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INTERIOR CLEANING AT SAINT JOHN THE DIVINE: PRACTICAL AND LOGISTICAL CONSIDERATIONS

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Abstract

One of the primary tasks following a major fire at the Cathedral Church of Saint John the Divine was the cleaning of all of the interior masonry. In addition to considering the effect of each potential cleaning method on the masonry substrates and the level of cleaning achieved, the review process also had to include the enormous scale of the undertaking, the desire to use a single method to clean multiple substrates, and the fact that portions of the building were to remain open while work was on-going. Ultimately, Arte Mundit® was selected for cleaning the two primary interior cladding materials: limestone and Akoustilith tile. The many construction-related issues addressed during the course of the project included procurement, containment, health and safety, and waste disposal. Additionally, a great deal was learned about the relatively new cleaning method during the course of the work and the technique was modified in response to issues that were encountered, including appropriate conditions for cure, amount of scrubbing of the substrate following product removal, and the need to inspect for chemical and latex residues at the conclusion of the cleaning.

Keywords: Arte Mundit, latex, interior masonry cleaning

1. Introduction

Following a major fire at the Cathedral Church of Saint John the Divine in the Morningside Heights neighborhood of New York City in December of 2001, the decision was made to clean the massive interiors. All cleaning projects on buildings of historic significance require a thoughtful study of appropriate techniques. Cleaning a large scale historic interior added an additional layer of complexity, both in selection of an appropriate cleaning technique and in the logistics associated with achieving optimal results and ensuring timely completion of a project. The chosen technique, the proprietary Arte Mundit cleaning system, was new in the United States at the time it was selected and therefore the project had an additional issue of learning how best to use the product as the work progressed. This paper catalogues the practical and logistical issues related to the use of the proprietary Arte Mundit system for cleaning interior masonry at the Cathedral, and describes the lessons learned.

A description of the Cathedral and its history (Dolkart 1998), a characterization of the interior fire soil prior to deciding to clean the interiors and a description of the comprehensive cleaning test program conducted to assess appropriate methods for cleaning the interior (Gembinski et al. 2005), and a study of the associated repairs undertaken as a part of the post-fire restoration (Buchner 2010) are detailed in other publications.

2. Arte Mundit

The proprietary Arte Mundit, manufactured and distributed by FTB-Remmers, is a two-component system based on natural latex rubber. The thick white paste cures to form a film that can be peeled from the substrate. Four variations of the product are currently marketed: Type I contains no chemical additives specifically included to facilitate cleaning; Types II, III, and V contain differing concentrations of EDTA. Other components of the product are not released by the manufacturer but have been studied by others (Morasset 2008).

3. Saint John's materials of construction

Construction of the Cathedral began in the 1890s and continued, with some interruptions, until the start of World War II. Additional progress was made on the west elevation towers in the last quarter of the twentieth century; however, the building's exterior and interior remain unfinished. The interior walls of the Cathedral are clad primarily in smooth sawn Indiana limestone. The regular coursed ashlar walls comprise the minority of overall surface area; bundled columns with ornate capitals, various large moldings, and carved ornament interrupt the flat surfaces frequently. In some areas of the interior the cladding is not yet installed; in these locations, brick and large units of rough-cut granite back-up masonry remain exposed. The vaulted ceilings have cast stone ribs and Akoustilith tile vaults (Pounds 1999). Flooring materials include finished surfaces of limestone, argillite, and tile; there are also large expanses of concrete, where the finish floor was never installed. The interiors of the Ambulatory chapels comprise a greater range of unique decorative stones and tiles.

4. Evaluation of cleaning method

Evaluation of cleaning methods can generally be divided into two categories: *material issues* related specifically to the substrate to be cleaned and *constructability issues* related to the logistics of completing a project on a schedule and within a proscribed budget.

