How to Achieve Superior Building Envelope Performance in Rainscreen Wall Design

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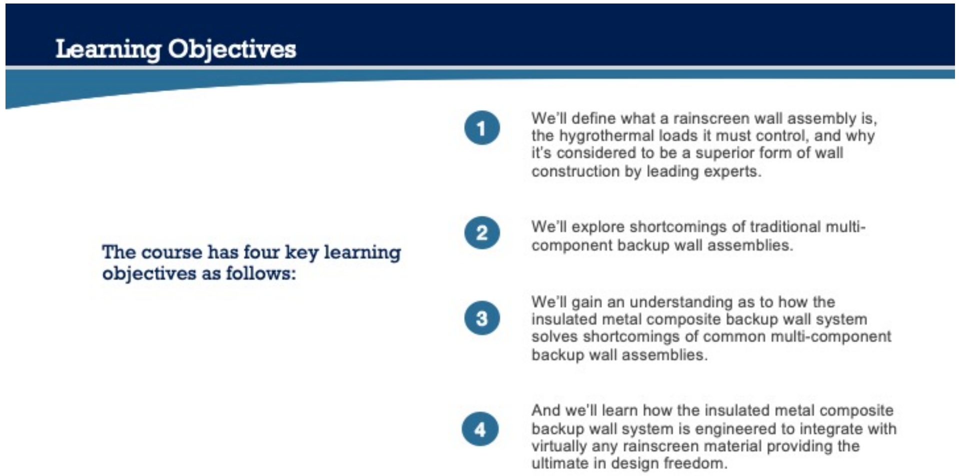
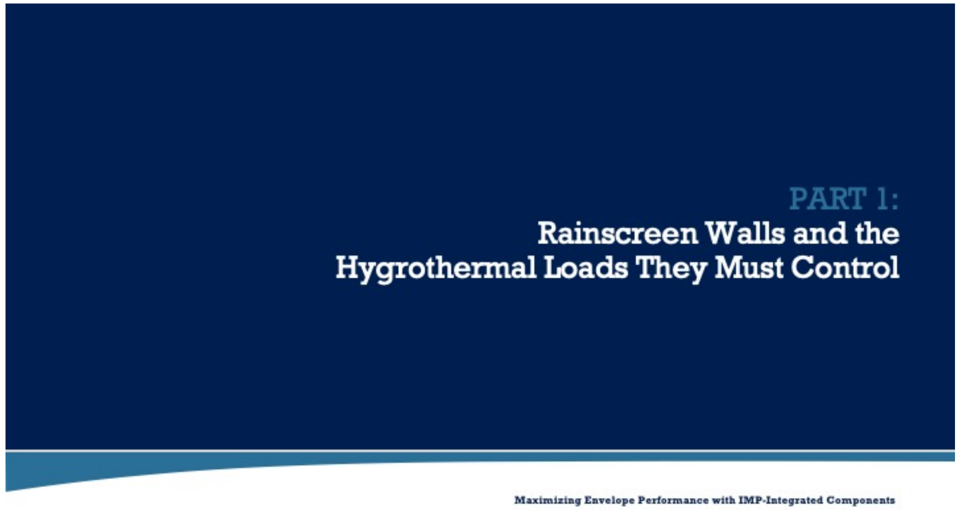
Course Description

How to Achieve Superior Building Envelope Performance in Rainscreen Wall Design explores rainscreen wall design theory, how rainscreen walls control hygrothermal loads, and shortcomings of today's multi-component backup wall assemblies used in rainscreen wall construction. The course will compare and contrast the common multi-component backup wall assembly with the single-component insulated metal composite backup wall system, and demonstrate how the latter overcomes deficiencies of the former in creating a building envelope with superior performance as well as other key benefits.



The course has four key learning objectives as follows:

- We'll define what a rainscreen wall assembly is, the hygrothermal loads it must control, and why it's considered to be a superior form of wall construction by leading experts.
- We'll explore shortcomings of traditional multi-component backup wall assemblies.
- We'll gain an understanding as to how the insulated metal composite backup wall system solves shortcomings of common multi-component backup wall assemblies.
- And we'll learn how the insulated metal composite backup wall system is engineered to integrate with virtually any rainscreen material providing the ultimate in design freedom.
- Let's get started.



In Part I of the course, we will examine rainscreen wall design theory.

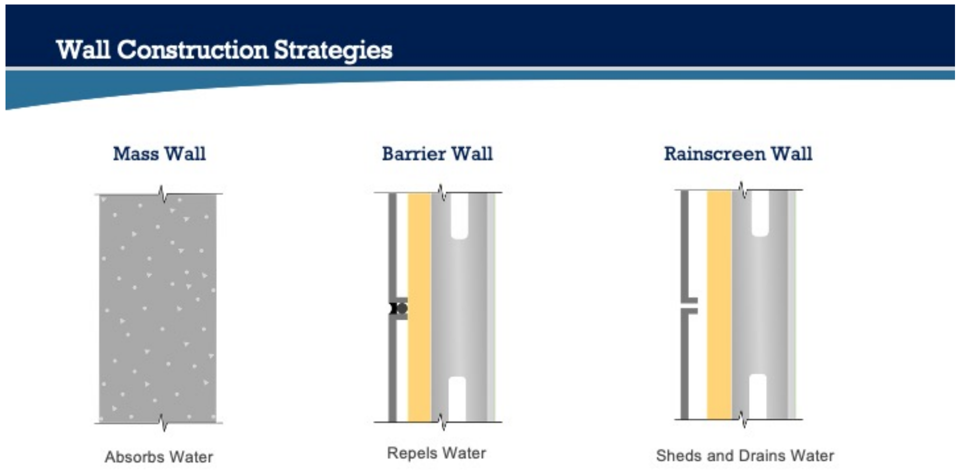
Hygrothermal Loads Impacting the Building Envelope

Hygrothermal (adj.): of or relating to a combination of moisture and heat

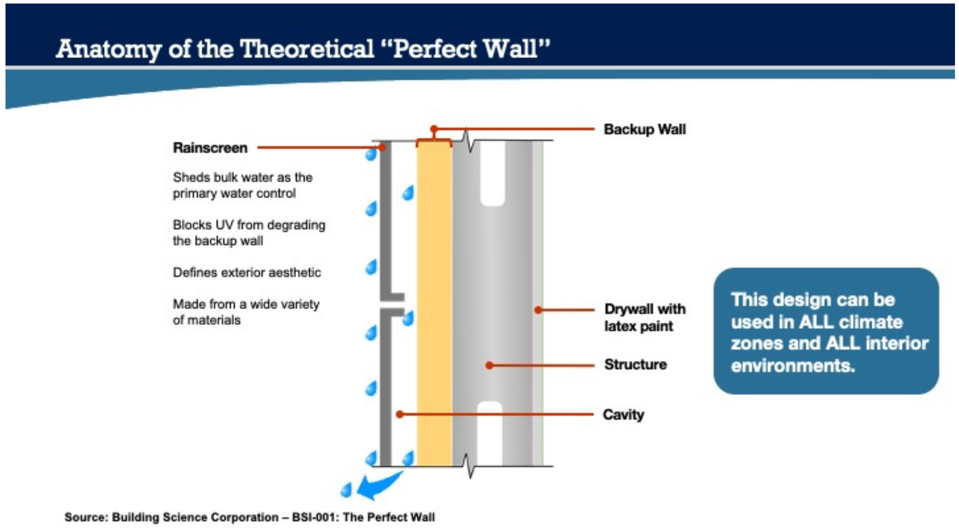
There are four hygrothermal loads that the building envelope must effectively control in order to produce a long-lasting, comfortable, energy-efficient and healthy building. The term “hygrothermal” simply refers to a combination of moisture and heat. These hygrothermal loads are thermal, air, water, and vapor. The building envelope must be constructed in a manner that controls each of these loads, regardless of whether these loads are applied from the exterior or from the interior. In either direction, the envelope is responsible for ensuring each hygrothermal load is addressed and effectively controlled.

Examples of failed hygrothermal control are numerous. The photo on the upper left shows what happens when air isn't properly controlled. The bottom left photo captures the result of entrapped moisture – toxic mold. Wet and damaged batt insulation is seen in the upper right photo. And steel studs that have been irreparably damaged from unchecked moisture is shown at the bottom right. Uncontrolled hygrothermal loads lead to all kinds of problems, the least of which is energy inefficiency. It can lead to a serious risk to occupant health, costly litigation and remediation, and damage to the reputation of building professionals. This is why it is of utmost importance to get hygrothermal controls on the building envelope right - both in their material selection, design, and construction.

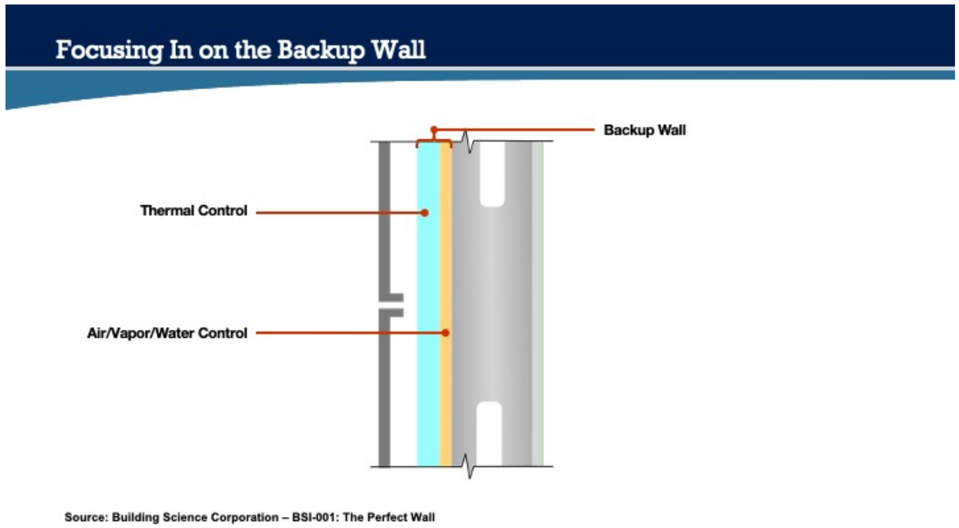
Joe Lstiburek (pronounced Steebrick), Ph. D, P.Eng., and ASHRAE Fellow leads Building Science Corporation. Joe is arguably the world's leading expert and authority in building envelope science. Joe places hygrothermal controls in order of importance as follows: Rain, Air, Vapor, and Thermal. His rationale for this prioritization is reinforced by a quote from his illuminating white paper entitled "The Perfect Wall". Let's now explore each of these controls following Joe's order of importance.



