# DESIGN CONSIDERATIONS FOR OPEN JOINT RAINSCREEN ASSEMBLIES

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## ABSTRACT

Recent years have seen an increased trend towards rainscreen cladding system for the benefits they offer in terms of rain water management. These systems typically consist of an exterior cladding, a drainage cavity and a back-up weather resistive barrier. Traditionally in rainscreen cladding designs the joints in the exterior cladding are sealed to minimize the potential for water intrusion into the drainage cavity with the exceptions of weeps and pressure equalization vents which are generally sheltered from water ingress. However recent trends in the design of exterior claddings have seen an increased use of open joint rainscreen cladding systems. In these systems the joints between the cladding elements are intentionally left open. This paper will discuss the implications of open joints for the performance of rainscreen systems. Various approaches to the design of open joint rainscreen cladding systems will be reviewed and case studies demonstrating their construction will be presented.

## 1. INTRODUCTION

A rainscreen cladding assembly is commonly classified as a wall system that includes: a continuous water shedding surface, a means of draining water behind the water shedding surface and a continuous concealed weather resistive barrier. The role of the water shedding surface is typically performed by the exterior cladding, while the weather resistive barrier tends to perform as a 'second line of defense' for rain water mitigation. Rainscreen design is becoming a standard form of construction in many markets with higher exposure to wind driven rain within the United States.

Open joint rainscreen assemblies are cladding systems that employ the basic principles of a rainscreen assembly with the exception that the joints between the cladding elements (water shedding surface) are left open. The size of the open joint varies relative to the type of cladding used. Although this type of rainscreen is not currently heavily employed in the United States, it has been used in Europe for a number of years and appears to be gaining popularity locally with architects, builders and cladding manufacturers for its aesthetic qualities. There are a number of methods currently being employed when installing open joint rainscreen systems; however, none of these methods have been in use for long enough to definitively set any one of them ahead as a design with improved performance over the others.

Many building envelope designers are hesitant to use open joint rainscreen systems because of the idea that leaving joints open essentially introduces holes into a system that has traditionally been designed to be as tight as possible. This hesitation is most pressing at interfaces such as windows, doors and

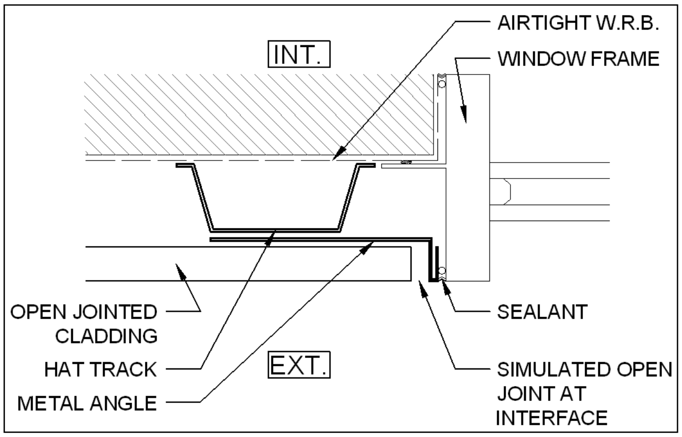


Figure 1: Simulated Open Joint at Window Interface

through-wall penetrations, which even in sealed systems experience statistically higher occurrences of moisture related failures [1] than field conditions. When designing an open joint rainscreen system, it is advisable that these locations be carefully considered to ensure that they are not exposed; one option is to simulate an open joint at interfaces in such a way that they appear to have open joints, but remain protected from direct exposure to the weather (see figure 1).

There are a number of unknowns that arise when introducing open joints into a rainscreen assembly, such as the influence of the open joints on the ability of the rainscreen to shed water, the effects of increased ultraviolet radiation within the drainage cavity, and the influence of the increased venting area on the underlying assembly. Though several studies on the advantages of traditional rainscreen assemblies exist, there appears to be a lack of any scientifically based research into the performance of open joint rainscreen assemblies.

The most common occurrences of open joint rainscreen assemblies on the market today are occurring in the commercial and institutional sectors and have not been as heavily used in residential construction. This paper examines performance and design considerations when designing an open joint rainscreen system.