Material Issues

- Potential effects of the cleaning system on each substrate
- Degree and uniformity desired and achieved
- Potential for cleaning product to leave residues in substrate

Constructability Issues

- Cost associated with cleaning system
- Product availability and quality control
- Availability of manufacturer support
- Shelf life of cleaning product
- Access of materials to work area
- Ease of product application and removal
- Control and containment of cleaning products and waste products
- Disposal of waste products
- Noise and odor issues

- Schedule impact
- Ability of one product/system to clean multiple substrates
- Dependence of successful results on operator skill
- Worker health and safety

The relative value assigned to the various items within each category necessarily varies on a project-by-project basis. On a very large-scale project with limited funds, compromises are sometimes made, but all items should be considered.

When work began at Saint John, the use of Arte Mundit as an interior masonry cleaning system was new to the United States although it had been in use in Europe for some years. In order to reduce risk and establish an estimate of schedule and cost with some degree of confidence, a large-scale mock-up was produced prior to commencing with full-scale work. The mock-up was performed on two entire walls of a chapel that occupies one bay of the nave. The mock-up allowed the team to assess application rates, containment and ventilation needs, and noise and odor issues, and permitted the project team's conservators to assess results of the various types of Arte Mundit in large areas in terms of appearance and of material impact on substrate.

5. Access considerations

The Cathedral is approximately 183 m in length. The nave is approximately 75 m long. The highest point at the center of each nave vault reaches nearly 38 m. Thus, access to work areas, and the associated cost, was necessarily an important consideration at the planning stages of the project. The decision was made early on to keep portions of the building open to the public at all times and this decision impacted access options. There was also a desire to have visitors walk the length of the nave even when the construction work was in progress in that space so that they could experience the enormity of the building despite the restricted access.

Use of aerial lift equipment suitable for use on interiors was considered but rejected for several reasons. First, it would not be possible to fit all the personnel and equipment required for cleaning operations on the lift's platform. Second, the amount of time for the lift to repeatedly raise and lower in order to access supplies at least partially negated the estimated cost savings. And third, although it was believed (based on the mock-ups performed) that Arte Mundit would require far less rinse water and containment than other types of cleaning systems, issues of containment during application and removal still existed and would be extremely difficult to address using lift equipment.

During the restoration, surfaces were accessed primarily using stationary pipe frame scaffolding. The pipe frame enabled containment of discreet work areas and permitted the contractor to access many areas simultaneously. It also facilitated design team review of completed areas while work was progressing in new locations. At the perimeter, pipe frame was erected to the full height of the nave, crossing, and great choir/high altar walls. A rolling platform, sized to fit within two bays of the nave and set at approximately 30 m – near the spring point of the nave vaults – allowed for access to the nave ceiling while keeping the nave's center aisle free for pedestrian traffic (Figure 1). Stationary pipe frame was also erected across the full width of the building at the juncture of the Nave and the Crossing. This portion of the pipe frame was necessary to reach certain otherwise inaccessible surfaces. It was also used as a physical separation

between work areas and areas open to the public. Sheets of plywood were secured to the pipe frame, forming a solid wall; when work shifted from the crossing to the nave, the plywood was moved from one face of the pipe frame to the other.

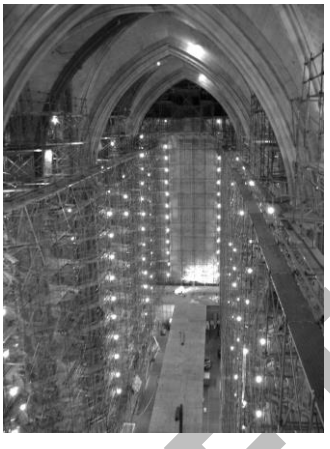

Figure 1. View of scaffolding at nave. Center aisle is open with plywood-roofed pedestrian walkway. Plywood secured to pipe frame, visible at center rear, provides separation between nave and crossing. Photograph by the author.