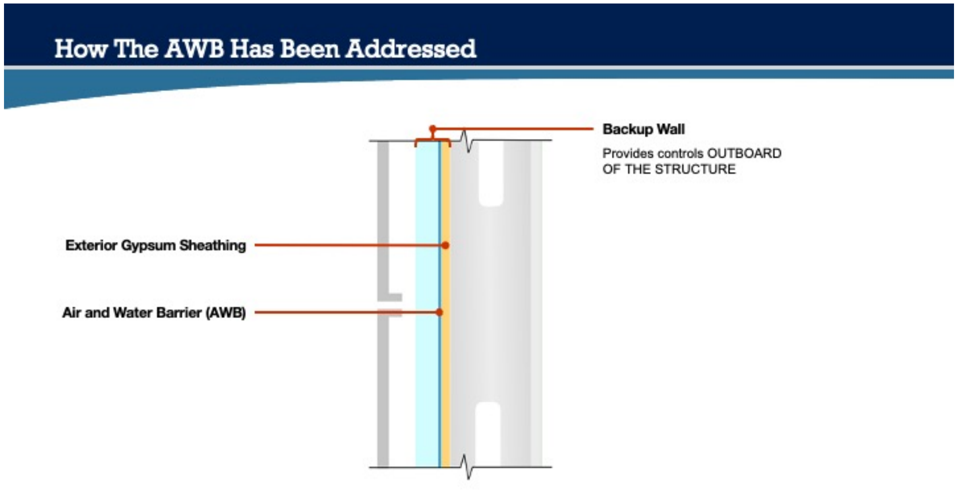
But first, let us distinguish three general categories of wall construction strategies so that we understand how a rainscreen wall differs from other types. Mass walls are designed to absorb water, then slowly release this water through evaporation. It is one of the oldest technologies for resisting rainwater. Examples of mass walls include concrete tilt-up, concrete masonry units (CME), and structural brick and stone. Barrier walls are characterized by a single layer which must repel all rainwater. Note that panel joints are wet sealed. Any failure in this seal will permit water to travel into the wall cavity, where it is trapped. This water cannot drain out of the cavity and the cavity cannot dry rapidly since there is no airflow. In contrast, rainscreen walls have a water shedding exterior layer, an air gap, and a redundant drainage plane. Let us take a closer look at the mechanics of the rainscreen wall.



In Dr. Lstiburek's white paper, this is what he defines as the theoretical "perfect wall" for commercial buildings—a rainscreen wall design. What distinguishes the rainscreen wall is its ability to control liquid water better than other types of walls. This is because there are effectively two water controls, rather than a single control. The first liquid water control—the rainscreen—sheds the vast majority of liquid water—what is referred to as bulk water. Any liquid water passes behind the rainscreen—due to kinetic energy, air pressure, capillary action, etc., —drains downward behind the rainscreen and back out to the exterior of the building at the base of the wall. Made from a wide variety of materials, including metal, brick, terra cotta, fiber cement, stone and high-pressure laminate. Because the rainscreen is placed away from the backup wall, a cavity is created. Air circulates behind the rainscreen, within this cavity, which promotes evaporation and drying of the cavity. The cavity drains water to the exterior and creates air circulation which promotes evaporation and drying. With "the perfect wall", it is the backup wall—shown here in yellow—that provides controls, outboard of the structure, for this secondary water, but also for air, thermal, and vapor. The rainscreen, in turn, protects the backup wall from damaging UV rays that can degrade and compromise its performance. The rainscreen is what is visible from the exterior and what defines the character and aesthetic of the structure. It can be virtually any durable material including metal, brick, terra cotta, fiber cement, stone, high-pressure laminate, and more. What is beautiful about this design concept is that it can be used in any climate and any interior environment.



Further unpacking Dr. Lstiburek's "perfect wall," he makes it very clear that the backup wall assembly should locate the thermal control outboard of the air, vapor, and water controls. Here, the thermal control is rigid, closed-cell foam board insulation located outboard of the air, vapor, and water controls. Locating the thermal control outboard, in effect, protects the air, vapor, and water barriers from freeze-thaw cycling—a process that eventually damages these critical controls. It is important to keep these materials protected by insulation from temperature swings that can result in premature failure. He also notes that locating the thermal control outboard also prevents steel studs from expansion and contraction—movement that damages interior drywall. Note that there is no insulation in the stud cavity. Why this is so is explained shortly.



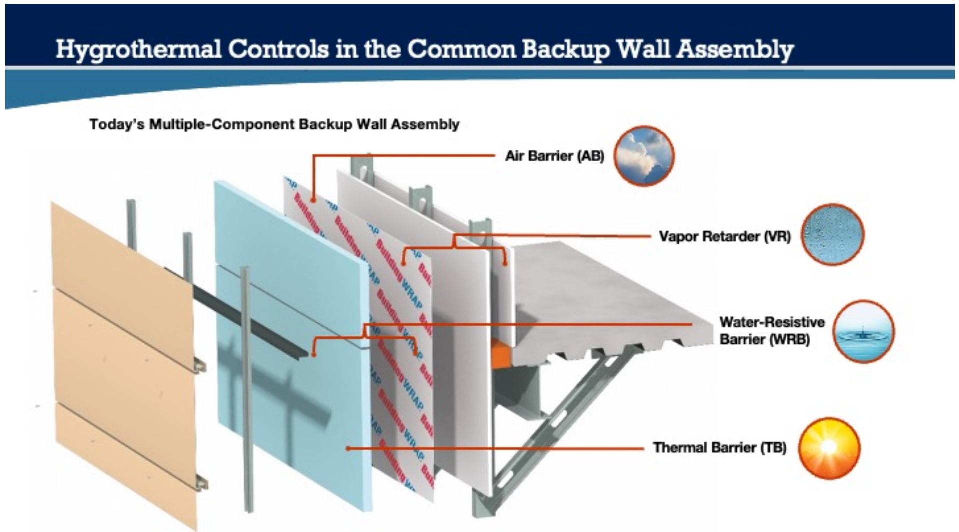
In reality, Dr. Lstiburek's "perfect wall" is being widely adopted in commercial construction today. This illustration shows how the air and water barriers are being frequently executed today. Exterior gypsum sheathing is attached to the steel stud framing, then building wrap or a liquid-applied membrane is attached to the sheathing. Together, these two materials provide control for air and water. These materials also slow the transmission of vapor, so they are also part of the vapor control, which we will discuss shortly.

Backup Wall: Provides controls Outboard of the structure for:

- Secondary Water
- Air
- Thermal
- Vapor

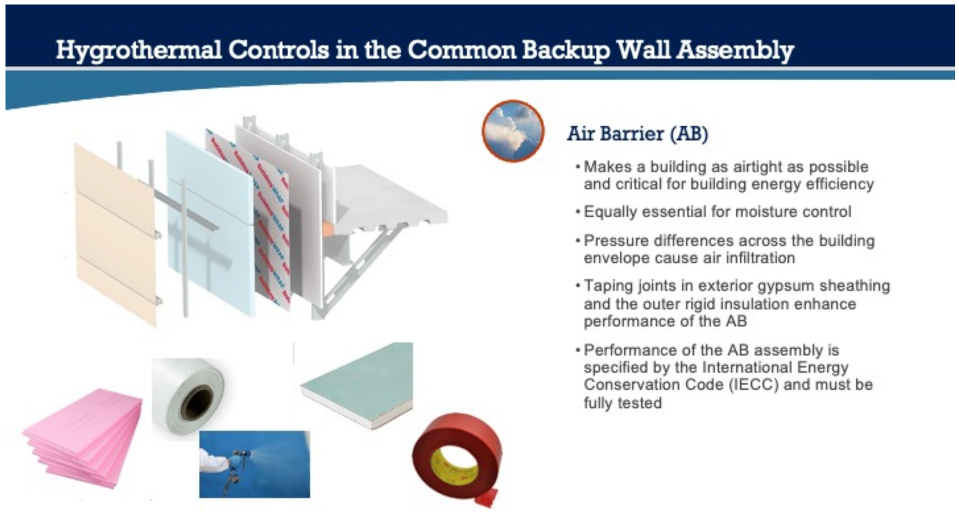
Air and Water Barrier (AWB)

- Building wrap or
  Liquid-applied membrane



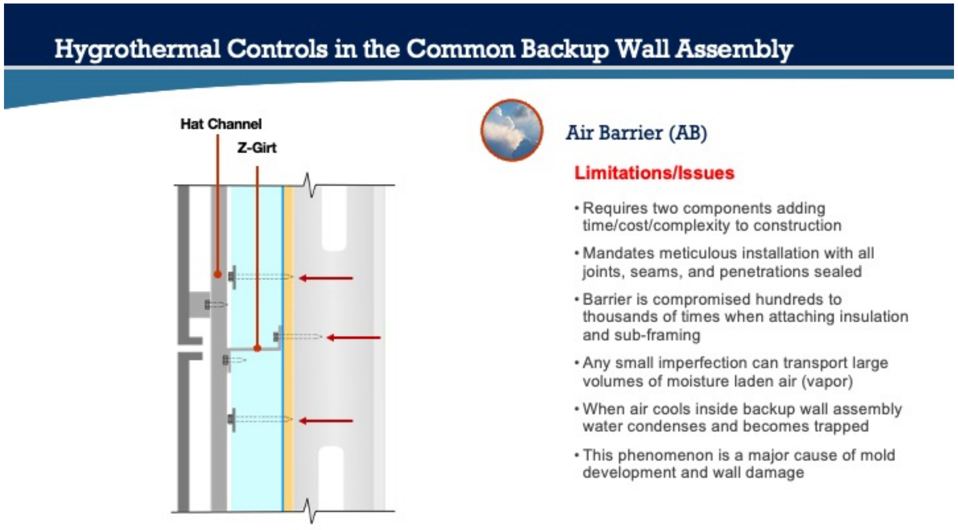
Here is the same assembly shown on the previous slide, but in a three dimensional view. The illustration shows the components that are responsible for each hygrothermal control. The air barrier is created from building wrap, which could also be a liquid-applied membrane. A water-resistive barrier is created by a combination of rigid insulation board and building wrap. A vapor retarder is created is created with latex painted interior drywall and building wrap. And the thermal barrier, protecting these other controls, and is provided with rigid insulation board. Now let's dive a little deeper into each of these backup wall controls in this particular assembly.

