CONSERVATION OF ARCHITECTURAL MARBLE AT THE NEW YORK PUBLIC LIBRARY

Timothy Allanbrook[1] and Andrew Wilson[2]

[1] *FAIA, Senior Principal, Wiss, Janney, Elstner Associates, Inc.*
[2] *Co-President, Nicholson & Galloway, Inc.*

Abstract

The contracted scopes of restorative work at the New York Public Library (NYPL) were established based on the results of laboratory and field evaluations and included cleaning, repointing of masonry joints, targeted protective surface treatments, systemic repairs, and localized repair or replacement of deteriorated elements. This paper will describe as-found conditions, selection of treatments, and the 'production level' execution of the work as it progressed across the four facades of the library (Figure 1).

Marble cleaning included overall, specialized, and localized treatments in different combinations depending on the substrate configuration and soiling patterns observed. Cleaning systems included an overall system utilizing soap and cycled steam for overall baseline cleaning supplemented with cycled water misting, micro-abrasives, and poultices.

Localized treatments with ammonium oxalate were applied to preferentially consolidate friable surfaces in conjunction with lime-based shelter coat treatments to provide sacrificial protection to the stone surfaces. Hydrophobic and anti-microbial treatments were also applied at select areas.

Certain 'systemic' repairs were implemented throughout the entire facade. These repairs were preventative in nature, designed to assure long-term integrity and control deterioration. Systemic repairs to the marble included repointing of masonry joints, lead weather caps at skyward-facing joints, drips and ledge flashings, and bird controls.

Finally, many localized distress conditions required specific, localized repairs such as spalls, deteriorated ornamental features, cracks, and unsound or destabilized stone units. Repairs for these conditions varied depending on the type of architectural feature.

A detailed tracking and reconciliation process utilizing unit prices, estimated quantities, and reserve quantity allocations allowed the team the flexibility to adjust specific scopes of work as required in the field based on existing conditions and the evaluation and evolution of different repair techniques.

Keywords: marble, facade, restoration, preservation, hydraulic lime mortar, ammonium oxalate, lime shelter coat, zinc oxide patches, dutchman patches, drip edges, contracting, logistics, tracking, unit prices, allocations

1. Introduction

WJE Engineers & Architects, P.C. (WJE) was retained by the New York Public Library in April 2006 to investigate and make recommendations regarding the exterior of the main building, now known as the Stephen A. Schwarzman Building (Figure 1). Broadly, the scope of work under consideration includes cleaning and restoration of the masonry and sculpture, repair of the roofs, restoration of the historic bronze windows and doors, and restoration of the raised plazas or "approaches" upon which the structure is placed. This paper focuses on the marble restoration at the facades.

Figure 1. The New York Public Library

WJE assembled a broad team of in-house specialists and sub-consultants to execute the project. Senior staff participants and/or advisors in this effort included Kyle Normandin (Masonry Specialist), Matt Haberling (Project Architect), Remo Capolino (Roofing Specialist), Joshua Friedland (Conservator), and Tim Allanbrook (Project Manager). Sub-consultants that were part of the WJE team included Conservation Solutions, Inc. (fine art conservators), and A. Elena Charola (masonry conservation chemist). The scope of restoration for the marble facades needed to address four primary evaluative factors: preservation and retention of historic fabric, cleanliness, safety, and cost. These evaluative factors influence the choices of restoration techniques in ways that are sometimes contradictory (Figure 2). For example, a delicate but eroded carved marble element can be carefully cleaned and the historic fabric preserved but it may present an unacceptable safety risk. Ironically, the retained patina of age, desirable from a philosophical standpoint, may not be particularly 'clean' from a practical perspective. Conversely, should the eroded element be replaced with a new piece of marble, the new material will, in many instances, stand out brightly and not blend into a monolithic whole. Finally, the costs of alternative restorative choices do not consistently favor one approach over another.

