Building Envelope Condition Assessment and Commissioning

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ABSTRACT

This paper will discuss important details of current standards and practices for façade condition assessment and building commissioning, including:

- Documentation of building façades using high resolution digital imaging technology
- Methods and processes for organizing the façade images for use in mitigation and commissioning
- Use of digital images to prepare façade maps, which graphically depict and locate façade information
- Preparation of façade condition assessment reports, bid documents, and mitigation repair documentation using façade maps.
- Managing and controlling the façade mitigation quality control, change order, and draw request processes using integrated digital data.

SPEAKER

William Hicks is a licensed architect whose technically driven architectural practice has focused on condition assessment and mitigation repairs to building façades for the past 30 years. As an adjunct to the inspection, documentation, and mitigation work related to building façades, his firm has developed unique methodologies and equipment which document (via high-resolution digital images) 100% of a building façade. The resulting data provides for accurate, verifiable, and detailed information with which to make informed decisions regarding the condition assessment and mitigation repairs required for a building façade.

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INTRODUCTION

When reviewing current and future trends in the U.S. façade inspection market, it is important to realize the underlying currents influencing the practice of and methodologies in acquiring inspection data. Such factors include ASTM standards, façade ordinances of major U.S. city governments, and building owners' expectations for increased efficiencies and cost effectiveness. The industry standards, practices, and values being driven by these parties converge on a point: better quality information and data tracking will lead to enhanced analysis, safer structures, and more profitable business. As noted in the ASTM STP-144, p. 110:

> "Building façades present unique challenges, even for the alert building owner. The conditions that can precipitate enormous problems are, practically speaking, out of sight, and therefore out of mind."

The quote above reinforces the need for a coherent imaging system to manage building façade inspection data. Traditionally, inspection data is acquired during close-up, hands-on visual inspection from swing stage platforms and includes data from manual sounding of façade materials. Henceforth, this paper will address the benefits of including digital image collection for coherent inspection process.

While planning for an approaching façade inspection, cost effectiveness and efficiencies, as well as achieving a thorough and accurate inspection, should be a priority. Advances in technology allow for both concerns to be addressed through the use of large-format, high-resolution digital images. Such images should capture large areas, (at least 40 sq ft per image), and be captured at high resolution so that micro investigation of cracks, delaminating, cohesion failures, and other visible distress indicators are irrefutably observable.

Photo 1 – This circa 1920 building has a reinforced concrete structural frame and masonry/terra cotta façade supported with steel shelf angles.

Large-format, high-resolution digital images of 100% of a façade, which are then cross referenced and indexed for easy access, eliminate the "out of mind" circumstances referenced above and provide all interested parties (architects, engineers, building owners, contractors, government bodies, lawyers, etc.) the ability to see more (close-up), know more (through a coherent system to manage and visualize façade data), and do more (make informed decisions regarding façade material and repair).

This mode of inspection requires some rethinking by the parties conducting the inspection and the parties paying for inspection. Under current standards and practices of façade inspection, the photographic data collected are a subset of the conclusions. Implementing a complete digital image inspection, however, should not adversely impact the total cost of a façade inspection. If done in conjunction with a planned scaffold inspection, the additional field hours of operational costs are limited to setup of the cameras, marking of the building, and the cost of an imaging specialist crew member. Cost of processing the collected data is offset by being done in an office environment rather than an architect or engineer being required to take extensive notes and supporting photos during scaffold time. It is the experience of this author that high-resolution digital image services should range as follows:

1. Field operations and organization of image databases: +/- $0.30 per sq ft.
2. Charting of distress data and previous maintenance into CAD drawings: +/- $0.30 per square foot

Following are two case studies from the author's firsthand experience using large-format, high-resolution digital images as part of a façade inspection. The process and some of the benefits of using digital image inspection methods will be outlined.

CASE STUDY 1

Terra Cotta

Photo 2A – Full image area 8 ft x 6 ft (reduced to 12.5% original).

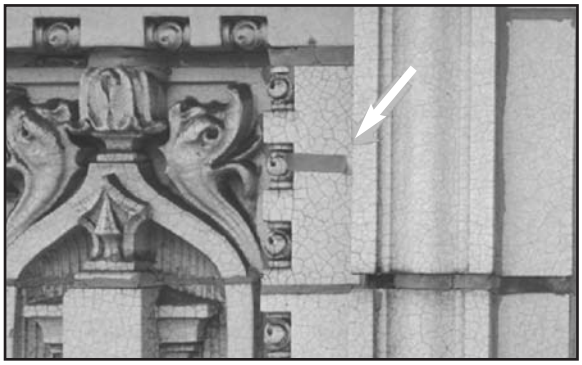

Photo 2B – Image (partial) reduced to 50% original.

