing, also known simply as "pointing" or—somewhat inaccurately—"tuck pointing"*, is the process of removing deteriorated mortar from the joints of a masonry wall and replacing it with new mortar. Properly done, repointing restores the visual and physical integrity of the masonry. Improperly done, repointing not only detracts from the appearance of the building, but may also cause physical damage to the masonry units themselves.

The purpose of this Brief is to provide general guidance on appropriate materials and methods for repointing historic masonry buildings and it is intended to benefit building owners, architects, and contractors. The Brief should serve as a guide to prepare specifications for repointing historic masonry buildings. It should also help develop sensitivity to the particular needs of historic masonry, and to assist historic building owners in working cooperatively with architects, architectural conservators and historic preservation consultants, and contractors. Although specifically intended for historic buildings, the guidance is appropriate for other masonry buildings as well. This publication updates *Preservation Briefs 2: Repointing Mortar Joints in Historic Brick Buildings* to include all types of historic unit masonry. The scope of the earlier Brief has also been expanded to acknowledge that the many buildings constructed in the first half of the 20th century are

now historic and eligible for listing in the National Register of Historic Places, and that they may have been originally constructed with portland cement mortar.

**Tuckpointing technically describes a primarily decorative application of a raised mortar joint or lime putty joint on top of flush mortar joints.*

Historical Background

Mortar consisting primarily of lime and sand has been used as an integral part of masonry structures for thousands of years. Up until about the mid-19th century, lime or quicklime (sometimes called lump lime) was delivered to construction sites, where it had to be slaked, or combined with water. Mixing with water caused it to boil and resulted in a wet lime putty that was left to mature in a pit or wooden box for several weeks, up to a year. Traditional mortar was made from lime putty, or slaked lime, combined with local sand, generally in a ratio of 1 part lime putty to 3 parts sand by volume. Often other ingredients, such as crushed marine shells (another source of lime), brick dust, clay, natural cements, pigments, and even animal hair were also added to mortar, but the basic formulation for lime putty and sand mortar remained unchanged for centuries until the advent of portland cement or its forerunner, Roman cement, a natural, hydraulic cement.

Portland cement was patented in Great Britain in 1824. It was named after the stone from Portland in Dorset which it resembled when hard. This is a fast-curing, hydraulic cement which hardens under water. Portland cement was first manufactured in the United States in 1871, although it was imported before this date. But it was not in common use throughout the country until the early 20th century. Up until the turn of the century portland cement was considered primarily an additive, or "minor ingredient" to help accelerate mortar set time. By the 1930s, however, most masons used a mix of equal parts portland cement and lime putty. Thus, the mortar found in masonry structures built between 1871 and 1930 can range from pure lime and sand mixes to a wide variety of lime, portland cement, and sand combinations.

In the 1930s more new mortar products intended to hasten and simplify masons' work were introduced in the U.S. These included **masonry cement**, a premixed, bagged mortar which is a combination of portland cement and ground limestone, and **hydrated lime**, machine-slaked lime that eliminated the necessity of slaking quicklime into putty at the site.

Identifying the Problem Before Repointing

The decision to repoint is most often related to some obvious sign of deterioration, such as disintegrating mortar, cracks in mortar joints, loose bricks or stones, damp walls, or damaged plasterwork. It is, however, erroneous to assume that repointing alone will solve deficiencies that result from other problems. The root cause of the deterioration—leaking roofs or gutters, differential settlement of the building, capillary action causing rising damp, or extreme weather exposure—should always be dealt with prior to beginning work.

Without appropriate repairs to eliminate the source of the problem, mortar deterioration will continue and any repointing will have been a waste of time and money.

Use of Consultants

Because there are so many possible causes for deterioration in historic buildings, it may be desirable to retain a consultant, such as a historic architect or architectural conservator, to analyze the building. In addition to determining the most appropriate solutions to the problems, a consultant can prepare specifications which reflect the particular requirements of each job and can provide oversight of the work in progress. Referrals to preservation consultants frequently can be obtained from State Historic Preservation Offices, the American Institute for Conservation of Historic and Artistic Works (AIC), the Association for Preservation Technology (APT), and local chapters of the American Institute of Architects (AIA).



Masons practice using lime putty mortar to repair historic marble. Photo: NPS files.

Finding an Appropriate Mortar Match

Preliminary research is necessary to ensure that the proposed repointing work is both physically and visually appropriate to the building. Analysis of unweathered portions of the historic mortar to which the new mortar will be matched can suggest appropriate mixes for the repointing mortar so that it will not damage the building because it is excessively strong or vapor impermeable.

Examination and analysis of the masonry units—brick, stone or terra cotta—and the techniques used in the original construction will assist in maintaining the building's historic appearance. A simple, non-technical, evaluation of the masonry units and

mortar can provide information concerning the relative strength and permeability of each—critical factors in selecting the repointing mortar—while a visual analysis of the historic mortar can provide the information necessary for developing the new mortar mix and application techniques.

Although not crucial to a successful repointing project, for projects involving properties of special historic significance, a mortar analysis by a qualified laboratory can be useful by providing information on the original ingredients. However, there are limitations with such an analysis, and replacement mortar specifications should not be based solely on laboratory analysis. Analysis requires interpretation, and there are important factors which affect the condition and performance of the mortar that cannot be established through laboratory analysis. These may include: the original water content, rate of curing, weather conditions during original construction, the method of mixing and placing the mortar, and the cleanliness and condition of the sand. *The most useful information that can come out of laboratory analysis is the identification of sand by gradation and color.* This allows the color and the texture of the mortar to be matched with some accuracy because sand is the largest ingredient by volume.

In creating a repointing mortar that is compatible with the masonry units, the objective is to achieve one that matches the historic mortar as closely as possible, so that the new material can coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity. The exact physical and chemical properties of the historic mortar are not of major significance as long as the new mortar conforms to the following criteria:

- The new mortar must match the historic mortar in **color, texture and tooling**. (If a laboratory analysis is undertaken, it may be possible to match the binder components and their proportions with the historic mortar, if those materials are available.)
- The **sand must match the sand** in the historic mortar. (The color and texture of the new mortar will usually fall into place if the sand is matched successfully.)
- The new mortar must have **greater vapor permeability** and be **softer** (measured in compressive strength) than the masonry units.
- The new mortar must be **as vapor permeable** and **as soft or softer** (measured in compressive strength) than the historic mortar. (Softness or hardness is not necessarily an indication of permeability; old, hard lime mortars can still retain high permeability.)

Mortar Analysis

Methods for analyzing mortars can be divided into two broad categories: **wet chemical** and **instrumental**. Many laboratories that analyze historic mortars use a simple **wet-chemical** method called acid digestion, whereby a sample of the mortar is crushed and then mixed with a dilute acid. The acid dissolves all the carbonate-containing minerals not only in the binder, but also in the aggregate (such as oyster shells, coral sands, or other carbonate-based materials), as well as any other acid-soluble materials. The sand and fine-grained acid-insoluble material is left behind. There are several variations on the simple acid digestion test. One involves collecting the carbon dioxide gas given off as the carbonate is digested by the acid; based on the gas volume the carbonate content of the mortar can be accurately determined (Jedrzejewska, 1960). Simple acid digestion methods are rapid, inexpensive, and easy to perform, but the information they provide about the original composition of a mortar is limited to the color and texture of the sand. The gas collection method provides more information about the binder than a simple acid digestion test.

Instrumental analysis methods that have been used to evaluate mortars include polarized light or thin-section microscopy, scanning electron microscopy, atomic absorption spectroscopy, X-ray diffraction, and differential thermal analysis. All instrumental methods require not only expensive, specialized equipment, but also highly-trained experienced analysts. However, instrumental methods can provide much more information about a mortar. Thin-section microscopy is probably the most commonly used instrumental method. Examination of thin slices of a mortar in transmitted light is often used to supplement acid digestion methods, particularly to look for carbonate-based aggregate. For example, the new ASTM test method, ASTM C 1324-96 "Test Method for Examination and Analysis of Hardened Mortars" which was designed specifically for the analysis of modern lime-cement and masonry cement mortars, combines a complex series of wet chemical analyses with thin-section microscopy.

The drawback of most mortar analysis methods is that mortar samples of known composition have not been analyzed in order to evaluate the method. Historic mortars were not prepared to narrowly defined specifications from materials of



This late 19th century granite has recently been repointed with the joint profile and mortar color carefully matched to the original. Photo: NPS files.



This mortar is the proper consistency for repointing historic brick. Photo: John P. Speweik.

uniform quality; they contain a wide array of locally derived materials combined at the discretion of the mason. While a particular method might be able to accurately determine the original proportions of a lime-cement-sand mortar prepared from modern materials, the usefulness of that method for evaluating historic mortars is questionable unless it has been tested against mortars prepared from materials more commonly used in the past.

Properties of Mortar

Mortars for repointing should be softer or more permeable than the masonry units and no harder or more impermeable than the historic mortar to prevent damage to the masonry units. It is a common error to assume that hardness or high strength is a measure of appropriateness, particularly for lime-based historic mortars. Stresses within a wall caused by expansion, contraction, moisture migration, or settlement must be accommodated in some manner; in a masonry wall, these stresses should be relieved by the mortar rather than by the masonry units. A mortar that is stronger in compressive strength than the masonry units will not "give," thus causing stresses to be relieved through the masonry units—resulting in permanent damage to the masonry, such as cracking and spalling, that cannot be repaired easily.

While stresses can also break the bond between the mortar and the masonry units, permitting water to penetrate the resulting hairline cracks, this is easier to correct in the joint through repointing than if the break occurs in the masonry units.

Permeability, or rate of vapor transmission, is also critical. High lime mortars are more permeable than denser cement mortars. Historically, mortar acted as a bedding material—not unlike an expansion joint—rather than a "glue" for the masonry units, and moisture was able to migrate through the mortar joints rather than the masonry units. When moisture evaporates from the masonry it deposits any soluble salts either on the surface as *efflorescence* or below the surface as *subflorescence*. While salts deposited on the surface of masonry units are usually relatively harmless, salt crystallization within a masonry unit creates pressure that can cause parts of the outer surface to spall off or delaminate. If the mortar does not permit moisture or moisture vapor to migrate out of the wall and evaporate, the result will be damage to the masonry units.



This early 19th century building is being repointed with lime mortar. Photo: Travis McDonald.

Components of Mortar

Sand

Sand is the largest component of mortar and the material that gives mortar its distinctive color, texture and cohesiveness. Sand must be free of impurities, such as salts or clay. The three key characteristics of sand are: particle shape, gradation and void ratios.

When viewed under a magnifying glass or low-power microscope, particles of sand generally have either rounded edges, such as found in beach and river sand, or sharp, angular edges, found in crushed or manufactured sand. For repointing mortar, rounded or natural sand is preferred for two reasons. It is usually similar to the sand in the historic mortar and provides a better visual match. It also has better working qualities or plasticity and can thus be forced into the joint more easily, forming a good contact with the remaining historic mortar and the surface of the adjacent masonry units. Although manufactured sand is frequently more readily available, it is usually possible to locate a supply of rounded sand.

