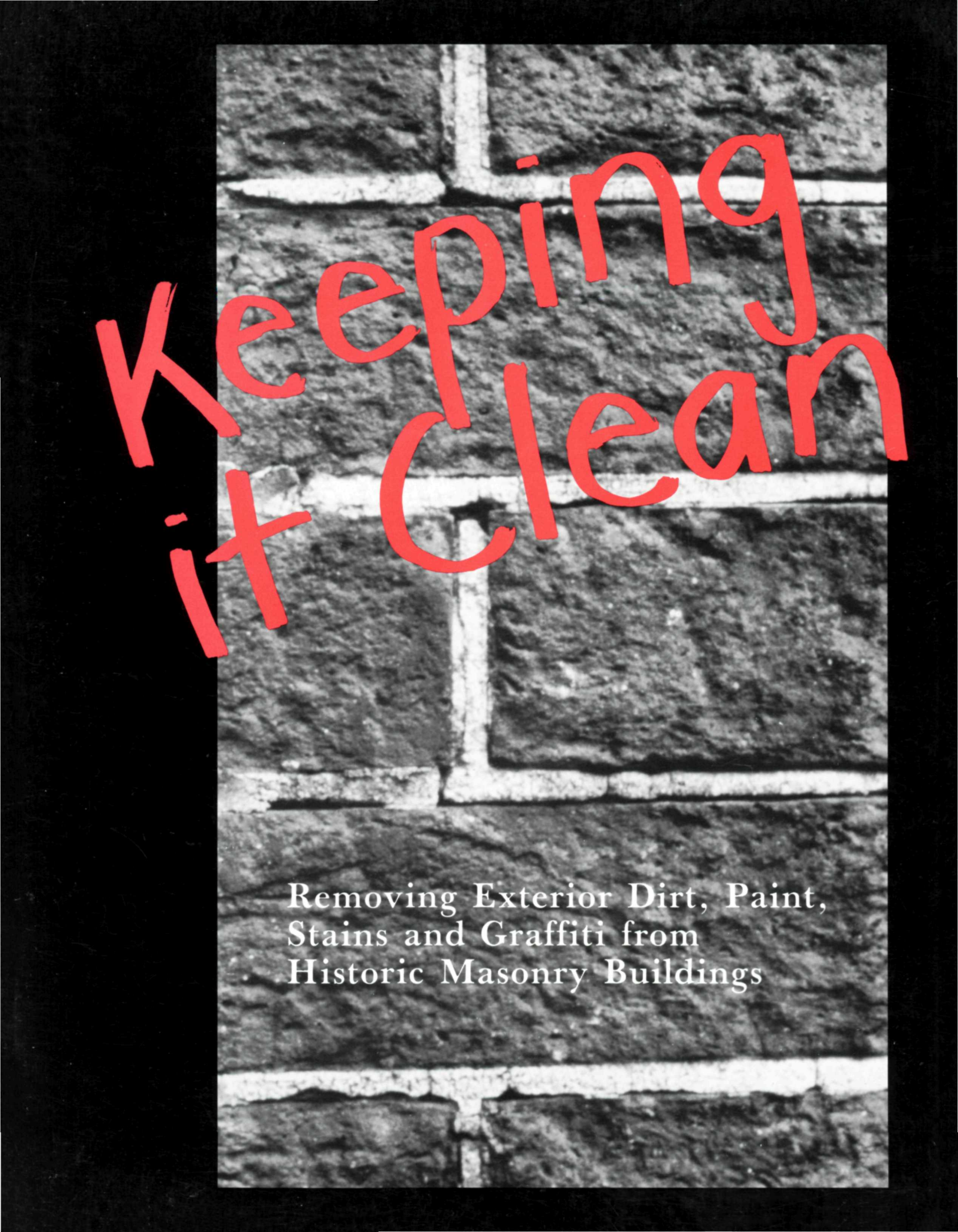
Keeping it Clean
Removing Exterior Dirt, Paint, Stains and Graffiti from Historic Masonry Buildings

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Preface

Despite the inherent hazards, cleaning historic masonry,which includes stone, brick, architectural terra cotta, and cast stone, stucco and concrete, is one of the most common—and most visible—undertakings when rehabilitating or restoring historic masonry structures. Yet basic information and good technical advice may be hard to find. As a result, those responsible for the care of historic buildings frequently must rely upon the recommendations of a cleaning contractor or a cleaning product manufacturer who may not be completely objective, or familiar with all the cleaning options currently available. The cleaning of historic masonry should thus always be carried out under the supervision and guidance of a preservation or conservation specialist.

The purpose of this technical report is to provide information on removing dirt, stains, paint and related coatings, graffiti, and other disfiguring or potentially harmful substances from exterior masonry. First, however, there is a general discussion on all aspects of planning and carrying out a cleaning project, including anticipating potential problems; correctly identifying what is to be removed; identifying all building materials to be cleaned as well as other materials that might be affected by cleaning; and testing cleaning procedures to ensure the most successful project. The report also includes warnings about using certain techniques on specific building materials, as well as possible dangers to project personnel and the building's environment.

Unless otherwise credited, photographs were taken by the author.

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Part I
What to Consider Before Cleaning

Reasons for Cleaning

There are two primary reasons for cleaning a historic masonry building: 1) to improve the appearance of the structure; and 2) to remove dirt, stains, coatings, efflorescence (salts) and pollutants that may be causing deterioration of the masonry. Generally, the two are intertwined, but the most common motivation for cleaning masonry is the desire for cosmetic improvement. It is easy to understand this rationale, especially considering the positive visual impact of a clean building.

Cosmetic Improvement

A most important factor to consider before cleaning a historic masonry building is its patina—the color and surface texture, or the appearance which only time can impart. Patina usually includes a combination of surface stains, deposits, discoloration, and changes to the surface texture that may result from atmospheric dissolution and erosion. Naturally, patina includes a certain amount of dirt. As long as it does not contribute to, or conceal deterioration, patina is indeed part of the character of a historic building, and careful consideration should be given to its preservation. Determining when patina may be harmful or disfiguring must be done on a building-by-building basis, and will depend on the *type of masonry, the type and degree of soiling, and how much it might be obscuring damage to the masonry units themselves or to the mortar joints.* Careful removal of dirt and pollutant crusts can restore many aspects of the original appearance of the masonry—the color, texture and carved detailing that might have been hidden for years.

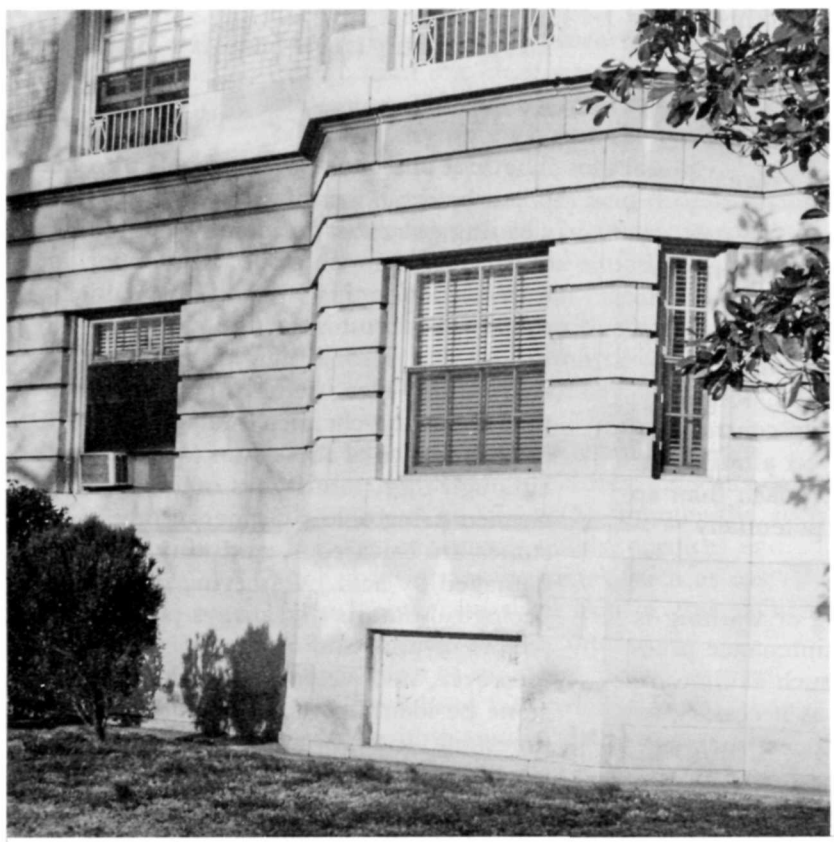


Figure 1. When an inappropriate chemical cleaner was used to remove graffiti, it resulted in permanently bleaching the limestone foundation, and left a mark as unsightly as the graffiti.

The unwelcome presence of graffiti usually triggers an urgent need for cosmetic improvement. An owner or building manager would likely want to remove graffiti as quickly as possible after it appears. Prompt removal is, in itself, a logical approach to the problem because it tends to discourage the incidence of more graffiti. On the other hand, if cleaning is undertaken too hastily, the results may be less than satisfactory (figure 1).

Removing paint from masonry, particularly from brick, is another common "cleaning" treatment, although it may not always be an appropriate or successful treatment for the building. Often, it may be preferable to retain the paint. Painted brick buildings were very popular throughout several historic periods. Many, in fact, were painted immediately after construction. Decorative treatments, such as the penciling of mortar joints, should be carefully examined; they may be original or may have acquired significance over the years. Paint may also have been applied as a protective coating, usually on

some of the more porous types of brick and sandstone; or applied to camouflage alterations or incompatible masonry repairs. All of these factors should be taken into consideration before paint removal is begun. If all nondamaging methods of paint removal have been tried and proven ineffective, it may be best to leave the masonry painted. Or, if the paint is in poor condition, the best approach may be to remove only the loose and peeling paint to a sound surface, and then repaint.

Slowing the Processes of Deterioration

The strongest practical argument in support of masonry cleaning is that it may slow the processes of deterioration and decay. Heavy layers of dirt not only interfere with natural weathering and washing patterns, but also obscure deterioration (figure 2). Cleaning is often necessary to help the architect or building conservator detect problems, and correctly interpret them, in order to take corrective measures, and to prepare a regular maintenance schedule for the building. The cleaning process itself, as well as the close-range view of historic masonry afforded by the scaffolding or other access equipment, also provides an important opportunity to evaluate the condition of the building. Once rid of dirt and pollutant crusts, the conditon of the masonry will be more clearly revealed.

One of the best reasons for a regular cleaning program is that it may remove efflorescent salts from the masonry, thereby reducing potentially harmful salt buildup within the masonry,which can cause spalling or delamination. Regular cleaning or washing can help control plant or other biological growth on a building; it is a safer and gentler approach than applying herbicides that are potentially harmful to the masonry.

Generally, regular cleaning or washing is good preservation and maintenance practice for calcareous stones such as limestone and marble. But it is not as necessary for the less soluble siliceous stones, such as granite and some sandstones, nor for some brick and some glazed architectural terra cotta, all of which have a harder, more impervious outer layer, and are thus better protected from dirt penetration than calcareous stones.

Figure 2. The building on the left is an obvious candidate for cleaning, as the heavy black crust may be concealing or contributing to deterioration of the stone. Despite its more recent cleaning, the stone facade of the house on the right exhibits the same distinctive, and hard-to-eliminate rainwater wash patterns under the eaves and window sills, as its unwashed neighbor.

Identifying the Masonry Substrate

Avoiding Damage

The first and most important step to be taken before beginning any masonry cleaning project is to identify the masonry. When dealing with stone, it is important to select a cleaning method or chemical solution best suited for the kind of stone—that is, one that will not dissolve or etch it. It is also useful to have information about the chemical and geological characteristics of the stone. (For example, although most sandstones may be safely cleaned using acidic cleaners, some sandstones are calcareous, and thus may be damaged by acid.) Gathering detailed geological data is not always possible if the factors of time and cost are prohibitive. However, it *is* essential that the generic stone be identified (i.e., whether it is limestone, marble, sandstone, or granite) because of the differing properties of porosity, solubility and hardness, and mineralogical composition. It is these properties that determine which cleaning methods can be used without adversely affecting the stone.

Tricks of the Eye

Another potential problem is that what might appear to be one type of masonry may actually be another. For example, architectural terra cotta, artificial cast stone, or pre-cast concrete were often manufactured to imitate natural stone. Pre-cast concrete or "cast stone" was being used imitatively as early as the late eighteenth century and still is to this day. Architectural terra cotta was used with this intent in the mid-to-late nineteenth century, and through the early twentieth century. Both materials were popular for decorative features such as window and door moldings. Terra cotta, in particular, was applied on upper floors of tall buildings where distance enhanced the illusion of stone.

