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PRESERVATION OF HISTORICAL MASONRY STRUCTURES

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SUMMARY

Methods for cleaning, restoring and preserving stone, marble and brick historical structures have been studied and are discussed. Requirements and tests for masonry preservatives are cited, and many organic and inorganic materials used for this purpose are evaluated. Cleansing methods often required prior to preservation are included.

Recommendations for preserving the First Bank of the United States include a step-by-step schedule for the entire job and also processes and materials selected for the various components that require special treatment.

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1. INTRODUCTION

The purpose of this program was to outline methods for the restoration and preservation of historical masonry structures. The First Bank of the United States was given special attention, and the recommendations given for it can apply to other buildings within the Park area.

The approach to the problem had to be based mainly on past results (which tend to be generally unfavorable) rather than undertaking a long term program such as that now in progress by the National Bureau of Standards. This was done by examining protected buildings and reviewing the results reported in literature. Much of the work in the field of preservatives is done on statuary and other small objects where success is the usual outcome, but scaling these up to building surfaces is to some degree a gamble. The conclusions given herein are, out of necessity, conservative.

Consolidation of marble by both organic and inorganic methods is possible on small samples with good results, but applying these methods to large surfaces is difficult and at the same time the outcome is final and irreversible. Consolidation is therefore recommended only for smaller stones that need strengthening which, at worst, can be replaced at some future time if unexpected problems arise.

Materials have been found for brick and marble wall protection. They are expected to be effective for five years and not cause any problems after their useful life is past, meaning they can be reapplied, or with the development of new products, replaced by another material.

2. MASONRY PRESERVATIVES

The preservation of masonry can be achieved by the use of organic materials applied in solution or melted into the surface or by the application of solutions which form inorganic compounds within the stone.

Both preservative methods have their advantages and disadvantages, but overall, the organic materials are preferred for large surface areas. Inorganic methods require the submersion or soaking of the surface for extended periods of time in aqueous systems while organic materials, in general, are applied quickly by spraying or brushing the diluted resin onto the surface. The vehicles are usually organic solvents which do not contain or transport destructive mineral salts. The organic materials do degrade in time and may discolor or pick up dirt. Inorganic processes bind into the stone matrices, most of them being less soluble than calcerous stone. They do not waterproof, but allow good breathing.

Nearly 50 years ago, Warnes ⁽¹⁾ listed the desirable properties which a preservative should have. These are briefly stated below in their order of decreasing importance:

1. It must not change the appearance of the stone.
2. It must expand and contract with the stone.
3. It must prevent the penetration of water, but still breathe.
4. It must not form a hard surface crust, but be able to resist erosion.
5. It must penetrate deeply.
6. It must be non-corrosive.
7. It must be economical.
8. It should preserve the stone indefinitely.

There are no organic coating materials available that can preserve exposed masonry surfaces indefinitely. Twenty years of protection would be desirable and may possibly be achieved, but at the present time, any materials having a useful life of over five years should be considered, and silicones with even shorter life-spans should not be discarded.

The eight properties which a stone preservative should have implies that the material in question has undergone extensive testing over a reasonable time period. Since this is not directly stated, it is added here as the ninth criteria that a preservative must have a use history of at least five years.

The ability to remove a protective coating when it becomes desirable due to the loss of any one of the properties mentioned above is an added property which a stone preservative could have, but this is impractical unless the object can be submerged in a solvent. Stambolov ⁽²⁾ states that on large surfaces, even when large quantities of solvents are used, dissolution is only partial. The necessity to remove a preservative is the result of faulty selection or application which should be avoided in the first place, however, the removal of a material from the outer surface is acceptable to improve the appearance of a well impregnated wall.

It is difficult to coat a light colored marble with an organic protective material that is hard enough to resist erosion and at the same time not change the surface appearance of the stone. Furthermore, the materials that often strengthen the marble do not penetrate deeply, and when penetration is achieved, permeability to moisture and gases is reduced. In order to achieve an acceptable balance of properties, careful studies must be made beforehand on stone similiar to that which is to be coated.

The depth to which a preservative should penetrate depends on the material to which it is applied and its state of decay. For deep penetration, dilute solutions are required and without added appli-

cations, consolidation is unlikely ⁽³⁾. Also, the evaporation of the solvents tend to draw the consolidant back toward the surface. The preservative should bind the decayed material to sound material. For the marble of the First Bank of the United States it will be desirable to achieve a penetration of three millimeters or more.

The degree of breathing which a preservative must allow depends on the condition of the masonry, the amounts of moisture and salts present, climatic conditions and the hardness of the coating. Surface treatments that reduce breathing seem to promote crystal growth. This growth can accumulate and build up great pressures behind a water repellent material and may cause exfoliation ⁽⁴⁾.

The question then arises whether a preservative should prevent efflorescence or allow it to appear on the surface. Prevention of its appearance may be merely a method of hiding it below the surface where it can eventually cause damage. Stone objects small enough to be totally cleaned of mineral salts and completely dried before total preservation do not fit the conditions for scaling up to the preservation of large walls. Also, small patch testing on large walls cancels out the effects of efflorescence since the preferred location for deposition of the salts will be in the surrounding areas where the moisture evaporation is greater.

A method has been devised for testing the effects of efflorescence on coated brick. It is a modified system described by Anderegg ⁽⁵⁾. The coating to be tested is applied to all surfaces of a brick but one end, which is to be placed in a 20% sodium sulfate solution. To prevent the migration of efflorescence up the outside of the brick, a wall of low melting wax is placed about a third of the way up the brick. It is allowed to stand in the solution for several days, then removed and allowed to dry. The efflorescence will appear on the surface as the brick dries if it has penetrated the film. This is shown in Figure 1. The preservative used in the initial test was Hydrozo Clear. This was also used on six other materials to determine if this effect is limited to those materials that breathe well.

The materials evaluated were an acrylic from solution, an acrylic emulsion, an epoxy, boiled linseed oil, a urethane and Hydron 300.

The linseed oil coating was tested shortly after its application and showed the greatest amount of efflorescence on the surface. The acrylic emulsion developed a hazy-white appearance and small amounts of efflorescence developed on the surface. The acrylic applied from an organic solvent remained clear and showed no signs of efflorescence. Both the urethane and epoxy coatings showed hazy spots behind the film and no efflorescence appeared on the epoxy but a few specks developed on the urethane. The Hydron 300 showed no color change or efflorescence.

The conclusion drawn from these tests is that water repellent coatings that do not form a complete coat over the surface allow mineral salts to pass through while hard complete films hold back the evaporation and the formation of salts on the surface. The buildup of salts behind the film can create great pressures which can break off the surface layer of the coated masonry.

Waterproofing and consolidation at the same time is limited to organic coatings only and these two properties are not necessarily found in all organic preservatives. Oils, waxes and silicones waterproof very well, but do not strengthen the masonry to any degree. Epoxies, acrylics and other resins that cure to a hard polymer and adhere to the matrix strengthen the masonry but do not repel water as well as the waterproofing materials. Waterproofing only is sufficient for sound masonry and should be considered as a temporary treatment. Consolidation with deep penetrating organic materials on the other hand must be considered as a permanent treatment and must be used with caution.

