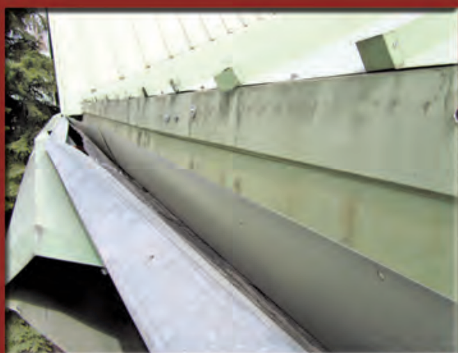
DESIGNED TO FAIL:

Three Case Studies Illustrating Common Exterior Wall Practices Guaranteed to Leak



By Lurita McIntosh Blank

ABSTRACT

Moisture is the primary perpetrator in building enclosure failures; we spend an inordinate amount of time in our professional practices designing waterproofing systems, and leaks are the number-one complaint of building occupants. Yet time and again, the same poor design choices are employed to manage water in the exterior wall, resulting in uncontrolled moisture infiltration. Three case studies are presented, each illustrating common water management details with known and documented histories of failure:

- A new elementary school with single-wythe block walls experiencing virtually uncorrectable leakage
- A healthcare facility battling extensive leakage through the integral gutter and pervasive mold growth in the exterior wall
- A high-end commercial building experiencing severe deterioration of the exterior wall system and mold growth because of flashing issues

This article will be of interest to all design professionals whose practice involves the building envelope and will provide guidance on how to identify and avoid common, deficient water management details.

INTRODUCTION

Failure of water management systems is the bane of construction professionals in every facet of the building industry. Litigation involving building leakage is among the most common claims made against new construction, affecting both designers and contractors. While leaks in new buildings are often indicative of construction defects, the insistent use of failure-prone detailing on the design side is equally to blame.

This article will present three projects from Walter P. Moore's Diagnostics Group in which water infiltration has led to costly and invasive repairs of the exterior wall system because of underperforming water management systems. None of the buildings in these case studies is extraordinary; quite the opposite, they are unglamorously ordinary in design, function, and use. However, it is precisely their commonplace nature that necessitates discussion of the inherent deficiencies of the three widely implemented water management systems presented herein.

"F" IS FOR FAIL: SINGLE-WYTHE WALLS AND PLASTIC PAN FLASHING

In 2012, our group was engaged by the construction manager of a recently completed elementary school. Pervasive leakage through the block walls had brought the project team and owner to the brink of litigation. The new school was constructed to provide state-of-the-art facilities for its award-winning early-learning programs, and the ongoing water infiltration became a political issue within the school district.

The exterior walls were single-wythe, integrally insulated architectural concrete block. Interior finishes were directly applied to the inside face of the block. Efflorescence began almost immediately at the exterior wall of the gymnasium, appearing at mid-height of the wall. As the efflorescence worsened, infiltration of liquid water began, both at the gymnasium and in numerous other locations around the building, damaging interior finishes and furnishings. Certain architectural features appeared to coincide with leakage locations: bond beams, exterior grade, parapets, and changes in wall plane or geometry. Critical review of the construction documents and limited investigation on-site revealed that nearly every water infiltration point shared one feature: flashing.

Single-wythe walls are by themselves troublesome to waterproof efficiently; the lack of drainage plane, the porosity of concrete block, and the inability to install true through-wall flashing all contribute to the susceptibility of these systems to water infiltration. At the elementary school, the embedded flashing system was a modular polyethylene pan flashing (*Figure 1*). The interlocking flashing pans are centered over the block cells and positioned so that the molded weeps are flush with the exterior face of the block. To maintain mortar bond between the block units—critical in a single-wythe wall system—the pan flashing is recessed approximately 1 in. from the faces of the block. The intention of the pan flashing is to allow rapid drainage of liquid water from inside the block cells.

Figure 1 – Plastic pan flashing exposed in an investigation opening.

Although the pan flashing was typically installed at industry-recommended locations within the exterior walls, the discontinuity of the flashing system allowed water to bypass the plastic pans at mortar joints, penetrations, mortar droppings, and, particularly, grouted cells (*Figure 2*). According to the design specifications and manufacturer product data, the architectural block was required to have been manufactured with an integral water repellant. Subsequent laboratory material testing failed to identify any integral repellents; additionally, the architectural block was found to have excessive pinholing. These two factors (which allowed rapid saturation of the architectural block) in combination with discontinuous flashing and a wall system inherently susceptible to leakage created an exterior wall that was unlikely *not* to leak.