The gradation of the sand (particle size distribution) plays a very important role in the durability and cohesive properties of a mortar. Mortar must have a certain percentage of large to small particle sizes in order to deliver the optimum performance. Acceptable guidelines on particle size distribution may be found in ASTM C 144 (American Society for Testing and Materials). However, in actuality, since neither historic nor modern sands are always in compliance with ASTM C 144, matching the same particle appearance and gradation usually requires sieving the sand.

A scoop of sand contains many small voids between the individual grains. A mortar that performs well fills all these small voids with binder (cement/lime combination or mix) in a balanced manner. Well-graded sand generally has a 30 per cent void ratio by volume. Thus, 30 per cent binder by volume generally should be used, unless the historic mortar had a different binder: aggregate ratio. This represents the 1:3 binder to sand ratios often seen in mortar specifications.

For repointing, sand generally should conform to ASTM C 144 to assure proper gradation and freedom from impurities; some variation may be necessary to match the original size and gradation. Sand color and texture also should match the original as closely as possible to provide the proper color match without other additives.

Lime

Mortar formulations prior to the late-19th century used lime as the primary binding material. Lime is derived from heating limestone at high temperatures which burns off the carbon dioxide, and turns the limestone into quicklime. There are three

types of limestone—calcium, magnesium, and dolomitic—differentiated by the different levels of magnesium carbonate they contain which impart specific qualities to mortar. Historically, calcium lime was used for mortar rather than the dolomitic lime (calcium magnesium carbonate) most often used today. But it is also important to keep in mind the fact that the historic limes, and other components of mortar, varied a great deal because they were natural, as opposed to modern lime which is manufactured and, therefore, standardized. Because some of the kinds of lime, as well as other components of mortar, that were used historically are no longer readily available, even when a conscious effort is made to replicate a "historic" mix, this may not be achievable due to the differences between modern and historic materials.

Lime, itself, when mixed with water into a paste is very plastic and creamy. It will remain workable and soft indefinitely, if stored in a sealed container. Lime (calcium hydroxide) hardens by carbonation absorbing carbon dioxide primarily from the air, converting itself to calcium carbonate. Once a lime and sand mortar is mixed and placed in a wall, it begins the process of carbonation. If lime mortar is left to dry too rapidly, carbonation of the mortar will be reduced, resulting in poor adhesion and poor durability. In addition, lime mortar is slightly water soluble and thus is able to re-seal any hairline cracks that may develop during the life of the mortar. Lime mortar is soft, porous, and changes little in volume during temperature fluctuations thus making it a good choice for historic buildings. *Because of these qualities, high calcium lime mortar may be considered for many repointing projects, not just those involving historic buildings.*



Caulking was inappropriately used here in place of mortar on the top of the wall. As a result, it has not been durable. Photo: NPS files.

For repointing, lime should conform to ASTM C 207, Type S, or Type SA, Hydrated Lime for Masonry Purposes. This machine-slaked lime is designed to assure high plasticity and water retention. The use of quicklime which must be slaked and soaked by hand may have advantages over hydrated lime in some restoration projects if time and money allow.

Lime Putty

Lime putty is slaked lime that has a putty or paste-like consistency. It should conform to ASTM C 5. Mortar can be mixed using lime putty according to ASTM C 270 property or proportion specification.

Portland Cement

More recent, 20th-century mortar has used portland cement as a primary binding material. A straight portland cement and sand mortar is extremely hard, resists the movement of water, shrinks upon setting, and undergoes relatively large thermal movements. When mixed with water, portland cement forms a harsh, stiff paste that is quite unworkable, becoming hard very quickly. (Unlike lime, portland cement will harden regardless of weather conditions and does not require wetting and drying cycles.) Some portland cement assists the workability and plasticity of the mortar without adversely affecting the finished project; it also provides early strength to the mortar and speeds setting. Thus, it may be appropriate to add some portland cement to an essentially lime-based mortar even when repointing relatively soft 18th or 19th century brick under some circumstances when a slightly harder mortar is required. The more portland cement that is added to a mortar formulation the harder it becomes—and the faster the initial set.

For repointing, portland cement should conform to ASTM C 150. White, non-staining portland cement may provide a better color match for some historic mortars than the more commonly available grey portland cement. But, it should not be assumed, however, that white portland cement is always appropriate for all historic buildings, since the original mortar may have been mixed with grey cement. The cement should not have more than 0.60 per cent alkali to help avoid efflorescence.

Masonry Cement

Masonry cement is a preblended mortar mix commonly found at hardware and home repair stores. It is designed to produce mortars with a compressive strength of 750 psi or higher when mixed with sand and water at the job site. It may contain hydrated lime, but it always contains a large amount of portland cement, as well as ground limestone and other workability agents, including air-entraining agents. Because masonry cements are not required to contain hydrated lime, and generally do not contain lime, they produce high strength mortars that can damage historic masonry. *For this reason, they generally are not recommended for use on historic masonry buildings.*

Lime Mortar (pre-blended)

Hydrated lime mortars, and pre-blended lime putty mortars with or without a matched sand are commercially available. Custom mortars are also available with color. In most instances, pre-blended lime mortars containing sand may not provide an exact match; however, if the project calls for total repointing, a pre-blended lime mortar may be worth considering as long as the mortar is compatible in strength with the masonry. If the project involves only selected, "spot" repointing, then it may be better to carry out a mortar analysis which can provide a custom pre-blended lime mortar with a matching sand.

In either case, if a preblended lime mortar is to be used, it should contain Type S or SA hydrated lime conforming to ASTM C 207.

Water

Water should be potable—clean and free from acids, alkalis, or other dissolved organic materials.

Other Components

Historic components

In addition to the color of the sand, the texture of the mortar is of critical importance in duplicating historic mortar. Most mortars dating from the mid-19th century on—with some exceptions—have a fairly homogeneous texture and color. Some earlier mortars are not as uniformly textured and may contain lumps of partially burned lime or "dirty lime", shell (which often provided a source of lime, particularly in coastal areas), natural cements, pieces of clay, lampblack or other pigments, or even animal hair. The visual characteristics of these mortars can be duplicated through the use of similar materials in the repointing mortar.

Replicating such unique or individual mortars will require writing new specifications for each project. If possible, suggested sources for special materials should be included. For example, crushed oyster shells can be obtained in a variety of sizes from poultry supply dealers.

Pigments

Some historic mortars, particularly in the late 19th century, were tinted to match or contrast with the brick or stone. Red pigments, sometimes in the form of brick dust, as well as brown, and black pigments were commonly used. Modern pigments are available which can be added to the mortar at the job site, but they should not exceed 10 per cent by weight of the portland cement in the mix, and carbon black should be limited to 2 per cent. Only synthetic mineral oxides, which are alkali-proof and sun-fast, should be used to prevent bleaching and fading.

Modern Components

Admixtures are used to create specific characteristics in mortar, and whether they should be used will depend upon the individual project. *Air entraining agents*, for example, help the mortar to resist freeze-thaw damage in northern climates. *Accelerators* are used to reduce mortar freezing prior to setting while *retarders* help to extend the mortar life in hot climates. Selection of admixtures should be made by the architect or architectural conservator as part of the specifications, not something routinely added by the masons.

Generally, modern chemical additives are unnecessary and may, in fact, have detrimental effects in historic masonry projects. The use of antifreeze compounds is not recommended. They are not very effective with high lime mortars and may introduce salts, which may cause efflorescence later. A better practice is to warm the sand and water, and to protect the completed work from freezing. No definitive study has determined whether air-entraining additives should be used to resist frost action and enhance plasticity, but in areas of extreme exposure requiring high-strength mortars with lower permeability, air-entrainment of 10-16 percent may be desirable (see formula for "severe weather exposure" in Mortar Type and Mix). Bonding agents are not a substitute for proper joint preparation, and they should generally be avoided. If the joint is properly prepared, there will be a good bond between the new mortar and the adjacent surfaces. In addition, a bonding agent is difficult to remove if smeared on a masonry surface.

Mortar Type and Mix

Mortars for repointing projects, especially those involving historic buildings, typically are custom mixed in order to ensure the proper physical and visual qualities. These materials can be combined in varying proportions to create a mortar with the desired performance and durability. The actual specification of a particular mortar type should take into consideration all of the factors affecting the life of the building including: current site conditions, present condition of the masonry, function of the new mortar, degree of weather exposure, and skill of the mason.



Thus, no two repointing projects are exactly the same. Modern materials specified for use in repointing mortar should conform to specifications of the American Society for Testing and Materials (ASTM) or comparable federal specifications, and the resulting mortar should conform to ASTM C 270, Mortar for Unit Masonry.

Specifying the proportions for the repointing mortar for a specific job is not as difficult as it might seem. Five mortar types, each with a corresponding recommended mix, have been established by ASTM to distinguish high strength mortar from soft flexible mortars. The ASTM designated them in decreasing order of approximate general strength as Type M (2,500 psi), Type S (1,800 psi), Type N (750 psi), Type O (350 psi) and Type K (75 psi). (The letters identifying the types are from the words MASON WORK using every other letter.) Type K has the highest lime content of the mixes that

Here, a hammer and chisel are being correctly used to prepare a joint for repointing. Photo: John P. Speweik.

contain portland cement, although it is seldom used today, except for some historic preservation projects. The designation "L" in the accompanying chart identifies a straight lime and sand mix. Specifying the appropriate ASTM mortar by proportion of ingredients, will ensure the desired physical properties. Unless specified otherwise, measurements or proportions for mortar mixes are always given in the following order: cement-lime-sand. Thus, a Type K mix, for example, would be referred

to as 1-3-10, or 1 part cement to 3 parts lime to 10 parts sand. Other requirements to create the desired visual qualities should be included in the specifications.

The strength of a mortar can vary. If mixed with higher amounts of portland cement, a harder mortar is obtained. The more lime that is added, the softer and more plastic the mortar becomes, increasing its workability. A mortar strong in compressive strength might be desirable for a hard stone (such as granite) pier holding up a bridge deck, whereas a softer, more permeable lime mortar would be preferable for a historic wall of soft brick. Masonry deterioration caused by salt deposition results when the mortar is less permeable than the masonry unit. A strong mortar is still more permeable than hard, dense stone. However, in a wall constructed of soft bricks where the masonry unit itself has a relatively high permeability or vapor transmission rate, a soft, high lime mortar is necessary to retain sufficient permeability.

Budgeting and Scheduling

Repointing is both expensive and time consuming due to the extent of handwork and special materials required. It is preferable to repoint only those areas that require work rather than an entire wall, as is often specified. But, if 25 to 50 per cent or more of a wall needs to be repointed, repointing the entire wall may be more cost effective than spot repointing.

Total repointing may also be more sensible when access is difficult, requiring the erection of expensive scaffolding (unless the majority of the mortar is sound and unlikely to require replacement in the foreseeable future). Each project requires judgement based on a variety of factors. Recognizing this at the outset will help to prevent many jobs from becoming prohibitively expensive.