## 2. PERFORMANCE CONSIDERATIONS

Visualize two rainscreen assemblies that exist adjacent to each other, each with similar size panels, joints, cavity depths and localized weather; the only difference being that one cladding has not been sealed at the joints. The inclusion of open joints into a rainscreen assembly introduces a number of variables over that of the 'traditional assembly' that may affect the performance of the system and should be taken into consideration when designing such a system.

Among these variables, the most notable is the higher presence of rain water in the drainage cavity and thus, a heavier reliance on the underlying weather resistive barrier as a primary water shedding surface. This is especially important as the height and exposure of the cladding is increased. A higher exposure of the weather resistive barrier to rain water reduces it's usefulness as a redundant 'second line of defense' (its role in a traditional rainscreen system). This leads to areas of the cladding assembly with no redundancy for rain water management. In an open joint design, the role of the weather resistive barrier must be carefully considered to account for increased water management. One option in mitigating the increased direct rainwater on the exterior sheathing is by installing a waterproof membrane as opposed to the water shedding membranes that are currently in wide use. This is a design change that may also require a change in the location of any wall insulation. Similarly, any elements of the wall assembly that are susceptible to corrosion will experience relatively higher exposure to water. Most notably, cladding anchors and hat tracks should be considered and may require altering to perform in the more exposed system.

Increased air movement within the drainage cavity is another factor to consider in the open joint rainscreen assembly. This increased airflow within the cavity may allow for quicker drying within the cavity when the air itself is relatively dry, but it effectively diminishes any pressure equalization that could occur in a rain screen system. A number of proprietary systems currently on the market tend to use the term 'open joint rainscreen' interchangeably with 'pressure equalized'; however, this is a misnomer on the part of the manufacturers. For a wall to perform as a pressure equalized assembly the wall would require a rainscreen, an air barrier and compartmentalized air chambers [2]. Open joint rainscreen systems however, have a rainscreen and an air barrier but lack compartmentalized air chambers. As such, in a rain event, air is able to flow relatively easily within the open joint assembly, carrying with it wind driven rain into the cavity. This exposure to wind increases with the height of the building.

Along with air and moisture, the open joint rainscreen assembly exposes the drainage cavity to an increased presence of light. Many weather resistive barriers and waterproof membranes are susceptible to ultraviolet solar radiation and require a certain level of isolation. The open joint rainscreen will expose the underlying weather resistive barrier to a greater amount of ultraviolet radiation, particularly at the locations of the open joints themselves, than a traditional rainscreen. This also applies to any insulation materials in the drainage cavity.

The risk of pests entering and nesting within the drainage cavity is also increased in an open joint system. Insect screens and sealant joints are used to mitigate this in traditional rainscreen assemblies. The open joint rainscreen does not have sealant at the joints and does not typically include insect screen at the edge of every panel. Insect screen could be installed at every panel joint; however this becomes very labour intensive, particularly in systems with smaller panel sizes.

Similarly, debris such as dust or pine needles may settle on or behind open joints. There is also the risk, particularly at the lower levels of buildings, of passersby introducing trash or inflicting damage on the weather resistive barrier behind the cladding. In one notable instance, a large commercial centre in Seattle with an open joint rainscreen cladding reported experiencing the introduction of lit cigarette butts into the drainage cavity of the cladding at street level through the open joints. To prevent instances like these, the size, and accessibility of the open joints near street levels should be carefully considered. It may also be advisable to not employ open joints at easily accessible locations.

## 3. DESIGN CONSIDERATIONS

There are a number of ways that an open joint system can be designed to resist the demands mentioned above. These methods can be largely broken down into two main categories. One approach is to use open joints and modify the underlying assembly to accommodate the new demands as a result of the open joints. Another approach is to modify the exterior cladding assembly, giving the cladding the appearance of open joints without actually leaving the joints completely open. Our observations have led us to identify five distinct installation methods that appear to be in use when designing open joint rainscreen assemblies; they include the open cavity rainscreen, the deep cavity rainscreen, the dual weather resistive barrier rainscreen, the baffled joint rainscreen and the simulated open joint rainscreen.

### 3.1 Open Cavity Rainscreen

The method that is currently most commonly employed is the open cavity rainscreen approach. This design is essentially a typical rainscreen assembly without sealant at the joints and with no modifications to account for the increased demand on the underlying assembly as a result of the open joints. In some installations, a secondary layer of weather resistive barrier has been installed to coincide with the open joints of the cladding and conceal the main weather resistive barrier. Although this has been largely done for aesthetic reasons, it has the added benefit of protecting the main weather resistive barrier at the most exposed locations from ultraviolet radiation and from direct exposure to the weather (see figure 2).

