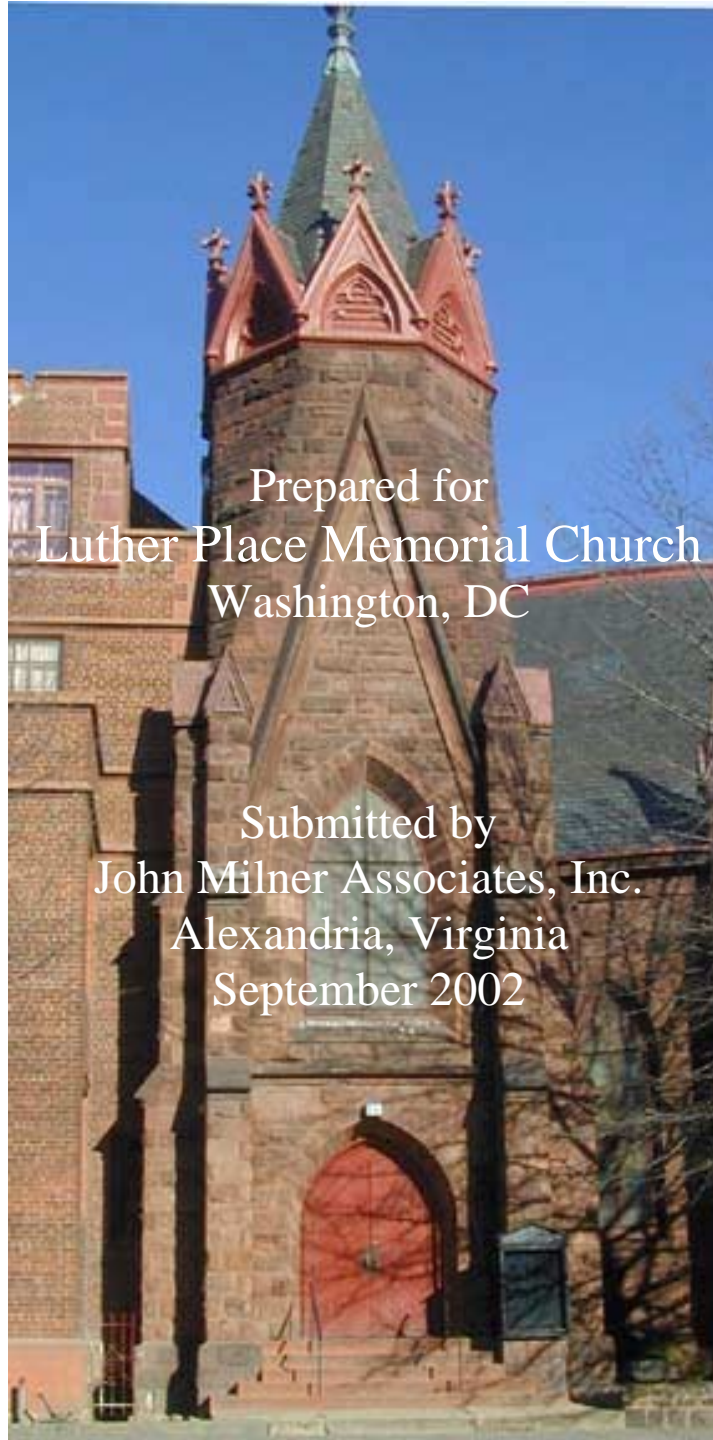


Sandstone Conservation Assessment East & West Towers



Prepared for
Luther Place Memorial Church
Washington, DC

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Luther Place Memorial Church
Washington, DC

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EXECUTIVE SUMMARY

The focus of this conservation assessment of Luther Place Memorial Church –East & West Rear Towers has two specific objectives: First, to carry out a visual inspection of sandstone surfaces; primarily to locate, identify, and document all materials and their deterioration and/or failure. Second, to analyze and assess our findings with regard to the existing conditions of material in order to develop recommendations for sandstone and methodologies for conservation, stabilization, and reinforcement. Materials testing aided in properly understanding each material and developing recommendations.

During the site survey all accessible exterior materials were examined to try to determine which material was historic and to detect any signs of deficiencies. In general, stones with more than one exposed face suffered from the most deterioration.

Methodology used was a survey of the exterior elements as accessed by a lift and conducted by direct visual observation.

Structural element types, their deterioration, their locations, and the approximate surface areas affected were noted on existing condition drawings. A photographic record of the major deterioration problems supplements the on-site survey and is included as an appendix in this report.

CONDITION ASSESSMENT

Introduction

Purpose of Assessment

A condition assessment for Luther Place Memorial Church was initiated in July of 2001. This assessment has two primary components:

1. Carry out a visual inspection of all sandstone surfaces; primarily to locate, identify, and document all materials and their deterioration and/or failure.
2. Analyze and assess our findings with regard to the existing conditions of material to help develop recommendations for sandstone and methodologies for conservation, stabilization, and reinforcement.¹

Methodology

An on-site visual survey was used to identify the types of materials, their deterioration, locations, and the approximate surface areas affected. A photographic record of the major deterioration problems supplements the on-site survey and is included in the appendices of this report.

A stone-by-stone survey of sandstone was conducted by direct visual observation. Investigations were primarily directed at the sandstone elements.