6. Procurement considerations

Arte Mundit is manufactured in Europe. Although currently available for purchase within the United States, at the start of the project it could only be obtained from Europe. Thus, it had to go through Customs upon arrival in the United States. United States Customs, when questioned in advance, would not give an estimate for the amount of time it would take to approve the shipment. The contractor allowed for a two-week delay at Customs, which turned out to be an accurate estimate. Because of the unknown factor and risk of delaying the work, in order to maintain a constant supply of product at the site very large quantities were ordered four months in advance of anticipated need date. To accommodate project requirements, full shipping containers were purchased. Ordering such large quantities at one time carried the risk that the product would not be used within the presumed shelf life. The manufacturer initially stated that the material should be used within six months; this was later revised to one year. Since the calculation had to include the estimated amount of time between manufacture and arrival at the job site, the shelf life upon arrival was closer to eight months. During the course of the project it was found that product up to eighteen months old performed satisfactorily. The manufacturer has since revised their recommendation again, with a current stated shelf life (premixing) of fourteen months.

Despite its high cost, using Arte Mundit appears to be comparable to the estimated cost of other cleaning methods used on large scale architectural interiors, such as wet chemical cleaning and micro-abrasive methods. This is because labor costs for related activities, such general worksite cleanup, containment of product during use, and waste product containment and disposal tend to be much less for Arte Mundit.

7. Surface preparation considerations

Thorough vacuuming of surfaces to receive Arte Mundit proved to be essential to successful use of the product. There was a significant amount of loose particulate matter on the stone surfaces, which impeded contact of the latex with the substrate. Leaving the loose soil on the stone resulted in uneven cleaning results. A variety of vacuum nozzle attachments were used. Large nozzles with a soft brush permitted large flat surfaces to be vacuumed rapidly; small nozzles of different shapes gave access to molded stone and deep crevices in stone carvings.

Latex remnants can impair adhesion of new mortar, and latex remnants are particularly difficult to remove from the concealed faces of stone at joints between units. If repointing is a part of the scope of work, the order in which tasks are carried out must be carefully considered. Repointing may be performed first, to avoid the risk of residue affecting adhesion of mortar. However, there may be reasons to defer work with mortars until the stone is clean, including the desire to finalize the appearance of pointing and composite patches after the stone is cleaned. In these cases, insertion of a flexible, reversible material, such as a backer rod, can be used to protect the surfaces during Arte Mundit application.

The Cathedral's many stained glass windows had to be protected against the cleaning product. The risk of damaging glass as a result of the peeling of the dried latex was deemed to be unacceptable because of the strong adhesion of the latex to glass. Additionally, many pieces of the Cathedral's glass are painted and Arte Mundit has the potential to alter and/or remove paints. Also, the stable and uniform corrosion product on the lead cames was affected by the product. Installation of protection was time-consuming because of the intricacy of the windows; the workers cut stiff plastic to fit the variety of shapes created by the window tracery.

8. Application considerations

Arte Mundit can be applied by roller, brush, or spray. Workers have also been observed using trowels to apply the material. In addition to the mixing equipment needed to prepare the two components of Arte Mundit for any application method, the typical set up for a spray application will include a compressor, a container (hopper) to feed the wet material to a hose, a large diameter hose to carry the material to the point of application, and a spray nozzle. Although a diesel compressor can be used and may be advantageous for smaller jobs of shorter duration, at Saint John a large electric compressor was purchased so that it could be situated inside the building, avoiding the noise and odor issues associated with locating a diesel compressor in an urban neighborhood that includes a large hospital and many residential apartment buildings.

A spray application was found to be optimal at Saint John as well as at several subsequent projects. Spraying facilitates the application of the product, particularly when the stone is deeply carved or has deep crevices, and has critical impact on cure time, the removal process, and the degree of cleaning largely because of the thickness and uniformity of application that can be achieved by spraying. Brush or roller application did not achieve comparable results at Saint John. Use of a roller resulted in too thin an application, especially on uneven and high relief substrates, because the stiffness of the roller did not allow the product to settle uniformly. Conversely,

application of too thick a coating (more likely when using a trowel or brush) was found to be problematic because of its impact on cure.