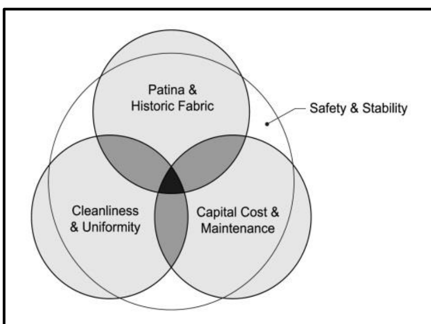


Figure 2. Venn diagram illustrating the sometimes contradictory restoration goals.

The specified scope of work sought a judicious balance of cleanliness along with the preservation of valuable historic fabric and patina. Balanced choices were required at all levels from the selection of overall restorative materials and techniques to the assignment of individual repairs at each stone unit. Safety of the restored facade was a baseline assumption and, when necessary, this factor overrode philosophical, aesthetic, and/or cost based considerations that could not be otherwise addressed.

2. History of construction

The commission to design the New York Public Library was the apex of Carrère and Hastings' work and the firm's most famous project. Design and construction of the new Library took twelve years, and was completed at a cost of $9 million. Before construction could begin, the Croton Reservoir had to be dismantled, a process that involved 500 workers and took two years. The cornerstone of the library was finally laid in May 1902. (www.NYPL.org)

Relevant provisions from the original contract specifications dealing with stone procurement and quality provide a glimpse into the contracting conventions of the time:

> *"... the marble for all of the exterior work shall be white with a very slight amount of clouding of gray blue. The material shall be of such character that it will retain its white color under the action of the weather without discoloration from chemical changes or decomposition of the surface. No marble will be accepted which changes in color through any such decomposition of the surface, and the architects will not accept any material of which a sample cannot be shown which has been in a building and exposed to the weather for at least twenty years; the condition of such sample to be considered in the selection of the material for the Library building.*
>
> *... the general color and character of material desired will be similar to the character and color of the so-called Drexel Building at the southwest corner of Broad and Wall Streets, in this city.*
>
> *... the marking s of the material shall be uniform so that the finished work will not show spots of color or marking, except in the courts where a greater amount of clouding and color will be permitted, but this shall not exceed the clouding and color on the south face of the bank building at the northwest corner of Fourteenth Street and Eighth Avenue, New York City."* (NYPL Contract Specifications).

The original stone ultimately selected to construct the facades was a commercial white marble quarried by the Norcross-West Marble Company in southwest Vermont. The marble had a uniform appearance that was regular and smooth, with light varied veining visible throughout the surface of many of the blocks. The completed library incorporated 530,000 cubic feet of marble, making it one of the largest all-marble building projects in the United States.

Figure 3. Exterior facade near completion in 1907 - note that no sculptures are yet in place

The construction of the building was photographically documented month by month. (NYPL Building archive). During the summer of 1905, the columns were put into place and work on the roof was begun. By the end of 1906, the roof was completed and five years of interior work began (Figure 3). In 1910, seventy-five miles of shelves were installed to house the collections, which included more than one million books set in place for the dedication.

The official dedication of the Library occurred on 23 May 1911, sixteen years after the agreement was signed that created the Astor, Lenox, and Tilden Foundations and established the Library. The ceremony was presided over by President William Howard Taft and was attended by New York Governor John Alden Dix and Mayor William J. Gaynor. On the following morning, the

Library opened to the public and between 30,000 and 50,000 people visited the building on the first day. (www.NYPL.org)

3. Survey methodology

The NYPL's digital scans of the original Carrère and Hastings architectural elevations and sections served as the starting point for development of CAD base drawings. These drawings, in due course, served as the basis for survey documentation, presentation drawings, and contract documents. Given the magnitude of the survey, a decision was made to conduct a tablet computer based survey of the masonry rather than to utilize hand annotation of base drawing sheets. The CAD elevation database was loaded into the tablet and provided a basis for linking photos and observations on a stone by stone basis.

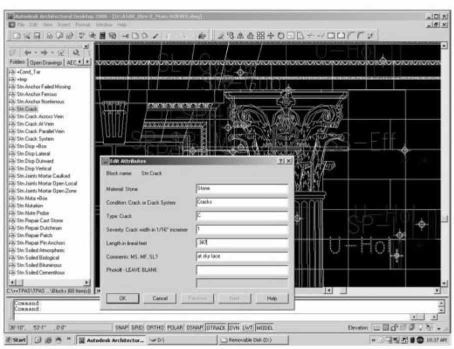


Figure 4. Screen capture from tablet software used to record existing conditions.