Inorganic treatments are intended for reconsolidation only. In marble, all treatments of this type including the precipitation of calcium carbonate, are foreign to the stone and therefore must be used with caution. Hard coatings near the surface tend to spall off easily. Some have lower water solubilities making them more durable than

the stone. The penetration of water is at best only slightly reduced but evaporation is not hindered. Their satisfactory application to large surfaces is difficult and at the present time not widely used.

2.1 ORGANIC MATERIALS AS PRESERVATIVES :

Under this category, a wide range of materials are available. They range from long used natural materials such as oils and waxes to today's highly developed synthetic materials such as epoxies and acrylic monomers. A brief discussion of each type material is presented here to show their properties, advantages and disadvantages.

1. Waxes

A variety of waxes have been used for many years, and no doubt bees wax has been used more than any other type. Waxes must be applied by either heating the stone to melt the wax or by the application of dilute solutions. Heavy coats of wax are good water repellants, but these tend to show on the surface. Bees wax is too sticky and picks up dirt so it is often mixed with harder resins or conversely, added to hard resins to soften them. Solvent diluted waxes penetrate well on warm stone and hardly alter the stone's appearance. Studies being done in England by Hempel and Moncrieff ⁽⁶⁾ show some promise. Treatments from dilute solutions or emulsions breathe well but thick coatings may spall from the buildup of minerals behind the film. The removal of wax coatings with solvents is difficult. Since the useful life of these materials is not well documented, an estimate of five to ten years is probably representative.

2. Oils

Boiled linseed oil and tung oil are used most frequently. Their main disadvantages are that they darken with aging ⁽⁷⁾ and may spall. Heller and Erb ⁽⁸⁾ have found that a heavy application of boiled linseed oil has very low permeability to air.

3. Paints

Paints can be used as a preservative where the alteration of surface appearance does not matter. Otherwise, their use on masonry historical buildings should be avoided.

4. Bitumens

These are best used below ground as water tight barriers on foundations or sealing cracks on roofs. Their use on other masonry should be avoided.

5. Casein Cements and Soaps

These materials have been used very little and no data has been found on their ability to protect stone. They combine with calcium to form an insoluble product.

6. Chlorinated Rubber

This material, an elastomer, is applied as a clear coating. This type preservative had been applied to a small area on the south side of the First Bank three years ago and at this time appears dark and absorbs water at a faster rate than untreated marble (see Figure 2).

7. Polyesters

These are one or two component systems which when cured form a hard clear to light tan polymer. They bond well to masonry but tend to yellow on aging ^(9,10). A modified polyester tradenamed Barrier showed excellent resistance to UV degradation when rated for its ability to repel liquid water, but with continued exposure it developed a slight tackiness which would collect dirt.

8. Polyvinyl Acetates

These can be used in emulsion form or dissolved in a solvent such as acetone. They have good U. V. resistance and weather well. The emulsion types tend to soften when soaked in water and do not penetrate as deeply as the solvent systems. The emulsion form can be admixed to mortars and cements for better adhesion. There appears to be a lack of literature pertaining to their use as stone preservatives.

9. Polyurethanes

This is a very durable material having widespread use on indoor wooden surfaces. It is used as a building preservative around the Philadelphia area. Applications on marble and brick buildings were examined and found to alter the surface appearance in both cases. They also tend to yellow with aging ⁽¹¹⁾ and it is suspected that penetration is minimal.

10. Silicones

Silicone resins have been widely used for preservation purposes in concentrations from two to five percent. The only drawback to their use is their short effective life of about two to three years.

11. Siliconates

These are water soluble silicones. The solution is alkaline and reacts with marble giving a "bleached" appearance. Deeper penetration of this type over the solvent systems is claimed by one manufacturer. This type has been applied 10 years ago to the Second Bank which today remains quite clean. On close examination of this building, it was found that surfaces exposed to the weather are not protected but areas such as the protected surfaces of the columns still repel water.

12. Epoxies

These are two component systems having a wide range of properties. Their chief drawback had been their high viscosity, but today low viscosity resins are available and they can be diluted with organic solvents. If not properly applied, they will show on the surface and some types tend to yellow. Before any epoxy system can be used, it must be thoroughly tested on a similar type surface to determine penetration, appearance, proper curing and U.V. resistance.

13. Acrylic Resins

These are clear solvent diluted polymers. They form a coating by evaporation of the solvent and therefore are reversible. Their appearance and water repellancy are good when applied properly. A lifespan of three years is known but lab tests show that their water repellency is reduced when exposed to U.V. Light. Laboratory examination of a marble block coated with an acrylic by the manufacturer showed that the coating only penetrated to a maximum of only 0.5 mm.

14. Monomers

This type of preservative is ideally suited for consolidating stone. It has a very low viscosity which allows for good penetration, and polymerizes to a clear resin without evaporation. It has good adhesion and U.V. resistance. Styrene monomer is not used as much as methyl methacrylate or butyl-n-methacrylate and therefore not enough data is available for its use. However, the methacrylates have been used with good success. Munnikendam⁽¹²⁾ studied two methacrylates, methyl and poly-n-butyle methacrylate. There are problems with evaporation and retardation of polymerization which require close control for acceptable results.

15. Miscellaneous Materials

There are still other materials that have been tried or may be used, and in some cases, combinations of materials have been used.

2.2 INORGANIC MATERIALS AS PRESERVATIVES

The main purpose of these materials are to reconstruct or consolidate stone. These materials and their application processes are briefly outlined below.

1. Calcium Hydroxide

Calcium hydroxide in solution precipitates out to form calcium carbonate. This process was evaluated in England ⁽¹³⁾ and was found to be useful but the process requires several months before there is any noticeable effect. Efforts to increase the deposition rate by using ammonium carbonate or urea appears to be a desirable approach, but the material being added is no less vulnerable to weathering than the stone itself.

2. Sulfate Solutions

Sulfate solutions of zinc, iron, aluminum, copper and alum have been used. Besides having sulfates crystallize out, their use has not been very successful ⁽¹⁴⁾.

3. Sodium and Potassium Silicates

These are water solutions which in the presence of air hydrolyse and precipitate colloidal silica. These materials do not penetrate deeply into marble and are alkaline. Riederer ⁽¹⁵⁾ and Insall ⁽¹⁶⁾ both report poor results with this type of preservative.

2.3 SILICON ESTERS

These are organic solvent solutions of organic silicones. Upon hydrolysis the silica is precipitated and alcohol is formed. Their advantage over the sodium and potassium silicates is that they do not form from water soluble salts in the stone. Deeper penetration is possible also but their use on large surfaces of sound marble is not recommended. These are more compatible with sandstone.

The combination of a silicone ester and epoxy has been reported by Munnikendam ⁽¹⁷⁾ and requires further testing.

2.4 SILICOFLUORIDES

These are hydrofluorosilicic and soluble silicofluoride salts which react with the stone, this being one of their disadvantages. surface hardening of the stone results from the quick reaction and this can lead to spalling. A possible change in color can occur and soluble salts may be formed ⁽¹⁸⁾.

