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Journal

Guide to Campus-Wide Building Envelope Assessment

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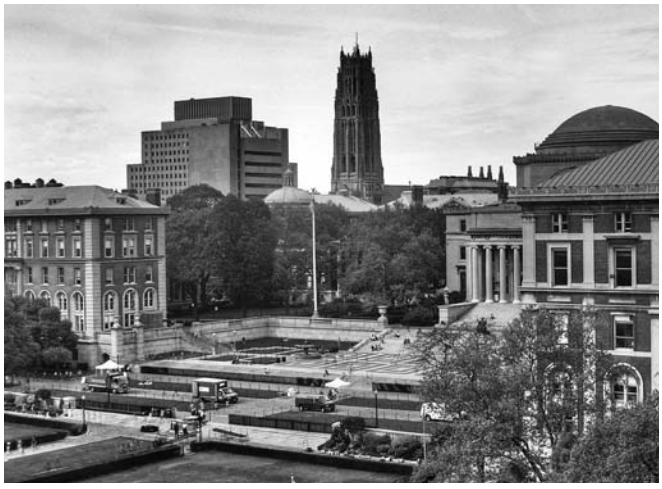
At a facility with many buildings, such as an educational institution, healthcare complex, or corporate campus, prioritizing repair and maintenance needs and anticipating the service life of building envelope components can be intimidating. Even with the most diligent record-keeping, knowing which problems to attend to first, and where to best allocate limited resources, involves difficult decision-making that is often complicated by insufficient information on building conditions and projected construction costs. To address critical conditions while planning ahead for major rehabilitation or replacement, a multi-building assessment provides the data to confidently build a comprehensive long-range facility management strategy.



A Assessment of nearly 60 buildings on this urban university campus led to a long-range maintenance and rehabilitation master plan.

Depending on the size of the campus and the scope of the project, such an assessment can vary from a general condition survey of a large group of buildings to in-depth testing and evaluation for a select segment of the facility, such as older historic buildings or those deemed to be at higher risk. The survey might focus on a single aspect of the building envelope, such as a roof assessment or window condition evaluation, or it might focus on a specific building occupancy type, like dormitories or patient towers, or those from a particular period. The options for how to focus a large-scale building envelope study are as varied as are types of facilities, and it is best to tailor the scope and methodology of the assessment to the overall facility planning objectives.

Developing a prioritized schedule of repairs not only allows for more effective and accurate budgeting, it optimizes repair sequencing to reduce downtime, capitalize on setup and staging, and reduce the likelihood of damage to adjacent areas from ill-timed repairs. With detailed building component information, comparative condition evaluations, itemized repair recommendations, photographic documentation of key problem areas, and construction cost estimates, a campus-wide building envelope assessment provides a written record of the facility at a given moment in time. The document serves both as a roadmap for the care and upkeep of the buildings, and as a snapshot of the state of

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Sample Conditions Observed during Building Envelope Assessment

Deteriorated roof membrane.

Displacement and fracture at stone facade.

Shattered glass block windows.

the campus. When leveraging governing authorities, boards of directors, trustees, and other interested parties for facility rehabilitation funding, it is much more clear-cut to provide a tangible document that enumerates projected repairs, their timeline, and costs, than it is to present a lump-sum figure or guess at the breakdown of expenses by building or area.

To provide a better understanding of what to expect as part of a multi-building assessment, this guide will describe the types of testing and evaluation typically employed to determine building envelope conditions, along with the historical document review and interpersonal research that can inform recommendations for repair. How that information is compiled, organized, presented, and used will be considered, with an eye to creating a living document, one that is continually amended, referenced, and consulted, rather than another binder gathering dust on a shelf.

Assessment Techniques

Depending on the size of the facility, the scope of the investigation, and the information available from previous surveys and repair projects, determining the construction and condition of building envelope elements may involve a number of different strategies.

Visual Observation

For general information on building configuration, construction style, and overall condition, there is no substitute for an old-fashioned close look at the building. Much can be accomplished in a relatively short period of time, and some assessments might entail only a brief visual survey per building for a large facility. The more time the design professional has to poke around, though, the more he or she can uncover, so a quick turnaround may mean that some conditions go unnoticed, especially in difficult-to-access areas.