In scheduling, seasonal aspects need to be considered first. Generally speaking, wall temperatures between 40 and 95 degrees F (8 and 38 degrees C) will prevent freezing or excessive evaporation of the water in the mortar. Ideally, repointing should be done in shade, away from strong sunlight in order to slow the drying process, especially during hot weather. If necessary, shade can be provided for large-scale projects with appropriate modifications to scaffolding.

The relationship of repointing to other work proposed on the building must also be recognized. For example, if paint removal or cleaning is anticipated, and if the mortar joints are basically sound and need only selective repointing, it is generally better to postpone repointing until after completion of these activities. However, if the mortar has eroded badly, allowing moisture to penetrate deeply into the wall, repointing should be accomplished before cleaning. Related work, such as structural or roof repairs, should be scheduled so that they do not interfere with repointing and so that all work can take maximum advantage of erected scaffolding.



When repairing this stone wall, the mason matched the raised profile of the original tuckpointing. Photo: NPS files.



A mechanical grinder improperly used to cut out the horizontal joint and incompatible repointing have seriously damaged the 19th century brick. Photo: NPS files.

Building managers also must recognize the difficulties that a repointing project can create. The process is time consuming, and scaffolding may need to remain in place for an extended period of time. The joint preparation process can be quite noisy and can generate large quantities of dust which must be controlled, especially at air intakes to protect human health, and also where it might damage operating machinery. Entrances may be blocked from time to time making access difficult for both building tenants and visitors. Clearly, building managers will need to coordinate the repointing work with other events at the site.

Contractor Selection

Contractor Selection The ideal way to select a contractor is to ask knowledgeable owners of recently repointed historic buildings for recommendations. Qualified contractors then can provide lists of other repointing projects for inspection. More commonly, however, the contractor for a repointing project is selected through a competitive bidding process over which the client or consultant has only limited control. In this situation it is important to ensure that the specifications stipulate that masons must have a minimum of five years' experience with repointing historic masonry buildings to be eligible to bid on the project. Contracts are awarded to the lowest responsible bidder, and bidders

who have performed poorly on other projects usually can be eliminated from consideration on this basis, even if they have the lowest prices.

The contract documents should call for unit prices as well as a base bid. Unit pricing forces the contractor to determine in advance what the cost addition or reduction will be for work which varies from the scope of the base bid. If, for example, the contractor has fifty linear feet less of stone repointing than indicated on the contract documents but thirty linear feet more of brick repointing, it will be easy to determine the final price for the work. Note that each type of work—brick repointing, stone repointing, or similar items—will have its own unit price. The unit price also should reflect quantities; one linear foot of pointing in five different spots will be more expensive than five contiguous linear feet.

Execution of the Work

Test Panels

These panels are prepared by the contractor using the same techniques that will be used on the remainder of the project. Several panel locations—preferably not on the front or other highly visible location of the building—may be necessary to include all types of masonry, joint styles, mortar colors, and other problems likely to be encountered on the job.



Unskilled repointing has negatively impacted the character of this late-19th century building. Photo: NPS files.

If cleaning tests, for example, are also to be undertaken, they should be carried out in the same location. Usually a 3 foot by 3 foot area is sufficient for brickwork, while a somewhat larger area may be required for stonework. These panels establish an acceptable standard of work and serve as a benchmark for evaluating and accepting subsequent work on the building.

Joint Preparation

Old mortar should be removed to a minimum depth of 2 to 2-1/2 times the width of the joint to ensure an adequate bond and to prevent mortar "popouts." For most brick joints, this will require removal of the mortar to a depth of approximately Ω to 1 inch; for stone masonry with wide joints, mortar may need to be removed to a depth of several inches. Any loose or disintegrated mortar beyond this minimum depth also should be removed.

Although some damage may be inevitable, careful joint preparation can help limit damage to masonry units. The traditional manner of removing old mortar is through the use of hand chisels and mash hammers. Though labor-intensive, in most instances this method poses the least threat for damage to historic masonry units and produces the best final product.

The most common method of removing mortar, however, is through the use of power saws or grinders. The use of power tools by unskilled masons can be disastrous for historic masonry, particularly soft brick. Using power saws on walls with thin joints, such as most brick walls, almost always will result in damage to the masonry units by breaking the edges and by overcutting on the head, or vertical joints.

However, small pneumatically-powered chisels generally can be used safely and effectively to remove mortar on historic buildings as long as the masons maintain appropriate control over the equipment. Under certain circumstances, thin diamond-bladed grinders may be used to cut out *horizontal* joints only on hard portland cement mortar common to most early-20th century masonry buildings. Usually, automatic tools most successfully remove old mortar without damaging the masonry units when they are used in combination with hand tools in preparation for repointing. Where horizontal joints are uniform and fairly wide, it may be possible to use a power masonry saw to assist the removal of mortar, such as by cutting along the middle of the joint; final mortar removal from the sides of the joints still should be done with a hand chisel and hammer. Caulking cutters with diamond blades can sometimes be used successfully to cut out joints without damaging the masonry. Caulking cutters are slow; they do not rotate, but vibrate at very high speeds, thus minimizing the possibility of damage to masonry units. Although mechanical tools may be safely used in limited circumstances to cut out horizontal joints in preparation for repointing, they should never be used on vertical joints because of the danger of slipping and cutting into the brick above or below the vertical joint. Using power tools to remove mortar without damaging the surrounding masonry units also necessitates highly skilled masons experienced in working on historic masonry buildings. Contractors should demonstrate proficiency with power tools before their use is approved.

Using any of these power tools may also be more acceptable on hard stone, such as quartzite or granite, than on terra cotta with its glass-like glaze, or on soft brick or stone. The test panel should determine the acceptability of power tools. If power tools are to be permitted, the contractor should establish a quality control program to account for worker fatigue and similar variables.

Mortar should be removed cleanly from the masonry units, leaving square corners at the back of the cut. Before filling, the joints should be rinsed with a jet of water to remove all loose particles and dust. At the time of filling, the joints should be damp, but with no standing water present. For masonry walls—limestone, sandstone and common brick—that are extremely absorbent, it is recommended that a continual mist of water be applied for a few hours before repointing begins.

Mortar Preparation

Mortar components should be measured and mixed carefully to assure the uniformity of visual and physical characteristics. Dry ingredients are measured by volume and thoroughly mixed before the addition of any water. Sand must be added in a damp, loose condition to avoid over sanding. Repointing mortar is typically pre-hydrated by adding water so it will just hold together, thus allowing it to stand for a period of time before the final water is added. Half the water should be added, followed by mixing for approximately 5 minutes. The remaining water should then be added in small portions until a mortar of the desired consistency is reached. The total volume of water necessary may vary from batch to batch, depending on weather conditions. It is important to keep the water to a minimum for two reasons: first, a drier mortar is cleaner to work with, and it can be compacted tightly into the joints; second, with no excess water to evaporate, the mortar cures without shrinkage cracks. Mortar should be used within approximately 30 minutes of final mixing, and "retempering," or adding more water, should not be permitted.

Using Lime Putty to Make Mortar

Mortar made with lime putty and sand, sometimes referred to as roughage or course stuff, should be measured by volume, and may require slightly different proportions from those used with hydrated lime. No additional water is usually needed to achieve a workable consistency because enough water is already contained in the putty. Sand is proportioned first, followed by the lime putty, then mixed for five minutes or until all the sand is thoroughly coated with the lime putty. But mixing, in the familiar sense of turning over with a hoe, sometimes may not be sufficient if the best possible performance is to be obtained from a lime putty mortar. Although the old practice of chopping, beating and ramming the mortar has largely been forgotten, recent field work has confirmed that lime putty and sand rammed and beaten with a wooden mallet or ax handle, interspersed by chopping with a hoe, can significantly improve workability and performance. The intensity of this action increases the overall lime/sand contact and removes any surplus water by compacting the other ingredients. It may also be advantageous for larger projects to use a mortar pan mill for mixing. Mortar pan mills which have a long tradition in Europe produce a superior lime putty mortar not attainable with today's modern paddle and drum type mixers.

For larger repointing projects the lime putty and sand can be mixed together ahead of time and stored indefinitely, on or off site, which eliminates the need for piles of sand on the job site. This mixture, which resembles damp brown sugar, must be protected from the air in sealed containers with a wet piece of burlap over the top or sealed in a large plastic bag to prevent evaporation and premature carbonation. The lime putty and sand mixture can be recombined into a workable plastic state months later with no additional water.

If portland cement is specified in a lime putty and sand mortar—Type O (1:2:9) or Type K (1:3:11)—the portland cement should first be mixed into a slurry paste before adding it to the lime putty and sand. Not only will this ensure that the portland cement is evenly distributed throughout the mixture, but if dry portland cement is added to wet ingredients it tends to "ball up," jeopardizing dispersion. (Usually water must be added to the lime putty and sand anyway once the portland cement is introduced.) Any color pigments should be added at this stage and mixed for a full five minutes. The mortar should be used within 30 minutes to 1½ hours and it should not be retempered. Once portland cement has been added the mortar can no longer be stored.

Filling the Joint

Where existing mortar has been removed to a depth of greater than 1 inch, these deeper areas should be filled first, compacting the new mortar in several layers. The back of the entire joint should be filled successively by applying approximately 1/4 inch of mortar, packing it well into the back corners. This application may extend along the wall for several feet. As soon as the mortar has reached thumb-print hardness, another 1/4 inch layer of mortar—approximately the same thickness—may be applied. Several layers will be needed to fill the joint flush with the outer surface of the masonry. It is important to allow each layer time to harden before the next layer is applied; most of the mortar shrinkage occurs during the hardening process and layering thus minimizes overall shrinkage.

When the final layer of mortar is thumb-print hard, the joint should be tooled to match the historic joint. Proper timing of the tooling is important for uniform color and appearance. If tooled when too soft, the color will be lighter than expected, and hairline cracks may occur; if tooled when too hard, there may be dark streaks called "tool burning," and good closure of the mortar against the masonry units will not be achieved.

If the old bricks or stones have worn, rounded edges, it is best to recess the final mortar slightly from the face of the masonry. This treatment will help avoid a joint which is visually wider than the actual joint; it also will avoid creation of a large, thin featheredge which is easily damaged, thus admitting water. After tooling, excess mortar can be removed from the edge of the joint by brushing with a natural bristle or nylon brush. Metal bristle brushes should never be used on historic masonry.

Curing Conditions

The preliminary hardening of high-lime content mortars—those mortars that contain more lime by volume than portland cement, i.e., Type O (1:2:9), Type K (1:3:11), and straight lime/sand, Type "L" (0:1:3)—takes place fairly rapidly as water

in the mix is lost to the porous surface of the masonry and through evaporation. A high lime mortar (especially Type "L") left to dry out too rapidly can result in chalking, poor adhesion, and poor durability. Periodic wetting of the repointed area after the mortar joints are thumb-print hard and have been finish tooled may significantly accelerate the carbonation process. When feasible, misting using a hand sprayer with a fine nozzle can be simple to do for a day or two after repointing. Local conditions will dictate the frequency of wetting, but initially it may be as often as every hour and gradually reduced to every three or four hours. Walls should be covered with burlap for the first three days after repointing. (Plastic may be used, but it should be tented out and not placed directly against the wall.) This helps keep the walls damp and protects them from direct sunlight. Once carbonation of the lime has begun, it will continue for many years and the lime will gain strength as it reverts back to calcium carbonate within the wall.

