

FLASHING OF CURTAINWALL AND STOREFRONT SYSTEMS IN COMMERCIAL APPLICATIONS

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ABSTRACT

Flashing of high-end commercial and institutional curtainwall and storefront systems is traditionally a combined effort of the project architect, the installation contractor, and the system manufacturer. Frequently, however, details provided by the architect or the manufacturer fall short, leaving the flashing to be installed in the field without forethought to design. The purpose of this presentation is to provide insight into proper flashing techniques for both curtainwall and storefront systems that can be used proactively by participating parties to ensure the integrity of the building envelope is preserved when constructed.

SPEAKERS

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DAVID CANNON, AIA, has over 35 years of experience as an architect. He has been involved in the design and creation of construction documents, as well as construction administration for several different building types. These include retail, mixed-use developments, high-rise hotels, office buildings, university buildings, medical buildings, regional malls, multifamily housing, industrial buildings, and churches. His primary areas of research and expertise have been in building envelope design and construction, building code analysis, and evaluation of the “standard of care” for architects.

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MATTHEW SMITH, AIA, has over 10 years of architectural design and forensic architecture experience. He has performed forensic evaluations of buildings throughout the United States and been involved in the design and project management of multiple healthcare projects. Smith’s primary areas of focus and expertise include building envelope and flashing systems, window systems, stucco and EIFS veneer systems, architectural design and detailing, and review of building codes and accessibility standards.

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INTRODUCTION

Flashing of high-end commercial and institutional window wall systems (curtainwall and storefront) is traditionally a combined effort of the architect, the installation contractor, and the system manufacturer. However, during the design phase, when the overall building envelope is being developed by the architect, the process for the installation of the window wall system flashing is often left uncoordinated and under-designed. Even though the details of the window wall system provided by the manufacturer are typically very product-specific, they lack instructions for integrating the window wall system's flashing with the other elements of the building for a particular project. Therefore, it becomes the architect's responsibility to coordinate these details to create a complete overall building envelope.

Water intrusion caused by improper flashing can result in recurring moisture staining, interior finish distress at and below the window system, corrosion and deterioration within the wall assembly, and, in extreme cases, section loss in the structural members.

Properly installed window wall flashing will prevent moisture intrusion, be realistically buildable in the field, and prevent the need for excessive maintenance by the building owner. Designing and installing flashing for the appropriate window wall system type is the best approach to prevent water intrusion and maintain the integrity of the building envelope.

BACKGROUND

While curtainwall and storefront are both commercial window wall systems, their background, typical building applications, and internal drainage systems are somewhat different. Conceptually, curtainwall was designed to be a major portion of an overall building envelope system, and storefront was originally designed as a mere infill component of the building envelope.

The development of steel and concrete structural frames during the early twentieth century enabled building designers to abandon

height-restricting perimeter bearing walls and use the exterior walls as a skin or building envelope, used to protect the interior of the building from the elements. Therefore, curtainwall systems were developed as non-load-bearing walls to hang on the side of multistory buildings like a "curtain."

Curtainwalls are designed to be attached to the sides of a building's structural elements (e.g., concrete floor slab edges) and hang from the building's structure, spanning from floor to floor. Even though curtainwalls do not carry the building's vertical loads, wind loads create a necessity for horizontal structural resistance to be designed into the curtainwall system. In order to accomplish this, the horizontal mullions are typically framed into vertical mullions that are structurally sized to carry the wind loads and accommodate the floor-to-floor span. This configuration is easily recognizable in multistory building lobbies, where the vertical mullions are usually larger in size than the horizontal mullions. Depending on the desired aesthetic considerations, curtainwall systems can be infilled with a combination of vision or opaque (spandrel) glass, or a variety of other materials, such as stone or metal panels.

As opposed to the overall building envelope-enclosing concept of curtainwall systems, storefront systems were originally created to be used as storefront windows for retail displays. Storefront systems are typically designed to be installed at and around ground-floor entrances; between floor slabs; and/or as punched or ribbon windows within independent wall systems, such as masonry, stone, or stucco. Since storefront systems lack the design sophistication of curtainwall systems and have minimal horizontal load-carrying capacity, the height of each section of a storefront installation is commonly limited to approximately 10 feet.

Curtainwall Construction

The installation of curtainwalls involves either a stick-built process, unitized process, or some combination thereof. Stick-

built systems are assembled in the field, allowing the curtainwall to be adjusted to accommodate as-built conditions. Unitized systems are prefabricated and shipped to the construction site in large sections. Therefore, unitized curtainwall systems require less labor on site. However, unitized systems offer less installation flexibility and require adherence to more stringent construction tolerances.

Water management within both systems can include weeps and sloped glazing pockets. Due to their higher achievable height, contemporary curtainwall systems have been designed to drain water that accumulates in the framing system's internal components out to the exterior at each individual horizontal mullion, rather than allowing it to travel down the vertical mullions and overload the sill. To achieve this, each horizontal mullion has its own separate set of weeps and zone dams installed to control the flow of water and prevent it from draining down the vertical mullion at each end (*Figures 1 and 2*).

Curtainwalls can be hundreds of feet in height, so it is important to have weeps in the horizontal mullions below each individual section of glass. An additional measure to direct water to these weeps, and away from the interior, is to slope the glazing pockets toward the exterior. Sloped glazing pockets promote proper management by diverting water to the weeps and mitigating the accumulation of water adjacent to the internal sealants and/or gaskets.

Storefront Construction

Storefronts are typically composed of similarly sized horizontal and vertical mullions with vision glass infill panels. Due to the smaller size of the units compared to curtainwalls, water that enters into the internal system is purposefully diverted to the vertical mullions to flow to the weeps at the sill. Therefore, the system relies heavily on properly designed and constructed sill pans, end dams, and flashing at the bottom of the system to catch this water and divert it to the exterior. Properly installing the sill pan's end dams and sealing all

Figure 2 – Curtainwall assembly installed with zone dams and weeps (without beauty caps).

