2015

Cataloging Built Heritage: Methods of Recording Unit Masonry for the Future of Historic Preservation

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Cataloging Built Heritage: Methods of Recording Unit Masonry for the Future of Historic Preservation

Abstract
There is a discrepancy between standardized and infield practices for documenting historic structures—from the surveyor’s intention of interpretation to how the project team chooses to adapt alongside a constantly evolving technology-dependent environment. A successful restoration project relies on comprehensive documentation and active communication among the entire project team including conservator, architect, engineer, contractor, (AEC), and client. If there is instability in creating a common language and method of disseminating information across these parties, the project suffers.

The published literature on documentation techniques does not fully represent the work of practitioners on projects, specifically for unit masonry restoration. Recording a historic site is not static over time and should incorporate annotations of change. The standards in recording are not always suitable for the restoration contract and the project team is pressed to create their own standard of documentation. These proactive teams are turning to the advances in technology and digital collaboration (through tablets, mobile devices, databases, and scanners) to track the progress of each individual masonry unit from dismantlement to reinstallation, archive ongoing changes to conditions and site logistics, and reduce lag times in communication and review between project members.

Should the restoration field choose to act now, they can have a voice in this technological transformation for recording historic sites. The ability to communicate within a unified platform for documenting and monitoring a restoration project from conditions survey through to cleaning and repairs and finally to project closeout will enrich the dialogue between the construction and conservation industries and ultimately save more cultural heritage sites.

Keywords
database, barcode, QR code, building information modeling, BIM

Disciplines
Architectural Technology | Communication Technology and New Media | Historic Preservation and Conservation

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CATALOGING BUILT HERITAGE: METHODS OF RECORDING UNIT MASONRY FOR THE FUTURE OF HISTORIC PRESERVATION

Lauren Rachel Shaughnessy

A THESIS

in

Historic Preservation

Presented to the Faculties of the University of Pennsylvania in Partial Fulfillment of the Requirements of the Degree of

MASTER OF SCIENCE IN HISTORIC PRESERVATION

2015

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Dedicated to my inspiring parents
and gelato-loving friends
ACKNOWLEDGMENTS

An abundance of gratitude to my advisor Roy Ingraffia for guiding me during the creation of this thesis and instilling a captivating enthusiasm for masonry from Praxis, lectures, and beyond.

Thank you to my program chair and academic advisor Randy Mason for always greeting students with an open door and open mind.

Thank you to the faculty of PennDesign’s Historic Preservation, Amanda Bloomfield and Suzanne Hyndman, for the countless laughs and Twizzlers.

This thesis would not be possible without the wealth of knowledge and experiences shared by the restoration industry correspondents consulted. Thank you sincerely for opening up your world and bringing practice into this discussion.

Kathryn Brown  Dan Lepore and Sons Company
Anthony Lepore  Dan Lepore and Sons Company
Robert Watt  RJW-Gem Campbell Stonemasons Inc.
Christy Lombardo  Integrated Conservation Resources, Inc.

Building Conservation Associates, Inc.
Constance Lai  Grunley Construction Co., Inc.
Mitchell Bring  Boston Valley Terra Cotta
Jeff Smith  Seaboard Weatherproofing & Restoration
Dan Jones  Seaboard Weatherproofing & Restoration
David Biggs  Biggs Consulting Engineering, Building Information Modeling for Masonry (BIM-M)

Lastly, thank you to my parents for their unwavering love and support in every aspect of my life. Thank you to my friends and family, from back home to the river to this memorable Penn 2015 class. Without your encouragement, sass, and generous hearts, I would not be where I am today.
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dedication</td>
</tr>
<tr>
<td>Acknowledgments</td>
</tr>
<tr>
<td>Table of Contents</td>
</tr>
<tr>
<td>List of Figures</td>
</tr>
<tr>
<td>Introduction</td>
</tr>
<tr>
<td>Current Stance of Data Collection and Processes in Restoration</td>
</tr>
<tr>
<td>Documentation Systems Relevant to Unit Masonry</td>
</tr>
<tr>
<td>Barcoding/QR Coding</td>
</tr>
<tr>
<td>Building Information Modeling (BIM)</td>
</tr>
<tr>
<td>Conclusion</td>
</tr>
<tr>
<td>Bibliography</td>
</tr>
<tr>
<td>Definitions</td>
</tr>
<tr>
<td>Case Studies – Project Teams</td>
</tr>
<tr>
<td>Index</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

Figure 1 | Renwick Smallpox Hospital 17
Figure 2 | Renwick site before biogrowth removal and stone survey 18
Figure 3 | Support ties for warped masonry wall 19
Figure 4 | Aerial view of warped elevation to be dismantled 19
Figure 5 | Renwick elevation with labeled stones 20
Figure 6 | Renwick detail of alphanumerical labeled stones 21
Figure 7 | Stone units to be dismantled are outlined in blue chalk after their label is applied 22
Figure 8 | Crane lowering individual stone at Renwick 24
Figure 9 | Palletized stone – Pallet A 24
Figure 10 | Stacks of unit pallets 25
Figure 11 | Palletized stone remaining on site 25
Figure 12 | West Block of Parliament Hill 26
Figure 13 | Heavily soiled and cracked stone units at West Block 27
Figure 14 | RJW-Gem Campbell’s alphanumerical stone tags 28
Figure 15 | Trinity Church 30
Figure 16 | ICC tracks its cleaning progress on the south elevation 32
Figure 17 | Screenshot of Bluebeam application 34
Figure 18 | Sample Barcode 38
Figure 19 | Sample QR Code 39
Figure 20 | Boston Valley Terra Cotta

Figure 21 | Labeled sample from the Strand Hotel in BVTC

Drafting Room

Figure 22 | Shop binder of barcodes for individual terra cotta units

Figure 23 | Barcode label and imprinted terra cotta

Figure 24 | Architectural drawing with each stone unit called out

Figure 25 | Once completed, units are highlighted in the work area

Figure 26 | Woolworth Building

Figure 27 | FacadeMD has conducted conditions surveys on Woolworth since 1987

Figure 28 | Cisco access points

Figure 29 | Stone D-22-1 and QR Code

Figure 30 | Stacks of QR coded stone for Woolworth

Figure 31 | iPhone scanning Stone BB-18-4

Figure 32 | Longwood Gardens

Figure 33 | Deterioration along fountain wall

Figure 34 | Deterioration along fountain wall

Figure 35 | Deterioration along fountain wall

Figure 36 | Photo documentation of UC-O.1 A, B before removal

Figure 37 | Step 1: Original UC-O.1 A,B Drawing

Figure 38 | Step 2: Lepore On Site Review UC-O.1 A,B Drawing

Figure 39 | Step 3: Lepore Edits UC-O.1 A,B Drawing

Figure 40 | Step 4: Architect & Lepore Edits UC-O.1 A,B Drawings
Figure 41 | Step 5: Final UC-O.1 A,B Approved Drawing 60
Figure 42 | Shop at Dan Lepore and Sons Company 62
Figure 43 | Stone PLV-NW-3 labeled with paint pen 63
Figure 44 | Non-corrosive tag 63
Figure 45 | QR label and mobile app from TimeStation 64
Figure 46 | Labeled crate with QR, repair checklist, and conditions survey 65
Figure 47 | Example of geotagged tracking for crated units 68
Figure 48 | Screenshot of unit-by-unit process tracking in Excel 69
Figure 49 | Phases of BIM-M 78
Figure 50 | Advantages and Disadvantages to BIM in Historic Preservation 79
INTRODUCTION

There is a discrepancy between standardized and infield practices for documenting historic structures. The gap within is not limited to the restoration field. The true challenge involves the communication within the construction industry among the architect, engineer, contractor (AEC), client, and consultants. If there is instability in creating a common language and method of disseminating information among new construction, the scenario becomes even more trying when an additional party, such as an architectural conservator, is brought on board.

This thesis aims to investigate the field practices currently in place for documenting restoration projects, specifically unit masonry, with a look to how digitally cataloging units might play in the future of restoration recording. Unit masonry has been selected as the focus of this thesis because many unit masonry projects have a common thread. A single unit possesses a collection of measurable properties related to its condition, repairs, and status of completion. Each of these characteristics is categorical with a conventional unit of measurement. They can be expanded to sets of masonry units or entire elevations and quantified for all project team members. There is no need for a set standard in the field, as each project will differ in scope, scale, professionals, schedule, budget, and contract goals but it is important to acknowledge why documenting unit masonry is particularly important. A number of historic buildings lack a detailed archival record of repairs and restoration work in a single format or location, if at any records were made at all. Later restoration campaigns would greatly benefit from having access to these reports in mapping patterns of deterioration over time and gaining a better understanding of how the structure functions in general.
Question

Is there a discrepancy in the field recording methods of historic structures?

What factors determine when a specific method is employed?

Who gets to make this decision?

What role does documentation play in the perspective of an architect vs. conservator vs. contractor?

How can the documentation system be reworked to better understand and monitor large-scale masonry restoration projects?

What methods work best in practice?

How might the project team adapt alongside a constantly evolving technology-dependent environment?

Is it advisable or even possible to create a standard across all project team members?

Hypothesis

There is an unavoidable inconsistency in recording methods of historic structures, not just from academic to practice, but also from site to site based on the projects team, funding, resource availability, and exchange of knowledge. The published literature on documentation techniques does not fully represent the work of practitioners on unit masonry restoration projects. This appears to be influenced by the misconception that those who write do not practice, and those who practice do not write—neither learning from one another the real trials and tribulations of putting the recording method into
action. In order to bridge the research and infield roles of the conservator, there must be open dialogue between the two sides as well as active engagement in documentation and communication with the rest of the AEC industry. The documentation system can be reworked to understand the historic fabric in a more efficient, collaborative, and ultimately sustainable process.

