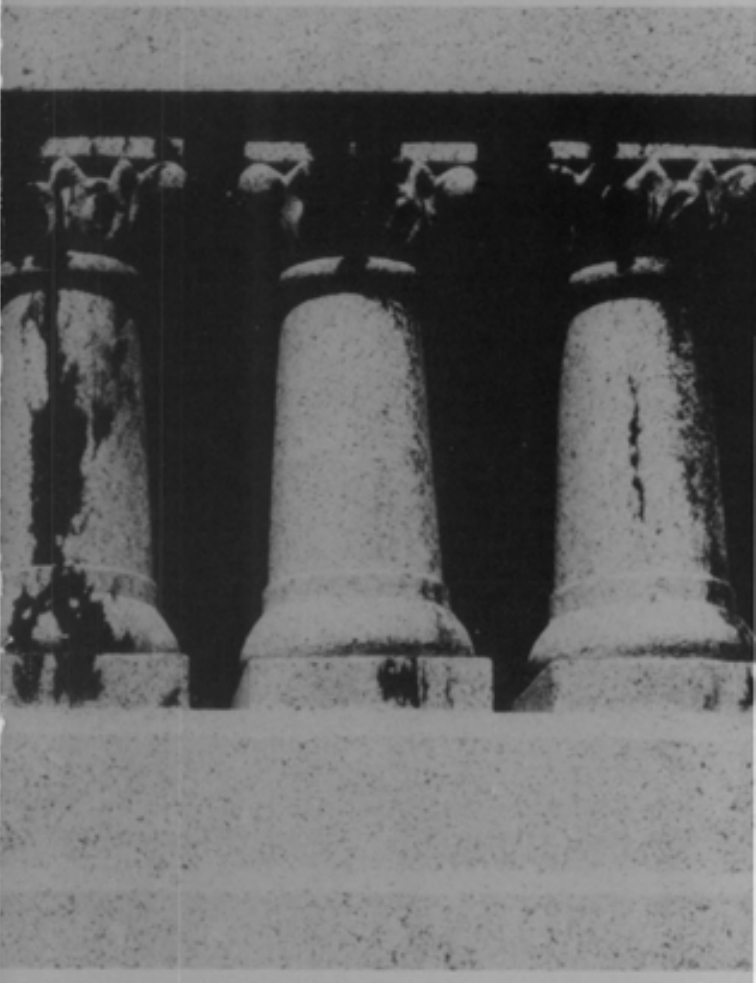
A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments



A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments

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Contents

Preface

In 1981, the Preservation Assistance Division of the National Park Service initiated the Census of Treated Historic Masonry Buildings in order to fulfill its responsibility to provide sound technical advice to Federal, State, and local officials concerning the preservation of historic structures. The purpose of the Census is to establish a system for documenting all types of treatments carried out on historic masonry and for keeping a record of environmental and treatment effects on the long-term preservation of the masonry. How to identify the many kinds of deterioration to which historic masonry is susceptible, and how to determine what, if any, treatment is best, or what degree of intervention might be necessary for its preservation, are not easy questions to answer. The continuing influx of new "miracle" products on the market makes these questions even more problematic. Although most of these products were originally developed for application in new construction, many are now being promoted by the manufacturer, or by architects and building contractors, as equally suitable for older and historic masonry materials. Too often, an incorrect and uninformed diagnosis of masonry deterioration results in the application of many such products—in particular water-repellent coatings and consolidants—to historic buildings without adequate, or in most cases without *any,* testing. Unfortunately, this haphazard use of inappropriate or incompatible materials often results in extensive and irreversible damage to the historic masonry.

To date, twenty historic masonry buildings have been recorded on the Census, reflecting a variety of treatments, masonry types geographical locations, and it is estimated that the project will ultimately include one hundred structures. As the Census project has evolved, we have realized the need for a standard set of definitions for masonry deterioration as well as the preservation treatments prescribed. There is a plethora of terms used to describe problems of historic masonry deterioration and preservation treatments. Because so many of these terms originate from different sources—the architectural profession, the building trades and industry, and scientific fields such

as geology and chemistry—many of them are used interchangeably, often indiscriminately and incorrectly. As a result, the preservation architect or building conservator is left in confusion, uncertain not only how to diagnose a problem, but what to call it, and whether to recommend a treatment.

To help clarify these different, but sometimes nearly synonymous terms, we have developed this illustrated glossary. The glossary is *not* a "how to" manual; it will not supply the technical information, such as specifications, necessary to carry out a cleaning or repair project. Instead it is intended as a general reference and interpretive tool to provide an explanation of all terms likely to be used in the Census to describe conditions of masonry deterioration and repair techniques and treatments to preserve historic masonry.

For purposes of the Census and the glossary, the term "masonry" includes all types of natural stone, brick, terra cotta and adobe, as well as concrete and other cementitious materials. Preservation treatments are broadly defined to include almost everything done to or applied to historic masonry in an effort to prolong its life. The glossary is illustrated and consists of two sections: Part 1 lists and defines problems of masonry deterioration in alphabetical order. Part 2 describes preservation treatments, grouped according to maintenance or repair techniques. It is hoped that the glossary will be useful to all those who are faced with the myriad problems of evaluating, preserving, restoring and rehabilitating historic masonry buildings. This includes historic preservation specialists and architects, architectural and museum conservators, and conservation scientists, as well as representatives of the building industry—such as contractors and masons, and building product representatives.

Although gathered from a wide variety of sources, we realize this glossary is by no means conclusive. It is presented as an initial effort and is intended as the first of many expanded editions to be improved through use and application in the field. We solicit your comments and suggestions for additional terms explaining historic masonry deterioration, and, as the science of masonry conservation continues to evolve, descriptions of new, more suc-

cessful and long-lasting preservation treatments for historic masonry.

The Preservation Assistance Division would like to express its appreciation to all those who have conveyed their experience with historic masonry through the publications which were consulted in the preparation of this glossary, and which are included in the selected reading list. In addition, I would like to personally acknowledge the contribution of the following individuals who provided technical comments on the manuscript: Michael F. Lynch; Erhard M. Winkler; the AIA Committee on Historic Resources; the National Park Service Regions; and the staff of the Preservation Assistance Division, including Michael J. Auer, Bruce Doe, Susan Dynes, Charles E. Fisher, Martha A. Gutrick, Alicia Hardison, H. Ward Jandl, Sharon C. Park, Susan I. Sherwood, Mae Simon, Christopher A. Sowick, and Kay D. Weeks.

This publication has been prepared pursuant to The National Historic Preservation Act Amendments of 1980, which direct the Secretary of the Interior to make available to Federal agencies, State and local governments, private organizations, and individuals information concerning professional methods and techniques for the preservation of historic properties and for the administration of the historic preservation programs at the Federal, State, and local levels. The publication is further evidence of the National Park Service commitment to identify and assess damage to materials and cultural resources as part of its participation in Taskgroup G of the National Acid Precipitation Assessment Program. *A Glossary of Historic Masonry Deterioration Problems and Preservation Treatments* has been developed under the technical editorship of Lee H. Nelson, AIA, Chief, Preservation Assistance Division, National Park Service, U.S. Department of the Interior, Washington, D.C. 20240. Comments on the usefulness of this information are welcomed and can be sent to Mr. Nelson at the above address.

September, 1984

Part 1
Deterioration Problems

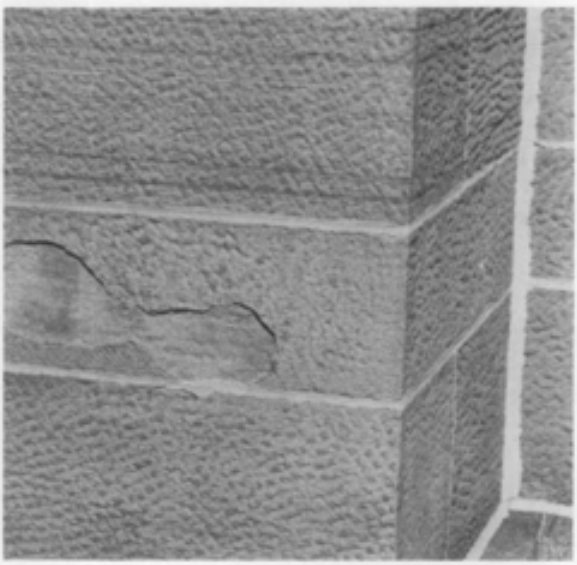
Part 1 provides definitions of the most common deterioration problems affecting historic masonry buildings. While there is an obvious similarity of meaning in a number of the terms—the terms blistering, delamination, exfoliation, flaking, peeling and salt fretting are notable examples—all possible definitions have been included in order to be comprehensive. The 22 terms include all levels of deterioration. For example, they run the gamut from lesser problems which appear to be fairly insignificant, such as blistering, to the more serious conditions of delamination or exfoliation. While it would be ideal to reference a treatment for every deterioration problem in the glossary, the very nature of masonry—the fact that stone is not a homogeneous substance, and manufactured masonry materials are not much more consistent—means that any treatment must be carried out only after testing and on a case-by-case basis. Some traditional preservation treatments have been tried and used successfully for a long time, as have some "modern scientific" treatments. But many others have not, and their application has resulted in greater damage to the masonry. Thus, it is clear that technology has not advanced to the point where there is a treatment for every problem. Where a preservation treatment or approach *can* be suggested, however, it is referenced after the description of the problem.

Finally, the reader should understand that if the degree of deterioration is minimal, it is preferable to leave the masonry alone, as long as the problem does not threaten the structural integrity of the building or detract too much from the architectural character. Historic buildings are old and they should not be expected to look perfect.

Blistering

Swelling accompanied by rupturing of a thin uniform skin both across and parallel to the bedding plane, usually a condition found on sandstone, but also on granite. Because blistering can be caused by de-icing salts and ground moisture, it is generally found on a surface close to the ground. Blistering may remain a relatively constant condition scattered over the masonry surface but, more often, it eventually results in greater surface peeling (exfoliation, delamination or spalling).

