WHITE PAPER

METAL CONSTRUCTION ASSOCIATION

Controlling Air and Rainwater Using Insulated Metal Panel Enclosure Systems

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Prepared by

Building Science Consulting Inc.
167 Lexington Court, Unit 5
Waterloo, Ontario
Canada N2J 4R9

John Straube, Ph.D., P.Eng.
Principal

www.buildingscienceconsultinginc.com

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METAL CONSTRUCTION ASSOCIATION
8735 W. Higgins Road, Suite 300, Chicago, IL 60631
847.375.4718 | mca@metalconstruction.org | www.metalconstruction.org

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847.375.4718 I mca@metalconstruction.org I www.metalconstruction.org

1. Introduction

Insulated metal panels (IMPs) are one of only a few types of building product that can provide an entire building enclosure in one prefabricated product. However, despite their use for several decades in North America, there remains confusion about how IMPs manage rain water penetration, control air leakage, and act as continuous insulation[1].

Insulated metal panels are composed of two layers of coated thin sheet metal wrapped around a rigid foam core to form a stiff composite. They are molded in a variety of styles and sizes depending on the application. The www.metalconstruction.org website provides more information.

An insulated metal panel system can be used on its own to provide a complete enclosure, can be added over a lightweight structure and interior finish in new construction, or can be added over an existing enclosure to provide a new level of enclosure performance.

Figure 1: California ISO Headquarters in Folsom, CA (Photograph: Metal Construction Association)

The basic nature of IMPs should be understood in the design of buildings and details. IMPs are longer in one direction than the other. Most manufacturers have standard panel widths, such as 36" or 42", but can produce very long panels up to 50 ft or more. The long edge often has a factory-formed shape that allows two adjacent panels to interlock, align, and often control air and water penetration. The panels may be installed vertically (spanning between horizontal structural supports, with factory-formed edges running vertically), or horizontally (spanning between vertical structural supports, with factory-formed edges running horizontally) (**Figure 2**).

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[1]Some code officials and some codes may not consider IMPs to be continuous insulation, but IMPs act at least as effectively as most other systems that are accepted as continuous insulation.

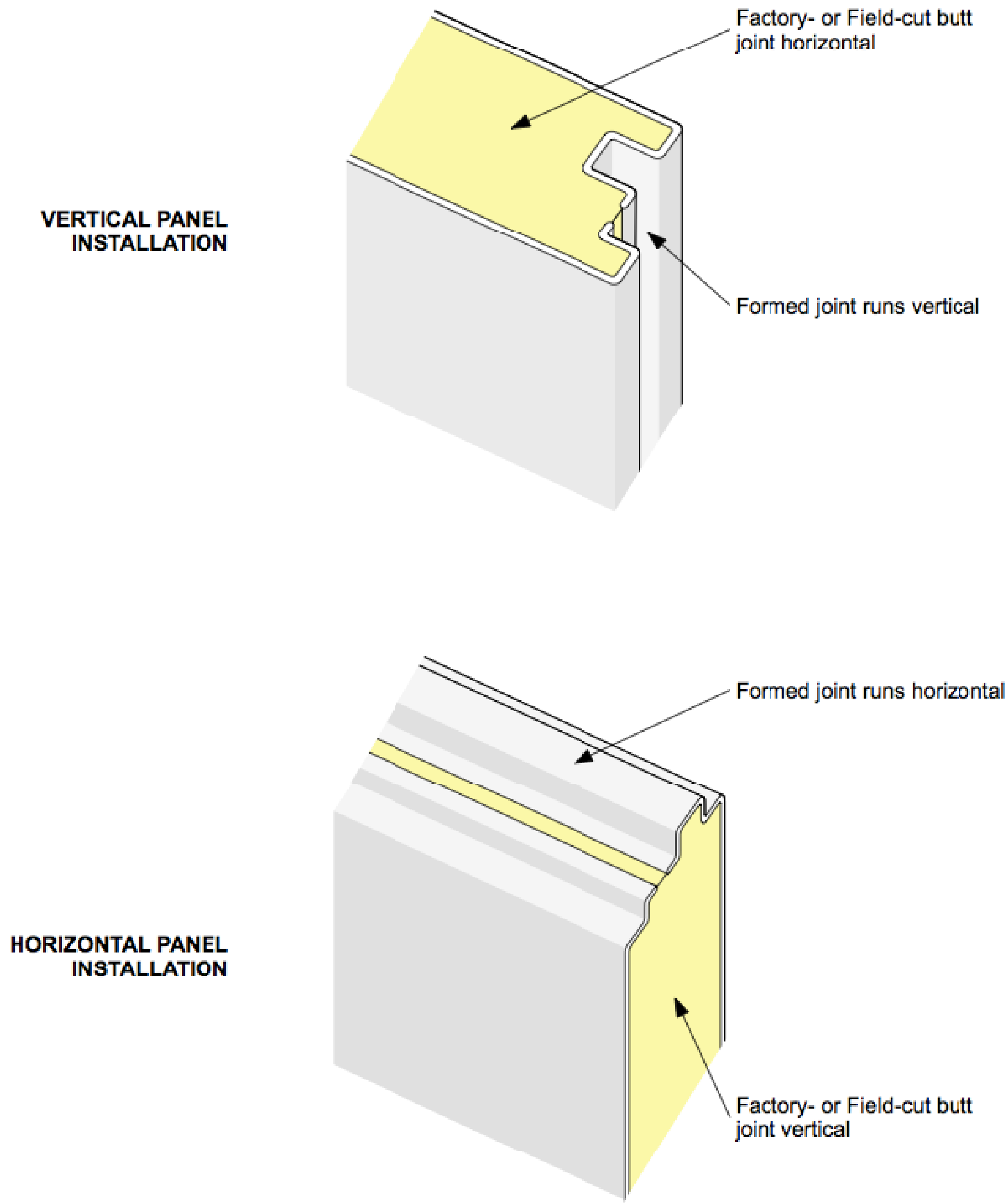

Figure 2: Insulated Metal Panels can be designed to be oriented vertically or horizontally

Although panels are intended to interlock along their length because of their specially-formed edges, the insertion of windows and the transition to other building components (walls, roofs, doors) may not always align with the standard module width. These conditions are termed "off-module" joints. In these situations the panel is usually cut, either in the factory or the field resulting in a butt joint condition essentially identical to end joints. The differences in these four conditions – horizontal joints of but edges, and vertical joints of butt edges – must be considered in the design and construction of buildings with IMP enclosures.

Although IMPs have been used for decades, there remains confusion about how they work and what they do. Some designers and builders confuse these IMP systems with site-assembled metal cladding systems and their separately installed layers. IMPs provide a complete building enclosure, including air and water control.

This brief guide will explain how IMPs can fulfill all of the required air and water control functions of a high performance building enclosure[2]. First, the guide reviews the functions of all building enclosures and introduces the control layers required. Then, water control and air control are described in more detail. Finally, a series of detailed drawings is provided to demonstrate how to achieve reliable, durable, high-performance enclosures using IMPs.

1.1 The Building Enclosure

The building enclosure is defined as the physical component of a building that separates the interior environment from the exterior environment: it is an environmental separator. In practice, the building enclosure has to provide the “skin” to the building, i.e., not just the environmental separation but also the visible façade. Unlike the superstructure or the service systems of buildings, the enclosure is always visible, and therefore of critical importance to owners, occupants, and the public. The appearance and operation of the enclosure has a major influence on the interior environment and on factors such as comfort, energy efficiency, durability, and occupant productivity, satisfaction and health.

In general, the physical function of environmental separation can be further grouped into three useful sub-categories as follows:

1. **Support**, i.e., to support, resist, transfer and otherwise accommodate all structural loading imposed by the interior and exterior environments, by the enclosure, and by the building itself. The enclosure is often no longer an integral part of the building superstructure in modern buildings.
2. **Control**, i.e., to control, block, regulate and/or moderate all the loadings created by the separation of the interior and exterior environments. This largely means the flow of mass (rain, air, water vapor, pollutants, etc.) and energy (heat, sound, fire, light, etc.).
3. **Finish**, i.e., to finish the surfaces at the interface of the enclosure with the interior and exterior environments. Each of the two interfaces must meet the relevant visual, aesthetic, durability and other performance requirements.

All practical building enclosures must satisfy support, control, and finish functions. However, only the support and control functions are needed everywhere an enclosure is needed. Control and support functions must continue across every penetration, every interface and every assembly. The lack of continuity is the cause of the vast majority of enclosure performance problems.

The **support function** is of primary importance. Without structural integrity, the remaining functions are of no use. The industry has reached a high level of understanding and accomplishment in this area.

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[2]The thermal control aspects of IMPs are not the focus of this document

For physical performance, the most common required enclosure **control functions** include resistance to or control of:

- rain penetration,
- air flow,
- heat transfer,
- condensation,
- fire & smoke propagation,
- sound and light transmission (including view, solar heat, and daylight),
- insect infestation,
- particulate pollutant penetration, and
- human access.

The most important control function with respect to durability is rain control followed by airflow control, thermal control, and vapor control. The level of fire and sound control required varies with code restrictions and owner requirements.

