Building Enclosure Forensics and the Need for a Site Communications Strategy

By Javeriya Hasan, PhD, PEng, PMP; Jeff Reitsma, PEng; Hitesh Doshi, PEng; and Claire Tam

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FORENSIC INVESTIGATIONS INTO building enclosure failures typically begin when moisture-related problems escalate beyond routine maintenance. These issues can lead to disputes and often result in structural deterioration, requiring significant repairs. Such failures are usually associated with serious moisture damage stemming from bulk water intrusion or condensation through air ingress. Investigations require the collection of various types of information and an in-depth analysis to determine root causes and inform liability. This paper examines single-family, custom-built homes in Ontario through three detailed forensic case studies. Each case highlights critical events in the five stages of the building life-cycle:

1. Preparation of design and construction documents
2. Permitting
3. Construction
4. Inspection
5. Occupancy

The key stakeholders involved in these processes include architects, builders, inspectors, and homeowners.

The case studies reveal several common patterns. First, inadequate architectural detailing stands out, alongside potential lapses in compliance with the *Ontario Building Code* (OBC). Additionally, there were concerns about insufficient oversight during inspections and instances of homeowner negligence. The forensic analyses highlight vulnerabilities in critical building components. These include roof-wall intersections, air and vapor barriers, attic ventilation, and wall flashing. Each case raises important questions regarding the responsibilities of key stakeholders. For instance, could architects or builders have identified and resolved moisture-related issues earlier in the construction process? Were inspectors negligent, allowing these deficiencies to go unnoticed? Finally, did homeowners unknowingly engage in actions that exacerbated or triggered the underlying problems?

CONTEXT

The increase in weather-related construction claims related to building enclosure failures highlights wider legal uncertainties and financial risks. The building enclosure serves as the crucial barrier between indoor and outdoor environments. It must effectively manage both liquid water and airborne moisture to ensure structural integrity and indoor health. Unfortunately, many failures remain hidden until they cause significant damage. This often leads to costly repairs and legal disputes. Such failures are especially prevalent in single-family residential structures, where oversight issues, budget constraints, and misaligned responsibilities among tradespeople can further complicate and worsen defects.

Forensic investigations often reveal persistent moisture problems in above-grade enclosure components. These issues typically arise from inadequate design details and construction oversights, which are worsened by harsh environmental conditions. Ingham and Leek studied numerous cases and documented instances of water ingress due to insufficient waterproofing, poorly executed rainscreen cladding installations, and the lack of necessary flashings and sealants around window interfaces.[1] Their analyses highlighted that water infiltration usually results from a combination of factors. Designers may fail to anticipate extreme weather, contractors might neglect essential details, or building products may fall short of their expected performance in actual conditions.

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Persistent moisture intrusion can have devastating effects. Over time, it leads to the corrosion of structural metals, decay in wooden elements, and mold proliferation. This cascade of issues ultimately contributes to structural instability. Each of these problems not only increases the scale of necessary repairs but also raises legal liability. In attic spaces, the accumulation of moisture and the resultant mold growth add further complications. These challenges disrupt our traditional assumptions about ventilation efficacy.

In their 2018 study, Ge, Wang, and Baril examined moisture and condensation problems in attics. Their research focused on residential buildings in a cold Canadian climate that closely mirrors the conditions found in Ontario, Canada.[2] The study revealed significant issues related to attic ventilation. Although standard practices are often followed, attics lacking adequate ventilation consistently face moisture problems, especially in winter. Condensation and frost formed when warm, humid air from indoors infiltrated the cold attic spaces. In contrast, ventilated attics maintained acceptable moisture levels due to effective drying processes, whereas unvented attics kept high moisture levels year-round. While this underscores the importance of adequate ventilation for controlling moisture, the root cause often lies in a compromised environmental separation, namely, persistent air leakage from the conditioned to the unconditioned space, so ensuring air barrier continuity should be the primary diagnostic and remedial focus.