Limitations

The analysis of recording practices has a greater impact with first-hand experience in the methods surveyed and will therefore rely on the evaluation from a selected pool of architects, conservators, and contractors involved in each case study.

Justification

Proper documentation serves as a multidimensional specification in the preservation of historic structures. While this thesis focuses on the mechanisms recording serves on exclusively masonry restoration projects, the study may be applicable to a broader range of conservation projects. It proves to be a useful portrayal of current documentation standards and how conservators can better utilize technology to promote valuable and cost and time-sensitive dialogue between the construction and conservation industries.
Background

Preservation depends on the comprehensive documentation of historic sites. With the threat of these structures and landscapes disappearing faster than they can be documented, conservators must look to quick and responsive methods of organization heritage data. “Documentation is the thread that runs though the entire process of cultural heritage conservation.”¹ There are persistent efforts to generate standards among recording methods, with the help of Historic American Buildings Survey (HABS), Historic American Engineering Record (HAER), Historic American Landscapes Survey (HALS), and English Heritage publication. These standards generally relate to means of capturing the information from a building with the proper formatting and graphic criterion. However, there are still mistakes and miscommunications that occur among details. For example, something as simple as the date on a drawing has no international standard of month/day/year versus day/month/year.² Since the HABS standards for documentation written in the 1930s, there have been minimal updates. But recording a historic site is not static over time.

Recorders cannot ignore the impact of time on a structure, whether surveying current conditions or tracking the status of a masonry unit throughout a project. The standards in recording for a Historic Structures Report (HSR) are not always suitable for the restoration contract and the project team is pressed to create their own standard of documentation. These proactive teams are turning to the advances in technology and


digital collaboration (through tablets, mobile devices, and scanners) to archive ongoing changes and reduce lag time in communication between project members.

Documenting a heritage site is a two-part process at its core: collection and interpretation. The first step must capture the information of the structure as defined by the survey goals. For a restoration project, this traditionally means gathering data related to physical characteristics, conditions and evidence of repairs. The recording approach can be limited by the project’s contractual schedule, available finances, and trained personnel. The surveyor’s perspective defines the annotated architectural drawings which must then be translated to all project members. An architect reads a building differently than a contractor would, as does an architectural conservator in comparison the project owner (see Project Teams, pg 9). Yet, there has to be a collaborative approach to restoring the structure with a cohesive understanding of the site’s logistics.

The initial condition surveys are meant to move fast in listing the amount of work expected so that it can be sent out for bid. The second step of documentation refers to how the information is received, by means of organizing, interpreting, and managing the data. The ultimate goal is to implement a system that serves the purpose and level of detail of the contract. What makes an information system effective, whether the system is complex or simple, manual or computerized (or some termination of the two), demands accuracy, reliability, efficiency, security, and cost-effective. It should improve the quality of work that is accomplished and increase productivity by allowing more work to be completed in less time.

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This thesis study begins with an overview of contemporary methods for recording historic properties as a means to better understand and document structural conditions. The analysis surveys large-scale masonry restoration projects only as they generate information that is easier to categorize and monitor by unit catalogs. The investigation continues to weigh the benefits and costs of methods used by AEC and conservator recorders, from past projects to their current practices that demand more of a technology presence.

The first focus calls on documentation systems where stones are individually numbered and later translated into a queried database in Microsoft Excel. Sometimes this is not enough and a more advanced method of tracking must be introduced with as bar QR coding. For each system, three case studies of completed or ongoing masonry restoration jobs are featured, complemented by first-hand perspectives of the architects, conservators, and stonemasons who worked onsite. Lastly, conservators are at a crossroads where they can choose to continue using the pen-to-paper or learn from the technology pushes in the new construction field. New construction’s use of 3-D Building Information Modeling (BIM) is becoming more and more of a standard practice and is on the move to further update specific building materials, like masonry units. Should restoration choose to act now, they can have a voice in this technological transformation for historic site projects.
Methodology

Part 1:

Gather Initial List of Contemporary Documentation Methods

- Review published literature for recording tools in restoration
- Survey local architects and contractors involved in restoration
- Begin comparison of how these documentation methods are introduced and received in practice
- Overview research on what technological advances have prompted these changes

Case Studies

- Understand brief history and significance of documentation on each site
- Contact architect/contractor involved for their review of their recording method of choice

Part 2:

Evaluate Documentation Methods of Historic Structures

- Define what makes documentation successful
  - Different meanings to architect, conservator, contractor, owner
- Find which recording methods specifically relate to unit masonry
- Relate to basis of knowledge and experience among today’s recorders
- Research proposed technology-reliant documentation methods
Case Studies

- In-depth research of each method used
- Site visits, where appropriate
- Follow-up interviews with architect/conservator/contractor
- Analysis of where and how these methods succeeded or failed

Part 3:

Now What?

- Suggest how to incorporate and adopt method into common practice
- Address where does BIM come into the conservation field
- Future thesis questions
CURRENT STANCE OF DATA COLLECTION AND PROCESSES IN RESTORATION

The fundamental analysis of the problems that deficient documentation can generate must first begin with an overview of the methods employed in practice. While published summaries of potential documentation methods exist, the thesis attempted to combine and analyze the comparison between academic publication and reviews of infield practice on restoration jobsites.

The initial research laid a basis for the technicalities and explained the process of each method. By visiting each recording method individually, their advantages and disadvantages are weighed in attempt to define their practicality to the field of conservation.

Roles within the Project Team

Defining the role of each participant on a given project is key as each may have a different approach to contract goals and priority of work or documentation.

Owner: The ultimate client and party responsible for the maintenance of the structure after restoration work is complete. Typically interested in only the big picture of documentation, or legal and financial requirements.

Architect: The designer who also advises during the construction phase. Depending on the intent of the architect, documentation may be catered to serve more aesthetic needs. A restoration project that enlists an architect
with familiarity of conservation terms is an important first step in trying to establish a common language.

**Conservator:** The technical consultant responsible for the conditions analysis, repair and restoration of the architectural piece. Their report is preservation-focused and usually the most detailed. Level of detail of documentation can range from elevation to unit-by-unit depending on the intended interpretation.

**General Contractor:** The manager responsible for overall coordination of a project. Recording is more broad and collective, largely tied to site logistics, budget, schedule, and legal documentation.

**Masonry Contractor:** The masonry (stone, brick, terra cotta, concrete) builder. They can also be the masonry supplier, if not reliant on an outside fabricator. Documentation usually summarizes project tasks completed (ie. pin, patch, reinforced tie, replacement, etc.), rather than conditions. Their report informs the project bid and budget closeout. A Masonry Restoration Contactor will know more about conservation treatments appropriate for specific masonry conditions.

Prior to recording for historic sites, the surveyor should be fully familiar with the scope and limitations of the contractual work and the recording approaches available. Unfortunately this is often where the gap in documentation for conservation projects originates. The specification can leave major survey decisions up to the contractor and b detrimental to the aims of a conservator if the quality of recording is inadequate. In
practice, a specification will be method-based or performance-based\textsuperscript{4} but should ideally address both purposes.

An approach to recording a historic site may fall into one of two main categories: direct or indirect.\textsuperscript{5} A direct survey has a predicated domain of study and minimizes post-capture processing. These methods include measured drawings and the use of total stations or global positioning systems. An indirect survey requires processing after on-site capture but allows for a greater density of data interpretation. Common indirect recoding methods are rectified photography, photogrammetry, and laser scanning.

\textit{Direct Surveying}

Direct methods are easily accessible but are harshly defined by its chosen data set. The scope of the information generated must be decided before the method is carried out and remains centralized throughout its production. The method is only as effective as its contractual specification and the experience of the surveyor allows.

\textit{Indirect Surveying}

Indirect methods map large sets of data that can be later interpreted for a variety of objectives. This versatility, while efficient in cataloging a massive amount of building


information, usually leads to increased costs or frustration in application if the project specification for recording is not direct.

Rectified photography is a simple survey that can be used to convey scale and detail of an elevation, producing a content-rich 2-D image. A photo is taken with a quality camera and then corrected to match predetermined measurements or grid patterns. The grid is recreated in AutoCAD and placed on top of the photo that is then rectified to fit the control points. This typically includes adjusting for perspective, scale and position of the image. Rectified photography is an approach conservators can easily use because of its quick and low-cost application. The surveyor needs only two basic tools: a camera and the rectification software. The accuracy of the shot can be enhanced with the use of a tripod and level. The image can be manipulated with various software programs in the Adobe Creative Suite or CAD. Some CAD and Geographical Information System (GIS) packages may offer basic rectification routines or plug-ins but come with additional expertise and financial costs. Because of distortions that can occur with uneven wall surfaces, rectified photography is recommended for use on flat façades. Its graphic legibility makes it an excellent selection for visual mapping of existing conditions across a building elevation.

Photogrammetry is more involved than rectified photography and will work to render a 3-D final product. Initial measuring is carried out with plastic targets to demark the major dimensions or grid. Two pictures taken from slightly different positions are compiled together, where their overlap represents the frame of the final product. An operator then produces a line drawing by tracing the details of the photo. The process of

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6 Ibid, 12.
photogrammetry has seen great strides with technological advances that have transferred the tracing process from heavy, complicated machinery to PC-based digital systems. While this has contributed to its argument for most economical and accurate survey method, cost and specialized training has limited its widespread adoption in the heritage sector. Orthophotography also requires two superimposed photos similar to photogrammetry. Once the final photo is corrected for errors of camera tilt and scale, it can be draped over a Digital Terrain Model (DTM) to produce topographic maps and 3-D elevations.

