[81] SESSION 2.12 – System Performance

LEARNING FROM EXTERIOR WALL PROBLEMS

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ABSTRACT[1]
The exterior “cladding” or “skin” gives a building architectural character and protection from the elements. It can also be a source of major headaches for both building owners and property managers. The exterior may be an aluminum and glass curtain wall, stone veneer, brick veneer, precast, metal panels, or a complex mixture of many other components. Building facades have a minimum expected life of approximately 20 years. Unfortunately, many building facades require major renovation much sooner, and sealants are one major component that requires maintenance. Defects often manifest themselves in the form of leakage, stains, “unexplained” glass breakage or cracks in stone panels. Key factors are provided for Property Managers and Building Engineers to properly address the evaluation of the exterior façade.

The exterior “cladding” or “skin” gives a commercial building architectural character that will distinguish its identity, whether it is a 2-story building in a rural area or a 70-story tower in a congested downtown district. This same component that makes it unique also provides protection from the elements of wind, weather, and extreme temperatures. It is a presumption by all who enter these structures that they will be protected from the elements, but that presumption can easily turn into frustration if the exterior wall performance does not provide the expected comfort.

Common types of cladding, such as glass curtain walls, metal panel systems, stone veneer, brick veneer, exterior insulation finishing systems (EIFS), and precast concrete, can be used in any complex mixture with many other components to achieve a desired or one-of-a-kind aesthetic. Whether simple or complex, the exterior wall can also be a source of major headaches for building owners, property managers, and tenants. The most common exterior wall problems manifest themselves in the form of leaks, stains, “unexplained” glass breakage, or cracks in the façade. These issues can occur within the first year of building occupancy or as far out as 25 years of service and beyond, depending on the defect or problem and the level of attention devoted to it.

CONSTRUCTION PROCESS

From a materials expectation, building facades are constructed to last a minimum of 20 years before some type of maintenance is required; however, many building facades require major renovation much sooner. Unfortunately, the industry practice is that most buildings are constructed with only a one-to-two year installation warranty specified. As a building is constructed, the project Gantt Chart (Figure 1) controls the jobsite schedule.

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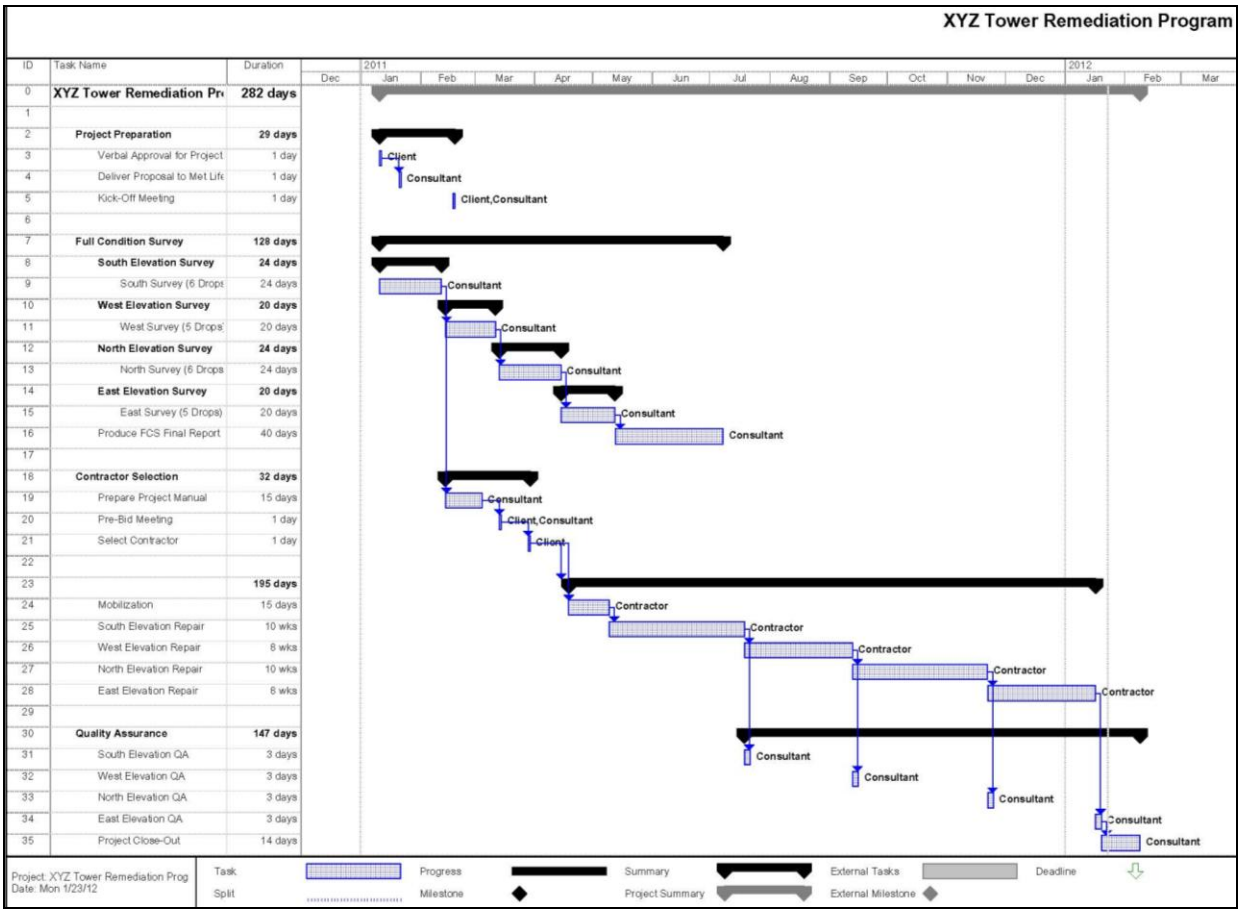