The studies reveal consistent central themes. First, inadequate detailing and a lack of redundancy in water management layers often lead to construction execution failures. These issues frequently arise under a backdrop of unclear or unenforced accountability. The findings emphasize the critical need for effective watershedding, proper material compatibility, and coordinated execution among trades. Moreover, they underscore an important point: code compliance alone is insufficient for ensuring durability. Enclosure resilience relies not only on good design but also on thorough construction oversight.

BUILDING ENCLOSURE FORENSIC CASE STUDIES IN SINGLE-FAMILY HOMES IN ONTARIO

This section presents three case studies investigated as part of forensic engineering practice. As is common in forensic investigations, the objective extends beyond merely identifying the cause of failure for the purpose of repair. It also involves formulating an expert opinion that may be utilized by legal teams to assign liability.

The three case studies include the following:

1. A 5-year-old custom-built residence exhibiting exterior wall moisture damage resulting from the intrusion of bulk water from outside
2. A 7-year-old home experiencing moisture damage within the roofing cavity, attributed to the condensation of airborne moisture
3. A 10-year-old residence where bulk water infiltration led to significant interior water damage

Water Damage on an Intersecting Wall

Problem: A 5-year-old, two-story, custom-built, single-family home in Ontario, featuring a brick masonry veneer exterior wall system, began displaying subtle but progressively worsening signs of water damage. The damage was localized specifically at the intersection where the west-facing wall joined the north-facing wall. Early symptoms included efflorescence, dark staining on the brick surface, intermittent spalling of bricks, and a persistent musty odor noticeable indoors, particularly after rainstorms. Interestingly, other areas of the house did not exhibit similar damage, highlighting the unique vulnerability of this particular wall intersection. Homeowners initially attributed these signs to minor cosmetic issues, unaware of the severity beneath the surface (**Fig. 1**).

Forensic Investigation Findings: A comprehensive forensic investigation combining visual inspections, moisture measurements, thermal imaging, and destructive testing was undertaken. Initial moisture meter readings indicated critically high moisture levels within the wall cavity, exceeding 30% moisture content, which far surpasses the safe range of 15% to 17% for wood framing.[3] Upon opening sections of the wall, extensive hidden damage was found, including severely rotted oriented strand board (OSB) sheathing, advanced decay of structural framing members, and widespread mold growth.

Detailed examination pinpointed the primary cause: improperly managed rainwater runoff from the north-side roof. The absence of a critical kickout diverter flashing and gutter at the roof-wall intersection was discovered. This omission allowed large volumes of rainwater to cascade directly onto the vulnerable west-facing wall. Compounded by prevailing local wind patterns, wind-driven rain pushed water deeper into the wall assembly, exacerbating moisture penetration (**Fig. 2**). Over time, persistent runoff had gradually eroded mortar joints, creating additional pathways for water intrusion behind the brick veneer. The investigation further