Unlike the control and support functions, which rely on continuity to achieve performance, the **finish function** is optional, and may not be needed in some areas, such as above suspended ceilings or in service or industrial spaces where the finish is deemed unimportant. Exterior finish components are often termed "cladding", but the term is imprecise, since cladding systems and materials often include some control functions (such as UV control, solar control, impact resistance, etc.) while also serving their finish function.

1.2 Enclosure Control Layers

Figure 3 shows an idealized arrangement of an enclosure, with the four control layers labelled, along with exterior finish, support and interior finish layers [Lstiburek 2007, Straube 2012].

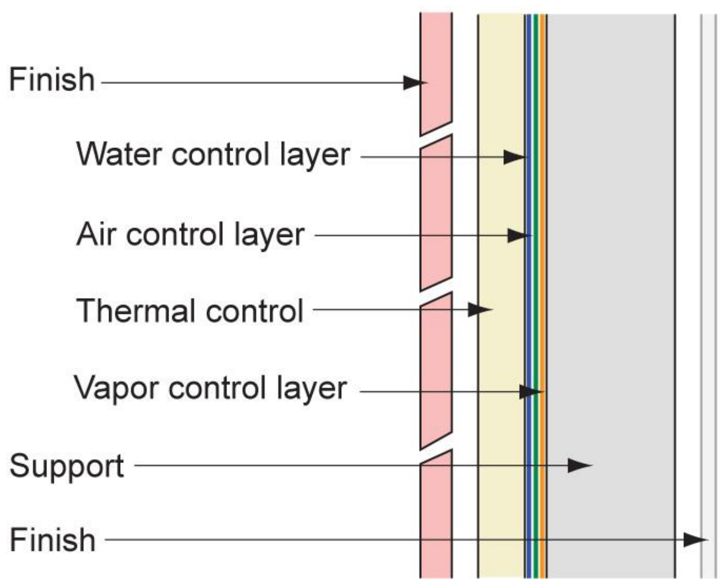

Figure 3: Idealized enclosure showing the four primary control layers

The water, air and vapor control layers are shown as thin lines to indicate that they can, in reality, be quite thin (e.g. less than $^{1}/_{16}$" or 1 mm) and still perform their functions very well. Sheets of polymer or bituminous membranes are commonly used for water, air, and vapor control layers; when so used, these materials should be installed behind the insulation and the exterior finish to protect them from temperature extremes and UV radiation. The support and the thermal control layer are shown as thicker components, because in practise these layers need to be thicker (e.g., well over 1" or 25 mm) to perform their function.

1.3 Enclosure Principles Applied to Insulated Metal Panels

In an Insulated Metal Panel system, the composite panel itself provides both the support and control functions, and in many cases, the interior and/or exterior finish of the building enclosure.

The support function of an IMP is provided by the metal skins combined with the rigid foam insulation core. Thicker panels can span larger distances and resist higher loads, if matched to the appropriate thickness of metal skin. The metal skins act as the water, air, and vapor control layers and the bare or coated metal acts as the finish. (**Figure 4**).

In most cases the interior steel sheet acts as the air and vapor control layer. However, in special circumstances (e.g., a cold storage building in a warm climate), the exterior sheet may be defined as the vapor and air control layer.

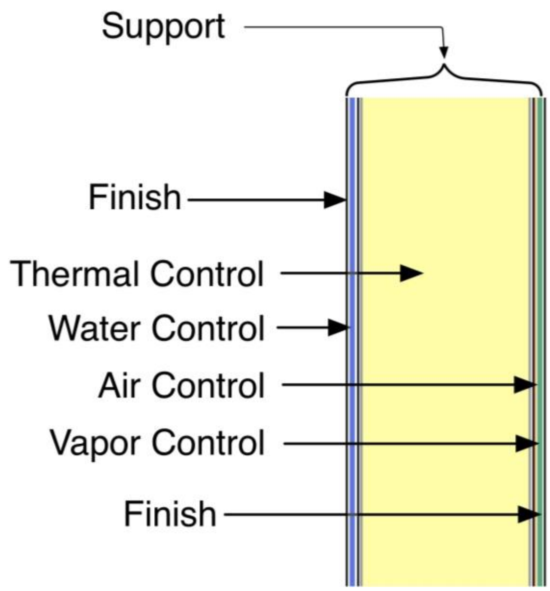

Figure 4: Insulated Metal Panel Control Layers

As the most important control function, the control of rain penetration deserves special attention in all designs. The control of air flow is usually the second most important function for the enclosure. The next section focuses on the rain control of wall systems in general, and insulated metal panels in particular. Section 3 describes air flow control.

2. Rain Control Principles

There are three recognized design strategies to control rain penetration within and through the enclosure [Straube & Burnett 1999, CMHC 1999]. These are the Storage, Drained and Perfect Barrier approaches (**Figure 5**).

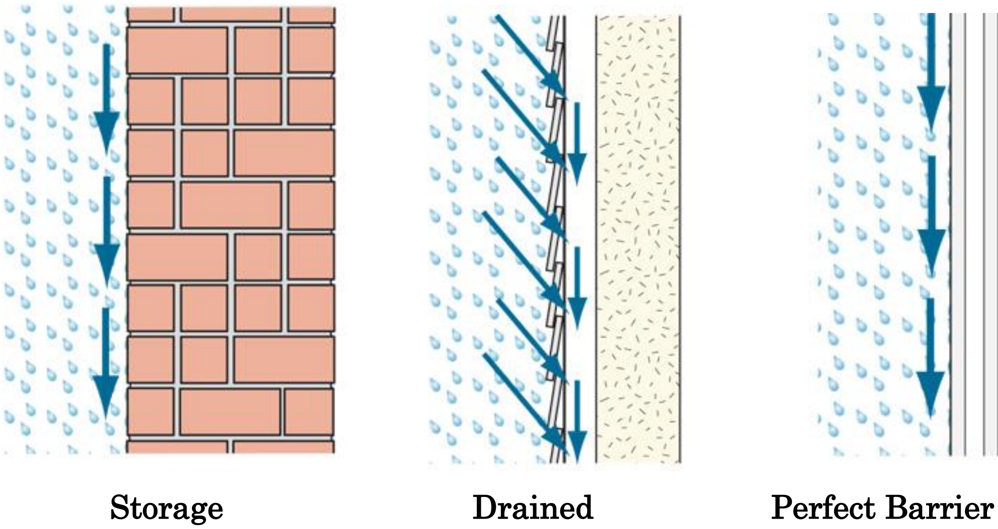

Figure 5: The three rain control strategies

Building enclosures have been, and continue to be, designed and built successfully using all three strategies. The newest strategy, the drained, or "rainscreen" approach is widely used and promoted. While it is ideal for some types of enclosure systems, it is not appropriate for all situations (that is, it can result in less reliable performance or simply a higher risk of leakage in some situations). The mass approach has been used successfully for thousands of years, and the perfect barrier approach has also been used successfully by glazing, membrane roofs, and precast concrete walls, as well as IMPs. Each rain control strategy is examined in more detail below.

Storage: Storage (or **mass**) is the oldest strategy. This approach assumes some rainwater will penetrate past the outer surface of the enclosure. It requires the use of an assembly of materials with enough moisture storage capacity and moisture tolerance (that is, sufficient "mass") to absorb all rainwater that is not drained (i.e., shed) from the outer surface. In a functional mass / storage wall, this moisture is eventually removed by evaporative drying from both the inside and outside before it reaches the inner surface of the wall as a liquid. The maximum quantity of rain that can be controlled is limited by the storage capacity available relative to drying conditions. Some examples of mass systems include adobe walls, thatched roofs, and multi-wythe brick masonry.

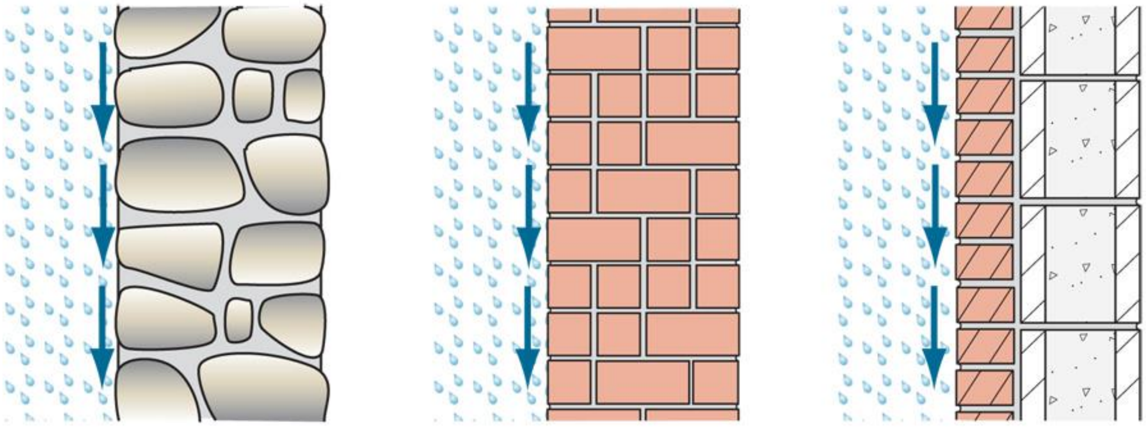

Figure 6: Mass (or storage) enclosure wall assemblies

Drained enclosures also assume that some rainwater will penetrate the outer surface but rather than storing it, the assembly is designed to remove this water by providing drainage (comprised of a capillary breaking drainage plane, a drainage gap, flashing, and a weep hole/drain). Many cladding systems, such as brick veneer, siding, and stucco, leak, as do the joints between other cladding types, such as shakes, terra-cotta, small metal panels, or natural stone. For these cladding types drainage is not just the most practical strategy, but has also been the most successful system of rain penetration control. IMPs have sheet metal as the outer skin, through which water cannot pass; hence, they use a different approach described below.