Preservation Treatment: To date, no completely effective treatment has been developed for this condition.



Blistering of sandstone. Photograph: Anne E. Grimmer.

Chipping

Small pieces or larger fragments of masonry separating from the masonry unit, often at corners or mortar joints. This may be the result of damage caused by later alterations or repairs, such as use of too hard a mortar, or by accident or through vandalism.

Preservation Treatment: See Dutchman Repair, p.56; Replacement/Patching with Like or Compatible Substitute Materials, p.59.

Chipping of granite sill. Photograph: Anne E. Grimmer.

Coving

The hollowing out of an adobe wall just above grade level. Coving may be caused by standing rainwater or rainwater splash off the ground. It can also be caused by salts deposited in the adobe by the evaporation of water.

Preservation Treatment: See Replacement/Patching with Like or Compatible Substitute Materials, p.59.

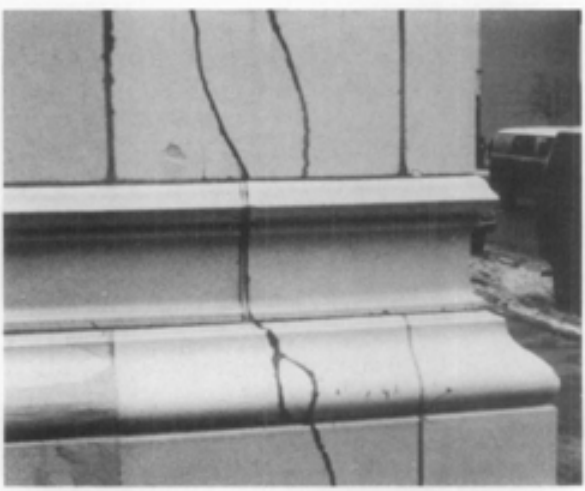
Coving of adobe wall. Photograph: National Park Service.

Cracking

A term describing narrow fissures from 1/16 to 1/2 inch wide in a block of masonry. Cracking may result from a variety of conditions, such as structural settlement of a building, too hard a repointing mortar, or it may be an inherent characteristic of the masonry itself, such as unfired brick or adobe. Small cracks within a single block of masonry may not be serious, but longer and wider cracks extending over a larger area may be indicative of structural problems, and should be monitored.

Preservation Treatment: See Mechanical Repair, p.58; Replacement/Patching with Like or Compatible Substitute Materials, p.59.

Cracking of limestone. Photograph: John H. Myers.



Cracking of glazed terra cotta. Photograph: National Park Service.

Crazing

The formation of a pattern of tiny cracks or crackles in the glaze of glazed terra cotta. Crazing (dunting as it is called when it occurs immediately after the firing process and is caused by too rapid cooling) may develop over time as the terra cotta is exposed to the weather. When a terra cotta unit first comes from the kiln after firing, it has dried to its smallest possible size. With the passage of time it expands as it absorbs moisture from the air. The glaze then goes into tension because it has a lesser capacity for expansion than the porous tile body; it no longer "fits" the expanding unit onto which it was originally fired. If the strength of the glaze is exceeded by this expansion, the glaze will crack or craze (sometimes called moisture crazing). Unless the cracks visibly extend into the porous tile body beneath the glaze, crazing should not be regarded as highly serious material failure. It does, however, tend to increase the water absorption capability of the glazed terra cotta unit.

Crazing can also occur on the surface of concrete, generally due to its expansion and contraction, or by excessive water or improper trowelling of a too-rich mix.

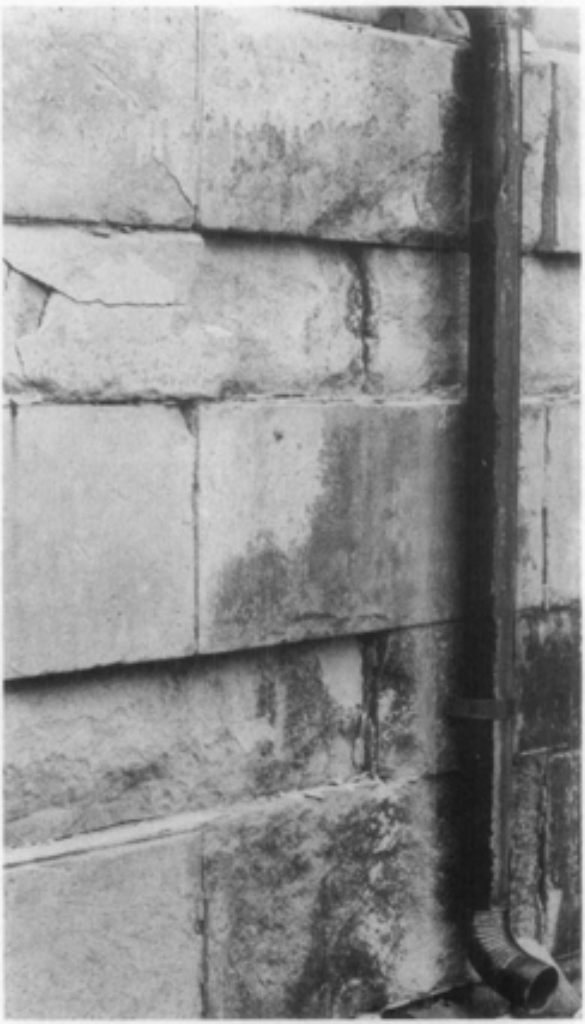
Preservation Treatment: To date, no completely effective treatment has been developed for this condition.

Crazing of glazed terra cotta. Photograph: National Park Service.

Crumbling

This condition is indicative of a certain brittleness or tendency of the masonry to break up or dissolve. It may be caused by an inherent weakness of the masonry and gradual dissolution of the binder, or it may be the result of external factors affecting the strength or durability of the masonry, such as salts or moisture entering the masonry.

Preservation Treatment: See Consolidation, p.52.



Crumbling limestone resulting primarily from excess moisture penetration. Photograph: National Park Service.

Delamination

A condition of stone in which the outer surface of the stone splits apart into laminae or thin layers and peels off the face of the stone. Because of their layered composition, this may be a natural condition of sedimentary stones such as sandstone or limestone; and the presence of clay-rich layers can accelerate the process. Delamination differs from spalling in that it is a condition confined to natural, primarily sedimentary, stone and is not a condition that occurs in manufactured products, such as brick.

When sedimentary stones are used in building, this tendency to peel off in layers can be exacerbated by improperly laid stones. Delamination takes place along the natural bedding planes of the stones when they are laid vertically, instead of horizontally—the correct way—and, as a result, are exposed to weathering.

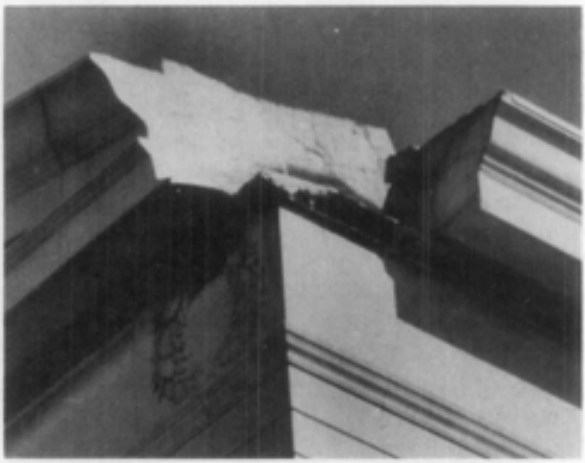
Preservation Treatment: See Stucco, p. 33; Composite Patching/Plastic Repair, p.50; Mechanical Repair, p.58; Replacement/Patching with Like or Compatible Substitute Materials, p.59.

Delamination of sandstone along the bedding planes. Photograph: U.S. Corps of Engineers.

Detachment

The result of a complete break (or failure of an original construction joint) in which the detached portion of masonry survives intact.

Preservation Treatment: See Mechanical Repair, p.58.



Detachment of section of marble pediment. Photograph: Walter Smalling.

Section of marble lying on the ground at base of building after it had separated from pediment above. Photograph: Walter Smalling.

Efflorescence

A whitish haze of soluble salts on masonry generally caused by excessive "pulling" of soluble salts into the masonry and out through the surface. Capillary action may pull soluble salts which result in efflorescence from the ground into the masonry, such as chlorides from salting of streets and sidewalks in winter and nitrates from fertilizers. In addition, carbonates from lime mortar and air-borne or water-deposited pollutants in the atmosphere may cause sulfates to be deposited on the surface of the masonry. Sulfates resulting from the curing and firing process are a common source of efflorescence in brick. Finally, efflorescence may be a combined salt residue left on the masonry surface by chemical cleaning, too strong a chemical solution, or improper rinsing.

Efflorescence itself may be more unsightly than harmful, but its presence on an older or historic masonry building often serves as a warning, indicating that water has found a point of entry into the structure. Once this has occurred, more serious damage can usually be predicted. Efflorescence may also indicate salt accumulations under the surface of the masonry (subflorescence) which are potentially damaging to the masonry, and are most definitely a matter of concern.

Preservation Treatment: See Poulticing, p.44; Water Washing, p.46.

Efflorescence and spalling on brick wall. Photograph: Anne E. Grimmer.

Erosion

Wearing away of the surface, edges, corners or carved details of masonry slowly and usually by the natural action of wind or windblown particles and water. Erosion is one of the most serious kinds of adobe deterioration.

Preservation Treatment: See Replacement/Patching with Like or Compatible Substitute Materials, p.59.

Differential erosion of sandstone steps follows bedding planes of greater and lesser resistance. Photograph: Anne E. Grimmer.

Exfoliation

Exfoliation, like delamination, is a term primarily used to describe natural stone deterioration. Peeling, scaling or flaking off of the surface of stone in thin layers is caused by the expansion and contraction of trapped moisture, by chemical action such as rusting of metal, or by weathering. Exfoliation most often occurs along natural bedding planes, resulting in an unevenly layered surface. Incorrectly laid stones with their bedding plane laid up parallel or perpendicular to the surface of the building thus have a natural tendency to exfoliate faster, following the lines of the bedding planes.

