“By Others”: Transitions Between Enclosure Systems

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Abstract

Buildings rely on many different systems and materials to provide a continuous enclosure, including roofing, cladding, windows, and below-grade waterproofing. Individually, enclosure systems are generally well understood. However, transitions between two or more systems are less straightforward. Transition details are unique to each project. The design often includes some transition concepts, but may not consider constructability issues such as sequencing. Construction often includes carefully detailed system shop drawings that lack details of adjacent systems manufactured and installed “by others.” Construction has added challenges, including tolerances and sequencing. Ultimately, many transition details are left to the discretion and experience of the installers.

The design and construction of reliable transition details requires an understanding of enclosure concepts and careful coordination among all involved parties. Coordinated details must consider enclosure continuity, compatibility between materials, constructability, warranty implications, installation sequence, and other issues.

The authors will discuss continuity of the building enclosure and present strategies for designing and constructing coordinated transition details based on their combined experience. Topics will include material selection and compatibility, constructability review, coordination among trades, and addressing the inevitable challenges of construction. They will discuss several case studies to illustrate successful development of difficult transition details.

Speakers

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INTRODUCTION

Building enclosures are made up of many different materials, components, and systems that provide separation between the inside and outside environments, including roofing, cladding, fenestration, and waterproofing. Individually, the performance and installation of various enclosure systems are generally well understood by the design and construction industry. However, buildings consist of multiple enclosure systems and materials joined together with transition details to provide a continuous enclosure. Transition details can be complex and often involve products from different manufacturers, installed by different trades, and assembled in a unique way to form a custom, site-built product. Air leakage, water infiltration, moisture issues, and related building enclosure problems most frequently occur at these critical transition details. Design and construction of reliable enclosure transition details require an understanding of material behavior and building enclosure engineering concepts, as well as careful coordination among all involved parties.

THE BUILDING ENCLOSURE ENGINEERING CONCEPTS

Building enclosure engineering concepts establish how we assemble materials to form a series of barriers that control the flow of liquid water, heat, air, and vapor across the building envelope. These barriers are how buildings prevent water intrusion, moisture migration, and condensation while also providing thermal comfort and improved energy performance. We briefly describe the four primary functions of the building enclosure as follows:

- **Water Barrier**: The water barrier resists liquid water (e.g., rainwater and groundwater) entry into the building. This barrier must be continuous and shingled in the direction of water flow to properly manage water. The water barrier typically includes provisions to collect and conduct water away from the enclosure (e.g., with flashings and drains).
- **Thermal Barrier**: The thermal barrier helps manage occupant comfort and is a key contributor to the energy efficiency of a building. A continuous thermal barrier is necessary to provide reliable thermal performance.
- **Air Barrier**: The air barrier resists air infiltration and exfiltration driven by air pressure differential across the building envelope. Uncontrolled air movement can decrease energy efficiency, transport significant amounts of moisture, and cause condensation that can damage building components. The building air barrier is a series of materials and assemblies that may be composed of multiple materials and products. The air barrier must be continuous around the entire building, including reliable seals at transitions between the air barrier components of different building enclosure systems.
- **Vapor Retarder**: The vapor retarder (or vapor control layer or vapor barrier) resists water vapor transmission driven by vapor pressure differential across the building envelope, which generally follows the tendency of warm, moist air to migrate toward cooler and drier environments. The building vapor control layer is composed of a series of materials that can have different vapor permeability ratings. The use and placement of a vapor control layer, if any, must carefully consider the building operating conditions and the relative configuration of the thermal barrier in the building enclosure to limit the potential for moisture accumulation from condensation.

BUILDING TRENDS

In general, architectural trends have evolved to favor increasingly complex building designs, including the use of multiple cladding materials, irregular geometry, greater ratios of glass-to-opaque-wall area, and mechanically controlled interior humidity. What once was a rectangular brick masonry-clad building with windows in punched openings and uniform building height may now be a building with a combination of cladding materials (e.g., rain screen metal panels, precast concrete, stucco, and fiber cement claddings), fenestration systems (e.g., multistory curtainwalls with sun shades), and multiple roof areas in a step-back configuration.

Each of these systems also has multiple options, including different manufacturers of similar products (e.g., different curtainwall manufacturers) and different products that provide similar functions using different technologies (e.g., modified-bitumen roofing vs. single-ply roofing), with new products and new variations on existing products regularly entering the market. Each system or product has specific requirements for design and installation that the design and construction industry should carefully consider for each system and at each intersection between different cladding materials, roofing assemblies, and fenestration types in order to design and construct a reliable building enclosure that includes continuity of the four barriers: water, thermal, air, and vapor.