Aging the Mortar

Even with the best efforts at matching the existing mortar color, texture, and materials, there will usually be a visible difference between the old and new work, partly because the new mortar has been matched to the unweathered portions of the historic mortar. Another reason for a slight mismatch may be that the sand is more exposed in old mortar due to the slight erosion of the lime or cement. Although spot repointing is generally preferable and some color difference should be acceptable, if the difference between old and new mortar is too extreme, it may be advisable in some instances to repoint an entire area of a wall, or an entire feature such as a bay, to minimize the difference between the old and the new mortar. If the mortars have been properly matched, usually the best way to deal with surface color differences is to let the mortars age naturally. Other treatments to overcome these differences, including cleaning the non-repointed areas or staining the new mortar, should be carefully tested prior to implementation.



This 18th century pediment and surrounding wall exhibit distinctively different mortar joints. Photo: NPS files.

Staining the new mortar to achieve a better color match is generally not recommended, but it may be appropriate in some instances. Although staining may provide an initial match, the old and new mortars may weather at different rates, leading to visual differences after a few seasons. In addition, the mixtures used to stain the mortar may be harmful to the masonry; for example, they may introduce salts into the masonry which can lead to efflorescence.

Cleaning the Repointed Masonry

If repointing work is carefully executed, there will be little need for cleaning other than to remove the small amount of mortar from the edge of the joint following tooling. This can be done with a stiff natural bristle or nylon brush after the mortar has dried, but before it is initially set (1-2 hours). Mortar that has hardened can usually be removed with a wooden paddle or, if necessary, a chisel.

Further cleaning is best accomplished with plain water and natural bristle or nylon brushes. If chemicals must be used, they should be selected with extreme caution. Improper cleaning can lead to deterioration of the masonry units, deterioration of the mortar, mortar smear, and efflorescence. New mortar joints are especially susceptible to damage because they do not become fully cured for several months. Chemical cleaners, particularly acids, should never be used on dry masonry. The masonry should always be completely soaked once with water before chemicals are applied. After cleaning, the walls should be flushed again with plain water to remove all traces of the chemicals.

Several precautions should be taken if a freshly repointed masonry wall is to be cleaned. First, the mortar should be fully hardened before cleaning. Thirty days is usually sufficient, depending on weather and exposure; as mentioned previously, the mortar will continue to cure even after it has hardened. Test panels should be prepared to evaluate the effects of different cleaning methods. Generally, on newly repointed masonry walls, only very low pressure (100 psi) water washing supplemented by stiff natural bristle or nylon brushes should be used, except on glazed or polished surfaces, where only soft cloths should be used.**

New construction "bloom" or efflorescence occasionally appears within the first few months of repointing and usually disappears through the normal process of weathering. If the efflorescence is not removed by natural processes, the safest way to remove it is by dry brushing with stiff natural or nylon bristle brushes followed by wet brushing. Hydrochloric (muriatic) acid, is generally ineffective, and it should not be used to remove efflorescence. It may liberate additional salts, which, in turn, can lead to more efflorescence.

Surface grouting is sometimes suggested as an alternative to repointing brick buildings, in particular. This process involves the application of a thin coat of cement-based grout to the mortar joints and the mortar/brick interface. To be effective, the grout must extend slightly onto the face of the masonry units, thus widening the joint visually. The change in the joint appearance can alter the historic character of the structure to an unacceptable degree. In addition, although masking of the bricks is intended to keep the grout off the remainder of the face of the bricks, some level of residue, called

"veiling," will inevitably remain. Surface grouting cannot substitute for the more extensive work of repointing, and it is not a recommended treatment for historic masonry.

***Additional information on masonry cleaning is presented in Preservation Briefs 1: Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings, Robert C. Mack, FAIA, and Anne E. Grimmer, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 2000; and Keeping it Clean: Removing Exterior Dirt, Paint, Stains & Graffiti from Historic Masonry Buildings, Anne E. Grimmer, Washington, D.C.: Technical Preservation Services, National Park Service, U.S. Department of the Interior, 1988.*

Visually Examining the Mortar and the Masonry Units

A simple *in situ* comparison will help determine the hardness and condition of the mortar and the masonry units. Begin by scraping the mortar with a screwdriver, and gradually tapping harder with a cold chisel and mason's hammer. Masonry units can be tested in the same way beginning, even more gently, by scraping with a fingernail. This relative analysis which is derived from the 10-point hardness scale used to describe minerals, provides a good starting point for selection of an appropriate mortar. It is described more fully in "The Russack System for Brick & Mortar Description" referenced in [Reading List](#) at the end of this Brief.

Mortar samples should be chosen carefully, and picked from a variety of locations on the building to find unweathered mortar, if possible. Portions of the building may have been repointed in the past while other areas may be subject to conditions causing unusual deterioration. There may be several colors of mortar dating from different construction periods or sand used from different sources during the initial construction. Any of these situations can give false readings to the visual or physical characteristics required for the new mortar. Variations should be noted which may require developing more than one mix.

1. Remove with a chisel and hammer three or four unweathered samples of the mortar to be matched from several locations on the building. (Set the largest sample aside--this will be used later for comparison with the repointing mortar). Removing a full representation of samples will allow selection of a "mean" or average mortar sample.
2. Mash the remaining samples with a wooden mallet, or hammer if necessary, until they are separated into their constituent parts. There should be a good handful of the material.
3. Examine the powdered portion—the lime and/or cement matrix of the mortar. Most particularly, note the color. There is a tendency to think of historic mortars as having white binders, but grey portland cement was available by the last quarter of the 19th century, and traditional limes were also sometimes grey. Thus, in some instances, the natural color of the historic binder may be grey, rather than white. The mortar may also have been tinted to create a colored mortar, and this color should be identified at this point.
4. Carefully blow away the powdery material (the lime and/or cement matrix which bound the mortar together).
5. With a low power (10 power) magnifying glass, examine the remaining sand and other materials such as lumps of lime or shell.
6. Note and record the wide range of color as well as the varying sizes of the individual grains of sand, impurities, or other materials.

Other Factors to Consider

Color

Regardless of the color of the binder or colored additives, the sand is the primary material that gives mortar its color. A surprising variety of colors of sand may be found in a single sample of historic mortar, and the different sizes of the grains of sand or other materials, such as incompletely ground lime or cement, play an important role in the texture of the repointing mortar. Therefore, when specifying sand for repointing mortar, it may be necessary to obtain sand from several sources and to combine or screen them in order to approximate the range of sand colors and grain sizes in the historic mortar sample.

Pointing Style

Close examination of the historic masonry wall and the techniques used in the original construction will assist in maintaining the visual qualities of the building. Pointing styles and the methods of producing them should be examined. It is important to look at both the horizontal and the vertical joints to determine the order in which they were tooled and whether they were the same style. Some late-19th and early-20th century buildings, for example, have horizontal joints that were raked back while the vertical joints were finished flush and stained to match the bricks, thus creating the illusion of horizontal bands. Pointing styles may also differ from one facade to another; front walls often received greater attention to mortar

detailing than side and rear walls. **Tuckpointing** is not true repointing but the application of a raised joint or lime putty joint on top of flush mortar joints. **Penciling** is a purely decorative, painted surface treatment over a mortar joint, often in a contrasting color.

Masonry Units

The masonry units should also be examined so that any replacement units will match the historic masonry. Within a wall there may be a wide range of colors, textures, and sizes, particularly with hand-made brick or rough-cut, locally-quarried stone. Replacement units should blend in with the full range of masonry units rather than a single brick or stone.

Matching Color and Texture of the Repointing Mortar

New mortar should match the unweathered interior portions of the historic mortar. The simplest way to check the match is to make a small sample of the proposed mix and allow it to cure at a temperature of approximately 70 degrees F for about a week, or it can be baked in an oven to speed up the curing; this sample is then broken open and the surface is compared with the surface of the largest "saved" sample of historic mortar.

If a proper color match cannot be achieved through the use of natural sand or colored aggregates like crushed marble or brick dust, it may be necessary to use a modern mortar pigment.

During the early stages of the project, it should be determined how closely the new mortar should match the historic mortar. Will "quite close" be sufficient, or is "exactly" expected? The specifications should state this clearly so that the contractor has a reasonable idea how much time and expense will be required to develop an acceptable match.

The same judgment will be necessary in matching replacement terra cotta, stone or brick. If there is a known source for replacements, this should be included in the specifications. If a source cannot be determined prior to the bidding process, the specifications should include an estimated price for the replacement materials with the final price based on the actual cost to the contractor.

Mortar Types (Measured by volume)

Designation	Cement	Hydrated Lime or Lime Putty	Sand
M	1	1/4	3 - 3 3/4
S	1	1/2	4-4 1/2
N	1	1	5-6
O	1	2	8-9
K	1	3	10-12
"L"	0	1	2 1/4-3

Suggested Mortar Types for Different Exposures

Masonry Material	Exposure		
	Sheltered	Moderate	Severe
Very durable: granite, hard-cored brick, etc.	O	N	S
Moderately durable: limestone, durable stone, molded brick	K	O	N
Minimally durable: soft hand-made brick	"L"	K	O

Summary and References

For the Owner / Administrator

The owner or administrator of a historic building should remember that repointing is likely to be a lengthy and expensive process. First, there must be adequate time for evaluation of the building and investigation into the cause of problems. Then, there will be time needed for preparation of the contract documents. The work itself is precise, time-consuming and noisy, and scaffolding may cover the face of the building for some time. Therefore, the owner must carefully plan the work to avoid problems. Schedules for both repointing and other activities will thus require careful coordination to avoid

unanticipated conflicts. The owner must avoid the tendency to rush the work or cut corners if the historic building is to retain its visual integrity and the job is to be durable.

For the Architect/Consultant

Because the primary role of the consultant is to ensure the life of the building, a knowledge of historic construction techniques and the special problems found in older buildings is essential. The consultant must assist the owner in planning for logistical problems relating to research and construction. It is the consultant's responsibility to determine the cause of the mortar deterioration and ensure that it is corrected before the masonry is repointed. The consultant must also be prepared to spend more time in project inspections than is customary in modern construction.

For the Masons

Successful repointing depends on the masons themselves. Experienced masons understand the special requirements for work on historic buildings and the added time and expense they require. The entire masonry crew must be willing and able to perform the work in conformance with the specifications, even when the specifications may not be in conformance with standard practice. At the same time, the masons should not hesitate to question the specifications if it appears that the work specified would damage the building.