Preservation Treatment: See Stucco, p.33; Composite Patching/Plastic Repair, p.50; Mechanical Repair, p.58; Replacement/Patching with Like or Compatible Substitute Materials, p.59.

Exfoliation of sandstone. Photograph: Anne E. Grimmer.

Flaking

Flaking is an early stage of peeling, exfoliation, delamination or spalling, and is best explained as the detachment of small, flat, thin pieces of the outer layers of stone from a larger piece of building stone. Flaking is usually caused by capillary moisture or freeze-thaw cycles that occur within the masonry. The application of a water-repellent coating may result in flaking of the masonry when trapped moisture is forced to the surface.

Flaking also commonly occurs in masonry coatings, such as paint, or stucco, and results from a loss of adhesion between the coating and the masonry substrate.

Preservation Treatment: To date, no completely effective treatment has been developed for this condition.

Flaking of granite. Photograph: Baird M. Smith, AIA.

Friability

An inherent characteristic of some types of stone, particularly sandstone or limestone, which have a tendency to break up, crumble or powder easily.

Preservation Treatment: See Consolidation, p.52.

Friability in limestone. Photograph: Anne E. Grimmer.

Peeling

Peeling of stone may be caused by an inherent defect in the surface of the masonry or the result of weathering. Improper application of a masonry coating may result in a lack of adhesion to the substrate, and cause the surface of the masonry or coating to flake or peel away from the substrate in strips or layers.

Peeling may also describe a condition of terra cotta in which the glaze or slip has separated from the body of the terra cotta unit. It may be caused when slip is applied to a terra cotta unit that is too dry or a glaze is applied too thickly or to a dusty surface.

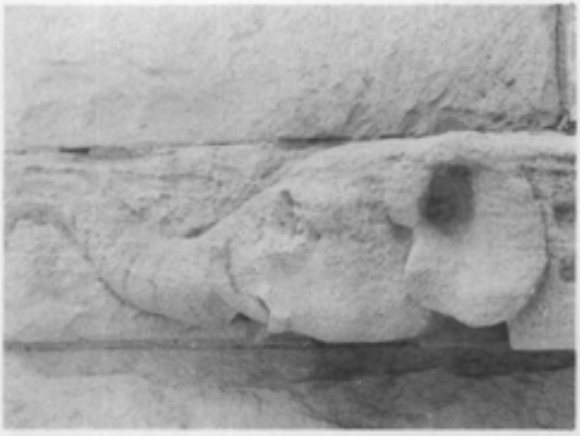
Preservation Treatment: To date, no completely effective treatment has been developed for this condition.

Peeling of granite. Photograph: Baird M. Smith, AIA.

Pitting

The development or existence of small cavities in a masonry surface which may be caused by the differential removal of individual components of the masonry and may be the result of natural weathering or erosion of an inherently porous type of masonry. Pitting may also result from a harsh or abrasive cleaning method. Pitting of concrete can be caused by improper mixing, and usually occurs during the curing period.

Preservation Treatment: To date, no completely effective treatment has been developed for this condition.



Pitting of limestone. Photograph: John H. Myers.

Rising Damp

The suction of groundwater into the base of masonry walls through capillary action is called rising damp. Moisture is drawn up into the building walls and released at the interior and exterior surfaces where a horizontal wet stain or tidemark is left. The moisture often carries with it salts in solution, which can result in efflorescence and lead to deterioration of masonry, plaster, wood and paint. Rising damp, often the result of improper drainage, is a problem common to many older masonry structures, and one that is difficult to solve completely.

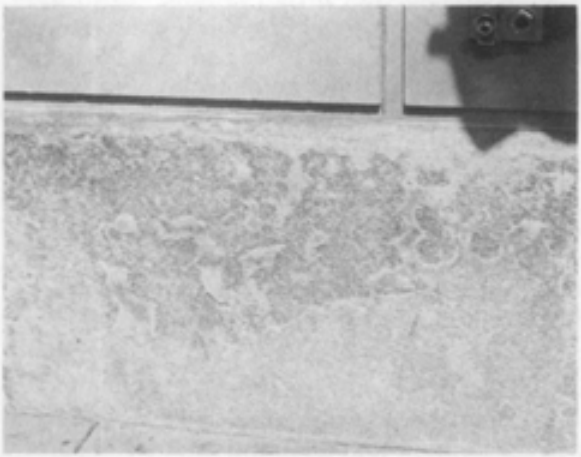
Preservation Treatment: See Dampproof Course, p.54.

Rising damp evidenced on parged foundation. Photograph: John Stubbs.

Salt Fretting

Sometimes called salt erosion, this condition results in an obvious pattern of erosion or etching of the stones caused by salt, usually from the salting of icy sidewalks. Unless the use of de-icing salts is discontinued, this condition can eventually result in spalling and exfoliation of the stone surface.

Preservation Treatment: To date, no completely effective treatment has been developed for this condition.



Salt fretting on granite base probably resulting from use of de-icing salts on sidewalk. Photograph: Anne E. Grimmer.

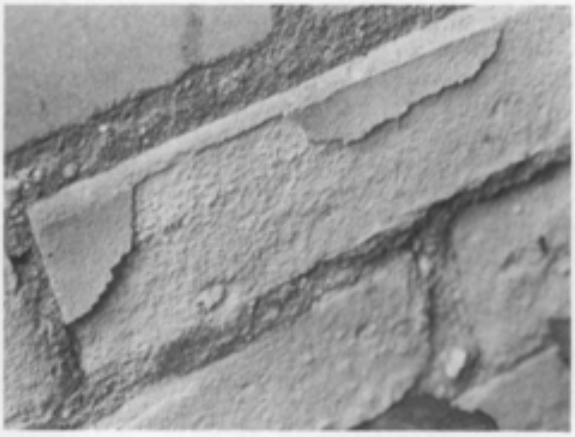
Spalling

A condition of masonry in which the outer layer or layers begin to break off (unevenly), or peel away in parallel layers from the larger block of masonry. Unlike exfoliation and delamination, spalling is not confined to natural stone, but is also common to brick, and other fabricated masonry materials such as cement products and terra cotta. Spalling is usually caused by the pressure of salts and freeze-thaw cycles of moisture trapped under the surface (subflorescence) which forces off the outer surface or layers of masonry. Spalling can also result from improper laying of stone, exposing bedding planes to weathering and consequent accelerated deterioration, or can be caused by improper repointing techniques utilizing too hard a mortar which does not allow for expansion and contraction of the masonry blocks, thus causing pieces or edges of the masonry blocks to chip or spall off. Improper cleaning techniques, especially abrasive methods, may remove the outer protective layer of brick, terra cotta, or stone, thereby hastening deterioration and spalling of masonry.

Spalling of terra cotta is of two types: glaze spalling and material spalling. Both are the result of air-borne water or water from other sources being trapped behind the glazed surface of the clay. When the water builds up in sufficient pressure to cause expansion of the clay body, the relatively impervious glaze prevents the water from escaping, and the glaze will blister or pop off from the clay surface (glaze spalling), or the clay body itself may fracture or disintegrate (material spalling). Spalling in terra cotta, as in other types of masonry, may also be caused by deterioration of the internal anchoring system which holds the units to the building structure. Water infiltration causes the metal anchors or metal reinforcement to rust which in turn creates increased internal pressure in the masonry units or concrete, resulting in spalling, and potential failure of the structural system if the anchoring fails completely.

Preservation Treatment: See Stucco, p.33; Water-Repellent Coating, p.36; Composite Patching/Plastic Repair, p.50; Consolidation, 52

p.50; Replacement/Patching with Like or Compatible Substitute Materials, p.59.



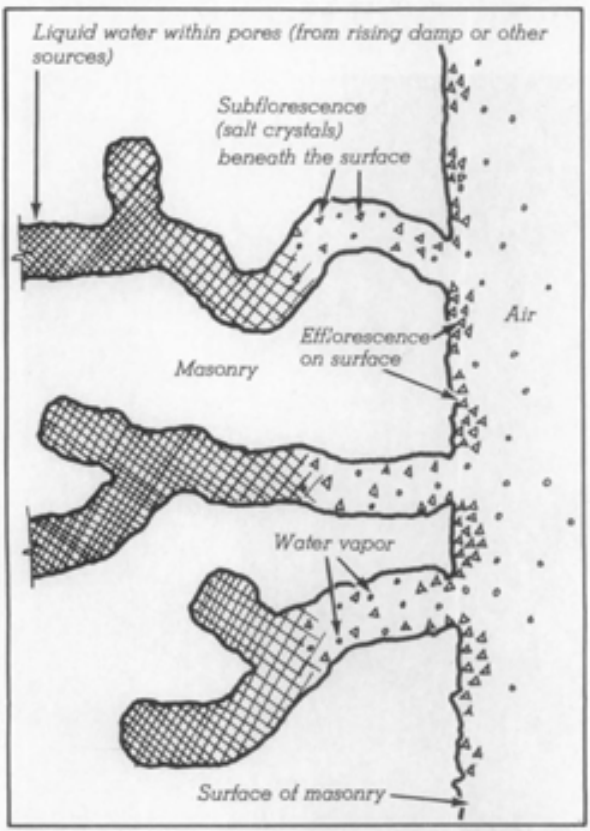
Spalling of brick. Photograph: Susan Dynes.

Glaze spalling of glazed terra cotta. Photograph: John H. Myers.

Subflorescence

Subflorescence is a potentially harmful accumulation, or hidden build-up, of soluble salts deposited under or just beneath the masonry surface as moisture in the wall evaporates. Particularly during the freeze-thaw cycle, the moisture and salts in the wall freeze and expand, building up pressure within the masonry, which, if sufficient, may cause parts of the outer surface of the masonry to spall off or delaminate. External signs of efflorescence may indicate the presence of subflorescence beneath the surface. (Subflorescence is sometimes referred to as cryptoflorescence.)