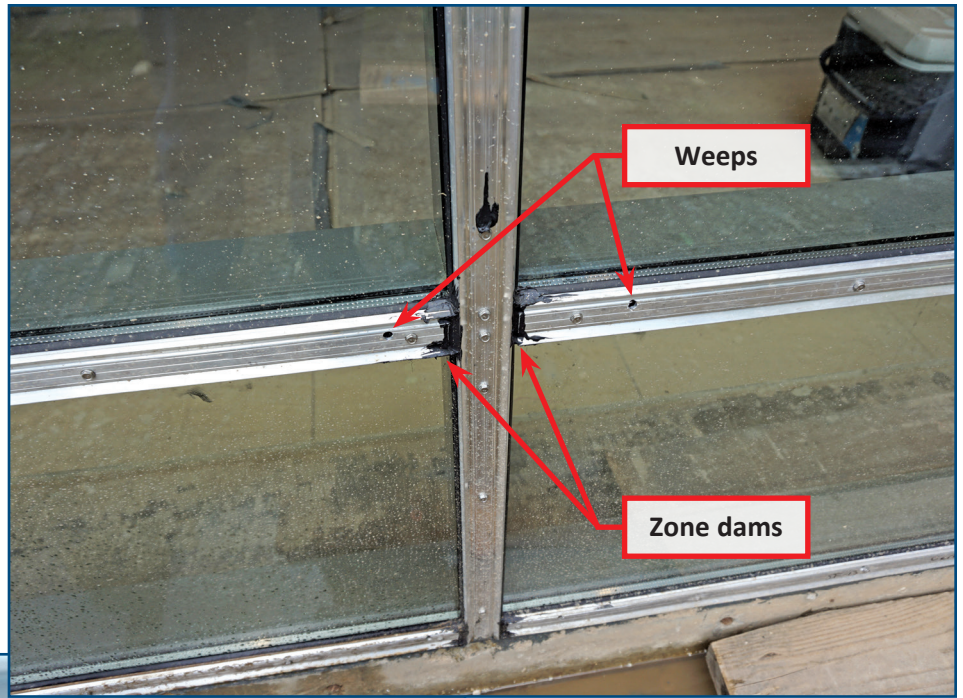
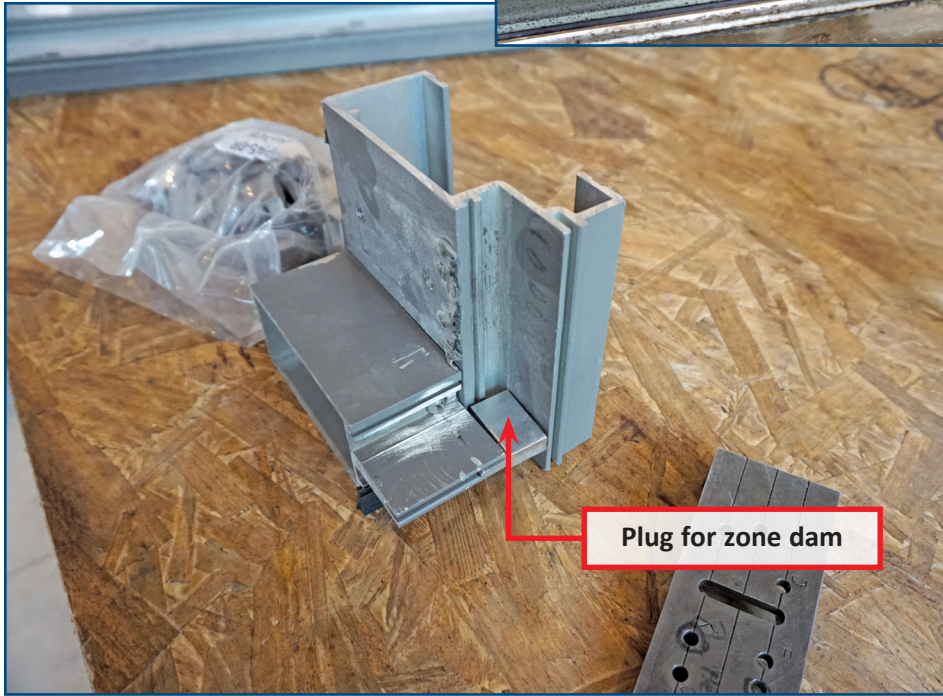


Figure 1 – Mock-up of typical horizontal and vertical mullion interface (without glazing and pressure bar).



related fastener penetrations is critical in preventing water intrusion at the jambs and sills of all storefront systems.

TYPES OF CLADDING SYSTEMS AND WEATHER-RESISTIVE BARRIERS

Exterior cladding of commercial buildings falls into one of two fundamental categories: barrier systems or drainage plane systems.

Barrier Systems

Barrier systems rely entirely on the impermeability of the exterior surface of

the cladding to prevent water intrusion. The interdependence of the exterior cladding with the sealant joints around the windows and doors creates the sole water-resistant barrier for the building. If either fails, water intrusion into the wall assembly will occur. Quality control for the installation of the barrier wall system, including both the sealant joints and the cladding, is difficult to regulate at the time of installation and through the life of the building. Because these components are exposed to the weather, the sealant and cladding become high-maintenance areas with short life expectancies. Therefore, a great deal of

monitoring and repair is required by the building owner to maintain the barrier system performance. Stucco and/or exterior insulating finish systems (EIFS) installed over certain types of wall systems can be constructed as barrier systems, along with various types of masonry, precast concrete panels, and tilt-up concrete construction.

Drainage Plane Systems

Drainage plane systems are designed to take on a limited amount of moisture through the cladding material, stop it with a secondary drainage plane, and redirect it to the exterior. A weather-resistive barrier (WRB) is typically installed behind the cladding material to create this secondary drainage plane. Usually, WRB materials are applied to the wall substrate to create the continuous drainage plane before the installation of the cladding material. Since this type of system is designed to stop moisture at the WRB, proper design and installation of sealant, flashing, and trim are critically important at locations within the WRB that are susceptible to water intrusion.

Gravity flow directs moisture that accumulates on the surface of the WRB down the wall until the WRB is interrupted, such as at a window head, door head, roof, parapet end wall, at grade, etc. At these terminations, through-wall flashings and weep openings are installed to divert water out of the wall assembly to the exterior.