Clearly, it is important to identify the material, since the best cleaning method for one type of masonry may not be as effective on another type, and may even cause damage. Many buildings feature a combination of materials. It is not unusual for a building or even a single facade to be composed of more than one type of masonry (brick with stone trim is particularly common), which may mean that more than one cleaning method will be necessary. If, after careful examination, there is any doubt about the type of masonry, a 3 percent solution of hydrochloric (muriatic) acid dropped from an eyedropper on an inconspicuous spot will quickly clarify the situation. This solution will bubble on calcareous stone, and on other acid-sensitive masonry, but will have no reaction on siliceous stone and acid-resistant masonry.

Indeed, some parts of a building, particularly decorative features, may not be masonry at all (figure 3). Frequently, such features as window hoods, cornices and balustrades may be metal, such as cast iron, galvanized sheet iron or zinc. When painted, they give an intentional appearance of masonry. Some features may have been fabricated of wood, then coated with a sanded paint to give the illusion of sandstone. Thus, the need to correctly identify the type of masonry, or other non-masonry materials on a building cannot be over-emphasized when planning a cleaning project.

Figure 3. Know what you are cleaning. If the painted surfaces of the projecting bay window on this once elegant Second Empire brick mansion were still intact, it would not be easy to identify the beltcourse as sandstone, the windows and window frames as wood, and the cornice and all of the window hoods as pressed metal. Cleaning so many different building materials may require a variety of techniques and treatments.

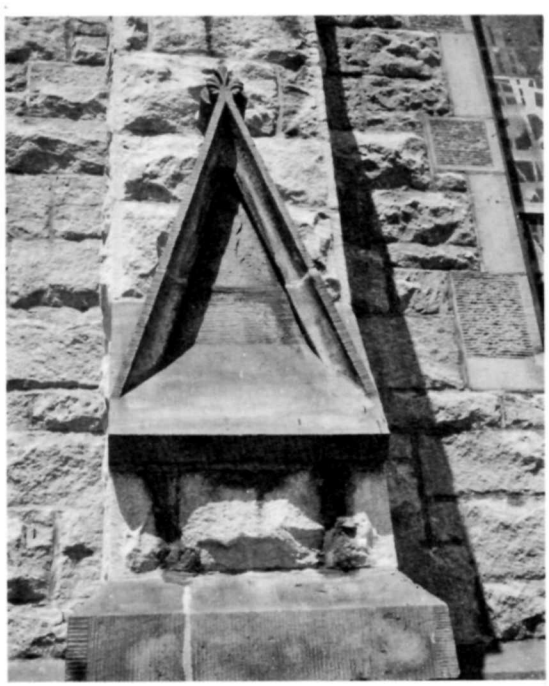
Identifying the Substance to be Removed

After the masonry substrate has been identified, the next step is to identify the substance or substances to be removed. The more information available about the substance to be removed, the more successful the cleaning effort will be. For example, the cleaning project can be greatly facilitated by knowing the composition of each paint layer, the cause or source of the stains, the primary components of the dirt, or the probable source of the efflorescence. And it is not uncommon to discover that all or part of a building has been treated with water-repellent coating. Unless the coating has caused discoloration or streaking, the fact that such a coating exists at all may be known only if cleaning test patches fail to react as they would on uncoated masonry.

Dirt and Pollutant Crusts

Dirt or "soiling" on masonry buildings may consist of particles of dust, sand or grit, or tarry soot (resulting from incomplete combustion of fuels). The exact composition of the dirt will vary according to the geographic location of the building, as well as its use. A building in an urban, or heavily industrial area, is likely to exhibit a completely different type of soiling from a building in a rural or agricultural area—or a building near the seacoast or in the desert. While dirt and dust on one building may result from heavy vehicular traffic in the area, soiling on another building may result from human traffic.

Dirt or soiling may include disfiguring pollutant or sulfate crusts, which usually build up in sheltered or protected areas not regularly washed by the natural action of rain. It is particularly common under cornices, window sills, or other projecting decorative features (figures 4a - 4b). Some pollutant crusts resulting from a chemical reaction of stone to airborne particulate matter, or particules in which cementing material of the stone has actually incorporated itself, indicate the beginning of dissolution of the stone and incipient decay. Removing these crusts will necessarily involve a loss of a small amount of stone (figure 5). While removal is generally recommended because pollutant crusts hasten stone dissolution, extreme care must nonetheless be exercised to ensure that loss of the stone is minimized.



Figures 4a-4b. Decorative architectural features that project from a wall surface, such as this granite belt course above an intricately-tooled limestone lintel, and this sandstone pinnacle topping a limestone buttress, may shield or protect masonry surfaces beneath them. But they are also responsible for creating unusual "wash" patterns and black crusts that form underneath them, further complicating cleaning projects.

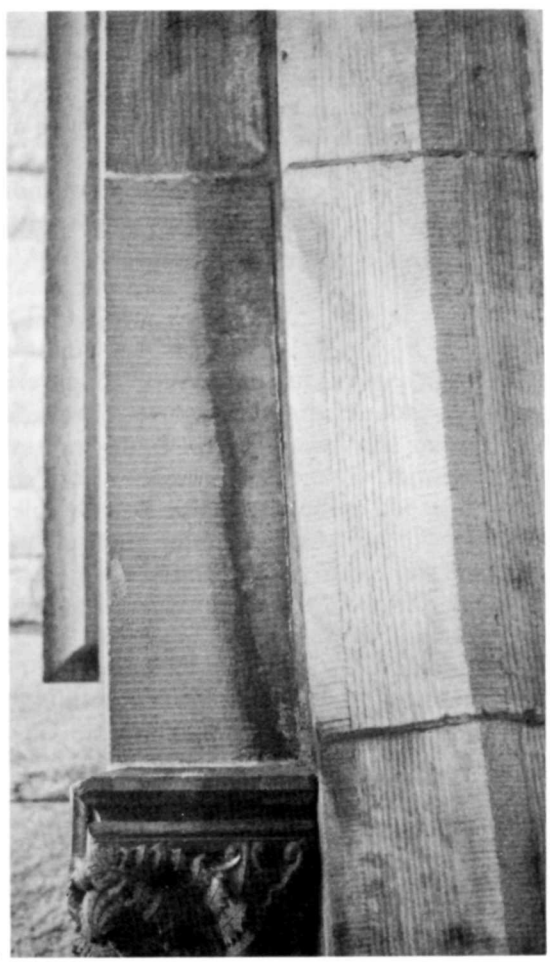


Figure 5. It is unlikely that this blackened crust can be removed without some loss of the tooled sandstone surface, because the sulfate crust has become integral with the stone.

Stains

Unlike particulate dirt, which tends to lie on the surface, stains in masonry are discolorations produced by foreign matter that has penetrated into—or permeated—the masonry. Stains can also result from a chemical reaction between the masonry and the foreign matter, or from impurities in the masonry itself. Common masonry stains include metallic stains caused by iron (rust) or copper, industrial stains of grease, oil, and tar, and biological and plant stains caused by lichens, mosses, algae, and fungal growth such as mildew. Even after removal of the vines themselves, ivy and Virginia Creeper can leave their "marks" on the masonry, which may also have to be removed by cleaning. Discloration can also occur when mineral inclusions or impurities which occur naturally in some stones, or in the clay of some bricks, react to water or chemical cleaners.

Graffiti

Graffiti created with paint or another medium may also be considered a stain. If graffiti is sprayed-on, it is generally likely to permeate the masonry (unless glazed or polished) in the same manner as most other stains. Thus, its removal must usually be carried out in the same manner as other stain removal.

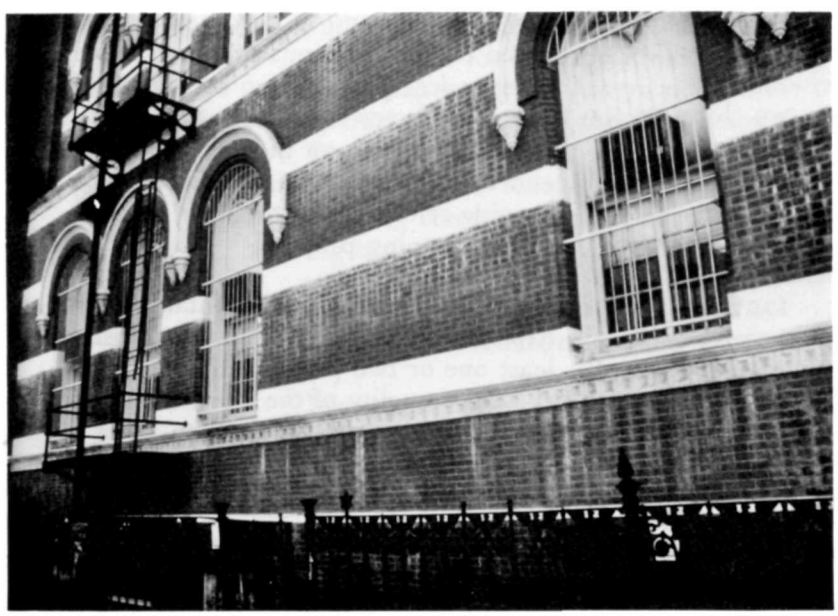


Figure 6. Chalking white paint from decorative metal and stone stringcourses has "bled" and run down the unpainted brick walls. Unlike efflorescence, for which it might be mistaken, chalking generally cannot be washed off, and paint remover will be required.

Paint and Other Coatings

Removal of paint or other coatings will, of course, be facilitated by knowledge about the kind or kinds of paint, and the number of layers to be removed. For example, it is useful, if at all possible, to know whether the paint is oil-based, water-based, or, as is often the case, whether it consists of a variety of paints and coatings, which might include layers of cementitious masonry paint, whitewash or limewash. In some cases, the pigment might be incorporated into the substrate, as is often typical of stucco and traditional limewashes.

Questions may arise about each layer or coating, further complicating the overriding need to remove the offending substance while not damaging the historic masonry. For example, if there is more than one layer of paint, is it consistent over all of the building surface? Or is there an "invisible" water-repellent coating or a wax coating, or perhaps even worse (from the standpoint of removal), an asphalt or bituminous waterproof coating on some areas? If so, will it come off successfully, or might it be better to camouflage it by repainting?

Efflorescence

Efflorescence, the result of capillary action pulling soluble salts up from the ground into the masonry, usually appears as a whitish haze on the exterior surface of masonry. Sulfate deposits may result from carbonates in lime mortar and airborne or water-deposited pollutants in the atmosphere. Another common source of efflorescence in brick is the firing process itself.

Efflorescence may also appear on a masonry surface after chemical cleaning. Some efflorescence is temporary, and will be removed by rain. Other types may disappear for awhile, but return periodically, and some require considerable and repeated efforts to eliminate. It is therefore always necessary to ascertain the source or sources of efflorescence, and it may even be useful to identify the salts that comprise the efflorescence. Further complicating the identification process, white paint from a painted surface above that has "bled" onto a

masonry surface below (particularly common under window sills) might be mistaken for efflorescence (figure 6). In short, it is very easy to misinterpret what is on the surface.

Combination Problems

Often, a cleaning project will involve removal of more than one substance. What first appears to be a straightforward task of paint removal may be complicated by the discovery of multiple layers of different types of paints and coatings on another elevation of the same building, or perhaps on only the first floor of the building. Moreover, what may initially appear to be one substance may, upon closer examination, turn out to be another, or often a combination of substances.

Project Personnel

Once the masonry and the substance to be removed have been identified, the next step is to match potentially appropriate cleaning methods with the particular project at hand.

Role of the Preservation Consultant

To ensure the best possible job, a professional preservation consultant should be retained, preferably someone with a technical or scientific background (an architectural conservator, a restoration architect, or a chemist or geologist). The advice of cleaning contractors or product representatives may be prejudiced by familiarity with only one or two cleaning techniques, or a desire to sell a particular product. Generally, their recommendations should not be substituted for the experience and impartiality of a technical preservation specialist or scientific consultant.

Basically, the consultant should supervise all aspects of the cleaning project—planning, identifying the masonry, identifying what is to be removed, selecting the cleaning methods and materials, selecting the contractor, and supervising the actual cleaning to ensure consistent quality and to minimize any possible damage to the surface.

Role of the Preservation Consultant

- Identify the building's materials.
- Evaluate condition of the masonry materials.
- Identify what is to be removed.
- Supervise the testing of the cleaning methods.
- Analyze the test patches.
- Based on the test patches, select the cleaning methods that most effectively clean the masonry without causing damage.
- Prepare specifications based on these test results (if they have not been prepared already prior to testing).
- Select cleaning contractor (if not already chosen).
- If possible, have cleaning test repeated by cleaning personnel who will do cleaning.
- Supervise actual cleaning process to ensure consistent quality.

