The Repointing Of Historic Masonry Buildings

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PROLOGUE

The restoration and rehabilitation of older buildings is one of the most interesting, yet challenging, trends in architecture today. This work not only heightens our awareness of our past while preserving the character of our cities and neighborhoods, it also makes good practical sense. Re-use of existing structures saves building materials and energy while providing usable space more quickly and at a lower cost than new construction. In addition, restoration and rehabilitation efforts are creating many new jobs throughout the country.

For many years, SERMAC Industries Inc. has been assisting in the maintenance of buildings; good maintenance has given these buildings longer life while making them more pleasant places in which to work and live. More recently, SERMAC has been active in the exterior cleaning and improvement of masonry buildings. We are gratified to have had a role in the restoration of many significant buildings.

In the interest of providing our clients and licensees with basic information concerning the repointing of masonry buildings, we are pleased to publish this booklet. Written by Robert C. Mack, a restoration architect, it is based in large part on material presented by James S. Askins, a masonry restoration specialist, during a symposium sponsored by SERMAC on July 15, 1977; Mr. Askins also took the photographs. We hope you find it interesting and useful in your work.

CONTENTS

Prologue .......................... 2
Introduction ........................ 3
Why Repoint ........................ 3
Logistic Planning .................... 4
Scaffolding ........................ 4
Contracts ........................... 5
Types ............................... 5
Bonds ............................... 5
Scheduling .......................... 5
Measurement & Payment ............ 5
Contract Documents ................. 6
Scope ................................ 7
Temperature ........................ 7
Job Layout .......................... 7
Final Tests .......................... 7
Technical Specifications .......... 7
Test Panels .......................... 8
Planning & Research ............... 8
Pointing Styles ...................... 8
Replacement Bricks & Stones ...... 10
Materials ............................ 11
Masonry Units ....................... 11
Mortar .............................. 12
Storage ............................. 12
Durability .......................... 12
Color and Texture .................. 13
Working Properties ................. 13
Mortar Mix ........................ 14
Execution of The Work .............. 15
Joint Preparation ................... 15
Mortar Preparation ................. 17
Mortar Application ................. 19
Aging the Mortar ................... 20
Curing ............................. 20
Cleaning ............................ 21
Conclusion ........................... 21
INTRODUCTION

This information has been written to assist building owners and their restoration contractors understand the purposes, techniques, and potential problems of repointing historic masonry buildings. No book can hope to teach a skill such as repointing; that skill can be gained only through experience. It can, however, form a sound basis for beginning to learn a new skill, as well as a basis for effectively dealing with masonry contractors, and with the masons themselves.

Simply stated, repointing is the process of removing deteriorated mortar from a masonry joint and replacing the old mortar with new, sound mortar. This process sometimes is referred to as “tuck pointing”; to the purist, however, “tuck pointing” more properly refers to a decorative treatment rather than a method of repair; true tuck pointing is the process of adding a finish layer of mortar, occasionally tinted, to the outer portion of a newly laid joint. Repointing also is simply known as pointing.

Why Repoint?

All buildings and building materials are in the constant process of deterioration. The speed with which this deterioration takes place depends upon the quality of the original construction, the original design of the building, the wear to which the building is subjected, and the quality of the maintenance and repair program for the building. Masonry has an advantage over many other building materials because it has areas which are designed to absorb many of the stresses which lead to deterioration, and these areas can be readily replaced as they deteriorate. A masonry wall has mortar joints which, if a building was properly designed, absorb the stresses of deterioration and then are replaced by repointing. If properly done, this process can be repeated many times without causing any damage to the masonry units themselves.

A building needs repointing if observations point to outward signs of deterioration (Figure 1). Loose bricks, falling mortar, or damp walls may well result from deteriorated mortar. They also can relate to a variety of other problems such as leaking gutters, settlement, or structural deterioration. It is important, therefore, to fully investigate the possible causes for deterioration prior to concluding that repointing is necessary. Repointing cannot solve other problems! It may be that the services of a consultant will be required at this stage, frequently saving money in the long run by preventing unnecessary work from being undertaken.
Logistical Planning

Once the decision to repoint has been made, consideration must be given to the timing of the work. In the case of a project involving more than just repointing, for example, the proper sequence of the different aspects of the project must be determined in advance, preferably under the direction of an architect or a qualified general contractor. It also is important to remember that the repointing will be a lengthy process, so it may need to be scheduled around special activities planned for the building. Similarly, many projects will require scaffolding, which may make access to the building difficult. In addition, the project must be planned for a time of year in which the mortar will neither freeze nor bake before it is properly cured.

Scaffolding

Nearly all projects will require some type of access to masonry above the ground level. The two most common means of providing this access are fixed tubular scaffolding and swing stage scaffolding (Figure 2). Each type has advantages and limitations, so the choice will depend upon the particular job requirements.

Fixed scaffolding: If all other factors are equal, fixed scaffolding is preferred because it does not move, thereby permitting masons to exert pressure more firmly against the wall during cleaning and filling operations. Fixed scaffolding also permits several operations with one erection, thus is less expensive for projects involving many operations. It also allows inspection of all areas of the work rather than only the area of current operations. There is no need to enter the building with fixed scaffolding, which may be more convenient for the tenants. On the other hand, machinery and equipment are less mobile with fixed scaffolding. The required climbing may be tiring for the masons. In addition, fixed scaffolding generally is practical for use only on low and moderate height buildings, although scaffolding of up to twenty stories is not impossible.