2.5 STRONTIUM AND BARIUM HYDROXIDE

The use of barium hydroxide as a preservative has been known for many years, but recently the process has been further improved by Lewin ^(19,20). The barium or strontium is precipitated out as a carbonate which in the presence of air pollution containing sulfur compounds forms a thin layer of barium or strontium sulfate on the crystal surfaces. The hydroxides alone react very slowly but the addition of urea increases the rate considerably when used in a hot solution.

Samples of marble from the First Bank were treated by this method for possible use on the capitals. These methods were used : One was the submersion of the sample in the hot solution containing urea, the second coated with barium hydroxide solution and glycerine and kept moist with repeated applications for 30 days and the third submerged in the barium hydroxide solution for 30 days. Process one and two did not penetrate more than 0.1 to 0.2 mm below the surface

while the third method penetrated up to 1.6 mm deep (Figure 3). Soft calcium carbonate powder filled into a cracked piece of marble and treated for 30 days bonded the pieces together quite well indicating that good adhesion to the stone is possible.

Lewin reported several locations where his process was used (21). One nearby location, the Josephine Fountain in Brandywine Park, Wilmington, Delaware, was examined in February. The consolidating was done in September of 1971 but the actual exposure time is limited due to the fountain's being covered with polyethylene sheeting this winter (and possible others too). The consolidation appears to be successful, but the surfaces are a rough chalky white which does not match the original description of the fountain's color or the color of the capitals on the First Bank. The solubilities of the materials in the various steps of the process are shown below to bring out its main attribute (22).

<u>Compound</u>	<u>Solubility (g/100 ml water)</u>	<u>temp. (°C)</u>
Barium hydroxide	5.6	15
Barium carbonate	0.002	20
Barium sulfate	0.00022	18
Calcium carbonate	0.0014	25

It can be seen from the table that the solubility of barium carbonate is close to that of limestone at room temperature. If it does not convert to the sulfate which has very low solubility, it may be leached out as easily as the calcium carbonate.

The Lewin method at this time can not be recommended due to its difficulty in applying and the possibility of a color change to the marble.

2.6 DIRECT PRECIPITATION OF BARIUM SULFATE

This is a relatively new method patented by Edward Sayre (23). It involves the precipitation of barium or strontium sulfate by the slow hydrolysis of a barium or strontium monoester of sulfuric acid

from an aqueous solution ⁽²⁴⁾. This method has been used successfully on soft limestone and at room temperature requires at least a month for good penetration. Its use on marble is most likely an improvement over the Lewin method, but it would take the same amount of time to apply. This would be the preferred method for the First Bank capitals. Laboratory tests have not been done on this material due to the lack of the proper materials.

2.7 CLEANING METHODS

The safest approach is to soak the surfaces with a fine water spray and then scrubbing off the dirt with bristle brushes. Chemical cleaning processes are easier and take less time, but these usually etch the surface or leave soluble salts behind. Dry and wet grit blasting does a good job of cleaning, but in the process an excessive amount of the masonry is removed.

Hydrofluoric acid does not leave any soluble salts behind when used as does ammonium bifluoride. In a discussion at the Meeting of the Joint Committee for the Conservation of Stone, Balogna, October 1971, Lewin stated that the use of these two materials is not advisable ⁽²⁵⁾. These materials etch the surface and form a thin skin of calcium fluoride having many micro-cracks and fissures which greatly increase absorption ⁽²⁶⁾. A process called Klenztone produced by the K & E Chemical Company of Cleveland, Ohio, is available in the Philadelphia area. This product contains ammonium bifluoride ⁽²⁷⁾, which produces soluble salts.

A commercial product is available from Phoenix Development, Inc. This product, Supersolve 88, was tested on a brick wall at Franklin Court and proved to be very effective. This test area should be evaluated periodically to determine if any adverse effects show up. Examination of brick samples soaked overnight in the cleaner show no deterioration, color change or visible deposits of salts after drying without rinsing in water. This cleaner cannot be used on

calcerous stone, but a diluted form can.

In cleaning a building, it is advisable to deflect excess water away from it. An example where this is necessary is on the ceiling behind the columns (Figure 4). Plastic sheeting will be needed to protect the wall and deflect the water toward the street.

Stains in the marble such as those under the front window at the southern end of the First Bank (Figure 5) should be removed. There are numerous materials for removing iron and copper stains. but some of these may add soluble salts to the stone. Ten percent aqueous solutions of formic or sulfamic acid can be used. Stanbolov (28,29) mentions various materials such as an aqueous solution containing sodium hydroxide, a non-ionic detergent and sodium borogluconate, an aqueous solution of the sodium salt of ethylenediamine tetraacetic acid and a potassium binoxalate paste.

Stains should be removed before overall washing to remove materials deposited in the process.

3. AN APPROACH TO THE RESTORATION AND PRESERVATION OF THE FIRST BANK

Scheduling of the various processes needed in the restoration and preservation of the First Bank is an important first step in the process. One possible approach is given here :

1. Work should start with the replacement of badly damaged bricks and all necessary repointing and repairs to the brick walls. An example of the problem is shown in (Figure 6). Work on the windows such as glazing and painting should be done at about the same time along with cleaning and caulking of all joints requiring flexible sealants. Also the repairing of stonework and the replacement of some small sections can be done at this time.

2. While the sealing process is going on, the removal of the loose stone grains by gently sandblasting and the removal of stains can be accomplished.

3. Once the building is sealed, a thorough washing of the entire building with water can follow. The brick surfaces will require only a gentle wash while the marble will require a long soaking.

4. Depending on the weather, drying for not less than one week will be needed. Rain should be kept off during this time.

If rainy humid weather does occur, a longer drying time may be needed.

5. The consolidation of specific stonework should be carried out before an overall preservative is applied. These areas would include window sills, the capitals and column bases and ornate stonework over the front windows and door. (Figure 7)

6. The final step should be the application of the preservatives.

The repair of the brick work is outside the scope of this project and can be handled well by experienced craftsmen in this trade. Caulking compounds of the polysulfide type manufactured by Thiokol are recommended for sealing all joints. This material has a long use history and when used properly should last 15 years or more.

A major problem exists with the stone fluting on the front of the building. This problem as shown in Figure 8 is partially due to the direction of the bedding planes. Repairs would probably be as costly as replacement, and if neither is to be done, loose pieces should be removed and all sharp edges toned down.

Along the south wall (Figure 9) broken out sections of marble should be cut out square for replacement of stone blocks. Failure has occurred at these locations due to the expansion of the rust on the underlying steel (Figure 10). It will be necessary to work these steel beams free so that they can be cleaned and painted. There should be a space left behind the new blocks to fill in with a flexible waterproofing material to protect the metal and allow room for expansion.

The removal of rust stains will require some on site experimentation. The process should not clean to the extent where the cleanliness will contrast with the rest of the stone. If this can not be avoided, the effect should be tapered to reduce contrast or a light overall sandblasting could be used.

A very light and low angle dry grit blasting should be given to all of the marble surfaces that have loose grains. This process should be done only with very close supervision and the final result should be barely visible.