An extremely detailed series of condition descriptions were developed to assure adequate flexibility in characterizing field observations. The conditions were categorized into broad types and sub-types. Finally, the quantity and severity of distress conditions observed, and comments relevant to the particular condition, were recorded through the course of the survey (Figure 4).

The team gained 100% hands-on access to the facades through the use of self-propelled boom trucks, suspended swing stage scaffolds, and industrial rope access techniques. The team's access contractor operated lifts, rigged and operated swing stages, made localized repairs, and provided ground support.

4. As-found conditions

Marble architectural features including highly decorative and ornate sculpted units varied in shape and size depending on the element and its building location. For example, the majority of the load bearing column units measure up to 36 inches in diameter while flat wall panels measure between 12 to 18 inches in width, 12 to 18 inches in height, and 4 to 8 inches in thickness.

The facades include a variety of stylistically integrated architectural elements such as entablatures, balustrades, columns, window and door surrounds, and corner quoins. Many of these marble elements were significantly deteriorated; however, their condition varied depending on the configuration, exposure, and characteristics of the specific stone units at each given location.

The marble was heavily soiled throughout with localized areas of black gypsum crust deposits and visible signs of sugaring. Generally, the most serious conditions had developed at the most delicately carved (and concomitantly more fully exposed) elements, such as the Corinthian column capitals, lion head keystones, and scroll modillions. In addition, the large, rusticated quoin units located at building corners and used to set off the massive Reading Room window openings had suffered from significant localized failures.

Across the estimated 20,000 marble units used in the construction of the exterior walls of the building, approximately 7,000 individual occurrences of marble deterioration or distress were recorded in the course of the survey. Some twenty-five types of distress were identified and grouped into eight general categories. The categories of distress are noted below in Table 1 below and include cracks, spalls, erosion, displacement, surface loss, surface disintegration, unsound units, previous repairs, and deteriorated anchors.

The most prevalent type of distress observed during the survey was cracking, with 2,905 cracked units representing approximately 15 percent of the marble units on the building. The second most prevalent distress type was spalling, which numbered 1,621 or 8 percent of the marble units on the building. Other distress included surface loss, disintegration, and hollow (unsound) units of all types, with each condition represented in less than 6 percent of the marble units overall.

Table 1. Types and Distribution of Primary Marble Distress Symptoms Observed

Code / Distress Symptom		**North 42nd**	**South 40th**	**East Fifth**	**West BP**	**Set backs**	**Court yards**	**All Facades**
Appr. Quant. Marble Units		2,400	2,400	3,300	3,800	(*)	8,100	20,000
A	All Types of Anchors	27	7	45	32	6	24	**141**
		1.1%	0.3%	1.4%	0.9%	(*)	0.3%	**0.7%**
R	All Types of Prior Repairs	43	12	84	42	32	35	**248**
		1.8%	0.5%	2.5%	1.1%	(*)	0.4%	**1.2%**
D	All Types of Displacement	12	3	3	9	1	8	**36**
		0.5%	0.1%	0.1%	0.2%	(*)	0.1%	**0.2%**
C	All Types of Cracks	496	309	729	600	125	646	**2,905**
		20.7%	12.9%	22.1%	15.8%	(*)	8.0%	**14.5%**
U	All Types of Unsound Units	140	116	85	104	11	74	**530**
		5.8%	4.8%	2.6%	2.7%	(*)	0.9%	**2.7%**
SL	All Types of Surface Loss	56	123	542	241	15	53	**1,030**
		2.3%	5.1%	16.4%	6.3%	(*)	0.7%	**5.2%**
SD	All Types of Disintegration	155	58	123	129	31	223	**719**
		6.5%	2.4%	3.7%	3.4%	(*)	2.8%	**3.6%**

SP	All Types of Spalls	256	136	706	359	36	128	**1,621**
		10.7%	5.7%	21.4 %	9.5%	(*)	1.6%	**8.1%**
Total Symptoms Recorded:		**1,185**	**764**	**2,317**	**1,516**	**257**	**1,191**	**7,230**
Percent of Units with Symptoms		**49%**	**32%**	**70%**	**40%**	**(*)**	**15%**	**36%**

(*) Areas of the setbacks are included in quantities of each major building elevation.

