Feature

Facade Failures: Common Types, Causes, and Lessons Learned

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This paper was presented at the 2025 IIBEC International Convention and Trade Show.

FACADE FAILURES

Facade systems serve several critical purposes for buildings and structures, including establishing the architectural identity and providing protection from the elements. Often unbeknownst to owners, occupants, and the public, the condition of facade systems is frequently compromised to some degree due to deficiencies in the original design and construction and/or deferred maintenance. Various factors contribute to the presence of these conditions, including an inability to verify systems' performance without completing hands-on surveys of elevated areas and challenges with completing destructive testing. Such conditions can lead to performance issues ranging from water leakage and isolated distress to detached cladding elements and collapsed facades that cause significant damage and pose life-safety hazards.

Although there are countless types of façade systems and causes of performance issues, select facade systems more commonly result in detachment failure. Understanding the limitations of these particular systems can reduce future failures. This paper discusses three facade systems that are more prone to detachment failure, reviews the common causes of their failure, and outlines lessons learned to reduce the prevalence of such failures.

EXTERIOR INSULATION AND FINISH SYSTEM (EIFS) CLADDING

EIFS cladding became popular in the 1970s and 1980s for large commercial and industrial applications and then expanded into the residential market in the 1990s. Its increase in use was due largely to its energy-efficient performance, its relatively low cost, its thin cross section, and its design versatility. Until the mid-1990s, EIFS cladding typically consisted of reinforced base and finish coats applied to insulation boards, which were adhered directly to the backup wall.

This system was considered a "barrier system," since the EIFS cladding relied on continuity of the base and finish coats for the waterproofing performance. During the 1990s, many class-action lawsuits related to wood-framed residential construction came forth due to systemic water leakage and detachment failures of this "barrier system." Due to water penetration and deterioration of exterior sheathing and framing, this led to the inclusion of a weather-resistive barrier (WRB) and drainage plane, inboard of insulation boards. Today's EIFS cladding consists of a multilayered assembly that includes a fluid-applied WRB applied to the backup wall, adhesive that adheres insulation boards and creates a drainage plane, and reinforced base and finish coats. This design evolution has improved the performance of EIFS cladding such that it now manages, collects, and discharges incidental moisture that bypasses the base and finish coats. Moisture is drained down the drainage plane and directed to the exterior through integral flashings.

Although the inclusion of a WRB and drainage plane has significantly improved the performance of EIFS cladding, it still has one of the highest prevalences of detachment failures when compared to other rainscreen cladding systems. This is counterintuitive to some in the industry, recognizing it can be considered a more clear-cut system, requiring only a few products and a relatively straightforward installation process. Some of the most common causes of EIFS detachment failures include the following:

- **Defective Adhesive Application:** EIFS cladding systems are tested in laboratory conditions to demonstrate their performance in resisting positive (inward) and negative (outward) wind pressures. The performance demonstrated through this testing should be compared to the governing components and cladding wind loads for a particular project to ensure that the EIFS cladding's demonstrated performance is greater than the governing loads. The adhesive used to secure insulation has historically been a polymer-modified, cement-based product; however, the use of polyurethane foam adhesive has recently become available as an alternative adhesive approach. For the cementitious adhesive approach, the adhesive must be applied with a U-notched trowel, typically 3/16 in. × 3/8 in. (4.75 mm × 9.5 mm), dependent on the manufacturer, to provide a specific size and spacing of vertical ribbons that adhere insulation boards and create the drainage plane. Due to misunderstandings regarding the critical importance of properly adhering insulation boards, cementitious adhesive is often misapplied, commonly as circular dollops that vary in size, spacing, and thickness. Compared to the vertical adhesive ribbons, dollops are not applied in a repeatable pattern and do not provide uniform adhesion of insulation; further, and critically, the use of cementitious dollops has not been tested by manufacturers to evaluate their performance, such that the negative wind resistance is unknown. A second significant concern with the use of dollops is that it impedes drainage, resulting in moisture accumulation on the WRB, increasing the potential for water leakage, and potentially compromising adhesion at dollops.