Common masonry drainage plane sys-

tems consist of (from exterior to interior): masonry, an airspace/drainage cavity, a surface-applied WRB, exterior sheathing (with continuous insulation if required), some type of stud wall framing infilled with insulation, a possible interior vapor barrier (depending on the climate), and interior finishes. EIFS or stucco veneer drainage plane systems are typically built with the same order of building elements. While an “airspace/drainage cavity” is not used in this type of system, the WRB still functions as the drainage plane behind the exterior cladding.

Weather-Resistive Barriers

As indicated earlier, a WRB is the primary element in a successful drainage plane system. The WRB can be sheet-applied, such as building paper (felt paper) or housewrap; fluid-applied; or part of a coated sheathing material. Proper design and installation of the WRB is critical for the building envelope to perform successfully. Manufacturer’s instructions are detailed and specific regarding the installation of the WRB; however, integration with other building components for a specific project is not provided. The lack of such detailed guidance is attributable to the varying conditions of each building.

PROPER FLASHING

In a drainage plane system, the proper integration of window wall flashing to the WRB is crucial for preventing water intrusion and related ongoing interior and exterior maintenance issues. Without a proper flashing installation, the building envelope becomes solely reliant on a bead of sealant to prevent water intrusion around the openings. At times, the rough opening surrounding window wall systems can produce gaps at the head, jamb, and/or sill that are too large to be properly spanned by sealant alone. Relying exclusively on a sealant bead, exposed to the harshness of the elements, is not desirable for a long-term successfully performing building—particularly considering that exterior sealants have an average lifespan of 10-15 years (WBDG 2016). In addition, in certain climates, the expected lifespan of sealants is much lower and, if not properly installed, could fail during the first few years of service.

For the window wall flashing, membrane-flashing materials (membrane flashing), such as ethylene propylene diene

monomer (EPDM) or any silicone-based material, are good products to use for reliable long-term waterproofing.

Curtainwall Flashing

Construction sequencing is essential for the proper interface of the WRB, flashing, and window wall system. The first step in

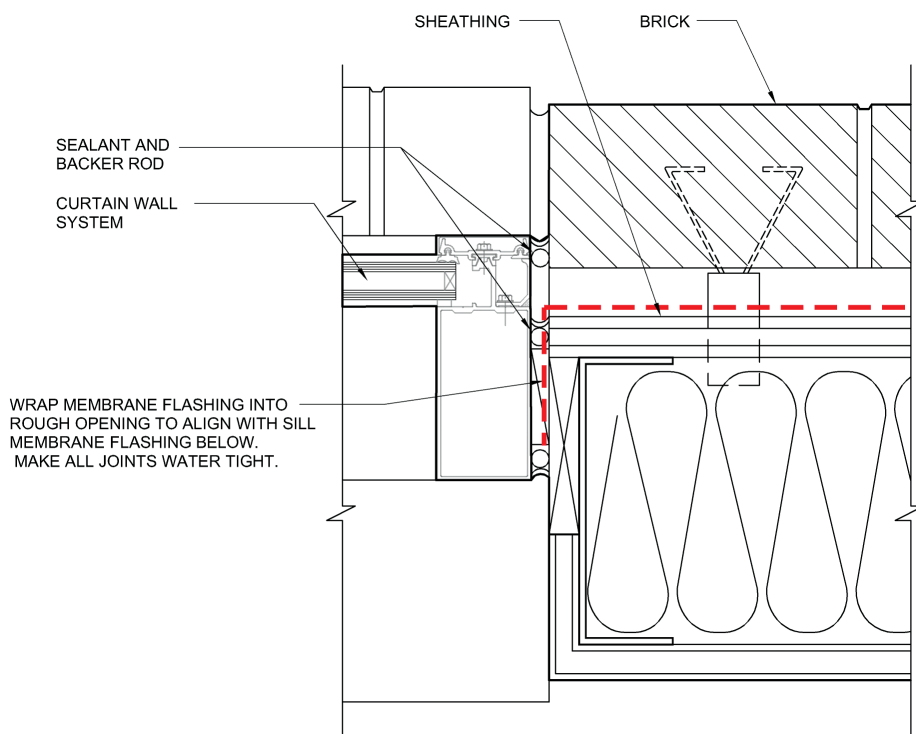


Figure 3 – Typical curtainwall jamb section detail.

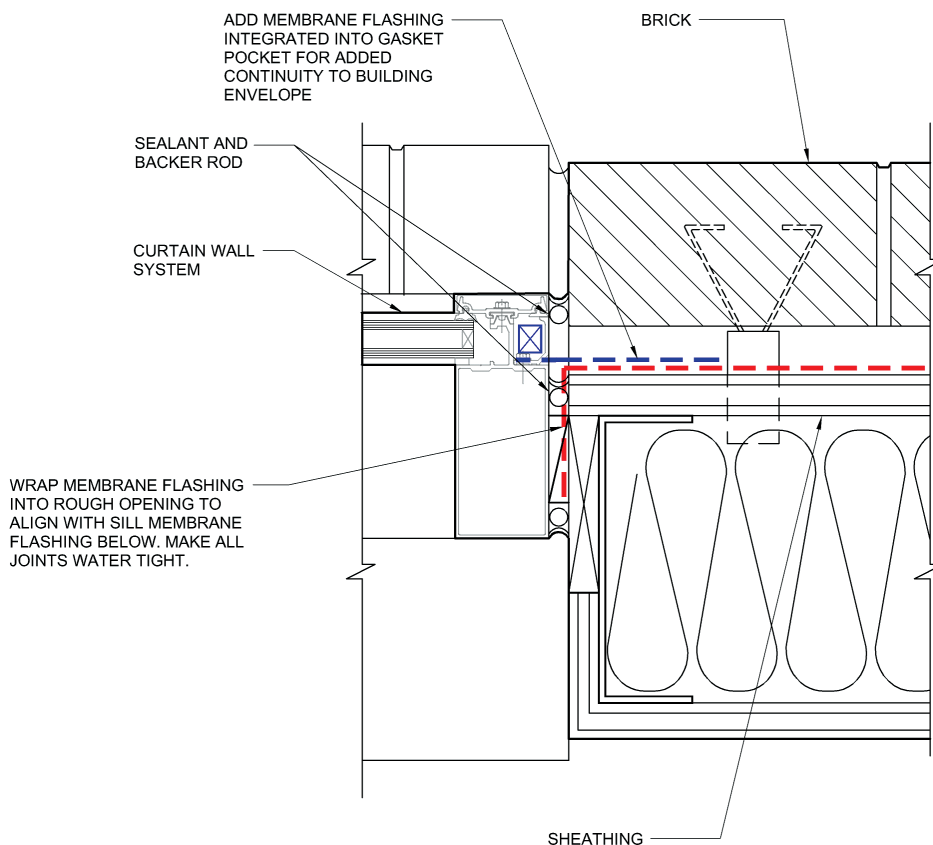


Figure 4 – Typical curtainwall jamb section detail with gasket pocket flashing.