Conclusion

A good repointing job is meant to last, at least 30 years, and preferably 50- 100 years. Shortcuts and poor craftsmanship result not only in diminishing the historic character of a building, but also in a job that looks bad, and will require future repointing sooner than if the work had been done correctly. The mortar joint in a historic masonry building has often been called a wall's "first line of defense." Good repointing practices guarantee the long life of the mortar joint, the wall, and the historic structure. Although careful maintenance will help preserve the freshly repointed mortar joints, it is important to remember that mortar joints are intended to be sacrificial and will probably require repointing some time in the future. Nevertheless, if the historic mortar joints proved durable for many years, then careful repointing should have an equally long life, ultimately contributing to the preservation of the entire building.

Useful Addresses

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11490 Commerce Park Drive
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National Lime Association

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Portland Cement Association

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Preservation Services (TPS), National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

October 1998

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PRESERVATION BRIEFS

1

Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings

Robert C. Mack, FAIA, and Anne E. Grimmer

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Appropriate cleaning of historic masonry. Photo: NPS files.

Inappropriate cleaning and coating treatments are a major cause of damage to historic masonry buildings.

While either or both treatments may be appropriate in some cases, they can be very destructive to historic masonry if they are not selected carefully. Historic masonry, as considered here, includes stone, brick, architectural terra cotta, cast stone, concrete and concrete block. It is frequently cleaned because cleaning is equated with improvement. Cleaning may sometimes be followed by the application of a water-repellent coating. However, unless these procedures are carried out under the guidance and supervision of an architectural conservator, they may result in irrevocable damage to the historic resource.



Ninety years of accumulated dirt and pollutants are being removed from this historic theater using an appropriate chemical cleaner, applied in

The purpose of this Brief is to provide information on the variety of cleaning methods and materials that are available for use on the *exterior* of historic masonry buildings, and to provide guidance in selecting the most appropriate method or combination of methods. The difference between water-repellent coatings and waterproof coatings is explained, and the purpose of each, the suitability of their application to historic masonry buildings, and the possible consequences of their inappropriate use are discussed.

The Brief is intended to help develop sensitivity to the qualities of historic masonry that makes it so special, and to assist historic building owners and property managers in working cooperatively with architects, architectural conservators, and contractors. Although specifically intended for historic buildings, the information is applicable to all masonry buildings. This publication updates and expands *Preservation Briefs 1: The Cleaning and Waterproof Coating of Masonry Buildings*. The Brief is not meant to be a cleaning manual or a guide for preparing specifications. Rather, it provides general information to raise awareness of the many factors involved in selecting cleaning and water-repellent treatments for historic masonry buildings.

Preparing for a Cleaning Project

stages. Photo: Richard Wagner, AIA.

Reasons for Cleaning

First, it is important to determine whether it is appropriate to clean the masonry. The objective of cleaning a historic masonry building must be considered carefully before arriving at a decision to clean. There are several major reasons for cleaning a historic masonry building: **improve the appearance of the building** by removing unattractive dirt or soiling materials, or non-historic paint from the masonry; **retard deterioration** by removing soiling materials that may be damaging the masonry; or **provide a clean surface** to accurately match repointing mortars or patching compounds, or to conduct a condition survey of the masonry.

Identify What is to be Removed

The general nature and source of dirt or soiling material on a building must be identified to remove it in the gentlest means possible--that is, in the most effective, yet least harmful, manner. Soot and smoke, for example, require a different cleaning agent to remove than oil stains or metallic stains. Other common cleaning problems include biological growth such as mold or mildew, and organic matter such as the tendrils left on masonry after removal of ivy.

Consider the Historic Appearance of the Building

If the proposed cleaning is to remove paint, it is important in each case to learn whether or not unpainted masonry is historically appropriate. And, it is necessary to consider why the building was painted. Was it to cover bad repointing or unmatched repairs? Was the building painted to protect soft brick or to conceal deteriorating stone? Or, was painted masonry simply a fashionable treatment in a particular historic period? Many buildings were painted at the time of construction or shortly thereafter; retention of the paint, therefore, may be more appropriate historically than removing it. And, if the building appears to have been painted for a long time, it is also important to think about whether the paint is part of the character of the historic building and if it has acquired significance over time.

Consider the Practicalities of Cleaning or Paint Removal

Some gypsum or sulfate crusts may have become integral with the stone and, if cleaning could result in removing some of the stone surface, it may be preferable not to clean. Even where unpainted masonry is appropriate, the retention of the paint may be more practical than removal in terms of long range preservation of the masonry. In some cases, however, removal of the paint may be desirable. For example, the old paint layers may have built up to such an extent that removal is necessary to ensure a sound surface to which the new paint will adhere.

Study the Masonry

Although not always necessary, in some instances it can be beneficial to have the coating or paint type, color, and layering on the masonry researched before attempting its removal. Analysis of the nature of the soiling or of the paint to be removed from the masonry, as well as guidance on the appropriate cleaning method, may be provided by professional consultants, including architectural conservators, conservation scientists, and preservation architects. The State Historic Preservation Office (SHPO), local historic district commissions, architectural review boards, and preservation-oriented websites may also be able to supply useful information on masonry cleaning techniques.

Understanding the Building Materials

The construction of the building must be considered when developing a cleaning program because inappropriate cleaning can have a deleterious effect on the masonry as well as on other building materials. The masonry material or materials must be correctly identified. It is sometimes difficult to distinguish one type of stone from another; for example, certain sandstones can be easily confused with limestones. Or, what appears to be natural stone may not be stone at all, but cast stone or concrete. Historically, cast stone and architectural terra cotta were frequently used in combination with natural stone, especially for trim elements or on upper stories of a building where, from a distance, these substitute materials looked like real stone. Other features on historic buildings that appear to be stone, such as decorative cornices, entablatures and window hoods, may not even be masonry, but metal.

Identify Prior Treatments

Previous treatments of the building and its surroundings should be researched and building maintenance records should be obtained, if available. Sometimes if streaked or spotty areas do not seem to get cleaner following an initial cleaning, closer inspection and analysis may be warranted. The discoloration may turn out not to be dirt but the remnant of a water-repellent coating applied long ago which has darkened the surface of the masonry over time. Successful removal may require testing several cleaning agents to find something that will dissolve and remove the coating. Complete removal may not always be possible. Repairs may have been stained to match a dirty building, and cleaning may make these differences apparent. De-



The decorative trim on this brick building is architectural terra-cotta intended to simulate the limestone foundation. Photo: NPS files.

icing salts used near the building that have dissolved can migrate into the masonry. Cleaning may draw the salts to the surface, where they will appear as efflorescence (a powdery, white substance), which may require a second treatment to be removed. Allowances for dealing with such unknown factors, any of which can be a potential problem, should be included when investigating cleaning methods and materials. Just as more than one kind of masonry on a historic building may necessitate multiple cleaning approaches, unknown conditions that are encountered may also require additional cleaning treatments.



Any cleaning method should be tested before using it on historic masonry. Photo: NPS files.

Choose the Appropriate Cleaner

The importance of testing cleaning methods and materials cannot be over emphasized. Applying the wrong cleaning agents to historic masonry can have disastrous results. Acidic cleaners can be extremely damaging to acid-sensitive stones, such as marble and limestone, resulting in etching and dissolution of these stones. Other kinds of masonry can also be damaged by incompatible cleaning agents, or even by cleaning agents that are usually compatible. There are also numerous kinds of sandstone, each with a considerably different geological composition. While an acid-based cleaner may be safely used on some sandstones, others are acid-sensitive and can be severely etched or dissolved by an acid cleaner. Some sandstones contain water-soluble minerals and can be eroded by water cleaning. And, even if the stone type is correctly identified, stones, as well as some bricks, may contain unexpected impurities, such as iron particles, that may react negatively with a particular cleaning agent and result in staining. Thorough understanding of the physical and

chemical properties of the masonry will help avoid the inadvertent selection of damaging cleaning agents.

Other building materials also may be affected by the cleaning process. Some chemicals, for example, may have a corrosive effect on paint or glass. The portions of building elements most vulnerable to deterioration may not be visible, such as embedded ends of iron window bars. Other totally unseen items, such as iron cramps or ties which hold the masonry to the structural frame, also may be subject to corrosion from the use of chemicals or even from plain water. The only way to prevent problems in these cases is to study the building construction in detail and evaluate proposed cleaning methods with this information in mind. However, due to the very likely possibility of encountering unknown factors, any cleaning project involving historic masonry should be viewed as unique to that particular building.

Cleaning Methods and Materials

Masonry cleaning methods generally are divided into three major groups: water, chemical, and abrasive. *Water methods* soften the dirt or soiling material and rinse the deposits from the masonry surface. *Chemical cleaners* react with dirt, soiling material or paint to effect their removal, after which the cleaning effluent is rinsed off the masonry surface with water. *Abrasive methods* include blasting with grit, and the use of grinders and sanding discs, all of which mechanically remove the dirt, soiling material or paint (and, usually, some of the masonry surface). Abrasive cleaning is also often followed with a water rinse. *Laser cleaning*, although not discussed here in detail, is another technique that is used sometimes by conservators to clean small areas of historic masonry. It can be quite effective for cleaning limited areas, but it is expensive and generally not practical for most historic masonry cleaning projects.

Although it may seem contrary to common sense, masonry cleaning projects should be carried out starting at the bottom and proceeding to the top of the building always keeping all surfaces wet below the area being cleaned. The rationale for this approach is based on the principle that dirty water or cleaning effluent dripping from cleaning in progress above will leave streaks on a dirty surface but will not streak a clean surface as long as it is kept wet and rinsed frequently.

Water Cleaning

Water cleaning methods are generally the *gentlest means possible*, and they can be used safely to remove dirt from all types of historic masonry.* There are essentially four kinds of water-based methods: soaking; pressure water washing; water washing supplemented with non-ionic detergent; and steam, or hot-pressurized water cleaning. Once water cleaning has been completed, it is often necessary to follow up with a water rinse to wash off the loosened soiling material from the masonry.

**Water cleaning methods may not be appropriate to use on some badly deteriorated masonry because water may exacerbate the deterioration, or on gypsum or alabaster, which are very soluble in water.*

Soaking

Prolonged spraying or misting with water is particularly effective for cleaning limestone and marble. It is also a good method for removing heavy accumulations of soot, sulfate crusts or gypsum crusts that tend to form in protected areas of a building not regularly washed by rain. Water is distributed to lengths of punctured hose or pipe with non-ferrous fittings hung from moveable scaffolding or a swing stage that continuously mists the surface of the masonry with a very fine spray.

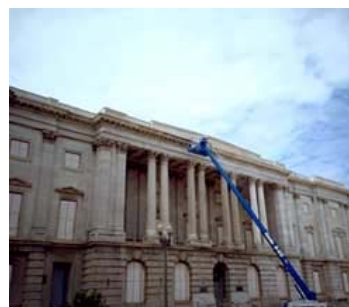
A timed on-off spray is another approach to using this cleaning technique. After one area has been cleaned, the apparatus is moved on to another. Soaking is often used in combination with water washing and is also followed by a final water rinse. Soaking is a very slow method—it may take several days or a week—but it is a very gentle method to use on historic masonry.