DESIGN

Along with architectural trends, the design process has also evolved to take advantage of computer-aided design (CAD) and building information modeling (BIM) technologies to create complex and awe-inspiring forms. However, with more complex forms come more unique and more complex transition details. In the past, two-dimensional depictions of building system transitions were often sufficient, and they still remain an effective way to communicate the configuration of simple or common transition details, such as a typical roof-to-wall transition at a parapet in the middle of a flat wall or a window-to-wall transition detail. More complex conditions warrant three-dimensional drawings or models to accurately depict the design intent. In the past, representing a three-dimensional form
required individually sketching isometric illustrations to depict a three-dimensional concept within a two-dimensional medium. Today, designers commonly use three-dimensional modeling programs and tools to create overall forms and then cut sections or take snapshots at areas of interest to create details. This is an effective method of producing basic geometric information. However, large-scale three-dimensional models are generally intended to show overall forms and identify major “clashes,” and often lack the resolution to show all the components necessary to establish continuity of the building enclosure systems. Consequently, snapshots taken from the overall model require additional development to describe the individual layers necessary at enclosure transition details. The process of identifying appropriate locations for transition details, along with the development of reliable transition details to convey design intent, require a thorough understanding of enclosure engineering concepts. The following sections provide guidance to assist designers in the development of enclosure transition details.

**CONTINUITY**

Continuity is a key tenet of building enclosure engineering. The water, thermal, air, and vapor (if required) control layers all must be continuous around a building to provide the expected performance. Continuity has different meanings in the context of each enclosure barrier. For example:

- **Overlapping two sections of a polyethylene sheet can create a reasonable vapor retarder.** As an industry, we typically add tape or sealant to join sections of a polyethylene sheet vapor retarder to prevent separation at seams, but the direction of the lap between sections of the vapor retarder is not critical.
- **A water barrier utilizes seams oriented in a shingle-lap manner to shed water and prevent leakage.** Loose laps between a water barrier and a through-wall flashing can be effective as long as they are shingle-lapped in the direction of water flow; however, the open seams would not be a barrier to air flow. Conversely, a reverse lap with a water barrier single-lapped inboard of a flashing will allow water to flow past the flashing and can result in water entering the interior.

- **Air barriers require airtight seals at transitions, as even small holes in the air barrier can allow a significant volume of air flow, defeating the purpose of the air barrier.**
- **When constructing the thermal barrier, it is often sufficient to butt layers of insulation together (e.g., cavity insulation at exterior walls), although it is more effective to provide multiple layers of insulation and stagger the joints between layers to improve the thermal resistance of the assembly, as is a common practice in the construction of roofing assemblies.** Transitions pose a particular challenge for the thermal barrier, as elements of the building structure often interrupt the continuity of the thermal barrier (e.g., parapet at a roof-to-wall transition), and alignment of the thermal barrier between exterior wall and fenestration systems must balance the architectural relationship between these components and the need to transfer cladding loads back to the building structure in a way that limits thermal discontinuities.

Further complicating matters, some materials can perform more than one function; for example, a single material (e.g., self-adhering sheet membrane) is often used to provide the water, air, and vapor barrier in an exterior wall assembly. In such cases, the most stringent transition detailing typically governs, meaning that seams between a combination water and air barrier must have both shingle laps and airtight seals. An exercise that designers can use to verify the enclosure system continuity and identify materials that may serve more than one purpose within the building enclosure design is to overlay four separate lines on the building enclosure details to illustrate the intended path for each of the four barriers (Figure 1). At each transition, designers should ask how they are providing continuity for each of the four barriers. This technique can help to identify and address many issues with enclosure transitions during a typical project design phase.

**CLARITY**

Communicating building enclosure continuity is an art form. As a graphic-focused profession, it is important for a design to accurately depict the relationship between different materials and components, and in most cases, it is desirable for drawings to be produced to scale. However, many components of the various building enclosure systems consist of thin elements, which are intended to be layered in a particular order and bonded to each other to form enclosure transition details. Accurately depicting the close proximity of the different layers at building enclosure transitions quickly becomes a muddled mess, if drawn strictly to scale. For simplicity, designers

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**Figure 1** – Line diagram indicating approximate locations of the air, water, thermal, and vapor barriers at a parapet.
will often depict systems made up of multiple overlapping layers as a single, dashed line which can be left up to interpretation by others. In the case of enclosure details, clarity often trumps strict conformance to a scale, and it is more effective to separate out the different layers of the building enclosure by providing space between lines to clearly show the intended relationship and overlap between different layers. Larger-scale drawings minimize the exaggeration necessary to clearly depict the relationship between components and are a preferred format to illustrate enclosure transition details.