Swing stage scaffolding: On projects involving only limited work, swing stage scaffolding normally is less expensive. In addition, it is more quickly installed and permits more rapid movement of equipment and materials. It also causes less interference with ground level movement. On the other hand, for involved projects several passes with a swing stage will be more expensive than fixed scaffolding. It also frequently is necessary to enter the building to install the swing stage, which may be undesirable for the tenants.
Contracts form the legal basis for the relationship between the building owner and the contractor, and the contractor and subcontractors. As such, it is essential that contracts be clearly written, understood by all parties, and enforceable in court, should the need arise. The contract normally consists of the construction documents (plans and specifications), a schedule for the work, a statement of the contract price, provision for progress payments, and other miscellaneous information. The contract documents will be discussed more fully later in this booklet.

**Types of Contracts**

There are three types of contracts in common use for construction projects. The primary difference between them is in the method of computation of the price for the work.

1. **Stipulated sum (also known as lump sum or fixed price) contracts** are the most commonly used form of construction contract. Under this type of agreement, the contractor agrees to perform a specified amount of work for a specific fee. Although this type of contract works well for new construction projects, where the work can be clearly defined, it frequently is not suited to a restoration project because of the uncertainties involved. When unanticipated work is discovered, necessitating a change to the contract, the contractor is in the most favorable position in negotiating the additional price!

2. **Time and materials contracts** are based on the actual cost of performing the work. The contractor computes the actual labor and materials costs of the project, then adds a percentage to the total to cover overhead and profit. The primary problem with this type of contract is that there is no incentive for the contractor to control the costs of the project since profit will be increased if the project cost is increased.

3. **Cost of the work plus a fee contracts** are based on the actual cost to the contractor plus a predetermined fixed fee for overhead and profit. Under this type of contract, most changes in the work result in an increase in contract price only for the actual increase in direct cost to the contractor; of course, if there is a truly major increase in the project it is only reasonable to adjust the contractor’s fee also. There is incentive for the contractor to be careful of costs since profit is not increased by using additional materials or taking additional time; in fact, it is to the contractor’s advantage to finish the job in an efficient manner since the workers then can proceed to another project.

**Bonds**

The requirement for bonds, if any, should clearly be stated in the contract. Bonds generally are recommended for all jobs over $5,000. The three types of bonds which are used most frequently are bid bonds, performance bonds, and labor and materials bonds.

- **Bid bonds** are used to insure that the low bidder on a project will actually sign a contract to perform the work.
- **Performance bonds** are used to insure that the work will be carried out in conformance with the plans and specifications.
- **Labor and materials bonds** (payment bonds) are used to insure that the contractor will pay for all the labor and materials used on the job; these bonds frequently are combined with the performance bonds.

In each type of bond, a surety company pledges to pay the client for any expenses incurred by the contractor’s failure to perform the task covered by the bond.

**Scheduling**

The contractor should be required to meet any scheduling requirements stated by the client in the bid documents. If the client has no particular schedule requirements, the contractor should include a proposed schedule as part of the bid. The proposed schedule then becomes part of the contract. If the work takes longer than the agreed period, the contractor may be required to pay liquidated damages to the client to make up for the increased cost of inspection, administration, and so forth which the client will incur. In the case of changes in the scope of the project, of course, the contract date will need to be revised along with the price for the work.

**Measurement and Payment**

The method of calculating payments must be clearly defined in the contract. In part, this will depend upon the type of contract selected. In the case of either type of contract based on time and materials, the calculations of payments normally are fairly straightforward. In the case of other methods of payment, however, differences of opinion frequently arise.

When a stipulated fee (lump sum) contract is used, the contractor agrees to perform all the work required by the contract documents for a stated sum. All work outside the original scope of work costs extra, frequently much more than would seem reasonable. One method used to overcome this problem is the use of "unit costs" for calculating payments. Under this method, the contractor agrees to perform the work for a set price per square foot of masonry or per lineal foot of joint. The contract must be exceptionally clear, however, in de-
fining the work and the method of measurement. Does the unit price include repairs only, or repairs and re-pointing of the repaired section? Does the measurement of area include openings, such as windows and doors? If not, how are returns at openings calculated? These questions must be answered before agreeing on unit prices for the work.

Most contracts will include provisions for partial payments during the course of the project. Contractors frequently like to have these progress payments “front-end loaded” so that they will not need to provide as much working capital. The contract should make it clear, however, that payment will be made only for work which is actually completed, as certified by the architect, if there is one engaged. The contract also should make clear that the owner reserves the right to suspend any or all portions of the work; this statement encourages the contractor to accurately evaluate each part of the work, since it is unknown which parts may be omitted.

A few rough figures may be helpful for general planning purposes. On low buildings, such as houses, re-pointing usually costs approximately $6.00 to $7.00 per square foot or $1.25 or $1.50 per linear foot based on 1979 wage rates. Other factors may modify these prices significantly. Unit costs on extremely small projects, for example, may be twice as high because the contractor’s costs for mobilization and administration are the same for a small job as for a larger one. Conversely, the unit costs on large projects may be reduced. On high buildings the costs also are higher because of the increased handling cost of materials and the decreased efficiency of the masons. The range of costs, therefore, may be as high as $10.00 to $15.00 per square foot in some areas of the country. A general rule is that labor costs will be approximately 6.5 times the material costs. With any estimate, the final figures normally reflect the general feeling of the estimator for the job as much as they reflect precise calculations.

For time estimating, a general figure is that a crew of two masons and one laborer can complete approximately 500 square feet per day at ground level using the hand methods discussed in this booklet. On projects where power tools are permitted for mortar removal, 800 to 1200 square feet may be completed by the same crew provided no masonry units are damaged by the power tools; if units which are damaged during the joint preparation must be replaced, the daily output may be reduced to nearly the same total area as for hand methods. These figures may be reduced as much as 20% to 40% for work above the ground level.