Selecting a Cleaning Contractor

A carefully executed cleaning job requires the experience of a reputable cleaning contractor who specializes in cleaning and restoring historic masonry buildings. Negotiating a fair price with one qualified contractor may be preferable to asking several contractors to bid on the cleaning job. The bids and final contract should be based on specifications prepared by the independent preservation consultant. A good contractor should be willing to provide information on the cleaning process, and on the product ingredients, and also provide references in the form of completed cleaning projects.

It is important that a consultant, who is experienced in such evaluations, visit at least one or two projects in order to inspect the quality of the work. A well-executed cleaning project should not show any signs of mechanical or chemical abrasion, nor should it exhibit areas or patches of efflorescence, which might indicate the use of too strong a chemical or improper or inadequate rinsing. (Sometimes efflorescence on a very recently cleaned building is only temporary, and will gradually wash away. It may be the result of salt-laden moisture *within* the masonry

suddenly being released when surface dirt or a coating is cleaned off.)

A responsibly and sensitively cleaned historic masonry building should retain some of its before-cleaning patina, perhaps appearing slightly "dirty," as if it had not been overcleaned. Clearly, however, there may be some aspects of a recently cleaned surface that are not so easy to explain. Sometimes an abraded or eroded surface is the result of natural weathering or a "flaw" in the original materials, or damage from an earlier, harsh cleaning treatment. Or what appears to be a stain may, in fact, be the result of an unexpected reaction of a natural impurity in the stone to a chemical cleaner. In short, as will be repeated again and again, it is not always possible to predict the exact outcome of a cleaning project because of the many variables associated with historic masonry. But despite some unavoidable uncertainty, a cautious, conscientious approach by the consultant, building owner or manager, and the contractor will always result in a better cleaning project—one that does not damage the historic masonry.

Although cost is often a factor in a cleaning project, the contractor should not be selected solely on the basis of a low bid, but rather on the quality of previous work, as well as on the basis of test patch results. Local historic district commissions and review boards, State Historic Preservation Offices, regional offices of the National Trust for Historic Preservation, local chapters of the American Institute of Architects (AIA) and the Association for Preservation Technology (APT), may be able to suggest reliable consultants and cleaning contractors experienced in cleaning historic buildings.

What to Require in a Contract and Specifications

Because cleaning a historic masonry building involves so many unexpected and unknown factors, each project is unique. It would be impractical to try to provide a standard set of specifications to cover *all* of the potential situations that might be encountered. But, while the actual specifications will vary from project to project, there are certain principles that should govern any cleaning project to ensure the best possible outcome.

1. The specifications should be very precise. The more specific they are, the less chance there is for mistakes.
2. Qualifications of project personnel should be included in the specifications.
3. If specifications are prepared before testing, they should clearly state that mock-up test areas will serve as quality-control for the project.
4. If testing has already been carried out, the specifications should state the exact cleaning method (technique and materials) to be used based on the testing.
5. If a specific product is to be used, it should be clearly stated so that the contractor is aware that *no* other product may be substituted, unless it is with the prior approval of the preservation consultant or supervising architect—and of course, only after it has been tested on the building. A building may often require more than one cleaning method or cleaning product. If so, each method to be applied to a different material and in a different location on the building should be identified.
6. The cleaning process should take place only under the careful supervision of a qualified professional preservation consultant or preservation architect. The cleaning method outlined in the specifications will have been prescribed only after careful testing on the building with time allowed for weathering. Any unforeseen problems that might arise during the course of the cleaning should be brought to the attention of the consultant (and the owner), and the cleaning halted until the problem is solved.
7. Finally, even a well-written specification is of no use if it is not read and followed.

Testing

Because of the wide variety of unforeseeable factors, the cleaning method or methods should always be tested on an inconspicuous area of the building and preferably in more than one location (figure 7). Such tests must be carried out before attempting any large-scale masonry cleaning project. Failure to do so may have disastrous consequences for the outcome of the cleaning as well as the long-term preservation of the historic building material. Testing should be carried out by the consultant or conservation specialist, or by the contractor, under the consul-

Figure 7. A contractor prepares equipment before testing a low-pressure water wash on a Roman brick and terra cotta building. Photograph: Sharon C. Park, AIA

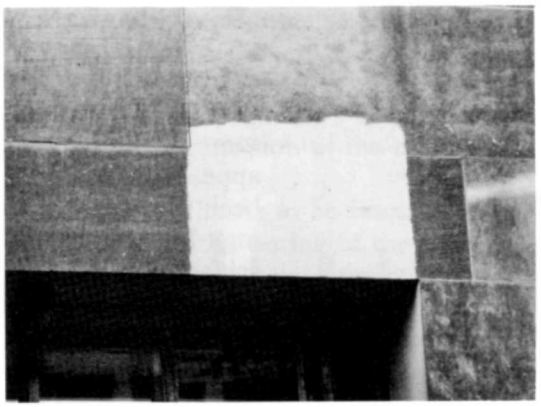


Figure 8. A test cleaning patch (unfortunately in a rather prominent location) on limestone discolored by urban grime and pollution reveals a marked color difference between the cleaned and the uncleaned stone as well as an unexpected discoloration (probably caused by a substance splashed on the wall at an earlier time). Removal of this spot may require a special cleaning treatment. Photograph: Sharon C. Park, AIA

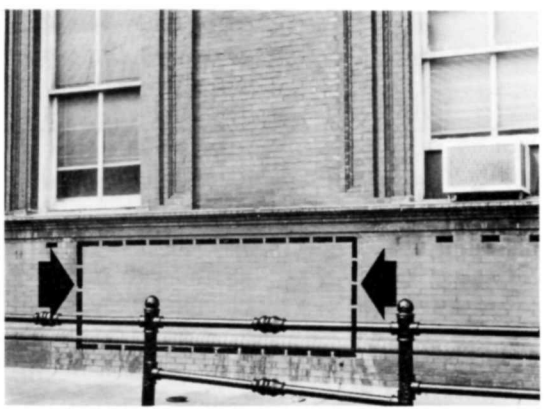


Figure 9. A test patch on brick to remove a century of dirt reveals only a slight difference in appearance between the cleaned and the uncleaned brick. The hard-baked outer skin of the brick provides a surface that is not only impervious to dirt penetration, but resists dirt accumulation. Photograph: Christina Henry

tant's careful supervision. Carefully controlled testing is probably the only reliable way to determine the best or most appropriate cleaning techniques and pressures to be used in a particular project (figures 8-9).

Selecting an "Appropriate" Water Pressure

The process of selecting the most appropriate water pressure should always begin with the lowest pressure, or the "gentlest means possible," proceeding gradually to a higher pressure, as needed. Although that philosophy is certainly sound, its application in a practical sense is very much more difficult. The difficulty lies in the fact that, although the terms "low," "medium" and "high" pressure have traditionally been used in cleaning specifications, they are general terms and subject to wide interpretation. Because of incalculable or unpredictable factors associated with pressure equipment—combined with different types of historic masonry itself—it is virtually impossible to define the categories of low, medium and high in a manner that would apply equally to all cleaning projects.

Precise definition of these pressures is further complicated by the fact that pressure measurement, or psi (pounds per square inch) varies according to the following: pressure as measured by a gauge at the pump; the volume of water (or other liquid cleaning agents) delivered per minute; the size of the nozzle or spray head opening; and the distance between the spray head and the masonry surface. But since most psi measurements are taken at only one location, these seemingly precise measurements may bear little or no relationship to the actual pressure reaching the building. As the variables multiply, it becomes more and more obvious that psi numbers do not really mean very much, or at least do not mean the same thing to all who employ them in cleaning. Thus, although exact pressures may sound precise, the fact that they are not must be kept in mind.

For this reason, until a system can be perfected that will allow greater certainty or precision, selecting a cleaning method and pressure should be done only after careful testing has produced a satisfactorily cleaned test patch to serve as a standard by which the rest of the project can be measured. *Thus, references here to specific pressures are provided only for comparative purposes, and should be considered only as general guidance.*

Choosing Representative Types of Masonry

Finding the appropriate cleaning method can be further complicated when dealing with especially fragile, damaged or deteriorated masonry. These are factors that must be taken into consideration when planning to clean historic masonry.

Areas of the building chosen as test spots should accurately represent the types of masonry material to be cleaned. As noted earlier, another masonry material may have been used to simulate stone. Also, a harder, higher quality brick or "face brick" was often used on the facade, while the less visible side and rear elevations were often covered with a cheaper, usually softer "common brick" as an economy measure. Results from a cleaning test performed on common brick, or a heavily textured brick, would probably not be applicable to smooth, face brick. Likewise, tests on upper parts of a building may not accurately reflect conditions on other areas, such as the foundation or horizontal surfaces that may have been treated with a waterproof or water-repellent coating.

Choosing Representative Soiling

The area or areas selected for testing should represent both the amount and type of the dirt deposits, surface pollutant crusts, stains, efflorescence, or paint on the majority of the building surface. For example, a prominent area of the facade may be stained, disfigured with a heavy coating of soot, or covered by heavy paint buildup. Another area of the building may be only lightly soiled or have only one coat of paint. These might require very different cleaning procedures. A project that proceeds after testing a limited area only might produce very unsatisfactory results.

To ensure the most accurate test results, as much as possible of the dirt, bird droppings, or problem substances should be removed from the surface by hand-scraping or brushing with non-metallic brushes *before* test cleaning. (This same practice should, of course, be followed when the actual cleaning is undertaken.)

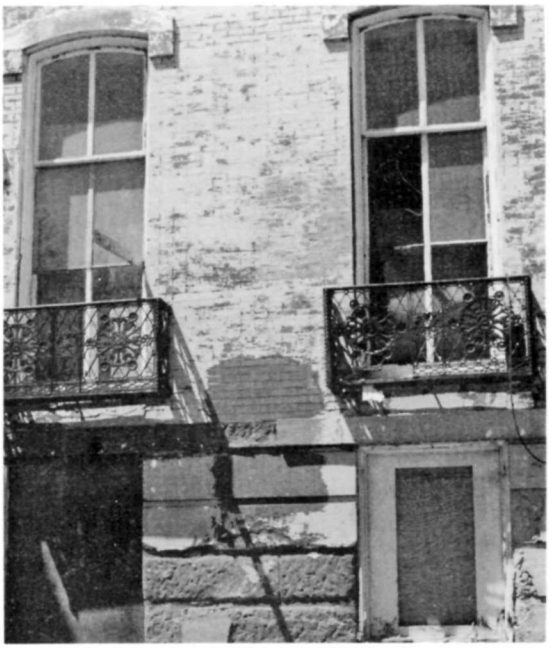
Evaluating the Test Patches

Althought a somewhat larger area is preferable, an area approximately one square meter or approximately one square yard will generally serve as an adequate test patch. If there are different types of masonry, or widely dissimilar substances to be removed, several test patches may be necessary. Representative, but inconspicuous areas should be chosen in case any of the tests are not successful, or in case the project does not progress beyond the testing stage.

One building, regardless of size, may require a variety or combinations of cleaning methods. If the type of scaffolding allows, it is advisable to clean the entire building using the gentlest technique to remove the prevailing substance. Then, localized stains on decorative features can be addressed individually. Too strong a cleaner for overall cleaning may harm the masonry. Instead, a milder cleaning solution should be used and augmented, if necessary, by additional applications on hard-to-clean areas or difficult stains. *Always underclean, rather than overclean.*

Test patches can be evaluated accurately only after they are dry. If chemical cleaning is being tested, non-staining pH papers should be held on the surface of the test patch area before and after cleaning to determine if any acidic or alkaline residues remain on the surface. If residues are detected, additional water rinsing or application of a neutralizing solution should be carried out until pH tests indicate that all residues have been removed.

A test patch should be allowed to weather as long as possible before the cleaning project is begun to give ample opportunity for an accurate evaluation of the results. One year is the preferred amount of time; this allows the patch to be exposed to a complete weathering cycle (figures 10a-10b). If this is not feasible, it is a good idea to



Figures 10a-10b. This test cleaning patch on brick and sandstone was allowed to weather over a full year, while other aspects of the rehabilitation were carried out. Finally the entire building was cleaned with a proprietary paint remover sprayed-on under low-pressure and then rinsed by workmen from a truck-mounted hydraulic platform lift.

wait as long as possible, and at least one month at a minimum. Once a cleaning project is begun, the work should proceed in clearly defined areas (preferably delineated by structural or architectural features), since it is difficult to match cleaned areas, especially if the project is halted for several days or more.

Reasonable Expectations

Tests are usually carried out under optimum conditions, and may therefore show better results than the actual cleaning project. For example, a cleaning contractor bidding on the job will naturally try to achieve the best possible result in a sample cleaning area in order to obtain the contract. It is also easier to clean a small area at ground level within a specified amount of time than to achieve the same results several stories above ground by workers who are tired after a long day's work. Overly optimistic estimates of time and costs supplied by a contractor based on the results of a test patch can be misleading.