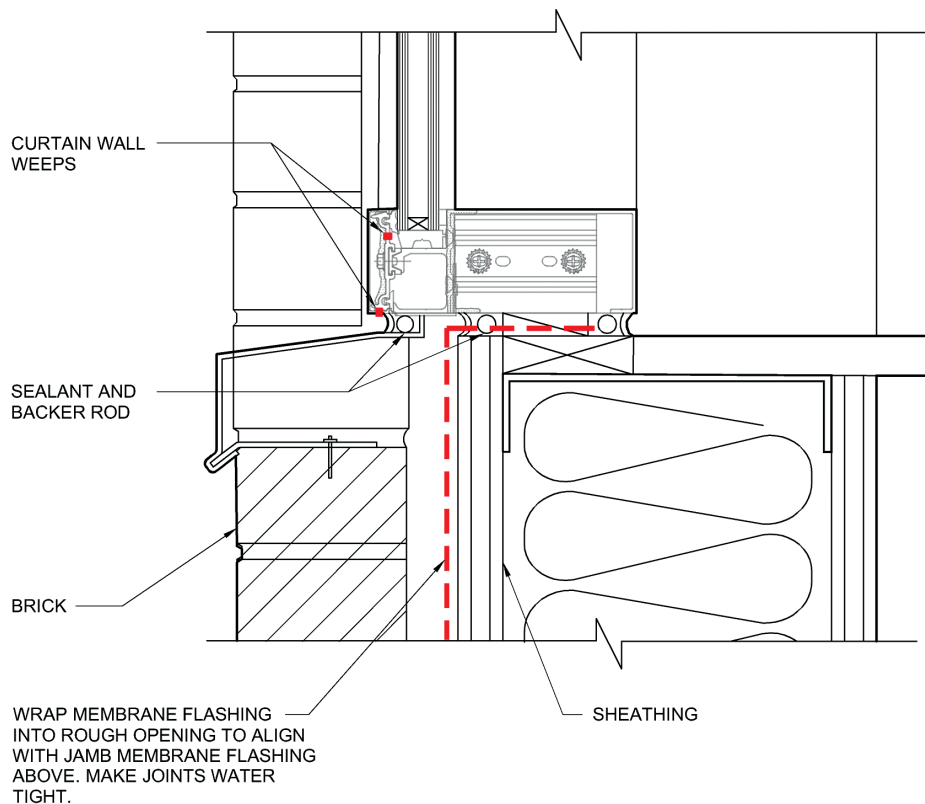


Figure 5 – Typical curtainwall sill section detail.

creating a continuous and integrated WRB and flashing system at curtainwall openings is to install the WRB (or membrane flashing integrated with the WRB) wrapped into the rough opening. This protects the rough opening from water damage and improves the durability of the interface. Wrapping the flashing at the rough opening should be done prior to the curtainwall system being installed. In many instances, the curtainwall and the surrounding rough opening are then sealed together with one or two sealant joints. If installed properly, this sealant will prevent water from entering the curtainwall opening (*Figure 3*).

To go one step further, for stick-built systems that have accessible glazing pockets, installing membrane flashing into the glazing pocket and then integrating the flashing to the WRB provides added protection to interior water intrusion around the curtainwall rough opening. Care should be taken to ensure that shingle-lapping of the flashing is achieved and the proper amount of flashing is installed in the glazing pocket to prevent wrinkling of the membrane. Refer to *Figure 4* for proper integration of the flashing, WRB, and curtainwall in this design solution.

The configuration of the head detail at

the curtainwall is dependent on the exterior cladding; however, the principles of diverting water to the exterior are the same. A properly flashed and weeped WRB termination at the head of the curtainwall is important to prevent water from collecting and migrating to the interior. Depending on the type of cladding, a drip cap installed at the head of the storefront can be used to divert water away from the head of the window system. In addition, shingle-lapping the WRB and membrane flashing with a lintel, if present, is also important to prevent water from migrating to the interior.

The sills of curtainwall systems are common locations for interior water intrusion issues. While a sill pan is not necessary in curtainwall construction, the inclusion of sill flashing provides an added layer of protection from water intrusion at the base of the opening and can better integrate the WRB with the curtainwall system. The sill flashing should prevent water accumulation at the interior stool and not block the weeping system of the curtainwall. To prevent water accumulation within the interior of the frame at the base of the curtainwall, the installer needs to ensure that the sealant is not blocking the weeps in the base of the mullions. A

detail of typical curtainwall sill flashing is provided in *Figure 5*.

Storefront Flashing

Due to the higher quantity of water collected at the sill from a storefront's internal drainage system, a sill pan is included below the sill to provide added surety against water intrusion into the building and a clear path for expulsion of the water to the exterior. End dams are added to the ends of the sill pan to prevent water collected at the sill pan from draining to the interior of the building at the bottom corners of the storefront system. When installed properly, the end dams are attached to the main sill pan in a bed of sealant. If possible, the selection of a sill pan with a positive slope can aid water drainage to the exterior.

Any openings caused by penetrations through the sill pan should be installed in an area subjected to minimal water and should be thoroughly sealed. In addition, the storefront installer needs to ensure that the interface of the storefront frame and the outer edge of the sill pan are not blocked with sealant in order to allow proper drainage of the system.