The term "**rainscreen**" is applied to some drained systems (since the cladding "screens" the rain), but the term is imprecise, as it means different things to different people. Drained walls may also be **vented** (a single opening or line of openings in the cladding connected to the exterior), **ventilated** (at least two openings through the cladding usually distributed between the top and bottom of the cavity), or even **pressure-moderated** (the air pressure in vented and ventilated walls tends to follow the exterior wind pressure, thereby "moderating the pressure"). The term "rainscreen" is applied loosely and inconsistently to all three different types of drained walls.

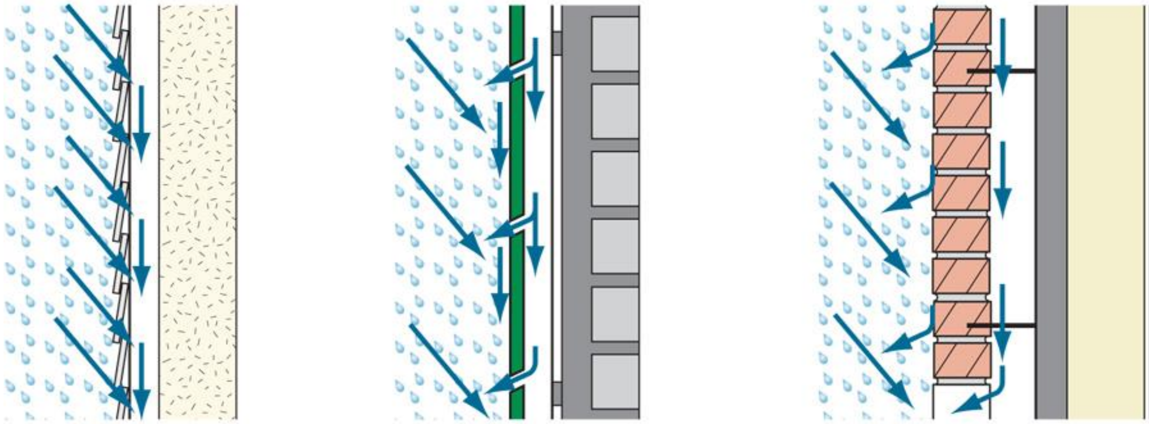

Figure 7: "Screened" and Drained enclosure walls

As drained systems can accommodate a range of claddings and backup systems, this approach to rain control has justifiably received a lot of attention from researchers and practitioners. However, drained systems are not always appropriate or the best strategy if good rain penetration control is desired. **Insulated metal panels, as well as existing multi-wythe solid masonry walls, glazing panels, large-format precast panels, and low-slope membrane roofs, are common enclosure systems that perform better when a rainscreen drained system is not used**.

Perfect Barrier systems stop all water penetration at a single plane. Such perfect control required the advent of modern materials. Because it is difficult to build and maintain a perfect barrier with many materials, it is common to recommend the use of drained walls. However, some systems, usually factory built, provide wall elements that are practical and durable perfect barriers. For example, metal sheets (such as the skins of a typical IMP), glass, precast concrete, and low-slope roof membranes can all be considered watertight (**Figure 8**). **The joints between perfect barrier elements should almost always be designed as drained joints in the form of two-stage sealant joints or similar**.

Perfect barriers may be **face-sealed,** where the perfect barrier is at the exterior face, or **concealed**, where the barrier is protected behind other materials. Some concealed barrier systems, such as Protected Membrane Roofs (PMR), have a long record of good performance. Others, such as stucco and adhered veneers applied directly over building paper have shown disastrously poor performance in many applications. The difference in experience is directly related to the likelihood of a perfectly waterproof barrier being achieved in construction and maintained over the desired lifespan. EIFS (synthetic stucco) can perform as a perfect barrier but experience has shown that rain leakage at the joints can be trapped within the system and this has caused thousands of failures. Current practise for EIFS is to use two-stage drained joints, and fully-drained systems are now widely available.

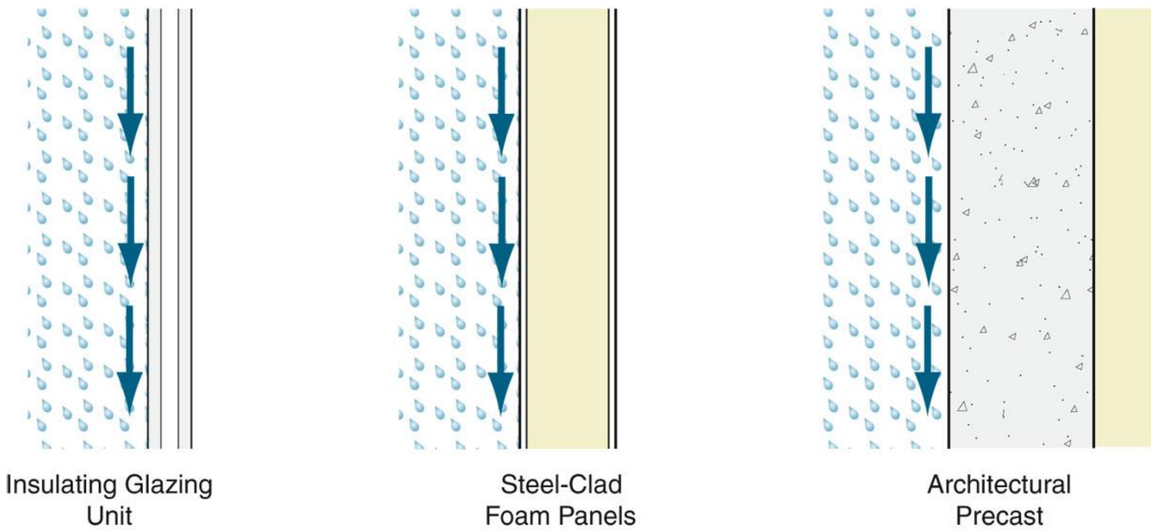

Figure 8: Perfect barrier enclosure walls

2.1 Rain Control Principles Applied to IMP

IMPs use a perfect barrier rain control approach for the enclosure element, and usually use a drained approach for the joints. The sheet steel is a high-performance, durable water control layer: water simply will not leak through steel, and cracks and holes will not form over time. The exterior location of the water barrier exposes it to weather, but coated steel is quite durable, and this location offers some real advantages. The barrier is easily inspected, and water does not enter the enclosure and need to travel via hidden paths. In many ways, IMPs act like very large sheets of glass: the factory-fabricated material is durably water tight, and hence only the joints require attention.

2.1.1 Joints and Penetrations

Joints may be classified in the same manner as enclosure elements (**Figure 9**). It is common for the enclosure elements and the joints between them to use different approaches. For example, walls which use mass and perfect barrier elements often use drained joints to form a complete system.

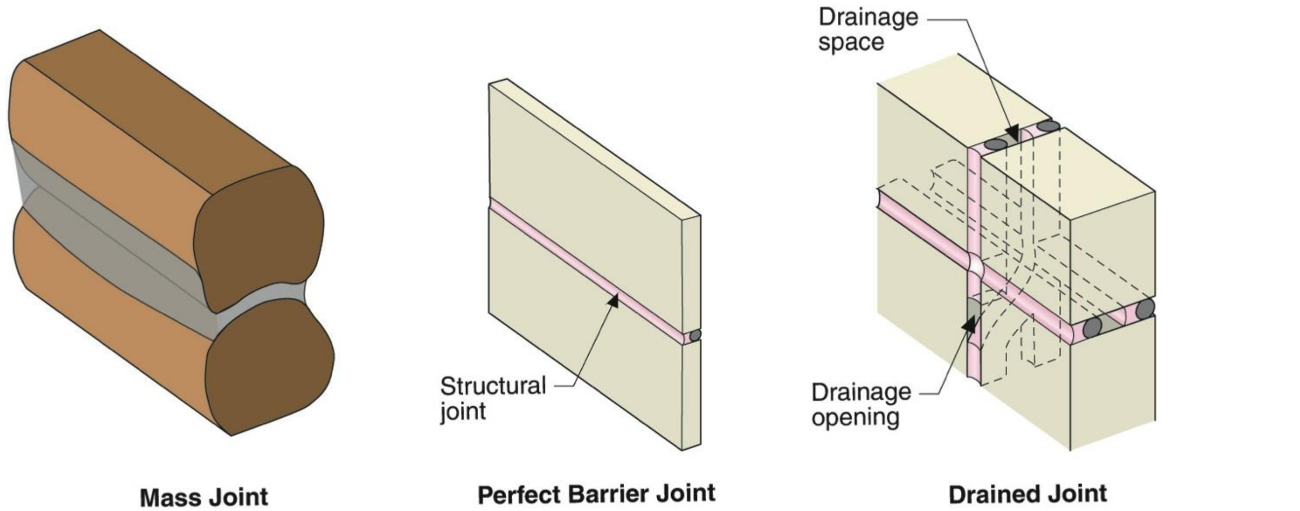

Figure 9: Three different rain control strategies at joints. Two-Stage drained joints are the recommended approach.