**CONTRACT DOCUMENTS**

Contract documents, also known as construction documents, consist of the drawings, photographs, and written instructions (plans and specifications) for the technical aspects of a project. They form the largest part of a construction contract. The contract documents are also the most important part of the contract, since they tell the contractor what will be done, where it will be done, and how it will be done. At the same time, they are the most difficult part of the contract to prepare and are most likely to be subject to disagreement by the parties to the contract.

**Scope**

Perhaps the most difficult requirement of a set of contract documents is to define precisely the desired results. In part, this is due to basic communications problems between the architect or consultant and the contractor. In many cases, however, even the consultant does not fully understand the problems and proper solutions. As a result, there are catch phrases which frequently appear on drawings or in specifications which have no real meaning: “Match existing” (existing what? deteriorated materials?); “match original” (match original what? match in what ways?). These are a few of the phrases which occur frequently which should either be avoided or explained in greater detail. Perhaps the most vague phrase of all in contracts is “contractor shall perform as directed,” which is used without any limits at all as to what the contractor will be asked to do!

Every effort should be made, therefore, to precisely define the work which will be expected. For the architect or consultant, this will mean spending adequate time in the preparation of the documents to fully explain the areas of work and the desired results. For the contractor, it will mean examining the documents in detail while preparing an estimate and asking pointed questions of the architect/consultant prior to submitting a final price for the work.

One effective way for the documents to convey information clearly is through the use of photographs to supplement drawings (Figure 3). Photographs clearly and concisely convey information to the contractor, without any details being omitted. Exact areas to be

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**Figure 3** Detail of working drawings prepared from photographs. (Courtesy of Miller-Dunwiddie Architects, Inc.)
repointed can be easily indicated with one type of shading while areas to be completely rebuilt can be identified with another. Because of the detail of the photograph, exact numbers of bricks or linear feet of repointing can be easily calculated.

**Temperature**

The contract documents should clearly state the temperature conditions under which work will be permitted and how the temperature will be evaluated. Repointing should be performed only when the temperature is between 40° F. and 80° F. If the temperature is below 40°, the mortar sets too slowly, and there is a good chance of freezing before it is fully set if the temperature drops. If the temperature is above 80°, the mortar will set too quickly, and there is a strong chance of excessive loss of water prior to adequate setting. It should be clear to the contractor at what location the temperature will be taken. On small projects, the obvious choice is the area in which the work is taking place. On larger projects the temperature should be taken in the area of most adverse conditions, which is the cold side during winter and the warm side during summer. If the temperature is above 80° F. the work should be thoroughly protected as discussed in the section on “Curing.”

Adequate inspection by the architect or client is essential on most jobs. The inspector’s right to be on the job site and to call for a halt to the work when necessary should be written into the contract. The inspector should be responsible for checking the temperature as well as the work itself.

In many cases it may be desirable to require inspection of the cleaned joints prior to beginning to apply the new mortar. If this practice is to be followed, it should be made clear in the contract documents. The inspector should visit the project site at different times each day, rather than in a predictable pattern, and should inspect the work from the mason’s work station rather than from the ground. Alternatively, the contract may make provision for final tests under the direction of the inspector.

**Job Layout**

The order in which the work is to be conducted should be clearly described in the contract documents. This is in addition to the sequencing of larger aspects of the work, such as cleaning, painting, roofing, and so forth.

All required masonry repairs should be completed prior to beginning the repointing. The outer surface of the joints in the repaired area should not receive any mortar so that the entire surface of the wall can be repointed and tooled at one time. Repairs should be allowed to cure for at least forty-eight hours before repointing so that any shrinkage will have already taken place.

“Cold” joints should be avoided to prevent weak areas in the work. Each day’s work, therefore, should extend the entire width of the building or should be terminated at a natural vertical joint such as a window opening. Natural horizontal lines, such as window heads and sills, belt courses, and so forth, should be followed as well (Figure 4). If a cold joint must be used, the mortar should be stepped back along the layers as they are filled (Figure 5).

**Final Tests**

If complete inspection between joint preparation and filling is not required, the contract should provide for tests of the completed repointing work. If the work fails the tests, the contractor should be required to re-do the repointing at no additional cost to the client.

The test procedure consists of removing the new mortar from random areas approximately two feet square to check for adequate joint preparation and filling. The mortar either should be removed by the inspector or by the contractor’s workers under the direct supervision of the inspector; the desired person should be made clear in the specifications. Once the joint has been inspected, it should be refilled using the layering procedure required for other areas.

The number of tests to be conducted should be indicated in the contract, since the contractor will be required to spend additional time and materials to conduct the tests and to re-fill the joints. The contract should also state, however, that if the work fails the tests and must be re-done, additional tests will be required at no additional cost to the client.

**Technical Specifications**

The actual materials and procedures to be used in removing and replacing the old mortar should be fully described in the contract documents. These procedures will be explained in detail later in this booklet.

![Figure 4](image_url) The horizontal bands and arched headers are logical places to break each day’s work to avoid a cold joint.

![Figure 5](image_url) If a cold joint must be made, it should be layered. The area on left the cleaned joint; central area has been filled with first two layers of new mortar; and area on right has been filled completely and tooled.
TEST PANELS

Perhaps the best way to convey information concerning the desired quality of the repointing job is through the use of test panels. If the project is to be awarded through competitive bidding, the test panel can be prepared in advance of the bidding under a small contract; the panel then can be referenced in the contract documents and all bidders will be able to know the exact standards required for the job. If the contract is to be negotiated, the test panel can be prepared by the selected contractor during the negotiations, thus giving the contractor a true indication of the time, materials, and problems related to the job. In either case, the test panel then becomes the standard against which all later work will be measured.