Here, rigid insulation board and building wrap comprise the water resistive barrier. It is purpose: to provide the second level of water control. Logically, any material tasked as a water-resistive barrier must be water resistive. These must be made of water-resilient materials: 1) rigid closed-cell insulation, 2) mineral wool insulation, 3) building wrap or liquid-applied air barrier membrane. If there are any breaches in the water-resistive barrier, problems can occur with other materials in the assembly that may not be water resistive. As a water vulnerable material, the exterior gypsum sheathing can be damaged if exposed to water, as can the steel stud framing. Sheathing with a robust water-resistive coating helps mitigate this potential issue.

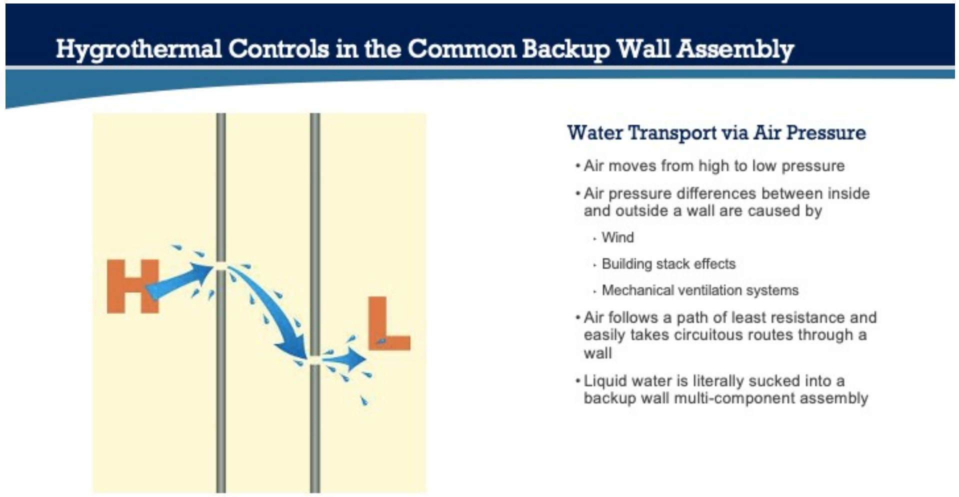


To control air, the air barrier—here comprised of building wrap and exterior sheathing—is intended to make the building as airtight as possible. But airtightness is equally essential for controlling moisture. We'll discuss this shortly. All joints in the sheathing, including around windows, doors, and other penetrations must be carefully taped to prevent air transport. Additionally, all fasteners used to attach the sheathing to the studs must also be taped or sealed. If using building wrap, special fasteners are used to seal penetrations into the sheathing and tape is used to seal wrap seams. When it comes to energy efficiency of a building, its airtightness is even more critical than the amount of insulation used. Recognizing this, recently the IECC ramped its requirements for air-barrier performance. Now, the entire air-barrier assembly is required to be tested and the assembly must demonstrate an air-penetration rate of no more than 0.04 cubic feet per minute per cubic feet at an air pressure differential of 75 Pascals. This requirement will help to increase building energy efficiency. However, it also drives up costs, due to mandated testing for every combination of materials that are used in an assembly.

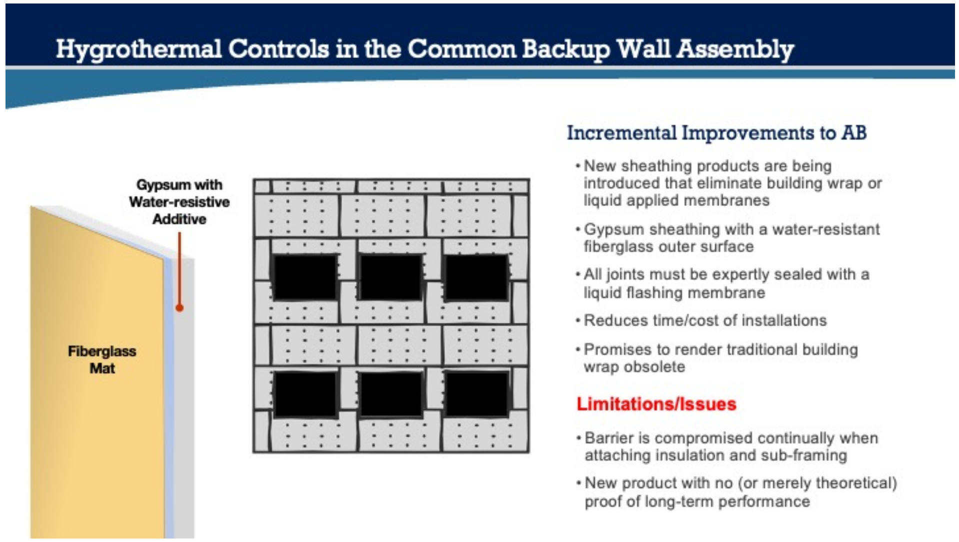
Must demonstrate an air-penetration rate of no more than 0.04 cfm/ft^2 at an air pressure difference of 75 Pascals.



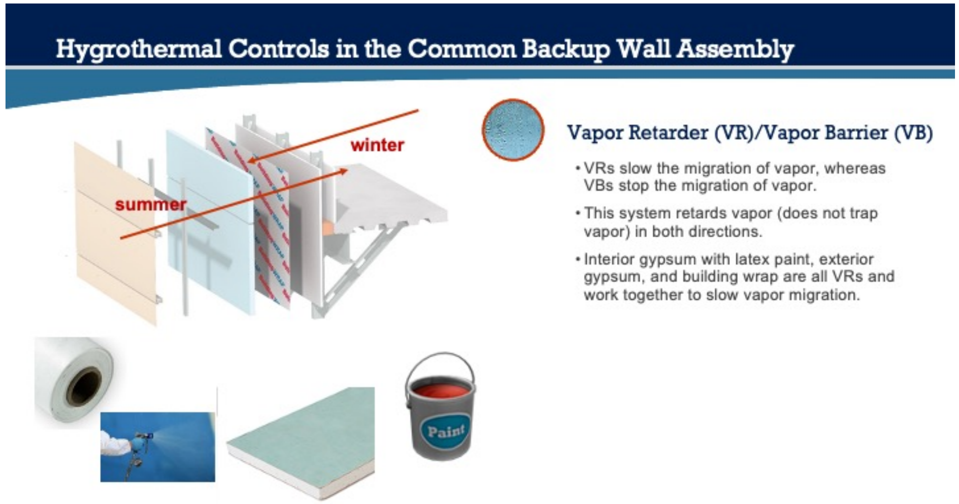
With the two different components required to be installed to create an air barrier, comes added time, cost, and complexity in construction. This assembly mandates meticulous installation—again—with all joints, seams, and penetrations sealed. However, no matter how carefully these materials are installed, ultimately the air barrier is penetrated thousands of times when insulation and sub-framing are attached. This illustration depicts these penetrations. First a horizontal Z-girt—used for supporting the rainscreen sub-framing and rainscreen—penetrates the air barrier. Then, the insulation board is fastened through the air barrier to attach it to the sheathing. Through powerful air pressure differences across the building envelope, even tiny breaches in the air barrier can cause massive volumes of air to be sucked into or out of a building. But it is not just air that gets sucked. Riding along with air is usually liquid water and vapor, where it can become trapped, support the growth of mold, and damage the wall's structural components.



This graphic depicts this phenomenon. Air moves from low to high pressure. This pressure difference is caused by wind, building stack effects, and mechanical ventilation systems. Following a path of least resistance, air will take even a very circuitous path through breaches in the air barrier. As warm and humid air is pulled through this breach, it cools when it reaches the air conditioned interior where it condenses and becomes liquid water. Water transport via air pressure is a major cause of many building envelope failures and subsequent litigation.

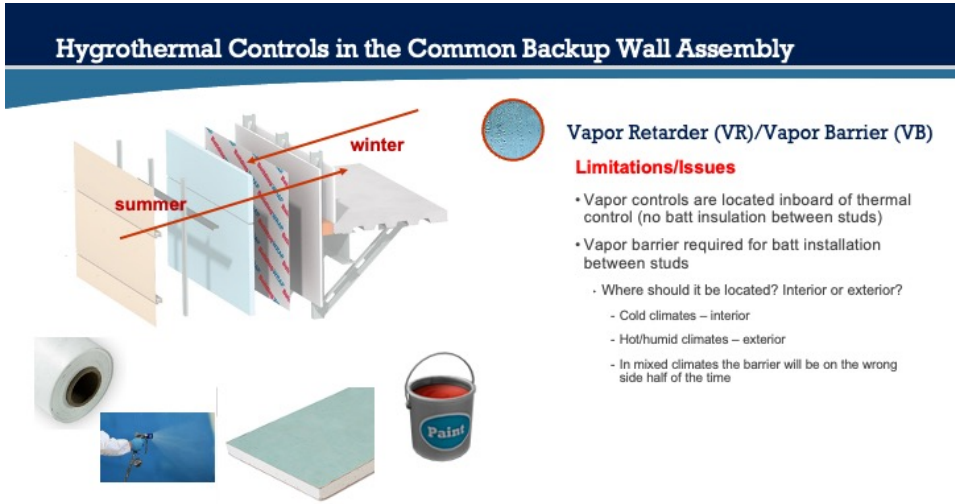


Fortunately, building science is beginning to make some incremental advancements to air barrier assembly solutions. A newer exterior gypsum product is an example. With this product, the use of a separate water-resistive barrier, such as building wrap or a liquid applied membrane is eliminated. Instead, the sheathing board is manufactured with a water-resistant fiberglass outer surface and a water-resistive additive. When installed, all panel joints and fastener penetrations must be carefully sealed using a special liquid-applied flashing membrane. Because the product eliminates the extra step of installing the additional wrap or liquid membrane, this method reduces installation time, cost, and scheduling complexity. Dr. Lstiburek considers the introduction of this and similar products as the end of traditional building wrap in building envelope construction. (See This Old House: www.youtube.com/watch?v=HhSWiO6oTP0In.) However, this newer strategy is not without its issues. First, the barrier must be must be compromised thousands of time to attach insulation and sub-framing. And second, it lacks proof of ultimate long-term performance due to its newness.



The third hygrothermal load—vapor—is controlled through a vapor retarder or a vapor barrier. A wall system must be able to either slow the migration of vapor through a wall assembly or block it, but it should never trap vapor in the interior of the assembly where a drop in temperature will cause the vapor to condense and form liquid water. A vapor retarder will slow the migration of vapor. Whereas a vapor barrier will stop it. The system shown here includes a vapor retarder control and is comprised of building wrap, exterior sheathing, in addition to interior drywall that's been painted with a latex paint. During hot and humid weather the vapor drive—the direction in which vapor will move—is from the exterior to the cooler interior of the building. In cold and dry weather, the vapor drive in in the opposite direction—warm interior air is driven to the cold exterior.