Assessment of Sandstone

Conditions Summary

The stone is a soft to medium, medium grained brownish red sandstone with abundant iron oxide. The sandstone is in the family of Seneca² sandstone and is often called Manassas Sandstone.

Iron oxide is the prominent binding material in this type of sandstone. The iron content of this stone is causing one of its deterioration problems. The oxidation (rusting) of iron in the stone has caused some, spalling, and loss of a cohesive binder in much of the stone. Binder loss has caused even further spalling. The iron oxide also gives it its deep red color.

Some of the stone has not been appropriately laid with the bedding planes horizontal and parallel to the ground. When stones are laid with their bedding planes they are likely to fracture between the planes, fail and fall. The stone at Luther Place also has a large amount of mica in its stone. Mica is a type of silicate that is brittle and tends to flake. It encourages fractures between bedding planes in sandstone.






¹ Note a laboratory findings and recommendations report will follow this report when all laboratory testing has been finished.





² Seneca sandstone is from the Triassic period (225-193 million years ago).

There have been substantial amounts of repairs done to the towers. These repairs include repointing work with a very hard Portland cement mortar. The repair mortars are the most significant deterioration problems the sandstone faces and will be discussed further.

The following table gives an overview of the typical conditions of the sandstone. This also includes the typical repair for each condition and a description of each condition.

Luther Place Memorial Church Sandstone Conditions

<i>Condition</i>	<i>Description</i>	<i>Repair</i>	<i>Example Photograph</i>
Biological Growth	Surface growth or coloration indicative of biological colonization. May be of varying thicknesses, colors, or biological origin	Remove by chemical cleaning	
Cracking	A fracture in the stone of variable width or length that could result in the movement of adjacent parts, potentially constituting structural failure or weakness or allowing water intrusion.	Clean out crack and repair with cementitious grout. A pin may also be required.	
Disaggregation-Minor	Minor loss of surface material in powder or granule form by deterioration and erosion of the binding material.	Tool unsound surface to restore sound profile.	
Embedded Ferrous Anchors or Pins	Previously installed anchors or pins, which are no longer in use and that may corrode and cause damage to the stone, or are actively used corrosive anchors/pins that must be replaced.	Remove abandoned anchors. Install new non-corrosive anchors as necessary.	
Exfoliation or Scaling	Detachment of planar elements in layers along natural bedding planes, usually in uniform thicknesses, creating contoured depressions parallel to the material surface.	For minor loss tool unsound surface material to restore sound profile. For major loss, install dutchman repair.	

Guano	The accumulated excrement of birds. Typically contains nitrogen, phosphoric acid, and potash. Guano may cause staining and encourage pests.	Remove by chemical cleaning	
Intact	Stone without any surface loss showing original tooling marks.	None Required	
Previous inappropriate or failing patches	Repairs performed with materials or methods, which cause damage to, do not match the original material's physical or visual characteristics.	Remove patch. For minor loss, tool back surface of stone to match original surface. For major loss, install dutchman repair.	
Salt Efflorescence	The formation of surface deposits, often white in color, crystalline in form, powdery to the touch, and composed of soluble salt.	Wash down with light water rinse. If efflorescence reappears, apply a water poultice.	

The condition of the sandstone varies by the areas of the building where it is found. Stone in shadows and lower portions of the building typically have a significant amount of biological growth. Rising damp with accompanying salts and pointing with a hard Portland cement mortar have aggravated deterioration of the stone in this location. Stone used on the buttresses typically has sustained more weathering issues due to its exposure.

The upper portions of the tower show the most uniformly severe deterioration. The condition of the stone ranges from sugaring where loose grains brush easily off the surface (disaggregation), to spalling (exfoliation). Nearly 100% of all joints are failing and are open.

There are at least four separate mortar repointing events. All of which are with a hard Portland cement. There has also been some repair work to the towers to tool back sandstone. You will find new tooling marks on flat stones that have had their faces knocked off. There have also been thin smears of a cementitious patching material placed on some of the tooled back stones. These thin patches appear to have accelerated the deterioration of the stone beneath and around the patches. Most of these patches are much lighter in color than the sandstone and are hollow and easily picked off, taking 1/4- 1/2" of stone from the surface.

**Luther Place
Condition Survey of Rear Towers**

Problem	PROBLEM #	EAST TOWER		WEST TOWER		TOTAL	
		TOTAL	Units	TOTAL	Units	TOTAL	Units
Inappropriate or Failing Patch	5	33	SF	42	SF	75	SF
Penetrations	6	60	EA	20	EA	80	EA
Biological Growth	7	73	SF	53	SF	126	SF
Very Minor Loss (minimal tooling)	14	119	SF	216	SF	335	SF
Minor Loss (tool, dutchman, or patch)	15	162	SF	108	SF	270	SF
Major Loss (entire stone replacement, veneer, large scale patching, or tooling)	16	194	SF	158	SF	352	SF
Efflorescence	19	1	SF	6	SF	7	SF
Total Loss of Face ³	20	160	SF	162	SF	322	SF
Exfoliation	21	382	SF	481	SF	863	SF
Disaggregation	22	6	SF	4	SF	10	SF
Guano	32	8	SF	16	SF	24	SF
Open, Failed or Inappropriate Mortar Joint	13	1-80%	%	2-80%	%	1-80 ⁴	%

Sandstone Repair Options

Sandstone

The very nature of the sandstone at Luther Place Memorial Church makes repair a difficult task. Some stone is in a weakened state by its high content of iron, its age, and previous repairs such as an inappropriate repointing mortar. Repair techniques that would typically be used to repair sandstone may not be appropriate for this building.