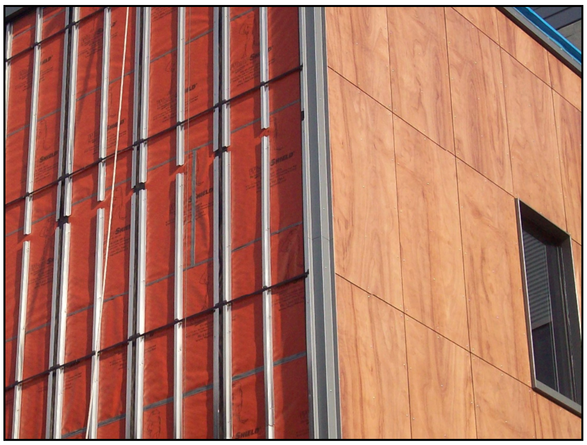

Figure 2: Open Cavity Rainscreen during installation. Notice vertical black strips of WRB that coincide with open joints.

To an extent, the performance of any wall in terms of moisture mitigation can be related to its level of exposure; for example, a wall under a large over hang is less likely to experience moisture related failures than an exposed wall with no overhang. For instances of low exposure to wind driven rain, and under large overhangs, open cavity rainscreen assemblies may be a viable option. However, the true performance of these systems will not be fully understood until further observation and research of existing systems has occurred. At the moment, owners and installers tend to use this method of installation because it offers the desired aesthetic appeal at a relatively low initial cost.

### 3.2 Deep Cavity Rainscreen

A similar method is the deep cavity rainscreen with open joints. This design is similar to the open cavity rainscreen assembly, with the difference that it includes a drainage cavity of 5 to 6 inches in depth which is much deeper than the drainage cavity in a typical rainscreen of approximately 1 inch (see figure 3). The intent of this design is to place the cladding out far enough from the weather resistive barrier to reduce the exposure of wind driven rain on the exterior sheathing, without over extending the cladding to a point where a similar result could have been achieved with a smaller cavity.  The theory in this method is that wind driven rain is forced to travel a farther distance before encountering the weather resistive barrier layer; this reduces the exposure of the weather resistive barrier in most storm systems. At some level of wind speed however, it is reasonable to assume that any benefit from the deeper cavity is diminished. No scientifically derived relationship to our knowledge has been researched between the depth of cavity and the exposure of the weather resistive barrier to rain water.

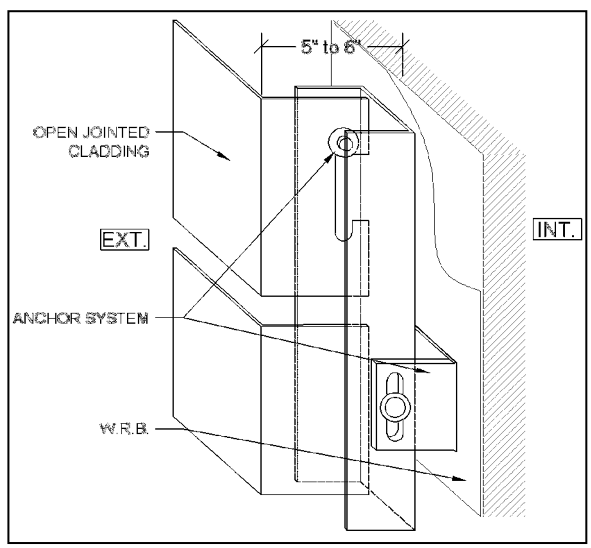


Figure 3: Schematic of proposed Deep Cavity Rainscreen Assembly

Deep cavity rainscreen systems are limited in the type of cladding that can be used, given that the anchors used to attach the cladding will be exposed to a larger moment arm than in a typical rainscreen system. Deeper cavities also tend to translate into thicker walls, which may reduce the usable floor areas and complicate through-wall penetrations, such as windows and doors.