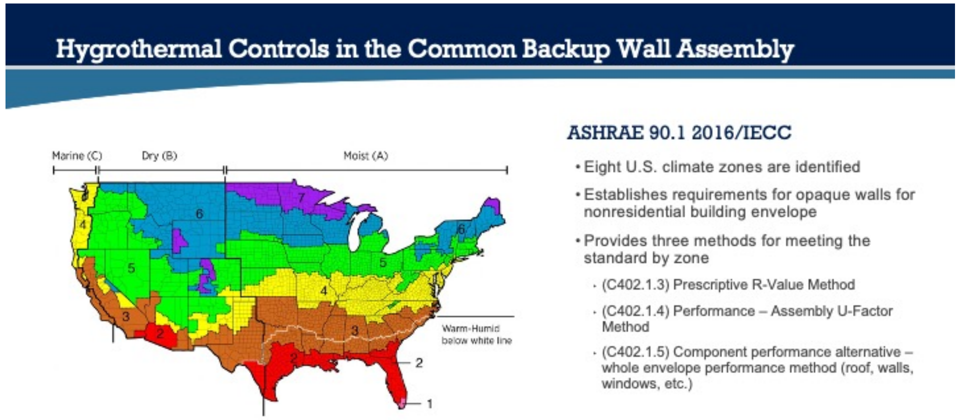
Warm season: Hot/humid air drives vapor to the interior.
Cold season: Hot/humid air drives vapor to the exterior.



This assembly will effectively retard the transmission of vapor and prevent vapor from condensing inside the assembly, because the thermal control is located outboard of the steel framing members. If this system, where to employ batt insulation, a vapor barrier - not a vapor retarder - would be required –such as polyethylene sheeting. In predominantly cold climates the correct location for a vapor barrier is on the interior side of the wall. In a predominantly hot and humid climate, the location of the vapor barrier would be on the exterior of the wall assembly. The problem with proper location of vapor barriers is in mixed climates where any vapor barrier will be on the wrong side of the wall half of the year. For this reason, the use of batt insulation is not part of" The Perfect Wall".

Moving to the fourth and final hygrothermal control—the thermal barrier—here, rigid foam insulation boards are used. In their outboard position, they provide maximum effectiveness. Exterior insulation reduces thermal bridging that is unavoidable with batt insulation located between steel studs. This is why outboard insulation, like this, is referred to as continuous—in that the insulation control is not interrupted by steel studs that easily conduct heat. As mentioned earlier, its outboard position prevents thermal cycling of the water resistive barrier, air barrier, and vapor retarder materials as well as the structural framing members. Again, the thermal barrier must be water resilient. Insulation materials with high degrees of water resilience include polyisocyanurate, polyurethane, WPS, and EPS foam as well as mineral wool. Thermal codes are driven by ASHRAE 90.1-2016 standard and this standard is codified through the IECC. Let us take a look at this standard and code.

- Minimizes thermal bridging that occurs with insulation between steel studs
- Prevents thermal cycling (expansion and contraction) of other critical controls (e.g., AB, WRB, VR) leading to failure
- Minimizes risk of drywall damage due to building movement caused by thermal cycling

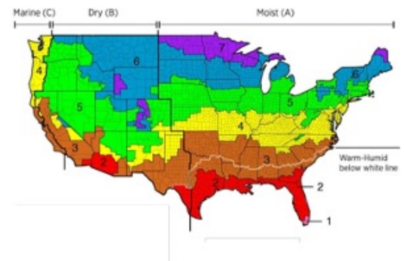


For the United States, ASHRAE 90.1 2016 identifies eight distinct climate zones, as well as providing longitudes for humidity levels: marine, dry, and moist. It also provides a latitude in the moist region where south of this latitude you can expect a warm and humid climate. Within the eight climate zones—conveniently color-coded—ASHRAE has established requirements for opaque walls for non-residential building envelopes. To meet these requirements, ASHRAE also provides three different methods for meeting requirements. The first is the Prescriptive R-Value Method. With this method, for each climate zone, ASHRAE lists the minimum amount of between stud insulation—which we have determined is never a good idea—and outboard insulation. The second method is the Performance Assembly U-Factor Method. Here, ASHRAE provides the maximum U-value of the entire wall assembly that is required for each climate zone. Remember, with U-value, the lower the number, the better the insulating value. With this method, the entire assembly has to be formally tested and documented. The third method—the component performance alternative—is the most complex and costly, as it requires calculating the overall performance of the entire building envelope inclusive of the roof, walls, windows, and doors. Let us take a look at what ASHRAE 90.1 2016 requires for the first Prescriptive R-Value Method and the second Performance U-Value Method.

Hygrothermal Controls in the Common Backup Wall Assembly

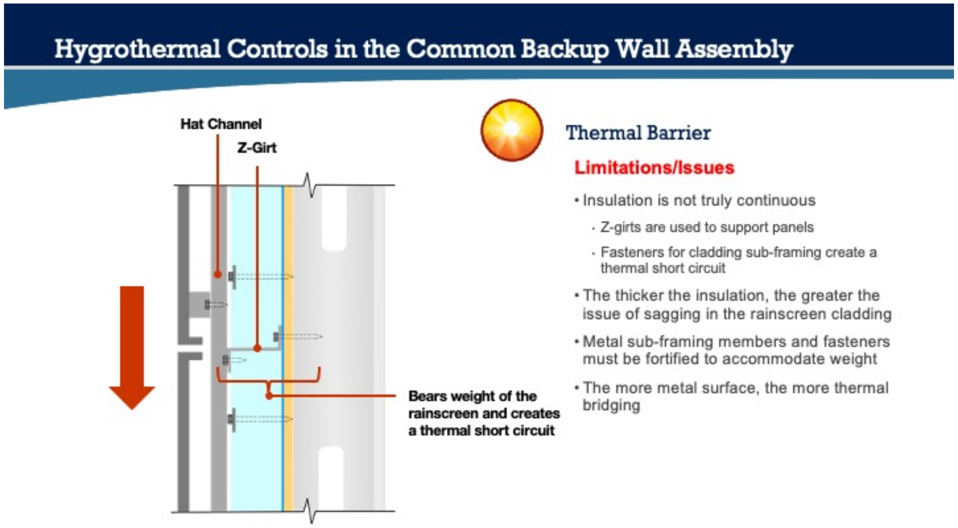
ASHRAE 90.1 2016/2018 IECC
Metal Framed Wall Construction – 3.5" Studs @ 16" OC

1		2		3		4		5		6		7		8	
R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method	R-Value Method	U-Value Method
R-13 + R-5 ci (R-11)	U-.077 (R-13)	R-13 + R-5 ci (R-11)	U-.077 (R-13)	R-13 + R-7.5 ci (R-13.5)	U-.064 (R-15.6)	R-13 + R-7.5 ci (R-13.5)	U-.064 (R-15.6)	R-13 + R-7.5 ci (R-13.5)	U-.064 (R-15.6)	R-13 + R-7.5 ci (R-13.5)	U-.064 (R-15.6)	R-13 + R-7.5 ci (R-13.5)	U-.064 (R-15.6)	R-13 + R-7.5 ci (13.5)	U-.045 (R-22.2)



Rigid outboard insulation is available to meet every U-value method requirement in every zone, thereby eliminating the need to use between-stud insulation.

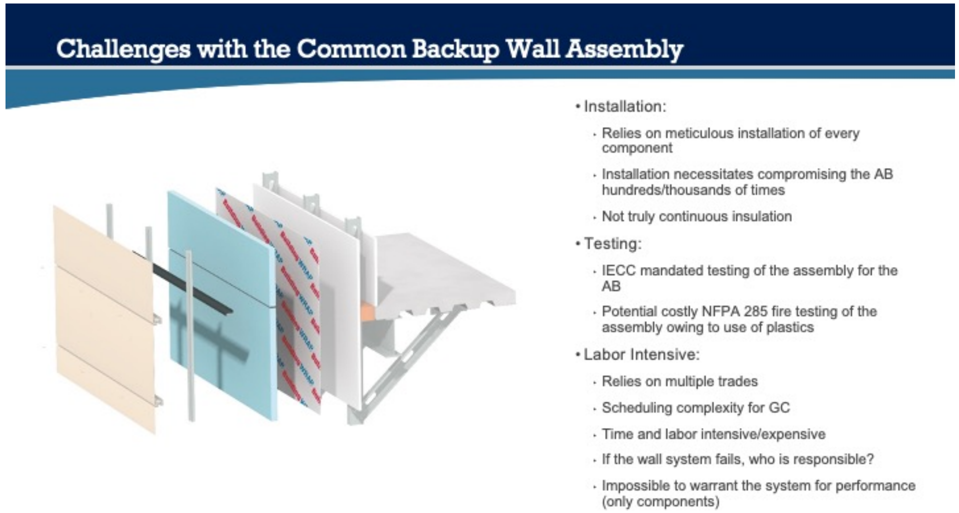
This chart shows, by climate zone, both the R-value and U-value requirements for metal framed wall construction—the most common form of commercial construction. In the pink climate zone 1—which includes the southern most tip of Florida as well as Hawaii, Guam, Puerto Rico, and the Virgin islands—using the R-value method, ASHRAE minimally prescribes R-13 insulation between metal stud framing, in addition to outboard continuous insulation with an R-value of 5. It is important to note that ASHRAE applies a 54 percent reduction to R-13 insulation when it is located between 3.5-inch steel stud framing at 16 inches on center. This reduction is because of the thermal bridging of the steel studs. This 54 percent reduction produces an effective insulation value of just R-6. Therefore, the actual total insulation value of this combination—between stud and continuous insulation—produces a total insulation value of R-6 + R-5 or R-11. This actual value is listed in parentheses. Note that this is the same minimum requirement for zone 2, shown in red. Zone 3, further north, ups the actual value to R-13.5, and curiously R-13.5 is the same minimum requirement for all remaining zones, which includes the coldest areas in Alaska. Despite this clear shortcoming in the standard, the 2016 revision at least now requires the use of CI in every zone. However, batt insulation between studs should always be discouraged for the reasons covered in the VR/VB section. Instead, architects and owners truly concerned with energy efficiency should look to meet the U-value method using continuous insulation. Again, the U-value method measures the insulating value of the entire assembly, and the lower the U-value, the more energy efficient the wall. ASHRAE 90.1 2016 identifies a U-value of .077 for zones 1 and 2. This value converts to an R-value of 13, which is better than the R-value method of just R-11. For zones 3 through seven this is decreased, or made more insulative, to U-.064, which equates to R-15.6. And for zone 8, this is decreased again to U-.045, which equates to a hefty R.22.2. Clearly, the U-value method will produce a far more efficient building. It is important to note that even zone 8 can be satisfied by using rigid outboard insulation. What ASHRAE 90.1 2016 does not account for is thermal bridging caused by sub-framing and fastener penetrations, which building science professionals have measured and are significant. As energy standards and codes continue to evolve look for these enhancements.