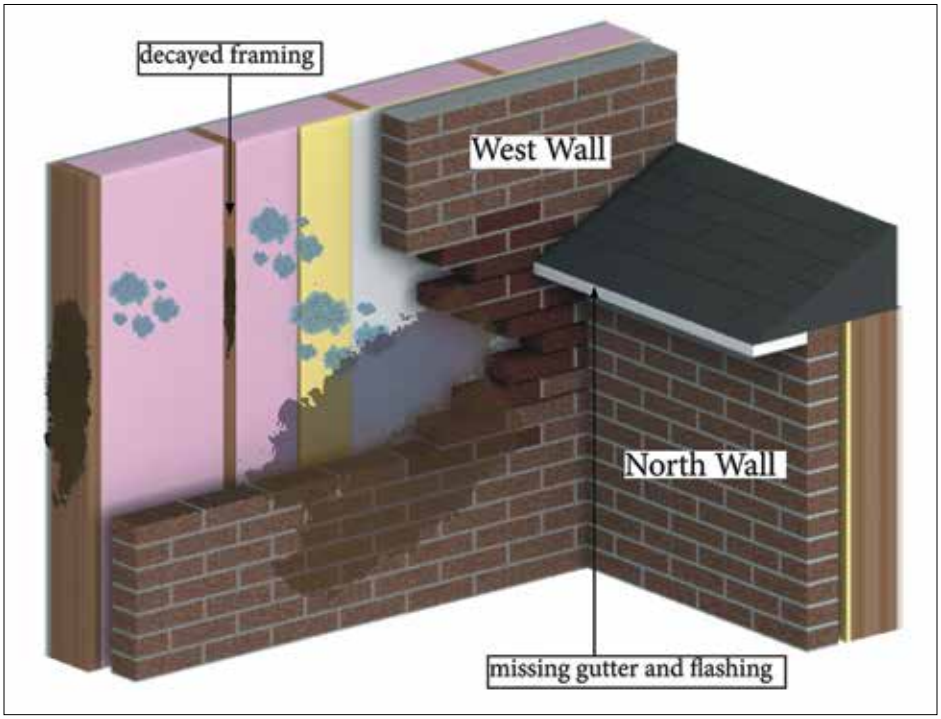


Figure 1. *Structural damage (rotting and mould growth) on the west wall due to water deposition from the roof-wall intersection.*

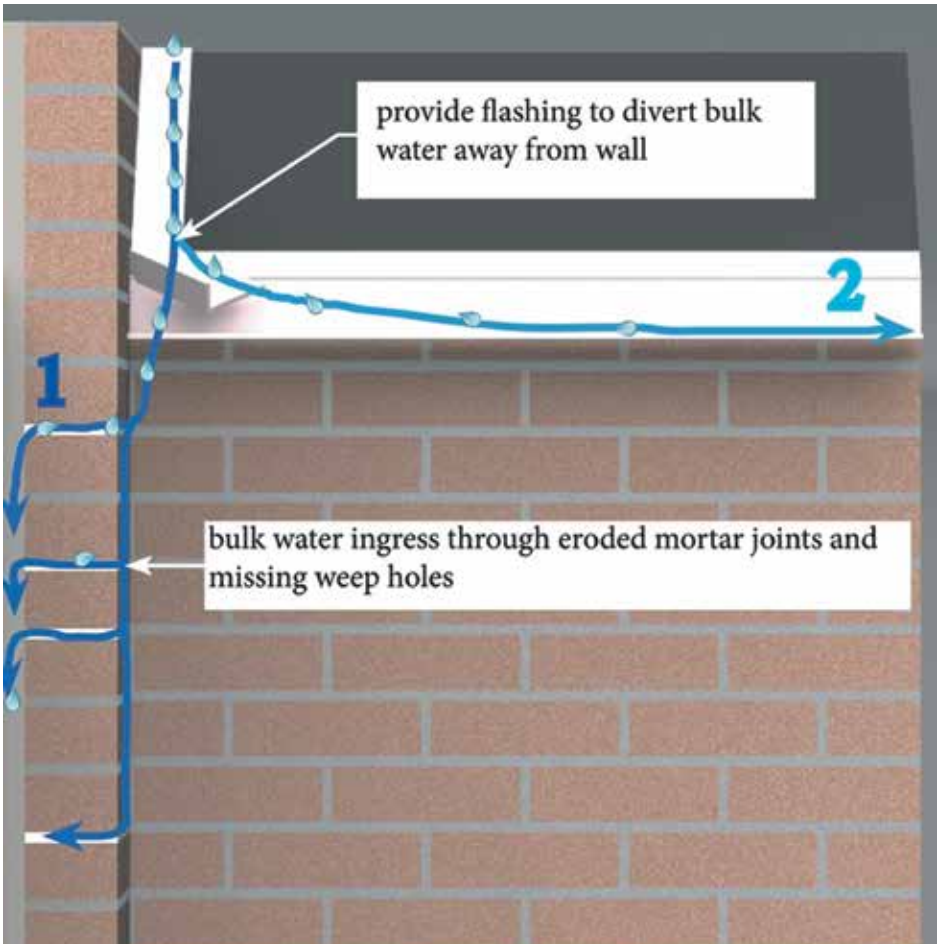


Figure 2. *At the critical roof-wall intersection, the natural water pathway (indicated as 1 on image) needed to be diverted to a controlled route of water shedding (indicated as 2 on image).*