Shop drawings are one form of larger-scale details and have the added benefit of helping to confirm that the construction team understands the design intent. The design team should specify submission of coordinated building enclosure shop drawings that include transition details among the different enclosure systems. Although the construction team will produce the shop drawings, the design professional should critically review shop drawings to verify that they appropriately show the relationship among different materials and trades at enclosure details, especially at transitions between different enclosure systems. Refer to the “Construction” section of this paper for additional advice regarding shop drawings.

The team should also consider how materials will be assembled in three dimensions. A two-dimensional section detail through a parapet can provide enough information for the typical parapet condition; however, when the parapet intersects a rising wall, more information is needed. Providing three-dimensional details at irregular or complex transitions and identifying locations of enclosure mock-ups to allow further coordination in the field can reduce headaches during construction.

MATERIAL PROPERTIES

Designers have a responsibility to understand the properties of different materials and systems, including appropriate uses and limitations. Materials and systems that perform well in certain applications may not perform as expected in other applications. For example, a standing-seam metal roof can provide a durable and long-lasting steep-slope roofing assembly. However, that same standing-seam metal roof installed in a low-slope application, such as a small step-back cornice roof, can be vulnerable to water infiltration at laps, seams, and attachment points, especially where standing water or snow can build up. Manufacturers’ published literature and technical representatives are good sources of information on the proper uses and limitations of their products. Communication with product manufacturers early in the design phase can aid in appropriate material selection for specific applications and can help designers understand the challenges associated with unique applications of specific products.

MATERIAL COMPATIBILITY

Designers also have a responsibility to consider compatibility between different materials. Chemical compatibility is often the first thing people think of when material compatibility comes to mind, due to the potential for dramatic failures in extreme cases of incompatibility. One example of chemical incompatibility is an asphalt-based self-adhered membrane lapped over a polyvinylchloride (PVC) roofing membrane, where the asphalt and PVC interact, which can result in liquefied self-adhered membrane and brittle PVC membrane (Figure 2). This condition can be solved by providing a separation material, such as sheet metal, between the PVC and self-adhered membranes. The sheet metal may need to be set in sealant if the transition between the two membranes is required to function as part of the air barrier assembly.

Material compatibility also includes adhesion between two different materials. While direct contact between two materials may not cause material deterioration, lack of adhesion can reduce performance or cause failures of the enclosure systems. One example is the reduced bond strength when certain fluid-applied membranes are applied to smooth surfaces such as polished metals or concrete with a steel-trowel finish. Adhesion issues can often be solved by providing a separate layer or implementing a variety of surface preparation techniques, such as roughening a smooth surface or using a primer.

Different materials do not have to be in contact to demonstrate compatibility issues. For example, metals have the potential for galvanic corrosion when exposed to other metals in the presence of water, which can cause accelerated deterioration and staining.
For example, water that drains across a copper coping or panel onto a zinc-metal panel below can cause staining and rapid deterioration of the zinc (Figure 3).

Understanding material compatibility issues is essential to the design of reliable transition details. Manufacturers are a good source of compatibility information, both physical and chemical, as they often have experience dealing with transitions between their products and other manufacturers’ products and can often provide advice or prior testing data associated with many different materials.

Testing is another way to explore material compatibility issues. Some common types of testing are reasonable and advisable for building enclosure transition details, such as sealant adhesion to the various substrates on a project, air and water testing of fenestration products, and evaluation of staining potential between sealants and natural stones (e.g., ASTM C1248, Standard Test Method for Staining of Porous Substrate by Joint Sealants). More extensive testing to validate custom assemblies (e.g., curtainwall) is something designers and owners must consider on a case-by-case basis. We provide additional discussion of testing in the construction section of this article.

DIFFERENTIAL MOVEMENT

Anticipated differential movement is an important consideration at transitions between adjacent enclosure systems. An understanding of the interaction between the building structure and enclosure, including where differential movement will occur and how the building façade elements will account for that movement, is critical when detailing transitions. While some materials are specifically designed to accommodate movement, such as sealants and premanufactured expansion joints, many materials have important limits that designers should understand and consider, such as movement capacity and capability to accommodate movement in different directions.