At the jambs, membrane flashing should wrap into the rough opening and seal to the WRB. To integrate the sill pan with the jamb flashing, the flashing must be shingle-lapped to the sill pan over the vertical leg of the end dam, as shown in *Figure 6* and *Figure 7*. The details for the interface of the flashing membrane with the storefront are generally not included in the manufacturer's instructions. To avoid relying only on a sealant joint to integrate the storefront with the building envelope, the rough opening gap can be bridged by sealing a second section of membrane flashing to the jamb of the storefront and the WRB, similar to the gasket pocket curtainwall flashing approach.

Sealant at Window Wall Systems

Sealant joints are installed to seal the exposed joints between the building's exterior cladding and the heads, jambs, and sills of curtainwall and storefront systems. As stated earlier, care should be taken at sill conditions not to seal over the weeps in the horizontal mullion at the sill of a curtainwall system or the edge of the sill pan in a storefront system. Sealing these openings during initial construction or during maintenance activities will trap

the water collected from the curtainwall or storefront's internal drainage system and prevent it from draining to the exterior of the building.

To improve the longevity and performance of the perimeter sealant joints, a backer rod should be installed behind the sealant between the cladding and the window wall system. To accommodate the backer rod and ensure proper sealant installation, the joint between the cladding and the window wall system needs to be installed at least $\frac{1}{4}$ in. wide and follow a 2:1 joint-width-to-sealant-depth ratio for joints measuring $\frac{1}{2}$ to 1 inch in width. For joints measuring $\frac{1}{4}$ to $\frac{1}{2}$ inch in width, the sealant depth should equal the joint width; however, the installed condition must meet the manufacturer's requirements (ASTM E2112).

The Architect's Role at the Genesis of the Project

A combination of both sealant and membrane flashing that is properly installed will prevent water intrusion at the perimeter of curtainwalls and storefronts. The details provided by the window wall, flashing, sealant, and WRB manufacturers should be coordinated, evaluated, and approved by the architect collectively. While creating the building envelope details in the construction drawings and reviewing the shop drawings, the architect is responsible for ensuring that the overall integration of the WRB, flashing, and window wall are clearly indicated to convey the level of quality and design intent to facilitate proper construction. Furthermore, the installation of each element of the building envelope must be in accordance with the governing building codes, industry standards, and manufacturer's instructions.

Ideally, drawings fully detailed with each recommended product are provided by the architect when the construction documents are created. Then the final products selected are coordinated, evaluated, and approved by the architect during the shop drawing submittal process before installation of the building envelope commences. Full understanding of the design and construction issues involved in properly integrating a window wall system into the building envelope prior to construction is crucial to the success of the building envelope.

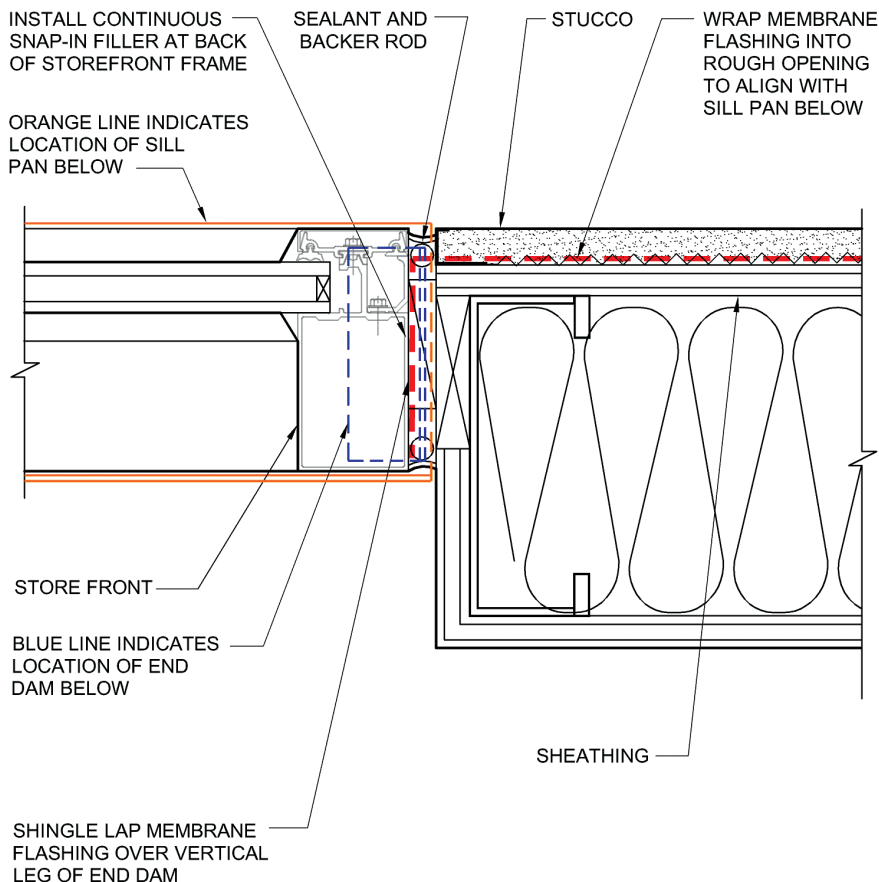


Figure 6 – Typical storefront jamb plan detail.