³ Loss of face refers to the complete loss of the projecting surface and rustication. This typically indicates prior intervention of tooling back a damaged surface.

⁴ The tops of the towers have around 80% open joints while the bottom of the towers range from 1-15%.

Luther Place Memorial Church is a significant architectural treasure. It is our responsibility to save as much remaining original material as possible. With the view of maintaining as much historic material as is practical, a combination of the treatments below will be used. As with the other treatments, existing failed patches should be removed from stones to assess their condition. Deteriorated wash surfaces on otherwise sound stone would be treated with Jahn patching or tooled. Stone that was severely deteriorated would be replaced with an appropriate replacement stone. The final appearance would not be completely uniform. Surfaces would still be weathered.

By varying treatments by stone, sound historic material could be retained while heavily deteriorated stone would be replaced in kind. Over time, the differences in the new and old stones would diminish. Restored wash surfaces would help keep water from sitting on damaged stone. Though these patches would lighten with time, restored wash surfaces could extend the life of the stone.

Replace in kind

Replacement in kind would require existing deteriorated sandstone be replaced with new matching stone. Decisions must be made as to which stones or portions thereof will need to be replaced or repaired with a stone dutchman and which existing stones should remain based on their current condition. Existing patches should be removed from stones to assess their condition.

The final appearance will depend upon the amount of stone replaced. Partial replacement and dutchman repair will give a less uniform appearance. Partial replacement will remove severely deteriorated stone while retaining significant historic material but will give a less uniform appearance. However, with time the new stone will weather and the differences in old and new should diminish.

Patching

Sandstone could be patched with a repair mortar. Original profiles could be restored and the patching material would closely match the color of the sandstone. This would mean a great deal of entire faces that would be entirely patching material.

Many of the stones have already been repaired with patching materials. The patches on the building vary greatly in appearance and functionality. We would recommend Jahn repair mortars. Jahn repair mortars are at the top of the synthetic repair options.

Repairs to the sandstone will be made with a custom color Jahn restoration mortar. Decisions need to be made as to which stones will be patched and the extent of patching. Existing patches should be removed from stones to assess their condition. Stones to be patched must be tooled back to a minimum 1/2" into sound stone.

Tooling

Some uniformity of the surface could be achieved with tooling in designated areas. For instance, columns that have lost material may be tooled to almost an oval shape, while still having the appearance of being round.

Consolidation Testing

Condition Assessment and Sampling

Based on observations made during the condition assessment, stones representative of the range of stone types were selected for sampling. Stone samples were obtained for testing by core drilling. Four core samples were taken from the building façade. All the 2" diameter core samples were taken with a hand-held drill equipped with a hollow, water-cooled coring bit. A sample list is presented in Table 1. Hereafter, all the samples will be referred to by number.

Table 1- Core Sample List

<i>Sample Number</i>	<i>Stone Type</i>	<i>Location/Description</i>
Core-A	Medium Red	East Facade
Core-B	Medium Red	East Facade
Core-C	Medium Red	East Facade
Core-D	Medium Red	East Facade

The above core samples were cut into ¼” slices. The following table outlines each individual sample number for untreated stone.

Table 2 – Cut Core Sample List –Untreated Stone

<i>Sample</i>	<i>Treatment</i>
A-1	Untreated
A-2	Untreated
A-3	Untreated
A-4	Untreated
A-5	Untreated
A-6	Untreated
B-1	Untreated
B-2	Untreated
B-3	Untreated
B-4	Untreated
B-5	Untreated
B-6	Untreated
C-8	Uncoated (DUMMY)

Stone Characterization

The first step in determining if consolidation is an appropriate conservation treatment is the characterization of the stone. A range of laboratory tests were used to identify the composition and type of stone, and to evaluate the physical properties relevant to consolidation.

Test Program

The sandstone samples were subjected to a range of laboratory tests to obtain an understanding of the stone, to determine how and why it is deteriorating, and to help in informing consolidation treatment methods. The components of the stone characterization test program included water vapor transmission rate determinations, and absorption rate testing.

Water absorption is an important property for two reasons. First, most weathering and deterioration processes are moisture dependent. Generally, highly absorbent stone types are less durable than those that are less absorbent, although pore size distribution, permeability, and mineralogical composition are also important factors in determining durability. Second, the effectiveness of some conservation treatments such as consolidation is partially dependent upon the absorption characteristics of the treated material.

The water vapor transmission rate (WVTR) test measures the rate of passage of water vapor through a porous material under specific conditions of temperature and humidity. Water vapor transmission rates can be calculated from the data obtained. This information is frequently used to select compatible patching materials. When the patching compound is as permeable or more permeable than the underlying stone, failure of a patch due to the existence of a vapor barrier is avoided. Permeability data are also valuable in selecting appropriate consolidants. Consolidation should not appreciably alter the permeability of the stone (thereby creating a superficial vapor barrier) to prevent accelerated deterioration by various mechanisms (for example, freeze-thaw, salt crystallization).

