REMR Technical Note CS-MR-9.5

Repointing Mortar Joints in Masonry Structures

Purpose

The purpose of this technical note is to provide guidance for understanding the need for repointing masonry structures and to demonstrate the proper techniques to accomplish this task.

Application

The methods described herein can be used on any masonry structure to renew the mortar in the joints between brick or stone. These techniques can be used on masonry structures whether they are new or old and will be suitable for any of the purposes of maintenance of masonry, improving the water resistance of the structure, or for purposes of historic restoration.

Background

The U.S. Army Corps of Engineers (CE) is responsible for the maintenance of many old structures in its building inventory, some because of their historical significance and others to allow the structure to continue to be useful with proper maintenance and repair. Because of historical significance or location in historical districts, some of these structures must incorporate restoration technology into their repair strategies while others can suffice with proper maintenance and repair techniques to keep them in proper service. Regardless of the reasons for repair, proper and high-quality restoration techniques will always serve well for long-term care of masonry structures.

Throughout this technical note, certain repair and restoration procedures and techniques are described that are considered to be beneficial in preserving the state of older masonry structures. While each structure will have unique conditions that dictate the level of effort to be used in the repair or restoration, the procedures and techniques discussed herein will help the reader to further understand the reasons why they are used.

No text can teach the skills necessary to achieve quality masonry repointing. This is a skill that must be learned from experience. However, a basic knowledge of the reasons for repointing and an understanding of the steps that are necessary to produce a properly repointed joint will provide the engineer with the proper

information in dealing with contractors who will be chosen to accomplish the repointing task.

What Is Repointing?

Repointing is often called either pointing or tuckpointing. Whatever name is used, simply stated, it is the process of removing old and deteriorated mortar from between courses of masonry and replacing the old mortar with new, sound mortar.

When Is Repointing Needed?

All masonry buildings will eventually need to have the mortar in the joints repointed at some time. The mortar provides a number of qualities to masonry. It provides the strength that holds the brick, stone, or block together; it acts as a cushion between individual masonry units; and it provides a water-resistant barrier that excludes moisture and other damaging agents from entering the structure.

Deterioration of the mortar is the main reason for undertaking repointing. All building materials will deteriorate with time and exposure to the elements. Freezing and thawing in cold weather can cause the mortar to deteriorate. Expansion and contraction from extreme thermal changes can exceed the material capabilities of the mortar and cause either crushing or debonding at the masonry and mortar interface. Extreme stress on a structure can cause mortar to crack and debond from the masonry, indicating that the mortar has become too rigid and inflexible.

A masonry structure needs repointing when an examination of the mortar reveals any signs of deterioration: cracks in the mortar, loose or missing mortar, weak or crumbly mortar, gaps between the mortar and the masonry, loose bricks, or damp spots on the surface of the masonry. These are all deterioration signs that can lead to further deterioration of the mortar, the masonry, and the overall health of the structure. A number of steps are appropriate in repointing any CE structure.

Execution of the Work

Mortar removal

The first task in repointing is the removal of the mortar. Proper joint preparation calls for removal of the deteriorated mortar to a minimum depth of 2-1/2 times the thickness of the mortar joint. In normal brick masonry, this will be about 1 in. (25 mm). In stone masonry, it will be about 1-1/2 in. (37 mm) (Mack, Tiller, and Askins 1980). If the mortar is still deteriorated at this depth, it should be removed to a depth where sound mortar is found. The depth to the bottom of the cleaned joint should be uniform across the width of the joint to ensure that the new mortar forms a strong base and will not break with movement.

Removal methods

There are three methods of removing old mortar: hand chisels, rotary power grinder, and power chisel. The method used will depend on the size of the job and the skill of the contractor. On small jobs and ones where extreme care in use of tools is important, the use of hand tools to remove the mortar is the method that will cause the least amount of damage to the surrounding masonry units. Hand-held chisels can be chosen to match the width of the joint and ensure that the impact is directed against the mortar and not the masonry. Many sizes and types of chisels are available. The chisel is placed into the joint and struck with a hammer to disintegrate the mortar. A second tool, a joint rake, is then used to clean out the resulting cavity. With this method, precise depths of mortar can be removed. This method is the slowest but will damage the least number of masonry units.