Correction of the known deficiencies at the elementary school will not be possible without excessive reconstruction of the exterior walls. Remedial solutions, including coatings, have been discussed. At this time, the options are still under consideration by the project team.

While single-wythe block walls may never be considered ideal from a waterproofing or building enclosure performance perspective, it is neither practical nor practicable to globally preclude their construction. However, thoughtful design, coupled with comprehensive quality assurance measures during construction, must be employed to sufficiently protect the owner (and, consequently, the project team) against construction defects, especially leakage. Knowing the vulnerabilities of single-wythe block walls warrants careful consideration of the water management systems to be utilized; continuous and seamless flashings with back legs, end dams, weeps, and rigid drip edges are still the most efficient methods for controlling liquid water inside the wall system.

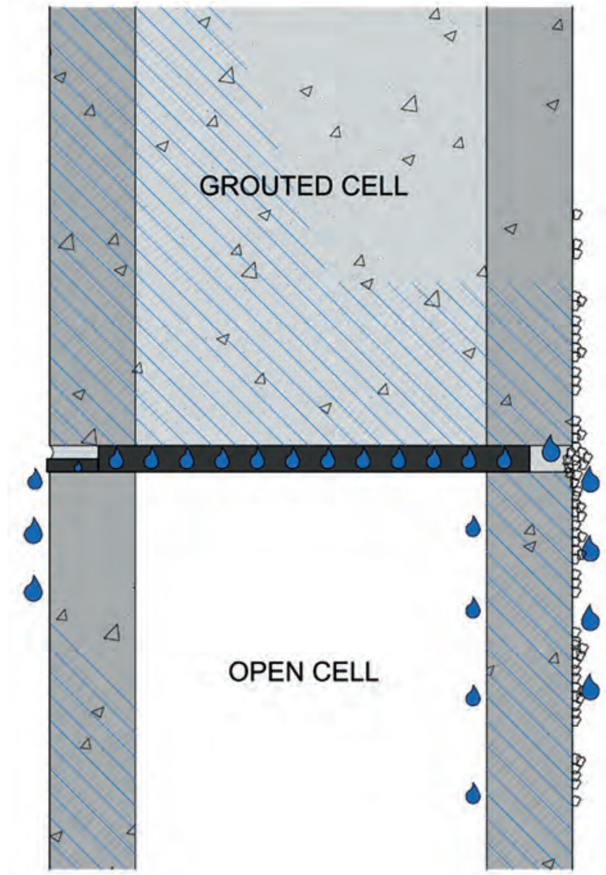


Figure 2 – Plastic pan flashing allowing water to bypass flashing at saturated block, leading to efflorescence and leakage at interior.

MOLD IS A FOUR-LETTER WORD: WHEN INTEGRAL GUTTERS ARE A BAD IDEA

Integral gutters (also called box gutters, built-in gutters, or eave troughs) are constructed into the roof framing rather than hung from the eave, and are typically located inside the plane of the exterior wall. In 2010, our group became involved with a residential care facility with systemic building enclosure issues, including massive water leakage through the integral gutters.

The facility had been experiencing water leakage through the gutters since opening. Haphazard repairs had failed to address the water infiltration issues, and mold growth was being identified across the entire facility, with the worst conditions being found in patient rooms directly under the integral gutters. A comprehensive assessment of the building enclosure using destructive investigation techniques, including partial disassembly of the existing gutter system, was necessary to identify all the failures contributing to the pervasive water infiltration.

Integral gutters can become a seemingly insurmountable problem when the system's serviceability is compromised. They are rarely designed with any secondary drainage or with waterproofing redundancy. Small flaws in the design or installation are readily magnified into full-system failures; and the expense and invasiveness of proper repairs prolong the opportunity for infiltrating moisture to damage adjacent components in the exterior wall, exacerbating deterioration and compounding ultimate repair costs. It is not unusual for a consultant to be contracted only after these secondary failures occur, as was the case at the care facility.

While integral gutters usually rely on a seamless or soldered-seam liner to create a watertight assembly, investigation into the as-built construction at the care facility showed that the integral gutters were break-formed (*Figure 3*). A prefinished steel sheet liner was set into a galvanized steel trough with a loose-laid membrane flashing sandwiched between the two. Corners and seams were left unsealed, and the mem-

Figure 3 – Integral gutter in place (left) and at beginning of exploratory demolition (right).