### 3.3 Dual Weather Resistive Barrier Rainscreen

The creation of a two-stage weather resistive barrier behind the cladding can be applied to help mitigate the increased demand of the underlying assembly. This dual barrier is constructed by installing an air tight 'second line of defense' layer under a 'primary water shedding' layer of weather resistive barrier. The dual weather resistive barrier is installed behind the cladding, separated by it with a drainage cavity. Of the observed 'true' open joint rainscreen methods, this is our preferred method because the continuity it offers.

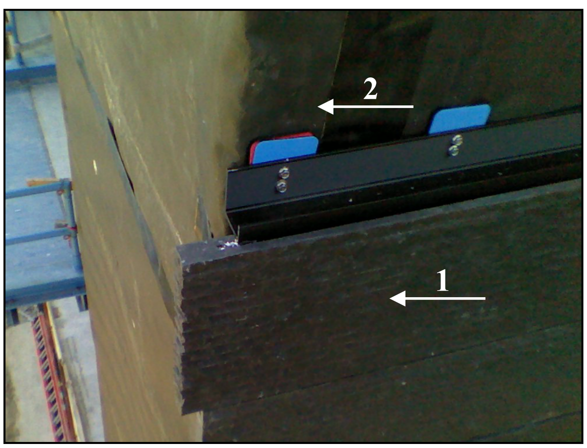


Figure 5: Installation of dual weather resistive barrier rainscreen assembly. This photo depicts the open joint cladding (1) being installed over the primary water shedding surface layer (2). The secondary line of defense layer is concealed in this photo.

The theory behind this method of installation is that the primary water shedding surface layer of weather resistive barrier will perform the function of the cladding, particularly in areas near open joints. The cladding itself is assumed to function as a non-continuous screen. The water shedding weather resistive barrier should be loose-laid to allow for drainage but anchored at regular intervals to prevent displacement. It can include creases to further increase drainage. It can also be separated from the air tight weather resistive barrier with a layer of rigid insulation as depicted in figure 4. This design allows for a continuous water shedding surface, a drainage medium and a 'second line of defense' weather resistive barrier, while maintaining the appearance of an open joint rainscreen assembly.

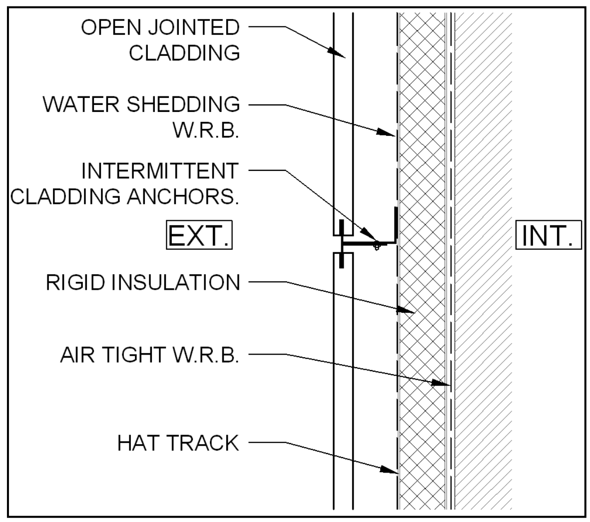


Figure 4: Section view of proposed Dual Weather Resistive Barrier Rainscreen Assembly

The cladding is then installed exterior of the water shedding surface with a normal drainage cavity separating it from the water shedding surface. As with the deep cavity rainscreen assembly, the cladding used in this method should be carefully considered, particularly when including a layer of rigid insulation; although the drainage cavity itself is likely no deeper than a traditional rainscreen, the distance that any anchors span may increase with thicker insulation.

### 3.4 Baffled Joint Rainscreen

The appearance of an open joint system can be achieved without using joints that are completely open; this type of design can be considered a baffled joint rainscreen system. Some common baffled joint systems on the market include panels with offset joints that impede the entry of wind driven rain into the drainage cavity. This option reduces the exposure of the weather resistive barrier and drainage cavity to direct rain, wind, and light relative to a non-baffled open joint. The joints remain open to air movement and thus have a reduced capability to achieve pressure equalization within the drainage cavity. Baffled panels are also constructed in a manner that is simple to install. These panels have a baffled end on two sides, and a receiving end on the other two sides making it possible for installers to slide panels into place.