The visual investigation typically encompasses:

- **Roofs,** with a walk-through for low-slope assemblies, including parapet walls, copings, flashings, and appurtenances like gutters, snow guards, and rooftop equipment;
- **Facades,** along with sills and lintels and foundation walls, with special attention to unusual intersections or construction styles, and to elements like sealant that tend to degrade quickly;
- **Windows and doors,** as well as curtain walls and storefront-type window walls, including hardware and operable elements;
- **Terraces, ramps, and exterior stairs,** particularly where they intersect or overlie interior occupied spaces;
- **Site walls, water features, and plazas,** which may or may not be included in the scope of the investigation; and
- **Any unusual or distinctive features,** especially if their condition merits special consideration.

In addition to a basic inventory of wall and roof construction and material types, the visual observation can identify areas requiring more detailed investigation. Sites for exploratory probes to uncover concealed conditions may be flagged at this stage, and material samples collected for off-site testing. If information on recent repairs is available, the design professional can use this opportunity to evaluate the performance of rehabilitated materials. In addition to estimating the remaining lifespan of repair areas or replacement components, the architect or engineer can establish a record of their integration into surrounding materials as the building weathers over time.

To evaluate the performance of building envelope elements under different climate conditions, it is beneficial to conduct observational site visits at different times of the year. An

Site wall and exterior stair damage.

Interior finish damage from roof leaks.

Spalled brick masonry at chimney.

investigation in the spring might pick up on cracked foundation walls that would be concealed by snow later in the year, but would miss ice damming or condensation that is only present during the winter.

For buildings of similar vintage and construction, visual observation may aim to identify consistencies across structures and to note those areas on individual buildings that are performing differently from the norm. Cataloging window types and conditions is one example of a building element that can benefit from such an analysis. It is helpful to define categories of deterioration or disrepair, such that components can be comparatively evaluated across buildings. For instance, windows might be classified as follows:

- **Weathered,** exhibiting only normal signs of mild wear;
- **Deteriorated,** with some physical damage requiring restoration or repair;
- **Severely deteriorated,** such that extensive defects prevent or markedly impair normal operation; and
- **Life safety risk,** requiring immediate attention to address a potential hazard to operators or passersby.

By providing an orderly way to categorize observed conditions, such taxonomies allow for the prioritized scheduling of repairs and maintenance across multiple buildings or even an entire campus. The building assessment report should define the properties of each category of deterioration, ideally with photographs documenting conditions typically observed for each, to facilitate future assessments. Should the scope of the survey permit, field observations may then be transposed onto building plans, using a numbered or color-coded system to identify levels of distress and failure for a given building element, such as windows or roof areas, for easy reference when it comes time to schedule repairs. Similar keyed drawings can expedite investigative testing and identify sites for in-depth analysis.

Material Sampling and Analysis

Testing of building materials assists in planning for ongoing rehabilitation projects.

Mortar analysis. If large-scale mortar joint repointing is recommended, knowing the components of the existing mortar will aid in specifying new mortar. The test method described in the ASTM International standard, *ASTM C1324: Standard Test Method for Examination and Analysis of Hardened Masonry Mortar,* breaks down mortar samples and identifies proportions of sand, cement, and hydrated lime, which assists in determining the mortar type. A sieve analysis may be used to determine the grain size and colors of the aggregate. Given these characteristics, close approximation of existing mortar is possible, which is especially important for historic structures.

Concrete core sampling. Concrete structures, including parking garages, can benefit from sample analysis and testing to determine conditions that could lead to cracks and spalls. Cylindrical cores may be extracted from existing concrete slabs and evaluated for chloride ion content (a marker for accelerated corrosion of embedded steel), as well as strength and general composition. By analyzing factors that could contribute to premature deterioration, concrete testing provides building owners and facility managers with information to anticipate concrete lifespan and guide long-range planning for rehabilitation.

Roof cuts. While it may seem counter-intuitive to cut holes in an existing roof as part of an assessment, roof cuts provide vital information that not only determines the remaining roof lifespan, but also influences the design for eventual replacement. Besides providing samples for hazardous materials

testing, invasive probes through a roofing system at select locations allow the design professional to understand the depth of the system, as well as the condition and configuration of the roof deck. Probes can provide critical information otherwise unknown by the building owner and architect/engineer. For example, a roof deck assumed to be concrete may actually be gypsum, wood, or metal. Each of these materials may require different anchorage methods for a new roof.