The area for the test panel should be selected carefully. First, the panel should include all the types of masonry, joint styles, and types of problems to be encountered on the job. At the same time, it should be located in an inconspicuous place so that unsuccessful experiments in joint cleaning or filling will not be noticeable to the public. The panel also should be readily accessible so that it can serve as the standard throughout the project (Figure 6).

PLANNING AND RESEARCH

The key to any successful restoration or rehabilitation project is adequate advance planning. In the case of a repointing project, this planning is necessary to insure the physical integrity of the masonry as well as the visual integrity of the architectural features. Some considerations, such as scheduling of the project have been mentioned earlier. This section, therefore, will deal primarily with the research which is necessary before preparing contract documents or entering a contract.

Pointing Styles

The tooling or other treatment given to a mortar joint has a significant impact on the visual qualities of the masonry wall. During the nineteenth century, for example, brick joints became thinner as the uniformity of bricks improved; at the same time, the design of the final tooling also changed. The repointed area should match the original pointing in joint thickness and tooling if it is to blend well with the adjacent areas. Even on a wall which will be completely repointed, the original pointing design should be followed in order to preserve the historic quality of the masonry. When examining the joint treatment, it should be remembered that the horizontal joints may have been treated differently from the vertical joints. It also should be remembered that the order of striking the horizontals and the verticals can effect the appearance of the wall. Some of the more common types of joints used on both brick and stone are given in the accompanying photographs (Figure 7). For additional information on pointing styles see “Preservation Briefs: #2, Repointing Mortar Joints in Historic Brick Buildings” (U.S. Department of the Interior, Washington, D.C. 20240, April 1976. USGPO #1977-726-159) and “Notes on the Evolution of Virginia Brickwork” by Calder Loth (Bulletin of the Association for Preservation Technology, Volume VI, Number 2, 1974).
Figure 7b) Beaded joint.

Figure 7c) Flush joint in dressed stone.

Figure 7d) Flush joint in rubble stone.
Replacement Bricks and Stones

The masonry units themselves should be examined, particularly if additional units will be required for replacement purposes. There will be a remarkable range of sizes, colors, and textures of masonry units within any wall, and replacements should reflect this range rather than duplicating a particular brick or piece of stone. (Note Figures 6 and 7a.) The requirement for replacement units should receive early attention by the owner or consultant, because it frequently will take an extended period of time to obtain the new units.

In the case of bricks, it may be possible to obtain similar bricks from nearby buildings which are being demolished. In general, bricks from interior portions of the wall are not suited to re-use on the exterior. Interior bricks frequently are softer than exterior bricks, or are otherwise imperfect, which is the reason they were selected for unexposed areas. In addition, they frequently have mortar stains, which makes them unsuited to areas which will be seen. If not available from salvage sources, it will be necessary to have the bricks custom made, which is both time consuming and expensive (Figure 8).

Stones are more difficult to match, because there seldom are buildings of a similar nature which can serve as a source of salvage, and quarries either are closed or are at a new level of stone, which is a different color than the original. It may be necessary, therefore, to conduct an extensive search to find suitable replacement stones (Figure 9).

Figure 8a) Note the difference in size and surface texture of the new lintel bricks.

Figure 8b) Even though these bricks are fairly close to the originals in texture and color, the size difference makes them obvious; in addition, the repairs to the header course should also have been done with headers.

Figure 9) The drum of the Georgia state capital was completed in two stages. Note that the portion below the balustrade is a lighter color than the upper portions.
MATERIALS

Masonry Units

As was mentioned earlier, it may be difficult to obtain new bricks or stones which match the originals. The importance of matching the originals cannot be overemphasized, however, both for the visual quality and the long term durability of the wall.

Bricks and stones come in a wide range of sizes, colors, and textures. If masonry which is not similar to the original units is used, the difference will be immediately apparent, even to the untrained eye. At the same time, if the replacement units do not have the same physical characteristics as the originals, they will react differently to changes in temperature or moisture. The patched area may, for example, be harder than the original masonry and, at the same time, may not shrink as much in cold weather; in this example, as the wall contracts during cold weather the patch will cause extreme stress in the wall, possibly leading to additional damage to the original materials.

Custom made bricks and custom cut stone are quite expensive. Custom bricks, for example, range from $350 to $600 per thousand bricks. Economics, however, should not be an excuse for using masonry units which are not compatible with the originals. Although the price difference between the correct materials and more readily available materials may seem significant, labor is far more expensive than materials and is the same for both correct and incorrect materials. Economics, therefore, should not be an excuse for selecting inappropriate materials.

Special brick shapes should be ordered, rather than attempt to cut the brick to the correct shape on the job site because the inner portions of a brick normally are not the same color as the originals, nor do they have the same durability. The color difference, therefore, would make the cut bricks visibly apparent while these same bricks would be subject to more rapid deterioration.

A useful analogy to include at this point is applicable not only to this discussion of special bricks but also to the later discussion of joint cleaning and the possibility of damaging the bricks (Figure 10). First, let us compare a brick, a baked product, with bread, another baked product. A "crust" will form on the brick as part of the firing process, just as a crust forms on a loaf of bread. Just like the bread crust, the brick "crust" is more durable and of a different color than the interior. If part of the "crust" is cut away, either to make a special shape or as part of the joint cleaning, the softer and differently colored inner portion of the brick is exposed.