_Prospective Documentation_

The review in preparation of this thesis also relied on in-field accounts. Speaking with multiple parties involved in a restoration project shed light on what each defines as successful documentation. The most frequent challenge mentioned was rapid functionality among the conservator, contractor, architect, and owner alike. The conservator is trained to pinpoint restoration details and it can be difficult to downsize the amount of building information into priorities that do not overwhelm a technical drawing or photograph. The contractor is fast-paced and cost-driven to move forward with the project. When a more intensive investigation of conditions and potential preservation techniques is required, a conservator is brought to the table. The architect typically establishes the regulation of the recording method and therefore has a great influence on its tactic. In the end, documentation of substance must be created for the client. This can

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7 Ibid, 14.
be very different from the end products of the previous parties and instead is geared towards maintenance and archival purposes. Looking at prospective documentation, the conservation field must decide how it can utilize digital recording in a sustainable archived manner that is still accessible should the modern trend of technology change.
DOCUMENTATION SYSTEMS RELEVANT TO UNIT MASONRY

Documentation on any scale must adequately meet the goals of the given project. A restoration contract can range from quick-response preliminary conditions mapping to more meticulous stone-by-stone indexing. The most basic method of recording restoration work for unit masonry may include marking up drawings to map or number conditions by hand until digital versions are created. The following case studies examine how the project teams select and implement a system(s) of recording to best serve the project.

Case Study 1 | Renwick Smallpox Hospital
Photograph Numbered Stone

Case Study 2 | Parliament Hill
Catalog Numbered Stone

Case Study 3 | Trinity Church
Conditions Markup and Query

Case Study 1, Renwick Smallpox Hospital (see Figure 1), visited the emergency response to a site of threatened ruins completed in 2008. The contract was simplistic in demands, neither providing nor requiring any architectural drawings to be produced by the masonry contractor. This project was chosen to show how even at a small and fast-paced scale, some sort of organization was applied to monitoring masonry dismantlement and reinstallation and can rely on a tool as basic as an image.

The massive project at Canada’s Parliament Hill (see Figure 12) was selected for Case Study 2 as it related to the stonemason’s cataloged management of individual units. For the purposes of this thesis, this case represented a less tech-heavy approach with hand-written tags and manually input of each unit’s alphanumeric code into a database as
record of masonry conditions before, during, and after work. The contract for the West Block began in 2012 and is currently ongoing.

Case Study 3 at Trinity Church Wall Street in New York (see Figure 15) was another project that is still underway. The documentation processes for masonry restoration at Trinity had to serve two conservation consultants simultaneously and therefore relied on a more advanced method for communication across architectural drawings and conditions records. The project was chosen for study as the joint team implemented one of the more common software uses in the construction field with onsite iPad notation in Bluebeam, a real-time update program on stored digitally.
CASE STUDY

Nestled in the middle of East River in New York City, Roosevelt Island is home to institutional structures associated with their dark history and neglect. In the 19th and 20th centuries, the island was dotted with hospitals, an asylum, and a penitentiary that made sure to keep visitors at a minimum. As the structures began to fade away and relocate, the island became a source for affordable housing in the 1960s and 70s. Renwick Smallpox Hospital sits at the southern tip of the island, neighboring Louis Kahn’s Franklin D. Roosevelt Four Freedoms Park and the sprawling development endeavor on the north side today.

By the 1950s, the hospital was abandoned and in 1976, the New York City Landmarks Preservation Commission (NYCLPC) named it the only ruin landmark in the city. More recently, NYCLPC added the endangered site to the 2012-2013 Seven to Save list. While it was among the most historically and architecturally significant sites, regrettably it was also in the worst state. In 2007, the future of the ruins was in jeopardy when a portion of the north wall collapsed and an emergency request for action prompted the draft of a stabilization plan. The plan listed existing conditions provided by an engineer and would rely on a masonry contractor to dismantle and reassemble the warped and unstable elevations (see Figure 3 and 4).

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8 Preservation League of New York State, Seven to Save – 2012-13, (23 April 2012).
The existing conditions list is as follows:  

- Partial collapse of crenellations and walls
- Delamination of stone veneers from deteriorated brick back-up
- Walls out of plumb
- Dislocated stone lintels at window and door openings
- Collapse of interior brick walls, rubble piles leaning on walls

Figure 2 | Renwick site before biogrowth removal and stone survey  
Dan Lepore and Sons Company, 2008

9 Columbia University, GSAPP. *New Life Within the Ruins*, (2013).
Figure 3 | Support ties for warped masonry wall
Dan Lepore and Sons Company, 2008

Figure 4 | Aerial view of warped elevation to be dismantled
Dan Lepore and Sons Company, 2008
The stabilization work was awarded to masonry subcontractor, Dan Lepore and Sons Company (hereafter referred to as Lepore). Because of the scope and scale of the project, Lepore did not require intensive documentation records. The design-build project did not provide any bid drawings or specification documents throughout the work nor did it require final as-built drawing sets. Instead any documentation records were based off photographs. Lepore developed a simple numbering system to keep track of stones that would be removed, repaired, and reinstalled. These stones scheduled for dismantling were alphanumerically labeled on site with waterproof paper before the each elevation was photographed (see Figure 5-7).

Figure 5 | Renwick elevation with labeled stones
Dan Lepore and Sons Company, 2008

10 Interview with Kathryn Brown from Dan Lepore and Sons Company, (15 January 2015 and 15 April 2015).
Stone Numbering Key:  

<table>
<thead>
<tr>
<th>Stone Numbering</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Crenellation</td>
</tr>
<tr>
<td>B</td>
<td>Bracket Stone</td>
</tr>
<tr>
<td>BR</td>
<td>Bracket Return</td>
</tr>
<tr>
<td>SE</td>
<td>South East</td>
</tr>
<tr>
<td>SER</td>
<td>South East Return</td>
</tr>
<tr>
<td>HL</td>
<td>Left Window Header</td>
</tr>
<tr>
<td>HR</td>
<td>Right Window Header</td>
</tr>
<tr>
<td>CR</td>
<td>Crenellation Return</td>
</tr>
<tr>
<td>SEA</td>
<td>South East Parapet Course A</td>
</tr>
<tr>
<td>SEB</td>
<td>South East Parapet Course B</td>
</tr>
<tr>
<td>SELC</td>
<td>South East Left Corner</td>
</tr>
<tr>
<td>SERC</td>
<td>South East Right Corner</td>
</tr>
</tbody>
</table>

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Since all dismantled stone stayed on site, no exhaustive tracking method was needed to track the stones’ location and progress. Once the units were taken down, the same alpha-number was spray painted on the side of the stone and then palletized with stones of similar location (see Figure 9). This method of marking ensured the numbers would not rub off or be visible once reinstalled. When it came time to reassemble the elevation, the plan was very straightforward. Each stone was fit back into its respective spot after cross-referencing the earlier photographs of the numbered stones.

The stone palleting procedure was as follows:

1. Stone will be brushed off and tagged.
2. Soft material (Homosote) will be on pallet.
3. Stone will be set on pallet.
4. Soft material between stones.
5. Wood spacing between stones.
6. Pallet will be shrink wrapped.
7. Pallet will be banded.
8. Pallet will be numbered.
9. Pallets and contents to be logged.

**Disadvantages**

Neither a database nor any drawings currently exist for documenting this restoration project and all records rely on a large set of photographs. Any communication about a particular stone unit would call out its location and tag, but the project team members would have to consult the series of images when necessary for visual reference.

**Advantages**

This method served the project’s goals with rapid dissemination of recording each stone unit so the structure could be stabilized. It was a fairly small-scale project with a manageable number of stones to track. The images were extremely useful with onsite masons who could consult the expanded picture collage when reinstalling the units. There was no additional training necessary for this documentation and therefore no time taken away from active restoration work that might have been spent on transcribing architectural drawings.
Figure 8 | Crane lowering individual stone at Renwick
Dan Lepore and Sons Company, 2008

Figure 9 | Palletized stone – Pallet A
Dan Lepore and Sons Company, 2008
Figure 10 | Stacks of unit pallets
Augustin Pasquet, 2008

Figure 11 | Palletized stone remaining on site
Dan Lepore and Sons Company, 2008
CASE STUDY

Ontario’s Parliament Hill is currently undergoing a major renovation of the interior and exterior of its parliamentary historic buildings. When completed, it will be the biggest project of its kind in Canadian history and the largest contract in North America, employing a “small army of masons, carvers, technicians, and laborers.”

“The initial estimate alone called for $5 billion in restoration work over 25 years” for the entire Parliament contract, with the West Block budget already over projection and behind schedule. Sparked by the 2002 restoration of the Library of Parliament, the Public Works and Government Services Canada (PWGSC) is turning its focus to the core structures—the West Block, Centre Block, and East Block. Each Block is set to undergo structural adaptation to match up to current building

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standards and exterior masonry restoration including cleaning, repairs, repointing, and replacement where needed.\textsuperscript{15}

Nailing down logistics is mandatory for handling schedule and budget fluctuations on currently the world’s largest stone masonry restoration project. Which is even more reason why the team is stressing organization and efficiency through this restoration.

\textit{Figure 13} | Heavily soiled and cracked stone units at West Block
Korky Koroluk, 2007

\textsuperscript{15} Conservation Solutions, "Heritage CSI Lead Conservator For Canadian Parliament Building," Conservation Solutions, Inc. (29 November 2012).
West Block masonry restoration is being done by RJW-Gem Campbell Stonemasons Inc.\textsuperscript{16} Following a prolonged standstill after a conditions survey completed in 1994, the conservation and design consultants on the West Block first collaborated to create a more recent study with detailed heritage photogrammetry. All stone units are inspected, numbered, photographed, and high-resolution images imported into AutoCAD and matched to a gridded surface elevation. Each portion of the grid measured approximately 7’0” x 3’6”-4’0”. The recorder numbers the grid square in addition to the numbering of each stone within that square. This is then compiled into drawings. There are annotations on the drawings that indicate stone by stone, mortar joint by mortar joint, the status of repointing, repairs, or replacement.