Meeting required U-values using only rigid insulation means the insulation has to get thicker and this means the rainscreen has to be moved out even further from the stud framing. The further the rainscreen is cantilevered away from the framing the weaker the connection becomes. As a result rainscreen sagging becomes a factor. To remedy this, sub-framing has to be enhanced to support the weight of the rainscreen. However, an increase in number and/or gage of these steel structural components also increases the amount of thermal bridging that will occur, thereby reducing thermal efficiency.

Z-girts are used to support panels of insulation

Metal sub-framing members and fasteners must be fortified (made thicker) to accommodate weight.



Challenges associated with the multi-component backup wall assembly are many. Long-term performance of the assembly relies on highly detailed and meticulous installation. Its installation requires that critical control layers are penetrated thousands of times. These penetrations, in combination with sub-framing, also create thousands of short-circuits which negates the idea of continuous insulation. The IECC mandates testing of any assembly to ensure its air barrier meets minimum code standards. Since the assembly contains plastics it may also require expensive NFPA 285 fire testing.

(The **NFPA 285 Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Wall Assemblies Containing Combustible Components** testing is required for Construction Types I, II, III, and IV. Using the wall assembly shown here would require NFPA 285 testing because the assembly contains plastics (insulation and building wrap). If any single component is changed and still contains plastic, this new altered assembly must be tested. NFPA 285 testing is costly.)

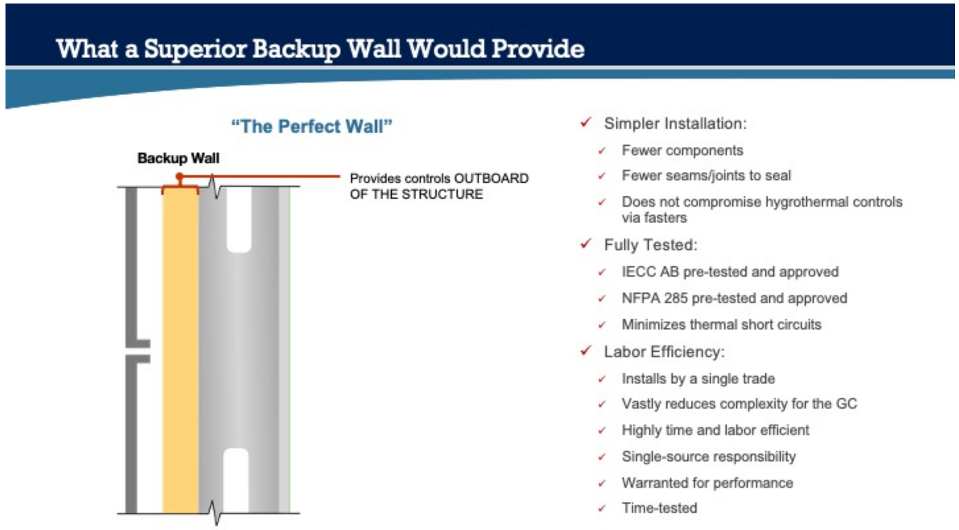
This assembly's installation requires multiple trades—as many as four different subs (Exterior Gypsum Sheathing, Water & Air Barrier, Insulation, Rainscreen). This adds to GC staging and scheduling complexity, which can further delay installation. Because contractors have to "Circle the Building" up to four times, this adds to schedule and cost. And if the assembly fails, it is very difficult to identify the responsible party—a manufacturer, a contractor, the engineer, the architect? Finally, it is impossible to warrant the performance of the assembly because it is not provided by a single source.

Relies on meticulous installation of every component (e.g., sealing every seam/joint/penetration of each component)

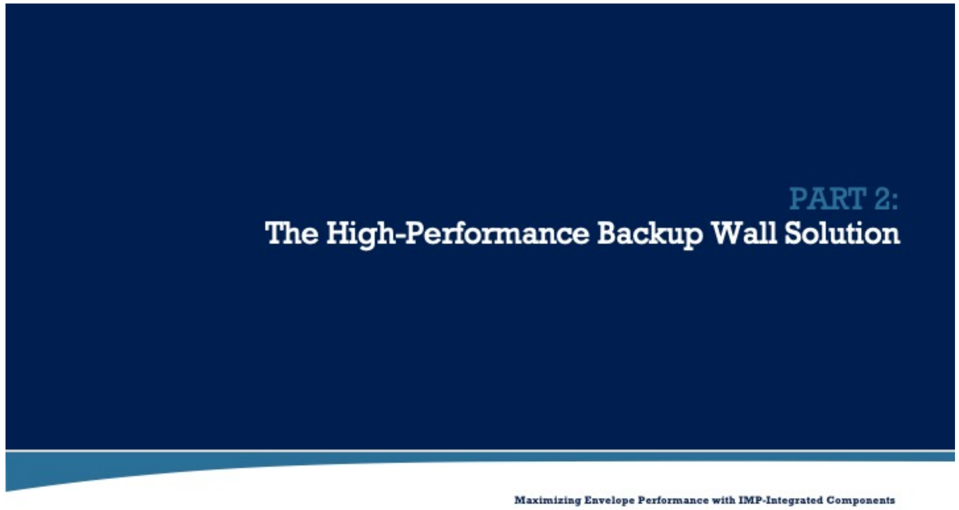
Not truly continuous insulation due to hundreds/thousands of thermal short circuits

Relies on multiple trades (up to four)

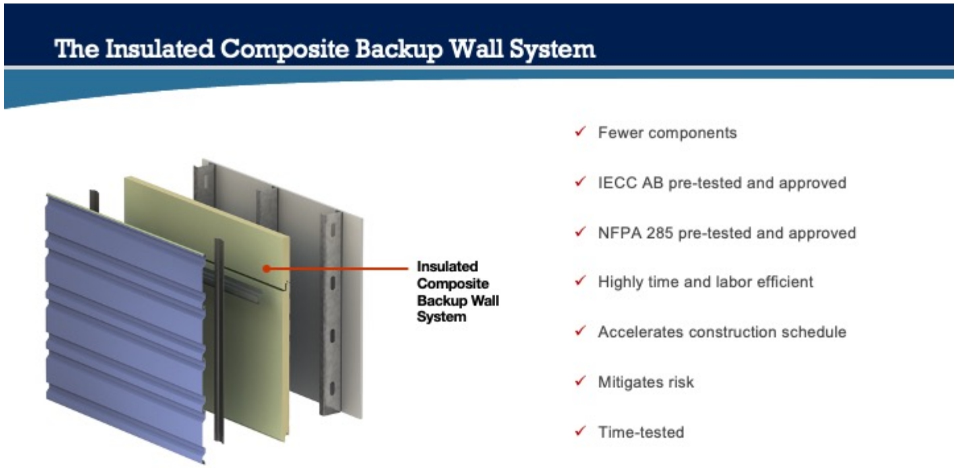
If the wall system fails, who is responsible? Which contractor? Which product? The GC? The engineer? The architect?



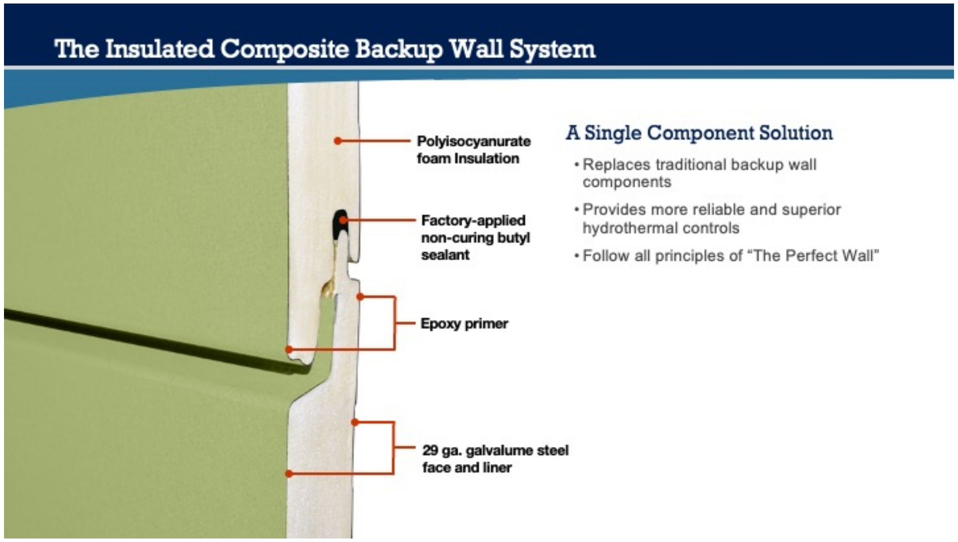
With all these challenges to overcome, it is easy to formulate a wish list for a superior backup wall solution. For example, a superior backup wall would have significantly fewer components, far fewer joints and seams to seal. Its fastening system would greatly reduce the number of penetrations through critical hygrothermal control layers. The system would be pre-tested and approved for both IECC air barrier requirements and NFPA 285. Thermal short-circuits would be minimized. It would be installed by just a single trade, which will significantly reduce complexity and time for the GC and schedule, meaning its highly time and labor efficient. The backup wall would have single-source responsibility and be warranted for long-term hygrothermal performance. Finally, it would be a proven solution as demonstrated by numerous installations in all climates and over an extended period of time. Fortunately, there is such a backup wall system and we will explore it now.



The rainscreen backup wall system we are going to explore has been engineered to produce a high-performance building envelope while solving the many issues associated with today's common multi-component backup wall assembly. It has been in use for more than a decade and is increasingly being adopted as architects, owners, and contractors begin to understand its many benefits over common assemblies.