Logistically, spray application presented several issues. The latex spray, although heavy, becomes air borne; residues from the spray application were observed at least 5 m from the work surface. However, containment proved to be a straightforward process because of the size of the particles; well-sealed sheets of polyethylene secured to the scaffold structure served to contain work areas. The latex overspray did coat the pipe frame scaffold pipe and wood planks, at time resulting in slippery surfaces. The latex-covered equipment initially caused complaints from the scaffold supplier when the rented scaffold was returned at the conclusion of the project, but after they found that the latex not only easily pulled off the frames and planks but that it removed soil from their equipment, complaints ceased. Worker and observer respiratory protection were controlled by the use of individual respirators. Given the high concentrations of latex in the air during spraying and the desire to reduce the risk of negative consequences or a breech in containment causing spread of latex to publically accessible areas and/or already cleaned surfaces, a negative pressure ventilation system was also installed. It consisted of large diameter hoses linked to fans equipped with filters. The biggest issue related to setting up and maintaining a negative pressure ventilation system turned out to be finding operable windows to vent the air in a Cathedral whose windows were nearly all comprised of fixed stained glass.

Latex allergies were a serious consideration. It was necessary to confirm that all personnel on the job site who would come in contact with the product did not have latex allergies.

A high degree of training and subsequently of on-going good concentration and sensitivity to the needs of the work effort on the part of the workers assigned to spraying was critical to successful application. The contractor arranged for a trainer from Belgium familiar with the system to do on-site training. Two workers were trained. It took approximately one month before they gained a sufficient level of expertise with the system to be able to produce consistently good results. Initially, it was thought that more workers would be trained but, given the amount of training and skill required, only the first two trained were assigned to this work for the course of the project. Impact of this limitation on schedule was considered, but because it takes far more time to remove the cured product than to apply it, the workers applying the product were able to stay ahead of the removal crews. Indeed, consideration of the speed of the spray application needs to be factored into the overall schedule. Thoughtful orchestration of tasks is needed since issues with removal can arise if the product remains on the surface too long prior to removal.

Individual worker strength is another important consideration because of the difficulties in maneuvering the heavy, cumbersome nozzle properly to achieve a smooth even application. The issue was compounded by the high percentage of high relief and carved elements at the Cathedral; a great deal of practice was required to master the correct duration and nozzle angle to achieve the right thickness on deeply carved surfaces.

9. Cure considerations

Following spray application, the product is left to cure. The product must be fully cured prior to removal. Generally, cure is apparent because of the color change from a white opaque paste to a yellow, somewhat translucent film. In addition, following application to the substrate, the product has more 'give' when touched where it is still wet.

Cure time is dependent on air temperature and relative humidity as well as on surface temperature and substrate moisture content. FTB product literature states that they have tested their product and found cure to be acceptable under a variety of conditions, ranging from 5 degrees to 30 degrees Celsius and a relative humidity of 40 percent to 95 percent. Whether the product contains additives to increase the range of acceptable conditions is not known. In general, the warmer the temperature and the lower the relative humidity, the faster the latex will cure. A very high relative humidity may create moist conditions such that the latex will become brittle and therefore difficult to remove following cure. If latex freezes, it is unusable.

In practice, it was found that Arte Mundit does not cure adequately at a surface temperature below 10 degrees Celsius. Importantly, this means that issues with cure can arise when exterior temperatures are below below 10 degrees Celsius and the work location is on the interior surface of exterior walls (thinner walls are more susceptible) or adjacent to windows. For example, stone tracery at stained glass windows has a tendency to maintain a surface temperature closer to the exterior environment.