Figure 1: Example Gantt Chart of an Exterior Wall Survey and Remediation Program.

While computer software allows a Construction Manager to shorten the duration of any given task by simply shifting the task bar , a disconnect may occur regarding how much time it would actually take a tradesperson to properly perform a particular task. If the completion schedule is critical, contractors may be given a bonus to finish more quickly. In an effort to meet the advanced schedule, sadly enough, in many cases crucial steps may be skipped. Subsequently, the quality of the finished product suffers, resulting in exterior wall construction defects. In these circumstances, perhaps a better solution would be to provide a bonus incentive for quality installation.

MAINTENANCE

In some instances, once a building is occupied, building owners and property managers may not realize the damage that can occur on exterior wall components if the façade is not properly and proactively maintained. Their focus is mostly on tenant satisfaction, so leak stains are painted; ceiling tiles and floor coverings are replaced; and a quick dab of some random type of sealant is eagerly placed over the presumed water entry point by a building engineer or perhaps by a window cleaner as he performs his normal cleaning, addressing the valued tenant's needs. Unfortunately, in many

situations, it is not until organic growth (mold) develops or stone panels, brick veneer, or chunks of precast fall from the building that it is deemed necessary to make an evaluation of the problem and proceed with a scheduled maintenance program. (Figure 2) If the needed repairs go too long without a proper remedy, the repair costs can dramatically increase from an anticipated maintenance budget to an exponential version of the budget, becoming a tremendous burden to the property owner, management, and tenants.

Figure 2: Cracks in Veneer cannot only allow water penetration, but can be a sign of structural instability in the cladding.

EXTERIOR WALL CONSULTANTS

So what can be done about these issues in a preventive approach or as a proactive resolution? It can be found in a rather small community within the construction industry, specific to building enclosures, known as Exterior Wall Consultants (EWC). Exterior Wall Consulting firms specialize in the evaluation of exterior wall systems and building enclosure quality control during construction or remediation. By expectation and nature of “consulting,” these firms have a team comprised of individuals from building enclosure backgrounds, including manufacturing, fabrication, installation, design, testing, engineering, and architecture—any and all combinations that develop expertise in this small field over years of work experience.

In new construction, the building envelope design is typically reviewed for compliance with industry standards and best practices, trade associations, project specifications, and quality of installation. An EWC is typically introduced to the project via the Owner, Developer, General Contractor, or Architect. The scope of work for the Consultant varies from project to project and for each client, depending upon specific need and allocated budget. In certain cases, an EWC is incorrectly considered an additional team member to a project scope and budget rather than an integral part of the construction team and a budget line item because their particular expertise and contribution to a project are unfamiliar.

NEW FACADES

Encompassing system design to architectural drawing review, contractor shop drawing review, submittal review, and schedule review, the initial consulting peer review process becomes essential to obtaining a successful and expected outcome. Once the construction documents and submittals are finalized, the exterior cladding will begin to take shape on the jobsite. Prior to actual construction, as the exterior wall components are being fabricated and shipped, there are many items that should be considered. Exterior Wall Mock-Ups are a relatively low-cost way of confirming not only the façade aesthetics, but also assuring how the parts and pieces will fit together, seal to each another, and perform in an industry-specified water test scenario. This can be installed on-site or at a certified testing lab specializing in façade testing.