Water Washing

Washing with low-pressure or medium-pressure water is probably one of the most commonly used methods for removing dirt or other pollutant soiling from historic masonry buildings. Starting with a very low pressure (100 psi or below), even using a garden hose, and progressing as needed to slightly higher pressure—generally no higher than 300-400 psi—is always the recommended way to begin. Scrubbing with natural bristle or synthetic bristle brushes—never metal which can abrade the surface and leave metal particles that can stain the masonry—can help in cleaning areas of the masonry that are especially dirty.

Water Washing with Detergents

Non-ionic detergents—which are not the same as soaps—are synthetic organic compounds that are especially effective in removing oily soil. (Examples of some of the numerous proprietary non-ionic detergents include Igepal by GAF, Tergitol by Union Carbide and Triton by Rohm & Haas.) Thus, the addition of a non-ionic detergent, or surfactant, to a low- or medium-pressure water wash can be a useful aid in the cleaning process. (A non-ionic detergent, unlike most household detergents, does not leave a solid, visible residue on the masonry.) Adding a non-ionic detergent and scrubbing with a natural bristle or synthetic bristle brush can facilitate cleaning textured or intricately carved masonry. This should be followed with a final water rinse.



Low-to-medium-pressure steam (hot-pressurized water washing) is a gentle method of softening heavy soiling deposits and cleaning historic marble. Photo: NPS files.

Steam/Hot-Pressurized Water Cleaning

Steam cleaning is actually low-pressure hot water washing because the steam condenses almost immediately upon leaving the hose. This is a gentle and effective method for cleaning stone and particularly for acid-sensitive stones. Steam can be especially useful in removing built-up soiling deposits and dried-up plant materials, such as ivy disks and tendrils. It can also be an efficient means of cleaning carved stone details and, because it does not generate a lot of liquid water, it can sometimes be appropriate to use for cleaning interior masonry.

Potential Hazards of Water Cleaning

Despite the fact that water-based methods are generally the most gentle, even they can be damaging to historic masonry. Before beginning a water cleaning project, it is important to make sure that all mortar joints are sound and that the building is watertight. Otherwise water can seep through the walls to the interior, resulting in rusting metal anchors and stained and ruined plaster.

Some water supplies may contain traces of iron and copper which may cause masonry to discolor. Adding a chelating or complexing agent to the water, such as EDTA (ethylene diamine tetra-acetic acid), which inactivates other metallic ions, as well as softens minerals and water hardness, will help prevent staining on light-colored masonry.

Any cleaning method involving water should never be done in cold weather or if there is any likelihood of frost or freezing because water within the masonry can freeze, causing spalling and cracking. Since a masonry wall may take over a week to dry after cleaning, no water cleaning should be permitted for several days prior to the first average frost date, or even earlier if local forecasts predict cold weather.

Most important of all, it is imperative to be aware that using water at too high a pressure, a practice common to "power washing" and "water blasting", is very abrasive and can easily etch marble and other soft stones, as well as some types of brick. In addition, the distance of the nozzle from the masonry surface and the type of nozzle, as well as gallons per minute (gpm), are also important variables in a water cleaning process that can have a significant impact on the outcome of the project. This is why it is imperative that the cleaning be closely monitored to ensure that the cleaning operators do not raise the pressure or bring the nozzle too close to the masonry in an effort to "speed up" the process. The appearance of grains of stone or sand in the cleaning effluent on the ground is an indication that the water pressure may be too high.

Chemical Cleaning

Chemical cleaners, generally in the form of proprietary products, are another material frequently used to clean historic masonry. They can remove dirt, as well as paint and other coatings, metallic and plant stains, and graffiti. Chemical cleaners used to remove dirt and soiling include **acids**, **alkalies** and **organic compounds**. Acidic cleaners, of course, should not be used on masonry that is acid sensitive. Paint removers are **alkaline**, based on **organic solvents** or other chemicals.

Chemical Cleaners to Remove Dirt

Both alkaline and acidic cleaning treatments include the use of water. Both cleaners are also likely to contain surfactants (wetting agents), that facilitate the chemical reaction that removes the dirt. Generally, the masonry is wet first for both types of cleaners, then the chemical cleaner is sprayed on at very low pressure or brushed onto the surface. The cleaner is left to dwell on the masonry for an amount of time recommended by the product manufacturer or, preferably, determined by testing, and rinsed off with a low- or moderate-pressure cold, or sometimes hot, water wash.

More than one application of the cleaner may be necessary, and it is always a good practice to test the product manufacturer's recommendations concerning dilution rates and dwell times. Because each cleaning situation is unique, dilution rates and dwell times can vary considerably. The masonry surface may be scrubbed lightly with natural or synthetic bristle brushes prior to rinsing. After rinsing, pH strips should be applied to the surface to ensure that the masonry has been neutralized completely.

Acidic Cleaners

Acid-based cleaning products may be used on **non-acid sensitive masonry**, which generally includes: granite, most sandstones, slate, unglazed brick and unglazed architectural terra cotta, cast stone and concrete. Most commercial acidic cleaners are composed primarily of hydrofluoric acid, and often include some phosphoric acid to prevent rust-like stains from developing on the masonry after the cleaning. Acid cleaners are applied to the pre-wet masonry which should be kept wet while the acid is allowed to "work", and then removed with a water wash.

Alkaline Cleaners

Alkaline cleaners should be used on **acid-sensitive** masonry, including: limestone, polished and unpolished marble, calcareous sandstone, glazed brick and glazed architectural terra cotta, and polished granite. (Alkaline cleaners may also be used sometimes on masonry materials that are not acid sensitive--after testing, of course--but they may not be as effective as they are on acid-sensitive masonry.) Alkaline cleaning products consist primarily of two ingredients: a non-ionic detergent or surfactant; and an alkali, such as potassium hydroxide or ammonium hydroxide. Like acidic cleaners, alkaline products are usually applied to pre-wet masonry, allowed to dwell, and then rinsed off with water. (Longer dwell times may be necessary with alkaline cleaners than with acidic cleaners.) Two additional steps are required to remove alkaline cleaners after the initial rinse. First the masonry is given a slightly acidic wash--often with acetic acid--to neutralize it, and then it is rinsed again with water.

Chemical Cleaners to Remove Paint and Other Coatings, Stains and Graffiti

Removing paint and some other coatings, stains and graffiti can best be accomplished with alkaline paint removers, organic solvent paint removers, or other cleaning compounds. The removal of layers of paint from a masonry surface usually involves applying the remover either by brush, roller or spraying, followed by a thorough water wash. As with any chemical cleaning, the manufacturer's recommendations regarding application procedures should always be tested before beginning work.

Alkaline Paint Removers

These are usually of much the same composition as other alkaline cleaners, containing potassium or ammonium hydroxide, or trisodium phosphate. They are used to remove oil, latex and acrylic paints, and are effective for removing multiple layers of paint. Alkaline cleaners may also remove some acrylic water-repellent coatings. As with other alkaline cleaners, both an acidic neutralizing wash and a final water rinse are generally required following the use of alkaline paint removers.

Organic Solvent Paint Removers

The formulation of organic solvent paint removers varies and may include a combination of solvents, including methylene chloride, methanol, acetone, xylene and toluene.

Other Paint Removers and Cleaners

Other cleaning compounds that can be used to remove paint and some painted graffiti from historic masonry include paint removers based on N-methyl-2-pyrrolidone (NMP), or on petroleum-based compounds. Removing stains, whether they are industrial (smoke, soot, grease or tar), metallic (iron or copper), or biological (plant and fungal) in origin, depends on carefully matching the type of remover to the type of stain. Successful removal of stains from historic masonry often requires the application of a number of different removers before the right one is found. The removal of layers of paint from a masonry surface is usually accomplished by applying the remover either by brush, roller or spraying, followed by a thorough water wash.

Potential Hazards of Chemical Cleaning

Since most chemical cleaning methods involve water, they have many of the potential problems of plain water cleaning. Like water methods, they should not be used in cold weather because of the possibility of freezing. Chemical cleaning should never be undertaken in temperatures below 40 degrees F (4 degrees C), and generally not below 50 degrees F. In

addition, many chemical cleaners simply do not work in cold temperatures. Both acidic and alkaline cleaners can be dangerous to cleaning operators, and clearly, there are environmental concerns associated with the use of chemical cleaners.

If not carefully chosen, chemical cleaners can react adversely with many types of masonry. Obviously, acidic cleaners should not be used on acid-sensitive materials; however, it is not always clear exactly what the composition is of any stone or other masonry material. For, this reason, testing the cleaner on an inconspicuous spot on the building is always necessary. While certain acid-based cleaners may be appropriate if used as directed on a particular type of masonry, if left too long or if not adequately rinsed from the masonry they can have a negative effect. For example, hydrofluoric acid can etch masonry leaving a hazy residue (whitish deposits of silica or calcium fluoride salts) on the surface. While this efflorescence may usually be removed by a second cleaning—although it is likely to be expensive and time-consuming—**hydrofluoric acid** can also leave calcium fluoride salts or a colloidal silica deposit on masonry which may be impossible to remove. Other acids, particularly **hydrochloric (muriatic) acid**, which is very powerful, should not be used on historic masonry, because it can dissolve lime-based mortar, damage brick and some stones, and leave chloride deposits on the masonry.

Alkaline cleaners can stain sandstones that contain a ferrous compound. Before using an alkaline cleaner on sandstone it is always important to test it, since it may be difficult to know whether a particular sandstone may contain a ferrous compound. Some alkaline cleaners, such as **sodium hydroxide (caustic soda or lye)** and **ammonium bifluoride**, can also damage or leave disfiguring brownish-yellow stains and, in most cases, should not be used on historic masonry. Although alkaline cleaners will not etch a masonry surface as acids can, they are caustic and can burn the surface. In addition, alkaline cleaners can deposit potentially damaging salts in the masonry which can be difficult to rinse thoroughly.

Poulticing to Remove Stains and Graffiti

Graffiti and stains, which have penetrated into the masonry, often are best removed by using a poultice. A poultice consists of an absorbent material or clay powder (such as kaolin or fuller's earth, or even shredded paper or paper towels), mixed with a liquid (a solvent or other remover) to form a paste which is applied to the stain. The poultice is kept moist and left on the stain as long as necessary for it to draw the stain out of the masonry. As it dries, the paste absorbs the staining material so that it is not redeposited on the masonry surface.

Some commercial cleaning products and paint removers are specially formulated as a paste or gel that will cling to a vertical surface and remain moist for a longer period of time in order to prolong the action of the chemical on the stain. Pre-mixed poultices are also available as a paste or in powder form needing only the addition of the appropriate liquid. The masonry must be pre-wet before applying an alkaline cleaning agent, but not when using a solvent. Once the stain has been removed, the masonry must be rinsed thoroughly.