As joints made on site are more susceptible to workmanship errors and are made of materials that are more likely to degrade (due to ultraviolet radiation and high and low temperatures), they should use a drained strategy. **Face-sealed polymer sealant joints (e.g. a single line of exposed sealant) have a poor record of performance and cannot be recommended for controlling rain entry.** Even exposed gaskets, often used to create the joint between insulated glazing units and the window frame, tend to shrink and crack over time. When these seals fail, as field experience shows is likely [Lacasse & Miyauchi 2009], significant water penetration occurs. For these reasons, a drained approach is recommended at joints for many systems, such as the joints between the glass and frame of windows, between panels of precast concrete, and between IMPs and windows, doors, and other IMPs.

The concept of a drained joint, or two-stage seal has been promoted for almost 50 years [Garden 1963, 1968, AAMA 1971] based on solid research [Svendsen 1967, Isaksen 1967, Platts & Sasaki 1965] and has been widely used with great success for almost as long in the precast concrete and curtainwall industries.

The interior seal in a two-stage joint acts to ensure both air control and water control continuity (**Figure 10**). The outer seal is a protective screen that ensures that little water enters the joint, and that the inner sealant is protected from UV radiation and temperature extremes. The inner seal can be installed from either the interior or the exterior and be formed of many different materials, although metal flashing and polymer-based sealants are the most common. Gaskets, unless mechanically compressed, do not usually provide sufficient tightness for the inner seal, but are often preferred for outer seals.

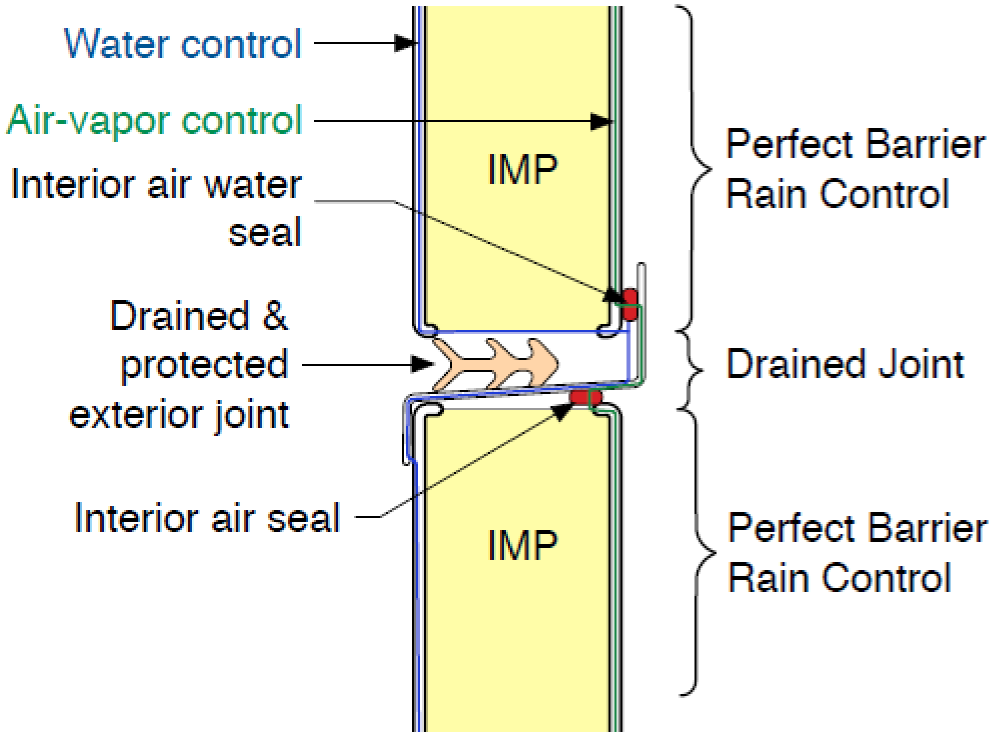

Figure 10: Horizontal joint at ends of vertically installed panel demonstrating air (green) and rainwater (blue) continuity across drained joint of an IMP

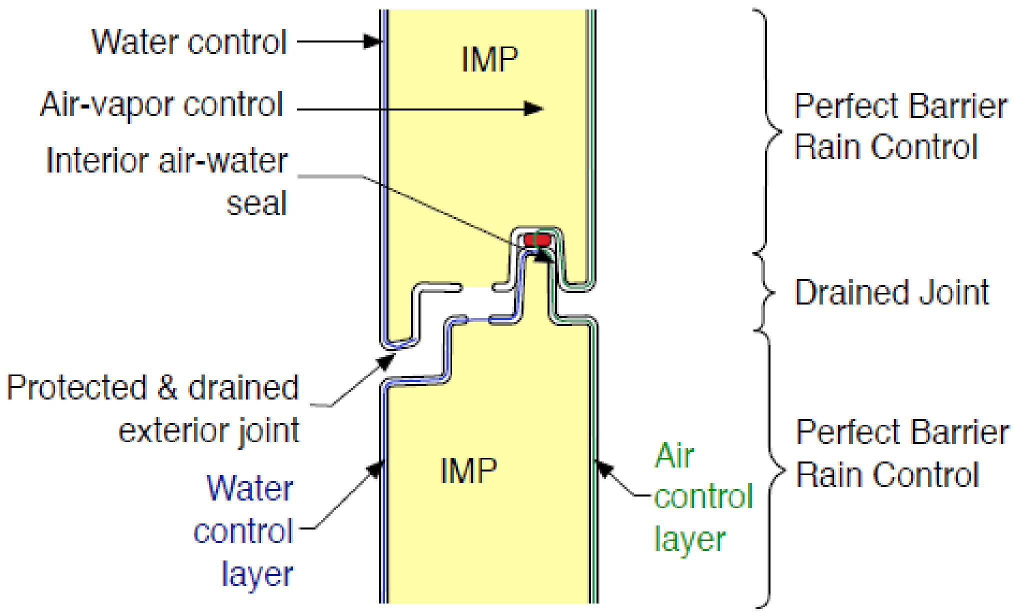

Figure 11: Horizontal joint at factory-formed long panel side. Air-vapor and water control layers shown in green and blue respectively

In general, the inner seal should be held back about 1" (25 mm) behind the backer rod, gasket, or overlap of the outer seal to create a well-drained air gap. The gap can be larger, if convenient, and often is in thick wall systems.

Weep holes, with a minimum dimension of about 1/2" (12 mm) or continuous unsealed overlaps, must be provided to facilitate drainage. Weep holes are almost always installed at the base of vertical joints, and protected unsealed laps are used at horizontal joints on top of flashing.

It is ideal, especially in enclosures that are highly exposed to wind-driven rain, to provide some protection for weep holes by adding exterior drip edges or additional layers of internal baffles to interrupt the direct kinetic energy of raindrops.

In practise it is generally accepted that the most common rainwater control failures occur at window and door penetrations [e.g. Finn 1995]. Regardless of which rain penetration control strategy is used, window and door penetrations through enclosure walls should be based on a drained approach.

Sub-sill flashings (**Figure 12**) of various types are widely available to create a drained opening for windows and doors. For drained wall systems, the sub-sill flashing can drain into the drainage gap. For perfect barrier (e.g., IMP) and mass systems, the flashing must drain water to the exterior face of the assembly (that is, the water control layer of the rough opening made must be continuous with the water control layer of the wall).

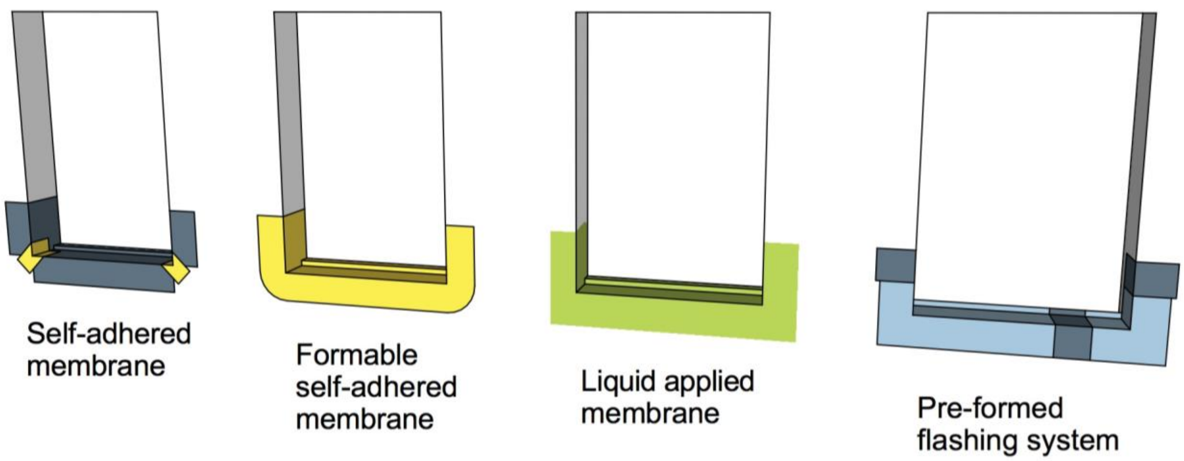

Figure 12: To ensure resistance to rain penetration, sub-sill flashing below all window and door openings is a critical requirement.