Different types of movement will affect the building enclosure in different ways. For example, installation of the façade places a superimposed dead load on the construction at the edge of the floor plate. This causes an initial deflection at slab edges but will not cause regular movement throughout the life of the building. In-service movements, such as occupant live loads, and movements that occur after construction, such as long-term creep and column shortening, will cause movement throughout the life of the building. Designers should consider and accommodate these different movements.

Continuing with the example above, providing a deflection track at the top of metal-framed backup walls is commonplace in the industry to prevent deflection from transferring load to the metal framing and causing damage to interior finishes. Any materials that span across this joint, such as an air/water barrier applied to the exterior sheathing or cladding, should also include provisions to accommodate this deflection with a corresponding movement joint. We include an example of such a transition in Figure 4.

LONG-TERM PERFORMANCE AND DURABILITY

The performance history of enclosure transition details on past projects is a fantastic barometer of expected performance. Often, success on previous projects can be repeated by using similar details appropriately adapted to address project-specific conditions. Often overlooked is the importance of verifying that previously constructed details actually work as expected, and not just verifying that someone used it in the past.

Of course, creating something new means you may not always find examples of similar enclosure details on past projects. If a new detail or approach is appropriate, scrutiny is healthy. Engaging a peer review professional, building enclosure consultant,
or an experienced quality trade contractor can be a valuable resource to properly vet a concept. Although material warranties can be a good indication of the history and performance expectations of a particular product, they should not be relied upon as a “catch all”—especially at transition details, which are often excluded. Warranties can provide some protection but are not a replacement for good design.

In addition to long-term performance, designers should consider the need for future replacement of enclosure systems that have a shorter expected service life than the building and therefore must be replaced (e.g., replacing a roof assembly but not the exterior cladding). In some cases, this means removing copings to access and install new parapet details as part of a new roofing assembly. In other cases, the design should include removable features, such as removable counterflashing skirts on through-wall flashings at rising walls above roofing base flashing terminations, to facilitate removal and replacement of enclosure components.

**CONSTRUCTABILITY**

Construction relies on someone physically assembling components to create a built work from a design. Accessibility is a key aspect of constructability. A worker’s ability to touch something with sufficient space to manipulate the appropriate tools will directly influence the quality of building enclosure details. For example, placing a vertical electrical conduit penetration through a roof in close proximity to a wall can limit a worker’s ability to wrap membrane around the conduit and may require installation of a sealant pocket detail, which typically requires more frequent maintenance by an owner. Anticipating how each component and material will be installed, especially at transitions where two or more trades may be involved, is critical to limiting constructability issues. Developing design details with overly restrictive access or excessively stringent tolerances can lead to incomplete details in the field or undesired last-minute modifications.

Assembly of building enclosure details often requires a specific sequence. Some sequences are common, such as installing windowsill flashings before installing windows. Providing details that require uncommon construction sequences can challenge the project team during construction. Reviewing the expected construction sequence and highlighting details that will require unusual or “out-of-sequence” work as part of the design documents or during preconstruction meetings can help identify and avoid constructability issues.

Considering the experience of the overall team and local market preferences is also important. Anticipating what trades will be responsible for what systems, what level of experience the installers have, and how much experience the construction team has on similar projects can guide the level of detail and direction required as part of the design.

Specifying design phase mock-ups and testing is a good idea for most projects as they offer a chance to evaluate concepts and demonstrate proper sequencing and use of various enclosure materials. Mock-ups and testing become even more valuable when working with an enclosure system or material that is unfamiliar to the project team, or one that is new to the market. While skill and experience with systems and materials are often evaluated by the construction team, the overall project can benefit if the designer also thinks through such issues.

**SUMMARY OF DESIGN PHASE RECOMMENDATIONS**

Designing reliable building enclosure details will set the project up for success during construction. We provide the following summary of advice as a reference to assist the project team with enclosure transition details during the design phase:

- Verify that the air, water, thermal, and vapor (if required) control layers are continuous and that seams or penetrations through each layer are detailed appropriately.
- Provide large-scale visual representations that clearly illustrate the design intent at transitions between systems.
- Understand the properties of materials that will come into contact or be near each other; if compatibility is unknown, consider testing and involving manufacturers.
- Account for differential movement between systems, and if necessary, involve the structural engineer of record to confirm the amount of expected movement.
- Consider the performance history of a system and seek out example projects with long track records for verification of performance.
- Anticipate construction sequencing and methods to try to predict problems that may arise during construction.