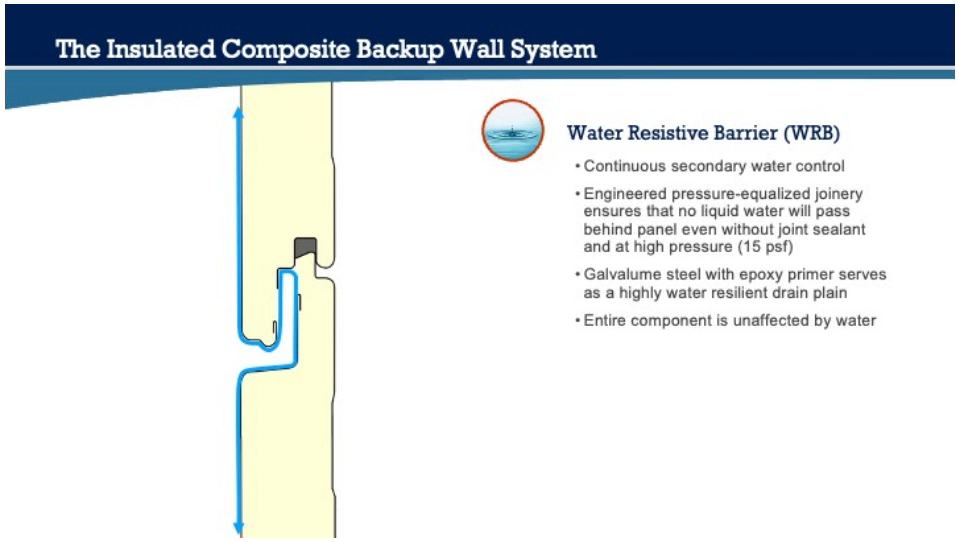
This solution is the insulated composite backup wall system. As we explore this solution what we'll learn is that it features far fewer components than the multi-component backup wall assembly. It has far fewer seams and joints. Its fastening process is engineered to minimize penetrations through critical hygrothermal controls. It's pre-tested and passes the IECC's requirements for air barrier performance and NFPA 285 fire performance. It minimizes thermal short circuits for enhanced thermal performance. Unlike any other solution, the insulated composite backup wall assembly installs by just a single trade which vastly reduces GC complexity. It's highly time and labor efficient and uniquely allows construction schedules to be accelerated significantly. Unlike multiple component wall assemblies, with up to six different products from as many manufacturers, each with their own product warranties and installations by up to four contractors and no ability to provide a longterm performance warranty – the insulated composite backup wall system is a single-source solution that's fully warranted for performance. This greatly mitigates risk for the entire building team. Finally, the system is proven over time as it's been in use for 40+ years. Let's take a close look at this system.



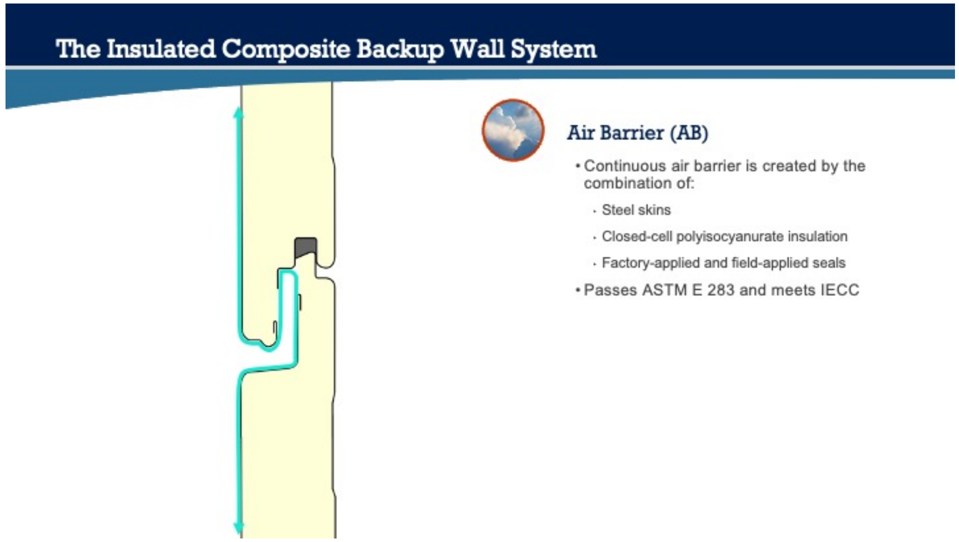
First, let's break down the features of this single-component system solution. This system is engineered from the ground up specifically for use as a high-performance backup wall for rainscreen wall construction. It carefully follows all the principles of "the Perfect Wall" that we covered in detail earlier. The core component of the system is an insulated metal panel. These panels feature 29 gage galvalume steel face and liner with foamed-in-place polyisocyanurate foam insulation.

(Foamed in place means that – during these panel's manufacture – the liquid ingredients for the foam are added as the face and liner panels are roll-formed and positioned in place. The ingredients interact and quickly expand, completely filling every space between the steel face and liner and forming a strong bond with the steel. An alternative and inferior method of manufacturing an insulated metal panel involves cutting rigid foam pieces to fit inside the skins and laminating these foam pieces to the steel. This method sacrifices not only thermal performance, but also the structural strength of the panel.)

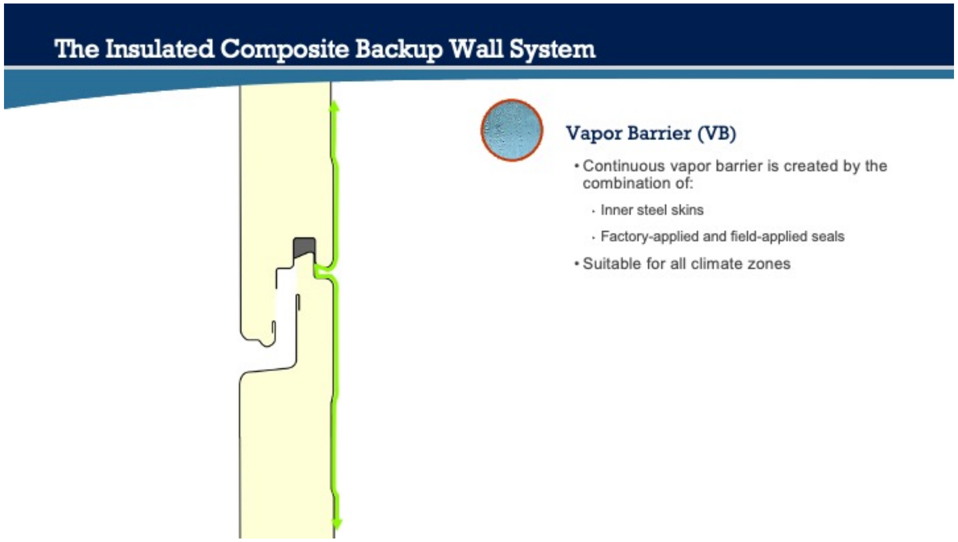
The steel galvalume skins are further protected with a highly durable primer coat that inhibits steel corrosion. These panels feature interlocking horizontal joinery. This sophisticated joint is engineered to prevent the infiltration of water, even under high pressure differentials. The joint is sealed with a non-curing butyl sealant and this sealant is pre-applied at the factory to ensure quality and to speed installation. Because of the sophistication of the horizontal joinery, even if this sealant were not present, water would still not penetrate the horizontal joint even under high pressure-differentials. This type of joinery is referred to as pressure equalized. When installed on the building, this system provides far more reliable and effective controls for all hygrothermal loads, producing the secondary water control, the air barrier, the vapor barrier, and thermal barrier – all in one – and eliminates the use of exterior gypsum sheathing, building wrap or membranes, and both rigid outboard and between stud batt insulation. Let's look at each of these hygrothermal controls.



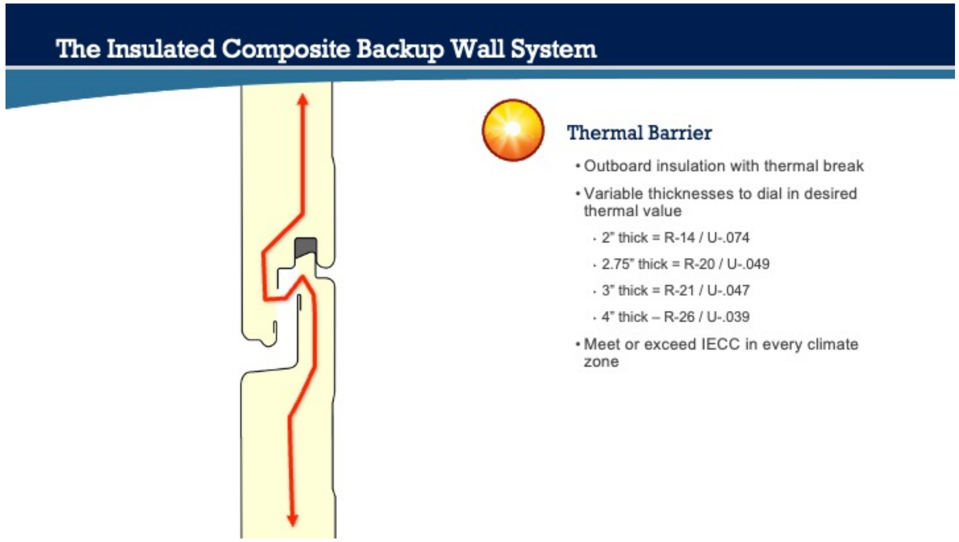
This slide illustrates the location of the water-resistive barrier. It follows the exterior face of the system. Again, the horizontal joint is pressure-equalized, so even in the highly unlikely event that the factory-applied sealant were compromised, water would still not penetrate through the joint, even up to a pressure difference of 15 psf. The height and geometry of this joint, in fact, prevents water from ever reaching the sealant. This ensures the sealant's long-term integrity. The Galvalume steel construction with a durable epoxy primer serves as a highly resilient drain plain for secondary water that penetrates past he rainscreen. And the entire panel component is water resilient and totally unaffected by water.



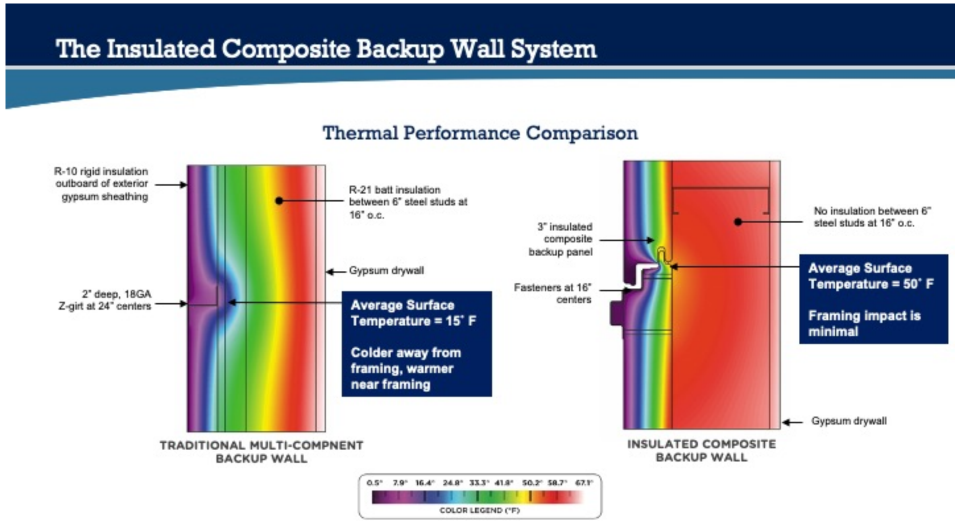
The air barrier follows the same line and is created through the combination of the system's steel skins, its closed-cell polyisocyanurate foam core, its factory-applied horizontal sealants and its field-applied sealants that we will cover a bit later in the course. This air barrier passes ASTM E 293 and meets the IECC's requirements for air barrier performance.