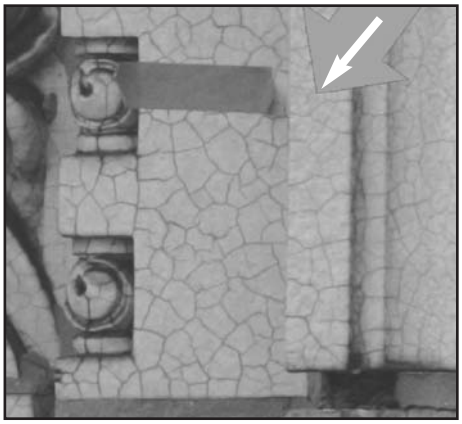

Photo 2C – Image (partial) at 100% original size.

Masonry

Photo 3A – Full image area 8 ft x 6 ft (reduced to 12.5% original).

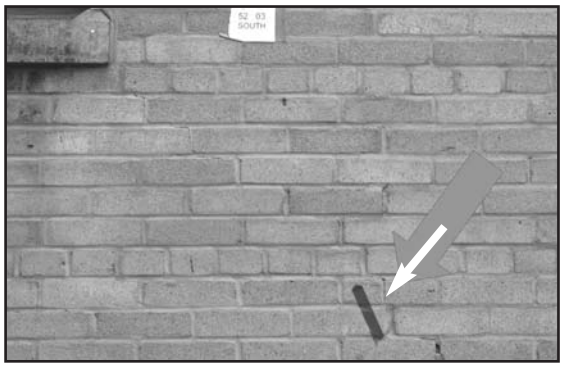

Photo 3B – Image (partial) reduced to 33.3% original.

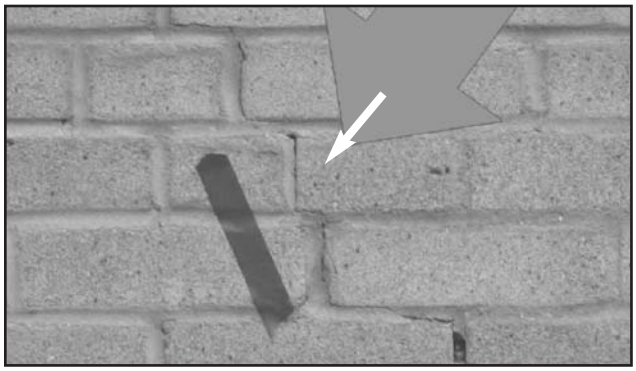

Photo 3C – Image (partial) at 100% original.

The author's firm was retained to prepare a Critical Exam Report (as per city of Chicago Façade Ordinance, Section 13-196 of the Chicago Building Code) for a ten-story building (circa 1920) with a reinforced concrete structural frame and masonry/terra cotta façade supported with steel shelf angles.

The field investigation methodologies followed Chicago's Rules and Regulations for Exterior Wall Maintenance and included 100% close-up, hands-on inspection of the façade from swing-stage scaffolding and 100% sounding of terra cotta materials with a soft mallet.

Traditional field investigation methods such as recorded observations in notes, sketches, annotations on elevations, and close-up photography of the select areas were substituted with the methods noted below.

Scaffold operators (qualified skilled tradesman) and the inspecting architect worked as a team to observe and sound building materials. When façade distresses were observed, color-coded tapes were adhered with specific orientations to the distress site. The color-coded tapes each represented a different type of façade distress and could be easily identified.

Large-format (8 ft x 6 ft), high-resolution (16.7 mega pixel) digital images were collected for 100% of the inspected areas of the façade after the tape marks had been applied. These images could then be easily referenced via computer to assess and document the distress. Because of the high-res-

olution at which the photos were taken, there was no loss in quality due to pixilation and distresses were accurately represented and documented with respect to exact location and size. See *Photos 2A-2C* and *3A-3C*.

The shooting plan was organized in advance so that optimal light conditions (no shadows, no overexposed areas, etc.) on each elevation were achieved throughout the process. The current performance of the high-resolution cameras recommended (provided there is an experienced operator) offers a wide range of light conditions for working while maintaining quality image data collected.