Water infiltration testing. Implementing a water test, via a spray rack or even a garden hose, will help to identify where and why an assembly or system leaks. So often, facilities personnel deal with recurrent leaks in a particular building over a lengthy period of time. With a controlled water test, the source of those persistent problems may be identified within a few hours. And, if indicated, the rate at which water and air infiltrates an assembly, such as a window, can be measured using standardized procedures.

Invasive Probing

To examine concealed conditions, it may be advisable to create a probe into the building facade. A brick wall surface, for example, may be but one of a number of wythes of solid masonry, or it might be a single layer of brick anchored across a drainage cavity or a veneer of very thin brick adhered to a metal panel, or perhaps some other construction type altogether. While straightforward visual observation offers some clues, certain types of wall construction are indistinguishable until the inside of the wall can be examined. Knowing the wall type also aids in diagnosing deteriorated conditions.

Even in cases where original documents and drawings illustrate the composition of the exterior wall assembly, as-built construction can differ markedly from the design. Invasive probes can also reveal construction

Hazardous Materials Testing

Lead, asbestos, and polychlorinated biphenyl (PCB) are often found in aging construction materials, such as paint, sealant, roofing mastics and membranes, and plaster. To streamline future rehabilitation work and prepare for necessary abatement, it can be beneficial to incorporate testing for harmful compounds into the scope of a multi-building assessment.

The presence of hazardous materials affects a bidding contractor's price. In fact, bidding contractors frequently ask if suspect materials have been tested. Procedures regulated by the Environmental Protection Agency require specific methods of hazardous material handling and disposal to protect not only construction workers but building occupants and the general public from exposure to toxins. These regulations directly affect construction costs, sometimes significantly. It is therefore in the best interest of building owners and managers to have suspect building materials tested prior to the bid. Finding hazardous materials after a project is bid and awarded will yield increased costs for abatement through the change order process as well as potential construction delays.

Sampling plans for hazardous materials typically encompass suspect compounds as well as those that might be contaminated through contact. Testing facilities should provide a report documenting types of samples collected, sampling locations and dates of collection, and the results of testing for bulk solid samples, such as sealant or soil; surface samples, like masonry, concrete, wood, or metal; and indoor air samples. Such analysis can become part of the campus-wide building envelope assessment documentation and may be used to provide more accurate construction cost estimates, as well as to expedite planned repair work. ■

▲ Elevations can be keyed to the defect survey to identify levels of deterioration.

Assessment in different seasons permits observation of weather-related conditions.

defects or design deficiencies that can lead to problems, from leaks to displacement to structural failure. For the purposes of a complete and comprehensive condition survey, removal of a section of the wall area may seem unnecessarily destructive. However, the small patch needed to restore the facade might be worth it if the investigation uncovers problems that might have been catastrophic had they been missed.

Photography

A picture is worth a thousand words! Oftentimes it is difficult to describe a deteriorated detail using text, but this text illustrated with a photograph clearly describes the condition. Photography should be utilized extensively throughout the campus assessment. Not only will deteriorated conditions be documented, a carefully planned photographic survey will allow the architect or engineer, now back in the office, to evaluate found conditions. Overall photographs of each building elevation accompanied by close-ups of details can be transposed or keyed to building drawings.

To aid in diagnosing pesky – and sometimes mysterious – leaks, infrared or thermal photography is beneficial. While this type of photographic documentation "sees" heat or temperature differentials and not moisture, the presence of water can be confirmed with a moisture meter or an invasive probe. Thermal photographs also reveal missing or insufficient insulation, discern air leakage at dissimilar component interfaces such as window to wall intersections, and can even detect embedded pipes and electrical wires.

Existing Record Consultation

If historical records, such as drawings and specifications, roof warranty documents, or facilities department work orders, are available, the information these documents provide is invaluable. This documentation may assist the architect or engineer in determining the remaining useful life of a roof or window, or may allow the owner to implement immediate roof repairs covered by a manufacturer's warranty.

The designs for repairs by previous professionals are also useful in determining lifespan and understanding built conditions. If these are available, they can be reviewed and considered as part of the assessment.