Stone, on the other hand, is more uniform. Special shapes can, therefore, be cut on the job site if necessary. Although the surface of the newly cut stone may be less weathered than the original, it normally blends with the surrounding areas fairly quickly. At the same time, the newly cut areas are not subject to more rapid deterioration.

In ordering replacement units, it is best to use the actual existing masonry units themselves, rather than trying to describe them in the specifications, in order to duplicate the color and size of the originals. Bricks or stones representing the desired range of shapes, colors, sizes, and textures possibly may be removed from the wall and taken to the brick yard or quarry for comparison. If it is not feasible to remove samples of the masonry units, other masonry units which represent the desired range should be identified in situ and used as standards for the samples of the replacement units. In either event, it should be clear to all involved that the samples must be approved prior to beginning to make or quarry the full complement of replacement units.

A satisfactory range of sizes usually can be obtained through the use of three sizes of replacement units. Approximately 25% of the masonry units should match the small sized units of the original materials, approximately 50% should match the median, and 25% should match the large units. It is important to remember that this is only a "rule of thumb," since the actual wall may have different size ratios or a size range requiring more than three types of replacements. The existing units should be measured only after removal of the mortar, since the exposed portions of the face may not actually represent the full size of the units. In comparing visual aspects of replacement units with the originals, all the masonry units should be dry.

In calculating the number of replacement units required for a repair project, it is important to remember that some of the units will be damaged before being placed in the wall, while additional original units may be found to require replacement. It generally is best, therefore, to order at least 25% more bricks or stones than originally calculated. There will probably be the chance to use any leftovers in future work!

Figure 10) The outer surface of most of these bricks was removed through harsh cleaning, leaving the softer and rougher inner portions exposed to rapid deterioration. Also note the "crust" which does remain on part of one brick.
Mortar

Standard Specifications. The use of standard specifications for materials, such as those developed by the American Society for Testing Materials (ASTM), provides an easily referenced level of quality. Characteristics which are not part of the standard specification but which are desired for a particular job will need to be written into the specification as needed. The general information which should be included in materials specifications for repointing mortar is as follows:

Lime should conform to ASTM C 207, Type S, Hydrated Lime for Masonry Purposes. Lime which meets this standard will “work” well, resists drying during curing, and is sufficiently strong for the purpose of repointing. Lime expands as it hydrates, making high lime mortars more resistant to crack formation.

Cement should conform to ASTM C 150, Type II. It should not have more than 0.60% alkali nor more than 0.15% water soluble alkali. Cement meeting this standard will add “workability” to the mortar, if needed, will accelerate setting, and will give a slightly stronger mortar when desired. At the same time, the low alkali content will prevent efflorescence. Non-deteriorating white cement should be used, rather than the usual grey cement to obtain the proper color match.

Sand should conform to ASTM C 144. Sand meeting this standard will have the proper gradation and will be free from impurities. The colors, sizes, and textures of the sand should be similar to the original sand.

Water should be potable and free from deleterious amounts of acids, alkalis, or other materials. If the water must be transported or stored in a container, the container must not impart any chemicals to the water.

Storage. Materials must, of course, be stored properly. Lime and cement must be protected from water, both rain and ground moisture; even well protected materials have a limited life, however, for water vapor in the air can begin the setting process. Other materials also should be protected from contamination.

Durability. Repointing mortar must always be softer than the masonry units and the original mortar. If the new mortar is harder than the masonry or the original mortar, it can cause serious stresses within the wall during thermal expansion and contraction, which can lead to deterioration of the masonry units rather than the mortar (Figure 11). If the mortar is softer, any deterioration which occurs will take place in the mortar, which is easily replaced by the next repointing project. Even if the original mortar was quite hard, the repointing mortar should be fairly soft to reduce stresses at the edge of the masonry and, in the case of lime mortar, to reduce shrinkage which can cause cracks in the mortar.

Stresses can be created within the wall either by thermal expansion and contraction or by settlement. If the mortar is relatively soft, it can “flex” with these stresses to relieve them. If the mortar is too hard, the stresses will be relieved by the masonry units themselves in the form of cracking or spalling.

Figure 11a and 11b) As masonry with soft lime mortar moves and contracts the mortar “flexes” slightly, maintaining a tight bond with the masonry and avoiding stresses.

Figure 11c and 11d) As masonry with hard portland cement moves, the mortar does not give, thus opening cracks or creating stresses which cause spalling of pieces of brick or stone.
carbon dioxide, primarily from the air, combines with the hydrated lime to form calcium carbonate. Hardening takes place first at the surface of the joint. As carbon dioxide slowly penetrates to the interior of the joint, the interior portions harden, a process which can take months or even years.

**Color and texture.** It is important for the repointing mortar to match the original mortar in color and texture, as well as physical characteristics, if the visual integrity of the building is to be preserved. The simplest, most economical, and most durable method of obtaining this match is through the proper selection of the sand. Every reasonable effort, therefore, should be made to use sand which is similar to the original in color and gradation. In many cases, this may require using sand from more than one source in order to obtain a range of colors.

If the original mortar was tinted, or if it is impossible to obtain a color match through the use of sand, it may be necessary to use a special mortar pigment. Pigments can cause problems, however, which do not occur with sand. Poor pigments, for example, may react with other ingredients in the mortar to form efflorescence. Even good pigments may weather at a different rate than natural coloring, leading to a color difference in the future. If pigments must be used, pure mineral oxides should be used because they do not fade or leach out of the mortar. In no event should the pigment exceed 2% of the mortar mix by weight.