Additionally, for this project there were projecting terra cotta copings at the street elevations of the building. In this case, the cameras could capture details seen above overhang, on overhang, and below overhang by taking additional straight-on photos near these overhanging areas. It is important to note that if overhangs are more pronounced (over 2 ft), the cameras should have the ability to be tilted to appropriate angles.

The impact of using color-coded symbols and large-format, high-resolution images of the façade radically improved the façade inspection, analysis, construction documentation, and construction bidding phases of this project in the following ways:

Field Efficiencies

Integrating the scaffold operators (skilled mechanics) into the inspection process via sounding and application of color-coded tapes on the façade reduced the architect/engineer inspection time and reduced the overall field time associated with this activity. The large-format, high-resolution digital image of 100% of the façade captured the location of each color-coded tape symbol. Therefore, the architect/engineer did not have to undertake the arcane process of note taking, sketch making, building elevation annotation, and hand-held snapshot imaging that is typical in most swing-stage scaffold inspections. Eliminating the difficulty of locating, re-locating and then recording information while maximizing use of A/Es' and mechanics' expertise at identification, the digital image inspection greatly enhanced the quality of the information collected in each area and the overall quantity of area recorded. The efficiency of the swing-stage scaffold inspection process using large-format, high-resolution digital images is able to match the contractor's ability to mobilize and move the swing stage. The increase of time to image the façade was minimal, while the increase in quality of information was exponential.

Compliance With City of Chicago Façade Ordinance Data Requirements

The rules and regulations for exterior wall maintenance of the Chicago Façade Ordinance (Rule 19L) require a comparison of conditions of exterior walls on the building with conditions observed during previous examinations.

In addition to Chicago, New York City's Local Law-11, now in its sixth round of façade inspection cycles, also "requires detailed photographs to itemize defects and compare the façade prior to and after repairs," (*New York Construction Law*, July 2007 - "NYC Façade Inspection Law Quandaries," by John E. Osborn.)

The challenge set forth by these two ordinances is easily and accurately comparing data from one inspection cycle to the next. Neither city has defined an exact process, while both have changed requirements since these laws were put in place. To address this challenge, the digital images are hyperlinked according to their location on the building façade elevation drawings. The end result is that photos taken of the same area at different times could be easily compared to those taken during this inspection in order to observe changes in the façade over time.

By coherently collecting and organizing digital images related to 100% of the building's façade, the ability to manage building issues over a total lifecycle was greatly improved. This allows the building owner to have documentation that is appropriate for lifecycle management and is comprehensive in nature to comply with current and future documentation requirements.

Overcoming Non-Existent or Incomplete Documentation

Prior to the inspection, original drawings of the terra cotta ornamentation were not available for use during the inspection process.

The large-format, high-resolution digital images eliminated the architect/engineer from painstakingly documenting the terra cotta assemblies piece by piece while in the field. This type of documentation was deferred to an office setting where CAD draftsmen could easily and more accurately document the terra cotta assemblies and individual pieces.

The ability to obtain the most complete as-built drawings to work with as templates increased the accuracy of condition assessment, construction documents, and bidding documents for this project. By collecting high-resolution digital images of façade surfaces, this time-consuming and often inaccurate field process was shifted away from high-cost field operators to lower-cost back office personnel with greater accuracy.

Quantification and Positioning of Distress Information

As previously stated, the sounding and tape coding with symbols of distresses eliminated the need for documentation via notes, sketches, and close-up photos of distressed areas.

During a typical inspection, in areas where complicated distresses are observed (such as micro cracks in terra cotta assemblies), the inspection can slow to a snail's pace as an on-the-spot analysis is conducted with decisions being made on possible causes. The addition of 100% high-resolution digital images to the inspection enabled the team to identify, mark, and record the details of each area more rapidly. The resulting data were then deferred to a back-office setting for clear interpretation, sharing, and reviewing by knowledgeable experts, and quantification so that accurate cost forecasts were developed.

The analysis and quantification of exact details were greatly enhanced throughout the report writing, repair documentation, and bidding package processes. Previously, the steps required in order to achieve this level of detail and accuracy would have been time consuming and cost prohibitive.

Increased Owner-Level Commitment to Project

The objective of any façade inspection is fundamentally to identify distress, determine the probable cause of distress, and recommend appropriate and long-lasting solutions. Inevitably, there is a need to communicate these findings to the stakeholders - building owners, management companies, mechanics, and so forth. Often, experts are limited in their ability to engage clients in proactive building maintenance and are directed to focus on "most important" or "mandatory" mitigations.