Preservation Treatment: See Dampproof Course, p. 54.

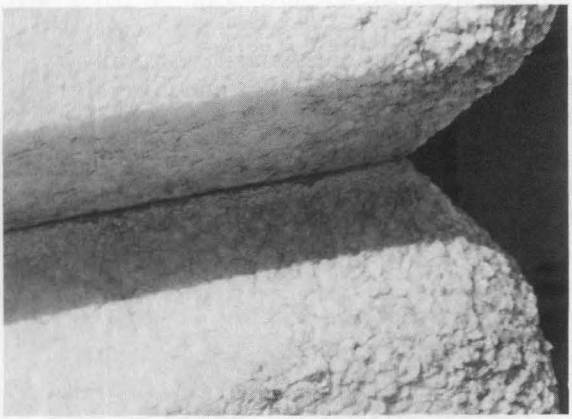


Salts dissolved in water drawn into stone through capillary action evaporate as subflorescence beneath the surface of the stone, and may be evidenced on the stone surface as efflorescence. Illustration: Christina Henry.

Sugaring

A characteristic of some masonry indicative of gradual surface disintegration, possibly caused by salts dissolved in and transported through the stone by moisture and consequent dissolution of the binder. Carbonate stones, especially fine grained marble, are particularly susceptible to this granular, sometimes powdery condition.

Preservation Treatment: See Consolidation, p.52.

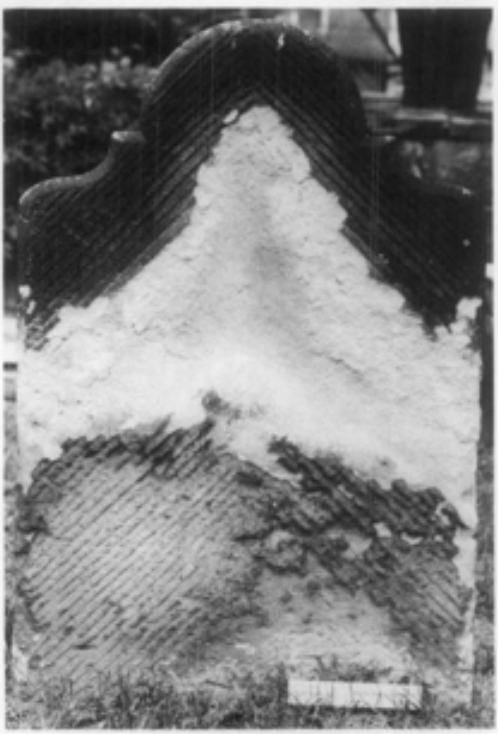


Sugaring of marble. Photograph: Anne E. Grimmer.

Surface Crust/Surface Induration

The movement of moisture toward the surface of stone and the outer edges results in the formation of a hard crust on the surface parallel to the worked surface. Some of these crusts, particularly if they are calcitic in nature, can provide a protective surface to the stone. Other such crusts resulting from a chemical reaction of the stone to airborne pollutants leading to the dissolution of, and migration of, cementing material from within the stone, may be temporary and, in fact, could be indicative of impending disintegration of the stone (especially sandstone), when the disintegrating block of stone through spalling or exfoliation is itself creating this temporary and superficial surface. (Sometimes this phenomenon is referred to as surface hardened or quarry crust.)

Preservation Treatment: To date, no completely effective treatment has been developed for this condition.



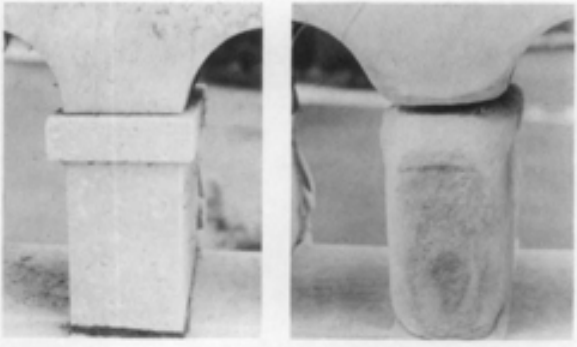
Surface crust on sandstone resulting from dissolution of the stone. Photograph: Erhard M. Winkler.

Weathering

The natural disintegration and erosion of stone caused by wind and rain, resulting in granular and rounded surfaces. Weathering is particularly pronounced on sharp corners, or highly carved or projecting architectural details. Acid rain water in particular, in contact with acid soluble, carbonate stone, can be very damaging, increasing the natural weathering rates, and also resulting in noticeable softening or loss of masonry details.

Honeycomb or alveolar weathering is a type of erosion common to sandstones and limestones, and other non-homogeneous masonry materials. It is characteristic of arid climates, but may also be found in more humid areas. Cavities (alveoles) are created in a honeycomb pattern on surfaces exposed to strong winds where evaporation of salts occurs directly below the surface.

Preservation Treatment: Replacement/Patching with Like or Compatible Substitute Materials, p.59.



Weathering has reduced the formerly sharp edges and rounded the corners of this marble baluster. Photograph: John H. Myers.

Part 2
Preservation Treatments

The preservation treatments defined in Part 2 are divided into two general categories: *Maintenance* (such as application of surface coatings, caulking and cleaning); and *Repair* (such as consolidation, plastic repair or patching/replacement). *Maintenance* treatments described and illustrated include those basic day-to-day practical and preventive procedures that should be carried out in an effort to preserve historic building material and prevent the need for repairs. *Repair* treatments imply that a greater degree of intervention into the historic fabric is necessary and thus describe and illustrate techniques which must be undertaken when regular maintenance treatments are not adequate to halt deterioration. Often, there simply is no effective preservation treatment that has been developed to date that can be recommended; however, where an appropriate treatment has been developed for a specific masonry problem that is defined and illustrated in Part 1, it is referenced in the Part 2 text.

The reader should be aware that Part 2 includes a number of treatments (such as abrasive cleaning and the application of a water-repellent coating) which are not generally recommended preservation treatments for historic masonry. Such treatments have been included here in an effort to be as comprehensive as possible, and because they may occasionally be recommended preservation treatments, if applied under appropriate professional supervision.

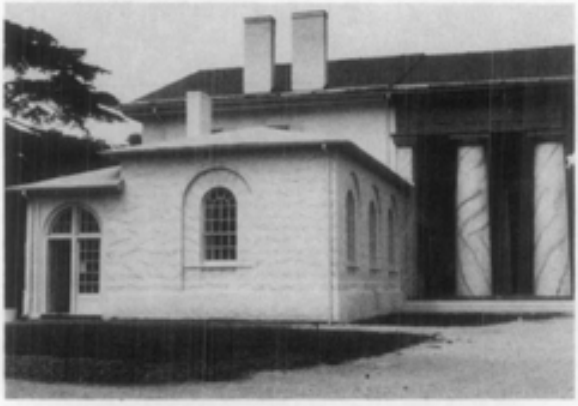
Maintenance

Application of Surface Coatings

Paint

Any pigmented liquid, liquefiable, or mastic composition designed for application to a substrate in a thin layer which is converted to an opaque solid film after application. Paint is generally applied as a protective coating to poor quality or porous masonry to keep out moisture; it may also be used purely for decoration on a historic building.

Paint applied to masonry may be solvent or water based, or may be a masonry paint of a slightly cementitious nature specially formulated with various types of aggregate or thickening agents to smooth rough or uneven masonry walls. Color washes based on lime, such as whitewash, although not technically considered to be paint, and color stains which do not form a film on top of the masonry, but instead penetrate into the masonry substrate, have traditionally provided many of the same benefits as paint.



Paint used as a purely decorative aspect to simulate marble on a stucco surface. Photograph: National Park Service.

Parging/Pargeting

In masonry construction, a thin coat of cement mortar (often containing dampproofing ingredients) applied to provide a smooth surface for rough masonry, or as a dampproofing measure for rough masonry, foundation and basement walls. In Great Britian, parging or pargeting describes the traditional decorative plastering of the exterior, including timbers, with a tough lime plaster reinforced with oxhair and decorated with impressions or patterns made with a mold or comb.

Parging over brick. Photograph: National Park Service.

Stucco

An exterior finish for masonry or frame walls, usually composed of cement, sand, and hydrated lime, which, when mixed with water and applied wet to a surface, adheres to it and subsequently sets or hardens, preserving in a rigid state the form or texture imposed during the period of elasticity. This term was originally used for all plasterwork, but now is generally confined to smooth plastering on the outside of a wall. Stucco was originally made with lime and sand, or gypsum plaster, often with the addition of mud, animal hair or other fibrous material to give color and/or body to the stucco mixture. Stucco is the term given to exterior plasterwork, which in some geographical regions may still be called plaster, in part to differentiate traditonal stucco (plaster) from the more common type used today which is composed primarily of portland cement and sand. Historically, stucco was generally smooth surfaced, and often scored to imitate ashlar; however, sometimes rough cast and pebble-dashed surfaces may also be included in the category of stucco.

Rendering is a term frequently used in Great Britain to mean stucco or coats of mortar applied to an external wall to produce a smooth surface and to prevent rain penetration. When referring to exterior or interior plastering, "render" can also mean the first thick or coarse coat of plaster on a wall, usually followed by a second or third finishing coat.

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Stucco scored to resemble blocks of stone. Photograph: Anne E. Grimmer.

Stucco (continued)

Rendering can also mean the process of applying stucco with a trowel or float.

If **delamination, exfoliation,** or **spalling** is present, the application of a stucco coating may be an appropriate repair treatment for stone. First, however, try to determine the source of the problem, and eliminate that if possible. While there are no satisfactory treatments known to prevent further spalling, there are a number of repair techniques available which may be successful. Depending on the cause and the degree of severity of the spalling, one option is to cover the deteriorated stone surface with a stucco coating which can be painted and scored to resemble the original masonry material.

Waterproof Coating

These coatings seal the masonry surface from both liquid water and water vapor; they may be clear or opaque—and include bituminous coatings such as those applied to building foundations, and also some paints. They generally do not cause problems as long as they exclude all water from masonry, but if water does enter the wall, the coating can intensify the damage to the wall because the water will not be able to escape. Basically, waterproof coatings make a surface *impervious* to water.