Absorption

Two absorption tests were used: initial rate of absorption and total absorption. The initial rate of absorption is a qualitative measure of the configuration of the pore spaces in the stone. Generally, stone with abundant small pores will absorb water more quickly than stone with the same volume of pore space in large pores. Initial rate of absorption is determined by comparing the dry weight of the sample with its weight after pre-determined time intervals. There is no standard test for this procedure.

Total absorption is related to the total porosity of the stone, but the two are not equivalent because not all of the pores may be accessible to water. The test method used for determining total absorption is based on ASTM C97⁵; samples used were smaller than called for and the immersion time 24 hours instead of 48 because of the small size of the samples.

Table 3-Total Absorption

Sample Number	24 Hr. Absorption* Untreated (%)
Untreated*	6.85%

*NOTE: The absorption is calculated as the average absorption of the discs from each core at 24 hours.

⁵ ASTM C97-90 *Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone.*

Table 4-Initial Rate of Absorption

Sample Number	5 Minutes	30 Minutes	60 Minutes
	Percent Absorption	Percent Absorption	Percent Absorption
Untreated*	4.65%	4.65%	4.85%

*NOTE: Figures derived from average of percents for all untreated sandstone samples.

This type of sandstone is highly absorptive. Note most samples neared their final total absorption readings within the first 30 minutes of immersion and reached near peak total absorption at 1 hour.

Water Vapor Transmission Rate

The permeability of the sandstones was evaluated using a modification of American Society for Testing Materials (ASTM) E96.⁶ The samples used for the test were discs cut from core samples Core A, Core B, Core C, and Core D. Discs were sliced from the cores perpendicular to the long axis with a small trim saw. The discs were washed in tap water to remove debris from cutting, then oven dried at 60°C for 24 hours and allowed to cool to room temperature. The edges of the discs were sealed with Teflon plumber's tape and then mounted in the top of a polypropylene vile filled with distilled water to a level ¾ inch below the sample. The gap between the edge of the beaker and the sample was then sealed with Ethylene Vinyl Acetate.

The samples were placed in a Forma Stericult 200 Model 3033 HEPA Filtered CO2/RH/Temp Incubator to control temperature and relative humidity, and weighed at regular intervals using a Ohaus Galaxy 400D Balance (Accuracy .001) Model G400DO to monitor the amount of water lost by evaporation through the stone.

The more permeable the material, the greater the weight loss will be. After a relatively steady daily loss is established, a water vapor transmission rate can be determined for the material. The average water vapor transmission rates of the samples are given in Table 5 in grams of water transmitted per square meter per hour.

Table 5-Water Vapor Transmission Rate*

Sample	Treatment	Average WVTR g·m- 2·hr-1
A 1:6 & B 1:6	Untreated	32.25

*NOTE: The average temperature and relative humidity during the test was 22°C and 50% RH. The Untreated is an average of multiple core samples. permeability of the entire stone.

⁶ ASTM E96-00 *Standard Test Method for Water Vapor Transmission of Materials.*

Consolidant Evaluation

The consolidation test program was designed to evaluate the option of consolidating the deteriorating sandstone. Consolidants have extremely small molecular structures that enables them to penetrate deeply into deteriorated masonry surfaces, collecting at contact points between individual stone grains. As the liquid consolidant dries it is transformed into typically a silicon dioxide (SiO₂) that binds the stone particles together. Six consolidant treatments were tested: Prosoco Conservare H100, Prosoco Conservare OH100, Keim Silex H, Keim Silex OH, Keim Fixative, Keim Granital Dilution, and Keim Restauro Fixative.

- Prosoco Conservare H100 is a combination consolidation/water repellent treatment based on silicic ethyl esters. This ethyl silicate treatment, modified with a silane water repellent, and is comprised of Di-n-butyltindilaurate, Organic Tin Compound, Ethyl Alcohol, Isobutyltriethoxysilane, and Tetra ethyl silicate, that replaces natural binding materials with silicon dioxide.
- Prosoco Conservare OH100 is a ready-to-use ethyl silicate consolidation treatment that stabilizes masonry by replacing the loss of natural binding materials with silicone dioxide. It consists of Di-n-butyltindilaurate, Organic Tin Compound, Ethyl Alcohol and Tetra ethyl silicate.
- Keim Silex H is a stone consolidant comprised of Silicic Acid Ethoxy Ester, Ketones, Tetraethylsilicate and Silanes in organic solvents. A poly-siloxane gives this treatment water repellance.
- Keim Silex OH is a stone consolidation comprised of Silicic Acid Ethoxy Ester, Ketones, and Tetraethylsilicate in organic solvents.
- Keim Fixative (referred to as Dilution) is pure liquid potassium silicate with stabilizers and diluted ammonia added as a keeping agent.
- Keim Granital Dilution (referred to as Granital) is a liquid potassium silicate with stabilizer and diluted ammonia has been added as a keeping agent.
- Keim Restauro Fixative (referred to as Restauro) is a liquid potassium silicate with stabilizer and diluted ammonia has been added as a keeping agent.