- **Inadequate Substrate Preparation:** EIFS cladding is commonly applied over various substrates, including plywood sheathing, gypsum sheathing, cement board, concrete masonry units (CMU), and concrete. Buildings typically include a combination of these materials, and the materials may abut in different vertical planes depending upon their installation, construction tolerances, and detailing. EIFS manufacturers have strict requirements for substrate preparation, including the smoothness of the substrate and how to deal with changes in plane between abutting substrates. Two common substrate requirements among manufacturers are that there shall be no steps in the abutting materials and that there shall be no planar irregularities greater than 1/4 in. (6.35 mm) in a 4 ft (1.22 m) radius. Deficiencies in the substrate are often overlooked because their potential contribution to compromised wind load resistance is not fully recognized. The EIFS installer is generally responsible for ensuring that the substrate is prepared in accordance with specific requirements prior to installing insulation boards; however, contractors often do not repair planar irregularities and instead attempt to apply supplemental cementitious adhesive with sufficient thickness to bridge between the substrate and insulation boards. Thicker, circular dollops of adhesive are commonly used to bridge between the insulation and substrate irregularities. This leads to uncertainty regarding the wind pressure resistance of the EIFS cladding system and the concerns noted above.

Simpson Gumpertz & Heger's (SGH's) experience demonstrates that there can be considerable reduction in the adhesion of EIFS cladding due to deficient adhesive application and/or inadequate substrate preparation. In 2024, SGH investigated a detachment failure of a 40 ft × 20 ft (12.2 m × 6.1 m) area of EIFS cladding 150 ft (45.7 m) above a busy roadway in New York City (**Fig. 1**). The maximum wind speed that occurred during the evening of the failure correlated to a negative wind pressure of approximately 35 lb/ft^2 (170.9 kg/m^2) at corner conditions, which is approximately 55 lb/ft^2 (268.5 kg/m^2) less than the wind pressure the EIFS cladding system should have been able to resist, as demonstrated by laboratory testing.

Through our emergency response to provide a safe facade system and our subsequent investigation, we concluded that substrate preparation deficiencies prevented continuous adhesion of the cementitious adhesive ribbons and that the failure appeared to occur at a building corner, where the wind pressures are greater than compared to field of wall conditions, which then progressed due to air flow behind the EIFS cladding. Upon review of failed wall sections, we observed many locations where less than 30% of vertical ribbons were bonded to the substrate, which was apparent because of the semi-circular dome profile of the cured adhesive (**Fig. 2**).

The installing contractor had applied adhesive ribbons, but the notched trowel provided inadequate depth to bond ribbons to the substrate due to the depth of planar deficiencies in the substrate. The installer elected to apply dollops of adhesive, in addition to vertical ribbons of adhesive, to address irregularities that varied in depth by up to 1 in. (2.54 cm). The dollops were irregularly spaced and ultimately provided an inadequate uniform bond compared to what should have been provided

Figure 1. *Substrate irregularities.*

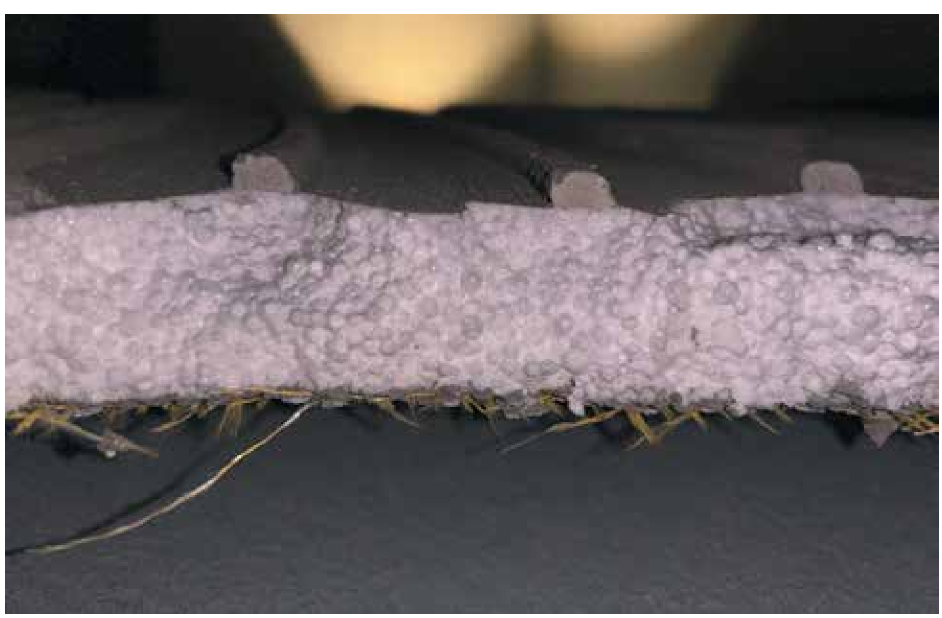

Figure 2. *Semicircular dome profile of cured adhesive ribbons.*

with adhesive ribbons (**Fig. 3**). Additionally, the dollops observed were thicker than the vertical ribbons of adhesive in many conditions which prevented the adhesion of the vertical ribbons of adhesive.