A neoprene coating over a limestone cornice has trapped water (which entered through leaks in the parapet) inside these stone dentils. The built-up water pressure has finally forced the coating to pop off, taking with it pieces of the stone. Photograph: National Park Service.

Water-Repellent Coating

A clear coating which keeps liquid water from penetrating the surface but allows water vapor to enter and leave through the "pores" of the masonry; although usually colorless or transparent (such as silicone coatings), they may change the reflective property of the masonry, and therefore change its visual qualities or appearance. Since these coatings do not seal the surface against water vapor, it can enter and leave the wall. But once inside the wall, the water vapor can condense into liquid water, which will not be able to get back out through the water-repellent coating. Trapped inside the masonry by the water-repellent coating, this liquid water may do considerable damage to interior finishes, or if it freezes,to the exterior. Water-repellent coatings create a surface that *repels* water.

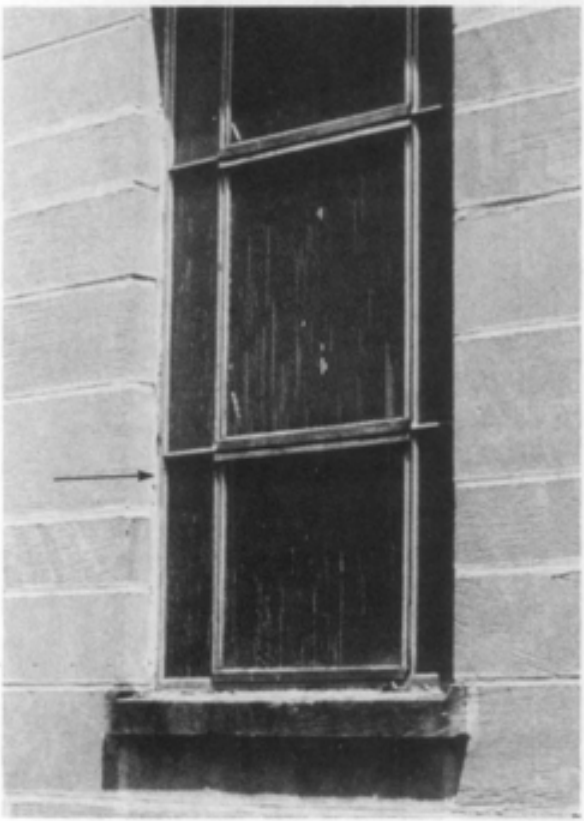
If **spalling** is present, and depending on the cause and the degree of its severity, the application of a water-repellent coating to a *limited* area, may—in some instances—serve to slow down the rate of deterioration. This treatment should only be employed when the masonry is completely dry before the water repellent is applied, when water is prevented from reentering, and when all other remedial techniques have been investigated. The application of a water-repellent coating will not, however, prevent further spalling and would be, at best, a temporary solution.

A water-repellent or waterproof coating should never be applied to an already damp or wet building which may be likely to have **subflorescence** under its surface. Such a coating would further prevent the excessive moisture (and dissolved salts) within the wall from evaporating out through the walls, thereby almost ensuring that the walls retain the water and salts, and thus increasing the possibility of spalling.

Water-repellent coating improperly applied gives a blotchy appearance to the stonework. Photograph: Walter Smalling.

Caulking

A resilient (semi-drying or slow-drying) mastic compound, usually of a synthetic composition such as silicone or acrylic, used to seal cracks, fill joints, prevent leaks and, in general, provide weatherproofing and waterproofing. Most caulking materials used today are non-historic materials (i.e., synthetic) and are used primarily in new construction. Caulking should not be used as a substitute for mortar in repointing; however, it does have some useful application on historic masonry, to seal between materials of different coefficients of expansion, such as caulking around wood or metal windows on a masonry building.



Caulking used as weatherproofing between window frame and masonry wall. Photograph: National Park Service.

Cleaning Methods

Abrasive Cleaning

Abrasive cleaning methods include all techniques that remove soil, discolorations or coatings. Such techniques involve the use of certain materials which impact and abrade the surface under pressure, or abrasive tools and equipment. Sand, because it is readily available, is probably the most commonly used type of grit material. However, many other materials may be substituted for sand and all can be classified, in varying degrees, as abrasive substances: ground slag or volcanic ash, crushed (pulverized) walnut or almond shells, rice husks, ground corncobs, ground coconut shells, crushed eggshells, silica flour, synthetic particles and glass beads, to name a few. Even water under pressure can be an abrasive substance. Tools and equipment that are abrasive and damaging to historic building materials include wire brushes, rotary wheels, power sanding disks and belt sanders.

The use of water in combination with grit may also be classified as an abrasive cleaning method. Depending on the manner in which it is applied, water may soften the impact of the grit, but water that is too highly pressurized (over 400 psi) can itself be very abrasive to historic masonry. There are basically two different methods which can be referred to as "wet grit." One technique involves the addition of a stream of water to a regular sandblasting nozzle, done primarily to cut down dust, and has very little, if any, effect on reducing the cutting action of the grit particles. With the second technique, a very small amount of grit is added to a pressurized water stream. This method can be somewhat gentler, its abrasive action controlled by regulating the water pressure and the amount of grit fed into the water stream. Other more euphemistic terms, such as "hydrosilica blasting" or "silica dusting," are used to refer to some abrasive cleaning methods, usually sandblasting.

Abrasive cleaning is generally not an acceptable cleaning method for historic masonry buildings except in a few very limited, and carefully controlled situations.

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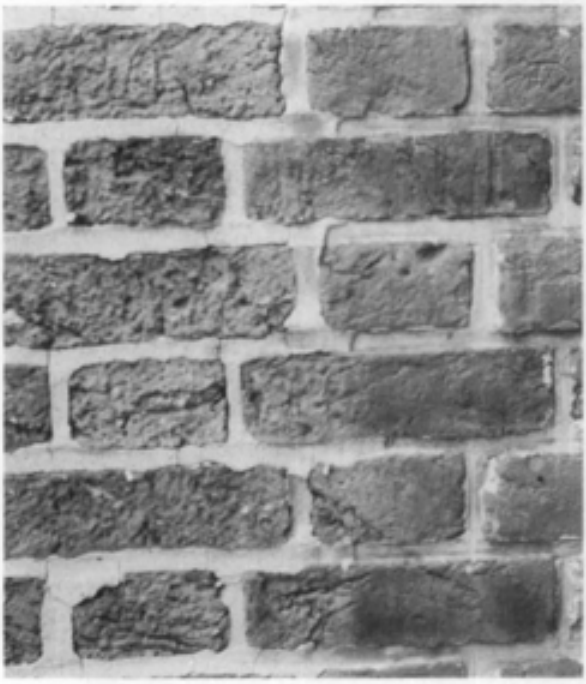
Abrasive Cleaning (continued)



Photograph: National Park Service.

Chemical Cleaning

Chemical cleaners for historic masonry buildings are of two types: acidic (low pH) cleaners which are formulated for use on *most* granite, slate, sandstone, and all non-calcareous stones, and unglazed brick; and alkaline (high pH) cleaners which are used on acid-sensitive masonry materials, such as limestone and marble, glazed brick and glazed terra cotta. Common to both types of chemical cleaners is the inclusion of surfactants (organic compounds with powerful properties of detergency and wetting). Acidic cleaners must be removed from the masonry by a thorough water rinse or a "neutralizer." Alkaline cleaners are rinsed off in a two-part process: first they are given a slightly acidic wash, then a thorough water wash.

Although chemical cleaning is generally an acceptable technique for cleaning historic masonry buildings, and certainly the most effective and least damaging method of removing paint, if not carried out with adequate precautions, it can also be damaging to historic masonry. Some of the potential hazards of chemical cleaning include inappropriate or too strong a chemical solution, cleaning during cold weather or when there is a possibility of frost, insufficient rinsing of the masonry after application of the chemical mixture, and environmental or health hazards.

Chemical cleaning to remove urban dirt and pollution from granite without causing damage or abrasion to the surface of the stone.
Photograph: H. Ward Jandl.

Paint Removal

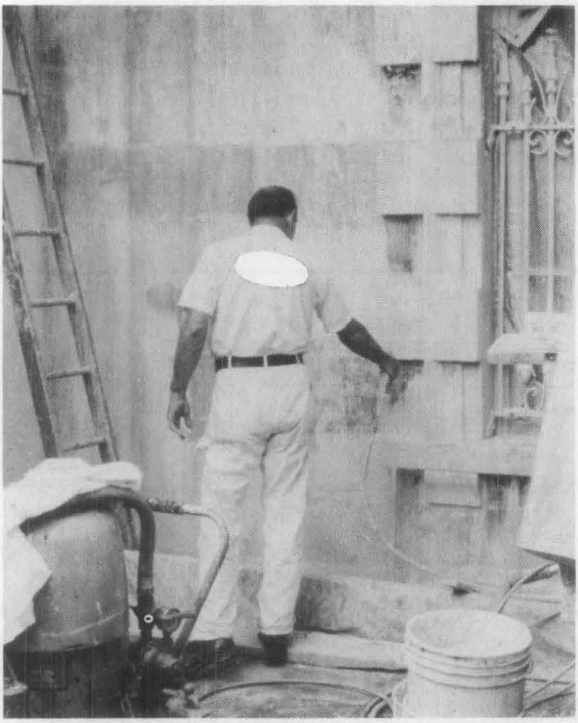
Total paint removal from masonry can usually be accomplished only with the application of chemical paint removers containing either alkalis such as sodium or potassium hydroxide, or organic solvents such as methylene chloride or combinations of other solvents. The dissolved paint is then rinsed from the masonry using a low pressure water wash. Most of these commercially prepared paint strippers also contain a thickening agent or gel that enables the remover to cling to a vertical surface.