**CONSTRUCTION**

Construction is a team effort, and each project ultimately ends when the project team brings the design to life. The specific rules and players vary from project to project. However, an overarching theme is the need for a coordinated plan and coordinated execution. Coordination and communication are the keys to achieving success in construction. While coordination applies to all aspects of the construction phase, this paper focuses on the coordination necessary to provide reliable transition details between different building enclosure systems.

As we have already discussed, the building enclosure is a combination of many different systems assembled by independent specialized trades. Transitions between

![Figure 4 – Sketch illustrating a deflection joint concept at metal panel cladding at a slab edge.](image-url)
Enclosure systems require coordination and cooperation between the individual trades during the planning and installation phases, as well as some flexibility to accommodate the dynamic nature and inevitable challenges of the construction phase. The following sections provide guidance to assist the project team with enclosure transition construction.

**BIM**

BIM has changed the design and construction industry and is a frequently lauded tool for good reasons. Numerous resources promote the virtues of BIM. For the purposes of this article, we will briefly touch upon coordination benefits of BIM. BIM allows the construction team to virtually construct a building and identify potential construction conflicts. Many construction projects already use BIM to identify conflicts, including placement of doors, electrical conduit, HVAC equipment, and HVAC ducts, and the potential to proactively identify and address conflicts between enclosure systems is only limited by the time and effort spent constructing a virtual model of the building. However, there is a tradeoff between spending time in the virtual world and the reality of construction. Many BIM models do not include the level of detail necessary to analyze transitions between enclosure systems. We believe that one day, technology advancements such as real-time, as-built updates to construction will make coordination of enclosure details more economical through a BIM interface, but it is not common in the construction industry at this time. Site-built project mock-ups assembled early in the construction process are an alternative and important way to facilitate coordination of enclosure transition details; refer to additional discussion in the “Mock-Ups” section below.

**SHOP DRAWINGS**

Shop drawings continue to provide an economical way for the construction industry to illustrate, and sometimes develop, enclosure transition details and proactively identify and address potential construction issues. While the origin of the term “shop drawings” comes from the fabrication drawings used by manufacturers for shop-produced components, the level of detail contained in such drawings is so valuable to the coordination process that it has been applied to field-constructed systems (e.g., below-grade waterproofing), too.

On the simplest level, shop drawings illustrate the implementation of the design using product- and manufacturer-specific systems and requirements. Manufacturers and installers are knowledgeable with their own products and craft, which makes them capable of producing detailed drawings to describe their systems. Shop drawings should include large-scale details and specific material callouts that would not be expected as part of the architectural drawings.

Unfortunately, many shop drawings fall into the “by others” trap in that they conceptually show materials that will not be furnished or installed by that particular entity as a schematic cartoon labeled “by others,” “not by [contractor name],” or something similar. These details often include overly simplified representations of the adjacent construction, which limits the benefits of the drawings. In some cases, what pass as shop drawings may only consist of generic manufacturers’ details that do not show the surrounding construction and offer little benefit to the project (Figure 5). The “by others” trap complicates coordination and can lead to on-site statements like, “What do you mean you’re going to install that silicone sealant between the window and the self-adhered membrane? Everyone knows that particular silicone sealant won’t stick to that particular self-adhered membrane!” While construction professionals often understand issues related to systems outside their trade or expertise, they typically do not have the same depth of knowledge as the manufacturers and installers of those systems and materials.

Many issues at transitions between different enclosure systems can be proactively addressed by producing coordinated shop drawings. Coordinated shop drawings show...
the project-specific work of a given trade, plus the surrounding construction (Figure 6). It is critical that coordinated shop drawings accurately depict the work of the given trade in relation to the adjacent construction. This includes the layers and orientation of each individual material, whether it is existing, expected to be installed by others prior to the work of the given trade, or work that will follow the given trade. Much of the design and construction industry is a visual profession, and accurate materials, orientation, and scale in coordinated shop drawings allow the project team to better evaluate, and, if necessary, make adjustments to, materials, sequences, or other aspects of the construction. Large-size shop drawing details allow some exaggeration out of scale to show the proper relationship between the different layers of thin transition materials that are in contact with each other (such as different membrane layers), while also showing items such as windows and cladding materials at scale to appropriately show the relationships between these larger materials.