Deteriorating marble above the front windows and door and window sills (Figure 11) should be treated with a polymeric material that will consolidate the stone. This should be first tried on the second floor window with an acrylic monomer after it is first tested

on a similiar piece of marble. The purpose of the test piece would be to determine penetration and curing time for the temperature of that season. The rate of polymerization must be controlled closely for the best results. Poly-n-butyl-methacrylate is preferred for these applications. The stone will need to be covered during the polymerization process which should not exceed four hours. The surface layer should be reduced by lightly rubbing off the excess with a solvent. A slight darkening of the stone is expected, but this will not matter much on stone surrounded by brick.

An alternative method of polymer consolidation is available through Universal Restoration Incorporated. This is a process developed by K. Lal Gauri ⁽³⁰⁾. The method is described in detail in Treatment of Stone ⁽³¹⁾. The claims of deep penetration up to two centimeters was verified on a sample of the First Bank marble. the epoxy did, however, darken the marble to give it a wet appearance as shown in Figure 12. This process is a possible second choice at this time.

Its use is being limited to specific areas of consolidation. One reason for this is that the "breathing" ability of stones treated this way is greatly reduced.

Another area requiring consolidation is the column bases. The base of the second column is very absorbent and as shown in Figure 13 still remains wet from rain the day before. Column bases three and four also show this to a lesser extent. The deep cracks must be sealed and it would be desirable to slightly smooth down the stone before adding the preservative.

The capitals present a special problem in that they are believed to be in an advanced state of decay. This will have to be determined before they are touched. Cleaning with water would be acceptable if they are solid. If not, rubbing with pumice may be necessary. All of the intricate stone-work on the front of the building (Figure 14) if required, could be carefully cleaned with a micro blasting gun manufactured by S. S. White using fine glass beads.

The equipment costs are rather high, but the time required to do the job would be reduced.

The Lewin method is no longer preferred for consolidating the capitals, but the Sayre method is under consideration. The chemicals needed for this process are on order and when received, an evaluation will be made on the process.

Sharp edges produced from exfoliation on the columns would be less conspicuous if slightly ground down to reduce shadows.

A preservative has been found for brick. This product is Hydrozo Clear and is manufactured by Hydrozo Products Company, Myrtle Beach, South Carolina. This product appears to be a waxlike substance dissolved in a solvent, possibly mineral spirits. It penetrates on the average of three millimeters deep into First Bank brick and coats the particles over which it spreads. A heavy coating on First Bank brick was found to allow the passage of soluble salts through the coating rather than accumulate them behind where they can damage the brick. It shows good resistance to U.V. light and does not change the appearance of the brick. Its ability to pass water vapor was tested on four millimeter thick marble saturated with it (brick is too open for this test) and the following results were found:

4 mm thick marble:	$3.61 \times 10^{-3} \text{ g/cm}^2/\text{day}$
4 mm thick marble coated throughout:	$1.09 \times 10^{-3} \text{ g/cm}^2/\text{day}$

This shows a considerable reduction in the rate of water vapor transmission under conditions of a better than average coating. This test was accomplished by sealing the stone over the mouth of a small glass container filled with water, and placing this in a desiccator containing calcium sulfate "Drierite". It was planned to visit buildings coated in the past to determine the approximate life of Hydrozo. The Todd House had been coated with Hydrozo ten years ago and this was checked by observing the behavior of water

droplets placed on the wall. It was found that some bricks still repelled water while others were intermediate to poor. The mortar absorbed water quickly indicating that no protection remained on it. It is estimated that Hydrozo will preserve old brick for five to seven years.

Two other products were considered for preserving the brick-work. These were Pol::ion, an acrylic formulated by George English and Hydron 300. These were first chosen on appearance along with Hydrozo. These were coated on old brick and evaluated for water repellancy and U.V. degradation. The George English acrylic did not completely repel water while the other two did. The contact angles of water drops placed on these were measured and this shows their degree of wettability (high angles mean better repelleancy).

CONTACT ANGLES OF WATER ON POLYMER COATED BRICK

<u>Pol::ion</u>	<u>Hydron 300</u>	<u>Hydrozo</u>
66°	98°	109°

The Hydron 300 broke down quickly under UV allowing water to pass through the coating rapidly. The Pol::ion coating was somewhat better and for equal exposure time, the Hydrozo was not effected. Hydrozo also penetrated much deeper than the other two.

The rate of capillary water rise through a section of old hand made brick supplied by the National Park personnel was measured to determine how long it requires to completely wet a brick from it's front face. Initial absorption is very rapid, but two hours are needed for complete penetration. This is shown graphically in Figure 15.

The major marble portions of the First Bank (columns, portico, and walls) present a problem in that histories of large surfaces having been successfully preserved are rare. Deep penetration of a preservative is unlikely and for the methods that do achieve this, a uniform appearance is questionable. Three temporary choices

appear to be usable. These are siliconates, Hydrozo Clear light and Pol::ion. A siliconate used on the Second Bank has preserved the building for at least three years and the building is still clean and in good condition today. The Hydrozo Clear light is a lower concentration of the Hydrozo Clear. This was found to penetrate up to three millimeters into First Bank marble, but it's repellency is reduced (but still good). There are no marble building coated in the past with this material and therefore its use is questionable. The Pol::ion acrylic has the least penetration of the three, but it has a good use history in this area. Its life expectancy is estimated to be five years.

Hydron 300 breaks down quickly in UV and various reports from National Park personnel indicate that it has not performed well.

If full restoration is desired for exhibiting the building in 1976, it will be necessary to apply a preservative over the clean, freshly worked marble even though its use will be temporary.

The majority of the exterior work must be done during the warmer parts of the year and the application of protective materials should be done during the summer months. It would be desirable to start the preservation of smaller portions of the Bank before the building is officially closed. A good starting place would be on the second and third story window sills. These will require special care in the application of an acrylic monomer and the first one treated will be, to some degree, experimental.

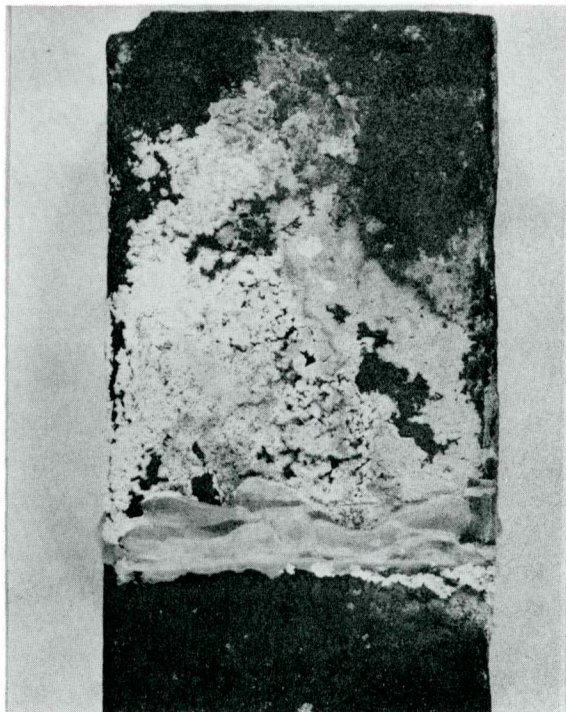


Figure 1. Sodium Sulfate Efflorescence on Brick Coated with Hydrozo Clear. The Crystals Formed on the Outer Surface of the Coating.