Consolidation should improve internal cohesion without altering other physical properties of the stone. Reduction in water absorption is viewed as desirable, as most deterioration of stone is caused by water-borne agents. However, water vapor transmission rates should not be reduced, allowing moisture to escape from the stone rather than trapping it in. Depth of penetration through the deteriorated surface zone is critical to successful consolidation.

The absorption of the three types of deteriorated sandstone is relatively high, and the configuration of the pore spaces as determined by initial rate of absorption tests suggested that sufficient consolidant should be absorbed to improve the properties of the stone. Changes in water vapor transmission and absorption

properties were evaluated as a measure of the potential for stabilization of the stone. Color change with treatment was also evaluated subjectively.

Treatment Materials and Process

A few samples, which had previously been tested when untreated, were again used to evaluate the consolidant treatments. These include samples A-4, A-5, A-6, B-5, and B-6. After the samples were treated, they were thereafter called A-4b, A-5b, A-6b, B-5b, and B-6b. All other samples were had tests run as either treated or untreated. The following table outlines each sample number and corresponding product.

Sandstone samples were treated according to the manufacturer’s instructions. Three impregnation cycles were used for all samples. The discs were impregnated with the consolidant by total immersion and a three coat brush applications. All the treated samples were allowed to air dry and cure at ambient room temperature and relative humidity for seven days.

Table 6 – Cut Core Full Sample List

<i>Sample</i>	<i>Treatment</i>
A-1	Untreated
A-2	Untreated
A-3	Untreated
A-4	Untreated
A-4b	Keim Dilution Purkristalt (Brush Applied)
A-5	Untreated
A-5b	Keim Granital (Brush Applied)
A-6	Untreated
A-6b	Keim Restauro (Brush Applied)
B-1	Untreated
B-2	Untreated
B-3	Untreated
B-4	Untreated
B-5	Untreated
B-5b	Prosoco H100 (Brush Applied)
B-6	Untreated
B-6b	Prosoco OH100 (Brush Applied)
C-1	Keim Silex OH (Brush Applied)
C-2	Keim Silex OH (Brush Applied)
C-3	Decothane (Brush Applied)
C-4	Decothane (Brush Applied)
C-5	Keim Dilution (saturated)
C-6	Keim Granital (saturated)
C-8	Uncoated (DUMMY)
C-9	Keim Restauro (saturated)
C-10	Keim Silex H (saturated)
C-11	Keim Silex OH (saturated)
D-1	Silex H (Brush Applied)
D-2	Silex H (Brush Applied)
D-3	H100 Conservare (saturated)

D-4	OH100 (saturated)
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Consolidant Uptake and Depth of Penetration

The amount of consolidant absorbed by the discs and cores was evaluated by the percent change in weight of the stone samples between the initial untreated weight to the treated and cured weight. The initial and cured weight of each sample is presented in Table 7. Note Keim Silex H and Keim Silex OH seemed to be the most absorbed and caused a 5% change in weight.

Table 7-Consolidant Uptake of Sandstone Samples*

<i>Sample</i>	<i>Treatment</i>	<i>Initial Weight (grams)</i>	<i>Cured Weight (grams)</i>	<i>Weight Change (grams)</i>	<i>Percent Weight Change (%)</i>
C-5	Keim Dilution (saturated)	27.25	28.20	0.95	3%
C-6	Keim Granital (saturated)	29.78	29.99	0.21	1%
C-9	Keim Restauro (saturated)	24.85	25.00	0.15	1%
C-10	Keim Silex H (saturated)	29.074	30.53	1.46	5%
C-11	Keim Silex OH (saturated)	23.85	25.02	1.17	5%
D-3	H100 Conservare (saturated)	29.16	29.62	0.46	2%
D-4	OH100 (saturated)	32.38	33.30	0.92	3%

Absorption

Test data for both untreated and treated samples are presented below and in the total-immersion-absorption test chart.

Table 8-Total Absorption – Treated & Untreated Samples

Sample Number	24 Hr. Absorption* Untreated (%)
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UNTREATED:

Untreated*	6.85%
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SATURATED:

Prosoco H100	1.32%**
Prosoco OH100	2.97%
Keim Silex H	0.72%
Keim Silex OH	4.00%
Keim Dilution Purkristalt	4.15%
Keim Granital	5.10%
Keim Restauero	5.08%

BRUSH APPLIED:

Prosoco H100	1.98%
Prosoco OH100	4.25%
Keim Silex H	0.95%
Keim Silex OH	7.34%
Keim Dilution Purkristalt	3.95%
Keim Granital	4.03%
Keim Restauero	4.07%

*NOTE: The absorption is calculated as the average absorption of the discs from each core at 24 hours.

**A Bolded figure indicates significant overall decrease in absorption.

Table 9-Initial Rate of Absorption – Treated & Untreated Samples

Sample Number	5 Minutes	30 Minutes	60 Minutes
	Percent Absorption	Percent Absorption	Percent Absorption
UNTREATED:			
Untreated*	4.65%	4.65%	4.85%
SATURATED:			
Prosoco H100	0.47%**	0.47%	0.81%
Prosoco OH100	3.00%	3.00%	3.12%
Keim Silex H	0.43%	0.43%	0.49%
Keim Silex OH	4.00%	4.00%	4.08%
Keim Dilution Purkristalt	3.30%	3.30%	4.04%
Keim Granital	1.97%	1.97%	4.03%
Keim Restauro	1.00%	1.00%	3.28%
Brush Applied:			
Prosoco H100	0.36%	0.36%	0.93%
Prosoco OH100	3.85%	3.85%	4.16%
Keim Silex H	0.62%	0.62%	0.47%
Keim Silex OH	6.83%	6.83%	7.33%
Keim Dilution Purkristalt	4.16%	4.16%	4.04%
Keim Granital	3.83%	3.83%	0.16%
Keim Restauro	4.11%	4.11%	4.21%

*NOTE: Figures derived from average of percents for all untreated sandstone samples.