Water testing is a preferred method to verify the weatherability integrity of a wall system. (Figure 3) The American Architectural Manufacturers Association (AAMA) and the American Society for Testing & Materials (ASTM) publish test criteria for product evaluation that are industry-specific to the laboratory and to the field. Certified testing agencies that provide this as an independent service are located throughout the United States. Once a mock-up has passed the testing and been approved, the installation process can begin. Periodic site visits made by the Consultant can provide some assurance that the cladding is being installed according to the architectural drawings and industry requirements. While ideally it would be advantageous that every single bolt, brick, flashing, and seal are inspected, in many cases that is not practical. It is difficult to truly “assure” the exterior is installed per the construction specifications without a significant level of observation. However, selective site visits provide periodic quality checks to support the team in achieving the expected outcome. Full mortar in brick head joints, sealant adhesion verification, and water testing are certainly only a few of the many items that can be observed during construction. This prudent process provides a specific means of quality control/assurance during the installation phase, which has a tendency to be permeated with field condition and schedule challenges. When EWC inspections are performed proactively, installation errors can be noted and corrected during installation with minimal impact to the construction cost, resulting in consistency of the installation process.

Figure 3: Water tests can be used to verify new construction or aid in troubleshooting existing defects. A spray rack Is mounted to a platform stage to test an entire window on the left photo and a B-25 spray nozzle is used to localize the testing on the window intersections.

On window systems in general, if the seals on the internal drainage system are not installed correctly in the shop or field, the installation will yield poor results and possibly allow water penetration. Components such as end dams and horizontal water diverters, which are located the internal glass pocket/gutter of the horizontal-to-vertical window mullion intersection, are frequently the culprit of water penetration issues on newly installed systems. Checking the integrity of these internal seals prior to glass installation will save the Building Owner from future problems and costs. Checking the end dams can be performed by simply blocking the weep holes with tape or putty and filling the horizontal with water. After a specified period of time (5 to 15 minutes), if water remains in the horizontal, the test was a success. If water appears on the interior space, then the seal is not effective. (Figure 4)

Figure 4: This is a typical end dam condition at a horizontal-to-vertical window mullion intersection. Checking window end dams by blocking the weep holes and filling the horizontal with prior to glass installation will save the Building Owner from future problems and costs.

Brick veneer systems can have issues with insufficient weep slots or holes or when excessive mortar has blocked the weep system. Excessive water can enter the wall cavity behind the brick if the head joints are not completely filled from front to back for the entire width of the brick masonry unit. After water enters the wall cavity, the system relies solely on the water-resistive barrier (WRB) to stop further penetration. Many times this WRB is ineffectively installed, breached with unsealed penetrations, or damaged during construction. These hidden holes in the WRB will allow water directly into the interior space and are very difficult to trace. (Figure 5)

Figure 5: Hidden breaches and installation defects in the water-resistive barrier can allow water into the wall cavity and building interior.

Sealant applications can also allow water penetration if not installed effectively. At a window perimeter, a window installer may have a window system with an exterior-applied face cap. Almost every major window manufacturer specifies in their installation manual that the window perimeter sealant must be held back and installed to the base framing member and not flush to the front of the window system to the side of the face cap. If sealant is applied to the face cap, it often captures water that has penetrated the seal, with no provision for weepage, and the captured water is forced to the interior of the building. (Figure 6) Some project specifications do not cross-reference the window sealants with the brick or precast sealants. It is not uncommon to have a polyurethane specified as a brick or precast sealant and a silicone specified as a window perimeter sealant, yet this could result in future failure. At some point, these two incompatible materials will meet, and the intersection will inevitably have a breach in the sealant due to lack of bond.

Figure 6: If sealant is applied to the face cap, disregarding the shop drawings, the condition captures water, which is forced to the interior of the building.

EXISTING FACADES

On existing buildings, minor problems can start to surface after a building has been occupied or in service for a only couple of years. Sometimes it takes just the right weather event or a change in seasons from hot to cold, to manifest problem areas. The most common and most annoying problem is water penetration. The failure mechanism of a water penetration issue is usually not a simple one to identify. It becomes more complicated if it is a systemic issue on new construction or a long-term, hidden problem on a building that has gone unnoticed for several years.

After a building has been completed and occupied with tenants, issues may develop over time. Sometimes an issue is not apparent because it has not visually manifested itself to a tenant or owner, but it could still be lurking in the wall cavity. Issues such as organic growth or even corrosion can be hidden for years before they are even noticed. (Figure 8) When cladding problems begin to reveal themselves in existing buildings, the exteriors should be surveyed to determine the cause of the exterior wall deficiencies, including such issues as water penetration, sealant failure, glass breakage, and/or other wall system failures.