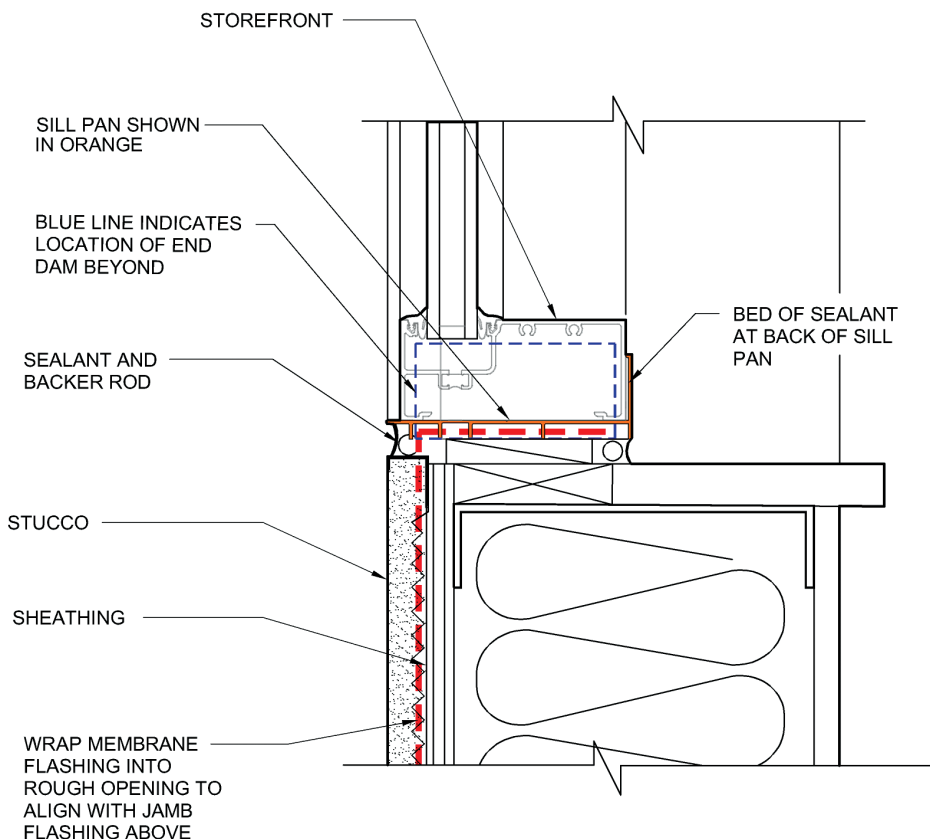


Figure 7 – Typical storefront sill section detail.

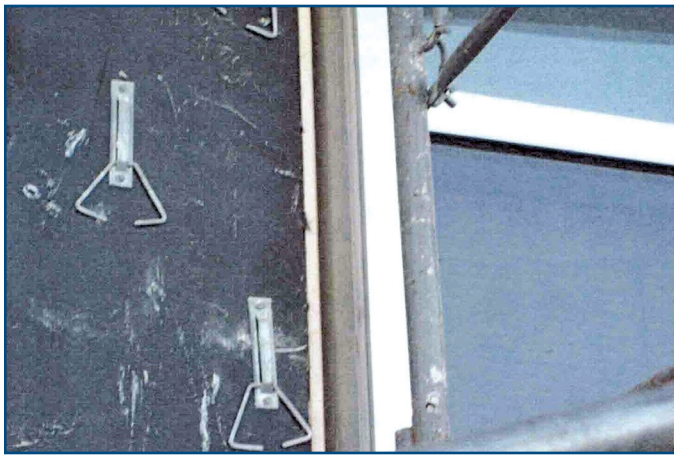


Figure 8 – Missing membrane flashing at curtainwall jamb (photo provided by client).

COMMON FAILURES

Curtainwalls and storefronts have similar coordination, design, and construction challenges. Failures at window wall perimeters occur when the WRB is disrupted, the flashing is not installed correctly, construction of subcontractors is performed out of sequence, and/or flashing details are not properly conveyed to the contractor.

Proper detailing and guidance by the architect regarding the flashing of unique architectural features is critical to the success of the design. Special design conditions that have not been detailed or addressed by the architect during the design phase of a project can result in discontinuous flashing or the omission of flashing by a waterproofing contractor not familiar with the architect's design intent. Improper installation of the window wall systems can occur and result in widespread water intrusion and costly remediation without proper design and construction coordination of the WRB and flashing.

CASE STUDIES

Four case studies are presented herein that discuss issues encountered with the WRB and flashing systems surrounding curtainwall and storefront systems. These case studies include institutional buildings in Texas and Louisiana, a multistory office building in Washington, D.C., and a hospital in Louisiana.

Remediation by Spot Repair

The institutional building in Texas was a concrete-framed multistory building with an exterior façade consisting of stone veneer, stucco, and curtainwalls that was constructed approximately 12 years ago.

The stucco and stone veneer wall systems were originally constructed with continuous secondary drainage planes. In addition, a fluid-applied dampproofing system was utilized as the primary WRB at the building.

The building was the subject of multiple remediation attempts to spot-repair numerous deficiencies within the building envelope

due to widespread moisture intrusion. Flashing issues at the curtainwalls included improperly installed or unadhered membrane flashing at multiple locations (Figure 8). In addition, there were large gaps between the sheathing and the curtainwall jambs with no membrane flashing installed at several curtainwalls to integrate the WRB with the curtainwalls for a watertight drainage plane.

Other conditions observed around the curtainwalls included no membrane flashing and/or WRB wrapped into the curtainwall rough openings and improper shimming of curtainwalls to account for the large gaps between the curtainwalls and the adjoining building elements (Figure 9). These conditions resulted in moisture-stained interior finishes and suspected fungal growth around the curtainwall openings.

During the multiple remediation attempts, it was noted that the construction drawings issued by the architect were underdeveloped and inconsistent with the flashing details actually installed in the field. Multiple curtainwall details within the drawings were basic in nature, did not graphically illustrate or note the use of flashing, and lacked specificity of the integration between the WRB/drainage plane and curtainwalls. This lack of proper detailing and coordination

by the architect during the initial phases of the project and poor construction coordination by the contractor were the two primary factors that lead to the problems encountered during the original construction of the building.

While several of the curtainwalls had been water-tested and spot-repaired during the remediation attempts, water intrusion at or around the curtainwalls continued to be an ongoing problem. Therefore, new curtainwall flashing was required to be installed around the perimeter of all curtainwall locations, and the curtainwall components were repaired and water-tested.

Deficient WRB, Flashing, and Weeping Systems

The institutional building in Louisiana was a six-story concrete and steel-framed building with brick veneer, aluminum storefront windows, and curtainwalls that was constructed approximately nine years ago. The exterior walls were designed as cavity wall drainage plane systems with a fluid-applied dampproofing used as the WRB.

The brick exterior wall system for the building consisted of (from exterior to interior): brick masonry, an airspace/drainage cavity, dampproofing/WRB, exterior sheathing, light-gauge steel framing infilled with insulation, and interior gypsum board walls. The WRB served as a moisture drainage plane and protective layer for the building's sheathing, structural framing, and interior.