**A Bolded figure indicates significant overall decrease in absorption.

The absorption tests showed that sandstone treated with Prosoco H100 & Keim Silex H greatly reduced water absorption. Consolidants should replace some of the voids left from failing binder in the material and cause water absorption to decrease. These two products were 5 times less absorptive than untreated sandstone roughly 81%. It is important to note that these were affective both when the sample was saturated and when brush applied. For testing purposes we brush applied each coating three consecutive times. It should also be noted that Prosoco OH100 cut down absorption by more than 50%. Keim Silex OH and Keim Dilution Purkristalt cut it down by more than 40%. Finally, Keim Granital and Keim Restauro cut it down by only 25%.

The following table shows the overall weight percent absorption over time of the total immersion absorption test. Note Prosoco H100 & Keim Silex H are the least absorptive as show below.

Chart 1-Total Immersion Absorption Test

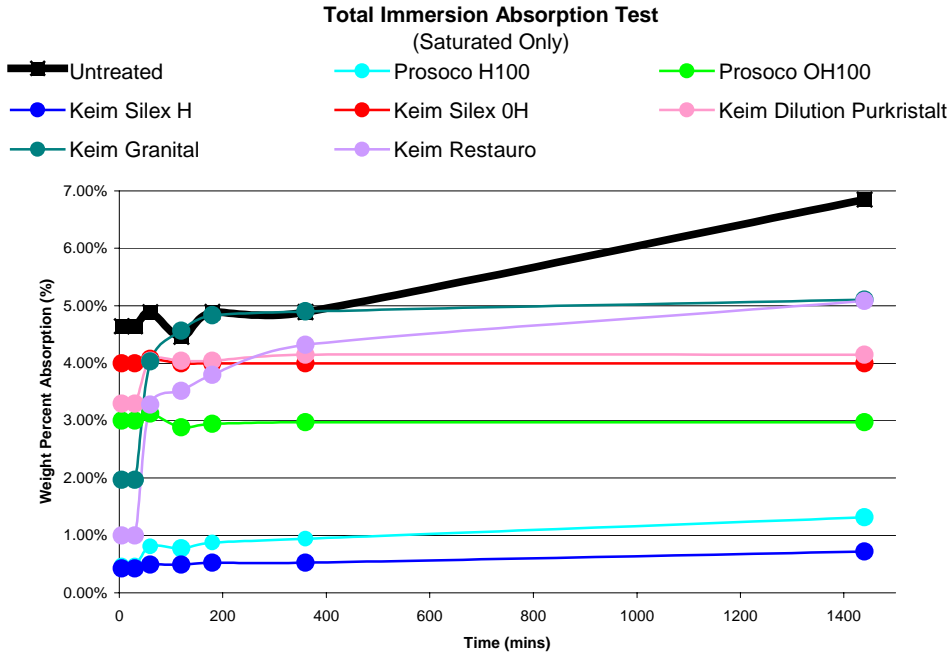


Chart Reading Tips:
Look for products with the lowest trend lines in total immersion absorption. The lower the better.
← BEST

Water Vapor Transmission Rate

The permeability of the consolidated sandstone discs was evaluated using the modification of ASTM E 96 previously performed to evaluate the untreated stone samples. The average water vapor transmission rates of both treated and untreated samples are given in Table 10 in grams of water transmitted per square meter per hour.

Table 10-Water Vapor Transmission Rate*

<i>Sample</i>	<i>Treatment</i>	<i>Average WVTR g·m⁻²·hr⁻¹</i>
C-1 & C-2	Keim Silex OH (Brush Applied)	34.20
D-1 & D-2	Silex H (Brush Applied)	33.46
A 1:6 & B 1:6	Untreated	32.25
C-11	Keim Silex OH (saturated)	31.84
C-9	Keim Restauro (saturated)	29.67
D-4	OH100 (saturated)	29.67
B-5b	Prosoco H100 (Brush Applied)	29.43
B-6b	Prosoco OH100 (Brush Applied)	28.99
A-5b	Keim Granital (Brush Applied)	28.05
D-3	H100 Conservare (saturated)	27.99
C-6	Keim Granital (saturated)	27.62
A-6b	Keim Restauro (Brush Applied)	27.43
A-4b	Keim Dilution Purkristalt (Brush Applied)	26.55
C-10	Keim Silex H (saturated)	26.50
C-5	Keim Dilution (saturated)	26.47

*NOTE: The average temperature and relative humidity during the test was 22°C and 50% RH. The Untreated is an average of multiple core samples. Its average is slightly lower than some treated samples because it illustrates the average permeability of the entire stone.

The above table illustrates the average total WVTR rate for selected treatments.