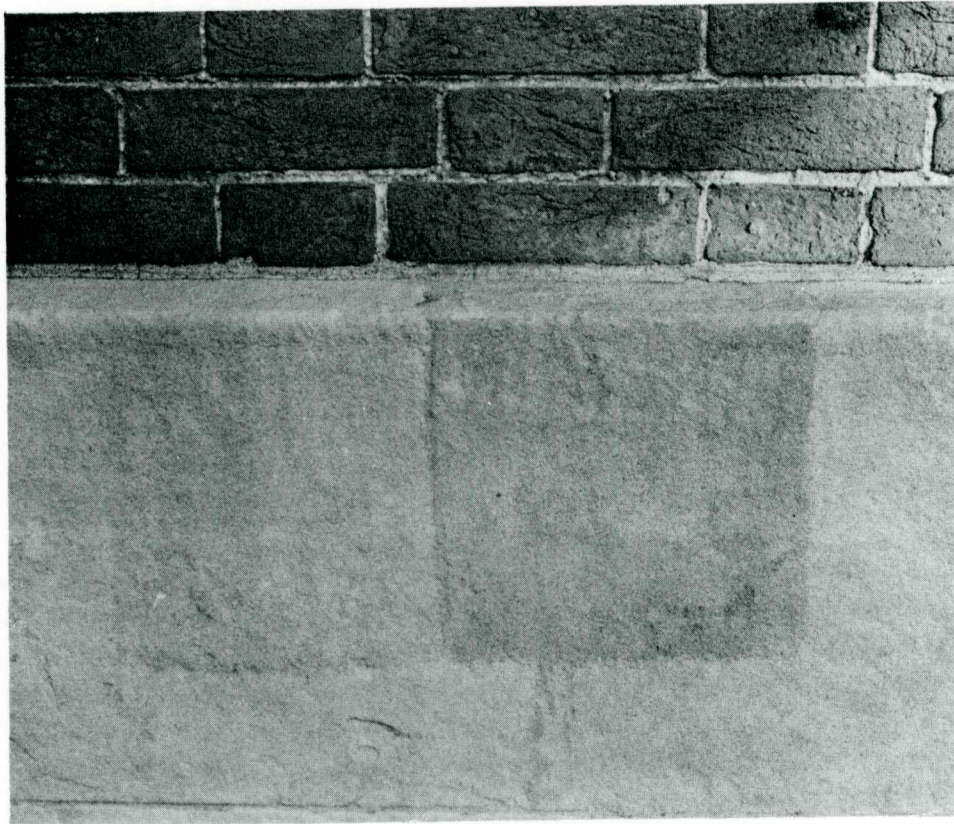


Figure 2. Marble Coated with Chlorinated Rubber Three Years ago.

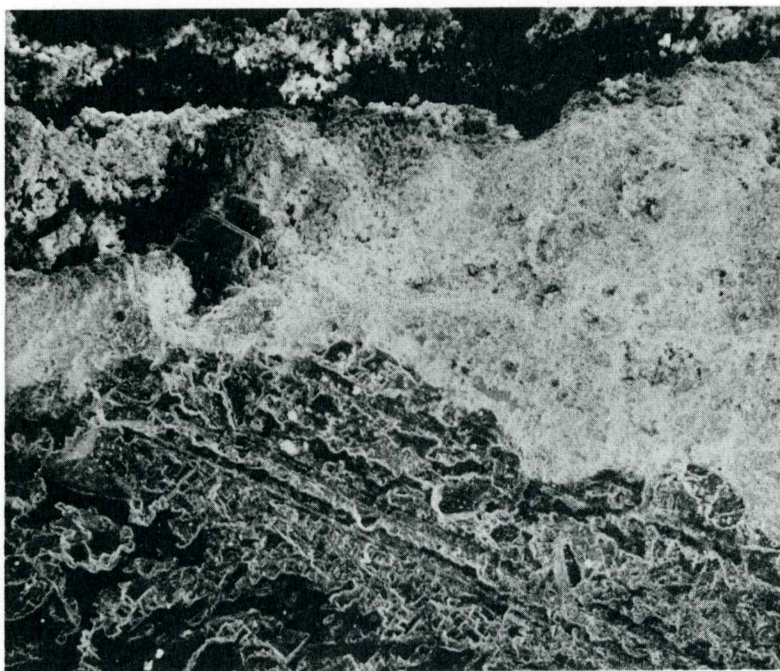


Figure 3. Barium Hydroxide Treatment Showing Depth of Penetration after 30 days Submersion. The White Material is Barium Carbonate (50X).



Figure 4. Dirt Incrusted Ceiling of the Portico on
The First Bank of the United States.

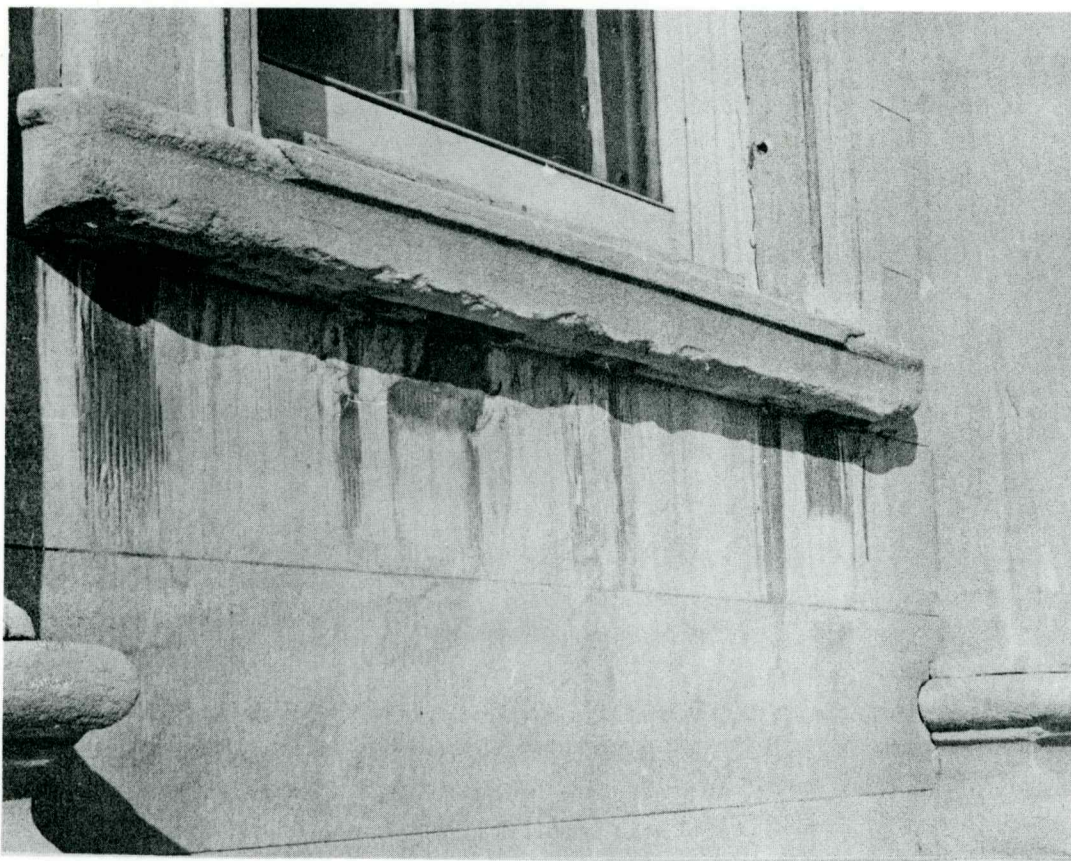


Figure 5. Stains under the South Front Window of The First Bank



Figure 6. South Wall Brick of The First Bank Showing Loss of Mortar, Breakage and Excess Wear.