Most paints are soluble in organic solvents; paints which have a linseed oil binder are also soluble in alkalis. Some other coatings, such as lime washes (including whitewash or color wash), are soluble in acid. None of these paint removal methods is without problems, however. Both organic solvents and alkalis can be dangerous to cleaning personnel. Organic solvents are expensive, and can also spread stains deeper into the masonry (unless used in poultice form—not always a practical method if removing paint from large areas); alkali-based cleaners can cause efflorescence unless the masonry surface is pre-soaked, and after cleaning, is thoroughly rinsed with water. Sometimes after cleaning the surface must be neutralized by rinsing with a mild acidic solution such as acetic acid, or brownish stains may occur if there are any iron compounds in the stone. Acidic cleaners can also result in efflorescence, or yellow staining, and can cause considerable damage to adjacent shrubbery, metalwork and glass.

Because of the problems inherent in any chemical removal of paint from masonry, it is not advisable to undertake such a project without first weighing the pros and cons of total paint removal, and of course, carrying out tests in an inconspicuous location on the building. Limited paint removal or removal of excess layers of paint or badly peeling paint in preparation for repainting, should be carried out by hand using natural bristle brushes and hand scrapers.

Paint which is significant as a historic finish should not be removed from those buildings which were painted initially or soon after con-

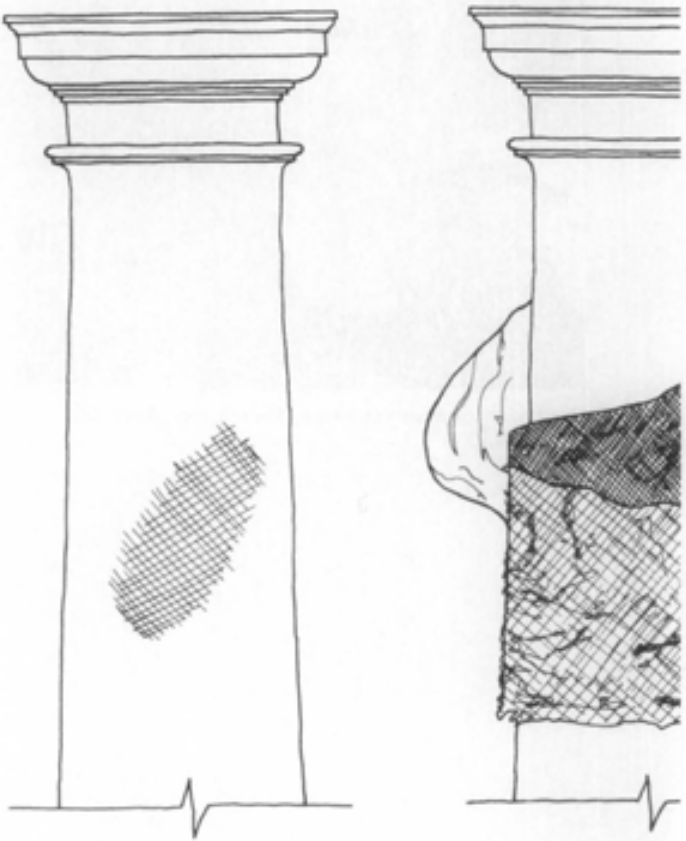
struction, either for aesthetic reasons or to protect inherently poor quality brick.



Paint removal from sandstone. Photograph: Baird M. Smith, AIA.

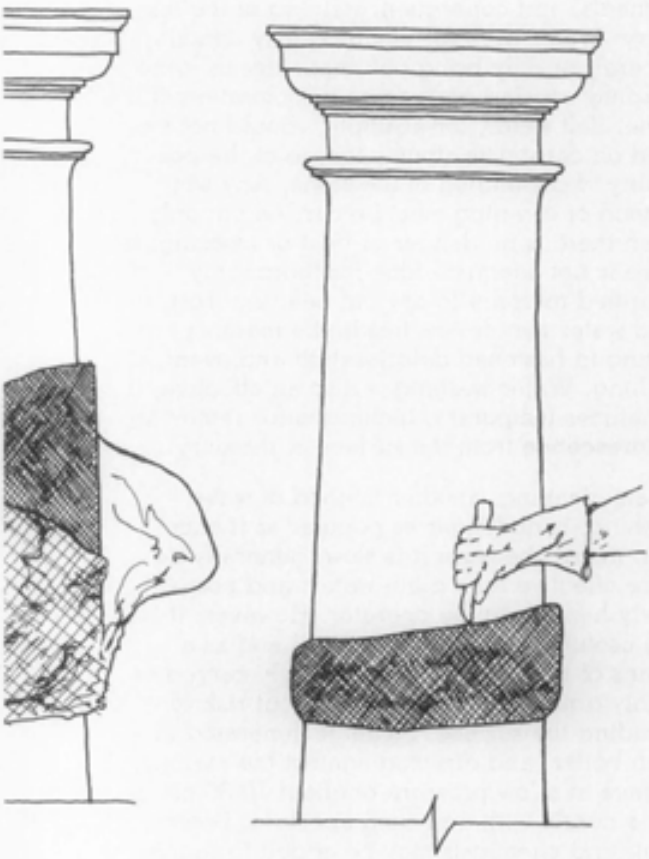
Poulticing

A technique used for cleaning or removal of stains from porous masonry. The principle of poulticing is to draw the stain out of the masonry, to be reabsorbed by the poultice material, while other cleaning methods would just tend to redeposit the stain in the masonry or push it deeper into the masonry. A poultice is composed of an absorbent material, such as



Poultice is applied (saturated with solvent appropriate to remove particular stain). Polyethylene sheet prevents too rapid drying of poultice. After poultice has dried out, the

talc, fuller's earth, whiting, or even shredded paper that has been saturated with a solvent chosen to dissolve the specific type of stain. Poultices may be successfully applied to remove such stains as: oil, tar, plant materials (lichens and algae), graffiti (including spray paint), metallic stains such as iron and copper, and occasionally, some types of salt deposits or **efflorescence.**

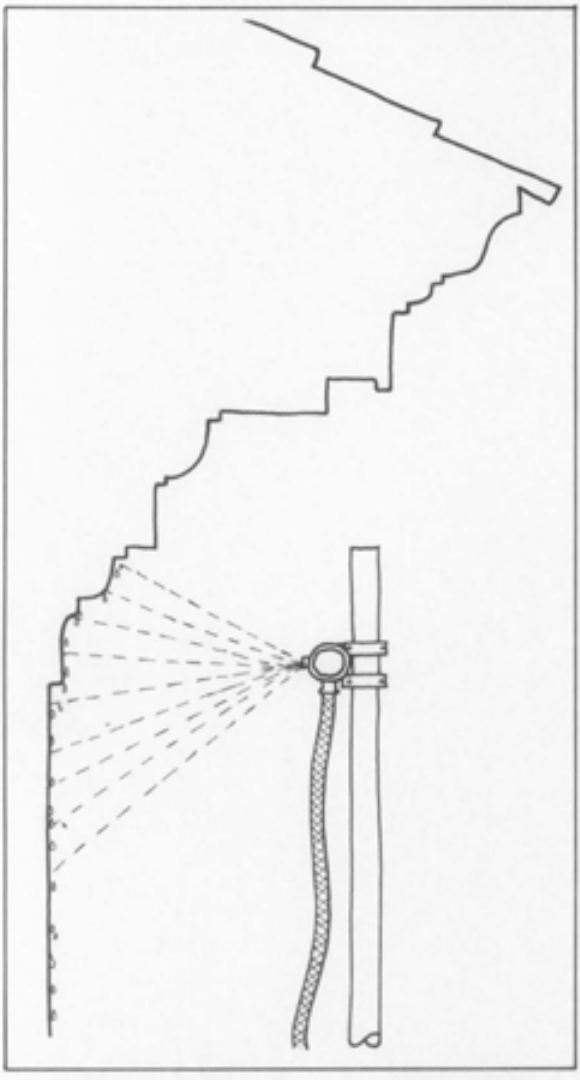


pack is removed carefully by hand with the aid of wooden spatulas. Finally, the column is rinsed with water. Illustration: Christina Henry.

Water Washing

Water washing may be the most versatile and gentle technique used for cleaning, or dirt removal, from historic masonry buildings. Different water washing methods include: prolonged spraying using a fine mist, high or low pressure washes, steam, water in combination with detergents, and water in combination with chemicals. But even simple water-based cleaning procedures and high pressure (over 400 psi) water blasting can damage historic masonry. The large quantities of water necessary to clean a large structure can seep into the masonry, often causing corrosion of hidden metal elements, and consequent staining of the masonry. Water used for cleaning may contain minerals or may bring out impurities in stone masonry causing permanent discoloration of the stone. Soft water, for example, should not be used on carbonate stone because of the possibility of dissolution of the stone. Any wet method of cleaning must be carried out only when there is no danger of frost or freezing; if there is not adequate time for thoroughly saturated masonry to dry out before a frost, liquid water may freeze inside the masonry, resulting in hastened deterioration and eventual spalling. Water washing is also an effective, if sometimes temporary, technique for removing **efflorescence** from the surface of masonry.

Steam cleaning, another method of water washing, is no longer as popular as it once was, in part because it is slow, generally no more effective than plain water, and poses safety hazards to the operator. However, it is still useful in some stain removal and as a means of removing dirt from highly carved or highly ornamented surfaces without risk of abrading the surface. Steam is generated in a flash boiler, and directed against the masonry surface at a low pressure of about 10-30 psi using a nozzle with a ½ inch aperture. Detergents and chemicals may be added to supplement the cleaning power of the steam.