Excessive cure times were associated with difficulty in removing the product and removing residual soil. Based on practical experience gained during the course of the project at Saint John, every effort was made to remove product after no more than a forty-eight hour dwell.

One of the most problematic cure-related issues is that latex becomes brittle in the presence of moisture. If the latex becomes wet prior to or during cure, the cured film cannot be removed in large sheets; when pulled, it breaks into very small (approximately 6mm square) pieces. At one wall in Saint John, where Arte Mundit was unknowingly applied over a damp substrate, workers spent several days rather than the normal few hours picking off small pieces of the latex. Re-application was then necessary when, after the wall had been scrubbed and left to dry, it was clear that the surface was not as clean as control samples. Therefore care must be taken to ensure the substrate is dry and relative humidity levels are within the recommended range. Inspections should be made following rain events to determine if water has infiltrated to surfaces prior to spraying. Since a surface may appear to be dry but still contain moisture, testing should be performed to confirm conditions where warranted. Comparative readings from a moisture meter may provide sufficient information; however, this method may necessitate creating holes in the stone surface to insert probes. ASTM International's standard D4263 provides a reliable non-destructive method. In brief, this method involves sealing a layer of transparent polyethylene sheeting on the substrate and noting whether water condenses on the inner surface of the sheeting after a proscribed period of time.

10. Removal considerations

The cured latex is pulled off the surface in sheets. The importance of applying a thick even film becomes apparent during removal as latex applied too thinly is more

difficult to remove because it cannot be pulled in large sheets and tends to break off and stay in crevices where it is even harder to remove. This is particularly problematic on stone surfaces that exhibit honeycombing, such as unfilled travertine, because of the tendency for remnants to remain in deep crevices.

Over the course of the project, it was discovered that the way in which the film was removed affects performance. Pulling the cured film some distance from the still-adhered edge makes it more likely that the film will break in small sheets as applied force exceeds the material's tensile capacity. If the worker's hands are always close the adhered edge, sheets of greater size can be removed. Pulling the material farther from the substrate also appeared to have a relationship to the amount of residue left on the substrate.

Some soil is removed with the latex. At Saint John, soil also remained on the surface and required a combination of scrubbing and sponging with clean water for successful results. More scrubbing was required to remove soil when the latex was left on the stone for an overly long dwell time, and, following an overly long dwell it was more difficult and sometimes was not possible to achieve a uniformly clean surface without reapplication of the product. It was found that scrubbing needed to be done immediately following removal of the film to achieve the desired level of soil removal, so there was careful scheduling of how much film was removed at any one time.

Significantly less water is needed with Arte Mundit than for the typical rinsing required with wet chemical cleaning methods, so the system removes the need for control and containment of large quantities of waste water, which can be problematic and costly to set up and maintain. At Saint John, the contractor set up a pump at floor level to provide sufficient pressure to deliver water through a hose to the work area even at heights in excess of 30 m, as well as a separate chute for disposing of waste water so that the workers did not have to leave the work area to obtain clean water. The workers were asked to always have two buckets of water: one in which to rinse a soiled sponge or scrub brush and one to obtain clean water prior to using the tool on the substrate. Regular changes of water were essential to avoid re-introducing soiled water into the stone, and the ease of access gave greater confidence that workers were exchanging dirty water for clean frequently enough.

At the start of the project, the workers began removal of the cured film at the top of the wall. The procedure was to expose only the amount of wall surface that could be scrubbed and rinsed during a typical work period of approximately four hours. The remaining adhered film below formed a lip that was initially was initially considered helpful because it aided in control of waste water. However, because the rinse water carrying soil tended to settle and rest at this lip, it resoiled the stone. Simply scrubbing with water and a scrub brush did not remove this soil; another application of Arte Mundit was required at this line. Since the surfaces to either side of the line had already been cleaned, the product was applied by brush joint-to-joint on the effected courses of masonry.