Figure 3. *Moisture damage on the west wall could have been avoided with the inclusion of proper kick-out flashing, drip edge at the roof, and gutter specified on architectural drawings and verified during construction.*

noted poor construction practices, including inadequate cleaning of the drainage cavity, improperly spaced and maintained weep holes, and poorly sealed seams in the weather-resistive barrier. Additionally, the hygroscopic nature of OSB contributed significantly, as it absorbed and retained far more moisture than plywood would have.

The unique geometry, wall assembly construction, and microclimatic conditions of this specific wall intersection made it exceptionally vulnerable to moisture-related deterioration. As required by the OBC, flashing must be installed at roof-wall intersections to prevent water infiltration (**Fig. 3**):[4]

OBC Division B, Section 9.26.4.4.: Requires that the intersection of shingle roofs and masonry walls or chimneys be protected with flashing to prevent water infiltration at these vulnerable roof-to-wall interfaces. This provision ensures that runoff is properly diverted away from the wall surface, reducing the risk of moisture intrusion behind cladding materials.

Outcome: The homeowners faced substantial repair costs due to these previously concealed defects. Architects neglected to detail this crucial roof-wall intersection clearly in the construction drawings, a critical lapse that went unnoticed during the permitting process. The competence and diligence of contractors and roofers were also questioned, as their practical experience should have alerted them to the potential for severe water intrusion, prompting them to raise concerns proactively. Furthermore, inspectors overlooked this detail during site reviews. This case highlights the necessity of rigorous oversight, detailed architectural documentation, and proactive communication among all stakeholders.

Roof Structural System Damage Due to Air Barrier Discontinuities and Inadequate Attic Venting

Problem: A 7-year-old, two-story, custom-built, single-family home in Ontario, featuring a flat-roof system, began to exhibit signs of attic moisture issues. Initial observations by the homeowners included intermittent damp patches and discoloration on ceilings, coupled with a persistent musty odor that intensified during colder months. Upon inspection and removal of the gypsum ceiling, a significant accumulation of water was discovered within the attic space. This condition became evident when an incision was made through the polyethylene vapor barrier, resulting in water actively draining from the attic area. The

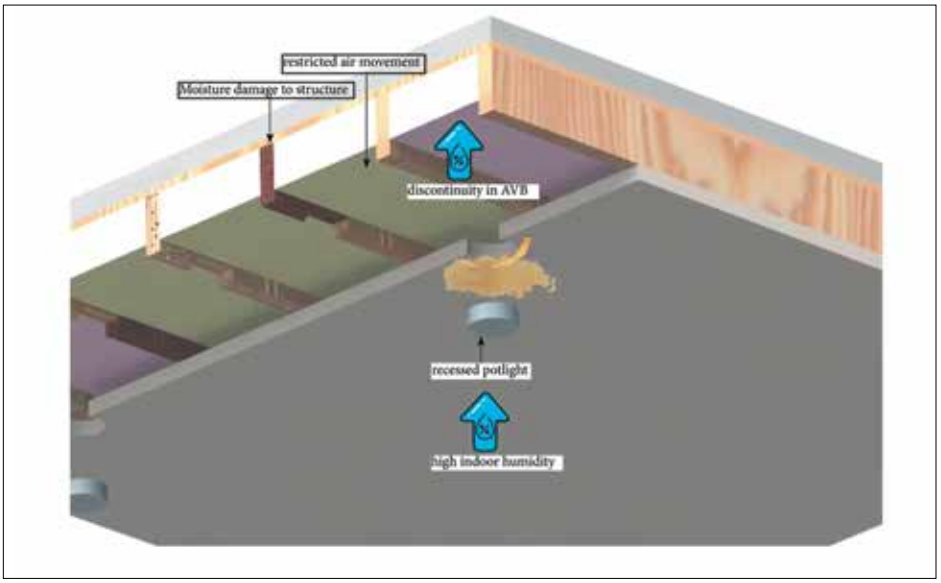


Figure 4. *Roof structural system condensation damage due to air barrier discontinuities and inadequate attic venting.*