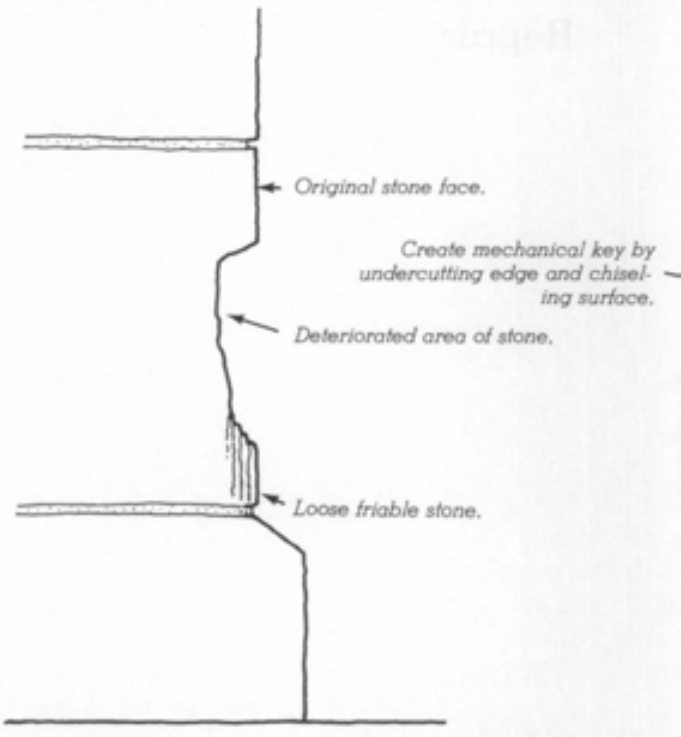


Water washing over an extended period of time using a fine spray or mist to gently soften areas of heavy dirt deposit. Water is sprayed through holes of a pipe or hose suspended from above area being washed. Illustration: Christina Henry.

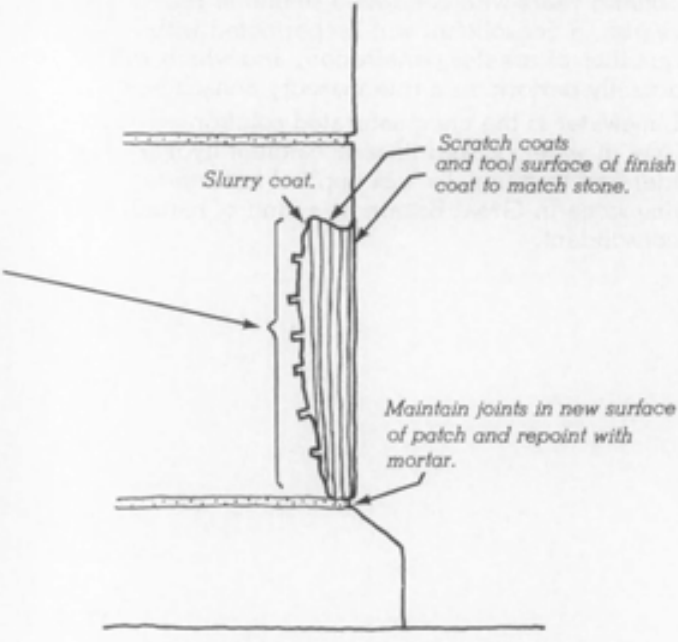
Repair

Composite Patching/
Plastic Repair

A repair treatment carried out by patching selected areas of deteriorating masonry with a cementitious material. Plastic repair can be quite successful if limited to small cavities or small areas of missing stone (no larger than 1-3 inches deep). If carried out by a skilled workman, plastic repair can sometimes be less obtrusive than a replacement in natural stone, and much cheaper. Mixes vary according to the type of masonry being repaired, but are based on a cementitious mix, and should always be weaker than the masonry being repaired. Sand and/or crushed stone is the usual aggregate. Some artificial coloring may be needed to make the patch blend in with the historic masonry, but it may reduce the strength of the repair and the color may fade. While larger patches may seem to require ad-



ditional support, in the form of stainless steel or polyester pins or anchors, use of such supplementary devices is not always very satisfactory. Successful composite patches should match the stone in color and texture, replicate surface tooling, adhere well to the stone substrate, and should not cause deterioration of surrounding stone. In comparison with natural stone, plastic repairs can look rather dull and lifeless, and for this reason also, should be used only in small areas; however, such repairs can sometimes be painted to match adjacent areas of masonry. If composite patching or plastic repairs are carried out using too hard a mix, they may not adhere, or may accelerate weathering and deterioration of the adjacent natural stone, partly because of the different rates of expansion. This type of repair may also be referred to as dental repair, and is sometimes appropriate for **delamination, exfoliation,** or **spalling.**

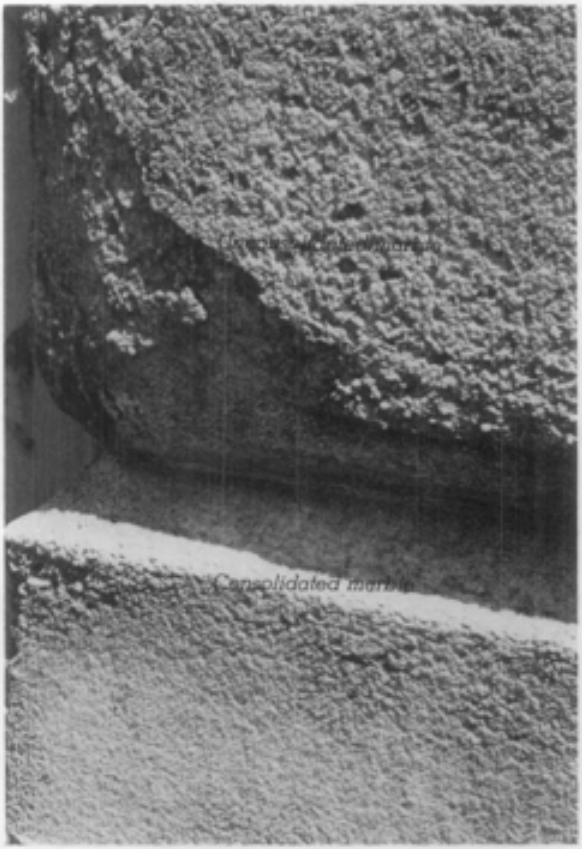


Shape cementitious patching material to match original profile of stone. Maintain joints in new patched surface and repoint with mortar. Illustration: Christina Henry.

Consolidation

Consolidation is a process carried out in a effort to strengthen masonry, particularly natural stone and concrete and is generally undertaken in an attempt to bring back together or consolidate deteriorating or disintegrating masonry (through **crumbling, friability, spalling,** or loss of binder in **sugaring**). Consolidation generally involves application of an inorganic substance such as barium hydroxide or injection of some type of a chemically-curable monomer such as methyl methacrylate and n-butyl methacrylate or a clear silicone polymer such as the group of silanes, silicones, alkoxysilanes, and silicone esters. Silicone surface coatings, wax or other water-repellent coatings are also often tried as consolidants—often without success. The difficulty or near impossibility of achieving a deep enough penetration or impregnation of the masonry with a consolidant makes the application of consolidants of somewhat dubious value at this time. However, it is anticipated that in coming years with continued scientific research, a consolidant will be perfected with qualities of greater penetration, and which will actually perform as a true masonry consolidant.

Limewater is the clear saturated solution of lime in water (slaked lime or calcium hydroxide) and traditionally was applied to historic limestone in Great Britain as a kind of natural consolidant.



A barium hydroxide consolidant (nearly invisible in the photograph) has been applied here in an attempt to consolidate this sugaring marble. Photograph: Christina Henry.

Dampproof Course

Installation in masonry of a horizontal layer of material which is impervious to water, such as tile, slate, lead-cored bituminous sheet or bituminized felt, polyethylene sheeting, or metal, to prevent the capillary rise of moisture—**rising damp**—from the ground into the masonry wall. Historically, some masonry buildings were constructed with a dampproof course, but usually dampproof courses must be added later as a remedial measure to correct problems caused by rising damp. A traditional dampproof course is not installed without difficulty, as a continuous horizontal course must be cut out of the mortar or brick at a level just above the ground and below first floor joists, and the dampproofing material inserted in an uninterrupted horizontal course. This system

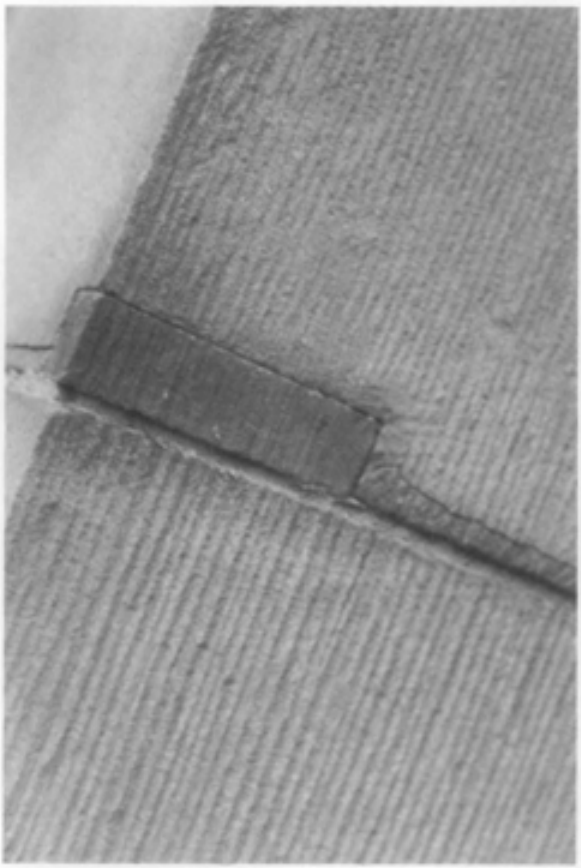
The horizontal row of white dots in the brick headers indicates that a chemical dampproof course has been injected. Photograph: Baird M. Smith, AIA.

can be utilized on walls that are regularly coursed and stable. If the mortar is severely deteriorated, the wall may be too unstable to cut out the joint without dislodging masonry units above. For walls more than eight inches thick, it may be necessary to work from both sides. Because of the difficulty of inserting this type of dampproofing, in recent years other techniques have been devised such as injection of a chemical dampproof course, insertion of a synthetic or plastic course, and a system based on electro-osmosis to create a dampproof barrier.