2.1.2 Structural Fasteners

IMP systems must be fastened back to a primary structure to safely and effectively transfer the collected loads. This is usually achieved using fasteners and clip systems. These discrete connectors vary in shape and size amongst different IMP manufacturers. They may occur only twice along the length of a panel or every few yards. The design of these details, and the construction of the IMP enclosure, must account for these special penetrations or leaks of air and rainwater may occur.

In many cases, sealant is applied around structural clips and large washer details to maintain continuity of the water control layer (**Figure 13**). Although bedding the clip/washer in sealant is effective, it is difficult or impossible to inspect and, therefore, sealant around the edges of the fastening, where continuity can be visibly confirmed, is often preferred. The clip should be outboard of the inner air seal if it is only sealed for water: both the water and air seal must be ensured for fastening systems that breach the inner air seal.

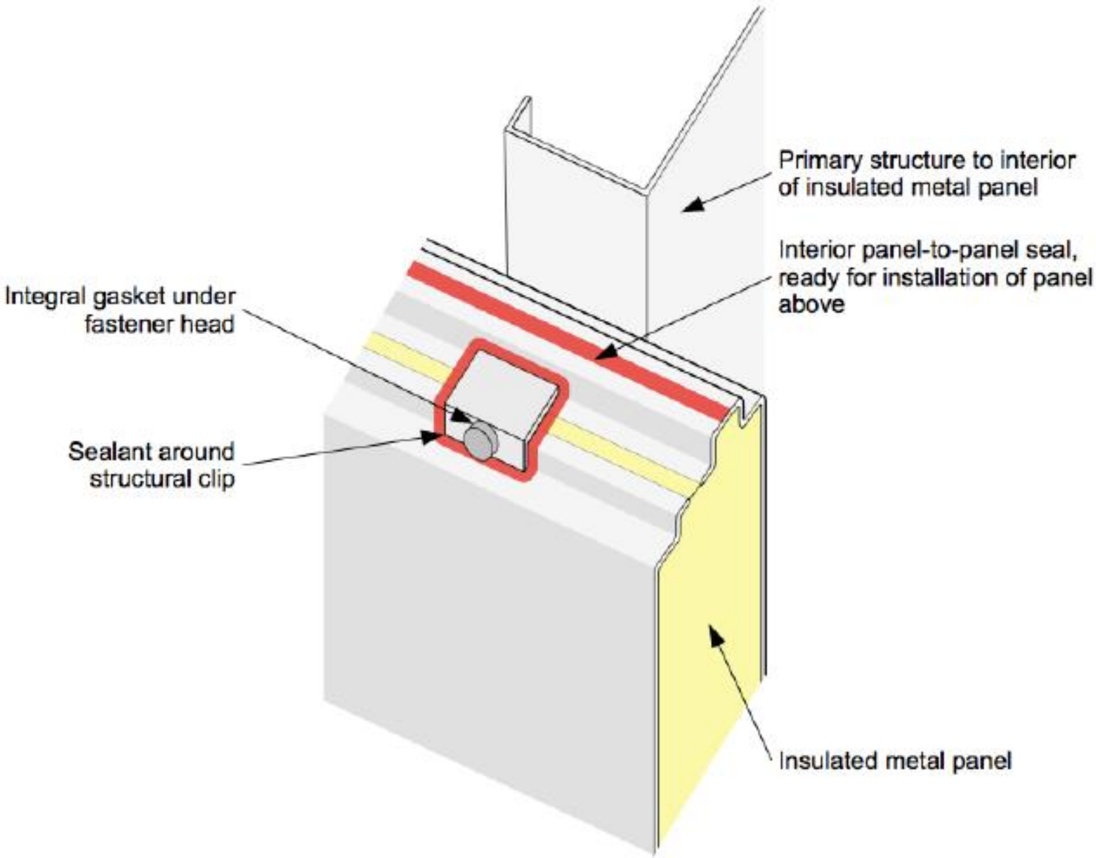

Figure 13: Sealing joints at structural clip attachments (upper panel not shown)

The sealant used should be a low-modulus, durable, non-hardening product, such as silicones with 50% movement capacity or high-grade butyl, to accommodate the movement metal undergoes with temperature changes. Although setting clips in sealant and sealing around all four sides is common practice, for water control, only the top and sides strictly need to be sealed: leaving the bottom edge open allows drainage. Air seals of course require all 4 sides to be sealed.

Through fasteners can either be hidden, and hence protected from direct rain impingement, or exposed. Exposed fasteners should be set in sealant or be provided with a pre-installed gasket and washer.

2.1.3 Cladding over IMP

A screen or cladding can be applied over an IMP system. As the IMP provides all performance functions of an enclosure, designers have tremendous freedom in choosing the type and details of such over-cladding. The cladding fulfills mostly an aesthetic function, but, depending on the choice, may also add considerable impact resistance, solar shading, and rain shedding, thereby improving the durability and performance of the IMP system behind it.

3. Air Flow Control

A strong, rigid, and air impermeable air barrier system is required in all building enclosures, and is critical to high-performance buildings [Straube 2012]. Codes and standards are increasingly specifying airtightness targets and requiring the measurement of the finished building product's installed performance. Controlling air leakage is desirable because air leaks cause comfort complaints, risk indoor air quality, waste energy, lead to poor humidity control, and allow odors and smoke movement. For air leakage to occur, both a continuous path from indoors to outdoors (a "hole") and a pressure difference must be present.

Air movement through an enclosure assembly is driven by air pressure differences between the interior and the exterior. These air pressure differences are caused by a combination of wind, stack effect (natural buoyancy of air), and mechanical pressurization. The combined effect of these forces can be quite significant and lead to a large volume of air movement.

To control air movement through the assembly, a continuous barrier to air movement is required (the air control layer). The location of the air barrier in the assembly is not strictly important[3]: it can be on the exterior, interior or middle and be equally effective at stopping air leakage.

The air barrier can be a single material or a layer of materials acting together as a composite to resist the imposed air pressure loads without rupturing. Materials, such as sheet polyethylene or taped foil- or kraft-paper facings, which historically were introduced as vapor barriers, have demonstrated poor performance as air barriers (due to their inability to resist air pressure loads). Materials such as fluid-applied or sheet membranes fully adhered to a solid substrate (exterior gypsum, masonry, and concrete) have demonstrated high levels of performance in practice (due to the structural nature of the combined membrane and solid substrate).

The five primary requirements of an air barrier system are that it be:

1. continuous (no holes, the primary need),
2. strong (to resist the full wind load),
3. durable (to last as long as the enclosure design life),
4. stiff (to avoid fatigue failure and pumping action), and
5. air impermeable (the easiest requirement).

In order for the air barrier to be effective it must be continuous in the field of the wall as well as at the connections to other components. It is also critical that the air barrier be continuous from one assembly to

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[3]In systems with air permeable insulation or continuous air gaps next to the air barrier, air flow from the indoors past the insulation to the air barrier and back to the interior must also be controlled. This is termed *convective looping*, and is not a concern for an IMP. Wind-driven air flow from outdoors, through air permeable insulation or around insulation gaps, back outdoors can also be a concern, and is termed *wind washing*. IMPs are immune to wind washing as there are no gaps or air permeable insulation. Both mechanisms *can* be an issue at joints between panels and must be managed by providing some airflow resistance on both the interior and exterior of the joint.

another (roof to wall, wall to foundation, and window/door to wall). If the air barrier is not continuous, then leakage of air will occur. The path of air movement will depend on the design of the assemblies and the location of the discontinuity. Condensation within the assembly can occur if moisture-laden air moving through the assembly comes into contact with a cold surface (i.e., a surface temperature below the dew point temperature of the leaking air). This can cause problems in both hot-humid and cold weather, but it more of a risk for special building types (swimming pools, cold storage buildings, etc.). Short-term condensation can be accepted if it is allowed to drain and ventilate away.

3.1 Air Flow Control for IMPs

Insulated metal panels can provide an exceptionally rigid, strong and air impermeable component of an air barrier system. The panels themselves meet all the requirements to be part of an air barrier. Sheet metal is clearly airtight, and hence is listed as an air barrier material in codes and standards (such as ASHRAE 90.1) without the need for any further testing. Therefore, joints, penetrations, and transitions are the critical link to achieving airtightness in IMP systems. At such conditions, the construction documents should detail how an uninterrupted, strong, and airtight plane transitions from the inner sheet steel layer to the adjoining curtainwall, roof, canopy, foundation, etc. while accommodating dimensional construction tolerances and in-service movement. Sealant, sheet metal, and sheet membranes are common transition components in successful details.