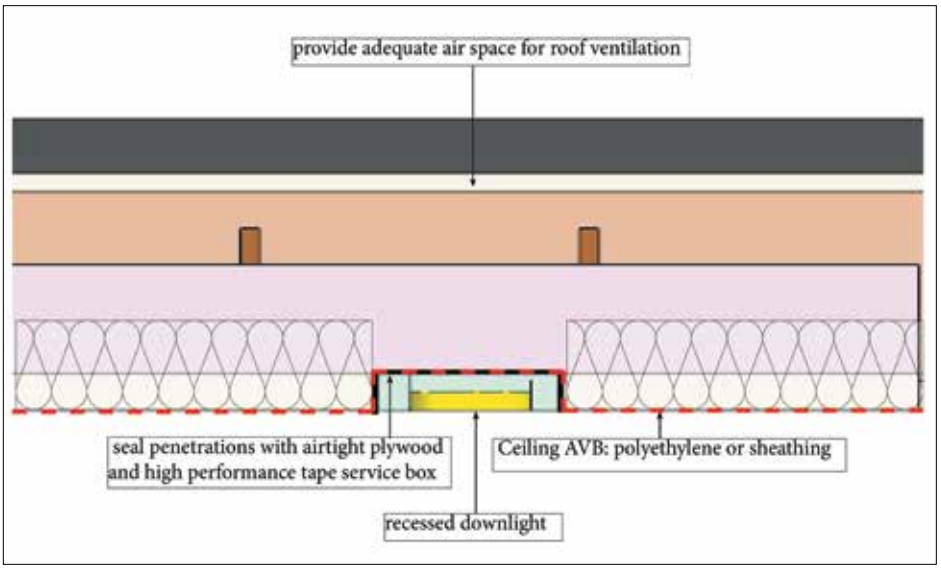


Figure 5. *Seal penetration of recessed downlight with airtight plywood and high-performance tape service box to prevent heat and air bypass.*

presence of extensive moisture accumulation indicated a critical underlying issue requiring immediate engineering assessment and remediation (**Fig. 4**).

Forensic Investigation Findings: A forensic investigation utilizing both visual and destructive inspection methods revealed significant concealed damage within the attic space. Severe decay resulting from condensation was evident on roof joists and plywood sheathing, indicating prolonged moisture exposure. Additionally, the home's interior environment exhibited high humidity levels and substantial air movement facilitated by the HVAC system. The investigation confirmed that the compromised polyethylene air and vapor barrier allowed indoor humidity to infiltrate the attic, where it condensed upon cooler surfaces.

These moisture issues coincided with recent interior renovations, specifically ceiling height modifications and the installation of new lighting fixtures, which inadvertently punctured the polyethylene barrier and compromised its continuity. Although the attic featured standard soffit ventilation, improper installation practices and compressed insulation materials obstructed these vents, severely restricting airflow and trapping moisture within the attic. Other areas of the home did not show similar moisture-related issues, indicating specific vulnerabilities associated with the flat-roof construction and recent modifications.

Outcome: The homeowners incurred substantial repair costs primarily due to their oversight in modifying the ceiling without adequately restoring the continuity of the air barrier. Additionally, the contractor was responsible for deficiencies in the roof ventilation system—specifically, constructing a roof cavity with inadequate space to ensure proper airflow and permitting batt insulation to obstruct the already limited ventilation pathways. These issues had not been identified during the inspection stage.

This case highlights the importance of homeowner awareness when making interior modifications that affect air barrier continuity, emphasizing the potential risks such changes pose to the integrity of the building enclosure (**Fig. 5**).