But an experienced and reputable contractor will be aware of these inherent problems and should be able to provide a reasonable estimate based on the testing. The test patches serve as a "standard of clean" and will provide guidance regarding the best cleaning method for the job; for example, how many applications of the cleaning material will be necessary if a chemical product is used, the dwell time (the length of time an application should remain on the surface), and what pressures should be used for the cleaning and the final rinse.

Scheduling the Cleaning Project

One of the most important considerations in a cleaning project is scheduling. Since the cleaning method cannot be selected until several techniques have been tested, it follows that the test patches should be done at the start of a rehabilitation or restoration project. And, because of the need for adequate time for the cleaning tests to weather before selecting one, the actual cleaning itself should be the last, or one of the last things to be done in the project.

Never begin cleaning when there is any likelihood of frost or freezing, as most cleaning operations involve the use of water. When the water penetrates the masonry pores during cleaning, the interior of the masonry retains moisture for

some time before it evaporates, even though the exterior surface may appear dry. If a frost occurs, the moisture inside the masonry units will freeze, which could eventually cause the masonry surface to spall. The presence of salts within the masonry wall may exacerbate the process.

The best times to clean a historic masonry building (other than in tropical or arid climates) are late spring, early summer and early fall when there is no danger of freezing. While warmer temperatures contribute to a faster chemical reaction, too much sun and too high temperatures do not result in a good cleaning project either. If cleaning is done in very hot weather, the masonry should be shielded from excessive heat by hanging protective netting or tarpulins around it.

Repointing, if necessary, should generally be carried out before cleaning to prevent damage to interior surfaces caused by liquid cleaning materials penetrating through open joints in the masonry.

Minimizing Hazards of Cleaning

Although most large-scale cleaning projects should be carried out by qualified cleaning professionals accustomed to working with historic buildings, it is still important to keep in mind all of the precautionary guidelines associated with masonry cleaning. Potential harm to the historic masonry and other building materials often used in conjunction with stone and brick, as well as potential harm to the environment and cleaning personnel must be carefully evaluated before initiating a cleaning project.

Protecting the Historic Building

Mortars, especially those of the traditional lime-based formulations, are among the most vulnerable substances to be considered when preparing to clean a historic masonry building. Deteriorated mortar joints can lead to major problems with water washing and other aqueous techniques. The entry of large amounts of water through spraying or prolonged misting may result in damage to interior plaster and other finishes, and in exterior staining as well. Water pressures for cleaning and rinsing operations should be monitored carefully to minimize physical damage to the masonry. Loose mortar can be dislodged by rinsing at too high a pressure, permitting deep penetration of water within the building.

The acidity or alkalinity of cleaning chemicals must be controlled to suit the chemistry of the individual masonry materials. Because chemical cleaning with acidic products is always potentially dangerous to acid-sensitive masonry and lime mortars, acidic cleaners must therefore be diluted carefully, in keeping with the sensitivity of the masonry. To accomplish this successfully, accurate identification of the masonry is essential. This may not be easy. Limestone and some cast stone, or other types of artificial stone, can look very similar.

Many other historic building materials can be damaged by chemical cleaning agents. Glass, glazed brick, and architectural terra cotta will be etched by strong solutions of hydrofluoric acid if not covered adequately. Metal, wood and paint can all be damaged by chemical cleaners, and must be shielded. Such materials can be temporarily protected by plastic sheeting or peelable coatings specifically made for this purpose (figure 11).

Figure 11. Removal of 100 years of grime from the brick and terra cotta facade of the Pension Building (now the National Building Museum), Washington, D.C., was accomplished by workmen on a swing stage using a chemical cleaning product. Note the polyethylene covering the windows to prevent damage. Also note the protective clothing for the workmen which hangs on the platform while not in use. Photograph: Christina Henry

Protecting the Environment

Damage to property, shrubs, trees and ground vegetation in the immediate vicinity can be avoided by using proper controls to avoid overspraying and by covering or shielding plants and property. Site drainage must always be considered when using an acqueous cleaning method, and disposal of toxic chemical runoff and dissolved paint may pose an even greater problen. Lead paint sludge should be placed in suitable containers and disposed of in accordance with enviromental regulations. In the case of organic solvents, a well-designed storage location is necessary to prevent explosion and fire. Use of many of these cleaning materials may require special permits or approval from local authorities, especially if run-off is to be channeled into city storm sewers.

Protecting Cleaning Personnel

Cleaning compounds pose many safety and health hazards, and working personnel must be equipped with protective clothing, gloves and toxic vapor masks. Strong cleaning agents can cause skin burns and irritation, and adequate eye protection is essential at all times. Hydrofluoric acid can cause severe burns and can also penetrate the skin, resulting in bone damage. Organic chemicals are equally health-threatening, because they are absorbed systemically through the skin and are carcinogenic. When using spray equipment containing acid cleaners, extreme caution must be taken to release the pressure slowly so that the contents do not spray or splash the operator.

Part II
Choosing the "Gentlest Means Possible"

Most cleaning techniques suitable for use on historic masonry buildings rely on aqueous or water-based systems, and chemicals. Water-based solutions (which can include detergents) and chemical solutions can be successfully applied separately or in combination, aided by a variety of hand-scraping methods. Properly used, these techniques can safely remove dirt, stains, graffiti, paint or other surface coatings, efflorescences (salts), and plant and fungal growth and stains from historic masonry buildings.

Water Cleaning to Remove Dirt

all types of masonry

Water-based cleaning can be the gentlest and simplest operation, causing the least amount of damage, if certain precautions are followed. It may also be the least expensive cleaning procedure. It is probably the most versatile technique available for sensitive cleaning and removal of dirt and pollutant crusts from *all* types of historic masonry materials, and it is generally the *simplest* method for cleaning limestone and marble. While there are several cleaning methods in which water is the sole ingredient, water is also the principle cleaning agent in other methods which utilize detergents and chemicals.

There are four principal types of water washing: soaking (misting and spraying); low-pressure and medium-pressure water washing; low-pressure and medium-pressure water washing supplemented with non-ionic detergents; and steam cleaning, by itself, or supplemented with non-ionic detergents.

Soaking (Misting or Spraying)

Prolonged spraying with a fine mist is a relatively simple washing method. This technique provides maxium wetting using a minimal amount of water. A mist is produced by inserting fine mesh filters over hose nozzles. Continuous soaking of the surface is then accomplished by running lengths of punctured hose (or a moveable pipe, or one supported on scaffolding) hung under the eaves or along the cornice line of the building. Water pumped up through a compressor at ground level slowly trickles down or sprays the building facade.

Low-pressure, low-volume misting devices with a wide angle of coverage may be the most efficient of the soaking techniques. They can also be set up to handle selected areas of heavy dirt or soot encrustation such as black sulphate or gypsum crusts that form in protected areas (especially under moldings and eaves not washed by rainwater) on limestone, marble and other calcareous stones. The effectiveness of this method relies on the fact that the sulfate crust, in which the dirt is incorporated, is several times more water soluble than the stone. Thus, water loosens the gypsum crust by partial dissolution, along with the material trapped within the network. As the description implies, this is a slow process and may take from four to six hours up to a week or more to soften heavy crusts or dirt deposits. After the dirt has softened, its removal can be facilitated by hand-scrubbing with non-metallic brushes or by using a moderate-pressure water wash; a wooden scraper may help in removing heavy sulfate crusts. A variation of this method is a timed schedule, or pulsed spray, which alternates periods of soaking (misting or spraying) with dry cycles, using a timer to regulate the intervals so the masonry does not dry out. This approach is also good for loosening dirt and pollutant crusts, although its use has been fairly limited in the United States. Before deciding to use any aqueous system, stone should be tested for free iron (iron not completely bound) to avoid the possibility of iron staining.

Low-Pressure and Medium-Pressure Water Washing

Another water-based cleaning method is low and medium-pressure "power" washing. It is always best to start with the lowest pressure possible, and to increase

the pressure only as much as necessary to loosen the dirt and adequately clean the building. Low-pressure water washing can be carried out with a common garden hose in a small-scale cleaning project, that is, one limited to a two-story structure that can be reached conveniently with a ladder. Again, removal of heavy grime can be facilitated by hand-brushing and scraping prior to washing. This is a very effective, gentle, and easily controlled method, unlikely to cause any harm to the building.

Low-pressure washing may also be successfully used for some large-scale cleaning projects, requiring scaffolding, or perhaps a "man lift" to provide access. Deteriorated areas will need specialized treatment, possibly by hand. After cleaning a building with heavy dirt encrustation, a final rinsing or a second cleaning using chemicals may be necessary in order to remove dirt already loosened by the initial washing.

Low-Pressure and Medium-Pressure Water Washing with Detergent Supplement

The best combination of prolonged spraying or dripping, low-to-medium-pressure washing, and brushing and hand-scraping, must be determined experimentally and on a case-by-case basis. While polished surfaces such as polished granite or glazed architectural terra cotta may sometimes be cleaned effectively of dirt simply with a low-to-medium-pressure wash, adding a non-ionic detergent that does not deposit a solid, visible residue, may often hasten cleaning. (Examples of non-ionic detergents include Tergitol by Union Carbide, Triton by Rohm & Haas and Igepal by GAF). Non-ionic detergents will also be needed to clean most textured masonry such as rusticated stonework, rough-surfaced brick, and intricately carved ornamental details; textured surfaces that hold dirt will require additional cleaning effort by hand-brushing with non-metallic brushes. After cleaning, it is important that the surface be carefully rinsed because, while not visible, a "gummy" detergent film tends to attract dirt.

With the exception of steam cleaning, which utilizes heated water, most water-based cleaning methods discussed here can be carried out successfully with cold water. Under certain circumstances however, warm or hot water may facilitate the cleaning process when removing greasy or oily dirt or stains, and sometimes in paint removal.

Steam

Steam cleaning is another water-based cleaning method. Although once used extensively, it is no longer as popular, possibly due to the increased sophistication of chemical methods. In this procedure, steam is generated in a flash boiler and directed against the masonry surface with the use of a very low-pressure (10-30 psi) nozzle, generally with a ½ inch diameter aperture. The heat of the steam swells and softens dirt deposits enough so that the low pressure of the steam is generally sufficient to remove the loosened dirt from the masonry surface. However, the density of the steam makes it difficult for the operator to see or monitor the cleaning process, and because the steam is heated to such a high temperature, it is not only a potential hazard to the operator, but may damage the stone as well.

Steam cleaning is most useful today as a method of removing vine disks and other vegetation clinging to masonry surfaces, and for cleaning small, hard-to-reach or highly carved or ornamented areas without causing mechanical damage. In such instances, it may be necessary to precede the steam cleaning with manual scrubbing using a non-ionic detergent or a low concentrate chemical-based cleaner, or to follow steam cleaning with a low-pressure water rinse. Steam cleaning may also be a suitably gentle method for cleaning damaged or friable stone. Steam cleaning is a technique that, under careful supervision, may occasionally be used for specialized interior cleaning because it does not produce large quantities of water, and therefore reduces the possibility of damaging fine finishes.

Cautions and Precautions. Despite the fact that water washing methods may be the gentlest of all cleaning methods they are not without hazards. Even these methods can be abrasive. Water pressure should always be kept at the lowest level that will clean the masonry without damage. Too highly pressurized water can etch or otherwise scar masonry, and may penetrate through the masonry walls (figure 12).

Figure 12. Water at too high a pressure from a pinpoint nozzle has etched this white Vermont granite. Photograph: David A. Look, AIA

With any aqueous cleaning system it is generally recommended that a masonry building be repointed, if necessary, before cleaning (allowing ample time for the pointing to cure adequately before cleaning, as the water may dislodge green mortar). Another possibility is to use caulking compound to fill in some of the larger gaps in the mortar joints temporarily to prevent water infiltration during cleaning. Before embarking on an aqueous cleaning project, it is important to make sure that the flashing around chimneys is tight, and that there are no open joints around doors and windows where water may enter.

Long periods of soaking or spraying may result in excessive moisture penetration of masonry walls, possibly leading to corrosion of metal anchors, and consequent exterior staining, or damage to interior plaster and paint finishes. To avoid these problems, cleaning personnel should inspect the interior periodically to check for moisture penetration. Prolonged soaking or spraying may also irreversibly weaken the masonry itself, since masonry, like other porous materials, tends to decrease significantly in mechanical strength when saturated.

Water cleaning of a moderate size building can require several million gallons of water. When such large amounts of water are involved, it is important to have a good drainage system available for the run off. Additionally, many city water systems may be heavily chlorinated or have a high mineral content. If this is the case, the water used for cleaning should be purified or distilled to avoid introducing chloride salts into the masonry or mineral deposits onto the masonry surface. In addition, water should be pumped through plastic, rather than copper, pipes to avoid possible staining of the masonry. Water cleaning may be rather time-consuming and expensive, particularly if the removal of heavy crusts requires much hand-scrubbing.