The most common source of air leakage through IMPs is at the panel-to-panel joints. Minimizing air leakage is both an issue of proper design and construction/assembly quality. At a two-stage drained joint, the inner seal provides the continuity of the air barrier from one panel to another. If joints are designed as recommended (i.e, drained) the vented outer joint cannot, of course, be part of ensuring air barrier continuity. To ensure good continuity and accommodate both dimensional tolerances and movement at joints between IMPs, high quality gun-grade sealants are preferred: compressed foam tapes often cannot accommodate the range of joints sizes demanded by dimensional tolerances on the job site, and polymer gaskets rarely remain pressed tightly to the metal skins. The service life of polymeric sealants is much longer when used on the inside than when exposed to UV radiation. Hence, protected interior seals made of quality polymeric sealant materials can usually provide service lives of 30 to well over 50 years.

Mechanically clamped gaskets and membranes perform exceptionally well but are usually practically difficult or too labor intensive to install between panels, whereas they are the preferred solution for joints between an IMP and another building component.

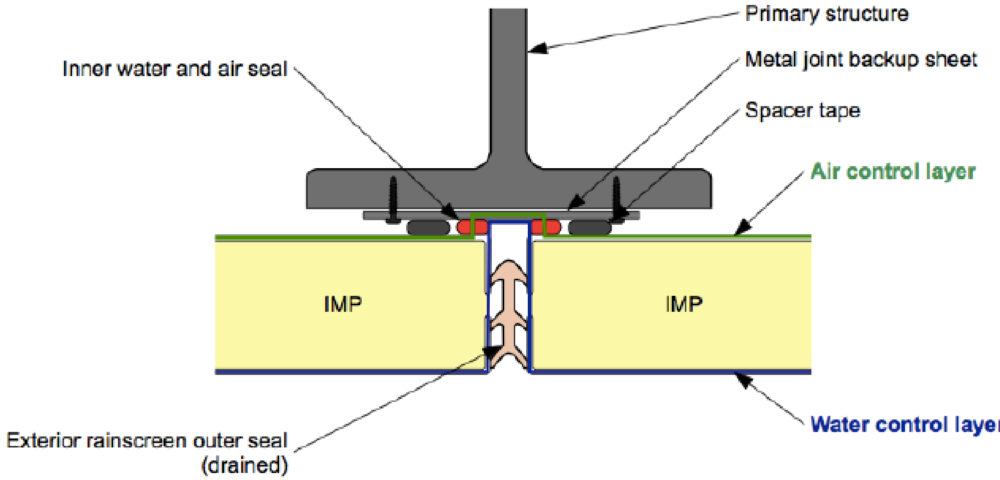

Figure 14: Plan section of a vertical butt joint demonstrating continuity of water and air control

Air leakage condensation cannot occur within the body of the insulated metal panel, even if one of the metal skins is breached, because *all* materials are completely air impermeable and there are no voids to allow air flow. However, excessive air leakage at joints may be a problem if air leaks across the air gap and contacts a cold surface on the other side. Drained and vented joints allow condensate and vapor to leave the joint and control condensation for all but the largest leaks, or most extreme climates (indoors or outdoors).

Hence, the rigid air impermeable metal skins of IMPs can be part of an excellent, durable air barrier system. Examples of designs for critical details are provided at the end of this document.

Sidebar: Vapor Barriers

Vapor barriers are required in many enclosure designs, particularly when used in very cold or very hot climates. Sheet steel is, by its nature, a perfect vapor barrier at a thickness of only a few thousands of an inch. The skins of an IMP are much thicker than this and hence are perfect vapor barriers (0 perm).

At joints between panels, achieving a low-permeance vapor barrier is not very important, except in demanding applications with very high average differences in vapor pressures (e.g. freezer warehouses, swimming pools, special-purpose factories). However, some vapor resistance should be provided. The typical backer rod and sealant used as an air barrier seal can also often provide a good vapor barrier. However, open-cell foam backer rods and silicone sealant are usually too vapor permeable for high interior humidity environments such as swimming pools. Urethane and butyl-based sealants over closed cell foam backer rods can be used to provide low-permeance vapor barriers. In all cold climate applications, a vented outer sealant is recommended to allow any moisture that may enter the joint from the interior to leave to the exterior. Hence, a vented two-stage joint provides a single interior air and vapor barrier, with the outer seal acting as a vented rainscreen with little air or vapor resistance.

4. IMP Enclosure Details

A number of conceptual details are provided in this chapter to demonstrate the practical implications of the rain and air control theory described above. Insulated metal panels are shown as forming the entire enclosure in the following details.

Although the full range of doors, windows, and louvers on the market can be designed to interface with all common IMPs, some manufacturers offer special window, door and louver components that integrate with the joints of their panels. In either case, the air and water control layers must be made continuous across the joint line to be effective.

It should be noted that any drained cladding system (e.g., terra cotta, ACM, fiber cement, perforated screen, masonry veneer) can be installed over an IMPS with no substantive change to the details: the exterior face of the IMP remains the water control layer but becomes a drainage plane (see Drained systems in Section 2), which is flashed outwards to the exterior at any obstructions to vertical drainage such as windows and doors.

An interior layer for special finishes (such as drywall, wood paneling, etc.) and service distribution can also easily be added to these drawings (by including light-gauge steel studs, hat-sections, Z-girts, etc.) without changing the fundamentals of the enclosure performance.

4.1 Window Head

The window head detail shown is at a butt joint (**Figure 15**): either the base of a vertically installed panel, or a field-cut off-module, horizontally installed panel. The detail employs a bent metal flashing as the interior line of water control, and an exterior sealant with weep holes as the rain shedding rainscreen. Achieving airtightness requires a number of sealant beads (3) in this approach. The metal flashing acts as a thermal bridge: numerous proprietary polymer-based or thermally broken metal flashings can be used to manage this.

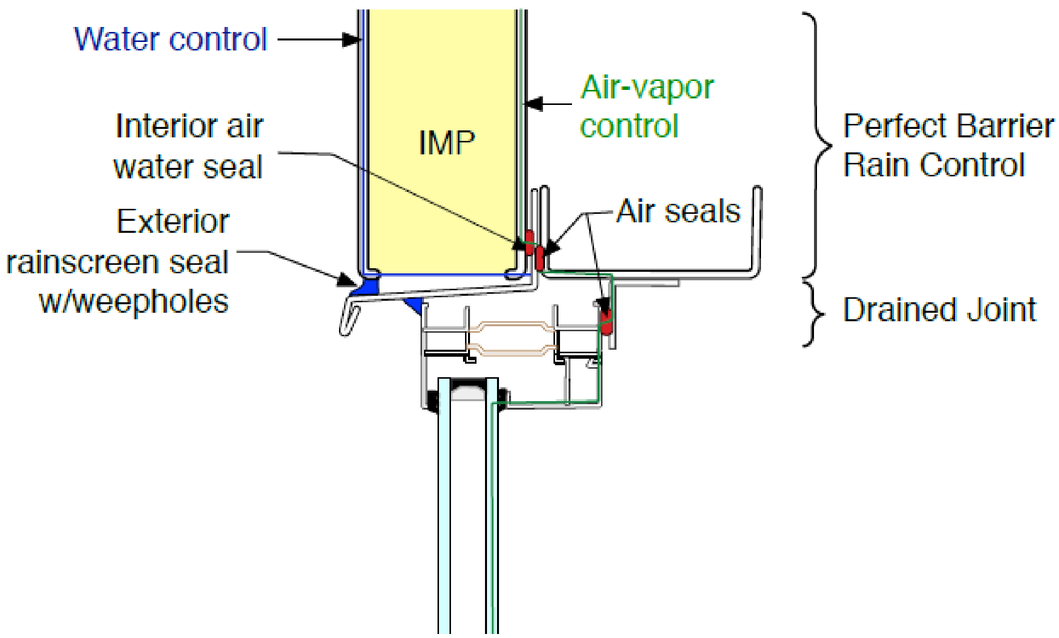

Figure 15: Window head

4.2 Window Sill

The window sill detail shown is appropriate for conditions similar to the head detail described above. (**Figure 16**) The design uses sub-sill flashing to manage rainwater penetration through the window and its installation. A metal angle is used to form a backdam, allows for reliable air sealing to the window frame, and provides a structural connection. The fully-adhered membrane acts as a combined air and water control layer that consolidates the control layers at the point of transition to the window frame. The exterior flashing can take on a number of forms provided it allows outward drainage from below the window and sheds the majority of water outward.