The ability to digitally record 100% of the façade with high-resolution digital images generated a complete record of the systems of distresses and clearly identified mitigation recommendations. The clarity of information presented facilitated a clear and open dialogue between the building owner and the inspecting architect. By presenting facts in a clear and non-technical manner, the building management team (which included both financial "lay persons" and experienced former masons) was confident in its decision to turn the recommended four-year façade mitigation repair schedule into a one-year, fast-track project.

The confidence in the accuracy of the data as collected and the knowledge that the inspection was comprehensive in nature gave the client confidence that he was entering an appropriate mitigation process that could further be justified to his stakeholders as a sound business decision.

Enhanced Construction Documents

The large-format, high-resolution digital images were indexed and cross referenced with embedded links into the construction documents and bid packages. Each bidder was able to easily access and look at each work area in great photographic detail of actual condition.

This information was provided to bidders in order to minimize ambiguities in bidding related to the scope of work and actual field condition of a specific area of the façade.

The resulting construction documents were issued with the exact scope of work identified via schedules and detailed drawings indicating the exact type, location, and magnitude of the repair for any given area.

Photo 4 – This 24-story reinforced concrete high-rise had floor-to-ceiling window/spandrel panel assemblies and concrete shear walls.

Increased Bidding Confidence

The use of large-format, high-resolution digital images provided detailed information for the preparation of construction documents with highly accurate and well-defined scope of work and material quantities. Bidders were able to easily assess the exact number of each type of distress, the exact quantity of each type of material, and the exact location of the specified work. These documents greatly enhanced the contractors' accuracy in bidding, reducing the amount built into the bid for "unknowns" and confidence in bidding with respect to commitments to schedule and budget.

Quality Control and Construction Management

Having set a baseline of information with the 100% large-format, high-resolution digital image inspection, the contractor was required to document work in

progress via close-up, still digital images. These images provided a record for the building owner and this author to confirm the quality of work as performed and the quantity of materials used on the job. Furthermore, the digital imaging of work in progress and completed work significantly reduced the time and expenses associated with on-site inspections and draw-request reviewing.

CASE STUDY NO. 2

The author's firm was retained to prepare a condition assessment report regarding the quality of façade mitigation repairs completed on a 24-story, reinforced-concrete, residential high-rise with floor-to-ceiling window/spandrel panel assemblies and concrete shear walls.

As in Case Study No. 1, the traditional field investigation methods of recording observations in the form of notes, sketches, and annotations on elevations and taking close-up photos of select (sample) areas of the façade were substituted with large-format (8 ft x 6 ft), high-resolution (16.7 megapixel) digital images of 100% of the façade. See *Photos 4A-C* and *5A-C*.

The impact of using large-format, high-resolution images of the façade improved the façade inspection, condition assessment analysis, construction documents, and construction bidding phases of the project, as well as facilitating the litigation documentation process in the following ways:

Field Efficiencies

The large-format high-resolution digital image of 100% of the façade captured the location of thousands of flat-head stainless steel screws that anchored the exposed aggregate panels to the

Spandrel Panels

Photo 5A – Full image area 8 ft x 6 ft (reduced to 12.5% original).

Photo 5B – Image (partial) reduced to 50% original.

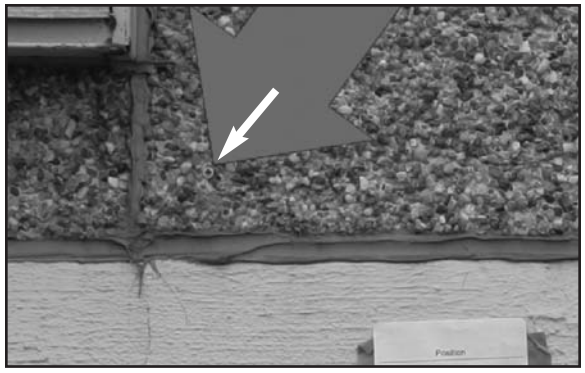

Photo 5C – Image (partial) at 100% original size.