It is important to realize that although some types of masonry may benefit from frequent water washing, others do not. While useful as a method of revealing sources of potential deterioration covered by dirt, frequent washing of some of the harder siliceous stones including granite and some sandstones, as well as brick, probably does not aid in their preservation. But the opposite is generally true of calcareous stones such as limestone and marble, whose long-term preservation may be enhanced by regularly scheduled water washing. Regular cleaning of calcareous stones (perhaps every seven to ten years in heavily polluted urban areas) can remove potentially harmful absorbed salts. On the other hand, calcareous stones also tend to be highly soluble and *too* frequent washing may result in accelerated dissolution and loss of surface caused by the slightly acidic water of some city water systems. In general, washing procedures for these stones should not be overly long to avoid excessive exposure of the stone to the dissolving nature of the water. The use of distilled water may further minimize dissolution.

To prevent possible staining of light-colored limestone or marble in areas where the local water supply has a high iron content, it may be useful to add a chelating or complexing agent such as EDTA (ethylene diamine tetra-acetic acid), to the wash water; this will combine with any metal ions present in the water and keep them in solution to avoid metal stains on light-colored stone.

Chemical Cleaning to Remove Dirt

If water-based cleaning is the gentlest and least damaging method of removing dirt from historic masonry, chemical cleaners represent the next level of intervention. Chemical cleaners may be required to remove heavy dirt buildup or layers of paint. Chemical-based cleaners for

masonry are generally one of three types: acidic cleaners, alkaline cleaners, or organic solvents. Acidic or alkaline cleaners are used for regular cleaning or dirt removal; alkaline cleaners or organic solvents are used for paint removal. All of these cleaners rely on water and most contain surfactants (''surface active'' agents)—organic compounds that concentrate at oil-water interfaces, and exert emulsifying actions, and thus aid in removing soiling. (Sometimes the term ''surfactant'' is used interchangeably with ''detergent.'')

Pre-wetting masonry surfaces is generally recommended for both acidic and alkaline products. In addition to loosening the dirt, this reduces the amount of the cleaning agent and the dirt-laden rinse water that can soak into the masonry and the contiguous mortar joints. Chemicals are then brushed or sprayed on under low pressure—brushing the chemicals on may actually help loosen surface dirt. When surfactant products are used, spraying or brushing generates suds that boost cleaning efficiency by lengthening contact time of the active chemicals with the masonry. Manual scrubbing with a non-metallic brush can have the same effect, and also assists in loosening dirt. After a few minutes (as indicated in the product literature or determined by testing), the cleaner is washed off by flooding the surface with a moderate-to-high (400-600 psi) water spray at a rate of three to four gallons per minute, rinsing from top to bottom. Extremely heavy dirt accumulations or many layers of paint may require repeated applications of the chemical cleaner. A hot water rinse may also facilitate paint removal.

Acidic Cleaners

most granites, most sandstones, slate, unglazed brick, unglazed architectural terra cotta, concrete

Acidic products can be used on unglazed brick and terra cotta, and most granites, sandstones, slate and other non-calcareous or siliceous stones. But acid-based cleaners generally should never be used on acid-sensitive materials that might be etched or abraded by acid. This includes masonry with a glazed or polished surface (glazed architectural terra cotta, glazed brick, polished stone or glass) as well as acid-sensitive stone such as limestone, marble, or calcareous sandstone.

Acidic cleaning is a two-part process: first, the acid cleansing solution is applied to the pre-wet masonry surface. After completing its action, the acid solution is then removed from the masonry by a thorough water rinse. Hydrofluoric acid is the most commonly used acid cleaner for historic masonry, usually with some phosphoric acid added to prevent development of rust-like stains that may appear after cleaning. Hydrofluoric acid specifically dissolves carbonaceous pollutant products, or dirt, and in most cases does not leave water-soluble salts in the masonry if the cleaning is properly carried out. It should preferably be used at a concentration 0.5 percent, but may be used at concentrations as high as 5 percent.

Hydrofluoric acid works on granite, slate, sandstone and brick by dissolving a minute amount of their surface, thus releasing the dirt. In this way, the introduction of potentially harmful residual salts into the masonry is kept to a minimum. The masonry should be kept moist throughout the cleaning operation to avoid silica deposition (efflorescence or the formation of a whitish powder). As most chemical cleaners (both acidic and alkaline) must remain on the surface for several minutes, keeping the masonry moist will also maximize cleaning efficiency. A second or third application of the cleaning agent may be necessary to remove particularly heavy dirt deposits.

Most commercially available products contain thickening agents to form gels or pastes that improve the cleaning agent's ability to cling to vertical surfaces. They also contain secondary solvents of a lower evaporation rate than water, such as glycerine to enable the cleaner to remain moist longer on the masonry surface. However, care must be taken to avoid exposing the masonry to cleaners containing hydrofluoric or other acids for more than five to seven minutes.

A variety of commercially prepared acid-based cleaners for masonry is available: products for granite, brick and sandstone, afterwash products, concrete cleaners and mortar removal products. The principal ingredient in granite products (restoration cleaners) is hydrofluoric acid. The afterwash products contain weak organic acids such as acetic acid. The mortar removers and concrete cleaners are based on

hydrochloric acid. Many of these commercial products are very effective on historic masonry buildings if used according to the manufacturer's directions and under the supervision of a preservation consultant.

It may be difficult to obtain a list of all the ingredients or their exact proportions for most of these products, since they are usually of a proprietary nature, and not patented. However, the Occupational Safety and Health Administration (OSHA), requires that Material Safety Data Sheets be supplied by manufacturers to distributors upon request; the provide information about all hazardous contents in commercially available cleaning products.

Cautions and Precautions. Hydrofluoric acid-based cleaners can sometimes leave whitish deposits of silica, or calcium fluoride salts (efflorescence). These deposits are generally not harmful to the masonry but may be disfiguring, especially on darker masonry. Since this efflorescence is soluble in hydrofluoric acid, it can usually be removed by a second chemical treatment, followed immediately by a thorough cold water rinse. It should be noted that hydrofluoric-based cleaners left too long on the masonry may result in a colloidal silica deposit that may be almost impossible to remove (figure 13).

Figure 13. While hydrofluoric acid-based cleaners are often appropriate for cleaning unglazed brick, they may form hard-to-remove whitish silica deposits if left too long on the surface.

Although cleaning non acid-sensitive masonry with hydrofluoric acid-based products is generally a relative safe undertaking—using proper precautions—hydrofluoric acid may lighten the color of some sandstones containing iron. This is another reason why it is always important to test the product on the masonry before beginning a full-scale cleaning project. Hydrofluoric acid can also severely etch aluminum and glass; therefore, these materials must be covered with acid-resistant coatings for protection during cleaning.

Hydrochloric (muriatic) acid is a very strong acid and thus should generally not be used as a cleaning agent on historic masonry (even when diluted). Rather than cleaning or dissolving dirt, it dissolves lime-based mortars and even some stones, and leaves chloride deposits on the masonry surface. *The fact that it dissolves lime-based mortar as well as lime contained in some stones clearly illustrates that its use on historic masonry is generally inappropriate, since many historic mortars have a high lime content.*

When used as a cleaning agent, hydrochloric acid also tends to result in the formation of water soluble salts in the masonry itself, which even thorough surface rinsing is unable to remove. Some of these salts deposited within the masonry will probably appear on the exterior surface of the masonry as efflorescence, which may be washed off or brushed off by hand. However, not all of these chloride sales will migrate to the exterior surface. Salts remaining within the masonry may eventually cause spalling of the masonry units themselves. Furthermore, the use of hydrochloric acid may also result in the formation of yellow ferrous chloride stains on some types of masonry.

Commercially available acid-based cleaners usually contain varying combinations of hydrofluoric, phosphoric, hydrochloric (muriatic), sufuric, acetic, and oxalic acid. As a final caution, it should be noted that despite the manufacturer's recommendations, commercially available "all purpose" cleaners that contain hydrochloric acid should not be used on limestone.

Generally, the only appropriate application of diluted hydrochloric acid to historic masonry is to remove excess mortar that

may have been splashed over the stone or brick while repointing, to remove whitewash or other lime or cement-based coating, or sometimes to clean concrete.

Alkaline Cleaners

limestone, marble, calcareous sandstone, glazed brick, glazed architectural terra cotta, polished marble, polished granite

Alkaline cleaners should be used on acid-sensitive masonry materials that would be damaged by acidic cleaners: limestone and marble, calcareous sandstone, glazed brick and glazed architectural terra cotta, and polished marble and polished granite.

Alkaline cleaners consist of two major ingredients: 1) a detergent (or surfactant), and 2) some type of alkali, usually potassium hydroxide. Following their application to the pre-wet masonry, alkaline cleaners are rinsed off with water; then the masonry is given a slightly acidic wash (for example, acetic acid) to neutralize the alkaline solution. The final step is to rinse the masonry with water a second time. Both potassium hydroxide and ammonium hydroxide (ammonia) are suitable alkaline cleaners for historic masonry. (Ammonia cleaners are especially effective in removing soil of a slightly greasy nature.) For lighter-colored calcareous masonry, a more uniform final appearance may require the addition of complexing agents (such as EDTA) and organic bleaches, but only under careful professional supervision. The effectiveness of alkaline cleaners, particularly for removing paint, wax coatings, grease and oil stains, may be increased by a hot water rinse (not over 160°F). Alkaline paint removers as well as alkaline cleaners for dirt removal from calcareous stones are used undiluted.

Cautions and Precautions. Sodium hydroxide (caustic soda or lye) generally should not be used on older or historic masonry. It is extremely harsh and can cause efflorescence and subflorescence, and may also cause physical abrasion and loss of small amounts of a brick surface (figure 14). Ammonium bifluoride is another alkaline cleaner that is commonly recommended as an "all-purpose" cleaner, but in general, ammonium bifluoride solutions are also not suitable for use on limestones, marbles, calcareous sandstones, or unglazed brick because of the likelihood of leaving ammonium salts on the surface or within the masonry.

Figure 14. Although the sodium hydroxide-based test cleaning patch on the right side of this wall of common brick appears to have been successfully cleaned, closer inspection reveals that a minute portion of the brick surface has been dissolved and removed by the cleaner. As a result, considerable brick dust can be seen in the cracks of the pavement beneath the wall.

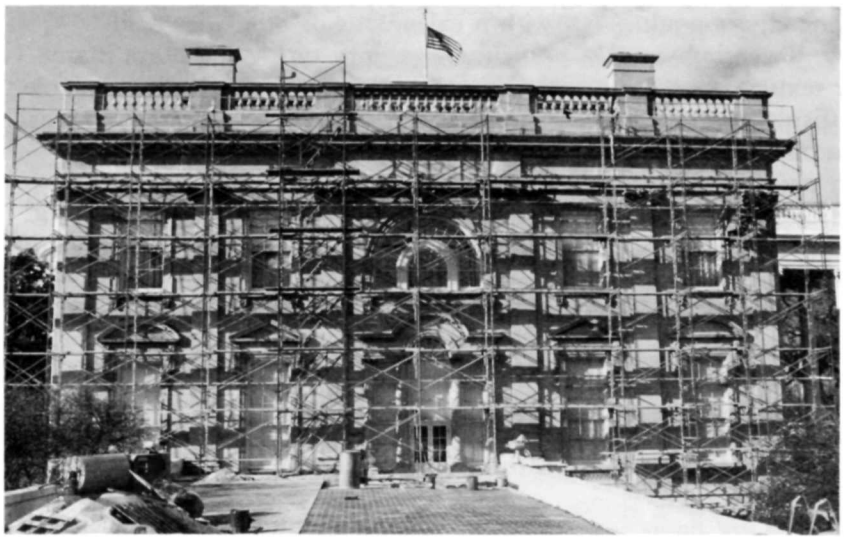
Surfactants and Detergents

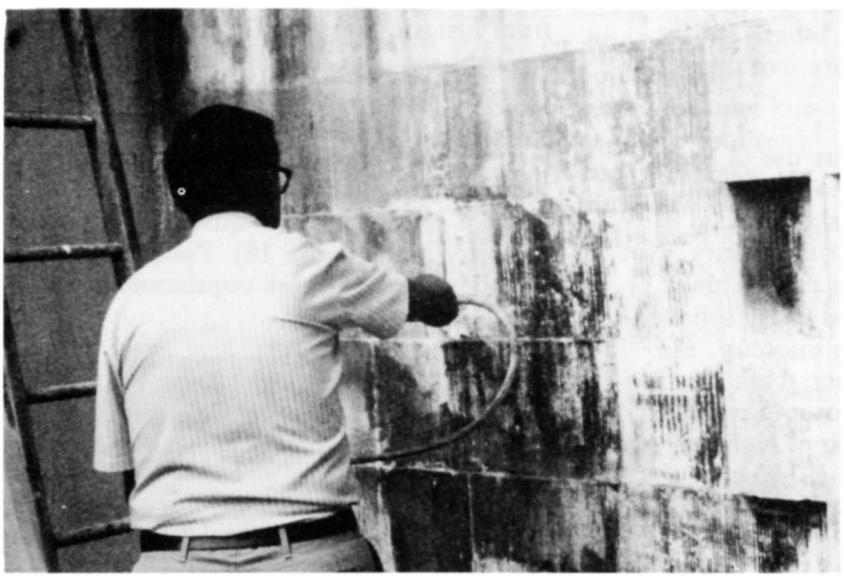
polished granite, glazed brick, architectural terra cotta

Surfactants (without acids or alkalies) can be used on polished granite, glazed brick, and architectural terra cotta without risk of etching. Scrubbing with non-metallic brushes (or sometimes even hand-sponging) with a detergent is another effective method of cleaning these smooth surfaces. (However, it may not be possible to remove discoloration caused by dirt that has penetrated a crazed terra cotta glaze.) Non-ionic surfactants can be especially effective in removing oily or greasy dirt.