Coordinated shop drawings require a steward, such as a general contractor, to shepherd the process and verify that appropriate trades review and comment on shop drawings of adjacent trades to allow an opportunity to identify material-specific requirements of adjacent trades that may not be known or obvious to the trades producing the shop drawings.

**MOCK-UPS**

Mock-ups in the field are another critical piece of the early construction process. Unlike laboratory mock-ups, which are often built and tested off site prior to construction to evaluate and demonstrate performance of a single system (e.g., curtainwall), project site mock-ups built by the construction professionals that will be installing the materials and systems on the building typically include multiple products and systems. These project site mock-ups allow construction professionals to work together and create a representation of, or in the case of mock-ups constructed on the building, a portion of the final product for evaluation by the project team (Figure 7). Rather than testing a single system, these mock-ups can include the transition details that may not be fully detailed in the construction documents. This provides yet another chance to identify and address issues with the materials, sequence, and means and methods of construction.

**TESTING**

Testing is another tool to evaluate the performance of building enclosure transition details. Common examples of useful field quality control testing of transitions include air- and water-infiltration testing of windows (e.g., ASTM E783, Standard Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors; and ASTM E1105, Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference), sealant adhesion testing, and air leakage through the building enclosure (e.g., ASTM E1186, Standard Practices for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems; ASTM E1827, Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door; and ASTM E779, Standard Test Method for Determining Air Leakage by Fan Pressurization). Field testing is a reasonable way to verify that the installed building enclosure assemblies provide air, water, thermal, and vapor (if required) control layer continuity, especially where some components may be concealed (e.g., behind cladding).

**ENCLOSURE COORDINATION MEETINGS**

Meetings are an integral part of the construction process and provide a forum for communication between all parties involved. Many projects already include numerous meetings, such as kickoff meetings as part of the on-boarding process, preconstruction meetings to review shop drawings, and other meetings throughout construction, as necessary. We doubt that many people would suggest the construction industry has too few meetings. Yet, when it comes to coordination of enclosure transition details, many construction
projects have trade-specific meetings and miss the opportunity for different trades to meet up, discuss, and coordinate transition details between their respective assemblies. Involving different trades in enclosure coordination meetings as part of the preconstruction process is another opportunity to identify and resolve potential issues before the pressures of active construction further complicate building enclosure transition details. Coordination of building enclosure transition details should include the obvious enclosure trades (e.g., cladding, roofing, and windows), but should also consider including several less-obvious trades, such as electrical (to coordinate conduit), landscaping (to coordinate irrigation requirements), concrete (to coordinate surface preparation requirements for roofing and waterproofing), and any other trades that will penetrate through the building enclosure.

CHALLENGES DURING CONSTRUCTION

Despite the best-laid plans, construction is not perfect, and projects will experience unforeseen challenges with enclosure transitions. Challenges can include missing details (e.g., details not developed as part of the design or shop drawings), material or product substitutions that change enclosure transition requirements, unanticipated conditions at existing buildings, changes to sequencing (e.g., caused by material lead time or delivery delays), items built out of tolerance or in the wrong location, and numerous other challenges. Early identification of challenges allows more opportunity to solve existing issues and course-correct to avoid issues at similar conditions as construction continues. While not part of coordination, third-party reviews of enclosure installations on a regular basis can help to identify potential issues and often provide practical advice to help the project team resolve the issues. Once a challenge is identified, involve the appropriate personnel, including the owner, designers, subcontractors, and consultants as appropriate, and focus on solutions.

SUMMARY OF CONSTRUCTION PHASE RECOMMENDATIONS

Coordination is key to constructing reliable building enclosure details during construction. We provide the following summary of advice as a reference to assist the project team with enclosure transition details during the construction phase:

• Provide coordinated shop drawings that accurately show the project-specific work of individual trades, as well as the surrounding construction. The general contractor should facilitate coordination among appropriate subcontractors to ensure that shop drawings accurately show the work of adjacent trades.
• Construct project site mock-ups of frequent building enclosure transition details, such as window perimeter construction, as well as new or challenging details to verify constructability and a proper understanding of installation needs.
• Conduct project-specific testing of building enclosure transition details, such as air and water testing of windows, sealant adhesion testing, and air leakage testing.
• Involve trades that work on the building enclosure in joint coordination meetings. Include trades that will penetrate through the building enclosure.