Figures 5a and 5b. Deteriorated modillions at main cornice without drip groove (left) and sound modillions at high cornice (right) with drip groove.

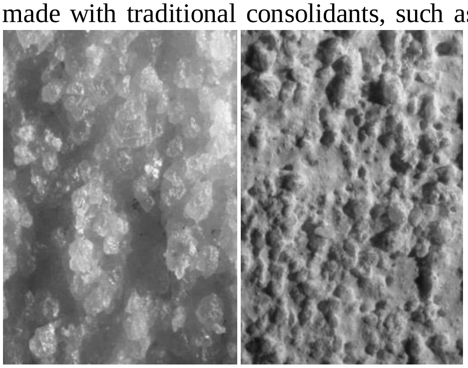
One of the more straightforward lessons learned from the library was the importance of drip edges. The high Reading Room cornice with its bold block modillions was provided with a sizable drip groove that prevented water running off the ledge above to wash back under across the modillions. The main cornice below with its decorative scroll modillions had no drip groove. There were no significant repairs required at the upper cornice – on the other hand, almost all of the scroll modillions under the main cornice required appreciable repairs (Figures 5a and 5b). A lead coated copper cornice ledge cover with a formed drip edge was specified to correct this problem for the future.

5. Selection of conservation treatments

The commercial white marble of the library was not highly metamorphosed, resulting in a heterogeneous structure wherein some areas had larger crystals and others smaller crystals. The main deterioration mechanisms were determined to include thermal cycling and acid dissolution leading to surface sugaring. Development of a conservation program to stabilize and protect these types of surfaces was of the highest priority but had to be balanced against minimum intervention principles.

As noted above, the marble of the library was found to be in a generally good state except for the more exposed and/or heavily washed elements. Preliminary tests were made with traditional consolidants, such as silicate esters. These did not perform well due to poor penetration into the sound substrate and so a more traditional approach using only inorganic materials was developed.

Spray application of an ammonium oxalate solution was found to assist in the mitigation of intensive sugaring of the marble. Localized treatments using



Figures 6a and 6b. Photomicrograph of disaggregated marble crystals before (left) and after treatment (right).

ammonium oxalate were evaluated both in the laboratory and later, through field trials on friable surfaces. To further protect the eroded surfaces, a lime based shelter coat was applied over the oxalate-protected surfaces. This method proved to be quite compatible with the marble substrate and in the end, provided a viable level of sacrificial protection to the material substrate (Figure 6a and 6b).

Three pre-blended proprietary patching materials were tested for repairs at small spalls. During field trials, a zinc oxide based composite patching mortar had the best workability and yielded the most aesthetically satisfactory results.

Figure 7. Marble dutchman patches were carved in place

Dutchman patch repairs are generally considered to be an appropriate restoration technique in the repair of distressed architectural stone work, particularly where stone elements are missing or are too severely deteriorated for other repairs to be effective. Some two thousand dutchman repairs were executed in the course of the work (Figure 7).

Dispersed hydrated lime injection mortar and hydraulic lime injection grouts were specified for crack fill repairs. Such repairs are designed to minimize water penetration into the stonework. Field and laboratory testing indicated limited depth of penetration and limited durability under freeze-thaw accelerated weathering. The DHL was specified as a sacrificial fill for non-structurally significant cracks.

Three mortar types were installed in sample trials, two lime based formulations and one portland-lime formulation similar to the original mortar. There are advantages of workability and ease of installation with lime putty and hydraulic lime mortars. The high calcium carbonate lime based mortars can provide better material compatibility with the high calcium carbonate composition of marble masonry. The hydraulic lime based mortar was ultimately selected over the lime putty mortar due to cost advantages.