Chemical Cleaning to Remove Paint and Other Coatings

Large-scale paint removal from historic masonry buildings can best be accomplished with chemical paint removers, based either on organic solvents or alkaline solutions. Commercial paint removers are





Figures 15a-15b. If a highly articulated facade is being cleaned it may be necessary to scaffold the building, one elevation at a time. When the monumental task of chemically removing all the paint from the White House was begun, each side was scaffolded in preparation for repainting. Removal of the many layers of paint that had obscured the stone tooling marks for almost a century, without damaging the historic sandstone, required much painstaking hand work. Photograph: National Park Service

generally formulated to remove most types of paint (except cementitious or lime-based paints such as whitewash) from all types of masonry. But it is always preferable to use an alkaline paint remover on acid-sensitive masonry (figures 15a-15b).

Alkaline Paint Removers

limestone, marble, calcareous sandstone, glazed brick, glazed architectural terra cotta, polished marble, polished granite

One type of paint remover is based on ammonium hydroxide (ammonia), potassium hydroxide, or trisodium phosphate. This alkaline-based paint remover is best used on calcareous and other acid-sensitive masonry, and is particularly useful for removing oil, latex and acrylic paint. (Many paint removers are composed primarily of sodium hydroxide—caustic soda or lye—which, as explained earlier, should not be used on historic masonry because of the likelihood of depositing harmful salts.)

Organic Solvent Paint Removers

A second type of paint remover is composed of a combination of organic solvents, which almost always includes methylene chloride, and others such as methanol (wood alcohol), acetone, xylene, and toluene. Organic solvent-based cleaners are particularly effective in removing more recently developed coatings, including epoxy and urethane-type coatings. However, methylene chloride-based cleaners may also tend to spread some stains deeper into the masonry, so they must be applied with caution, and of course, only after testing. Both types of paint removers are applied either with a brush or sprayed on the masonry surface. The addition of gels, thickeners and waxes prevents paint removers, which evaporate rapidly, from drying out so that they may remain active on the surface for several hours.

The softened paint is then washed off using a water rinse that may range from as low as 200 psi to possibly as high as 800 psi. Efficiency of the paint removal differs from project to project. Multiple layers of paint may require two or more applications of paint remover, or the use of several types. An intricately carved, rough or damaged masonry surface will also take more time and may not result in a surface completely free of paint. If the paint has penetrated into the masonry, total paint removal may be impossible to achieve without damaging the surface.

Removing Other Coatings

Traditional lime-based whitewash or color washes that have deteriorated and no longer bond to the substrate, may be removed with hydrochloric (muriatic) acid—which will dissolve the lime *(and also the masonry substrate if it is not applied with caution)*—or sometimes with acetic acid, and hand-scrubbing with non-metallic

brushes. Sometimes prolonged wet poulticing may also be necessary. Twentieth-century cement-based, or textured coatings, may be very difficult to remove without damaging the masonry. They are not likely to be soluble in paint remover, although occasionally hydrochloric acid may be effective, and sometimes they can be removed by hand-scraping. Removal of acrylic water-repellent coatings may usually be accomplished with an alkaline, possibly potasium hydroxide, solution.

Cautions and Precautions. In particular, those paint removers based on organic solvents should be handled with extra caution. Most organic solvents are flammable. Their vapors, easily absorbed through the skin and the lungs, are carcinogenic, and some are irritating to the skin.

It should be noted that the use of heat (applied with a propane torch or similar device) is *never* an acceptable method of paint removal from historic masonry. Not only is heat ineffective, it may actually damage the masonry, and cause softened paint to permeate porous masonry. Furthermore, use of a propane torch also introduces the hazard of fire to historic materials. Finally, the use of high-pressure water in itself is also not an effective or acceptable method of paint removal from historic masonry.

Poulticing to Remove Stains

The first step in stain removal is to identify the stain; the next step is to try to prevent recurrence of the problem by getting at its source. This source may be integral to the configuration of building materials in a historic structure, and as such, may not be feasible to eliminate. For example, copper flashing will often stain light-colored stone or brick. And the more porous the masonry, the greater the tendency for the masonry to become stained. Thus, while glazed brick and architectural terra cotta are generally resistant to penetrating stains, limestone and marble are considerably more likely to stain because of their porous nature. The fact that acids should not be used on acid-sensitive materials frequently means that, while an acid might indeed be capable of removing a certain stain from brick or a siliceous stone, an alternative, non-acidic cleaner must be substituted when dealing with a calcareous or otherwise acid-sensitive masonry type. There are many premixed poultices commercially available that are based on much the same composition as those described here.

Frequently stains will be removed during a general cleaning of the masonry. But the removal of disfiguring stains, graffiti, and efflorescent salt deposits from masonry is often a complex and challenging undertaking. It is complicated by the fact that, unlike particulate dirt which tends to sit on the surface, stains generally penetrate into and permeate the masonry.

For this reason, poulticing is generally the most effective means of removing stains from historic masonry. Efficient stain removal requires that a cleaning solution (selected according to the type of stain) be kept in contact with the stained area for as long as possible, and that the cleaning solution pull out the staining material without redepositing or spreading it on the masonry itself (figure 16). Poulticing methods meet all these requirements.

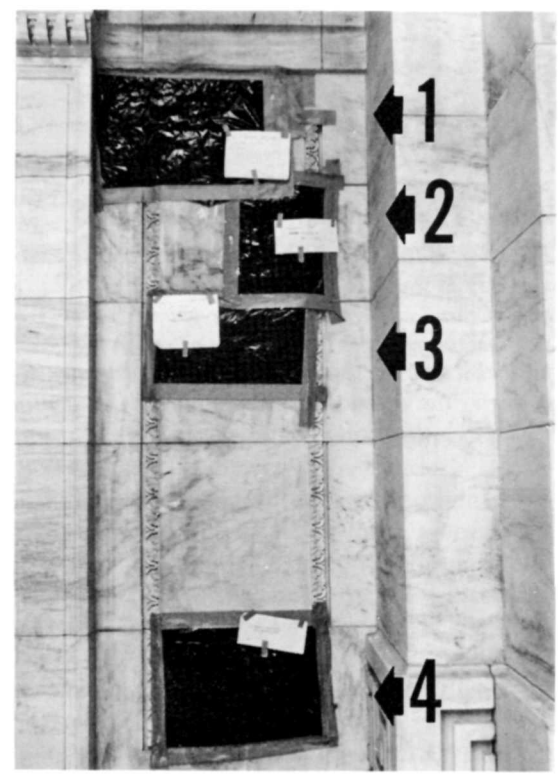


Figure 16. Four different poultice mixtures were tested to remove metal stains from this marble wall. From top to bottom, they included a commercial poultice, as well as formulations of peroxide and hydrated lime, ammonia and hydrated lime, and sodium citrate and glycerine with hydrated lime. Photograph: The Ehrenkrantz Group

Simply stated, a poultice is composed of an absorbent material or powder, mixed with a liquid to form a paste or slurry. The absorbent powders or chemically inert fillers used to make up the poultice not only slow the rate of evaporation or reaction, allowing adequate time for the solvent to dissolve the stain, but also provide a vehicle to accept the staining material after it has been pulled from the masonry. Among the powders commonly used for poulticing are clays (such as attapulgite, kaolin and fuller's earth), talc, chalk (whiting), sepiolite (hydrous magnesium silicate), diatomaceous earth (kieselguhr) and methyl cellulose. While absorbent clays and diatomaceous earth are the most efficient, whiting and kaolin are the cheapest. It should be noted that the absorbent material for a poultice does not always have to be powdered, but can consist of shredded acid-free paper or absorbent cotton or cotton pads. (Generally, whiting, or iron-containing clay such as fuller's earth, should not be used as the absorbent ingredient if an acid is used as the solvent; they will react with, and thus, negate the effectiveness of the acid.)

Next, the type of solvent (liquid) is chosen to match the requirements of the stain to be removed. It will either be water for a chemical poultice or an organic solvent for stains that are soluble only in solvents. A heavy or thick poultice may require additional support on vertical surfaces in the form of a non-ferrous, or plastic mesh which can be held against the wall with non-staining fasteners. The poultice will clean more effectively if kept wet throughout the dwell period. It can be covered with plastic to prevent it from drying out too rapidly, and can also be rewetted if it dries too quickly without having removed the stain. If a single poulticing operation is not effective, a second application can be made. After removing and discarding the poultice material, the area should be thoroughly rinsed with clean water to cleanse the masonry of any chemical residue (figure 17a - 17d).

The poultice is applied as follows: a ¼-¾ inch layer of the paste is applied to the masonry surface, and the liquid is absorbed into the masonry to act upon the stain. As the poultice dries out, the liquid is re-absorbed back into it, drawing out the stain. The poultice is allowed to dry completely, and is removed gently by

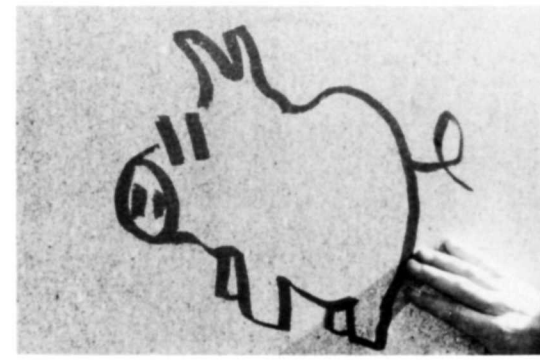


Figure 17(a). This graffiti was applied with a wide felt-tipped marker to a polished granite wall. To facilitate removal and to prevent the image from penetrating further into the stone, the masonry surface was first wetted with denatured alcohol.

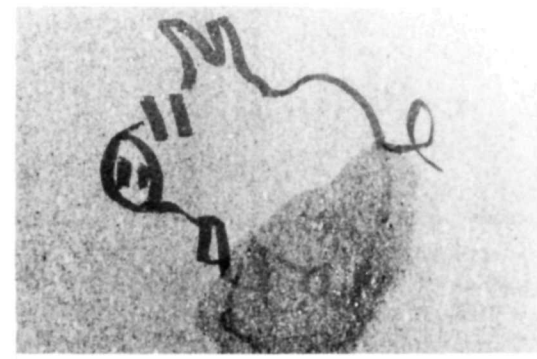
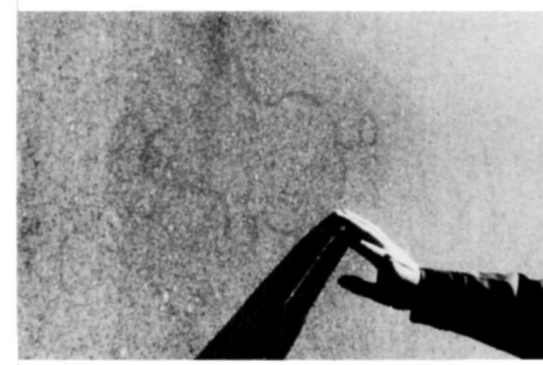


Figure (b) Most of the image was removed using a rag saturated with a mixture of solvents, including acetone, lacquer thinner and N-methy-2-pyrrolidone.



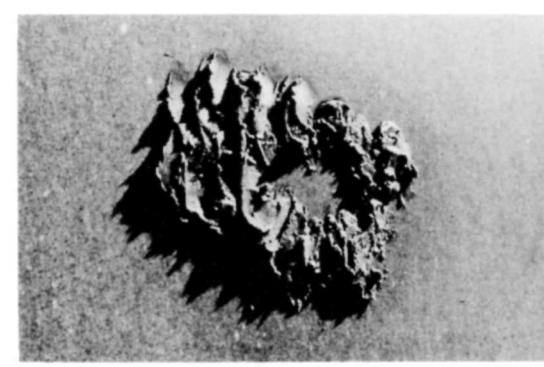


Figure (c-d) The slight ghost outline remaining was easily removed with the solvent mixture in a poultice composed of attapulgite and Kaolin clays and whiting, and followed by a thorough detergent and water wash. Photographs: Nicholas F. Veloz

hand with a wooden scraper or non-metallic brush.