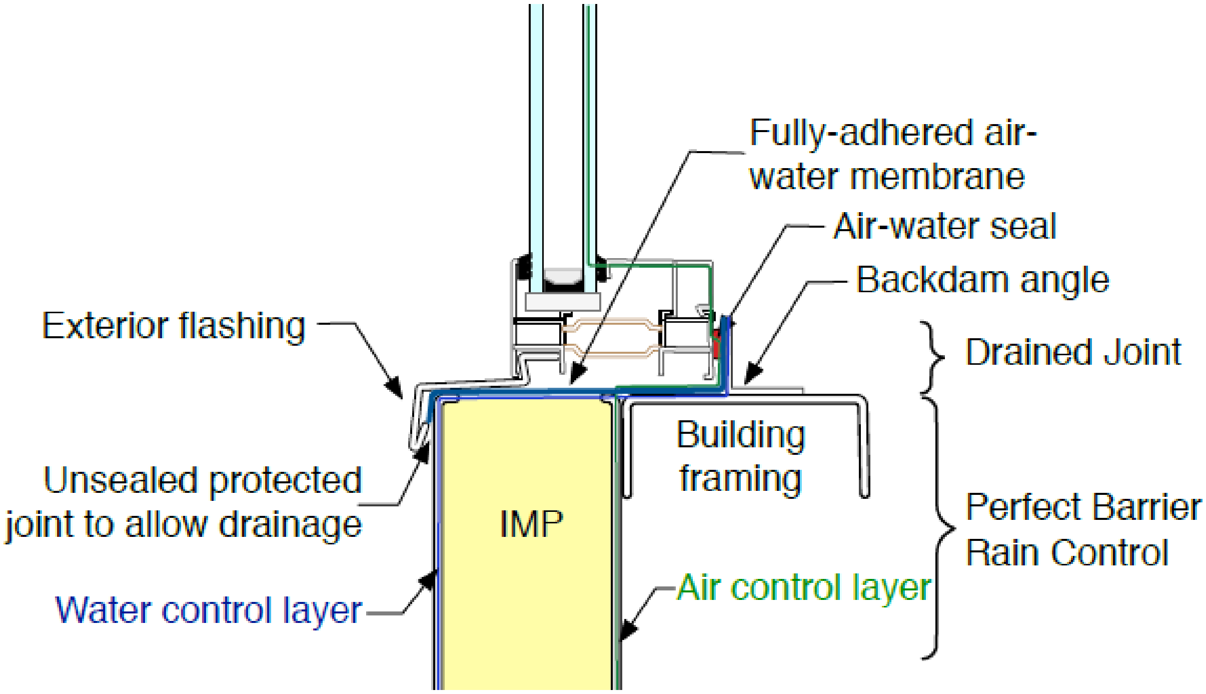

Figure 16: Window sill at IMP

4.3 Window Jamb

The window jamb detail shown represents a butt joint condition: either a standard horizontally applied panel or a field-cut, off-module, vertically installed panel. (**Figure 17**) The detail relies on gravity to drain water that penetrates the outer seal (shown as sealant, but it could be made of bent metal or a gasket) to the sill; where it is drained out at weep holes or unsealed joints. The air control continuity is provided by a fully-adhered membrane, sheet or fluid-applied, that connects the inter metal air barrier of the IMP to the backdam angle and then through the sealant to the window frame.

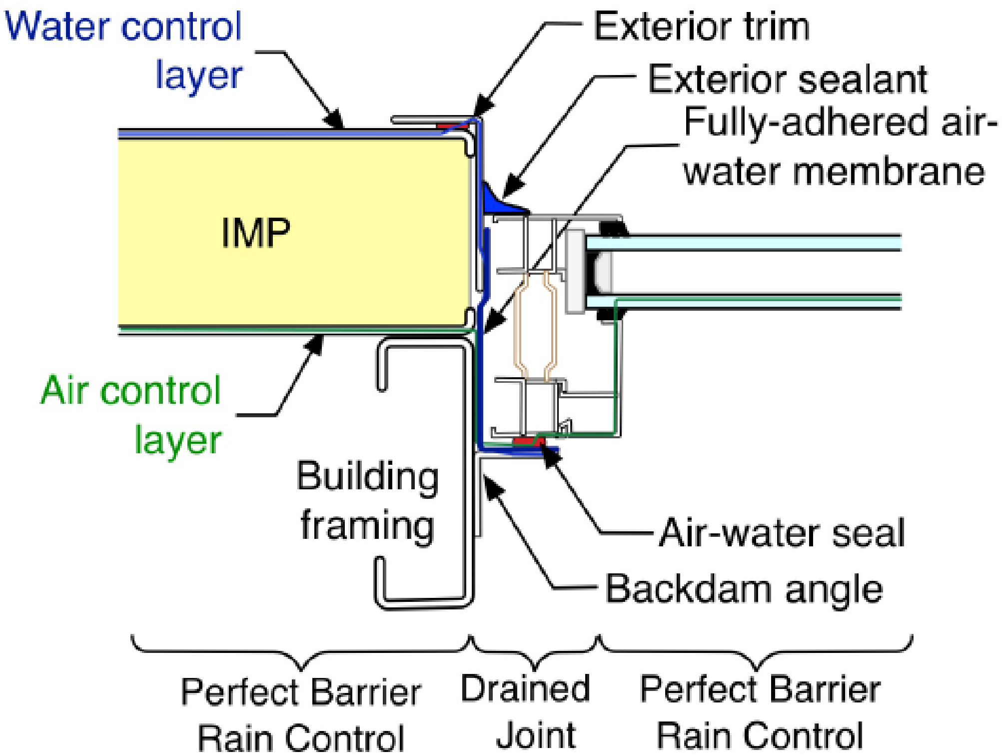

Figure 17: Window jamb detail at IMP

4.4 Parapet Intersection – Wall to Parapet

This detail (**Figure 18**) shows an exposed membrane roof on a lightweight metal deck / OWSJ system with a vertically oriented IMP enclosure wall. The exterior roof membrane is shown lapped up and over the IMP to transition the water control of the roof to the water control at the face of the IMP — either the roof membrane can be used or a compatible fully adhered membrane. The parapet flashing provides a rainscreen and protects the membrane from UV radiation.

Best practice requires a deck level air barrier, and this air barrier can be adhered to the back of the IMP to complete the air control layer continuity. As the membrane attaches to the inside sheet metal air barrier, there may remain holes at the vertical joint. This can be resolved by sealing the joints with a short line of sealant at the location where the membrane adheres to the IMP.

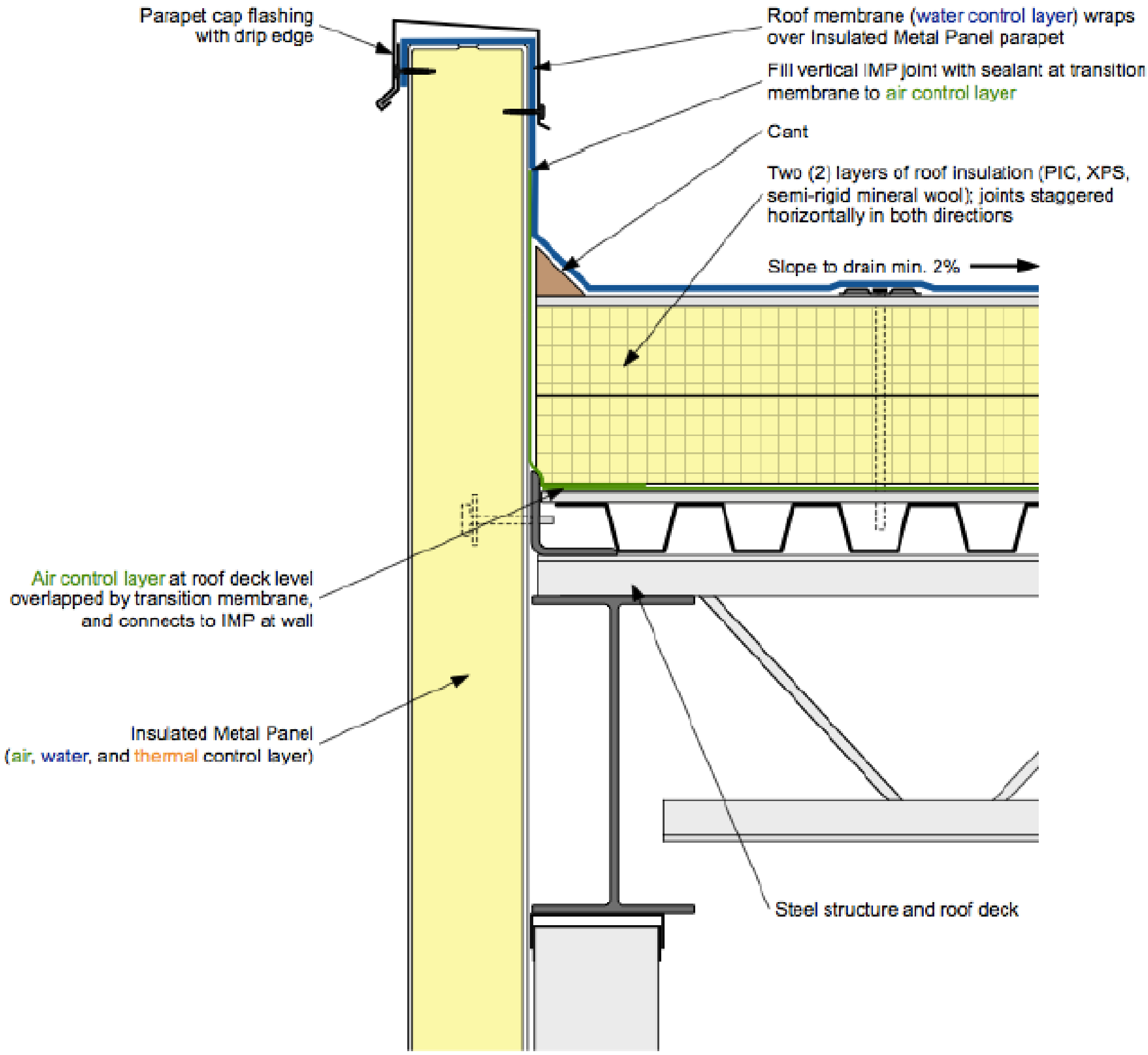

Figure 18: Parapet connection to IMP

4.5 Grade-level Intersection – Wall to Foundation

These details (**Figures 19 & 20**) show exterior insulation at the concrete foundation to meet the requirements of high performance building. Bent metal flashing is used as the inner seal at the transitions and exterior sealant with weepholes is used as the rainscreen outer line.