\textbf{Figure 14} | RJW-Gem Campbell’s alphanumeric stone tags
Korky Koroluk, 2007

\textsuperscript{16} Phone Interview with Robert Watt from RJW-Gem Campbell Stonemasons Inc., (10 February 2015).
Together the conservator, the stone mason, and the architect agree on the state of each individual stone—“establishing the extent of dismantling and rebuilding of deteriorated areas of masonry when required, defining repairs and/or replacement of the Nepean stone ashlar and Berea stone quoins, as well as the decorative façade elements, cleaning, and repointing.”¹⁷ The record is meant to track masonry conditions before, during, and after work. All project members have access to the Excel database through the cloud system. Every mason foreman has an iPad onsite while on the scaffolding where they can quickly bring up the stone’s tag and confirm its approval status immediately. The path flows from mason, to conservator, to architect, to general contractor, and finally directly itemized for final billing.

**Disadvantages**

The tags for each unit must be manually typed into the database each time, whether it is for initial input or when searching for a particular stone number.

**Advantages**

This database method gives easy access to all parties involved with real-time updates on the status of masonry restoration unit-by-unit. It does not require additional apps on mobile devices and still fosters prompt feedback from the entire project team.

¹⁷ Conservation Solutions, Inc, "Project Overview – West Block Masonry Conservation."
CASE STUDY

The restoration of Trinity Church in downtown Manhattan called for a survey in 2011 to analyze the current condition of the church and develop a master plan as a whole. The work is still underway today. Rather than numbering individual stones, the preliminary survey and management of conservation tasks would query conditions and repairs.

Trinity Church has enlisted the team of ICR and ICC (Integrated Conservation Resources and Integrated Conservation Contracting), two sister companies providing complementary services dedicated to the conservation and restoration of historic sites.\(^{18}\) The conservation plan of Trinity is devised into two major jobs—the first for the tower and spire and the second for the main body of the church.

The first round is a design-build project in need of a sophisticated method to itemize conditions onsite that is translatable to the entire project team. The upper tower and spire includes hundreds of treatment areas\(^{19}\) to be recorded. After the conservator and the contractor agree upon the scope of work, ICR/ICC continues to annotate architectural


\(^{19}\) Christy Lombardo, “An Approach To Architectural Conservation And Stabilization Of Trinity Church Tower And Spire, New York, NY”, (15 October 2013), Presentation at Association of Preservation Technology Annual Conference – Preserving the Metropolis.
drawings using a program called GoodReader. Previously, ICR/ICC had used only paper markups—as did most every onsite conservator, contractor, and architect. But as time and technology have progressed, paired with the urgency for automatic updates on sitework, project teams are looking for innovative devices to capture rapid and communicative recording. For the past three years, the ICR/ICC partnership has had a successful trial with the GoodReader application and other mobile access plugs like PDF Editor and iAnnotate. The inexpensive GoodReader app\(^{20}\) is made for viewing PDFs on an iPad, iPhone, and iPod Touch, bringing onsite drawing markups to mobile devices. Other mobile sharing sites can lag with large sets of drawings, slowing updates or even corrupting files but GoodReader holds the reputation of having the capacity to handle massive PDFs and renderings of 100 MB while still operating at good speed. In addition to mobile access to project files, the app gives the user the option to mark-up a PDF using textboxes, highlights, popup comments, lines, arrows, and freehand drawings that overlay the file. Once changes are made, the PDF is auto-synced to an online cloud—Dropbox, Box, WebDAV, ShareFile, Studio Projects, iTunes—or the company’s remote server. From the iPad, the file can be sent to other parties immediately without interruption.

ICR/ICC uses GoodReader to map intended repairs on the building exterior (see Figure 16) and assign the repairs a number that could be input a Microsoft Excel spreadsheet. The data for each entry includes start date, finish date, whether the repair has been reviewed and approved, and any additional notes.

In 2012, ICR/ICC was contracted to collaborate with another conservation firm, Building Conservation Associates, Inc. (BCA), on the second phase of Trinity Church’s restoration. This collaboration requires a system that can facilitate this joint recording effort. BCA proposed Bluebeam Revu\textsuperscript{21}, a program that holds Microsoft Office documents, AutoCAD drawings, and PDFs to similar readability and markup options as GoodReader (see Figure 17). The desktop\textsuperscript{22} and mobile application\textsuperscript{23} accepts 2-D and 3-D

\textsuperscript{21} Features of Bluebeam software summarized from author’s interpretation of the product website and contractors’ experiences with the program. http://www.bluebeam.com/


PDFs alike with no limit to the number of uploaded files or different job sites. Bluebeam Revu Standard is compatible with Microsoft Office files and PDFs while Revu CAD is needed to additionally work with creating PDF files from AutoCAD, Revit, Navisworks Manage, Navisworks Simulate, Sketchup Pro and SolidWorks. Bluebeam files can be edited on a Windows desktop as well as a mobile device—in this case, the conservators’ iPads. Multiple participants can be logged onto the same file, chat, follow another attendee’s view, and all edit notes in the same session. The owner can set permissions regarding which members can markup, save, and print, documents.

The application is designed with an elaborate toolset for marking up PDFs, including industry-standard symbols alongside user-customizable options. This presents the opportunity to import or define set default patches and color-coding that represent specific restoration conditions and repairs suggested. The custom toolset tailored for Trinity Church is saved for easy reuse so the onsite project team members are able to work directly from the primary survey documents created in Bluebeam. This way there is no overlap or miscommunication of individuals using conflicting classifications.

Some markup tools have a measuring capacity that the user can apply to verify length, area, perimeter, radius, and volume from a 2-D drawing. Pulling the extents on a patch reveals a 2-D estimate for quantifying area of a condition or repair. When this data is extracted into the spreadsheet, ICR/ICC can choose to apply multipliers that will be used to approximate the square footage of work, financial cost, and the duration of the task. The app additionally allows the user to embed photographs or videos directly onto the PDF pages and open them as a pop-up. The multimedia attachments can be taken from

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24 Preliminary survey documents created by BCA.
items stored in the Bluebeam project folder or those taken with the iPad Camera while on site. The team uses this feature to link photos of a stone piece before and after repair to its exact location on the drawing of the building façade. With each location tagged, ICR/ICC and BCA can extract annotations as an Excel spreadsheet with similar categories for inspection and approval as done with GoodReader. The name of the user who opens the file is recorded along with a list of their edits done during their session. Quality assurance of Bluebeam implementation extends in the archival mode as the user cannot exit out of the file before saving.

Figure 17 | Screenshot of Bluebeam application
Bluebeam, 2015
Overall, ICR/ICC’s and BCA’s commitment to sourcing efficient and technologically-incorporated methods of managing documentation for historic sites is an innovative step in the right direction. Updates in Bluebeam can be done on 2-D and 3-D files alike, on a handheld device, in real-time, and distributed without the reliance of Internet access. Yet the process comes with its flaws as well as blessings.25

Disadvantages

At this time, the Bluebeam software is more appropriate for architects. There are a lot of markup options and spreadsheet column categories that crowd the system. Practicing conservators mention they may only use less than half of these editing features while the rest is just unnecessary clutter. The app can shut down if overwhelmed risking the possibility of work being lost.

Advantages

ICR/ICC have been using Bluebeam for six to eight months now and are already pleased with its results regardless of the sometimes inconvenient transition. Bluebeam tries to mediate the chance of unsaved work by making it impossible to close out a file without answering whether or not the edits should be saved. For Trinity Church, a new file is saved to the iPad automatically and manually backed up to a server at the end of every workday. The real-time communication among project team members through these systems is also major benefit so time is well spent on and offsite.

25 Phone Interview with Christy Lombardo from Integrated Conservation Resources, Inc., (16 April 2015).
Lessons from Case Studies 1 – 3

On the debate if digital surveys are striving to replace paper, the industry has not reached a solid conclusion yet. Working with pen and paper onsite is initially quicker and there is no question about accidentally deleting an annotation or corrupting a file. But then this must be transcribed digitally to share with all project members. This does not just mean a scan of the revision. The change has to be presentable for architectural records and as-built closeout archives according to the contract standards, which can be a huge time trap.

Conversely, recording on a mobile device takes twice as long. The apps presented come with the uncertainty of relying on technology. They can be finicky or crash outright so users must be overly diligent about saving. Some apps have a helpful reminder and backup option, but system failures are still unpredictable. Even though project team members experience frequent crashes that close out the file and bring them back to the main screen, their overarching response to these programs is very supportive and adulatory.

With minimal IT experience required, the learning curve to working with the software is quick but still demands allocated time and repetition with practice. Yet once the file is established, communication is instantaneous and easily collaborative. In terms recording for masonry restoration, managing the project files in GoodReader or Bluebeam lets the team address and resolve individual treatment locations quickly on a simple platform.
**BARCODING/QR CODING**

Even with visible triumphs in digitally annotating and cataloging architectural drawings on site, some projects demand more organization. The scale of work is usually the biggest factor in determining this push for advancing the documentation system but the move can also be a result of a the level of detail for documentation stated in the contract. Most contracts for a restoration job may not specify a particular way to number individual stone and will leave this decision up to the architect, conservator, or masonry contractor. Each of these parties inherently has different priorities when it comes to classifying stonework. For example, an architect may use it as a checklist of work completion, a conservator seeing it as a map of conditions and repairs, and a contractor as a financial punch list for payout. If the same nomenclature for labeling the stone is not used across the entire project team, it could be a disaster.