Figure 4 – Mold growth and damage to wall components under and behind integral gutter.

brane flashing was not integrated into the downspouts nor formed into end dams. Water that entered the integral gutter had free range to migrate through open seams or out the ends of the gutter and flow past the membrane flashing. Because the gutters were positioned inboard of the cladding, water saturated the gypsum sheathing and fiberglass insulation. Unfortunately, the long-term leakage had also created the perfect microclimate for uninhibited mold growth, an intolerable condition at a medical facility (*Figure 4*). In addition to the hard costs of the repairs, the facility is also challenged with hazardous-material abatement, infection-control requirements, negative publicity in the local community, and a significant impact on the daily lives of the residential patients.

Permanent repairs to the existing gutter construction were not feasible. Solutions involving modification of the design and reconstruction of the integral gutter were explored but ultimately rejected by the project team. The preference was to remove the integral gutter system entirely. As part of the roofing and cladding replacement project currently under construction, the integral gutters will be removed, the eave structure extended, and commercial-grade hung gutters installed at the roof edge, outside of the plane of the exterior wall.

Although the construction of the integral gutter at this project was atypical, in many usages, integral gutters have the proclivity toward seam failure and hidden leakage. Copper is the most common material for soldered-seam liners. When properly designed and installed, a soldered copper liner has an extraordinary service life—50 to 100 serviceable years with minimal maintenance would not be unexpected. Unfortunately, soldered roofing is a declining skill, and in many parts of the country, finding experienced and talented installers is a challenge. Additionally, the design of an integral gutter is necessarily complex, particularly concerning accommodation of thermal movement. Alternate options employing high-build coatings, polymers, and membrane flashings simply cannot match the service life or durability of a metal liner. Finally, integral gutters suffer from the very characteristic that makes them so attractive: invisibility. Concealed leakage is a metastasizing failure. Unless active water infiltration is observed at the interior, it may be months or years before issues with the gutters become known.

Figure 5 – Fake drip edge inserted into the joint. The contractor must have forgotten to install the stainless steel drip.

Are integral gutters unsuitable for every building? To state so would be an oversimplification of a complex system that does indeed have many advantageous qualities. The answer lies somewhere amidst the experience of the designer, the availability of skilled labor, the appropriateness of the application, and the consequences of failure. If any of these variables factor heavily toward the negative, integral gutters would best be avoided.

FLASHING FOIBLES: THE RESISTANCE TO DAYLIGHTING DRIP EDGES

Flashing has the unfortunate idiosyncrasy of being both the most critical component of the building enclosure and yet the least respected component of the building enclosure. Any professional working in diagnostics or renovation can readily call to mind a dozen recent projects where improper or inadequate flashing was unequivocally associated with water infiltration, and through-wall flashing is a notorious offender. In our practice, we regularly provide third-party quality assurance review—sometimes called building enclosure commissioning—for new construction during the design phases. Comments that can consistently be applied to these projects invariably involve through-wall flashing, with particular reference to the necessity of an exposed drip edge (*Figure 5*).

Figure 6 – No drip edge at existing flashing (left) allowed water to saturate the exterior walls (right).

In 2013, our group was engaged by an architectural firm in the midst of the renovation of a corporate headquarters. Mold growth at the exterior walls had been unexpectedly encountered during demolition, delaying the project schedule and incurring unbudgeted remediation costs. As interior finishes were removed to assess the extent of the mold, the project team came to the realization that the moisture infiltration that facilitated the mold growth was a global issue. Destructive evaluation at numerous places across the interior and exterior revealed a number of deficiencies in the existing flashing at shelf angles and the foundation—most notably, the short horizontal leg of the flashing and the lack of a drip edge to direct water out of the cavity. Long-term water leakage had also severely deteriorated the gypsum sheathing and metal wall studs at grade (*Figure 6*).