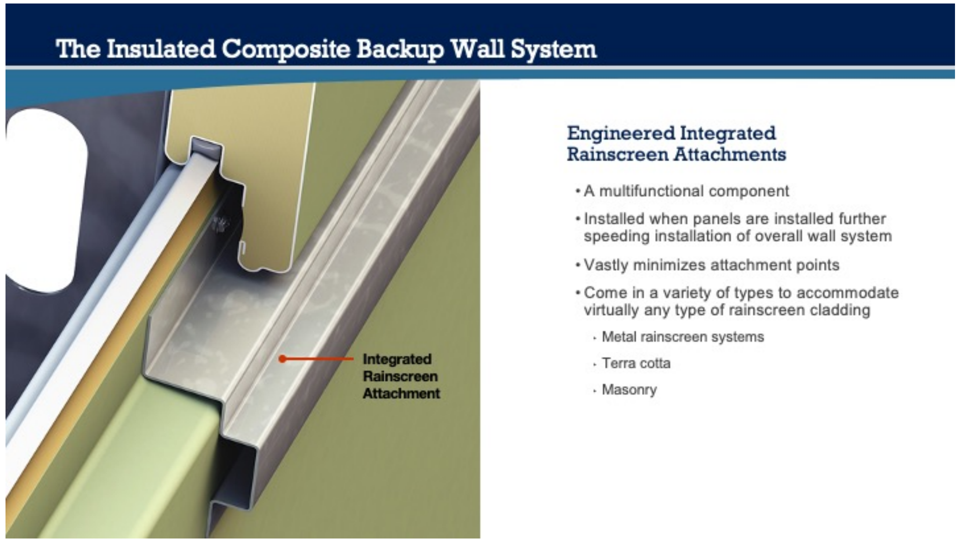
A highly effective vapor barrier is also created. Steel has a much lower perm rating so it effectively blocks vapor from penetrating through the wall. Furthermore, with the thermal control located outboard of the vapor barrier any issue of condensation on steel framing members is eliminated.



Finally, the thermal barrier is created by the polyiso foam insulation. Note the continuity of the thermal barrier and the thermal breaks that are included in the joint that prevent the outer face skins of the panels from conducting to the inner liner side of the panels. These breaks maximize the effectiveness of the insulation. The insulated composite backup wall system is available in a variety of thicknesses to match or exceed any thermal requirement according to ASHRAE and the IECC. 2"-thick panels achieve R-14 or U-.074.
2 1/4" provides R-20 or U-.049. 3"-thick panels achieve R-21 or U-.047 and 4" panels provide an outstanding R-26 or U-.039. Compared to the minimal IECC requirements, these values go well beyond, ensuring that it's a viable system for years to come as energy requirements continue to evolve and become even more stringent.



This thermograph illustrated the effectiveness of the insulated composite backup wall system, compared to a traditional system as prescribed by ASHRAE. The thermograph on the left is of a traditional multi-component backup wall. The right thermograph is the insulated composite backup wall. Note the loss of thermal value at the Z-girt on the traditional assembly. Even with batt insulation located between the studs, average surface temperature inside the wall at the Z-girt interface is 15 degrees Fahrenheit. Beyond its thermal inefficiency, this presents a significant opportunity for vapor to condense into liquid water and become trapped inside the wall where it can promote mold development and destroy structural framing. Conversely, at the same location in the insulated composite backup wall system thermograph, the average surface temperature at this location is 50 degrees, and this is with no batt insulation between studs. Keeping the liner side of the backup wall at this elevated temperature greatly reduces any chance of condensation inside the wall. Now let's look at how the insulated composite backup wall system addresses sub-framing to ensure superior thermal performance.

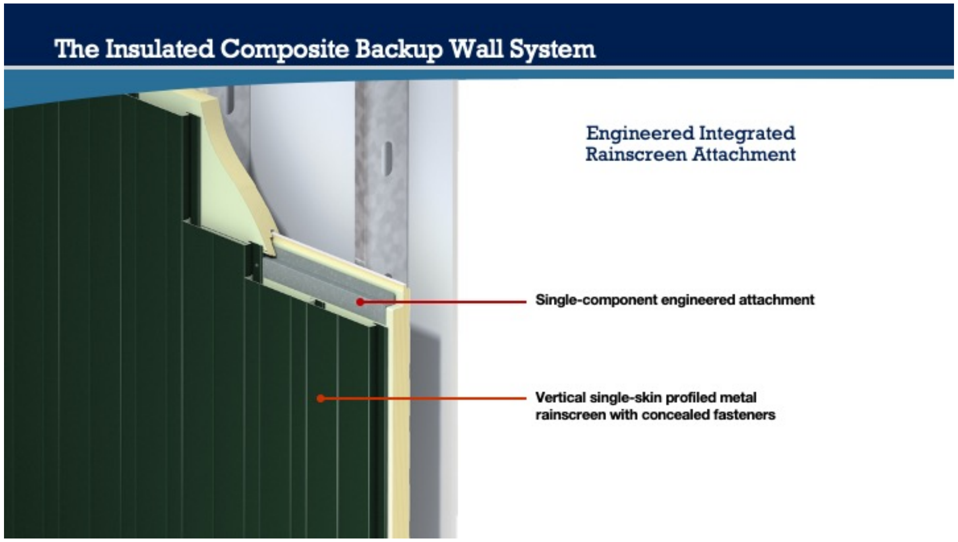


Unlike the traditional assembly that most frequently utilizes a Z-girt attached through wrap and sheathing, with the insulated composite backup wall system, the rainscreen sub-framing is attached at the same time the panels are installed, which speeds the entirety of the wall installation to completion. This integrated rainscreen attachment is placed along the outer skin of the panel where it remains thermally isolated from steel studs. In fact, the only thermal bridge is minimal and occurs at the single fastener that attaches the panel at every stud—usually 16 inches oc. This is a huge reduction in through fastening that occurs with traditional assemblies—penetrations that continually compromise the vital hygrothermal controls. The insulated composite backup wall system engineered integrated rainscreen attachments come in a variety of forms to accommodate virtually any combination of rainscreen material and allowing designers to freely mix and match rainscreen materials across the expanse of an exterior.

Vastly minimizes attachment points penetrating through critical hygrothermal controls

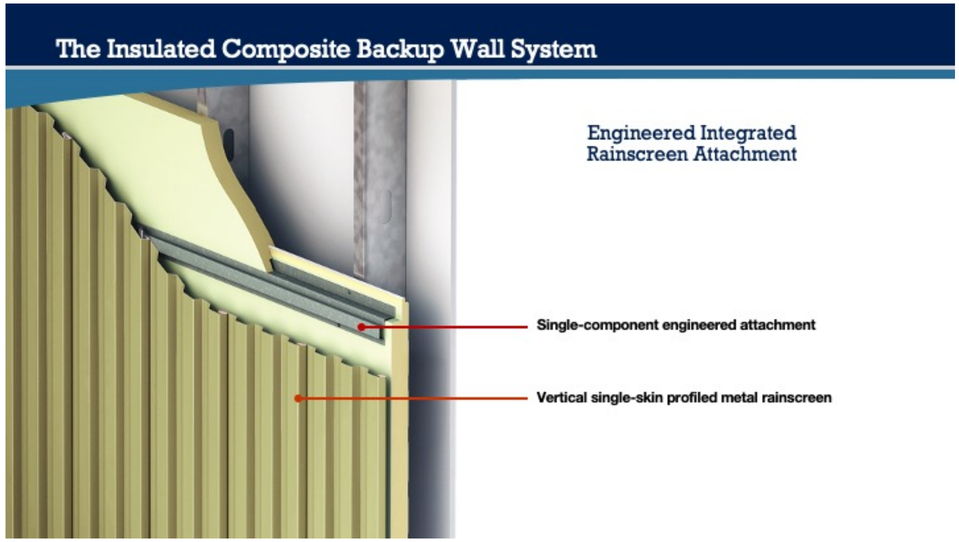
Come in a variety of types to accommodate virtually any type of rainscreen cladding

- Metal rainscreen systems
- Metal modular panels
- Terra cotta
- Masonry
- Etc.

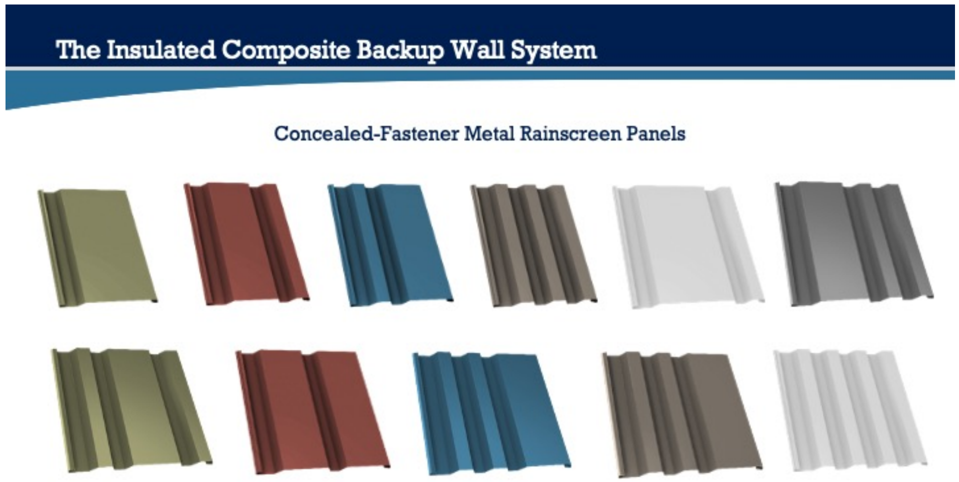


This basic Z-shaped attachment is used for installing single-skin profiled metal cladding with concealed fasteners in a vertical orientation. The legs of the these rainscreen panels create the stand off from the backup wall panels, creating the wall cavity.