The construction industry is invested in studying an assortment of methods and models for optimizing project management. The next step for automated masonry unit cataloging has been explored through barcoding and quick response coding (QR Code). These codes are designed to take the hassle out of manual input and tedious searches within databases often associated with inventory tracking and pricing outputs. Their function extends far past the grocery store market we are all familiar with and has transformed stock recording for countless commercial enterprises. The construction field is learning to tailor this technology to monitor real-time work progress on projects, excited about the possibilities programmed cataloging and remote access present for quality and time-efficient communication.
Barcode

A barcode (see Figure 18) is an optimized representation of data that is linked to a set of properties pertaining to the object it is attached to. The code is designed as a series of parallel lines of varying width and spacing. Originally, specialized optical scanners read barcodes while today there are countless software apps on desktops and smartphones readily available. After their spark in supermarket inventory and checkout, barcodes have served their purpose as a simple and universally low-cost classification method. They continue to transform other tasks and industries requiring automatic identification and data capture (AIDC).

Figure 18 | Sample Barcode
World Barcodes, 2015
Quick Response Code

A quick response code (see Figure 19) is a matrix code, also referred to as a two-dimensional barcode. It differs from a traditional barcode in that instead of a variation of line widths, a QR code is composed of a unique arrangement of black and white squares. This type of coding has gained expeditious popularity with the promotion that everyday tablet and smartphone apps can read the QR code and link to a URL.

![Sample QR Code](QR Stuff, 2014)

The following case studies examine how the recorder adopted a system of recording to best serve the project:

- **Case Study 4 | Boston Valley Terra Cotta**  
  Barcode by Fabricator

- **Case Study 5 | Woolworth Building**  
  QR Code by Contractor

- **Case Study 6 | Longwood Gardens**  
  QR Code by Conservator/Contractor

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Case Study 4, Boston Valley Terra Cotta (see Figure 20), was chosen to reveal the pervasive opportunities that barcoding units can provide from site to manufacturer, showing that up-to-date communication is not bound to the onsite project team. The company has worked as the terra cotta supplier on projects that range from a single unit to jobs with upwards of 16,000 individual pieces. They have developed their own method for tracking the location and status of pieces throughout their facility, from jobsite to fabrication to shipment.

The restoration of the Woolworth Building (see Figure 26) as Case Study 5 implemented the alternative coding option of a QR system. The project showed how technology continues to further recording in the construction industry, in this event wiring a restoration site with server access points. It also provided the perspective of the masons on site who used the mobile scanning application while on scaffolding to instantly communicate with in-office architects.

With a new Master Plan in place, the Fountain Garden Revitalization Project as Case Study 6 at Longwood Gardens (see Figure 32) has just begun. It was awarded during the initial phase of this thesis and will continue to provide a real-time showing of how the project team chooses to manage documentation of the $90 million job. The recorder interviewed has the duality of serving as both the masonry restoration and conservation contractor and will explore the what monitoring method works best for them to track and share updates on the thousands of stone pieces that will be dismantled, transported back to the shop, cleaned and repaired, shipped back to the site, and finally reinstalled.

CASE STUDY

Boston Valley Terra Cotta (BVTC) just outside Buffalo, NY is one of six leading manufacturers of architectural terra cotta, one of only three stationed in the United States. Their work crosses custom designs for both new fabrication and matching historic pieces of terra cotta. Representatives from the company recognize strong communication between all members of the design and construction team greatly influences the success of a unit masonry restoration project. Poor communication leads to issues that affect scope, production, delivery, schedule, budget, and overall coherence. There are lag times between waiting for drawings, production details, and approvals that could be minimized through rapid response from digital aides.

Boston Valley’s expansive facility is beyond impressive, housing drafting, clay mixing, production, and glazing departments all in one site. Recognizing that establishing a consistent method for tracking work throughout the cycle of production is key, the company has implemented a barcoding system to monitor each piece’s movement through the facility and calculate production rates.
From the initial estimate and contract award, another site survey is performed using iPhone/iPad annotations and photography. Boston Valley traditionally surveys using photogrammetry on small-scale projects and laser scanning for larger jobs. Every unit that is to be replaced is tagged with a number (see Figure 21), marked on the drawing, and photographed. These photographs are then compiled to create a 3-D digital model, which can be rendered into shop drawings for architect/owner/manufacturer review. The drafting team will continue to mark up the architectural drawings in Bluebeam throughout the project’s duration.

*Figure 21 | Labeled sample from the Strand Hotel in BVTC Drafting Room*
Photo by author, 2015
Working with new terra cotta pieces presents a different and more permanent unit tagging possibility in comparison to stone masonry. The terra cotta blocks are pinned with a printed label displaying an individual barcode, identification number, priority, drawing page, and project name. The alphanumeric identification code is then stamped into the clay with using letter blocks (see Figure 23). When the block is complete, it is scanned, checked off, and highlighted on the drawings that line the work area (see Figure 25).

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Priority</th>
<th>Block ID</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHB-12</td>
<td>3</td>
<td>SP-1L</td>
<td>602</td>
</tr>
<tr>
<td>AHB-13</td>
<td>3</td>
<td>SP-1L</td>
<td>603</td>
</tr>
<tr>
<td>AHB-12</td>
<td>3</td>
<td>SP-1L</td>
<td>605</td>
</tr>
<tr>
<td>AHB-12</td>
<td>3</td>
<td>SP-1L</td>
<td>606</td>
</tr>
<tr>
<td>AHB-13</td>
<td>3</td>
<td>SP-1L</td>
<td>613</td>
</tr>
<tr>
<td>AHB-13</td>
<td>3</td>
<td>SP-1L</td>
<td>614</td>
</tr>
<tr>
<td>AHB-12</td>
<td>3</td>
<td>SP-1L</td>
<td>615</td>
</tr>
<tr>
<td>AHB-13</td>
<td>3</td>
<td>SP-1L</td>
<td>616</td>
</tr>
<tr>
<td>AHB-17</td>
<td>3</td>
<td>SP-1G</td>
<td>625</td>
</tr>
<tr>
<td>AHB-17</td>
<td>3</td>
<td>SP-1G</td>
<td>626</td>
</tr>
<tr>
<td>AHB-17</td>
<td>3</td>
<td>SP-1G</td>
<td>629</td>
</tr>
<tr>
<td>AHB-15</td>
<td>3</td>
<td>SP-1G</td>
<td>630</td>
</tr>
<tr>
<td>AHB-15</td>
<td>3</td>
<td>SP-1L</td>
<td>637</td>
</tr>
<tr>
<td>AHB-15</td>
<td>3</td>
<td>SP-1L</td>
<td>638</td>
</tr>
<tr>
<td>AHB-15</td>
<td>3</td>
<td>SP-1L</td>
<td>639</td>
</tr>
</tbody>
</table>

*Figure 22 | Shop binder of barcodes for individual terra cotta units*

Photo by author, 2015
Figure 23 | Barcode label and imprinted terra cotta
Photo by author, 2015

Figure 24 | Architectural drawing with each stone unit called out
Photo by author, 2015
After final inspection, the terra cotta unit’s code is scanned, sorted by prioritized phasing, and prepped for shipment. The contents of every crate are photographed and archived. A final log is created for each shipment—listing crate number, block style, and unit codes—and shared with the client.
Disadvantages

If the unit-by-unit entry is not passed along to the other project team members (ie. architect, conservator, mason, owner), the function of the method is reserved to the creator (the fabricator in this case) and it may become complicated if any other party chooses to develop their own project-specific coding system for masonry units.

Advantages

The barcoding system is an inviting innovative processes to save time and encourage easy coordination. The systematic identification and scanning protocol provides by-the-unit updates from survey to project close out.
CASE STUDY

New York’s Woolworth Building has undergone multiple restoration campaigns since its early 20th century construction, the latest trial testing the impact of onsite servers and QR coding. The building’s vulnerable terra cotta cladding saw repetitive repairs to minimize remnants from high exposure to weathering, but none had been preventative measures. The most recent campaign by Facade Maintenance Design (FacadeMD) promoted the convergence of the historic with newer technologies and signed Urban Digital Solutions (UDS) and contractor Seaboard Weatherproofing & Restoration to develop the management framework.

Figure 26
Woolworth Building
New York, NY
Architect: Cass Gilbert
Built: 1910-1913

Figure 27 | FacadeMD has conducted conditions surveys on Woolworth since 1987
Michael Padwee, 2015

Anthony Pisano and Dan Jones, UDS & Seaboard Weatherproofing Restore the Woolworth Building Using Cisco Infrastructure, (Urban Digital Solutions, 17 December 2013), Online Video.
First, UDS lined the exterior of Woolworth with Cisco access points to create an entirely wireless infrastructure on site (see Figure 28). The connection allowed the architect, contractor, fabricator, technology consultant, and client communicate on any level of scaffolding as well as remotely without relying on a physical plug in to the network.

Seaboard devised an identification system for cataloging each unit—name, location, and area—that linked to a QR code (see Figure 29 and 30). Both the identification listing and QR square were printed on a label and attached to the stone.
Figure 29 | Stone D-22-1 and QR Code
Urban Digital Solutions, 2013

Figure 30 | Stacks of QR coded stone for Woolworth
Urban Digital Solutions, 2013
The conditions survey recognized over 2,000 cracks and delaminated stones, including repairs to over 400 decorative terra cotta pieces and complete replacements for 1,100 units. Over the course of the project, Seaboard updated drawings on site when and where additional conditions remarks arose.

**Disadvantages**

The installation of a Cisco network is not always feasible for a project depending on scope, location, and budget of work. The mobile apps that read the QR code are limited in querying options since most designed for creating inventory reports. Users must be

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29 Jim Parsons, "Restoration Challenges – Contractors and Designers Face Tall Order to Preserve Historic Details," *Engineering News Record-New York Construction*, (July 2006).
creative in how they define these classifications so that they are relevant to the masonry restoration project at hand.