The project team was in complete agreement that installation of a new flashing system at all façade locations was a necessary action. Repairs of this nature are exceedingly expensive and very disruptive, requiring removal of at least four courses of brickwork to access flashing locations. Noise and dust are always troublesome, and sourcing replacement brick units that

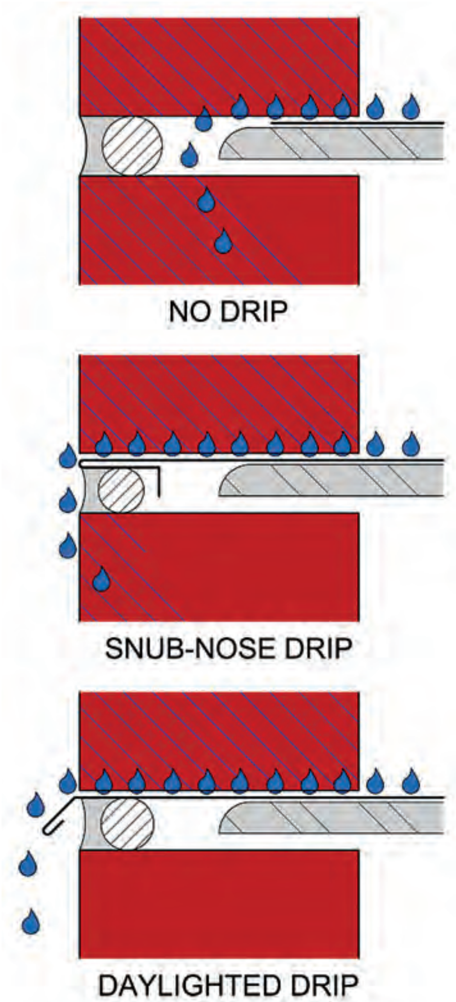


Figure 7 – How the design of the drip edge impacts the shedding of water from the wall system.

will blend with the existing masonry is a challenge at which it is not always possible to be successful. Although the project team had settled on the scope of remedial work, one component of the proposed flashing repairs was only hesitantly adopted: our recommendation that the new flashing have an exterior drip edge.

For flashing repairs, our typical approach involves a multi-ply membrane flashing with a stainless steel drip edge that extends beyond the face of the masonry. Resistance to a daylighted drip edge is a common response from architects and clients, the concern being that the exposed drip edge will be a visual disturbance. Various workarounds to daylighting the drip edge have been proposed: terminating the flashing at the face of the masonry, turning the flashing edge back into the joint, and even concealing the edge of the flashing behind mortar or sealant with the false assumption that the weeps will provide sufficient drainage (*Figure 7*). None of these alternate drip designs fully address the fundamental need for flashing to physically isolate liquid water within the wall system and force that water to exit the wall.

While most industry associations firmly support the need for flashing to incorporate an exterior drip, it remains wholly uncommon to find such drip edges detailed into through-wall flashings for new construction; and many designers are unwilling to agree to what they perceive as a compromise in aesthetics for purported improvement in waterproofing performance. Exposed drip edges need not be perceived as a scar on the façade of an otherwise lovely building; there are numerous design solutions that can be used to camouflage flashings if water management systems are taken into consideration early in the design process.

LESSONS LEARNED

Water infiltration does not happen in a vacuum and is rarely attributable to any single fault; not one of these case studies' failures occurred in an otherwise perfectly designed or perfectly constructed building. However, recognition and avoidance of commonly used and highly failure-prone water management detailing is an underutilized weapon in the architectural designer's arsenal.

Lurita McIntosh Blank

Lurita McIntosh Blank is a materials conservator with Walter P. Moore's Diagnostics Group in Kansas City, Missouri, where she is a core member of the building enclosure practice, focusing on faulty building enclosure systems and façade restoration. She has performed dozens of assessments and investigations into water leakage and waterproofing issues with a specialized insight into the integration of detailing and materials. She is also deeply involved with the Association for Preservation Technology, acting as current chair for the Central Plains Chapter and serving on its board of directors.

Crane Lifting Roof Collapses on São Paulo Arena

With Brazil under pressure to complete a stadium scheduled to host the 2014 World Cup opener on June 12, workers may have bypassed some safety issues that resulted in the collapse of a crane that was lifting a 500-ton metal structure on top of the new Arena Corinthians in São Paulo. Two workers were killed when the crane buckled, dropping the weight on top of the structure, clipping part of the roof, and cutting through a huge LED panel that runs across the venue's outer façade. The enormous metal roofing piece stayed atop part of the stands. The world soccer organization, FIFA, had set a December deadline for the stadium to be completed. The stadium's structure is said to not be compromised.

— *AP* and other sources