Inadequately Installed or Damaged Through-Wall Flashing Causing Water Leakage in the Basement

Problem: In a 10-year-old, single-family home with a brick masonry veneer exterior, the homeowners reported water leakage in the basement during moderate to heavy rainfall. The leakage was observed along the upper portion of the interior basement wall, particularly near the interface between the above-grade exterior brick cladding and the cast-in-place concrete foundation wall. Water staining, localized dampness, and efflorescence on the interior face of the basement wall were the initial indicators of moisture intrusion. These symptoms suggested an exterior enclosure failure near the wall transition (**Fig. 6**).

Forensic Investigation Findings: Visual and destructive inspections were conducted at the exterior wall assembly and the basement perimeter. Upon removal of select brick units and inspection of the drainage cavity, the investigation revealed that the through-wall flashing, intended to direct moisture outward at the brick-to-foundation transition, either had slipped out of position or had been improperly installed. The flashing material used was a flexible-membrane-based material, which was found to have delaminated or displaced over time. In some locations, the flashing was reverse-lapped over the weather-resistive barrier, allowing water to migrate behind it rather than being expelled through the wall face.

Additionally, the weather-resistive barrier was not properly integrated with the

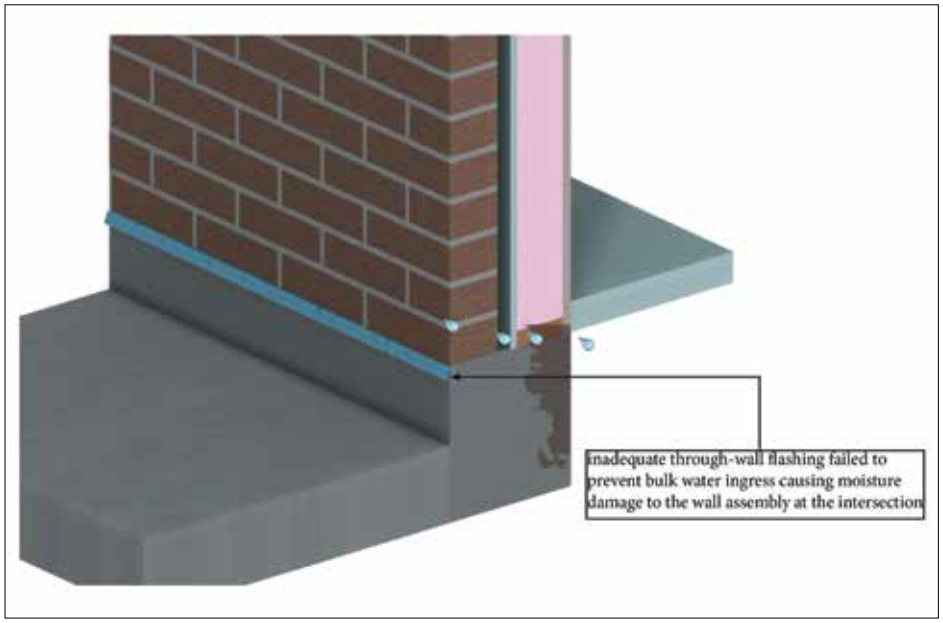


Figure 6. *Inadequately installed through-wall flashing causing water leakage in the basement.*