**Advantages**

In many restoration and new construction projects, the status of each unit has to be reported to all parties, which even with a comprehensive numbering system in place, could take a couple of days to a week before a response is received.\(^{30}\) Information has to go from the site, to the contractor, to the architect for approval, to the fabricator for production, and back to the architect for final review. Fortunately, implementing a QR code scanning method for each stone worked as a progressive documentation tool. Very minimal training is required and having the ability to instantly update the log or inquiry with the unit’s physical location and status saved the project team immensely.

\(^{30}\) Anthony Pisano and Dan Jones, op. cit.
CASE STUDY

The revitalization of the main fountain at Longwood Gardens has been long anticipated, hoping to emulate the grandeur of Pierre S. du Pont’s vision.

The masonry contract was awarded to Dan Lepore and Sons Company during the study of this thesis, providing a real-time showing of how the contractor moved from award through to active project management. While there was no official record of past restoration campaigns, Longwood does have a masonry unit numbering system already in place from previous surveys. The architect worked with this numbering system, labeling major stone units and marking repairs where appropriate on the architectural drawings. Lepore bid off these documents for the scope of work and project estimate. As with nearly all construction projects, new issues popped up after contract award.

The first step of documentation for Lepore begins when the company’s architectural conservator, who was also serving as the project manager for Longwood’s masonry restoration, came on site to conduct another detailed conditions survey. Every elevation is photo documented with close ups of damaged stonework. The initial conditions survey by the architect is completed while the stones are still covered with biogrowth and environmental soiling. Unfortunately, this misses a good portion of hidden repairs that will need a second round of review by the conservatory, architect, and client.
This occurrence is very typical on restoration projects and can add delays. Lepore continues to implement the existing coding system for stone units and conditions in addition to making their own notations directly on the printed out architectural drawings. For example, the conservator might propose patching a stone in place of where the architect intended to resurface the unit. Furthermore, the original drawings do not have a number for every stone. Only the decorative pieces are labeled, excluding any coping, panel, balustrade, and base units. Lepore has to create their own item number for these units, basing the format off the original numbering system (see Figure 36).

Figure 33| Deterioration along fountain wall
Daderot, 2013
Figure 34 | Deterioration along fountain wall
Valerie A Hoffman, 2014

Figure 35 | Deterioration along fountain wall
Freshfly, 2014
The Lepore annotations are then transferred from paper to a digital file for distribution to the other project team members, meaning a trip back to the main office and time to input these notes onto the PDF drawing in Adobe Illustrator or Acrobat. By this time, one drawing set has moved around 5+ times (see Figures 37-41). Eventually, all of the new tags created by Lepore will have to be inserted into all drawings.
Figure 37 | Step 1: Original UC-O.1 A,B Drawing

LONGWOOD GARDENS
MAIN FOUNTAIN GARDEN RENOVATION
LIMESTONE ORNAMENT RESTORATION

MATERIAL: Italian Limestone

OCTAGON 1, NORTH FACE
Infill cavities larger than 1/4" diameter to stone tops with pointing mortar.

- General Clean in situ prior to dismantling.
- Remove existing mortar.
- Bed & point stones on reassembly.
- Clean in situ after repair and reinstallation.
- Biocide to 100% weathering surfaces
- Consolidant & Water Repellent to 100% stone surfaces.

Concrete plinth demolished and reconstructed.
Figure 38 | Step 2: Lepore On Site Review UC-O.1 A,B Drawing
Dan Lepore and Sons Company, 2015
**Figure 39 | Step 3: Lepore Edits UC-O1 A,B Drawing**

- **OCTAGON 1, NORTH FACE**
  - Inlet cavities larger than 1/4" diameter to stone tops with pointing mortar.
  - General clean in situ prior to dismantling.
  - Remove existing mortar.
  - Bed & point stones on reassembly.
  - Clean in situ after repair and reinstallation.
  - Bicarbonate to 100% weathering surfaces.
  - Consolidant & Water Repellent to 100% stone surfaces.

- **Concrete plinth demolished and reconstructed.**

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**LONGWOOD GARDENS**

**MAIN FOUNTAIN GARDEN RENOVATION**

**LIMESTONE ORNAMENT RESTORATION**

**FEATURE** | **UC** | **UPPER CANAL**
---|---|---
**ELEMENT** | O1 | OCTAGON 1
**COMPONENT** | A & B | STONE
**REFERENCE** | UC-O.1 A,B
Figure 40 | Step 4: Architect & Lepore Edits UC-O.1 A,B Drawings
Dan Lepore and Sons Company, 2015
Figure 41 | Step 5: Final UC-O.1 A,B Approved Drawing
Dan Lepore and Sons Company, 2015
As the project progressed more, the team looks to more efficient means of transferring information. Drawings are stored online and accessible through a free mobile app called PlanGrid. Here, all project plans, specs, and photos can be uploaded to plangrid.com and opened on a desktop, phone, or tablet.\textsuperscript{31} There are two sets of drawings, one for large-scale elevations and the other for individual pieces to be removed and restored. The photos for each unit, taken before dismantle and again when ready for installation, are linked to their location on the drawing.

An additional tracking method still needs to be applied to the masonry restoration of Longwood Gardens. The database needs to serve over 3,000 workers managing thousands of masonry units.\textsuperscript{32} Lepore’s masons use the expanded drawings for reference and number the back of every dismantled stone with a paint pen (see Figure 43). When the shipment arrives at Lepore’s shop, a non-corrosive metal tag is then tied around each unit (see Figure 44).

\textsuperscript{31} PlanGrid, \url{http://www.plangrid.com/}

\textsuperscript{32} Longwood Gardens, Flowing Water Documentary Trailer, (3 December 2014).
Figure 42 | Shop at Dan Lepore and Sons Company
Photo by author, 2015
Figure 43 | Stone PLV-NW-3 labeled with paint pen
Photo by author, 2015

Figure 44 | Non-corrosive tag
Photo by author, 2015
Lepore looked to scanning options using a QR code. Most advertised products are used purely for inventory catalogs and do not give the option to connect customizable variables to each entry, only offering choices to “Buy New”, “Mark as Sold”, “Complete Item”, and “Delete Item”.

Lepore opted for the software, TimeStation. TimeStation is actually an employee tracking system that creates a QR code for every added employee yet Lepore is able to customize TimeStation’s input fields to cater to the Longwood project and generate a QR code for each crate of stone.

Department: Work Area on Site (ie. Pump Wall, Lower/Upper/or Central Canal)

Employee: Crate Number of Stone

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33 Anthony Pisano and Dan Jones, UDS & Seaboard Weatherproofing Restore the Woolworth Building Using Cisco Infrastructure, (Urban Digital Solutions, 17 December 17, 2013), Online Video.

34 TimeStation, https://www.mytimestation.com/
Every coding card is then printed, laminated, and attached to the crate. There is somewhere between 700 and 1,200 crates that have been shipped off site to Lepore, each with a designated QR. The QR code can be scanned using the camera on an iPhone, iPad, or Android through the TimeStation app which brings up the crate’s information. The app logs the user who scanned the code and the date and time at which the scan was made.

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35 Longwood Gardens, Flowing Water Documentary Trailer, (3 December 2014).
From TimeStation, Lepore has the option to extract the information into an Excel file and insert additional columns for:

- Date Unpacked
- Cleaning Start
- Repair Start
- Date Recrated

Each crate is scanned before leaving the Lepore shop and will be scanned once more when onsite. The on-staff masons will scan the crate, know the individual stones contained within, and be able to find them on the most recent drawings to match for reinstallation. Finally, the entire database will be given to the project architect and Longwood for archival records (see Figure 48).

*Figure 47 | Example of geotagged tracking for crated units*
Kathryn Brown, 2014
<table>
<thead>
<tr>
<th>QR CODE #</th>
<th>AREA</th>
<th>CRATE NAME</th>
<th>UNPACKED</th>
<th>CLEANING START DATE</th>
<th>REPAIR START DATE</th>
<th>RECREATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>00169</td>
<td>Lower Canal</td>
<td>Octagons LC-O.2 (1 of 4)</td>
<td>4/3/2015</td>
<td>4/6/2015</td>
<td></td>
<td></td>
</tr>
<tr>
<td>00171</td>
<td>Lower Canal</td>
<td>Octagons LC-O.2 (3 of 4)</td>
<td>4/3/2015</td>
<td>4/6/2015</td>
<td></td>
<td></td>
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<tr>
<td>00173</td>
<td>Lower Canal</td>
<td>Octagons LC-O.3 (1 of 4)</td>
<td>4/3/2015</td>
<td>4/6/2015</td>
<td></td>
<td></td>
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Figure 48 | Screenshot of unit-by-unit process tracking in Excel

Kathryn Brown, 2014
Summary of Lepore QR Recording

1. The location and elevation of the original stone location is documented. Photographs are taken and existing stone conditions documented on drawings.

2. Stones are marked with their assigned number which corresponds with drawings.

3. Each stone crate is tagged with a printed “QR code” tag to permit the tracking of the stone grouping; the cloud based management system indelibly marks and numbers the stone and records its location, destination, and time of extraction. The information is then available for reference by team members via the Internet.

4. Within Lepore’s warehouse the QR codes on the crates will be scanned upon arrival and processed in sequence. The QR code system is capable of cataloging and identifying all tagged cradles by the use of scanning the code attached to each cradle. The information is then uploaded into a database to be view by the entire Lepore team.

5. Stones are photographed and reviewed by Lepore and architect. Each stage of the stone removal, repair, and reinstallation will be cataloged using computer software; this information is then recorded and measured to the schedule.

6. Crate QR codes are scanned when the crate leaves Lepore’s warehouse and when they arrive onsite at Longwood again.
Disadvantages

There are challenges this combined methodology, but are more related to the upfront recording and implementation of the systems. Annotating drawings by hand on paper is faster and more reliable but will eventually need to be digitized. The back-and-forth pattern of drawing sets at the beginning of the project took time and revision, yet an absolute necessity in any restoration and construction job. The visual QR codes representing each crate are not located in the Excel database or on the drawings and instead the recorder must refer to the alphanumeric label for each masonry unit.