The following chart reflects these the adjusted average WVTR rate for each day over a period of 15 days. The first few days' trends are typically out of sink with the rest of the readings as the sample is adjusting to the tank. The heavy black line illustrates the untreated adjusted average daily rate for multiple samples. Other samples should be compared to this line. Note the brushed applied samples of Keim Silex OH and Keim Silex H brush applied applications had rates very similar to the untreated averages. When these products were saturated their permeability decreased.

Chart 2- Average WVTR Weight Loss Per Day

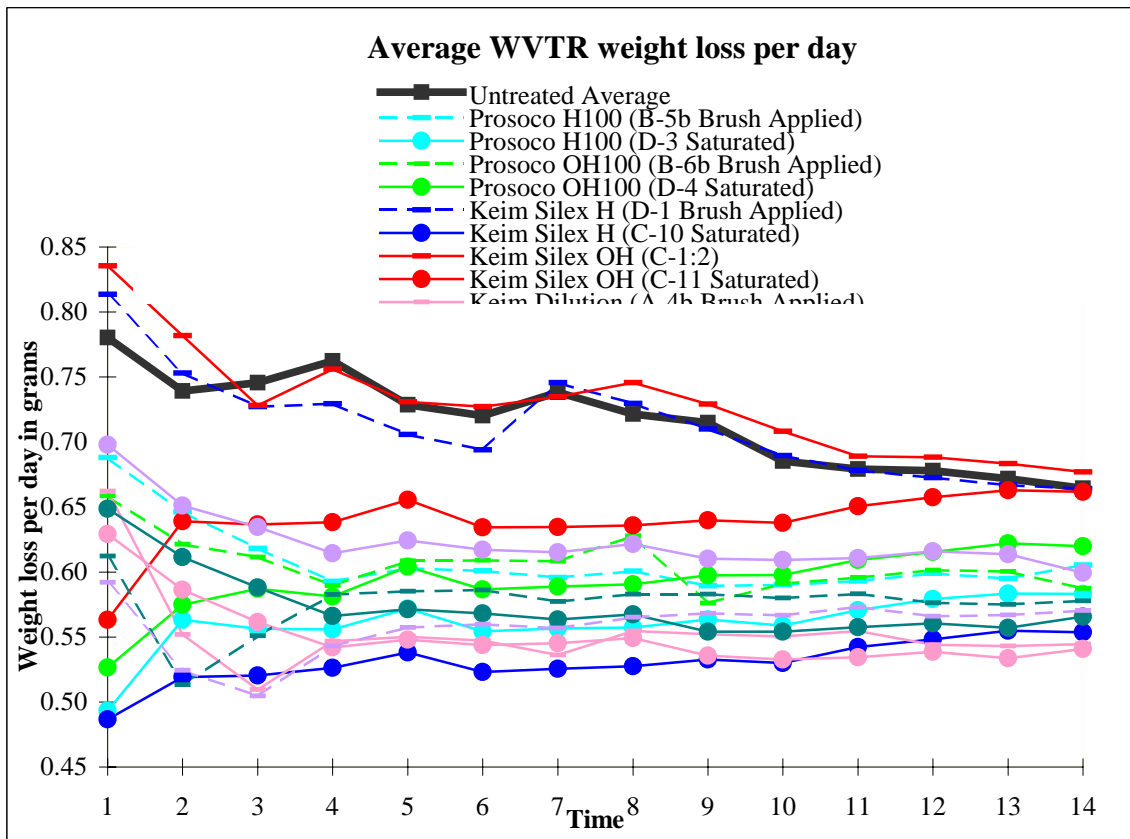


Chart Reading Tips:
Look for products that follow the same trend lines in for WVTR as the untreated sample.

} Good Range

Color Change

Evaluation of an acceptable degree of color change with a consolidation treatment cannot easily be made with existing standard tests, because most tests do not take into account all the variables affecting selection of a consolidation treatment. These include the severity of the deterioration, the extent of the proposed treatment, and the cultural importance of the object being treated. Color of stone consolidants are difficult to assess because the final color may not be attained for as much as a month after consolidation has been completed.

In general, the stone remained the same color and tone with all treatments. The only product that may have darkened it slightly was Keim Silex H. The change is so slight is it hardly quantifiable. It should be noted that Keim Fixative (Dilution), Keim Granital, and Keim Restauro all left a slight efflorescence bloom that was not removed with rinsing.

The best way to determine if the degree of color change with consolidation is acceptable is to evaluate a test panel applied on-site.

Consolidant Conclusions and Recommendations

When looking at all of the parameters tested in this study one single product did not out perform all the others in every test. Keim Silex OH & Keim Silex H tested very well as did Prosoco H100. The following chart breaks out some important factors looked at when selecting a consolidant product.