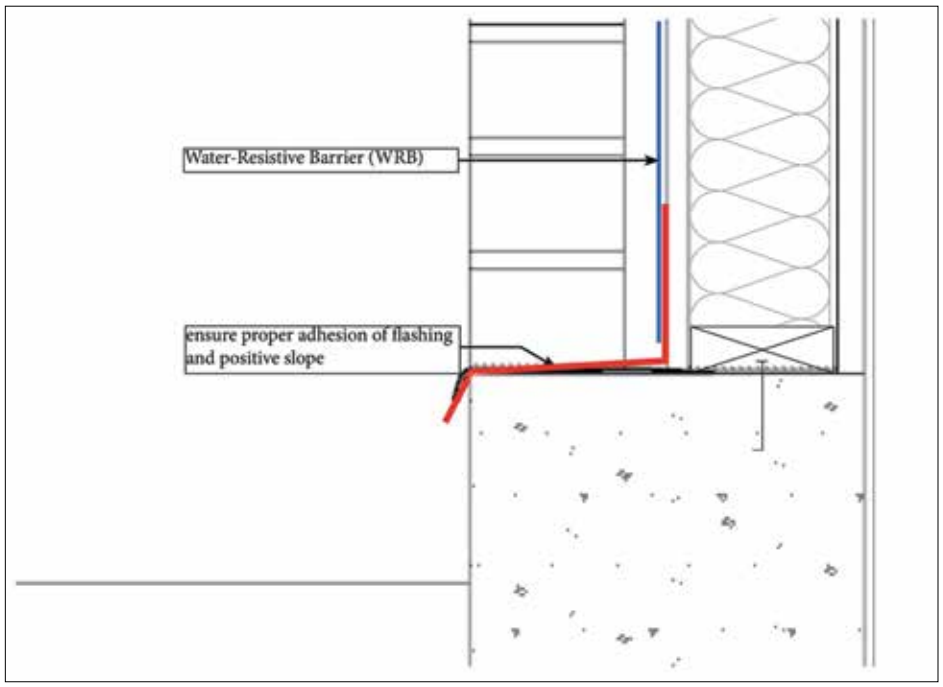


Figure 7. *Stakeholders must ensure the water-resistive barrier is properly integrated with the flashing and the flashing is securely fastened at the transition.*

flashing, and there was no termination bar or mechanical fastening to secure the flashing at the transition (**Fig. 7**). As a result, water penetrating the brick veneer through porous mortar joints or microcracks was able to travel down the cavity and bypass the compromised flashing. The water then infiltrated at the critical junction between the exterior wall and the top of the foundation, leading to basement leakage.

Outcome: Responsibility for the failure rested primarily with the masonry subcontractor, who failed to properly install and secure the through-wall flashing and to ensure it was lapped correctly with the weather-resistive barrier. The use of an unreinforced membrane-based flashing without mechanical support contributed to the material slipping over time. This issue was also missed at the inspection stage. The oversight led to ongoing water entry, basement wall dampness, and potential deterioration of foundation wall interfaces.

LESSONS LEARNED

These case studies highlight the critical importance of rigor and meticulous attention to detail across all phases of the building process. Each case demonstrates that lapses at specific stages, whether they occur during the design, construction, inspection, or occupancy stage, can contribute to building enclosure failures (**Fig. 8**).

Architectural Drawing Stage

Design professionals must visualize not only the aesthetic and functional aspects of design but also how water interacts dynamically with building components. In the section "Water Damage on an Intersecting Wall," the absence of a detailed kickout diverter flashing at a critical roof-wall intersection led directly to extensive moisture damage due to the unique geometry of the building interface. Detailed drawings should explicitly indicate such critical components, ensuring their locations and installation requirements are clearly articulated to avoid misinterpretations or oversights by contractors.

Permitting Stage

City permitting reviews should critically examine the completeness of submitted drawings with explicit attention to water management details. The oversight in the sections "Water Damage on an Intersecting Wall" and "Inadequately Installed or Damaged Through-Wall Flashing Causing Water Leakage in the Basement," where inadequate flashing installation resulted in bulk water-related damage, highlights the necessity for permitting reviews to catch incomplete detailing related to moisture management systems before construction begins.

Construction Stage

Contractors play a crucial role in accurately translating design intent into construction. As demonstrated in the section "Water Damage on an Intersecting Wall," reasonably competent and trained parties would have identified these issues at the outset or promptly raised a site query. Trades must rigorously adhere to industry best practices and manufacturers' guidelines, and contractors should foster an environment that encourages clear communication whenever specifications are unclear or incomplete.