Figure 7: Water penetration in the wall cavity can go unnoticed if not evident from the interior of the building. This can eventually lead to hidden organic growth.

SURVEY METHODS

An initial exterior wall survey can be performed from the ground floor/balcony/roof areas. Using a high-megapixel digital camera has proven to be very helpful in locating exterior anomalies, shadows, and cracks. Taking photos in high resolution allows further review of the images in more detail on a large computer monitor by zooming in to areas on the wall that would be hard to see even with binoculars. The digital camera can also assist in locating specific areas on the wall to target for close-up review. However, the best method to identify issues on an exterior wall is by being out on the wall and getting up close and within arm's reach. A hands-on, touch-and-feel approach is the most effective process when investigating wall issues.

Using controlled descent via a boatswain's chair is beneficial for specific locations. A boom lift provides versatility and good wall coverage; but there may be constraints in getting the lift up close to the building, and heights above 10 stories are challenging due to the limited reach of the vehicle. A powered platform stage is very effective from a review perspective, but has a tendency to be the most expensive

inspection method, particularly if the property does not have a house rig available and a contractor-rigged stage is required.
Water testing is also a common forensic method used to identify water entry points. As stated previously, the water testing methods of new construction using AAMA and ASTM are great references for testing protocols. A basic rule-of-thumb technique for water testing is to start low on the wall and raise the water source until leaks are found. Isolation of the substrates and wall cladding components by using visqueen to cover surrounding areas allows a Consultant to better determine the leak entry point or avenues for water penetration.

Another essential tool for an EWC is a borescope. Initially, the borescope was used mainly in the medical field, but has gradually benefited the automotive and exterior wall industries, among others. A borescope typically uses a light source to illuminate the wall cavity and a viewing lens to make observations and take photographs. Today there are many types of scopes that are designed for tight locations that make it indispensable in the building enclosure field. A small viewing port is needed when using a scope. Often access can made by cutting a small hole in the sealant, but it may require drilling a small hole (approximately 3/8" diameter) into the wall cladding. This provides a cost-effective means to literally see what is behind the wall surface in lieu of removing stones or panels to see behind the wall. Although this technique is very helpful, it can be limited based upon the type of obstructions within the wall cavity, like mortar or even insulation. These interior wall cavity elements can render the borescope useless, and other avenues may need to be employed. (Figure 8)

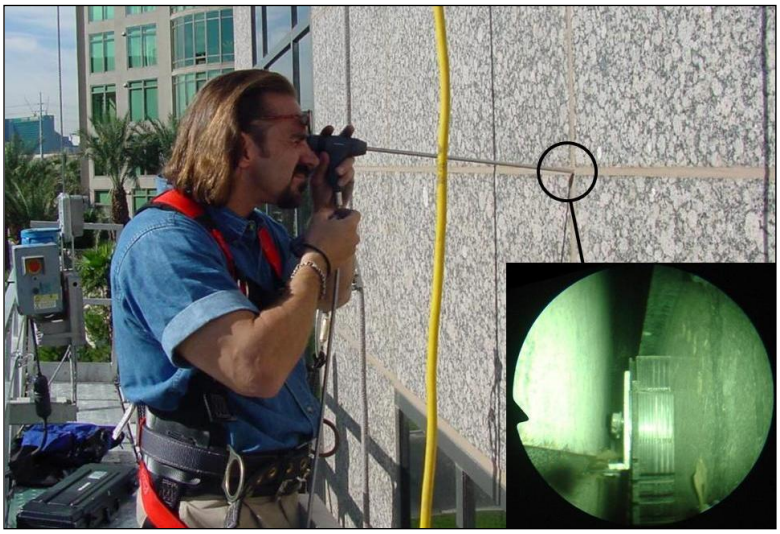

Figure 8: The borescope is an essential tool for reviewing conditions in the interior cavity of an exterior wall without destructive means.

Other exterior wall defects may involve cracks in the wall materials. Substrates such as stone veneer, brick, precast, Glass Fiber Reinforced Concrete (GFRC), Exterior Insulation Finishing System (EIFS), and tile are most common. The techniques to review these are similar and involve mapping the crack locations on the wall in an attempt to identify a pattern and establish a datum point in case the cracking is ongoing.