The air control layer continuity requires two lines of sealant to transition from the air control of the IMP (the inner sheet steel) to the concrete foundation air control layer.

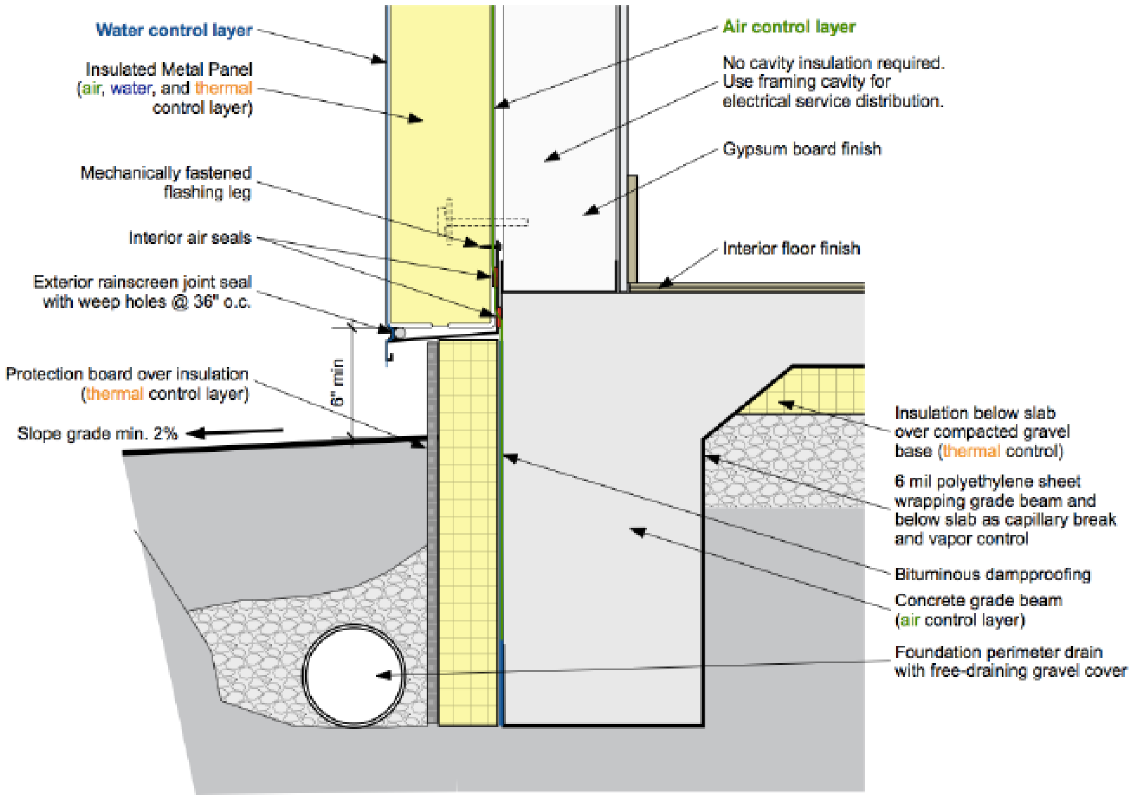

Figure 19: Grade transition from IMP to concrete foundation

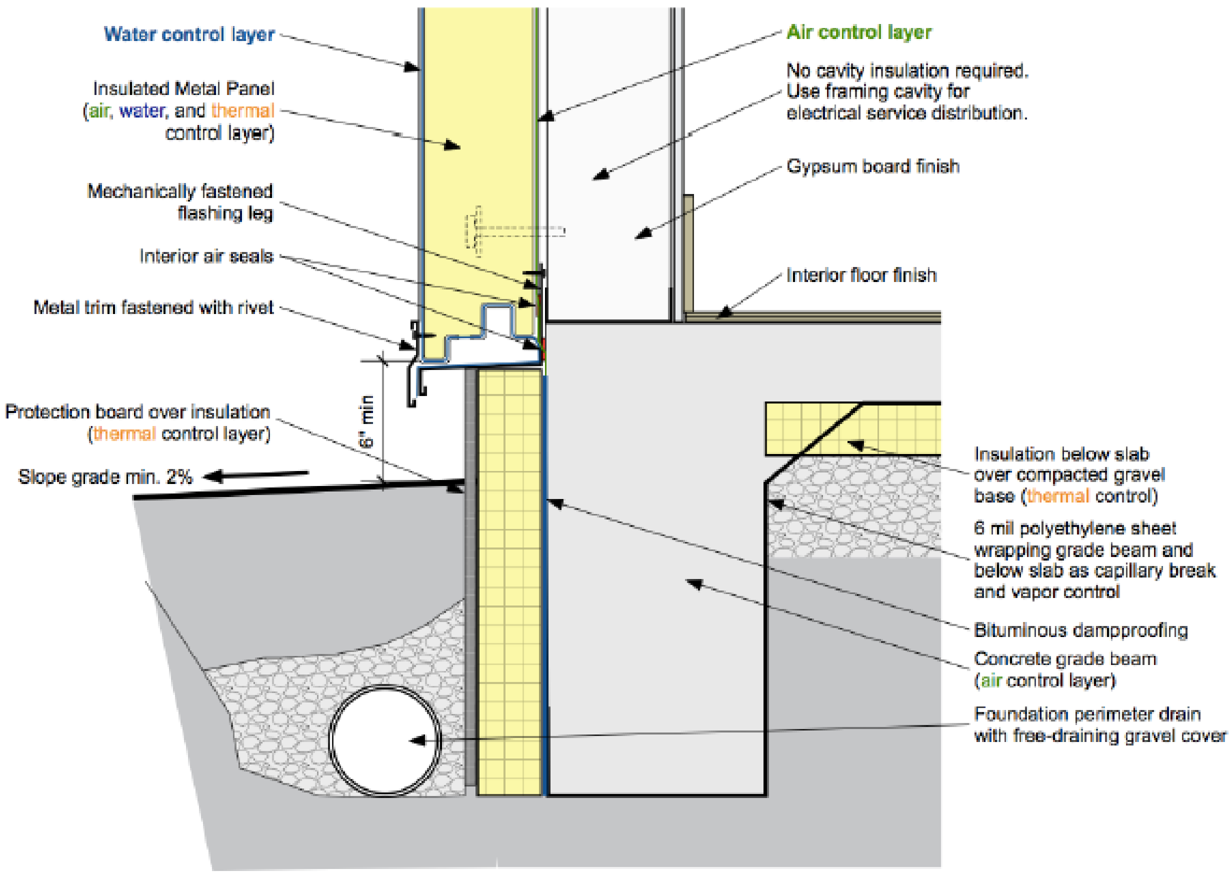

Figure 20: Grade transition from IMP to grade for a horizontally-installed panel

5. Conclusion

Insulated metal panel systems provide all the required functions of a modern building enclosure in one prefabricated product: from interior to exterior finish, to structural support and the control layers needed for environmental separation. The strong, stiff metal skins of IMPs provide excellent, time-proven water and air control. Unlike some other systems, drainage or rainscreen approaches are not recommended as such an approach will reduce the performance of the system.

The joints between panels and the transitions to other components, especially windows, doors, roofs, and foundations, demand critical attention if high performance is to be achieved. In most cases, these joints should be designed using a drained, two-stage strategy using some combination of membranes, sealants, and/or gaskets.

When designing joint details it is recommended that the outer metal sheet be considered the water control layer and that the inner sheet liner be designed as the air control layer. Connecting the control layers of other components of a buildings enclosure in this manner can provide reliable, durable performance.

6. Resources and References

The following resources provide additional general information about air control, rain control, building enclosures, and joints.

6.1 Resources

The following general building science resources are available at BuildingScience.com:

- *The Building Enclosure*. Building Science Digest 18.
- *Airflow Control in Buildings*. Building Science Digest 14.
- *Understanding Air Barriers*. Building Science Digest 104.
- *Rain Control in Buildings*. Building Science Digest 13.
- *Rain Control Theory*. Building Science Digest 30.
- *Drainage, Holes, and Moderation*. Building Science Insight 4.

6.2 References

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METAL CONSTRUCTION ASSOCIATION
8735 W. Higgins Road, Suite 300, Chicago, IL 60631
847.375.4718 I mca@metalconstruction.org I www.metalconstruction.org