To reduce the potential for detachment failure of newly installed EIFS cladding, a primary focus should be strict compliance with the manufacturer's installation instructions, including providing a smooth and continuous substrate and compliance with the application rate and pattern of the adhesive. Recognizing the critical nature of these requirements, mockup repairs of substrate deficiencies and the application of adhesion should be performed and approved by the project team before the work is executed. Frequent on-site reviews throughout the application of insulation boards are also critical to identifying issues that will otherwise be concealed.

To enhance quality assurance, field testing per ASTM E2359, *Standard Test Method for Field Pull Testing of an In-Place Exterior Insulation and Finish System Clad Wall Assembly,* can be performed to review the installed system's adhesion relative to its required performance (**Fig. 4**). In our project example, we performed this testing to evaluate the condition of EIFS cladding beyond the failure to determine whether the failure was systemic. Our testing demonstrated that the wind pressure resistance of EIFS cladding beyond the failure was adequately above the governing component and cladding negative pressure requirements. We concluded that the EIFS cladding at those areas had adequate adhesion, such that the recladding scope would be limited to the failed area and did not need to include the whole building.

MIDCENTURY BRICK CAVITY WALLS

Following centuries of mass masonry construction, brick masonry veneer cladding systems were introduced in the mid to late 20th century to provide an assembly and components intended to address shortcomings associated with the masonry construction utilized decades prior. While these newer systems included many improvements, including separating the facade cladding and building structure and the introduction of components to improve waterproofing performance, early masonry veneer cladding systems often lacked the provisions required to reliably secure the cladding. Therefore, there is an extensive stock of existing buildings in many regions of the US constructed with potentially problematic systems, recognizing the design and construction of these assemblies underwent a multi-decade trial-and-error period that eventually led to the code requirements, standards, and practices used today.

The prevalence of performance issues is compounded by the reality that these systems on some buildings are nearing the end of their service life. Further, building owners are contending with the poor thermal and waterproofing performance historically provided by these systems and the trend toward improving sustainability and performance. As a result, buildings with these cladding systems are commonly challenged by extensive rehabilitation scopes, including recladding entire buildings, to provide reliable cladding assemblies. It is important to note that reconstruction of these cladding systems commonly triggers repairs or upgrades to the backup wall construction, recognizing that deficiencies in the backup walls are one area with regular performance issues.

Some of the most common causes of brick masonry veneer detachment failures include the following:

- **Backup Walls:** Midcentury brick cavity walls were often constructed outboard of backup walls that lack the provisions that would be required under current building codes and that were intended as part of the original construction. Often, these backup walls are constructed of 4 in. (10.16 cm) CMU that lacks adequate grouted reinforcing and attachments at the top and bottom to resist lateral loads imposed by the brick masonry veneer anchors and transfer such forces to the building structure. We have investigated midcentury buildings with displaced backup walls that contributed to the failure of brick masonry veneer cladding (**Fig. 5** and **6**).
- **Masonry Ties:** Some masonry-related failures are related to corrosion of masonry ties. SGH has investigated corrosion of ties that resulted in full section loss of ties causing mortar failures and detachment

Figure 3. *Dollops of adhesive at failure of exterior insulation and finish system.*

Figure 4. *Exterior insulation and finish system adhesion testing.*

Figure 5. *Displacement of backup wall.*

Figure 6. *Displacement of brick masonry.*

of cladding. In most cases, masonry ties installed during the original construction of midcentury buildings should have many years of remaining service life; however, in some instances, section loss can be more severe than expected due to frequent and extended wetting of the masonry and use of accelerators in the masonry when it was originally constructed. Inadequate masonry ties that are properly secured to the backup wall also sometimes contribute to masonry-related failures. Recognizing the prevalence of these failures, within the last few years, New York City modified the existing facade ordinance, requiring that a design professional probe walls to verify the adequacy of existing masonry ties to ensure that these mechanisms of failure on the aging building stock are addressed.