Figure 7. Stonework over a Window of The First Bank Needing Consolidation.

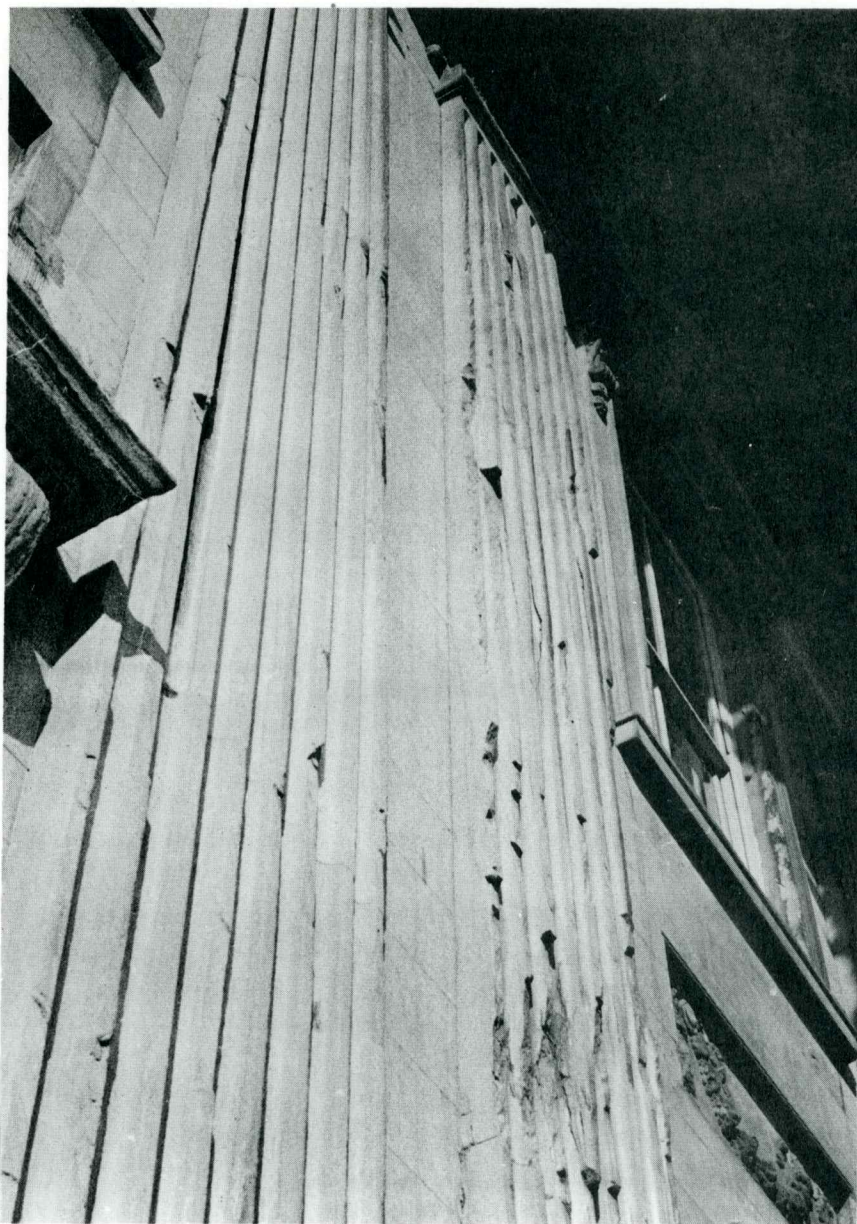


Figure 8. Stone Flutings on the Front of The First Bank Showing Excessive Exfoliation Along Bedding Planes.

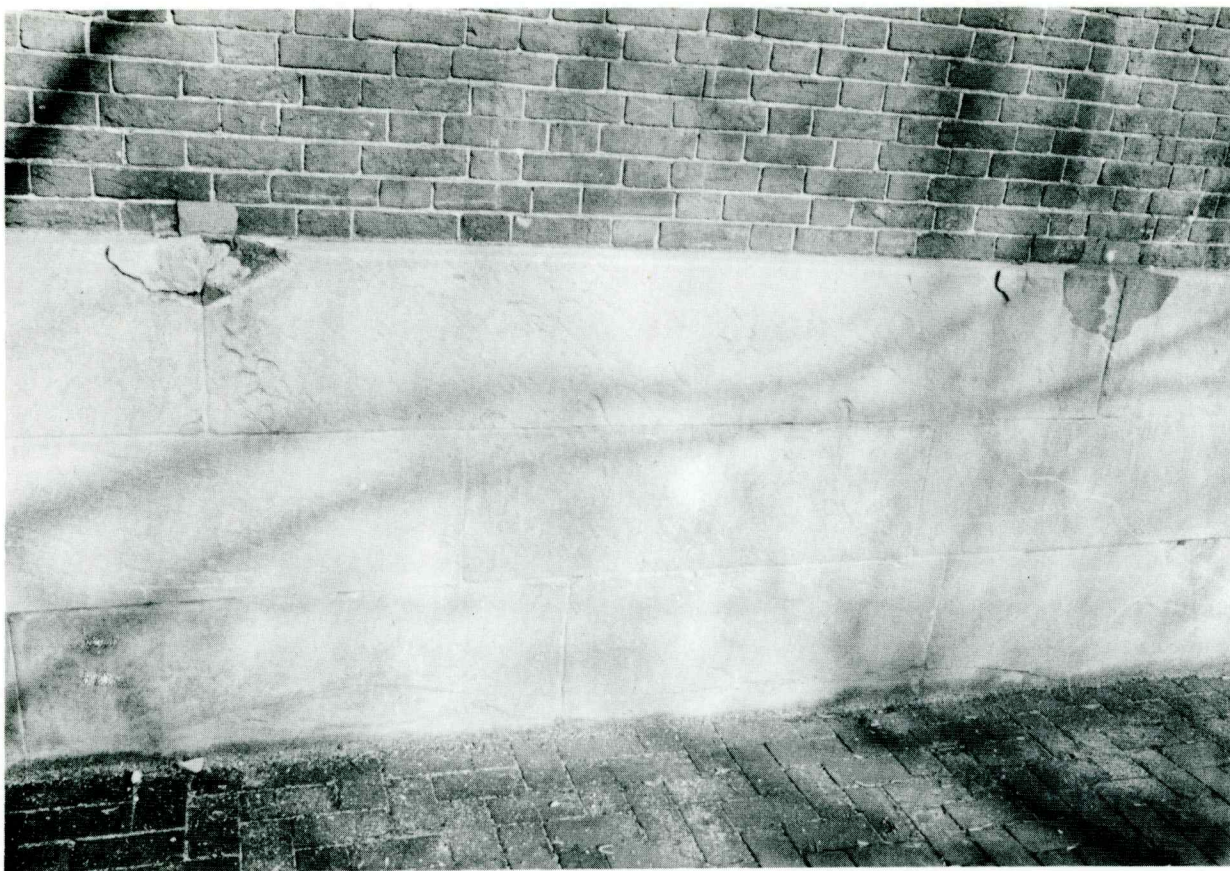


Figure 9. Stonework Along South Wall Showing Breakage from Expansion of Rust on Buried Beams.