Field cleaning trials were conducted to evaluate a variety of cleaning products and systems. Cleaning trials included cold water misting, hot water & steam, detergent, laser, microabrasive, and poultices. During the field trials, gentle water misting and steam cleaning in combination with detergents were found to be practical and effective at smooth wall surfaces and decorative areas subjected to gypsum crust build-ups while microabrasive techniques were needed to effectively clean more heavily eroded areas such as the corner quoins.

6. Contracted scope of treatments

The scopes of restorative work to be contracted at the New York Public Library were established based on the results of the above noted evaluations and included cleaning, systemic repairs, targeted protective surface treatments, and localized repair or replacement of deteriorated elements.

Marble cleaning included overall, specialized, and localized treatments in different combinations depending on the substrate configuration and soiling patterns observed. Cleaning systems included a system utilizing soap and cycled steam for overall baseline cleaning supplemented with cycled water misting, micro-abrasives, and poultices.

Certain ‘systemic’ repairs were implemented throughout the facade. These repairs were preventative in nature, designed to assure long-term integrity and control ongoing deterioration. Systemic repairs to the marble included repointing of masonry joints, lead weather caps at skyward-facing joints, drips and ledge flashings, and bird controls.

Localized treatments with ammonium oxalate were applied to preferentially consolidate friable surfaces in conjunction with lime-based shelter coat treatments to provide sacrificial protection to the stone surfaces. Hydrophobic and anti-microbial treatments were also applied at select areas.

Finally, many localized distress conditions such as spalls, deteriorated ornamental features, cracks, and unsound or destabilized stone units required specific, localized repairs. Repairs varied depending on the type of architectural feature.

7. Bidding

Four restoration companies were pre-qualified to bid on the project. The contract documents included bid quantities for stone repairs but not for stone treatments or cleaning procedures. The bidders were responsible for determining the surface area of treatment and cleaning processes using scaled drawings provided, and tables showing the percentages of each zone of the facade anticipated to require application of any given treatment or cleaning procedure.

Due to the large size of the facades the contract documents broke the project into three separate Phases, each with a one-year duration, commencing on the west (rear) facade and finishing on the east (front) facade. This phasing sequence was specified so that initial work was performed on the simpler, rear facades and assuring that the work at the front would benefit from the project's learning curve. Reserving the most important facade for last also allowed for a 'big finish' and reduced the likelihood that the last part of the project would be deferred or cancelled should the funding falter.

The bid form required unit prices for all repairs, treatments and cleaning procedures, allowing for equitable modifications to the contract amount to reflect actual work performed in the field. A detailed tracking and phase by phase reconciliation process based on the delineated quantities shown on the contract documents and specified reserve quantity allocations assured that the team would have the flexibility to adjust specific scopes of work as required in the field based on existing conditions and the evaluation and evolution of different repair techniques.

Despite the magnitude of the project, the complex nature of the work, and a variety of specialized treatments that were new to bidders, the four bids received were reasonably close in value with the highest bid being only 20% above the lowest bid.

8. Contractor's means and methods

Because of the constricted site that included Bryant Park and a restaurant immediately to the west, sidewalks on the north and south, and a public plaza on the east, the contractor was allowed virtually no staging areas at grade. Large protective sidewalk sheds were constructed in every phase to act as elevated staging areas and overcome this obstacle. Cable hoists from the street to the top of the sheds allowed materials to be hoisted directly from trucks up to the elevated staging area.

Modular pipe frame scaffolding was used to access the work at all locations. Prior to installation of the scaffolding, waterproofing membranes were installed on the sidewalk sheds to contain runoff from the cleaning procedures. The scaffolding system included hoist towers on all sides capable of lifting the largest replacement stones, the half-ton stones which capped the balustrades.

On the west elevation the scaffold was enclosed in a continuous substantially airtight white membrane to protect customers of the restaurant below whose business continued unabated throughout the work. On the other three facades the scaffold was enclosed in traditional debris netting.

Scaffolding was removed as each phase finished allowing the site to return to normal in sequential order. Scaffold erection and removal was generally coincided with early spring and early winter respectively.