Metallic Stains

In general, metallic stains on siliceous or acid-resistant surfaces can be removed effectively with a weak acid solution. Metallic stains on acid-sensitive masonry should be removed using an alkaline salt of the appropriate acid (for example, ammonium oxalate to remove rust stains). Metal compounds are responsible for a great number of stains on historic masonry structures. Of these, rust stains from *iron* are probably the most common. The orange color is caused by small particles of hydrous iron oxide. Most rust stains are directly related to the corrosion of exterior ironwork such as porch railings and grillwork, or concealed interior support mechanisms such as iron anchors and tie rods. Corrosion is usually initiated by water penetration into the building, primarily via cracks and open mortar joints, and the stains will continue to reappear if these leaks are not repaired. However, some rust stains are due to certain iron-containing minerals, such as pyrite, that may occur naturally in the stone and, as such, cannot be removed.

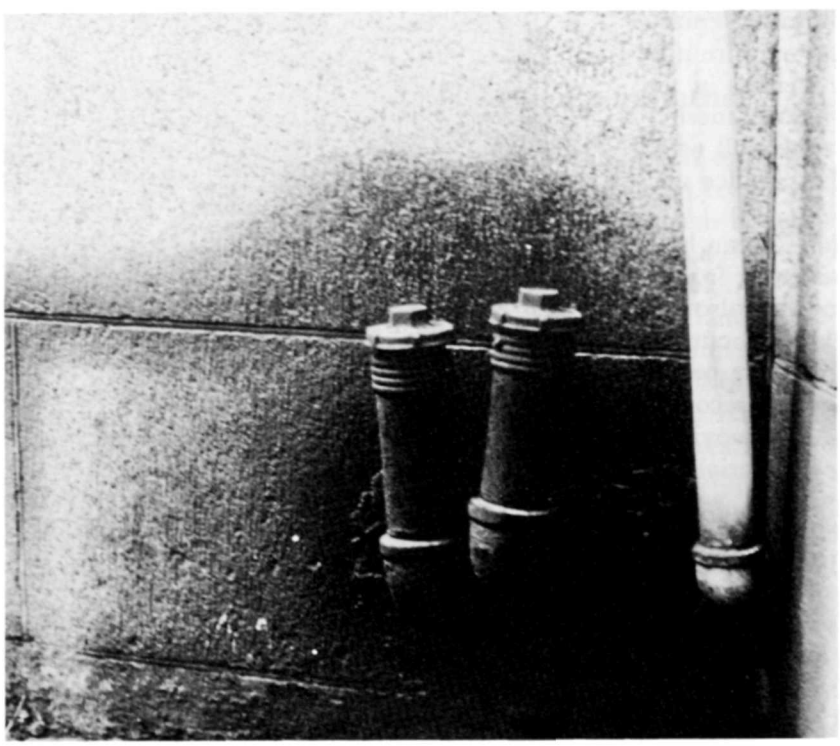


Figure 18. Removal of this oil stain which has penetrated deep into the granite will necessitate poulticing with an organic solvent.

Green stains are usually associated with the presence of a number of *copper* compounds. Copper roofing, brass ornaments and bronze hardware and sculpture are among the obvious scources of green staining. Copper and bronze stains are usually not difficult to eliminate successfully. Generally, they are soluble in an ammonia solution (aqueous ammonium hydroxide).

Industrial Stains

Industrial stains result from contact with such materials as *fuel oil, asphalt* and *tar.* Some superficial (or surface) industrial stains, like smoke and soot and oil, may be removed by gently scrubbing with a scouring powder containing bleach (but not household bleaches which are sodium-based) or water-based household detergents that are acid and alkali-free. However, scouring powders sometimes contain abrasives which may damage delicate masonry surfaces. Ammonia also dissolves some superficial oily stains; thus, a solution of ammonia and water applied in a poultice is useful for removing oil and grease stains from marble. But most procedures for the removal of these oily stains require the use of organic solvents. Because flooding the surface with solvents is both inefficient and costly, brushing with an emulsion of organic solvents such as mineral spirits may be more effective. A water rinse afterward is necessary.

Industrial stains that have penetrated more deeply into the masonry should not be rubbed in, but should always be removed with a poultice (figure 18). An appropriate solvent (or solvent mixture) must be selected. This will probably involve some testing to find a solvent best suited to the type of stain. Among the common organic solvents that may be effective in removing industrial stains are the following: naptha, mineral spirits, chlorinated hydrocarbons (such as methylene chloride and perchloroethylene), ethyl alcohol, acetone, ethyl acetate, amyl acetate, toluene, xylene, and trichlorethylene. (A slight variation of the poultice method consists of thoroughly soaking the stained area with the solvent, and immediately covering it with absorbent powder.)

It may not always be possible to remove all traces of asphaltic stains, but their visual impact will be substantially reduced

by using these methods. Additional washing and scrubbing with detergent or scouring powder following application of the poultice may further reduce staining.

Removal of larger chunks of asphalt or tar accumulations may be facilitated by applying dry ice or spraying with carbon dioxide. The asphalt or tar will be embrittled by the dry ice or carbon dioxide, and after tapping with a small hammer, can usually be removed from the masonry surface by prying it up with a putty knife, (figure 19). This same technique can be use for removing gum, adhesives or other sticky substances, Such techniques, however, should not be used on wet masonry, as they may freeze the moisture in the masonry, and cause cracking or spalling. Organic solvents or bleaches are also effective, sometimes in a poultice, on sticky substances.

Biological Stains

Heavy growths of *lichens, algae, moss and fungi* should be removed from masonry surfaces. Lichens in particular, and mosses, tend to encourage stone or masonry deterioration, because they produce oxalic acid, and, because like other plant growth, they attract—or are attracted to—moisture, one of the major enemies of masonry. Thus, in most cases, it is best to eliminate all plant, lichen and algae growth on historic masonry.

Lichens and algae can usually be removed with water and a stiff natural bristle brush, after soaking, if necessary (figure 20). Stains caused by plant growth such as mildew (which is a fungus) can sometimes be removed with organic solvents, but are generally best treated with diluted ammonia or bleaches. Hydrogen peroxide can also be effective. Calcium hypochlorite solutions and pastes (the basic of swimming pool chlorine) and Chloramine-T may also be useful in many cases. Chemical removal of the growth itself may sometimes be accomplished with zinc or magnesium fluorosilicate, copper naphthenate, or with a variety of quartenary ammonium salts. Low-to-medium-pressure (100-400 psi) water rinsing can be used to eliminate much of the plant material prior to treatment and stain removal. However, these compounds should be used with caution, as some copper compounds may stain light-colored masonry, and the use of zinc or magnesium fluorosilicate may result in formation of a surface crust on some masonry.

Figure 19. Efficient removal of tar splatters from limestone and sandstone may be facilitated initially by applying dry ice or carbon dioxide, but complete removal will probably require poulticing with an inorganic solvent.

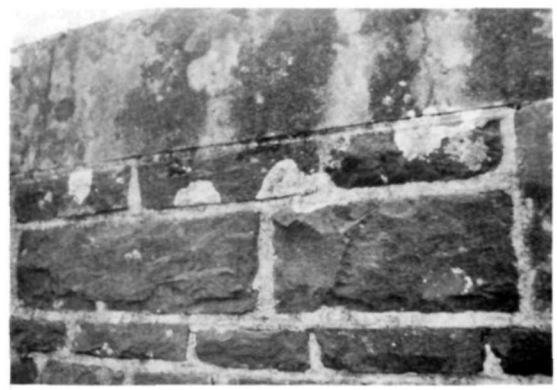


Figure 20. Plant growth such as lichens growing on a protected side of this limestone and granite parapet wall, can be damaging even to a relatively hard stone like granite because lichens secrete oxalic acid. Lichens can usually be removed, after soaking with water by scrubbing with a stiff natural bristle brush.

Other growing vines such as ivy and Virginia Creeper should be cut at the roots, and allowed to dry before removal to prevent the disk-tipped tendrils

characteristic of these plants from dislodging parts of the masonry. Once the plants have dried up they can be carefully pulled off; the roots should be killed (ammonium sulfamate may be applied to the roots if necessary, taking care not to get it on the masonry). Any remaining dried plant material on the walls can be removed by scrubbing with a non-metallic brush, and then washed off (figure 21). Except in extreme cases, herbicides should not be used to remove algae, moss or lichens because of the danger of introducing addtional salts or acids into the masonry, as well as the potential for creating environmental problems.

Most of these forms of plant growth on masonry buildings—algae, moss, lichens and fungi—are a direct result of moisture in the masonry and lack of sunshine. Thus, unless the specific conditions change, i.e., the moisture problem is eliminated, or the masonry is given more exposure to the sun, they will recur continually (figure 22). A leaking downspout or gutter can be repaired, a tree or bush too close to the building can be trimmed or pruned to introduce more sunlight, and even lawn sprinklers can be redirected so they do not repeatedly deposit excessive amounts of water on the same area of a building surface (figure 23).

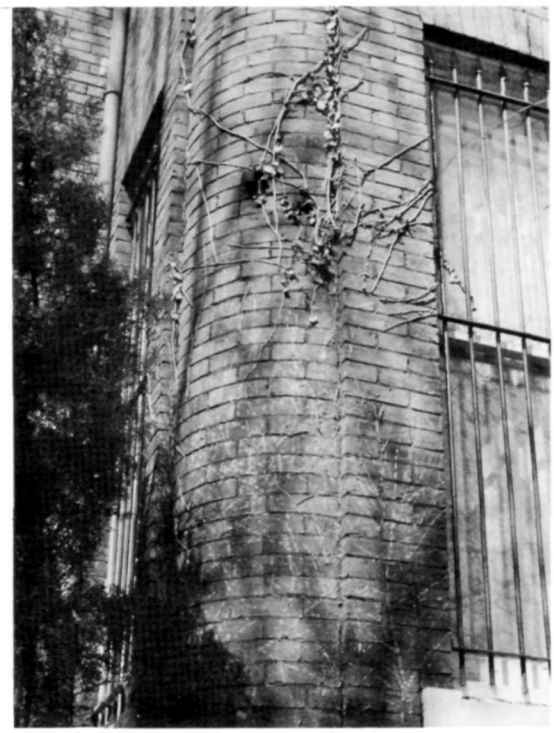


Figure 21. After the ivy was cut at the roots, it has been allowed to wither and die before being pulled off the wall. Most of the ivy has been removed, but a few tendrils still cling higher on the wall. After these have completely dried and have been pulled off, the remaining dried plant material can then be removed from the brick by scrubbing with water and a bristle brush.

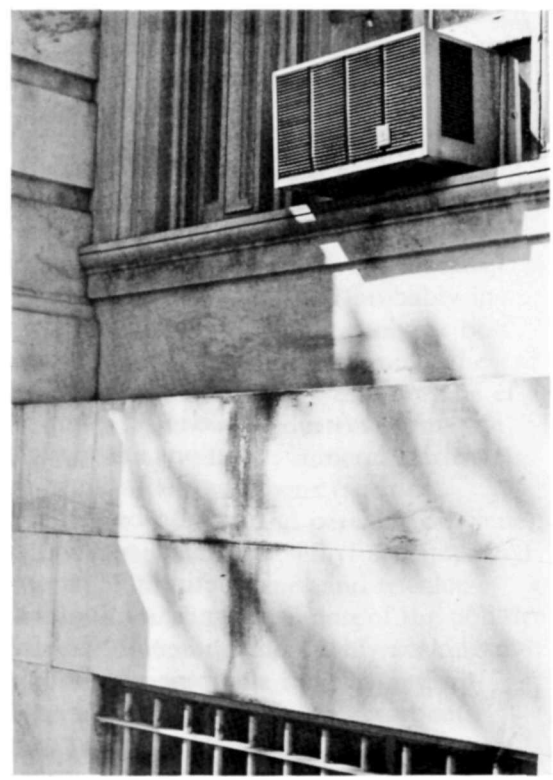


Figure 22. The discoloration on this white marble is a green-colored algae growth on a shady side of the building and caused by water dripping from the air-conditioner above it.

Figure 23. The moss growing around the downspout and along the base of this stucco building clearly indicates the presence of excess moisture—here due to rising damp as well as a leaky downspout. Photograph: Lee H. Nelson, FAIA

Graffiti

As with other types of cleaning problems, it is always preferable to identify the substance used to create the graffiti before selecting what is likely to be the best remover. If there is any possibility of discovering how the graffiti was applied (such as discarded spray paint cans in the immediate area), it is worthwhile to investigate, since the manufacturer of a particular product may be able to provide specific information concerning the ingredients of the paint, and thereby simplify the task of removal. It is also important to be aware that it may be extremely difficult, if not impossible, to completely remove all traces of some types of graffiti. Successful and total removal of graffiti may depend on the type and surface texture of the masonry, as well as the particular substance applied. After its removal, which is essentially a spot cleaning operation, the masonry surface may appear spotty. If too unsightly, cleaning the entire surface or wall may be necessary. Sometimes it may be easier to "redirty" slightly the cleaned area to blend in with the uncleaned wall.