Advantages

The QR Code quickly categorizes and creates a report for all of the crated stone units. The customizable tags make it appealing to project teams that expect more than just an inventory count. Regardless of Internet access, the TimeStation app records the scan and updates the database immediately once back in range.
Lessons from Case Studies 4-6

As the scale of projects increase, project teams rely on more advanced techniques for keeping records up to date. Barcoding/QR Coding has proven to be one of the top options for tracking individual units of masonry as it automatically links the recorder’s assigned label to the status of unit. Yet there is still room for improvement. Most of the applications in practice are not designed specifically for construction projects, let alone restoration. The team has to select the appropriate program that allows them to customize conservation categories related to dismantlement, cleaning, repair, and reinstallation. There is no visual connection between the actual bar/QR code, the stone identification number, the stone on the drawing, or the photo documentation. The next step for these processes might introduce a way for these to atomically link. It is too complex and probably unnecessary to insert the corresponding QR code for each stone on a drawing, but perhaps there are other options. The code could be tied to a set of masonry instead, as Lepore is doing at Longwood Gardens. Alternatively, this note could be added as a comment on a drawing file that when clicked displays a pop up with the stone’s alphanumeric identification, bar/QR code, and latest update. This way all team members can directly scan a drawing infield or in-office and remain informed about project logistics.
BUILDING INFORMATION MODELING (BIM)

The next leap for cohesive and time-sensitive documentation in restoration work relies on the incorporation of Building Information Modeling (BIM). Its presence on new construction projects has spiked remarkably in recent years, pushing for the collaborative software to become a standard in the building industry. Unfortunately, the historic preservation field is fighting against the threat of further excluding itself among the fast-paced construction world—being left behind due to a lack of thorough education and advocacy from both fields.

Overview

BIM is a multi-variant modeling approach that is designed to manage building components and processes on a single interface. While this concept of virtual building may have originated in the early 1970s, the term BIM was not coined until twenty years later and was not popular in practice until the early 2000s.36 The method of documentation deviates from the conventional two-dimensional images supplied by drawings and photographs as it generates a three-dimensional visual of the building with annotations connected to the project’s logistics, cost, and schedule. The software is an effective tool in recognizing clash detection between the building systems, structure, and architecture with

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immediate feedback allowing the architect, contractor, engineer, conservator, and site manager to all communicate on the one database.

There are a number of software platforms BIM can operate on—a popular one being Autodesk’s Revit Architecture. In this program, the action of drafting lines in AutoCAD is replaced with a series of customizable data entry options to create modularity and cut down on modeling time while also linking to an index of related material properties. For example, instead of drawing the individual lines to make up a cavity wall with a masonry stone veneer, Revit should already have the similar wall type loaded into the program with data assigned to that assembly (ie. material, quantity, cost, manufacturer, etc.) This assembly can be grouped as a 3-D “family” for standardized manipulation. In the cavity wall example, the family might consist of the masonry veneer, the backup CMU, insulation, and the steel ties that bridge the air space. The automation can further estimate the number of courses and overall masonry units required for the job, directly impacting valuations of labor, material costs, and schedule durations.

It might seem obvious that this technological endeavor should be integrated into easing the planning, construction, and management phases of a project. In 2012, an extensive survey of in-field use concluded 71% of architects, engineers, contractors, and owners have used BIM on their projects, a 75% growth surge from five years prior. The active use of BIM is still relatively young and has room for development of accessibility


for all trades, specifically for the masonry industry and even more extreme in documentation of restoration work.

Opportunities

Perhaps the most influential success of BIM is the collection of input from all members of the project team on one interface. The BIM model acts as a single operating file that multiple partners can reference and edit. When a note or change is added, the model is updated instantly for everyone to review in real-time eliminating the possibility of errors in referencing outdated information. The project manager can eliminate the clutter of back-and-forth RFIs and email updates and respond to them in a more organized and timely manner. This hopefully cuts down immensely on communication conflicts and time reserved for updating drawings and producing as-builts for closeout.

The BIM software is a means to better understand the building as a whole. The attachment of product data to a specific building processes leads to a more proficient and sustainable documentation set. BIM offers a pragmatic and dynamic tactic to the building practice unprecedented in comparison to the limitations of 2-D recording in a multidimensional world. Efficiency is gained by connecting labor and financial estimations to individual building components. Defined by the BIM-M Initiative, discussed later, virtual design and construction calls on “the use of BIM related technologies to inject a 4th dimension (time) and often a 5th dimension (cost) into complex building models.”

inform schedule delays which allow the project manager to reflect informed value engineering affecting with the project’s progress.

Challenges

Working with a new platform can be intimidating for anyone. Participants have to be familiar with the program’s operations and methods of interpretation to create the best use of the model. As of now, BIM functions as a single system to be used by architects, engineers, and contractors alike. But where do conservators fall in this scenario?

Introducing BIM into the field of masonry restoration is impeded by unwarranted hesitancy. Even as the building industry continues to integrate BIM as a standard, new construction AECs believe adding parameters related to restoration would be too much of a hassle because of the work’s intrinsic details. They think these details will waste time during input and slow down the model. A glitchy model meant to serve all members of the building process will be a disaster. There is truth in the fact that restoration typically entails more variables in comparison to repetitive new construction units, such as those tied to degree of deterioration, architectural integrity of the remaining structure, and method of conservation. However, it is possible to generate a simplified layer\textsuperscript{40} rather than excluding the trade entirely.

The masonry field is similarly not ready for BIM.\textsuperscript{41} Current masonry unit options in the software are general, with few practicing masons making the effort or even knowing

\textsuperscript{40} Discussed later in \textit{BIM for Historic Preservation}, See pg 79.

how to customize the BIM masonry assemblies. The practice is dominated by blue-collar, somewhat technophobic masons comfortable with their minimal calculations free of technological complexities. The progression of masonry work simulated through BIM will only occur once there is a cooperative exchange between the industry and the software designers to establish a basic masonry unit typology upon which suppliers can then customize in a digital format. Until then, masonry contractors will run the risk of reduced contract awards for not providing BIM services or losing business opportunities altogether.

The last opponent to BIM’s success in the realm of masonry restoration is perseveration itself. Whereas there is at least some movement for new construction masonry work in the program, very little exists for restoration. This often frustrates conservators, sometimes left out of the project model discussion and forced to invent their own methods to track masonry work. There is no widely specified standard in conservation work for these creative methods of documenting masonry unit restoration, ranging from non-query numbering to barcode cataloging discussed earlier. Conservators, also largely comfortable with traditional practices, must be willing to adapt alongside the changing technology introduced with BIM or stand to be marginalized even farther than they already are now.
**BIM-M Initiative**

In 2012, a team assembled with hopes to reassert the relevancy of the masonry industry where technology was advancing. They introduced the Building Information Modeling for Masonry (BIM-M) Initiative in partnership with prominent masonry institutions and the Digital Building Laboratory (DBL) at Georgia Institute of Technology (Georgia Tech) to carry out the following mission:

> **To unify the masonry industry and all supporting industries through the development and implementation of BIM for masonry software to facilitate smoother workflows and collaboration across all disciplines from owner, architect, engineer, manufacturer, mason, contractor, construction manager, and maintenance professionals.**

The Initiative aims to grow from the current issues within the industry, update technical software specifically for masonry, and promote continued advocacy and training for working with BIM. Where upgraded properly for unit masonry, BIM will allow essential topics like estimating, scheduling, material procurement and delivery, and project workflow to all fall in one file. The project is outlined in four phases: Roadmap, Preparation, Specification, and Implementation, currently well into Phase 3.

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*Figure 49 | Phases of BIM-M*
*Photo by author, 2014*

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42 David Biggs, Charles Eastman, and Russell Gentry, op. cit., 2.
The Roadmap sets the path to analyze this mission from a dynamic focus on “objects”, meaning the actual product, and “processes”, the reality of implementation. Each phase involves a series of intensive projects intended to challenge the Initiative to produce the most comprehensive and impactful result.

BIM-M addresses the lack of representation for masonry in existing modeling. The status of masonry detail in BIM today is fairly lackluster largely because of its expansive list of parameters that can embody multiple wall typologies, patterns, and shapes. Very often masonry work is noted as a hollow mass, either having rudimentary parameters or missing attribute data altogether. There is no way to query drawings or use the model effectively toward understanding the masonry in the buildings because no common standard exists for masonry unit infrastructure. The Initiative must first define a familiar database for masonry suppliers to contribute information to create a digital mockup. Case studies with BIM-M look to illustrate how BIM could have been used on existing masonry buildings and reveal where more software development is appropriate. In 2013, BIM-M listed ten top masonry wall types in the United States to be digitized for software vendors.

From there, the technology must communicate with the contractor and the mason. The team actively engages the contractor community during the Initiative’s progression, gathering the contractors’ critical feedback on comfort with and feasibility of the

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43 David Biggs, Charles Eastman, and Russell Gentry, defined objectives:
*object* – technical details and specifications describing how masonry will be represented in CAD and BIM computer software – and how this information will be preserved and transferred as building projects go from the planning to design to construction phases

*process* – how stakeholders in the masonry industry currently handle information regarding masonry; describe new BIM-enabled workflows in the design and construction phases of a project

software’s capabilities. Within this discussion, the team can test which apparatus works best for BIM-M information dissemination—using laptops, tablets, smartphones, etc.