CASE STUDY

We provide the following case study as an example of a key transition detail between a balcony and window to illustrate the process used by the design and construction teams to work together to identify a feasible solution to maintaining continuity of the four barriers described in this article.

BALCONY-TO-WINDOW TRANSITION

Projecting balconies can interrupt the continuity of the building enclosure if not properly detailed and constructed. At a recently completed mixed-use high-rise apartment building, balconies regularly project out from the slab edges of the concrete-framed building (Figure 8). The backup wall construction includes steel stud framing that spans from slab to slab, with exterior sheathing, self-adhered membrane air

Figure 8 – Windows span from slab to slab between projecting concrete balconies.
and water barrier, and exterior cavity insulation. Exterior walls are clad with fiber cement rain screen panels. The steel stud backup wall appropriately includes a deflection track at the underside of each slab edge to accommodate differential movement. The design also includes regularly spaced metal through-wall flashings at each slab edge to direct water within the wall cavity toward the exterior through joints in the cladding.

The building fenestration systems include aluminum windows set in punched openings and aluminum windows and balcony doors that span from slab to slab. The windows include a continuous nailing flange at the head, jamb, and sill. Self-adhered membrane laps onto the window nailing flanges at the head and jambs, and the sill flange is partially imbedded in sealant to provide air and water barrier continuity at the window perimeters. The concrete balconies include a pedestrian traffic coating on the top surface and are exposed concrete on the underside.

At the underside of each balcony, the design intent is to have the windows and balcony doors extend up to the underside of the concrete slab. The deflection track at the steel stud backup wall, therefore, cannot continue across the underside of each balcony. The design team had to consider how the exterior wall and window assembly would accommodate differential movement due to slab deflection at each balcony, without damaging the window or air-barrier membrane, all while providing air and water barrier continuity.

At opaque wall areas, the design team appropriately sized the height of the deflection joint to accommodate the anticipated slab deflection. The self-adhered membrane forms a bellows shape and extends across an oversized backer rod at the deflection joint, which provides a continuous yet flexible substrate for the membrane. The deflection track and membrane bellows continue to the corner of the balconies, which align with the corner of the slab-to-slab windows.

At areas below balconies with windows extending slab to slab, the construction team recognized that the nailing flange at the window head conflicts with the underside of the concrete balconies. Rather than alter the surrounding construction, the team for this project elected to alter the windows by removing the nailing flange from the head of the windows that extend up to the underside of balconies. To provide air and water barrier continuity, a sealant joint was installed from the window head to the underside of each concrete balcony. Similar to the deflection track at the opaque walls, the team had to confirm that the gap between the window head and the underside of the balcony was large enough to accommodate the expected slab deflection.

After working through the transition details at the opaque wall deflection track and at windows along the underside of balconies, the team had to consider how these details would meet and tie into the traffic coating at the top side of the balcony. Transitioning from a self-adhered membrane that spans over a backer rod to a sealant joint creates a small hole that is vulnerable to air and water infiltration. The team also had to consider compatibility of these materials and how they would perform after undergoing cyclic movement at the edge of slab. To cover this small hole, we recommended installing a silicone-sheet patch set in sealant at each balcony corner. The silicone sheet patch could be set in a sealant that is compatible with each material and would accommodate the differential movement at the slab edge.

The team also had to consider the transition from pedestrian traffic coating to air barrier membrane at the adjacent wall. The design included metal through-wall flashing at each slab edge between balconies. By providing end dams in the flashing at projecting balconies, the metal flashing can better collect and direct water to the exterior while also providing a substrate for the traffic coating to lap onto at balcony corners. The team was able to utilize the metal flashing, which was a material already included on the project, to provide a separation layer between the traffic coating and self-adhered membrane (Figure 9).

**Summary**

Building enclosure systems and materials such as those discussed in the case study above are individually well understood; however, the transition details where each of these systems meet are unique to each project. Transitions that projects commonly encounter include the following:

- Exterior wall to window
- Roof to exterior wall
- Expansion joints
- Exterior above-grade wall to below-grade wall
- Plaza to exterior wall
- Plaza to storefront
- Transition between different cladding systems
- Soffit to exterior wall

Design and construction of reliable transition details requires an understanding of building enclosure concepts, a well-thought-out design concept, and coordination among the construction team and all trades involved. Using the concepts described above can set the entire team up for success and avoid falling into the “by others” trap.