If the mortar removal task is large, then use of power tools is a consideration. The use of impact chippers and saws or grinders will speed the chore of removing mortar, but can lead to damage of the masonry by breaking of bricks or over-cutting of joints, which will damage the surrounding masonry units. Rotary saws grind the mortar from the joints. The width of the saw blade should be smaller than the width of the joint itself to eliminate any damage to the masonry unit. However, this leaves a thin layer of mortar attached to the masonry that may be weak and will not provide a good bed for the repointing mortar. Another problem associated with rotary cutters or grinders is that the grinding wheel will not be able to clear the extreme ends of head joints without sawing into the brick above or below the joint being prepared. This means that the head joints will have to be finished by hand anyway.

Power chisels are automatic impact tools, and while they are less likely to cause damage than grinding wheels, the operator can get careless or weary after long periods of use, and some damage can happen from the impacts that strike the masonry rather than the mortar joint.

Extreme care should be taken in the use of power tools. The contractor chosen to do the repointing should be skilled in the use of these tools and should be required to demonstrate his skill on a predetermined portion of the building in a test panel before he is allowed to use the tools on the rest of the building. Test panels will allow the owner or engineer-in-charge to determine if the contractor has the necessary skills. Test panels should be chosen on an inconspicuous portion of the building and should incorporate all types of masonry that are to be cleaned. The contractor's skill will be well demonstrated if he produces prepared joints that are clean and to the proper depth and he has not damaged the masonry either through cutting, chipping, or otherwise marring the masonry in the process. The prepared test panel can be used later in the process to test color and texture of the repointing mortar and the contractor's skill in applying the mortar to the joint.

Since the power tools are less accurate and thorough than the hand chisels, the final preparation of the joint should always be done by hand to leave a proper cavity into which the repointing mortar can be placed.

Selecting the Mortar

Constituents

Most mortars used in repointing will consist of sand, lime or cement, and water. There may be additional additives such as colorants or historic components, but these are unusual and less frequently found. In historically important structures, the matching of the constituents of the mortar to those of the original structure may be very important, while in other CE structures, the importance of the constituents may be more directed to providing specific material properties. Whichever the direction, good-quality materials will provide the best mortar.

Sand

Sand for mortar should be clean, preferably rounded, properly graded, and of the proper color and texture. The sand will probably be the component that most readily affects the appearance of the mortar. From this point of view, it should be chosen to provide a final mortar that matches the original in both color and texture. This should be true for all structures since the color and texture of the repointed mortar will affect how the repointing is viewed in the overall context of the remainder of the building regardless of its historical importance.

Sand that meets American Society for Testing and Materials (ASTM) Specification C 144 (ASTM 1997a) will have the proper gradation and be free from contaminants. Proper gradation will ensure greater workability of the mortar and provide a texture that is appropriate for current and historic mortars. Where historical correctness is important, sands should be matched to those found in the original mortar. A sample of mortar from the removed material should be collected and crushed, and the powders removed to leave the sand for examination. This sand should be observed under low-power magnification to find its color and surface shape. Sand used for mortar will either be rounded as in beach or river sand or it will be angular as in crushed or manufactured sand.

While the shape of the sand should be matched to that in the previous mortar, rounded sands will make a better mortar than angular varieties. Round aggregates produce a more workable mortar by allowing better packing of the mortar into small spaces in the joint and greater adherence of the mortar to the masonry. This will most likely be the choice for older mortars, which were traditionally made from rounded sands because these materials were more available and manufactured sands were more expensive to produce.