Overall, designing for manipulation of masonry construction and data parameters on the BIM platform should not present significant obstacles. The technical endeavor has already accomplished in the structural steel and precast concrete industries. Instead, the biggest challenge the Initiative will encounter is its actual application in the field. “As a material system, masonry is a much more diverse and ubiquitous material as compared to steel and precast.” In addition to material intricacies, many opinionated stakeholders who drive the masonry industry have competing views on this evolution of BIM. BIM-M must inspire and fulfill a common objective for this diverse span of supporters.

Russell Gentry, Associate Professor for the School of Architecture at Georgia Tech and Associate Director for Research for Tech’s Digital Fabrication Lab, knows the spiral effect discounting this proposal will create. If masonry in BIM continues to neglect sufficient masonry input, architects and engineers will not have the tools necessary to design masonry buildings. If masonry buildings cannot be designed, they won’t be built; no building means no work. With the help of current and prospective stakeholders, BIM-M has the potential to pioneer software development in construction. Its idea provokes active dialog and enthusiasm to keep masonry a competitive material.


**BIM for Historic Preservation**

The next move calls for a reaction from conservators to decide how they want to compete in the future of the building market. The construction industry will continue to evolve, receptive of advances matching the growing dependency on technology in outside fields and everyday life.

BIM is not always thought of in performing beyond the point of design and construction phases. Having an accessible building model could be a great asset for the maintenance and sustainability of a project once crews leave the job. As the software undeniably helps us better understand building makeup, applying the technology across new construction and historic structures equally would seem like commonsense. The following comparison summarizes the current status of the restoration work and BIM crossover:

![Figure 50](image)

**Figure 50 | Advantages and Disadvantages to BIM in Historic Preservation**

Photo by author, 2014

Before preservation and BIM can grow to learn from and support one another, we have to acknowledge the reality of their limitations. Modeling can significantly enhance the structural understanding of a historic site, but is not a viable solution for every
The decision to continue with a model should ultimately align with the objectives of the data collection, contractual specification, time frame, and anticipated interpretation.

Considering the lag in family assemblies of certain new construction trades in existing BIM software, it is not surprising there is next to nothing for historic work. For historic details to serve in the model effectively, more up-front work will need to be addressed and completed. This involves deciding the method of recording that best fits the project and acquiring the necessary equipment—hand measuring, photogrammetry, laser scanning, etc. Since recording is an ever-ongoing process and can become overwhelming very quickly, the team should consciously select which parameters are most essential to place into the model ahead of time. Then there is the actual crafting of the model layer in the software by a qualified team member. Each of these stages will influence the timeline of project and may even require preemptive padding for delays until a rhythm is established.

“Heritage buildings contain a wide range of materials and assemblies that are not documented and are not available from stock libraries of 3-D model parts.” Yet, there is no need for the software infrastructure of the historic details to be heavily embellished. All that most conservators are asking for is a basic layer that can be inserted into the model and tagged with variables related to conservation conditions and monitoring work. From that foundation, heritage professionals can contribute their expertise in preservation pathologies to design more accurate BIM models.

47 Van Wagenen, 46.

48 James Maddigan, BIM and Heritage Conservation, Presentation at National Heritage Summit (2012).
The ideal development in BIM for preservation would anticipate a way to illustrate and query conditions assessments complemented by a log of work up to date. A database of heritage sensitive information might include:

- Material
- Condition(s)
- Previous repairs
- Suggested Action
- Status of Completion
- Comments from AEC

Bridging BIM-M with innovative heritage information management would automate the numbering of individual masonry units and catalog them to a spreadsheet still tied to the project model. While extremely handy for conservators and on-site masons making notes, this spreadsheet may not need to be available to all parties. This is where the choice in access and real-time collaboration should be handled delicately. For example, while it is helpful to have an architect’s input on the choice of intervention the conservator has made, is it actually necessary for the plumber on the project to also be able to see the mason’s progress? Is it risky to have so many parties associated with the project able to manipulate the model on a single file?

BIM, as it exists now, is not the final solution to the building industry. We must continue to expand and sponsor its network of material information and manipulation parameters—specifically for masonry and restoration—to uphold a sustainable documentation method of the built environment.
CONCLUSION

While there are inherent gaps in communication on construction projects, there are efforts to minimize these translations and save everyone time and money. The surveyor’s training and objective largely influence the result of recorded drawings and it is up to the project team to decide how to best interpret and manage these processes.

The concentrated study of this thesis did invalidate the bias that preservationists are stubborn experts stuck in the past. On the contrary, many conservators are in very much touch with the latest advances in site documentation, actively familiar with AutoCAD and GIS manipulation, and always on the lookout for a new approach. While the case studies serve as examples to where databases, coding, and BIM can come with ease, it is important to remember these methods can be very project-specific.

Software products that advertise instant updates to all project team members are certainly valuable, but at times not worth the hassle. While all revolved around a relatively minimal monetary investment, time must be allocated to the adoption of the new application. Implementing these systems requires additional training and repetitive practice for the user to become confident and comfortable with its functions. Not only must the company then rely on multiple people to be fluent in the software, but this language must also be understandable to everyone onsite. The drawing annotation apps are flooded with tool sets unnecessary for conservators. The most prevalent response to GoodReader, Bluebeam, and PlanGrid was that it did not necessarily save time, but it did share information instantly. Much of the push for increasingly automatic restoration management has come from academia rather than infield operators. BIM has its place in new construction and engineering projects and should continue to evolve in quality control
efforts. BIM for preservation surely has its advantages and makes for great buzzword discussions, but at this time is not even on most conservators’ radar.

Regardless of the approach and technology being employed, the decision comes down to its practicality in field. Real-time conversations though digital applications and mobile scanners are still reasonably new and growing. There is an urge to keep things simple. Finding an architect, conservator, general contractor, mason foreman, fabricator, and site owner all conversant with the same software does not need to be overly complicated. Each interviewee found that their method was easiest when simple because everyone knows how to operate PDFs and Excel. The next step in querying conditions and unit masonry data would be to have the ability to link a barcode or QR code directly into the spreadsheet and drawing. The coded tracking system is easy to introduce and has proved to maintain accountability in scheduling, budgeting, and project coordination. The ability to communicate within a unified method for documenting and monitoring a restoration project from conditions survey through to cleaning and repairs and finally to project closeout will save more cultural heritage sites.
BIBLIOGRAPHY


at Association of Preservation Technology Annual Conference – *Preserving the Metropolis*.


TimeStation, https://www.mytimestation.com/


DEFINITIONS

AEC
Architecture, Engineering, Construction.

AutoCAD
Software application for 2-D and 3-D computer-aided design (CAD) and drafting.

Barcode
An optimized representation of data that is linked to a set of properties pertaining to the object it is attached to. The code is designed as a series of parallel lines of varying width and spacing.

Building Information Model (BIM)
A three-dimensional modeling approach designed to manage multi-variant building components and processes on a single interface; variables incorporated relate to project logistics, cost, and schedule.

Geographical Information System (GIS)
A computer system for capturing, storing, manipulating, and managing inputs tied to spatial or geographical data.

Portable Document Format (PDF)
An electronic file format resembling a printed document that contains text, graphics, or images of text and can be viewed, printed, and transmitted electronically.

Quick Response Code (QR)
A machine-readable code consisting of an array of black and white squares, typically used for storing URLs or other information for reading by the camera on a smartphone.
CASE STUDIES – PROJECT TEAMS

Project specific information provided by the following parties:

**Renwick Smallpox Hospital**

Owner: Roosevelt Island Operating Corporation
General Contractor: Alternate Construction Concepts LLC
Masonry Restoration Contractor: Dan Lepore and Sons Company

**Parliament Hill—West Block**

Owner: PWGS Canada
Architect/Consultant: ARCOP
Project Manager: PCL Constructors Canada Inc.
Masonry Restoration Contractor: RJW-Gem Campbell Stonemasons Inc.

**Trinity Church**

Owner: Trinity Church Wall Street

**Boston Valley Terra Cotta**

President & Gen. Manager: John Krouse
University of Buffalo: Mitchel Bring
Adjunct Professor

**Woolworth Building**

Owner: The Witkoff Group
Architect & Engineer: Facade Maintenance Design
Masonry Restoration Contractor: Seaboard Weatherproofing and Restoration
Technology Consultant: Urban Digital Solutions

**Longwood Gardens—Main Fountain**

Owner: Longwood Gardens
Architect: Beyer Blinder Belle
General Contractor: Bancroft Construction Co.
Masonry Restoration & Conservator: Dan Lepore and Sons Company
Conservation Consultant: Integrated Conservation Resources
New Masonry Work Contractor: Joseph Rizzo and Sons
INDEX

A
AEC, 1, 6, 81, 88
AutoCAD, 12, 32, 72

B
Barcode, 37-39, 44, 88
BCA, 32, 34
BIM, 71-81, 88
BIM-M, iii, 73, 77-78, 84-85
Bluebeam, 32-35, 42, 82, 84
Boston Valley Terra Cotta, iii, 39, 41

D
Dan Lepore and Sons Company, iii, 20, 52

E
Excel, 6, 29, 31, 34, 66, 83

G
GIS, 12, 82
GoodReader, 31-34, 36

H
HABS, 4, 87

I
ICR/ICC, iii, 30-35
iPad, 31, 34-35

L
Laser, 11, 42, 80
Longwood, 39, 52, 61, 64-66, 68

O
Orthophotography, 13

P
PDF, 31, 33, 88
Photogrammetry, 11, 13, 28, 42, 80

Q
QR, 6, 37, 39, 47-49, 64-65, 68, 83, 88

R
Rectified photography, 12
Renwick, 15-17
RJW-Gem Campbell Stonemasons, iii, 28

S
Seaboard, iii, 47-50, 64, 86

T
TimeStation, 64-66, 87
Trinity, 15, 30-41, 47, 52, 85

W
West Block, 26-29, 84
Woolworth, 39, 47-48, 64, 86