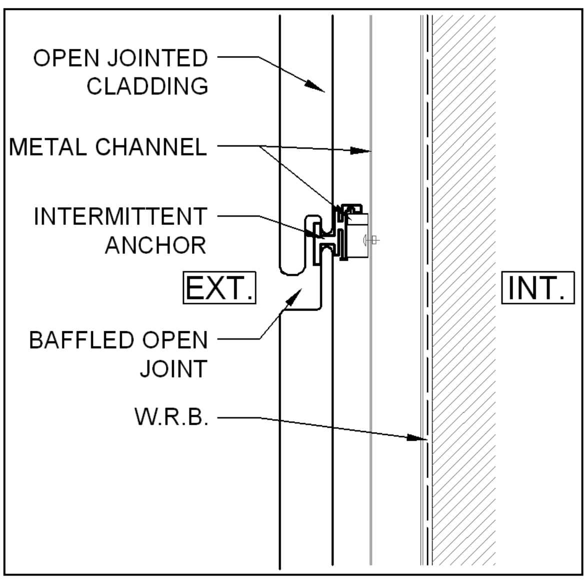


Figure 5: Example of common baffled joint. (Section view)

Another option for this method would be to create a baffle at the joints by installing a plate or flexible membrane at the perimeter of the cladding elements. This can be done with an EPDM or Neoprene membrane as depicted in Figure 6. In this option, the cladding elements can be fastened directly through the EPDM membrane. For cladding elements with smaller joints, a neoprene or EDPM membrane works well to portray the impression of a completely open joint while concealing the drainage cavity; this illusion is lost however with larger joint sizes.

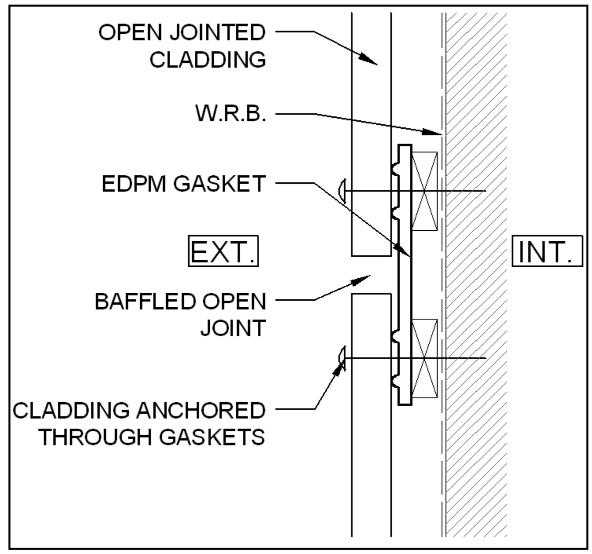


Figure 6: Example of Baffled Joint System with EDPM Gasket at joint.

A metal hat track at vertical joints, combined with through-wall flashing at horizontal joints (see figure 7) can also be employed as a baffled joint system. The benefit in this option is that rain water is expelled from the drainage cavity at the head of every cladding element. This is a labour intensive option however, particularly with smaller cladding elements. It requires careful detailing at four way intersections, and at every through wall flashing. To maintain the aesthetic illusion of an open joint, it is also likely that the metal flashing and hat track will need to be finished with a dark colour.