Concrete Masonry Unit

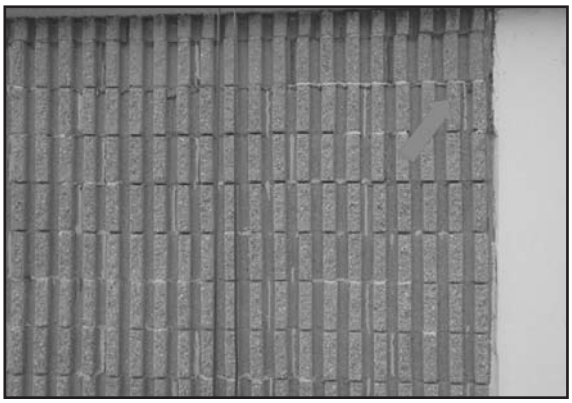

Photo 6A – Full image area 8 ft x 6 ft (reduced to 12.5% original).

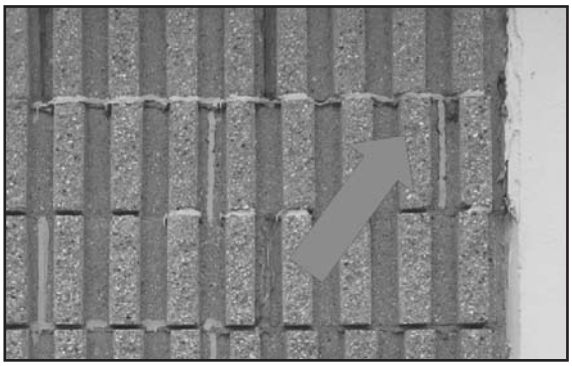

Photo 6B – Image (partial) reduced to 33.3% original.

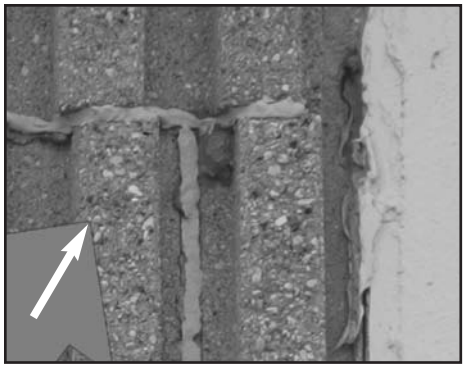

Photo 6C – Image (partial) at 100% original size.

façade and thousands of linear feet of spandrel panel sealants. A traditional inspection methodology of note taking, sketch making, and localized photos to record screw locations and sealants would have increased the time on the job by 500%, would not have quantified details as accurately, and would have been much more expensive.

Comprehensive Condition Assessment

The ability to observe every existing and missing panel anchor, as well as every inch of installed sealant quickly, while in an office setting, not only significantly reduced the field time associated with this inspection, but also reduced the in-office time to create the AutoCAD drawings used to quantify the failings of the contractor and prepare a condition assessment report.

Litigation documentation for claim against architect and contractor

The ability to index and cross reference images of the entire façade and use this information to create AutoCAD drawings that identified latent defects in the construction of spandrel panels was an invaluable tool in the documentation of the claim against the architect and contractor. All images captured were indexed for ease of access, high-resolution for unquestionable detail, and were easily distributed to the multiple parties involved in the lawsuit.

Bidding

The bid documents incorporated the complete set of images from the condition assessment study and allowed the contractors bidding the work to know the exact location of every missing spandrel panel anchor that required replacement.

The scope of work was specific and comprehensive; thus, the resulting bids received varied only by a small percentage and allowed the building management to look into contractor variables beyond simple "price" considerations.

Construction

As a result of definitive construction documents, the mechanics working on this project could do their work without becoming arbitrators who decided the exact work each spandrel panel required.

The focused scope of work eliminated many potential cost overruns, questionable charges, and ambiguity (vital during this litigious process).

SUMMARY

Removing arcane, inefficient inspection methods from façade inspections via the use of large-format, high-resolution digital imaging has the potential to:

- Reduce field inspection time of architects/engineers while at the same time improving the quality of the information collected during the field inspection.
- Allow the architect/engineer to stay focused during a swing-stage scaffold inspection and not be distracted by arcane, error-prone, documentation processes.
- Allow the architect/engineer to see more, know more, and do more, which results in better analysis and condition assessment of building façades.
- Increase cost effectiveness of inspections by deferring certain procedures traditionally done in the field to an in-house office function, which can process data with higher levels of accuracy and consistency.
- Have construction documents that are accurate and comprehensive as to the correct scope of work from the beginning of a project, thereby eliminating or greatly reducing the potential for costly "extras" and scope creep during the construction process.
- Increase owner/owner agent commitment and confidence in the project by providing a comprehensive process that results in information that is easy to understand in photo graphic clarity.
- Take advantage of existing and future software applications that can integrate these digital data to other project management, estimator, and analysis tools.