Many mortars used before the twentieth century have small lumps of incompletely burned or ground lime. Occasionally other impurities may be found as well. If the repointing is to match the original appearance of the masonry, these impurities must be included in the new mortar. The easiest way to accomplish this is through the use of identical materials, such as ground oyster shells (obtained at feed stores) or lumps of lime, to duplicate original lumps.

The best way to obtain a long term color match is to match the new mortar to the interior of the old mortar. It should be remembered, however, that the original joint may have had a tinted mortar applied to the outer 1/4" or so of the joint, and it is the interior of this portion which should be matched (Figure 12). If possible, a large piece of the original mortar should be removed from the joint intact, then broken to expose the inner portion. A number of samples approximating this inner color then should be made up and allowed to dry for at least 72 hours. The samples then are broken, and the inner portions compared with the originals. Additional samples should be made as needed to obtain the final match.

**Working Properties.** The “workability” or plasticity of the mortar is a direct result of the selection of materials. Most early mortars were made with bar sand or beach sand; this sand has rounded edges and flows easily during the mortar application. Most modern mortars, however, are made with crushed sand; this sand has sharp edges, which makes it more “sticky” and difficult to work into the joints. When possible, therefore, it is best to use bar sand for the repointing mortar. If crushed sand must be used, it is possible to improve the working
characteristics of the mortar by adding a slight amount of portland cement; the correct cement content can be determined only through experimentation, but should not exceed 20% of the total lime/cement binder. Up to 20% the cement has minimal effect on the hardness of the mortar, but above 20% it will make the mortar too hard.

To test the mix a trowel with mortar on it is held upside down and is shaken once; at this point the mortar should fall off. If the mortar falls off without shaking, it has too much sand. If more than one shake is required, the mortar is too sticky or "plastic" and the lime content must be decreased. (See Figure 21, page 18.)

**Mortar Mix.** Repointing mortar should not be harder than the masonry units or the original mortar, and the best way to insure proper hardness is to have a complete analysis of the mortar. If it is not feasible to have the mortar analyzed, or if the original mortar was too hard for the masonry, the following mortar mix may be used as the starting point for the development of an acceptable mix:

- 6 parts hydrated lime
- 12 parts sand
- 1 part white portland cement, if needed to improve plasticity (for extreme exposures, such as parapet walls, up to 20% cement may be used)

The exact mix required will relate to the grain size and sharpness of the sand and will vary depending on the supply. The ingredients should be measured by cubic volume using a pre-established uniform measure, such as a small bucket, rather than a less uniform measure such as a shovel (Figure 13). Additional information on the final mortar mixing will be given in the section on "Execution of the Work."

Once the correct sand color, cement content, and so forth have been determined through small tests, a final "job" size batch should be made to ensure the on-site mixing conditions will result in the same final product.

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**Figure 12a) Oyster shells may be crushed to simulate larger clumps of lime.**

**Figure 13a) Dry ingredients in measuring boxes.**

**Figure 13b) Leveling ingredients to insure accurate measure.**

**Figure 13c) Sand may require screening to standardize particle sizes.**
EXECUTION OF THE WORK

Joint Preparation

Adequate joint preparation is essential for the durability of the repointing job. If the joints are incompletely prepared, the new mortar will start "popping" from the joint after only a few seasons of thermal expansion and contraction. With a properly done job, the new mortar will last fifty or more years.

There are three primary methods used for removing old mortar: rotary power saws, power chisels, and hand chisels.

Rotary saws cut the old mortar from the joint. Ideally, the blade should be slightly smaller than the joint, which should leave the masonry units themselves undamaged. Unfortunately, sawing usually does not work as well as the ideal. First, as the mason tires during the course of the day some slipping of the saw is almost unavoidable; as the saw slips, the result is damage to the bricks or stones. The other major problem with rotary saws occurs at the head joints (Figure 14a). If the saw is to remove the old mortar to a sufficient depth, some overcutting of the joint will be required; this overcutting, however results in damage to the masonry units above and below the joint.

Power chisels (jack jammers) also cause damage to the masonry in nearly all cases (Figure 14b). Again, the mason may be as careful as possible, but as the day passes and the mason becomes tired, some slipping will occur, leading to damage to the masonry.

The third method of mortar removal is the only one which seldom causes damage to the masonry. In the hand method, a chisel is placed in the center of the joint and is pounded until the mortar disintegrates to the desired depth. “Floor chisels” of various sizes work well for this purpose, pounded with a striking hammer or a “No-Bounce” hammer. Another tool then is inserted into the joint to rake out the loose material. This method, obviously, is the slowest method of cleaning the joints. Unlike the other methods, it rarely damages the masonry units. If the time required to replace damaged units is included in the productivity rate for machine cleaning methods, the rate per unit for hand methods and machine methods will be approximately equal. The cost difference, therefore, should not be a significant deterrent to performing the job in the proper way (Figures 15 and 16).

The one time in which power tools can be helpful is in the case of a wall which has been improperly repointed using portland cement. Hand chisels are not effective in breaking up this extremely hard mortar, so power tools can be used to cut a narrow crack down the center of the joint. A hand chisel then is used to break off the remainder of the cement. The major problem with this process is that the cement frequently takes part of the masonry with it as it breaks off. The question then becomes: Which is more damaging, having portland cement in the walls or having masonry with broken edges?

Figure 14a) Overcutting of head joints with power saw.

Figure 14b) Chipping of bricks with power chisel.

Figure 14c) Chipping of edges and overcutting head joints.

Figure 15a) Chisels for stone only: heavy joint chisel, cold chisel, brick/pitching chisel, bull point chisel.
Figure 15b) Chisels for brick and some stone: floor/electrician's chisels (one ground for use at tight corners), joint chisels, joint chisels (one ground for starting work).