Abrasive and Mechanical Cleaning

Generally, abrasive cleaning methods are not appropriate for use on historic masonry buildings. Abrasive cleaning methods are just that—abrasive. Grit blasters, grinders, and sanding discs all operate by abrading the dirt or paint off the surface of the masonry, rather than reacting with the dirt and the masonry which is how water and chemical methods work. Since the abrasives do not differentiate between the dirt and the masonry, they can also remove the outer surface of the masonry at the same time, and result in permanently damaging the masonry. Brick, architectural terra cotta, soft stone, detailed carvings, and polished surfaces, are especially susceptible to physical and aesthetic damage by abrasive methods. Brick and architectural terra cotta are fired products which have a smooth, glazed surface which can be removed by abrasive blasting or grinding. Abrasively-cleaned masonry is damaged aesthetically as well as physically, and it has a rough surface which tends to hold dirt and the roughness will make future cleaning more difficult. Abrasive cleaning processes can also increase the likelihood of subsurface cracking of the masonry. Abrasion of carved details causes a rounding of sharp corners and other loss of delicate features, while abrasion of polished surfaces removes the polished finish of stone.

Mortar joints, especially those with lime mortar, also can be eroded by abrasive or mechanical cleaning. In some cases, the damage may be visual, such as loss of joint detail or increased joint shadows. As mortar joints constitute a significant portion of the masonry surface (up to 20 per cent in a brick wall), this can result in the loss of a considerable amount of the historic fabric. Erosion of the mortar joints may also permit increased water penetration, which will likely necessitate repointing.

Abrasive Blasting



The iron stain on this granite post may be removed by applying a commercial rust-removal product in a poultice. Photo: NPS files



Sandblasting has permanently damaged this brick wall. Photo: NPS files

Blasting with abrasive grit or another abrasive material is the most frequently used abrasive method. Sandblasting is most commonly associated with abrasive cleaning. Finely ground silica or glass powder, glass beads, ground garnet, powdered walnut and other ground nut shells, grain hulls, aluminum oxide, plastic particles and even tiny pieces of sponge, are just a few of the other materials that have also been used for abrasive cleaning. Although abrasive blasting is not an appropriate method of cleaning historic masonry, it can be safely used to clean some materials. Finely-powdered walnut shells are commonly used for cleaning monumental bronze sculpture, and skilled conservators clean delicate museum objects and finely detailed, carved stone features with very small, micro-abrasive units using aluminum oxide.

A number of current approaches to abrasive blasting rely on materials that are not usually thought of as abrasive, and not as commonly associated with traditional abrasive grit cleaning. Some patented abrasive cleaning processes—one dry, one wet—use finely-ground glass powder intended to "erase" or remove dirt and surface soiling only, but not paint or stains. Cleaning with baking soda (sodium bicarbonate) is another patented process. Baking soda blasting is being used in some communities as a means of quick graffiti removal. However, it should not be used on historic masonry which it can easily abrade and can permanently "etch" the graffiti into the stone; it can also leave potentially damaging salts in the stone which cannot be removed. Most of these abrasive grits may be used either dry or wet, although dry grit tends to be used more frequently.

Ice particles, or pelletized dry ice (carbon dioxide or CO₂), are another medium used as an abrasive cleaner. This is also too abrasive to be used on most historic masonry, but it may have practical application for removing mastics or asphaltic coatings from some substrates.

Some of these processes are promoted as being more environmentally safe and not damaging to historic masonry buildings. However, it must be remembered that they are abrasive and that they "clean" by removing a small portion of the masonry surface, even though it may be only a minuscule portion. The fact that they are essentially abrasive treatments must always be taken into consideration when planning a masonry cleaning project. In general, abrasive methods should not be used to clean historic masonry buildings. In some, very limited instances, highly-controlled, gentle abrasive cleaning may be appropriate on selected, hard-to-clean areas of a historic masonry building if carried out under the watchful supervision of a professional conservator. But, abrasive cleaning should never be used on an entire building.

Grinders and Sanding Disks

Grinding the masonry surface with mechanical grinders and sanding disks is another means of abrasive cleaning that should not be used on historic masonry. Like abrasive blasting, grinders and disks do not really clean masonry but instead grind away and abrasively remove and, thus, damage the masonry surface itself rather than remove just the soiling material.

Planning a Cleaning Project

Once the masonry and soiling material or paint have been identified, and the condition of the masonry has been evaluated, planning for the cleaning project can begin.

Testing Cleaning Methods

In order to determine the *gentlest means possible*, several cleaning methods or materials may have to be tested prior to selecting the best one to use on the building. Testing should always begin with the gentlest and least invasive method proceeding gradually, if necessary, to more complicated methods, or a combination of methods. All too often simple methods, such as a low-pressure water wash, are not even considered, yet they frequently are effective, safe, and not expensive. Water of slightly higher pressure or with a non-ionic detergent additive also may be effective. It is worth repeating that these methods should always be tested prior to considering harsher methods; they are safer for the building and the environment, often safer for the applicator, and relatively inexpensive.

The level of cleanliness desired also should be determined prior to selection of a cleaning method. Obviously, the intent of cleaning is to remove most of the dirt, soiling material, stains, paint or other coating. A "brand new" appearance, however, may be inappropriate for an older building, and may require an overly harsh cleaning method to be achieved. When undertaking a cleaning project, it is important to be aware that some stains simply may not be removable. It may be wise, therefore, to agree upon a slightly lower level of cleanliness that will serve as the standard for the cleaning project. The precise amount of residual dirt considered acceptable may depend on the type of masonry, the type of soiling and difficulty of total removal, and local environmental conditions.

Cleaning tests should be carried out in an area of sufficient size to give a true indication of their effectiveness. It is preferable to conduct the test in an inconspicuous location on the building so that it will not be obvious if the test is not successful. A test area may be quite small to begin, sometimes as small as six square inches, and gradually may be

increased in size as the most appropriate methods and cleaning agents are determined. Eventually the test area may be expanded to a square yard or more, and it should include several masonry units and mortar joints. It should be remembered that a single building may have several types of masonry and that even similar materials may have different surface finishes. Each material and different finish should be tested separately. Cleaning tests should be evaluated only after the masonry has dried completely. *The results of the tests may indicate that several methods of cleaning should be used on a single building.*

When feasible, test areas should be allowed to weather for an extended period of time prior to final evaluation. A waiting period of a full year would be ideal in order to expose the test patch to a full range of seasons. If this is not possible, the test patch should weather for at least a month or two. For any building which is considered historically important, the delay is insignificant compared to the potential damage and disfigurement which may result from using an incompletely tested method. *The successfully cleaned test patch should be protected as it will serve as a standard against which the entire cleaning project will be measured.*

Environmental Considerations

The potential effect of any method proposed for cleaning historic masonry should be evaluated carefully. Chemical cleaners and paint removers may damage trees, shrubs, grass, and plants. A plan must be provided for environmentally safe removal and disposal of the cleaning materials and the rinsing effluent before beginning the cleaning project. Authorities from the local regulatory agency--usually under the jurisdiction of the federal or state Environmental Protection Agency (EPA)--should be consulted prior to beginning a cleaning project, especially if it involves anything more than plain water washing. This advance planning will ensure that the cleaning effluent or run-off, which is the combination of the cleaning agent and the substance removed from the masonry, is handled and disposed of in an environmentally sound and legal manner. Some alkaline and acidic cleaners can be neutralized so that they can be safely discharged into storm sewers. However, most solvent-based cleaners cannot be neutralized and are categorized as pollutants, and must be disposed of by a licensed transport, storage and disposal facility. Thus, it is always advisable to consult with the appropriate agencies before starting to clean to ensure that the project progresses smoothly and is not interrupted by a stop-work order because a required permit was not obtained in advance.

Vinyl guttering or polyethylene-lined troughs placed around the perimeter of the base of the building can serve to catch chemical cleaning waste as it is rinsed off the building. This will reduce the amount of chemicals entering and polluting the soil, and also will keep the cleaning waste contained until it can be removed safely. Some patented cleaning systems have developed special equipment to facilitate the containment and later disposal of cleaning waste.

Concern over the release of volatile organic compounds (VOCs) into the air has resulted in the manufacture of new, more environmentally responsible cleaners and paint removers, while some materials traditionally used in cleaning may no longer be available for these same reasons. Other health and safety concerns have created additional cleaning challenges, such as lead paint removal, which is likely to require special removal and disposal techniques.

Cleaning can also cause damage to non-masonry materials on a building, including glass, metal and wood. Thus, it is usually necessary to cover windows and doors, and other features that may be vulnerable to chemical cleaners. They should be covered with plastic or polyethylene, or a masking agent that is applied as a liquid which dries to form a thin protective film on glass, and is easily peeled off after the cleaning is finished. Wind drift, for example, can also damage other property by carrying cleaning chemicals onto nearby automobiles, resulting in etching of the glass or spotting of the paint finish. Similarly, airborne dust can enter surrounding buildings, and excess water can collect in nearby yards and basements.

Safety Considerations

Possible health dangers of each method selected for the cleaning project must be considered before selecting a cleaning method to avoid harm to the cleaning applicators, and the necessary precautions must be taken. The precautions listed in Material Safety Data Sheets (MSDS) that are provided with chemical products should always be followed. Protective clothing, respirators, hearing and face shields, and gloves must be provided to workers to be worn at all times. Acidic and alkaline chemical cleaners in both liquid and vapor forms can also cause serious injury to passers-by. It may be necessary to schedule cleaning at night or weekends if the building is located in a busy urban area to reduce the potential danger of chemical overspray to pedestrians. Cleaning during non-business hours will allow HVAC systems to be turned off and vents to be covered to prevent dangerous chemical fumes from entering the building which will also ensure the safety of the building's occupants. Abrasive and mechanical methods produce dust which can pose a serious health hazard, particularly if the abrasive or the masonry contains silica.



The lower floors of this historic brick and architectural terra-cotta building have been covered during chemical cleaning to protect pedestrians and vehicular traffic from potentially harmful overspray. Photo: NPS files.

Water-Repellent Coatings and Waterproof Coatings

To begin with, it is important to understand that waterproof coatings and water-repellent coatings are not the same. Although these terms are frequently interchanged and commonly confused with one another, they are completely different materials. **Water-repellent coatings**—often referred to incorrectly as "sealers", but which do not or should not "seal"—are intended to keep liquid water from penetrating the surface but to allow water vapor to enter and leave, or pass through, the surface of the masonry. Water-repellent coatings are generally transparent, or clear, although once applied some may darken or discolor certain types of masonry while others may give it a glossy or shiny appearance. **Waterproof coatings** seal the surface from liquid water and from water vapor. They are usually opaque, or pigmented, and include bituminous coatings and some elastomeric paints and coatings.

Water-Repellent Coatings

Water-repellent coatings are formulated to be vapor permeable, or "breathable". They do not seal the surface completely to water vapor so it can enter the masonry wall as well as leave the wall. While the first water-repellent coatings to be developed were primarily acrylic or silicone resins in organic solvents, now most water-repellent coatings are water-based and formulated from modified siloxanes, silanes and other alkoxysilanes, or metallic stearates. While some of these products are shipped from the factory ready to use, other water-borne water repellents must be diluted at the job site. Unlike earlier water-repellent coatings which tended to form a "film" on the masonry surface, modern water-repellent coatings actually penetrate into the masonry substrate slightly and, generally, are almost invisible if properly applied to the masonry. They are also more vapor permeable than the old coatings, yet they still reduce the vapor permeability of the masonry. Once inside the wall, water vapor can condense at cold spots producing liquid water which, unlike water vapor, cannot escape through a water-repellent coating. The liquid water within the wall, whether from condensation, leaking gutters, or other sources, can cause considerable damage.