Figure 10. A Close View of the Rusted Steel that has Broken off Pieces of Marble.



Figure 11. Window Sill on Southern side of Building Showing Deterioration of Marble.

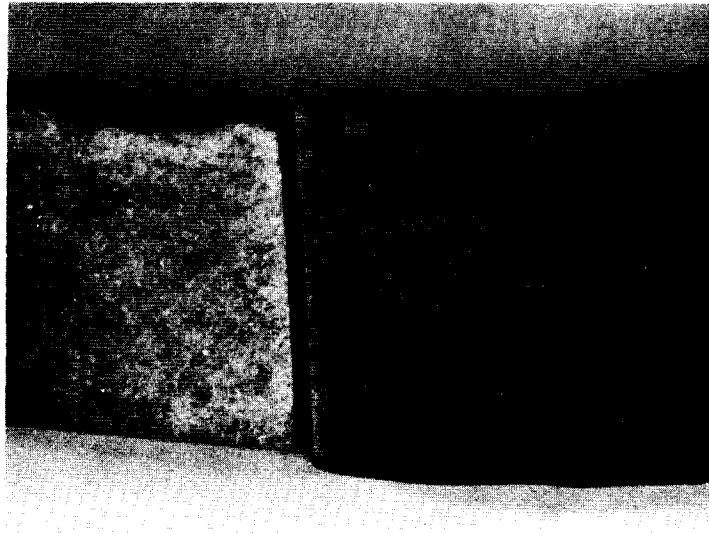


Figure 12. Marble from The First Bank Cleaned and Treated Deeply with Epoxy on Right Sample. The Darker Appearance is Due to Reduced Reflection of Light.

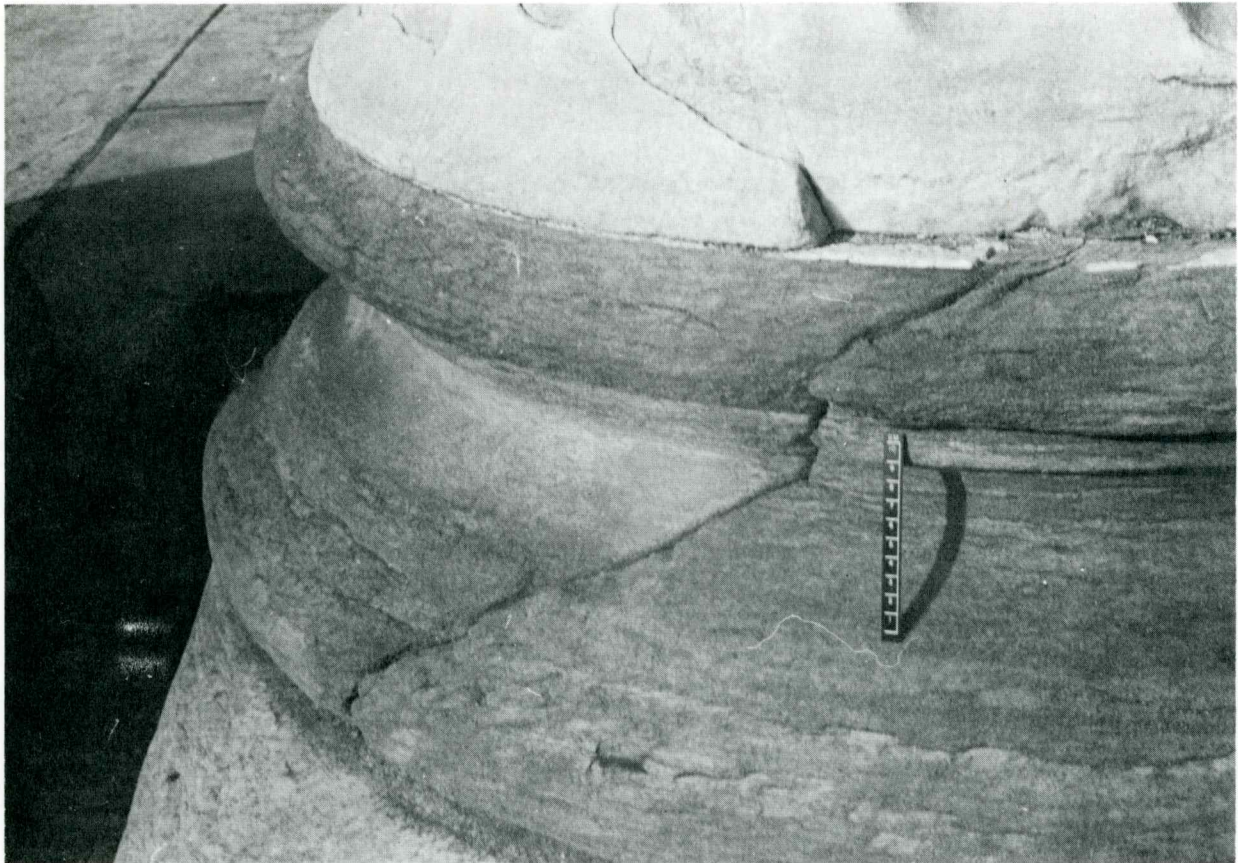


Figure 13. Column Base (Second from Southern End) Showing a Deep Crack. Note that the Stone is Still Wet from Rain the Day before the Photograph was taken.