The WRB was not sealed and integrated with the exterior wall systems through the use of flashing at discontinuities in the

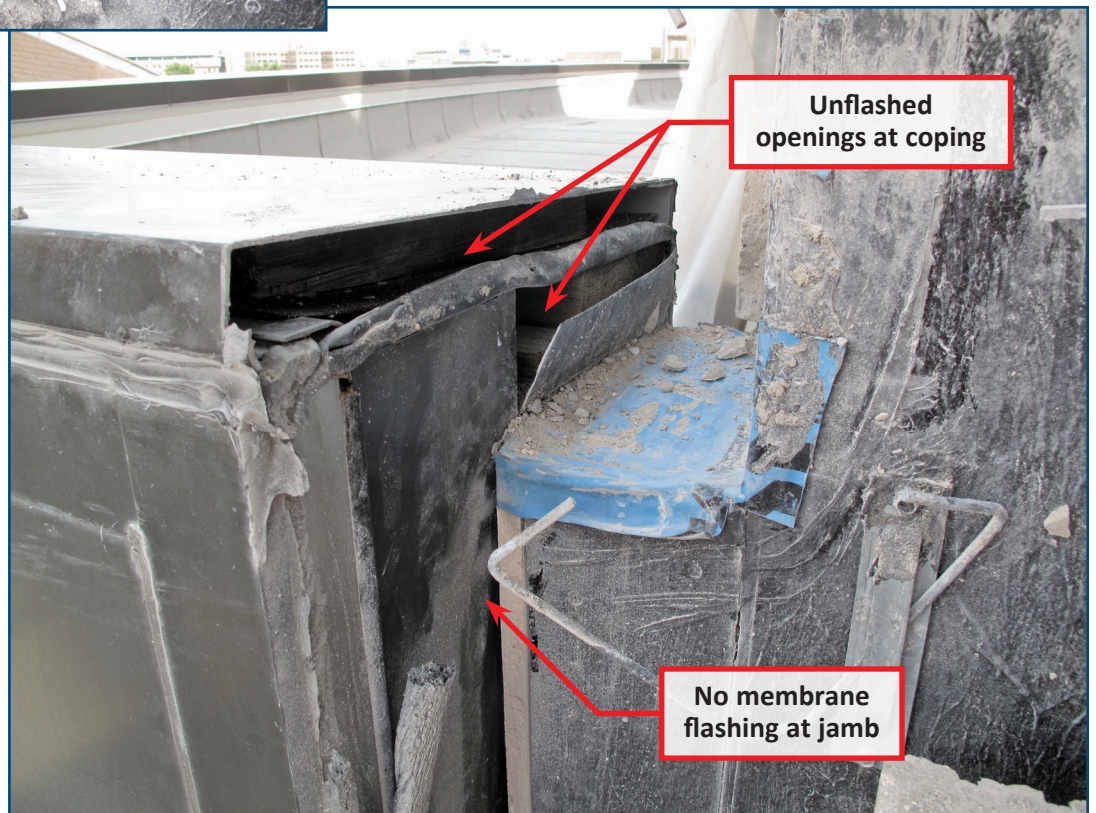


Figure 9 – Large gap at curtainwall jamb and no WRB or flashing wrapped in rough opening.



Figure 10 – No flashing integration of curtainwall jamb and WRB.

Figure 11 – Lack of flashing integration at head and jamb of curtainwall.



building envelope. These included material transitions, window openings, and roof-to-wall intersections to create a continuous barrier and protect the building against moisture intrusion and air infiltration. Therefore, ongoing moisture intrusion was observed adjacent to curtainwalls throughout the building. Through the removal of exterior finishes, multiple deficiencies in the WRB, flashing, and curtainwalls were noted.

A multistory curtainwall system was located above one of the main covered entrances to the building. The curtainwall sill intersected the roof of the entrance canopy. The base of the curtainwall terminated approximately 3 in. from the top surface of the roofing. Remedial sealant had been applied to mitigate the moisture intrusion at the jambs and sill of the curtainwall system and at the roof transition. At the base of the curtainwall, the bottom horizontal mullions were covered with sealant that prevented the bottom section of glass from weeping properly. The condition also lacked a proper roof curb transition and adequate space to properly flash and integrate the transition from the curtainwall to the roof. At the interior side of the curtainwall sill, the drywall below had extensive moisture-damaged finishes.

Deficient or missing flashing was observed around several curtainwall and storefront systems (Figure 10). At these locations, the building envelope relied solely on sealant joints to prevent water penetra-

tion into the wall cavity. These areas should have been flashed in a shingle-lapped manner and properly integrated with the vertical wall WRB.

Along the front of the building, the head of a curtainwall system at the interface of the top of a parapet wall intersected multiple components. The head of the curtainwall abutted a coping cap and an adjacent exterior brick cavity wall. Through removal of the brick veneer and adjacent coping cap, the lack of integration between the coping cap, WRB, curtainwall, and adjacent brick wall was observed (Figure 11). No membrane flashing was integrated with the curtainwall jamb and the WRB. Additionally, the weep holes in the brick

veneer terminated below the top of the parapet wall, allowing water within the cavity wall to migrate into the unsealed edge of the coping cap and curtainwall interface. Substantial moisture intrusion, including blistered paint and stained ceiling tiles, was observed at the interior of this location. At several other locations throughout the building, blistered and moisture-stained interior finishes were observed adjacent to curtainwall jambs, attributable to the lack of a continuous building envelope and an integrated WRB and flashing system. In this case study, poor construction coordination by the contractor and deficient installation of the WRB, flashing, and weeping systems were the primary factors that lead to the



Figure 12 – Suspected fungal growth at back of granite panels. Exposed backer rod (yellow in color) for exterior sealant between granite joints (photo provided by client).

problems encountered during the original construction of the building.

It was recommended that all curtainwalls, storefront windows, and parapet caps abutting curtainwalls be inspected for proper flashing and integration with the WRB. All deficient window wall systems were water-tested once new flashing had been installed to integrate the WRB and window systems for a watertight drainage plane.

Issues with Barrier Systems

The office building in Washington, D.C. was a concrete-framed, multistory building with an exterior consisting of a truss-framed curtainwall system clad with granite panels and vision glass. The exterior system was designed as a barrier system and was constructed in the 1980s. The interior wall finishes were built with painted gypsum board.