Water-repellent coatings are not consolidants. Although modern water-repellents may penetrate slightly beneath the masonry surface, instead of just "sitting" on top of it, they do not perform the same function as a consolidant which is to "consolidate" and replace lost binder to strengthen deteriorating masonry. Even after many years of laboratory study and testing, few consolidants have proven very effective. The composition of fired products such as brick and architectural terra cotta, as well as many types of building stone, does not lend itself to consolidation.

Some modern water-repellent coatings which contain a binder intended to replace the natural binders in stone that have been lost through weathering and natural erosion are described in product literature as both a water repellent and a consolidant. The fact that the newer water-repellent coatings penetrate beneath the masonry surface instead of just forming a layer on top of the surface may indeed convey at least some consolidating properties to certain stones. However, a water-repellent coating cannot be considered a consolidant. In some instances, a water-repellent or "preservative" coating, if applied to already damaged or spalling stone, may form a surface crust which, if it fails, may exacerbate the deterioration by pulling off even more of the stone.



This clear coating has failed and is pulling off pieces of the stone as it peels. Photo: NPS files

Is a Water-Repellent Treatment Necessary?

Water-repellent coatings are frequently applied to historic masonry buildings for the wrong reason. They also are often applied without an understanding of what they are and what they are intended to do. And these coatings can be very difficult, if not impossible, to remove from the masonry if they fail or become discolored. Most importantly, the application of water-repellent coatings to historic masonry is usually unnecessary.

Most historic masonry buildings, unless they are painted, have survived for decades without a water-repellent coating and, thus, probably do not need one now. Water penetration to the interior of a masonry building is seldom due to porous masonry, but results from poor or deferred maintenance. Leaking roofs, clogged or deteriorated gutters and downspouts, missing mortar, or cracks and open joints around door and window openings are almost always the cause of moisture-related problems in a historic masonry building. **If historic masonry buildings are kept watertight and in good repair, water-repellent coatings should not be necessary.**

Rising damp (capillary moisture pulled up from the ground), or condensation can also be a source of excess moisture in masonry buildings. A water-repellent coating will not solve this problem either and, in fact, may be likely to exacerbate it. Furthermore, a water-repellent coating should never be applied to a damp wall. Moisture in the wall would reduce the ability of a coating to adhere to the masonry and to penetrate below the surface. But, if it did adhere, it would hold the moisture inside the masonry because, although a water-repellent coating is permeable to water vapor, liquid water cannot

pass through it. In the case of rising damp, a coating may force the moisture to go even higher in the wall because it can slow down evaporation, and thereby retain the moisture in the wall.

Excessive moisture in masonry walls may carry waterborne soluble salts from the masonry units themselves or from the mortar through the walls. If the water is permitted to come to the surface, the salts may appear on the masonry surface as efflorescence (a whitish powder) upon evaporation. However, the salts can be potentially dangerous if they remain in the masonry and crystallize beneath the surface as subflorescence. Subflorescence eventually may cause the surface of the masonry to spall, particularly if a water-repellent coating has been applied which tends to reduce the flow of moisture out from the subsurface of the masonry. Although many of the newer water-repellent products are more breathable than their predecessors, they can be especially damaging if applied to masonry that contains salts, because they limit the flow of moisture through masonry.

When a Water-Repellent Coating May be Appropriate

There are some instances when a water-repellent coating may be considered appropriate to use on a historic masonry building. Soft, incompletely fired brick from the 18th- and early-19th centuries may have become so porous that paint or some type of coating is needed to protect it from further deterioration or dissolution. When a masonry building has been neglected for a long period of time, necessary repairs may be required in order to make it watertight. If, following a reasonable period of time after the building has been made watertight and has dried out completely, moisture appears actually to be penetrating through the repointed and repaired masonry walls, then the application of a water-repellent coating may be considered in *selected areas only*. This decision should be made in consultation with an architectural conservator. And, if such a treatment is undertaken, it should not be applied to the entire exterior of the building.



Improper cleaning methods may have been responsible for the formation of efflorescence on this brick. Photo: NPS files.

Anti-graffiti or barrier coatings are another type of clear coating—although barrier coatings can also be pigmented—that may be applied to exterior masonry, but they are not formulated primarily as water repellents. The purpose of these coatings is to make it harder for graffiti to stick to a masonry surface and, thus, easier to clean. But, like water-repellent coatings, in most cases the application of anti-graffiti coatings is generally not recommended for historic masonry buildings. These coatings are often quite shiny which can greatly alter the appearance of a historic masonry surface, and they are not always effective. Generally, other ways of discouraging graffiti, such as improved lighting, can be more effective than a coating. However, the application of anti-graffiti coatings may be appropriate in some instances on vulnerable areas of historic masonry buildings which are frequent targets of graffiti that are located in out-of-the-way places where constant surveillance is not possible.

Some water-repellent coatings are recommended by product manufacturers as a means of keeping dirt and pollutants or biological growth from collecting on the surface of masonry buildings and, thus, reducing the need for frequent cleaning. While this at times may be true, in some cases a coating may actually retain dirt more than uncoated masonry. Generally, the application of a water-repellent coating is not recommended on a historic masonry building as a means of preventing biological growth. Some water-repellent coatings may actually encourage biological growth on a masonry wall. Biological growth on masonry buildings has traditionally been kept at bay through regularly-scheduled cleaning as part of a maintenance plan. Simple cleaning of the masonry with low-pressure water using a natural- or synthetic-bristled scrub brush can be very effective if done on a regular basis. Commercial products are also available which can be sprayed on masonry to remove biological growth.

In most instances, a water-repellent coating is not necessary if a building is watertight. The application of a water-repellent coating is not a recommended treatment for historic masonry buildings unless there is a specific problem which it may help solve. If the problem occurs on only part of the building, it is best to treat only that area rather than an entire building. Extreme exposures such as parapets, for example, or portions of the building subject to driving rain can be treated more effectively and less expensively than the entire building. Water-repellent coatings are not permanent and must be reapplied periodically although, if they are truly invisible, it can be difficult to know when they are no longer providing the intended protection.

Testing a water-repellent coating by applying it in one small area may not be helpful in determining its suitability for the building because a limited test area does not allow an adequate evaluation of a treatment. Since water may enter and leave through the surrounding untreated areas, there is no way to tell if the coated test area is "breathable." But trying a coating in a small area may help to determine whether the coating is visible on the surface or if it will otherwise change the appearance of the masonry.

Waterproof Coatings

In theory, waterproof coatings usually do not cause problems as long as they exclude all water from the masonry. If water does enter the wall from the ground or from the inside of a building, the coating can intensify the damage because the water will not be able to escape. During cold weather this water in the wall can freeze causing serious mechanical disruption, such as spalling.

In addition, the water eventually will get out by the path of least resistance. If this path is toward the interior, damage to interior finishes can result; if it is toward the exterior, it can lead to damage to the masonry caused by built-up water pressure.

In most instances, waterproof coatings should not be applied to historic masonry. The possible exception to this might be the application of a waterproof coating to below-grade exterior foundation walls as a last resort to stop water infiltration on interior basement walls. **Generally, however, waterproof coatings, which include *elastomeric paints*, should almost never be applied above grade to historic masonry buildings.**

Summary and References

A well-planned cleaning project is an essential step in preserving, rehabilitating or restoring a historic masonry building. Proper cleaning methods and coating treatments, when determined necessary for the preservation of the masonry, can enhance the aesthetic character as well as the structural stability of a historic building. Removing years of accumulated dirt, pollutant crusts, stains, graffiti or paint, if done with appropriate caution, can extend the life and longevity of the historic resource. Cleaning that is carelessly or insensitively prescribed or carried out by inexperienced workers can have the opposite of the intended effect. It may scar the masonry permanently, and may actually result in hastening deterioration by introducing harmful residual chemicals and salts into the masonry or causing surface loss. Using the wrong cleaning method or using the right method incorrectly, applying the wrong kind of coating or applying a coating that is not needed can result in serious damage, both physically and aesthetically, to a historic masonry building. Cleaning a historic masonry building should always be done using the gentlest means possible that will clean, but not damage the building. It should always be taken into consideration before applying a water-repellent coating or a waterproof coating to a historic masonry building whether it is really necessary and whether it is in the best interest of preserving the building.

Acknowledgements

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November 2000

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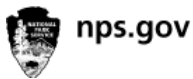
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PRESERVATION BRIEFS

9

The Repair of Historic Wooden Windows

John H. Myers

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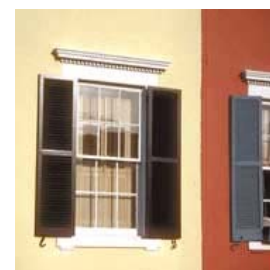
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Historic six-over-six windows--preserved. Photo: NPS files.

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. 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.

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.

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 proceed 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 runoff, particularly 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



Windows are frequently important visual focal points, especially on simple facades such as this mill building. Replacement of the multi-pane windows with larger panes could dramatically alter the appearance of the building. Photo: NPS files.

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. 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 endgrain 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 section 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



Deterioration of poorly maintained windows usually begins on horizontal surfaces and at joints, where water can collect and saturate the wood. Photo: NPS files.

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, 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.

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. 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, the glass should be removed or protected from the sudden temperature change which can cause breakage. An 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.

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 weather-tight seal. After the proper curing times have elapsed for paint and putty, the sash will be ready for reinstallation.



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. Photo: NPS files.



This historic double-hung window has many layers of paint, some cracked and missing putty, slight separation at the joints, broken sash cords, and one cracked pane. Photo: NPS files.



Sash can be removed and repaired in a convenient work area. Paint is being removed from this sash with a hot air gun. Photo: NPS files.

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. 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. 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 process 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.



Following the relatively simple repairs, the window is weathertight, like new in appearance, and serviceable for many years to come. Photo: NPS files.

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 waterproofed, 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. waterproof 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.



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: NPS files.

When sills or other members exhibit surface weathering they may also be built-up using wood putties or homemade mixtures such as sawdust and resorcinol glue, or whiting 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 semirigid epoxies which saturate the porous decayed wood and then harden. The surface of the consolidated wood can then be filled with a semirigid epoxy patching compound, sanded and painted. Epoxy patching compounds can be used to build up 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. 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. More information on epoxies can be found in the publication "Epoxies for Wood Repairs in Historic Buildings," cited in the bibliography.

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.

Summary and References

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.

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. Technical Preservation Services (TPS), National Park Service prepares standards, guidelines, and other educational materials on responsible historic preservation treatments for a broad public.

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Reading List

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