- **Differential Movement:** Differential movement between the brick masonry and structure occurs due to various factors, including irreversible moisture expansion of the bricks, temperature-related expansion and contraction, and structural deformations. When these types of movement are restrained, either by the rigidity of the backup wall or surrounding construction, stresses are introduced into the masonry. These stresses result in cracks and spalls, as well as lateral (out-of-plane) or longitudinal (in-plane) displacement of the masonry. To mitigate movement issues, modern construction industry guidelines and recommendations such as the Brick Industry Association recommend incorporating adequately sized expansion joints in the masonry system.

The detailed standards and industry guidelines that designers regularly utilize today were not available when midcentury brick-veneer-clad buildings were constructed. The trial-and-error methodology of construction often resulted in select conditions where excessive movement occurred or was restrained, including at opening perimeters, building corners, and relieving angles. Lack of adequate provisions to tolerate differential movement often contributes to the detachment and failure of these cladding systems. SGH has investigated many buildings where adequate expansion joints were not provided at the conditions noted, resulting in masonry distress and cladding reconstruction scopes (**Fig. 7**).

Midcentury buildings constructed with brick masonry veneer cladding often include various shortcomings relative to the requirements expected of more modern brick masonry cladding assemblies. Given the prevalence of cladding failures, it is critical that the potential flaws and modes of failure common with this cladding system be understood when condition

Figure 7. *Displacement of brick masonry veneer.*

assessments and investigations are performed. Similar to most facade failures, deficiencies associated with the backup walls, masonry ties, and movement provisions are often not readily apparent until there is sufficient distress and deterioration.

TERRA-COTTA

Terra-cotta has long been a favored material in facade design due to its durability and aesthetic qualities. Traditionally, it was used in mass masonry buildings to provide decorative appeal at select facade features, including parapets, cornices, water tables, window surrounds, columns, and building corners, and it was molded into ornamental elements such as friezes, medallions, and gargoyles. The material, made from fired clay, became especially popular in the late 19th and early 20th centuries. Despite its material benefits, which include its general resistance to weathering and providing a lightweight alternative to stone, detachment failures of terra-cotta are significantly more common than many other cladding materials.

Some of the most common causes of terra-cotta failures include the following:

- **Deterioration of Attachments:** Similar to other masonry materials, terra-cotta assemblies are not waterproof. In particular, water that penetrates mortar joints and adjacent enclosure systems can migrate within the cells of the terra-cotta units, wetting backup masonry, cementitious grout, and metal attachments that secure terra-cotta units together and to the building structure. Terra-cotta detailing historically has included mortared or sealed joints, precluding ventilation to evacuate moisture, resulting in extended moisture exposure for metal attachments. Further, this system is often more prone to water penetration because it is provided at parapets, which are exposed to increased wetting due to exposure on three sides, and sky-facing surfaces such as cornices and water tables. Traditionally, framing and anchors that secure terra-cotta have historically been steel; however, cast iron and wrought iron were also used, but to a lesser degree, given that they are more prone to corrosion. Decades of water penetration can eventually cause corrosion of the framing and attachments that can result in section loss of attachments and rust jacking, which is a phenomenon that occurs when rust builds up on metal, causing it to expand and put pressure on the surrounding materials. The combination of a reduction of the strength of the attachments due to section loss and the rust jacking process can cause stress at the terra-cotta connections which can fracture individual terra-cotta units (**Fig. 8**).
- **Material Failures:** The porous nature of terra-cotta makes it vulnerable to freeze-thaw cycles, where water absorbed by the material expands upon freezing, causing cracks and spalling in the terra-cotta units. Terra-cotta systems are particularly susceptible to localized failure that, if not remediated, can spread due to increased moisture penetration. These failures can result in glazing failures, where the protective glaze that seals the surface of the terra-cotta units cracks or delaminates and exposes the underlying bisque components. Once the bisque is exposed, the terra-cotta is much more susceptible to water absorption and freeze-thaw damage. This can happen even from a small failure in the glazing, which can allow moisture to penetrate deep into the terra-cotta units, resulting in more widespread degradation and failure (**Fig. 9**).