Figure 15c) Hammers: 5# stone dressing hammer, 2# striking hammer, brick hammer ("duck bill"), "No-Bounce" hammer (filled with lead shot), full-size and half-size brick hammers.

Figure 15d) Trowels: standard and modified tuckpointing trowels; "shoed" tuckpointers for head joints; 1/8", 1/4", 3/8", and 1/2" tuckpointers; margin trowel; brick trowel.

Figure 15e) Joint tools: 3/8"-1/4" raised beaded tool, 3/8"-1/4" beaded striking tool, 1/2" raised beaded tool with offset handle, 1/2" flat joint iron ("slicker"), "shoed" and regular tuckpointers.

Figure 15f) Hawks made of plywood are less expensive and easier to use than steel.

Figure 15g) Brushes for cleanup.

Figure 16a) Head joint Mortar Removal

Figure 16b) Bed joint Mortar Removal

Figure 17a) Poorly cleaned joint, showing saw cuts, brick damage, uneven mortar removal.

Figure 17b) Correctly cleaned joint, showing undamaged brick, deep mortar removal, and square back to cleaned joint.
Old mortar should be removed to a sufficient depth to allow the new mortar to bond to the masonry units and to the remaining old mortar. A general rule-of-thumb is to remove the mortar to a depth \(2\frac{1}{2}\) times the thickness of the joint. For brick, this usually will result in the mortar being removed to a depth of approximately 1", while for a stone wall a common removal depth would be approximately 1\(\frac{1}{2}\)". With extremely narrow joints, the mortar still should be removed to a depth of at least 1/2". All loose mortar should be removed, even if it is deeper than the depths indicated, because the new mortar must bond to sound existing mortar if the repointing job is to be durable.

The old mortar should be removed from both surfaces of the adjacent masonry and should be cut square at the back of the joint. Again, these steps are necessary for the new mortar to develop a sound bond with the masonry and the remaining mortar (Figures 17 and 18).

These procedures and recommended depths may seem to be excessive. In actuality, they should be considered minimums. Although the initial cost of less extensive joint preparation may seem significant, the less expensive work will prove far less durable and will need to be repeated at a much earlier date. The total "life cycle" cost of the good job, therefore, will prove to be less than for the poor one.

Finally, the joints should be thoroughly rinsed with water (Figure 19). The water rinse removes the fine particles which a jet of air cannot remove, and it moistens the remaining mortar and masonry units, thus preventing loss of water from the new mortar into the surrounding masonry. When possible, the cleaning and rinsing of the joints should be done the day before filling the joints so that the excess rinse water has a chance to evaporate or run off. When being filled, the joints should be moist, but no free water should be present.

**Mortar Preparation**

Thorough mixing is essential for obtaining uniformity in the appearance and physical characteristics of the mortar (Figure 20). Dry ingredients should be mixed thoroughly before adding any water. Water should be added slowly to prevent adding too much. A good practice is to add only half of the water at first, mix the mortar for approximately five minutes, then add the remaining water in small portions until a mortar of the desired consistency is reached (Figure 21). If an automatic mixer is used, it should have rubber blades. Mixers should be cleaned thoroughly after each use to prevent hardened lumps of mortar from contaminating the next batch of mortar.

Anti-freeze compounds should not be used, for several reasons. First, these compounds are designed for use with cement mortars, and their effectiveness with high lime mortars is questionable. Equally important, the compounds contain salts which can lead to serious problems in the masonry at a later time. Similarly, the use of air entraining agents is not recommended. These agents also are designed for use with cement rather than lime, and they result in decreased bonding of the mortar.
Figure 20c) Adding water: only part of the water is added at one time.

Figure 20d) Preliminary mixing: note that the mixture is fairly dry.

Figure 20e) Adding water to bring mix to working consistency.

Figure 20f) Final mixing.

Figure 21a) A mix of proper plasticity will stay on the trowel until it is shaken just once.

Figure 21b) If mortar falls from trowel before shaking, or if more than one shake is required to loosen mortar, working properties require modification.

Figure 22a) Use of mortar board.

Figure 22b) Use of trowel.
Mortar should be used within approximately twenty minutes of mixing; each mason, therefore, will need not more than one cubic foot of mortar at a time. On cool days this time limit may be extended slightly, but on warm days it will need to be shortened. Some masons attempt to keep the mortar workable by adding water as the mortar begins to set. This “re-tempering” should not be permitted because it seriously weakens the mortar and it alters the final color.

Mortar Application

Proper mortar application also is important to a durable job. Like joint preparation, this step can be done more quickly and inexpensively than in the manner described below, however, the long term costs will be higher than for a well executed job because poorly done work will need to be replaced much earlier.

If the joints have dried since being rinsed the day before, they should be moistened again with water. There should be no free water present, or it may cause voids in the mortar. Having the joints moist at the time of applying the mortar prevents water from being drawn from the mortar into the masonry before the mortar is sufficiently set. If the joints dry before all the layers of mortar have been placed, it is an indication that the joints were not sufficiently moistened in the beginning. Re-moistening should be avoided whenever possible because of the possibility of developing voids.

The joint filling is accomplished by holding a mortar board or trowel at the bottom of the joint and pushing mortar into the joint with a pointing tool. Plywood makes the most satisfactory mortar board because it is less prone to slipping off the face of the masonry. The pointing tool should be about 1/16" narrower than the joint being filled to achieve good compaction. In some cases, the joints will be so thin that a standard pointing tool will need to be ground down to fit the joint (Figure 22).