9. Execution of the work

The stone restoration work during each phase generally followed a predetermined order. Scaffold erection was followed by a confirmatory survey by the consultants wherein exact types and quantities of localized repairs were adjusted.

Cutting & pointing of mortar joints preceded the cleaning work in order to minimize risk of water intrusion into the facades but a subsequent thirty-day cure period was then required prior to cleaning operations due to the slower strength development of the specified hydraulic lime based mortars.

Figure 8. New turned marble balusters were installed at all balconies and parapets

Localized stone repair & replacement work was then conducted (Figure 8) along with the fine arts statuary conservation & cleaning work. Stone treatments such as the Ammonium Oxalate and Lime Shelter coats were then applied and a final wash-down performed. Final inspection, cleaning and/or treatment adjustments, and installation of bird netting in selected areas wrapped up the work in any given area. Due to the size of the building many of these procedures were being performed simultaneously at various areas.

Tracking the work was critical and entailed several distinct procedures. The construction manager typically accompanied the consultant during the initial confirmatory hands-on survey and marked up the elevation drawings showing minor modifications to the location or quantity of the repair work. Upon completion of the work in any given area, the consultant performed a punch-list inspection that verified the quality, quantity and location of the work.

Reconciliation spreadsheets were then created by the construction manager, and once the spreadsheets were agreed to by all parties, the contract amount was modified up or down via change orders, typically on a phase by phase basis. Despite many individual adjustments, both up and down, the overall project was completed on schedule and on budget. Finally the contractor issued detailed CAD As-Built elevation drawings that recorded final locations and quantities of all aspects of the work.

10. Unique contractor challenges

There were a number of challenges unique to this project. Ammonium oxalate, used to consolidate building stone, had not previously been used in the United States. The contractor had to arrange for importing large quantities of the material from Europe. There were no U.S. material safety data sheets or product data sheets. U.S. Customs required extensive information regarding the make-up and use of the material. Coverage rates for the material were unknown, and required broad assumptions during bidding.

The subcontractor used for laser cleaning was from Europe and brought crews over specifically for this project. Administrative issues such as insurance, workmen's compensation and contracts were difficult to sort out and required months of preparation before work could start.

Stone veining in the new replacement stones, while acceptable in ashlar units, became very prominent, and usually unsightly in the turned balusters. Unfortunately this was not detected during the submittal phase because the full size baluster samples submitted coincidentally did not have veins. This issue required replacement of many brand new balusters prior to installation.

Craftsmen capable of carving the detailed ornament found on the library's facades are not plentiful. The subcontractor performing the stone carving of the dutchmen started with three carvers and was only able to increase throughout the project to a maximum of six. Although they did an admirable job of keeping up with the schedule, falling behind on that portion of the work was a constant threat throughout the project.

11. Conclusions

The New York Public Library is considered a significant example of the Beaux-Arts style and the most important work of the firm of Carrère and Hastings. The New York City Landmark designation report notes:

Figure 9. Detail of completed front facade

"*This majestic marble building ... is a magnificent civic monument and fully justifies the pride of its generation and of ours. It sits regally enthroned on a terraced plateau, displaying urns, fountains, flagpoles, sculpture and ornament. Replete with sparkle and delicacy, it is by night or day a joyous creation.*" (Landmarks Preservation Commission, Designation Report 1967).

The restoration of this acclaimed building was executed with the highest quality and minimal compromise. The work sought a judicious balance of cleanliness with preservation of valuable historic fabric and patina. Thousands of instances of deterioration were recorded during the initial survey. These 'as-found' conditions were subjected to laboratory evaluation and field-testing of alternative conservation methodologies to establish the most appropriate and least invasive treatments.

Then, during the three-year construction period, members of the preservation team made repair and treatment decisions on a stone by stone basis ranging from crack fills to more than 2,000 carved dutchman patches (Figure 9). This was truly a career topping project for all parties involved.

References

City of New York, Department of Parks. Boroughs of Manhattan and Richmond. Contract and Specifications, New York Public Library.

New York City Landmarks Preservation Commission, Designation Report, January 11, 1967. www.nypl.org

Photographs are in the collection of the New York Public Library, Building Archive.