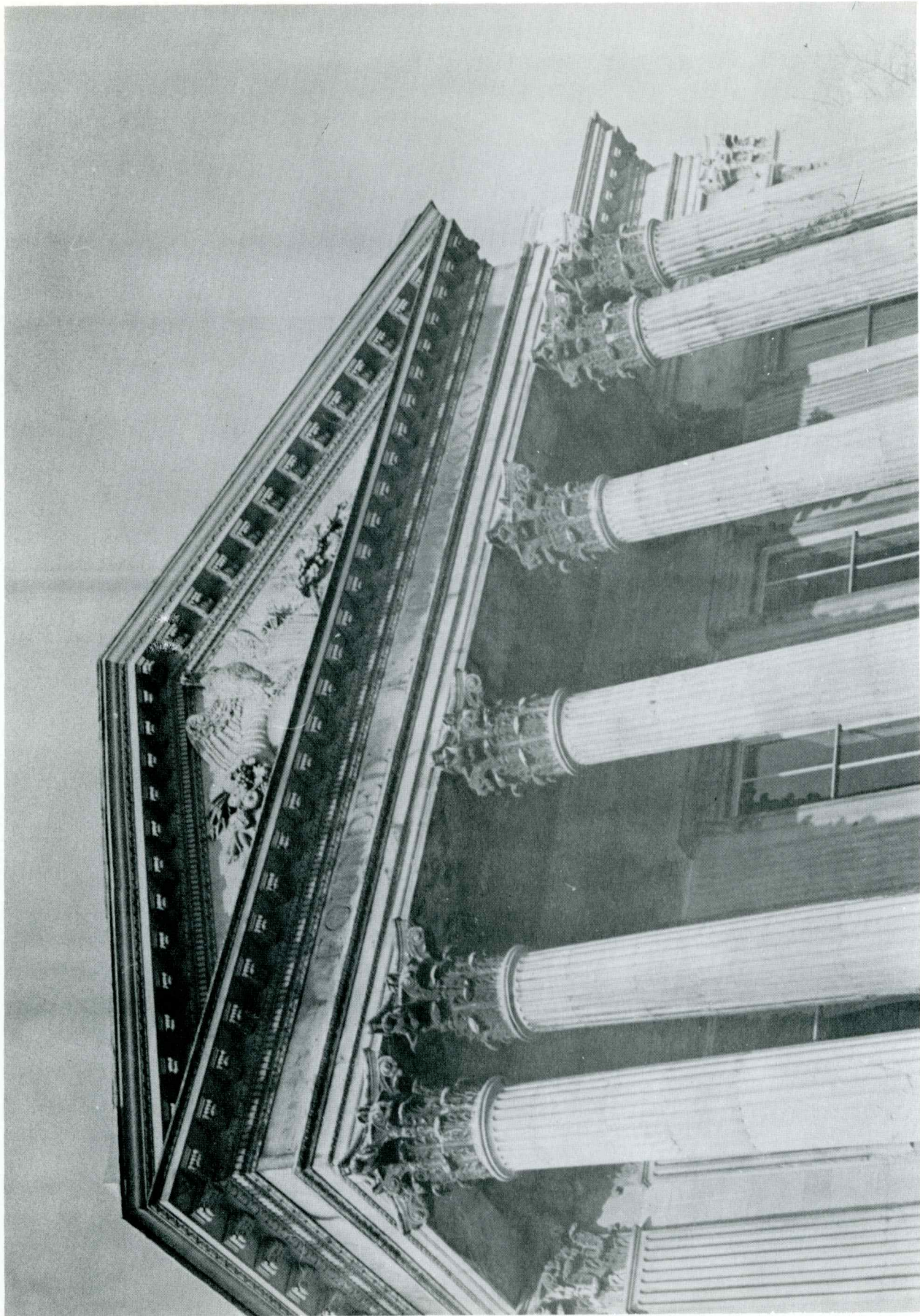


Figure 14. Portico of The First Bank of The United States.

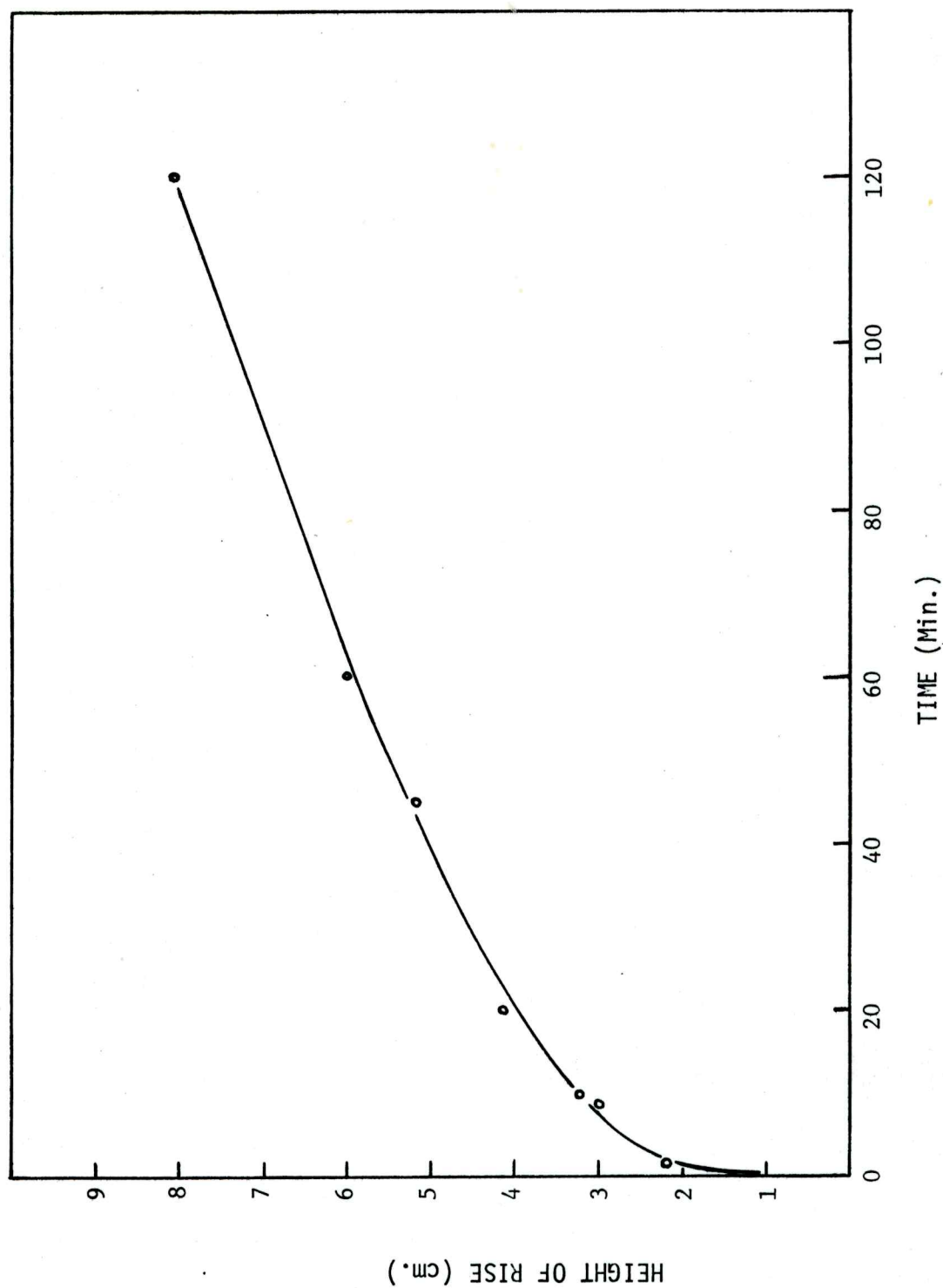


FIGURE 15: The Rate of Capillary Rise of Water Through an Old Hand Made Brick from Independence National Historical Park.

4. PRESERVATION OF OTHER BUILDINGS

Each structure should be considered individually for a preservative. The majority of the buildings in Independence National Historical Park are brick structures. They are in surprising good condition and should not be treated with a preservative unless it is essential. On these buildings it is important to keep excess rain water from the brick by keeping the drain spouts in good repair and making sure that water drains away from the foundation.

The Todd House and the Second Bank of the United States will need to be recoated within several years if it is desired to continue the use of the same preservatives that were previously applied.

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