Figure 8. *Each stage of a building's life cycle plays a part in adhering to building science principles and ensuring the durability of building details.*

Inspection Stage

Inspections represent critical checkpoints where construction compliance must be verified rigorously. In the section "Water Damage on an Intersecting Wall," the absence of necessary flashing went unnoticed by inspectors, highlighting the importance of thorough inspection of vulnerable components, such as flashing, barriers, and drainage details. Enhanced training for inspectors in identifying early signs of moisture intrusion and detailed checks of vulnerable intersections can significantly reduce the likelihood of overlooked deficiencies.

Occupancy and Homeowner Stage

Homeowners should be provided with comprehensive guidance, including manuals detailing maintenance requirements and signs of potential enclosure failures. The section "Roof Structural System Damage Due to Air Barrier Discontinuities and Inadequate Attic Venting" highlights the importance of homeowner education, showing how unauthorized interior modifications can inadvertently compromise critical barriers. Early detection and informed intervention can prevent minor issues from escalating into significant structural damage.

CONCLUSION

As weather extremes become more frequent and severe, buildings are increasingly exposed to intense rainfall, wind-driven moisture, freeze-thaw cycles, and prolonged humidity. These environmental stressors amplify the risk of enclosure failures, making it essential that every stakeholder, from design professional to homeowner, understands their role in safeguarding building performance. In an era marked by economic uncertainty and inflationary pressures, the financial cost of remediating preventable failures is rising sharply. Poorly managed water intrusion can lead to mould, rot, and structural compromise, which are issues that often remain hidden until significant damage prompts forensic investigations, insurance claims, or litigation. For developers and homeowners alike, the consequences are severe: costly repairs, delayed occupancy, reduced property value, and increased legal exposure.

In this context, this paper's lessons drawn from recent case studies take on heightened significance. They demonstrate that successful enclosure performance depends on more than just good intentions; it requires meticulous design detailing, proactive permitting reviews, vigilant construction oversight, comprehensive inspections, and informed homeowners. Each phase of the building process represents a critical opportunity to intercept failure before it occurs. Effective communication, clear delineation of responsibilities, and strict adherence to building science principles are essential not only to ensure resilience but also to manage financial risk in an increasingly unpredictable weather and economic landscape.

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ABOUT THE AUTHORS



JAVERIYA HASAN

Javeriya Hasan, *PhD, PEng, PMP, is an associate in the Civil & Structural Engineering and Building Science & Building Envelope groups at 30 Forensic Engineering in Toronto. She specializes in building enclosure forensics, risk engineering, and causation analysis within insurance and legal contexts. Her work focuses on determining the root causes of enclosure failures after they occur and communicating those lessons to improve design and construction practice. She also teaches Existing Building Forensics in the Department of Architectural Science at Toronto Metropolitan University.*



JEFF REITSMA

Jeff Reitsma, *PEng, is vice president and practice lead of 30 Forensic Engineering's Construction group, with nearly 25 years of experience in the engineering consulting and construction industries. Reitsma specializes in leadership of multidisciplinary forensic investigations and post-loss remediation projects nationwide and has led design and construction teams for some of the biggest engineering firms in North America. He has overseen municipal capital infrastructure projects from conception to completion and has designed and directed indoor air quality, catastrophic loss response, and fire and flood impact remediation projects. He is an Ontario Dispute Adjudication for Construction Contracts–registered adjudicator supporting dispute resolution under the Construction Act in Ontario.*



HITESH DOSHI

Hitesh Doshi, *PEng, is a professor in Toronto Metropolitan University's department of architectural science. He has over 35 years of experience educating and training professionals in building science. He has 40 years of experience practicing building science, with a focus on performance of building enclosure systems. He has contributed to knowledge on rooftop systems, such as urban farms, green roofs, and blue roofs. He has also been involved in advocacy work through regulatory warranty and builder authorities.*



CLAIRE TAM

Claire Tam *is a building science consultant specializing in building enclosure component modelling and performance analysis at Stantec. She applies her architecture and building science background and passion for high-performance enclosure detailing to evaluate building performance and sustainable design strategies. She is adept at using multiple simulation tools for two- and three-dimensional thermal, hygrothermal, whole-building energy, and Passive House design.*

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