Lime or cement

The binder in masonry mortars is generally lime. Lime conforming to ASTM C 207, Type S (ASTM 1997c) will serve the purpose of binder and will resist shrinkage and drying during curing. When portland cement is used, it should conform to ASTM C 150, Type II (ASTM 1997b). Portland cement can be mixed with the lime in quantities up to about 20 percent without changing the properties of the mortar too severely. The greater the amount of cement added, the greater will be the strength of the mortar, the speed of setting, and the shrinkage of the mortar. The resulting mortar will be harder and less flexible with higher amounts of portland cement. Cements used for mortar purposes should be low in alkali (less than 0.6-percent alkalis and less than 0.15-percent soluble alkalis) to minimize the chance of efflorescence.

Mortars made from lime will be softer than those made with large amounts of cement. As will be explained, softer mortars are generally more desirable. Lime mortars tend to expand slightly on hydration, which will help close any hairline cracks that may form; water passing through lime mortar will dissolve some of the lime and deposit it in small hairline cracks, which will further help seal them.

Water

The water used to make mortar should be clean, potable, and free from chemicals that would alter its pH. Water containing minerals that color the water may also adversely color the mortar.

Additives

Generally speaking, additives should not be necessary in either modern or historic mortars. They are mostly ineffective in high-lime mortars, and in some instances can be detrimental. Plasticizers that might be used to provide a more fluid mortar are very expensive, and the desired plasticity of the mortar can be achieved with proper mixture proportioning without the need for the plasticizer. Bonding agents to assist bond between old and new mortar are not needed either. A properly prepared joint that has been well cleaned will provide an adequate surface for new mortar adherence. Lastly, freezing and thawing should not be a serious problem, so air-entraining additives should not be necessary. Properly pointed masonry will effectively drain moisture and minimize situations where water could collect and freeze. Entraining air in mortar will make it more plastic, but will also cause a reduction in its strength.

Mortar properties

Repointing mortar should be soft and flexible rather than hard and rigid. Lime mortars are ideal for this purpose because the lime produces limited but adequate strength such that the resulting mortar will be soft. Lime mortars are also flexible. Rigid mortars that are harder than the surrounding masonry can cause damage to

the masonry if the materials expand. In a wall subjected to high temperature, the masonry units will expand; if the mortar is rigid and hard, there is the possibility that the mortar will chip edges and corners of the masonry unit, particularly if the masonry unit is soft. In cold weather, components of a masonry wall will contract, and a rigid mortar will not move with the contraction. In this situation, the mortar will crack, generally at the interface of the masonry and mortar, and this crack will now be a pathway for water to get into the structure.

Mixture Proportions

The exact mixture proportions for mortar for repointing masonry will vary depending on the type of structure, the material properties of the masonry and the mortar, the importance of historical accuracy, and the availability of materials. If historical accuracy is important, an analysis of the mortar should be conducted to match both physical and chemical requirements. If requirements are less stringent, the basic properties of color, texture, and strength of mortar should be followed. A good mixture proportion to start with could be the following:

5-6 parts lime
10-12 parts sand
1-2 parts portland cement (preferably white portland)

The amount of water used should be just enough to provide a plastic mixture that will give a smooth surface when the back of a trowel is used to smooth the surface of the mortar and will leave a sharp, vertical edge when cut with the trowel.

Repointing the Joint

Placement

Once the mortar has been mixed, the joint should be filled by the following process. A suitable length of joint should be chosen to repair at one time. This will depend on the amount of mortar that has been made and the volume of joint that can be repointed before the mortar becomes unusable. Standard practice suggests that the mortar should be used within 30 min of final mixing and that retempering of the mortar (adding water to renew its plasticity) should be avoided. Several feet of joint can be repointed at a time. The back of the joint should be filled first. Approximately 1/4 in. (6 mm) of mortar should be placed in the back of the joint and packed well into the corners and bottom of the opening. This should be allowed to set until the mortar is thumb-print hard. Then a second layer approximately 1/4 in. (6 mm) should be tamped in on top of the first layer. This process should be continued until the joint has been filled. The importance of letting each layer harden will prevent shrinkage damage to the entire joint. By the time the mortar is thumb-print hard, most of its shrinkage has taken place, and the next layer of mortar will not be affected by the previous one . This process will

also minimize overall mortar shrinkage and ensure a good bond to the surrounding mortar and masonry.