Some type of dampproofing treatment may be necessary to minimize **subflorescence,** or to eliminate the source of moisture which is carrying harmful salts into the building.

Dutchman Repair

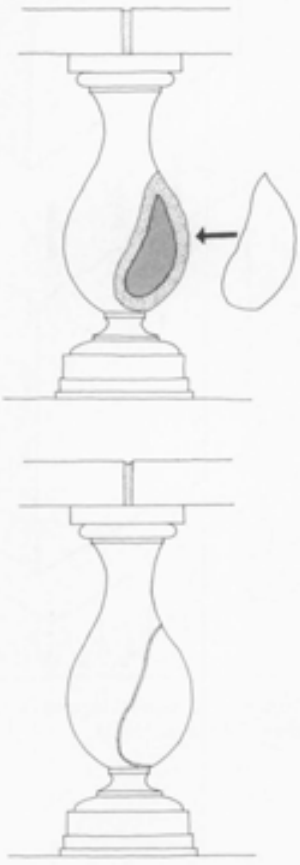
This type of partial replacement or "piecing-in" can be done either with natural stone or with a pre-cast imitation as a treatment for **chipping** stone. It involves replacing a small area of damaged stone with a new unit. The new stone is either wedged in place or secured with an adhesive. The joint between new and old should be kept as narrow as possible to maintain the appearance of a continuous surface.



Dutchman repair using sandstone to match original tooled sandstone. Photograph: Anne E. Grimmer.

Epoxy Repair

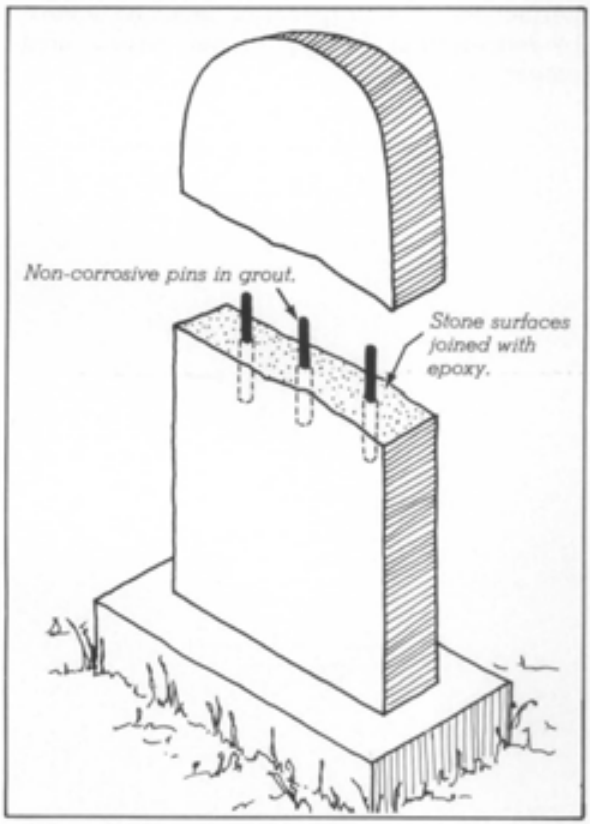
Repair carried out by patching selected areas of deteriorating masonry using an epoxy mixture, which is part of a class of synthetic, thermosetting resins which produce tough, hard, chemically resistant coatings and excellent adhesives. Epoxy resins can be used for repairing broken stones, and are particularly good for putting back together small, carved or other decorative details. Epoxies can also sometimes be used to repair small defects, imperfections, or thin pieces of detached stone by veneering or "gluing" on new replacement pieces.



Epoxy repair of broken terra cotta baluster in which epoxy is applied to the break. The broken piece is reattached and the joint smoothed so repair is not visible. Illustration: Christina Henry.

Mechanical Repair

This treatment may be defined as the use of cutting back, drilling, reinforcement pinning, and grouting methods to fasten together fractured masonry. This type of repair may be appropriate for use on the following kinds of deterioration: **cracking, delamination, detachment,** and **exfoliation.** Each of these problems merits a slightly different variation of mechanical repair.



Mechanical repair of detached tombstone using grout and pins. Illustration: Christina Henry.

Replacement/Patching with Like or Compatible Substitute Materials

The replacement of missing, broken, cracked or otherwise deteriorated historic masonry units with a new piece or pieces of the same material, such as stone, terra cotta, brick or adobe. This repair technique is generally preferable to repair with a non-matching or synthetic material, if suitable matching materials are available.

Areas of adobe that have been subject to **coving** should be patched with adobe, using clay with a texture and color close to the original, after improving the drainage and eliminating, if possible, the moisture problem. **Cracking** in adobe may be repaired using a procedure similar to repointing. It is necessary to rake out the cracks to a depth of 2 or 3 times the width of a mortar joint to obtain a good "key", and patch with adobe mud.

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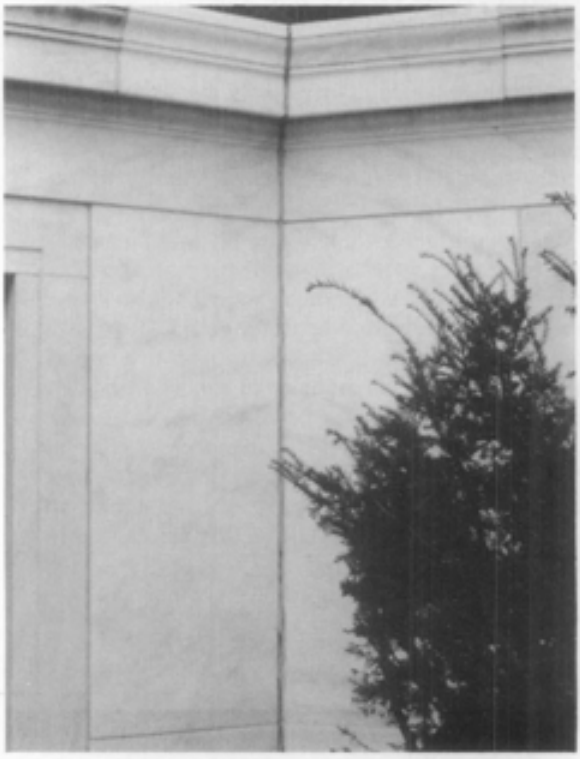

The two sections in the center have been replaced with marble matching the original. Photograph: Anne E. Grimmer.

Replacement/Patching (continued)

Once stone **delamination** or **exfoliation** has begun, there are at this time no methods of consolidation or of preventing further deterioration known to be completely successful. If the degree of delamination is only slight, it may be best to leave the stone as it is. In some instances however, there are several primarily cosmetic repair techniques which may be successful. If the block of stone is thick enough (and does not have decorative detailing), one method is to cut back the delaminating layers to sound stone, or another approach might be to remove the delaminating stones, then reverse and replace them on the facade. If these techniques are not feasible, it may be necessary to replace the deteriorating stone, either with matching stone, or a stone-like substitute (such as precast concrete or cast stone); or patch individual stones with a cementitious mixture; or cover the deteriorating stone facade with a stucco coating and scoring the surface to resemble blocks of stone, after cutting back to sound stone. Individual masonry units, badly damaged or disfigured by **chipping, erosion,** or **weathering,** may have to be replaced with a matching masonry material, an appropriate substitute material, or patched with a cementitious mixture.

Like delamination, there are no satisfactory treatments known to prevent further **spalling,** but there are a number of repair techniques available which may sometimes be at least temporarily successful. Depending on the cause, and the degree of severity of the spalling, there are a number of options. If deterioration is severe, the historic masonry can be resurfaced with natural stone or brick veneer; or the deteriorated masonry units patched with like or compatible substitute materials (such as cast stone or concrete).

Repointing/Tuckpointing

Repointing, or tuckpointing, is the process of removing deteriorated mortar by hand from the joints of a masonry wall to a depth of ½ to one inch, replacing the deteriorated mortar with new mortar, and finishing the joints with a profile to match the original. Ideally, repointing mortar should duplicate the original as closely as possible. This frequently means using a soft, high-lime content mortar that is softer (measured in compressive strength) than the bricks or stone and no harder than the historic mortar. Repointing mortar for most historic buildings (constructed before the 20th century) should ideally be composed only of lime and sand in water. White portland cement may be substituted for up to 20% of the lime to achieve workability or plasticity without adversely affecting the most desirable qualities of lime mortar. It may also be necessary to add pigment, crushed shells or colored sand to achieve a mortar that resembles the original.

In British usage, tuckpointing refers to a method of pointing in which a lime putty or

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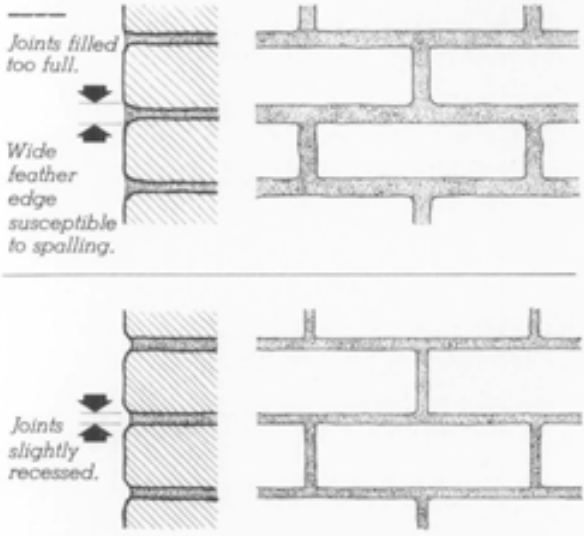

Comparison of visual effect of full mortar joints vs. slightly recessed joints. Filling joints too full hides the actual joint thickness and changes the character of the original brickwork. Illustration: National Park Service.

Repointing/Tuckpointing (continued)

mortar (white or black) is placed over a regular mortar joint as a decorative treatment to give the illusion of very fine joints.

Use of a scrub coating or face grouting is generally not an appropriate treatment for historic masonry and should not be substituted for repointing.

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