Figure 8. *Cracked terra-cotta at corroded beam.*

A challenge that is unique to terra-cotta is the difficulty with investigating the condition of its attachments. Terra-cotta is often used at some of the most elevated portions of buildings, such as cornices, restricting access to identify distress and perform investigations. Further, performing a hands-on assessment of concealed attachments requires the removal of terra-cotta units, which can be difficult to repair to match existing materials and finishes. Consequently, there is typically limited understanding regarding the condition of terra-cotta elements, and distress and deterioration often go unidentified until adequate deterioration occurs to cause detachment failures. Terra-cotta is particularly prone to detachment failures because it is often cantilevered, providing limited restraint of elements when distress (such as rust jacking from corrosion) occurs. Repairs and reconstruction of terra-cotta are often reactive to a detachment failure rather than proactive to address ongoing deferred maintenance. We have investigated many buildings where the failure mechanisms noted above were the causes of failure of the terra-cotta elements, ultimately resulting in both isolated repairs and total replacement of terra-cotta units.

REDUCING FUTURE FAILURES

Reducing facade failures begins with recognizing the facade systems that are more prone to failure and understanding the failure mechanisms that more commonly occur. For each of the cladding systems discussed, a proactive approach to assess existing conditions and rehabilitate systems can greatly reduce the prevalence of failures. Below we discuss strategies to manage this risk:

- Visual surveys and drone surveys provide significant benefits to assessing existing conditions, but neither type of survey provides the level of information and understanding gained by performing hands-on surveys. Close-up inspections should be performed periodically to collect information necessary to inform potential further review, including non-destructive or destructive testing, and review of exploratory openings.
- While New York City's recent facade ordinance modifications trigger the requirement for review of cladding anchors, this practice is not required by most other municipalities and is often not performed by design professionals as part of condition assessments. As discussed above, deterioration of attachments for EIFS, brick masonry, and terra-cotta often goes

Figure 9. *Removed cracked and loose terra-cotta.*

unidentified until failures occur. Performing condition assessment and investigation scopes that include review of the cladding's attachment systems provides information to further characterize the systems' condition and potential future performance and identify incipient failures.

- All too often, rehabilitation scopes associated with EIFS cladding, brick masonry, and terra-cotta do not address the underlying root cause of the distress, such that distress and deterioration recur in the years following completed repairs. Addressing the performance issues discussed herein often includes reconstructing cladding systems and potentially backup walls to provide durable and reliable cladding systems.
- Design: Designing facade systems per site-specific requirements and considering the project's location and environment, such as temperature, humidity, and exposure to wind and rain during the design, are critical to a project's success. Additionally, designing the facade system for long-term performance and durability is a must. This includes providing drainable cladding systems and incorporating waterproofing and flashings to manage and discharge water in a controlled manner.
- Construction Administration: Incorporation of field mockups is an excellent way to ensure the design and construction team understand the system requirements and detailing. Mockups help identify potential design issues and provide the installers with an opportunity to troubleshoot installation and detailing issues. Additionally, regular and frequent independent on-site reviews throughout the construction process are critical to the success of a project, along with designated field testing for additional quality control purposes.
- Maintenance: From a building maintenance standpoint, it may be difficult to identify issues early on that can lead to a collapse of a facade element, especially since many facade issues may be due to concealed components. Many times, these issues spread to readily visible facade components, and with time, even the smallest of issues, if left unaddressed, can deteriorate adjacent building components. Therefore, regular maintenance inspections and timely repairs are crucial to maintaining facade integrity. Facades should be inspected regularly for signs of weathering, cracks, spalls, and water infiltration. Any issue identified or reported should be reviewed in more detail and should be addressed promptly to prevent more significant problems from developing.

CONCLUSION

Facade failures can have serious consequences, not only in terms of safety but also in terms of financial cost. By understanding the specific vulnerabilities of the facade systems described, design professionals, building owners, and building personnel can take proactive steps to prevent these failures. The lessons learned from past failures highlight the importance of proper design, construction, and maintenance in extending the life of facade systems and ensuring the safety of building occupants and the public. Through these strategies, we can safeguard the performance of facade systems for years to come.

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Paul Sujka *has been a part of the construction industry since 2011, with 10 years of experience coming from working at Simpson Gumpertz & Heger Inc. (SGH), where he has worked on building enclosure projects of various sizes. He has been involved in all phases of building construction, including investigation, rehabilitation scope, new design scope, and construction administration services. His building enclosure experience is primarily focused on fenestration systems, above- and below-grade waterproofing, roofing, and contemporary wall systems.*

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