The first layer of mortar should be applied to areas in which the mortar was removed to a depth greater than the surrounding areas. This process, which is called “false pointings” will create a uniform depth for the later applications and should be thoroughly compacted into the cavities. This mortar should be applied to a maximum thickness of 3/8", which may, in actuality, require more than one application. In each application, the mortar should be applied, thoroughly compacted, and allowed to become thumbprint-hard prior to the application of the next layer.

After the joint has been filled to a uniform depth, the remaining mortar should be placed in the joint in three layers (Figure 23). The first and second layers should each be approximately 2/5 of the joint depth with the third layer filling the remaining 1/5. As mentioned earlier, each layer should be applied, fully compacted into the joint, and allowed to become thumbprint-hard.
prior to the application of the next layer. This three step process allows better compaction of the mortar than would be achieved if the entire joint were filled at once. At the same time, it minimizes overall shrinkage since the second and third layers fill any areas of shrinkage from the previous layers.

The final layer of mortar should be recessed slightly from the face of the masonry (Figure 24). Most masonry joints will have weathered slightly, causing a rounded corner on the brick or stone. If the mortar is filled flush with the face of the masonry, it causes the joint to appear thicker than it actually is and creates a thin section of mortar which is subject to damage and hairline cracking which can permit water to enter the wall. Recessing the mortar thus keeps the appearance of the joint equal to the actual joint thickness, and keeps the mortar in a compact shape which is less subject to deterioration.

When the final layer of mortar has become thumb-hard, it should be tooled to match the original appearance of the joint. Proper tooling is essential to a job which is both durable and visually correct. If toothing is done before the mortar is properly set, the joint will appear lighter than desired and hairline cracks may develop from additional shrinkage. If the toothing is done too late, dark streaks called "tool burning" may appear and the mortar will not form a tight closure with the masonry units. Excessive toothing may bring lime and fine aggregates to the surface, creating a visual change in the texture and a surface subject to early deterioration.

Excess mortar should be removed from the masonry after it is well dried, to prevent smearing, but before it is hardened and becomes more difficult to remove. The slight amount of mortar which frequently is left on the edge of the bricks or stones can be removed easily by light brushing with a natural bristle brush. Mortar spots on the faces of the masonry can be removed with either a brush or a wooden paddle.

"Aging" the Mortar

When repointing has been completed, it may be desirable to give it a special treatment to make the mortar look "old." This may be particularly desirable when only part of the wall has been repointed and these areas must be blended with the adjacent areas.

Both methods of aging the new mortar are safe and quite simple. One method is simply to brush the joint with a stiff bristle brush immediately after toothing. The second method is to apply a fine spray of water to the joint after toothing. Both of these treatments will roughen the surface of the mortar slightly, thus producing a weathered look. The spray also will remove a small amount of the lime from the surface, thus exposing the underlying grains of sand, similar to natural weathering.

Another "natural" way of aging new mortar is with the use of manure. Although there is some chance of introducing chemicals into the masonry which may prove harmful, this method has been successfully used in many cases. In this technique, a slurry of fresh cows' manure is allowed to "ferment" for approximately five days, then is troweled onto the new mortar and allowed to weather. The manure will remove a small amount of the surface lime, exposing the underlying grains of sand, and it will accelerate the growth of micro-organisms which naturally occur on the face of the masonry.

The use of pigments to color the new mortar artificially is not an acceptable substitute for the proper selection of mortar and masonry materials. Although the old and new mortars may match at first, they may weather at different rates, and later cleaning projects may remove the pigments, causing a color difference in the future. Pigments also may prove damaging to the masonry, particularly if they contain salts which can cause efflorescence.

Curing

New mortar should be cured for several days to permit proper hardening of the mortar. Curing is accomplished by keeping the mortar moist, which prevents excessive drying during the setting process. Two widely used methods of curing are covering the masonry with burlap, which is moistened periodically, and covering the wall with plastic sheets, which prevents the water from evaporating. Extra care should be taken to prevent rapid drying of the masonry during hot weather.
Cleaning

If the repointing has been conducted carefully, there should be little need for cleaning beyond the daily removal of small amounts of excess mortar as described earlier.

Some efflorescence, referred to as new construction "bloom," occasionally appears on the surface within the first few months following a repointing project. These deposits normally are harmless and are removed by the natural washing of the rain. If not removed by natural weathering, they can be removed with dry brushing with a bristle brush. The use of chemical cleaners to remove this type of efflorescence normally is not necessary; the use of acids, particularly muratic acid, specifically should be avoided.

CONCLUSION

Once the proper repointing is completed, everyone will notice and admire the change in the building. Nothing other than cleaning has such a dramatic effect on the appearance of masonry.

It should be remembered, however, that this will not be the last repointing work on the building. Upon completion, the new mortar will begin to deteriorate slowly, just like the old mortar did. If the job was done well, however, the new mortar should last from fifty to seventy-five years before requiring replacement. In some cases, it may last even longer; after all, the original mortar probably did! Hopefully, the historic building will be repointed equally well during the next project, and will continue to stand as a proud reminder of our cultural heritage.
SERMAC Industries Inc. is pleased to contribute to the body of knowledge surrounding America's architectural heritage through the publication of "The Repointing of Historic Masonry Buildings."

SERMAC Industries Inc. introduces a better method of cleaning and restoring exterior surfaces of historically significant structures. SERMAC technology, developed after more than ten years of research, combines high-pressure, low-volume water application with heat and specially formulated chemicals. Vital to the SERMAC System is the understanding of the causes of deterioration and the proper techniques involved to add life and utility to these structures.

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