INVESTIGATION DOCUMENTATION

In the investigation phase, it is important to define and document the manner in which an exterior wall is reviewed and data is collected. If there is any likelihood of litigation, then there are specific methods that are required for protocol and documentation in a legal environment. If these protocols are not followed to the letter, there is a real potential that the time and cost spent collecting data will be wasted because the data will not be admissible in court. It is crucial to know this going into an investigation; however, a consulting firm that uses standard industry methods for testing and collecting data will not be far off from the manner required in the legal realm.

Even if an exterior has not failed or is not showing problematic signs, it is a prudent step during the first five to ten years of a building façade's life to obtain a limited exterior wall condition review to identify general maintenance items needed. If no problems are found, that is good news. However, if issues are found, hopefully they are in the early stages and can be qualified and properly addressed. Once defects in the wall system are identified and qualified, remedial solutions can be designed to correct the deficiencies. This is dependent not only on the issues found, but also on the budget of the property owner. If any problems are not identified in the early stages, the cost to repair may be so large that a routine maintenance budget will not be sufficient to address the needs of the façade. Ultimately, it is best to develop a remedy that is cost effective and provides the owner with a durable, long-term solution.

RENOVATION

The renovation phase may involve sealant replacement, flashing repair, stone-precast-brick repairs, glass replacement, or even total recladding. Remedy specifications that detail each defect found, quantify the number of defects, and provide details for remediation are most effective. It is common to engage an EWC to combine an effective exterior wall survey with preparation of the repair specifications and be able to obtain a five-year remediation warranty from the repair contractor based upon the diligence exercised in recognizing the problems and developing durable solutions.

Quality control measures such as periodic water testing, sealant adhesion sampling and installation verification are typically performed by a consultant to ensure the installation is in compliance with the contract documents throughout the renovation program. This provides assurance not only for the owner, but also benefits the remediation contractor in limiting his exposure to warranty repairs. (Figure 9)

Most manufacturers endorse and promote the consultant's role on a project as it provides third-party verification to installation and use of products. Some manufacturers even provide longer, VIP warranties on projects where EWCs have been involved in the remedy design and quality control process. Ultimately, it is best to identify problems before they result in costly repairs for the building owner or property manager. An Exterior Wall Consultant, knowledgeable in and focused on the design, quality control, and testing of facades, can help eliminate these common building envelope issues in both new construction and after the building is occupied and will make a valued addition to a construction/renovation team.

Figure 9: Independent quality control and installation verification ensures the installation is in compliance with the contract documents throughout the construction/renovation phase. This not only benefits the Building Owner and Property Manager, but enhances the durability of the renovation for the installation contractors warranty period.

Key factors are provided for Property Managers, Building Engineers, and Architects to use a specialized Exterior Wall Consultant to properly identify and address issues regarding the exterior façade.

Keywords: Exterior Wall Consultant, curtain wall, windows, glass, stone veneer, brick veneer, exterior wall, cladding, condition survey, defects, sealants, remediation solutions.

REFERENCES

AAMA 501 “Methods of Test for Exterior Walls”

AAMA 501.1 “Standard Test Method for Exterior Windows, Curtain Walls and Doors for Water Penetration Using Dynamic Pressure”

AAMA 501.2 "Field Check of Metal Storefronts, Curtain Walls, and Sloped Glazing Systems for Water Leakage"

AAMA 501.3 "Field Check of Water and Air leakage through Installed Exterior Windows, Curtain Walls, and Doors by Uniform Air Pressure Difference"

AAMA 502 "Specification for Field Testing of Windows and Sliding Glass Doors"

AAMA 503 "Specification for Field Testing of Metal Store Fronts, Curtain Walls and Sloped Glazing Systems"

ASTM E 1105 Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Curtain Walls and Doors by Uniform or Cyclic Static Air Pressure Difference

ASTM E 2128 Standard Guide for Evaluating Water Leakage of Building Walls

ASTM E 331 Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference

ASTM E 547 Test Method for Water Penetration of Exterior Windows, Curtain Walls and Doors by Cyclic Static Air Pressure Differential

AAMA 501 Field Check of Metal Storefronts, Curtain Walls and Sloped Glazing Systems for Water Leakage

AAMA 502 Voluntary Specification for Field Testing of Newly Installed Fenestration Products

AAMA 503 Voluntary Specification for Field Testing of Storefronts, Curtain Walls, and Sloped Glazing Systems

AAMA 511 Voluntary Guideline for Forensic Water Penetration Testing of Fenestration Products

ASTM E 783 Standard Test Method for Field Measurement of Air Leakage through Installed Exterior Windows and Doors