During tenant improvements at two of the upper floors, suspected fungal growth was observed at the interior side of the exterior granite panels (Figure 12). When the interior wall and insulation were removed, it was discovered that there was no sheathing, WRB, or curtainwall flashing. The sealant at the panel joints and windows was the only protection against moisture intrusion. Removal of the sealant revealed that many of the backer rods were wet, indicating that the sealant had failed.

With no maintenance program in place, over time the sealant had slowly disintegrated and created conditions conducive

to moisture intrusion and suspected fungal growth. The hidden nature of the suspected fungal growth (generally behind dry-wall) made the maintenance of the sealant all the more important; however, from the exterior, the separations in the sealant were difficult to distinguish. Without the protection of a secondary drainage plane providing a more secure method of flashing, the building envelope was inherently weak and challenging to maintain.

Due to the expense of adding new sheathing, WRB, and flashing to the existing granite cladding system, it was decided to maintain the barrier system and remove and replace all the sealant and backer rods. However, these components will continue to be high-maintenance areas that are exposed to the weather and will require a great deal of monitoring by the building owner to maintain their performance.

Failure of End Dams

The hospital in Louisiana was a steel-framed, single-story building with an exterior consisting of stucco, brick veneer, and storefront, constructed approximately seven years ago. The stucco and brick veneer wall systems were originally built as secondary drainage plane systems with wall cavities in the brick veneer. In addition, a fluid-applied dampproofing system was utilized as the primary WRB at the building.

The building began experiencing water intrusion at several locations after completion of construction. Most notably, water was collecting at the base of the walls below

punched storefront windows at the stucco veneer portions of the building. Extensive water testing was performed on the windows to isolate whether the reported intrusion was the result of defects in the perimeter flashing or in the windows themselves. Once it was established that the intrusion was coming from the window perimeters, a select few windows were removed to investigate the flashing installation.

When the storefront frame was removed from these windows, it was noted that the sill pan was not fastened to the rough opening framing, but remained attached to the storefront frame (Figure 13). Further observation of the sill pan indicated that the intersection between the pan and the storefront vertical edge mullion had been sealed shut, damming water from being able to flow from the interior of the mullion to the weep slot between the sill pan and storefront frame along the sill of the window. A waterline was visible, indicating dammed-up water had accumulated up to approximately 1 inch above the bottom of the sill pan. The end dams had been directly attached to the rough opening and remained intact when the storefront frame and sill pan were removed (Figure 14). The WRB had also been terminated at the vertical face of the exterior sheathing and had not been extended into the window opening. Additionally, there were no backer rods installed behind the perimeter sealant joints, no end dams or weeps, and neither flashing nor vertical mullion cap flashings at the window heads.

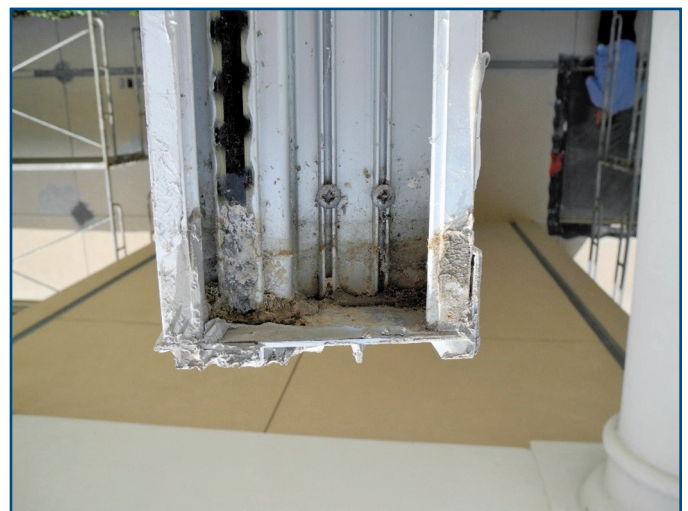


Figure 13 – Sill pan attached to storefront frame after removal from rough opening. Note sealant-damming intersection to vertical mullion and waterline approximately 1 in. above the bottom of the sill pan.

It was concluded that the damage at the interior was due to a number of factors. First, the improper head flashing was allowing an excessive amount of water to enter and travel down the vertical edge mullion where it was dammed up at the sill pan/vertical mullion intersection. This water leaked through gaps in the poorly sealed sill pan/end dam connection and spilled into the wall's exposed interior components with no flashing or WRB on the interior surfaces of the rough opening to stop it. This condition was exacerbated by water entering through the improperly installed and failing sealant joints. As mentioned in the previous case studies, poor construction coordination by the contractor and deficient installation of the WRB, flashing, end dams, and weeping systems were the primary factors that lead to the problems encountered during the original construction of this building.

To remedy this situation, it was recommended to reconfigure the head flashing, cut back the surrounding stucco, add inboard flashing around the perimeter of the opening, and add a new custom-designed sill pan with integrated end dams. Once this new sill pan (Figure 15) was installed, shingle lap flashing was added connecting the inboard flashing to the end dams in order to maintain the integrity of the building envelope. The edges of the stucco were then reinstalled with perimeter ½-in. sealant joints with backer rods in the proper 2:1 configuration.

CONCLUSIONS

Adequate detailing for the integration of the WRB and the window wall can prevent costly and exhaustive remediation efforts in the future. By preserving the integrity

of the building envelope through the use of flexible membrane flashing, principles of directing water to the exterior, and water intrusion testing, recurring moisture intrusion at and below the window system can be mitigated.

Furthermore, to provide owners with long-lasting, high-performing buildings, coordination between the architect, contractor, and window wall manufacturer/installer is critical. The installation of each element of the building envelope must be in accordance with the governing building codes, industry standards, and manufacturer's instructions.

However, the building codes, industry standards, and manufacturer's recommendations lack instructions specific to integrating the window wall and flashing systems with the overall building envelope. Therefore, the architect and construction team are responsible for designing and coordinating the integration of the WRB, flashing, and window wall systems to ensure a successfully performing building envelope. 



Figure 14 – End dams directly connected to rough opening rather than sill pan. Note the WRB terminating at vertical face of sheathing and not wrapped into rough opening.

Figure 15 – New custom-built sill pan with integrated end dams.



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