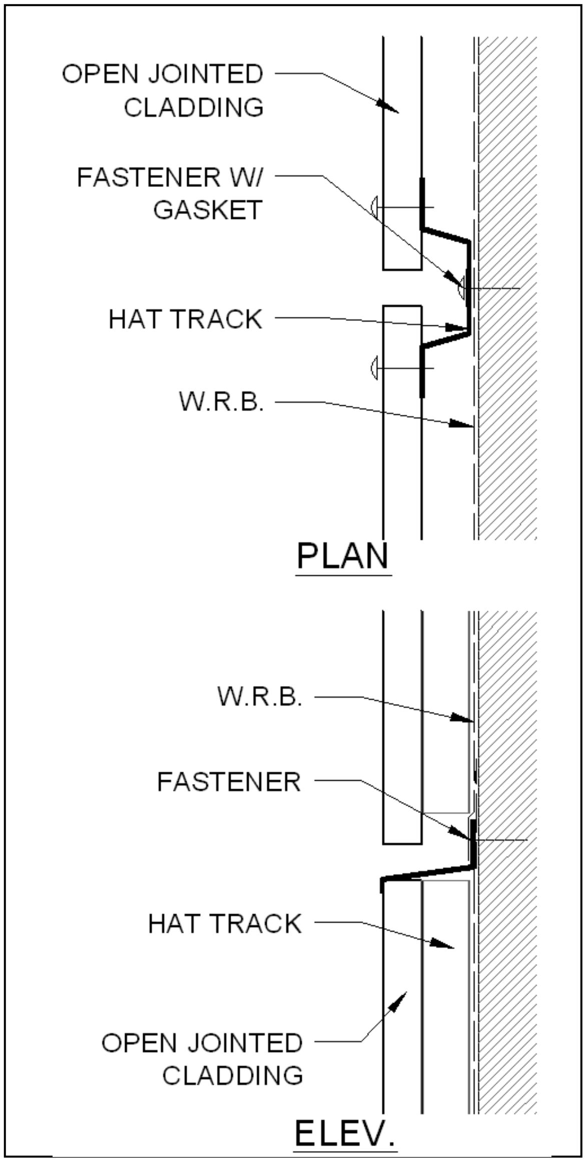


Figure 7: Example of Baffled Joint System with hat track at vertical, and through-wall flashing at vertical joints.

### 3.5 Simulated Open Joint Rainscreen

One method of creating an appearance of an open joint rainscreen assembly, without necessarily creating open joints is to create an open joint façade over a continuous substrate. This method can be ideal if the cladding element panel sizes are relatively small, requiring many open joints. In this installation method, cladding elements, typically some form of cultured stone, can be glued or mechanically attached to the face of a cement board, or some other robust substrate such as a scratch layer of stucco on a wire mesh, and then installed over a typical rainscreen assembly. The joints between the cladding elements themselves are open, but their connection to the continuous substrate performs as if it were a closed joint system. The joints of the substrate itself could then be sealed and treated as closed joint while maintaining the appearance of an open joint assembly. This method of installation provides a continuous water shedding surface and continuous protection for the drainage cavity while maintaining the desired open joint appearance. However the open joints in this assembly may be prone to efflorescence from dissolved salts and in cold climates may be subject to freeze-thaw damage if water accumulates within the open joint.

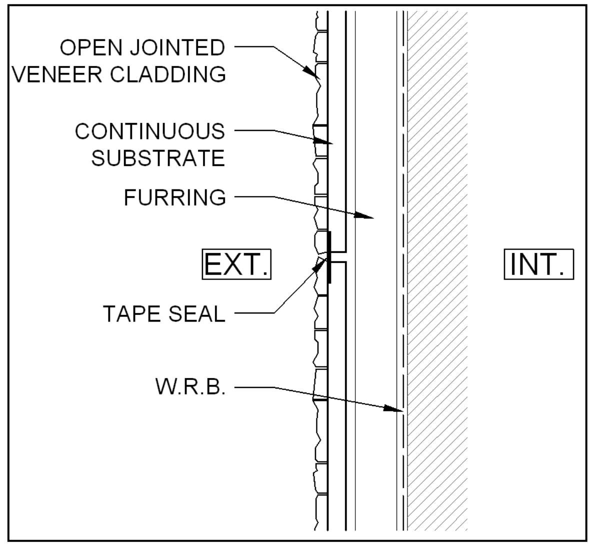


Figure 8: Example of simulated open joint rainscreen. (Section view)

## 4. CONCLUSIONS

Current building science theory suggests that the best practice when designing and constructing a rainscreen assembly is to install a closed joint system. These systems have been used extensively in the market and have shown durability and reliability over other designs of walls. This is not to say that open joint rainscreen systems are poor practice; only that they require further research and observation before their true performance characteristics can be fully understood. Ideally, building envelope designers require an improved scientific understanding of the relationship between joint size and cavity depths relative to the exposure of the drainage cavity to design more efficient and scientifically based wall systems. Until then, owners and designers should carefully weigh the risks and benefits of the open joint option in rainscreen design. Time and observation of existing construction is the best method of gaining understanding of the true performance of these types of open joint rainscreen systems.

## References


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[2] Rousseau, M.Z; Poirier G.F; Brown, W.C. (1998) "Pressure Equalization in Rainscreen Wall Systems", *Construction Technology Update No. 17*, IRC, pp. 3-4.