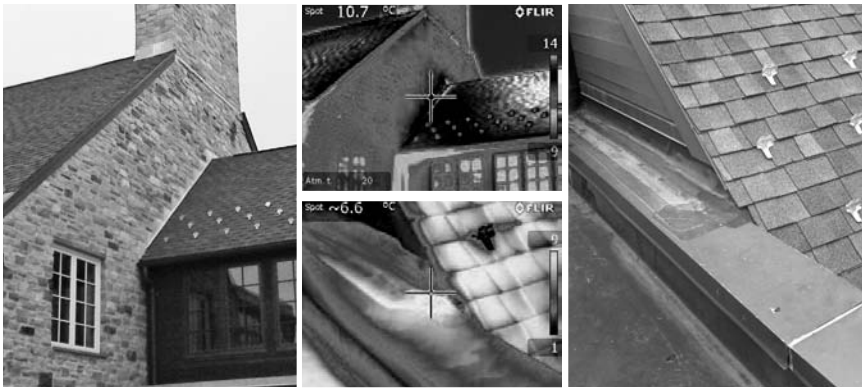
Original drawings and details are extremely beneficial. If the design professional is fortunate enough to have access to original building documents, they can be used to illustrate and map deteriorated conditions, better understand deterioration trends or common issues, and provide context for area take-offs, component counts, and cost estimating.

Interviews with Facilities Staff

The people who best know the conditions of a building are those who respond on a daily basis to maintenance and repair demands: the facilities team. Where written documentation falls short, staff members can fill in details of recent repairs and known issues that may not have been committed to the paper archive or may benefit from in-person elaboration. The people who deal with occupant complaints about drafty windows, a crumbling entry plaza, doors that don't close properly, or roof leaks are best suited to provide up-close and to-the-minute accounts of the challenges that should be included in building envelope maintenance planning. Without their inside information, the assessment could fall short of documenting the myriad small repair needs that can easily be overlooked in the scheme of major rehabilitation concerns at a large institution.

Facilities staff can also provide insight into project funding and the accurate allocation of resources to areas slated for repair. By helping to pinpoint the nature and extent of problems, the

Infrared Thermography



Infrared photographs (at center, converted to black and white) highlight areas of heat loss with color hues that represent thermal gradients.

Test cores may be used to evaluate conditions within a roof assembly.

Visual assessment permits close observation of defects at exterior walls.

Invasive probes can reveal concealed problems, such as corroded structural steel.

maintenance team can guide the architect or engineer in creating project cost estimates that are better in line with the true nature of the issue.

In addition to providing a day-to-day picture of current maintenance challenges, interviews with facilities staff can also reveal the priorities of trustees, alumni, and other stakeholders that might impact the approach to building envelope rehabilitation. For example, nostalgic university alumni might wish to maintain buildings exactly as they remembered them, not just in overall appearance but in every detail. Even when component replacement could recreate the original building element, it is useful to know going into the discussion that key decision-makers are adamantly opposed to removal of any existing material, no matter how deteriorated. Time and resources wasted researching in-kind replacement could then be saved, with the conversation firmly rooted in options for conservation.

Contrarily, another institution might find that the push from stakeholders is toward sustainability and energy efficiency at the expense of historic preservation, in which case replacement of a component in favor of a better-performing one would tend to be the preferred solution.

Without conferring with the facilities management team, the architect or engineer developing the building envelope assessment might miss these crucial pieces of information regarding the institution's stance on exterior rehabilitation.

Data Compilation: What to Do with All that Information

Different scopes and purposes will lend themselves to different presentations of the data collected. A detailed window survey, for example, might best be presented as a large-format compendium that includes elevation plans keyed to defect photographs and descriptions, along with the results of materials testing, invasive probes, infrared analysis, and water testing. An inventory that classifies the windows in each building according to defined categories of deterioration might be included in tabular and graphic formats.

More general condition surveys might begin with a list of buildings included in the report, accompanied by an overall photograph and basic description of the type of construction and materials. For each building, a more in-depth data sheet might provide a description of each exterior envelope element, including design, construction, materials, and observed defects. Supplemental photographs included with the data sheets provide documentation of typical conditions, as well as highlight any deficiencies or deterioration. If infrared photography was used or testing undertaken, the images and results would also be included for each building.