Table 11- Overall Test Performance Ranking

<i>Treatment</i>	<i>Consolidant Uptake and Depth of Penetration</i>	<i>Initial & Total % Absorption Weight for Saturated Samples</i>	<i>Initial & Total % Absorption Weight for Brush Applied Samples</i>	<i>Average Daily WVTR for Saturated samples as Compared to Untreated</i>	<i>Average Daily WVTR for Brush Applied Samples as Compared to Untreated</i>	<i>Average WVTR for Saturated Samples</i>	<i>Average WVTR for Brush Applied Samples</i>	<i>OVERALL RANK*</i>
	TABLE 7	TABLE 8	TABLE 8	CHART 2	CHART 2	TABLE 10	TABLE 10	
Prosoco Conservare H100	5	2	2	4	3	4	3	2
Prosoco Conservare OH100	4	3	6	3	4	3	4	4
Keim Silex H	1	1	1	7	2	6	2	3
Keim Silex OH	2	4	7	1	1	1	1	1
Keim Dilution	3	5	3	6	7	7	5	5
Keim Granital	6	7	4	5	5	5	6	6
Keim Restauro	7	6	5	2	6	2	7	6

* Overall rank is determined not only by individual rankings but by all information given about the performance of a proposed treatment.

Keim OH ranked number one in overall test results. It maintained a consistent WVTR with the substrate for both brush applied and saturated samples. It also achieved a high weight gain when comparing dry weight of the untreated verses treated sample. The only test where it did not come out on top was the initial and total Absorption Tests, improving absorption by around 40%. Keim OH is a German Product; however, there is a local distributor in the area.

The second ranked overall product was Prosoco Conservare H100. This product did not fair as well with WVTR rate tests but it did do very well with initial and total Absorption Tests, improving absorption by around 80%.

It is JMA’s recommendation that the top two consolidants be tried in a large-scale panel to be weathered over the winter. These panels could then be cored and have WVTR, water absorption tests, and petrographic analysis performed to verify field application success. This will also help determine product coverage and real world weathering characteristics.

Consolidates are very expensive to apply, ranging from \$15-30 a SF for application costs. There is no guarantee how long the consolidant will prolong the stones life. It will be necessary to compare the

application cost versus a planned repair/replacement cost for future lost material that may be saved using the consolidant. The prohibitive cost may require a selected localized treatment plan, which will include projecting and ornamental elements.

Final determination of consolidation as a treatment plan will be included in the Cost Estimate & Construction Document Phase after the entire façade has been studied.

Other Issues

Condition of Interior Towers

As part of our investigation of the condition of the towers JMA accessed the inner shaft of the towers with ladders. The upper portion of the tower is framed in wood that is supported by a rubble stonewall, which is clad in sandstone. The rubble stone wall is in good condition with some open joints.

We found the east tower to be in good condition. A few minor framing elements are in compression and an active birds nest. The sills, which support the rafters, are in fair condition. One sill has nearly 80% dry rot and three others have partial dry rot. The remainder of the framing i.e. rafters, outer sills, ties, etc. are in good overall condition. There are a few areas where the galvanized metal in the shape of louvers is loose and allows access for birds and insects.

Wood framing of the west tower is in considerably worse condition. All upper tower floor joints suffer from insect or dry rot and are loose in their connection to the wall. The main structural frame suffers from severe insect damage and dry rot. Six out of eight of the sills suffer from 50% or more loss and only two of eight rafters are supported by a sound connection at the sill. There is some form of compression in nearly every corner of louver framing elements as well as displacement. The northeast corner of the tower appears to have settled causing some shifting of the frame.

JMA obtained the services of a structural engineer for a preliminary investigation. His report is included in the appendix of this report. Cost for this repair work and the engineer's fees were not included in the cost given to restore the sandstone façade of the tower. Engineer's fees have been included in our Phase 2 Proposal dated May 17, 2002.

Cause of Water Infiltration

As discussed above the towers are constructed with an inner core of rubble stone and an outer façade of sandstone. As mortar erodes from between the sandstone joints it allows water to penetrate and erode backing mortar between the rubble stone and the sandstone. This creates a void where water can penetrate into the void and will either migrate both towards the exterior of the stone and into the interior of your building, whichever path has the least resistance. Although, it is difficult to determine the complete extent of this void, it has been observed in a few cored areas of the sandstone and from the interior where pockets for a prior floor in the tower were made. Allowances must be made for extensive injection grouting to fill the void.

There are several poor flashing details on the roof of the building where the wall is not flashed high enough to prevent a backup of water from a clogged drain from entering the building. The east tower has several pieces of sandstone, which have been cut to receive reglets for counter flashing.

The flashing was not installed into the reglet during reproofing efforts leaving the stone open from when sandstone was cut allowing water into the wall.

These issues will need to be addressed during the sandstone restoration to prevent additional water infiltration.

Estimated Cost

Based on the above conditions JMA believes repairing the stone & mortar of the two rear towers will cost between \$250,000-\$500,000⁷. This generalized cost estimate is from unit prices received by our office from a similar sandstone project.

The cost for including the main tower and the rest of the building would be an additional \$250,000-\$500,000. Preliminary investigation indicates sandstone on upper portions of the main tower is similar to the rear towers; however, without seeing the stone up close we are guessing about the condition of the tower. Please also note your windows are in exceptionally poor condition. This contributes to moisture penetrating the walls and damaging both your stonework and your interior plaster

The price fluctuation for both portions of the costs would lean towards the lower end if both portions of the work were done at once and towards the higher end if this were a phased project.

In addition to the above you will need to budget 10-15% for architectural and engineering services to prepare construction documents and provide high-level construction support. You will also need to budget for the Review Process of the District of Columbia Historic Preservation Division.

⁷ This does not include the cost for consolidation. Material costs for consolidation alone will be approximately \$600,000.