Like most other cleaning projects, successful graffiti removal will probably involve a "trial and error" approach, unless the material used to apply it can be readily identified before cleaning is begun. And, as with any type of cleaning of historic masonry, the gentlest method possible should always be tried first; otherwise, one may run the risk of permanently etching the graffiti into the masonry surface.

Figure 24. Spray-painted graffiti on this brick wall can be removed with paint remover, and in this case, probably will not require poulticing.

Painted graffiti applied from a spray can or by a felt-tipped marker or lipstick may generally be removed from masonry by a commercial paint remover—either a solvent type of remover such as lacquer thinner or acetone, or a methylene chloride-based remover (figure 24). In some instances, poulticing may not be necessary. If the graffiti has not permeated deeply into the masonry, it may be removed by the paint remover or a solution of trisodium phosphate brushed on with a non-metallic brush. After the paint has softened, as much as possible should be scraped off with a wooden scraper. Then the area should be washed again using a detergent and soapy water, and rinsed thoroughly with water.

A variety of commercial solvents are available on the market, which may contain aromatic non-chlorinated solvents such as xylol, toluene with methanol or ketone, or chlorinated hydrocarbon solvents such as methylene chloride. But before trying these solvents which, as noted, are effective but are also very toxic and dangerous to handle, it is always best to try something milder, such as a detergent solution and water combined with hand-scrubbing with a non-metallic brush.

Although many cleaning contractors may advise application of a coating to protect masonry surfaces that are particularly vulnerable to defacement by graffiti, a coating is generally not recommended. Historic masonry may be discolored or damaged more by such coatings, which may inhibit moisture evaporation, than by the graffiti. Furthermore, the coating itself is likely to be removed by subsequent graffiti removals.

Salt/Efflorescence

Efflorescence is a whitish powder made up of excess salts that have crystalized on the masonry surface. Because efflorescence may have many causes, it is important to identify the source of the problem. For example, although efflorescence is usually a sign of excessive amounts of moisture in the masonry, it may also result from

chemical cleaning or repointing if the masonry is not thoroughly rinsed. It may also come from heavy use of de-icing salts, or rain penetrating masonry through deteriorated mortar joints may result in efflorescent patches on an entire facade. Finally, air pollution often results in the formation of thick sulfate (salt) crusts on the underside of moldings and eaves—areas not regularly washed by rainfall (figure 25).

Efflorescence can usually be brushed or washed off with water since it is formed of water soluble salts. Some efflorescence that results from cleaning may eventually disappear through normal rain washing; however, some chemical residue left from the cleaning process can form damaging insoluble salts. Efflorescence resulting from water penetration into the masonry structure will continue to reappear unless the source of the water entry is removed; thus, the first task is to identify the point of entry and stop the water penetration (figure 26).

Figure 25. Excess moisture leaching out through the walls has resulted in the formation of white efflorescent salts on the brick and blackish sulfate salts on the limestone water table.

Figure 26. Efflorescent salts appearing on many of the brick piers of this turn-of-the-century building may indicate the existence of clogged interior gutters that, because they no longer function have been supplemented by an exterior rain removal system. Photograph: National Park Service

Sulfate encrustations often may be removed with a heavy wooden scraper. But removal of particularly heavy salt buildup may also require a poultice of one of the following: diatomaceous earth, cotton, crushed dolomite, crushed limestone, or shredded polyester fiber soaked in distilled water. The area of the masonry that displays efflorescence should also be soaked in distilled water before applying the poultice to avoid redistributing the salts back into the masonry.

Cautions and Precautions. Several points need to be made regarding the use of chemicals in poultices. First, copper stains should never be removed from limestone with potassium cyanide or sodium cyanide as is sometimes recommended. Both of these cyanide compounds can be lethal to cleaning personnel. Second, most organic solvents are flammable. Their vapors, easily absorbed through the skin and the lungs, are carcinogenic, and some are irritating to the skin. Third, bleach should never be used in conjunction with ammonia in a poultice; this simple-sounding household combination produces toxic chlorine gas that may cause lung tissue damage or death. Finally, spraying liquid nitrogen or asphalt or tar will make it brittle and thus removable, but it is highly flammable and so dangerous to work with that a user must be specially licensed.

Other Methods of Stain Removal

While it is usually necessary to employ a poultice to remove most stains on masonry, other, sometimes simpler, procedures may also be effective. If a stain is superficial, it may often be eliminated by applying a chemical remover or solvent with brushes, or by "washing" the solvent over the surface using a low pressure (under 100 psi) spraying apparatus. It may also help to coat the surface with talc

or similar material to help absorb the stain in a sort of simplified poultice. To prevent outward migration of the staining agent, which would increase the size of the stained area, the masonry immediately adjacent to the stain on all sides should be thoroughly prewetted. Following application of the cleaning solution, the masonry must be rinsed off, and the entire procedure repeated, as necessary. Rinsing need not be done with pressure; in fact, it is normally sufficient to gently flood the treated surface for several minutes.

Cautions and Precautions. Mechanical or abrasive procedures such as sandblasting, grinding or chiseling to remove dirt, paint, stains or graffiti are not acceptable methods of cleaning historic masonry. Such abrasive methods may—with varying degrees of success—remove the offending substance from the masonry, but may also damage the masonry by removing or abrading the outer surface layer (figure 27). Very loose or flaking paint or a similar coating on smooth surfaces, such as brick, may sometimes be successsfully removed by careful hand-scraping in preparation for repainting, but the physical irregularities of most rough-cut or carved surfaces make this impractical. Furthermore, abrasive cleaning techniques may also be harmful to the applicator, passersby and public property.

Cleaning to Remove Bird Droppings

Removal of small amounts of bird droppings may be accomplished as part of a regular cleaning project with cold water washing, possibly supplemented with detergents and chelating agents such as EDTA (ethylene diamine tetra-acetic acid), or on non-acid sensitive masonry with acidic cleaners, where appropriate. Removal may also be facilitated by brushing with a non-metallic brush and scraping with a wood scraper (figure 28).

In some instances where particularly porous types of stone may have been stained by heavy accumulations of droppings that have permeated into the stone over the years, they can be removed by using a combination of the above materials.

Cautions and Precautions. Histoplasmosis and cryptococcosis, both potentially fatal

Figure 27. Heavily pitted by sandblasting, this window recess provides a vivid contrast to adjacent undamaged brick protected from abrasion by a metal signboard.

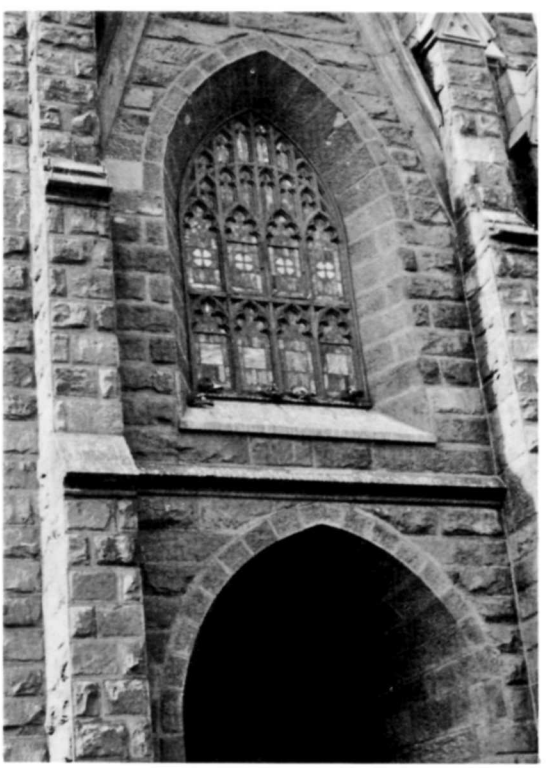


Figure 28. If water, or water and detergent wash, does not remove the pigeon droppings from this sandstone sill and stringcourse below, it may be necessary to use a dilute acidic cleaner containing hydrofluoric acid, providing the sandstone is not calcareous and thus, acid-sensitive.

diseases of the lungs and central nervous system, can result from exposure to accumulations of pigeon excrement. Because of this disease potential, it may be better to apply water pressure from a safe distance to remove excessive amounts of droppings and better not to attempt total removal, particularly if droppings are not highly visible or do not appear to be damaging the masonry. Bleach should not be used as a component of any removal process; bird droppings contain ammonia, which forms toxic gases when mixed with some bleaches. When removing bird droppings, cleaning personnel should guard against exposure to the attendant health hazards by wearing protective masks and clothing.

Part III
Summary of Guidance

The "Gentlest Means Possible"

Although masonry may be one of the most durable of historic building materials, it is nonetheless susceptible to damage by improper maintenance or repair techniques and by harsh and abrasive cleaning methods. Thus, cleaning historic masonry is recommended only when necessary to halt deterioration or to remove heavy soiling, and *only* after careful testing. Observing the "gentlest means possible" rule always means beginning with a low-pressure water wash, supplemented, if necessary, with non-ionic detergents and scrubbing with non-metallic brushes. If this very gentle method does not clean the masonry, or if paint or stains must be removed, the next step is to use a chemical cleaning process. Abrasive cleaning methods are damaging and are not suitable cleaning techniques for historic masonry buildings.

Summary of Cleaning Techniques*

Substance to be Removed	Acid-Sensitive Masonry **Limestone, Marble, Calcareous Sandstone, Glazed Brick, Architectural Terra Cotta, Polished Granite**	Non-Acid-Sensitive Masonry **Sandstone, Slate, Granite, Unglazed Brick, and Unglazed Terra Cotta, Concrete**
Dirt and/or Pollutant Crusts	Water wash Water + non-ionic detergent Alkaline cleaner (ammonia or potassium hydroxide)	Water wash Water + non-ionic detergent Acidic cleaner (hydrofluoric acid)
Paint (oil, latex, acrylic coating, vinyl, epoxy, urethane-type coatings)	Alkaline paint remover (ammonia or potassium hydroxide or trisodium phosphate) Organic solvent paint remover (methylene chloride)	Alkaline paint remover (ammonia or potassium hydroxide or trisodium phosphate) Organic solvent paint remover (methylene chloride)
Whitewash and Cementitious Paints	Acetic acid *or* very weak solution of hydrochloric acid	Acetic acid Hydrochloric acid
Stains - Iron (Rust)	*Poultice with:* Sodium citrate in water + glycerine *or* Ammonium oxalate	*Poultice with:* Oxalic acid or orthophosphoric acid + sodium salt of EDTA in water *or* Dilute hydrofluoric acid
Stains - Copper	*Poultice with:* Ammonium chloride *or* Aluminum hydroxide + ammonia	*Poultice with:* Ammonia (+ EDTA) *or* Dilute hydrofluoric acid
Stains - Industrial (smoke, soot, grease, oil, tar, asphalt, waxes)	Scouring powder with bleach Water-based household detergent Ammonia Mineral spirits Alkaline cleaner *Poultice with one of the following:* Sodium bicarbonate (baking soda) Naptha Mineral spirits Methylene chloride Perchloroethylene Ethyl alcohol Acetone Ethyl acetate Amyl acetate Toluene Xylene Trichloroethylene Dry ice/carbon dioxide (Tar, Asphalt, Gum)	Scouring powder with bleach Water-based household detergent Ammonia Mineral spirits Alkaline cleaner *Poultice with one of the following:* Sodium bicarbonate (baking soda) Naptha Mineral spirits Methylene chloride Perchloroethylene Ethyl alcohol Acetone Ethyl acetate Amyl acetate Toluene Xylene Trichloroethylene Dry ice/carbon dioxide (Tar, Asphalt, Gum)
Stains - Plant and Fungal (lichens, algae, moss, fungi)	Dilute ammonia Bleaches Hydrogen peroxide Sodium hypochlorite Chloramine-T	Dilute ammonia Bleaches Hydrogen peroxide Sodium hypochlorite Chloramine-T
Stains - Graffiti (paint, spray-paint, felt-tipped marker)	Organic solvent or alkaline paint remover Lacquer thinner or acetone Organic solvent (methylene chloride) See also **Paint,** above	Organic solvent paint remover Lacquer thinner or acetone Organic solvent (methylene chloride) See also **Paint,** above
Salt/Efflorescence	Water wash Water (poultice)	Water wash Water (poultice)
Bird Droppings	Water wash Water + detergent + chelating agent such as EDTA	Water wash Water + detergent + chelating agent such as EDTA Acidic cleaners (hydrofluoric acid)

*Cleaning techniques are listed in order starting with the "gentlest means possible."

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