Following the analysis of observed conditions and test results, the building envelope assessment report should provide prioritized recommendations for repair and rehabilitation, including construction cost estimates for each line item and total projected cost broken down by priority level. To facilitate planning and budgeting, a summary document listing recommended repairs by building is helpful. The report should culminate in a checklist of repairs prioritized based on remaining useful life, organized according to an established timeline (e.g. "Priority 1" might be within the next three years, "Priority 2" within the following three years, etc.).

An executive summary can distill these recommendations into key objectives, aimed at highlighting significant findings and establishing facility management priorities for both immediate needs and the long-term health of the facility.

Use for Future Reference

In addition to building-specific information, the campus-wide building envelope assessment report may include reference information to help contextualize the findings. Glossaries of industry terminology, descriptions of typical roof, facade, and wall assemblies and their properties, and articles on building systems and best practices related to the types of construction found at the facility provide background and further information to guide rehabilitation decisions.

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representative projects

Campus-Wide Building Envelope Assessment

Whether for a group of similar structures or a large property with varied building types, Hoffmann Architects creates assessment programs that document and prioritize rehabilitation needs across multi-building facilities. From universities to hospitals to office parks, our architects and engineers develop customized evaluations that uncover emerging problems, anticipate service life, analyze weather integrity, and guide building owners and managers in planning for repairs.

Our client list for campus condition assessments includes:

University of Hartford
West Hartford, Connecticut
Assessment of 42 Buildings

Westpark Business Campus
McLean, Virginia
Assessment of 4 Parking Structures

UMass Memorial Medical Center Memorial Campus
Worcester, Massachusetts
Facade Assessment of 6 Buildings

Hopkins School
New Haven, Connecticut
Assessment of 19 Buildings Plus Parking, Circulation, and Grounds

Wellesley College Tower Court Residence Halls
Wellesley, Massachusetts
Condition Assessment and Window Survey of 3 Buildings

The Hartford Financial Services Group Headquarters
Hartford, Connecticut
Assessment and Rehabilitation Master Plan

Quinnipiac University Anthem Campus
North Haven, Connecticut
Assessment of 4 Buildings Plus Plazas and Parking Garage

Greens Farms Academy
Westport, Connecticut
Campus-Wide Building Envelope Energy Assessment

The National Conference Center (former Xerox Document Univ.)
Leesburg, Virginia
Concrete Facade Study and Restoration

PHOTO: DAVID SHANKBONE

Rockefeller Center in New York, New York. *Assessment of 18 Buildings Plus Plazas, Gardens, Fountain, and Garage.*

Pickwick Plaza Office Complex
Greenwich, Connecticut
Assessment and Facade Stabilization of 3 Buildings

Columbia University Morningside Campus
New York, New York
Assessment of 57 Buildings

Hampshire College
Amherst, Massachusetts
Assessment of 43 Buildings

Carnegie Mellon University in Pittsburgh, Pennsylvania. *Assessment of 7 Historic Buildings.*

Quinnipiac University in Hamden, Connecticut. *Roof Assessment of 54 Buildings.*

Mount Holyoke College in South Hadley, Massachusetts. *Assessment of 20 Buildings.*

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Close-up investigation may be aided by lifts, drops, or other observation platforms.

Rather than a bulky binder full of self-important verbiage destined to serve as a very costly doorstop, the multi-building condition assessment must be designed for practical use. Its well-thumbed pages should be indexed for quick reference, and they should provide user-friendly tables and illustrations that present rehabilitation needs in a format that is at once accessible and insightful. Cursory, oversimplified reports will not yield comprehensive building envelope upkeep strategies, nor will lofty footnoted tomes likely generate any real-world solutions to the daily struggles of maintaining several buildings on a large campus.

Instead, the building envelope assessment should balance sophisticated technical inquiry with at-a-glance photographs and budget guidelines, which can be used for campus master planning and allocation of funds, with long-range projections for the best use of resources at different points in time. As a checklist for building envelope repairs, the report can guide restoration efforts over a period of years. For those conditions that do not demand immediate attention, subsequent assessments can be incorporated into the rehabilitation schedule to track deterioration over time and intervene when appropriate. As a scheduling tool, budget planner, rehabilitation guidebook, and condition log, the campus-wide building envelope assessment provides practical strategies for the effective management of a multi-building facility. ■

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