The joints should not be overly filled with mortar because this will leave an appearance of an uneven, extra-wide joint that will look uneven due to the geometry of the masonry. Older masonry units are often chipped or rounded on their edges either from wear or durability damage. If the mortar joint is filled too full, the mortar will fill into these spaces and leave an uneven appearance; the very thin layer of mortar deposited on these chips and irregularities will be susceptible to spalling and cracking from movement of the masonry. However, if the repointing effort is stopped just short of flush with the outer face of the masonry, the appearance of the joint will be uniform, confined to the width of the mortar joint, and there will be no thin sections of the mortar.

Tooling

Tooling of the final layer of the mortar should be done when the mortar has just set and is again thumb-print hard. The tooling will play an important part in the overall look of the masonry repointing work. To keep the look of the joints uniform, all repointed mortar should be tooled in the same manner as the original work. Using original tooling techniques will make the joints appear similar to surrounding areas that may not have been repointed, and even if the entire project is being repointed, the original tooling technique will preserve the historic quality of the facade. There are many different styles of tooling, and there are proper tools to form each type. For more information on these types refer to U.S. Department of the Interior, Preservation Brief No. 2. (Mack, Tiller, and Askins 1980).

Aging and Curing

New mortar will not look old without some special treatment to make it blend with other areas of the facade that were not repointed. Old mortar is weathered to the point that the surface lime has been worn away and the sand particles in the matrix have been exposed by age. The characteristic color of the aged mortar will therefore be dependent on the color of the sand.

There are two accepted methods of achieving this older, matching look on the mortar. The first involves brushing the joint immediately after tooling it. The brushing will roughen up the surface, bringing a number of sand grains to the surface and giving it a weathered look. If the sand was properly chosen for its matching color, this will help make the new mortar match the older mortar. The second method involves spraying the joints with a fine mist of water to remove some of the lime and expose the sand particles. Both methods work well to achieve this effect.

New mortar should be cured to prevent loss of moisture from the fresh mixture and to encourage proper hardening. Two commonly used methods to achieve this

are (a) covering the wall with burlap and keeping the burlap wet with moisture and (b) providing a moisture barrier such as plastic sheeting to keep the moisture in the mortar. The curing process should last for 2 to 3 days if possible.

Summary

Regardless of the degree of historical accuracy necessary in a repointing operation, there are a number of steps that should be taken to provide a high-quality process of replacing deteriorated mortar in masonry structures.

- Mortar should be removed using extreme care not to damage the masonry in the process. Hand methods of removing the mortar will do this the best, but for large projects, the use of power tools can be successfully employed if the contractor is properly trained and motivated to do a good job. Mortar should be removed to a depth beyond the damaged material. For general purposes, a depth 2-1/2 times the width of the joint should be sufficient. The bottom of the joint should be square, and all mortar should be cleaned from the cavity. Final preparations of the joint should always be done with hand tools.

- The constituents of the mortar should be chosen so that the new mortar matches the removed material in color and texture and is weaker than the masonry that it is binding together. The sand will be the constituent material that most dramatically affects color and texture, and the binder will affect the strength. Rounded sands are preferred, and lime is the binder of choice over portland cement. Water should be free of deleterious chemicals and should not contain any discolorants. In general, additives should not be necessary.

- Repointing mortar should be applied to the joint cavity in layers that are compacted and allowed to initially set before additional mortar is applied. The joint should not be filled too full, and the final tooling of the joint should be done when the mortar is thumb-print hard. Aging and curing are important to make new mortar look old and to allow the material to come to proper strength.

References

American Society for Testing and Materials. (1997). *1997 annual book of ASTM standards.* Philadelphia, PA.

1. Designation C 144, “Standard specification for aggregate for masonry mortar.”

2. Designation C 150, “Standard specification for portland cement.”

3. Designation C 207. “Standard specification for hydrated lime for masonry purposes.”

Mack, R.C., Tiller, D.T.C., and Askins, J.S. (1980). "Repointing mortar joints in historic brick buildings," Preservation Brief No. 2, U.S. Department of the Interior, National Park Service, Washington, DC.