Particularly when small pieces of latex remained on the surface and had to be individually picked off, pieces of latex tended to accumulate on the scaffold decking. Good housekeeping was important. Otherwise, the small pieces fell to lower levels where they adhered to walls, requiring careful inspection and additional removal later to

ensure that no pieces remained on the building surfaces. Testing confirmed that the waste product (removed latex film) could be disposed of as normal construction debris.

11. Inspection considerations

As with any masonry cleaning project, evaluation of results included whether the desired degree of cleaning established at the start of the project surfaces had been achieved and whether the final effect was uniform. Use of stationary scaffolding can make it difficult to evaluate results because it is not always possible to stand far enough away from the cleaned surface to evaluate uniformity over large areas. Sometimes imperfections that appear problematic upclose are not deemed significant when viewed from a distance. In addition, the shadows created by the scaffold structure and work lighting can distort the appearance of the substrate. Where these issues are likely, consideration should be given to incorporation of specific requirements into the contract documents to avoid additional costs during the course of the project to create adequate viewing conditions. For example, the contractor may need to temporarily remove sections of protection and scaffold structure for acceptable viewing conditions, and/or provide a different light source.

As with any project involving the use of chemicals to clean masonry, evaluation also included whether any residues had been left in the stone or on its surface. In the case of Arte Mundit, evaluation was made both for physical remnants of the latex and for chemical components of the product.

Although the potential implications of latex remnants on the substrate itself are not fully known at this time, and further study is indicated, there are known issues. Since latex darkens over time and attracts soil, there is a risk of aesthetic implications. Additionally, latex remnants may affect the adhesion of subsequently applied coatings, patching materials, or mortars. At Saint John, the large amount of scrubbing that was needed to fully clean the stone surfaces following removal of the latex film helped to ensure removal of the latex. The final inspection included a careful review under excellent lighting conditions for visible remnants. But as Morasset (2008) confirmed in her thesis work, latex residue may remain on the substrate's surface even if it is not visible to the naked eye. Morasset used ultraviolet light in laboratory tests to detect the presence of latex. Latex contains limini; under ultra-violet light, cured latex fluoresces a characteristic yellow-green color. The success of this technique to detect the presence of latex is predicted on the substrate either not fluorescing or fluorescing a different color from the latex. Case-specific testing is probably the most reliable confirmation of whether the latex will be discernable under ultra-violet light, since impurities and small quantities of minerals can impact how a substrate fluoresces. Field testing performed by the author thus far has been limited to the cleaning of brick work, where a significant difference in color of fluorescing components made the technique extremely useful in finding latex remnants. Where ambient light could not be dimmed sufficiently, the inspector wore a large dark cloth hood and performed the inspection using the darkness provided by it. Even when the ultra-violet light technique works well, however, to some degree latex remnants continue to be an issue with the Arte Mundit cleaning system because remnants can be trapped in deep crevices where the ultra-violet light cannot reach them.

The possible presence of EDTA residue was evaluated by periodically applying poultices to small areas of cleaned surfaces. Sterile cotton batting was submerged in distilled water and then placed firmly over a cleaned area approximately 4" x 4" in size. The batting was covered with polyethylene sheeting, which was taped at the edges to retard evaporation. The batting was removed after 24 hours and brought to the laboratory where conductivity measurements using an Accumet 50 pH/conductivity meter were made to determine salt content (Kavenagh et al. 2003).

12. Conclusions

Because the Arte Mundit cleaning system was relatively new at the time of the project, the project team had little product-specific experience to draw upon. On-going evaluation of material and constructability issues during the creation of a large-scale mock-up and throughout the course of the work resulted in modifications that improved both efficiency and results. Ultimately, Arte Mundit was successfully used to clean the limestone and Akoustilith-clad interiors of Saint John the Divine (Figure 2). The lessons learned can be utilized on future projects.

Figure 2. Detail of limestone surface cleaned by Arte Mundit adjacent to uncleaned section of stone. Photograph by Andrew Wilson.

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