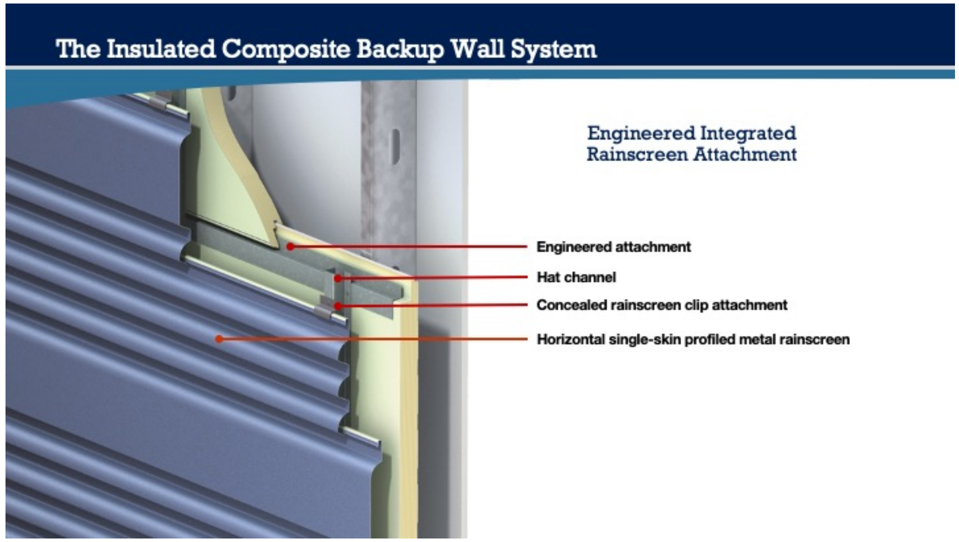
Here is a sample of the variety of profiles available with this type of concealed-fastener metal rainscreen panel system. These profiles feature common joinery, allowing the designer to mix and match profiles to create interesting rhythms across a facade.



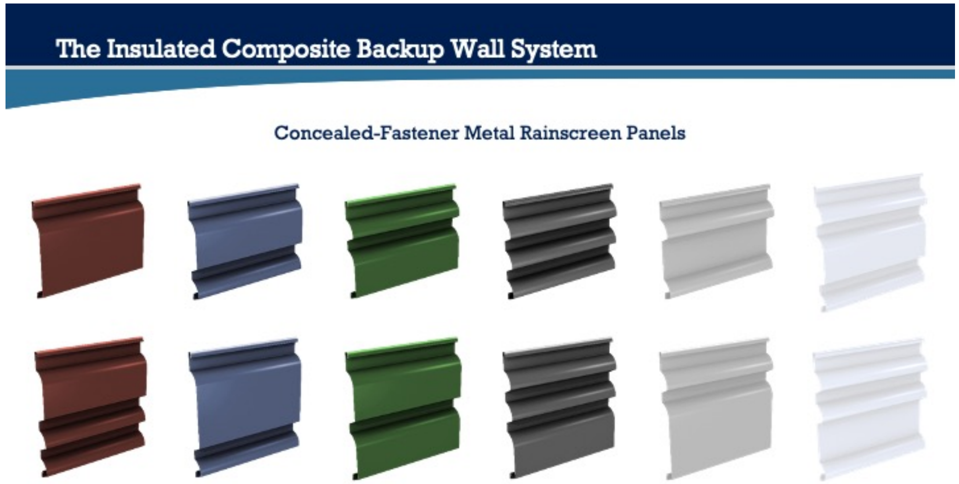
This attachment is used for installing another type of concealed-fastener metal panel in a vertical orientation. These panels may be installed horizontally as well, but for vertical applications, this attachment's hat-shape geometry creates space between the backup wall and the panels, creating the air and drainage cavity.



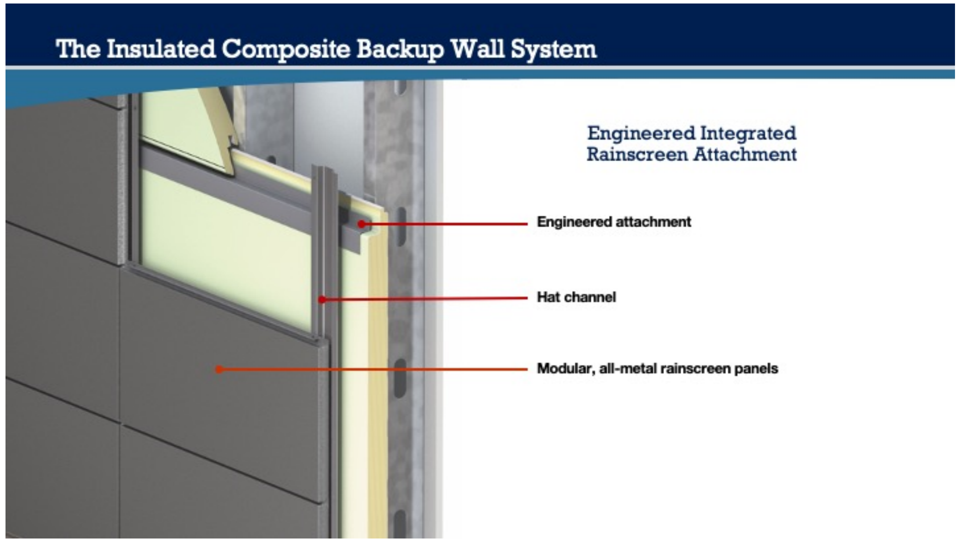
Here is the complete line of available panel profiles for this particular product. The panels in this series feature a common asymmetrical rib geometry. Panels come in a choice of two widths—12 inches and 16 inches—can be mixed freely across a facade owing to common panel joinery. Again, these rainscreen wall panels may be installed either vertically or horizontally as we will show on the next slide.



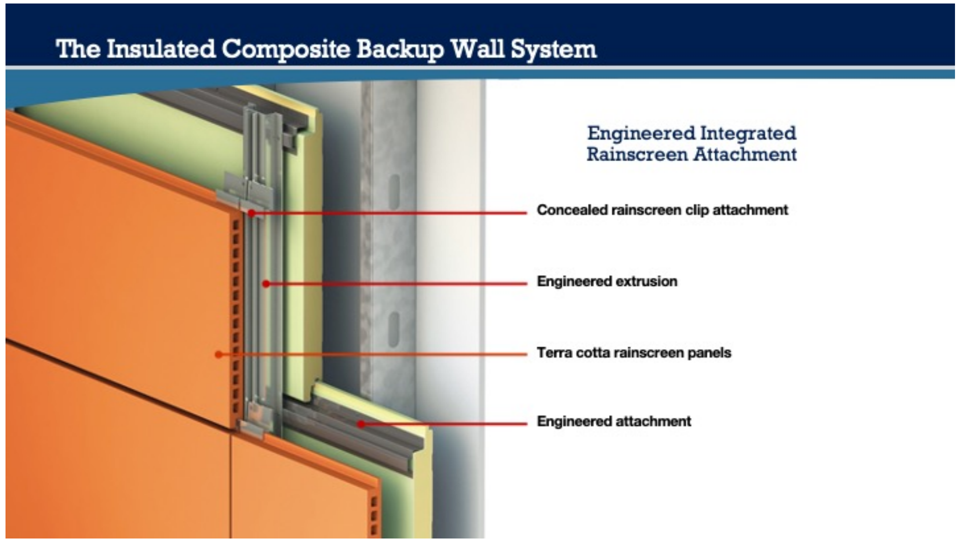
For horizontally installed single skin metal cladding with concealed clip attachments, the system comes with a two part integrated attachment. The horizontal Z-shaped component is installed simultaneous to panel installation. Then, the second vertical hat channel is added. Concealed clips that support the rainscreen are attached to this hat channel. Again, a cavity behind the rainscreen is created for secondary water drainage and drying.



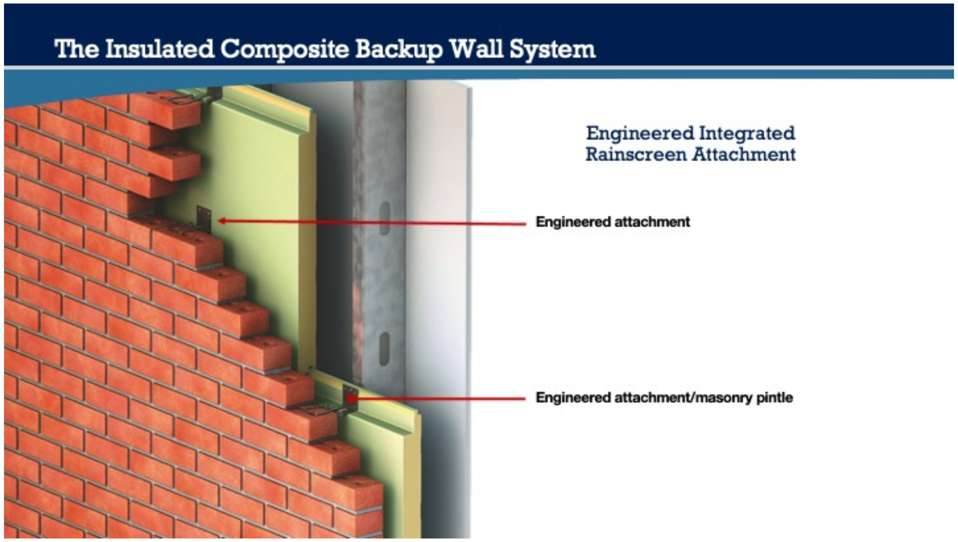
This series of rainscreen panels, also feature a common rib geometry—this time it is a curved rib shape. Common joinery allows designers to mix these panels freely to create unique facade designs.



This system is used for modular all metal panel rainscreens. Here, the hat channel is reversed to provide attachment points for adjoining panels.



For terra cotta panel systems, an engineered aluminum extrusion is used instead of a traditional vertical hat channel. This extrusion accepts the special clip attachments that are used for this type of rainscreen.



And for masonry, the system includes pintles that are placed at the horizontal joint and in intermediate locations directly on the surface of the panel. Pintles installed directly on the face of the panel are sealed with tape to ensure weathertightness.

Besides flat panels, modular all-metal rainscreen panels come in a variety of other design schemes as well as exciting new looks in façade design. Here are three of these schemes. The design scheme on the left feature panels of various thicknesses. In the middle is a scheme that incorporates panels with angled depths. On the right is a perforated version, which allows light and air to pass through.

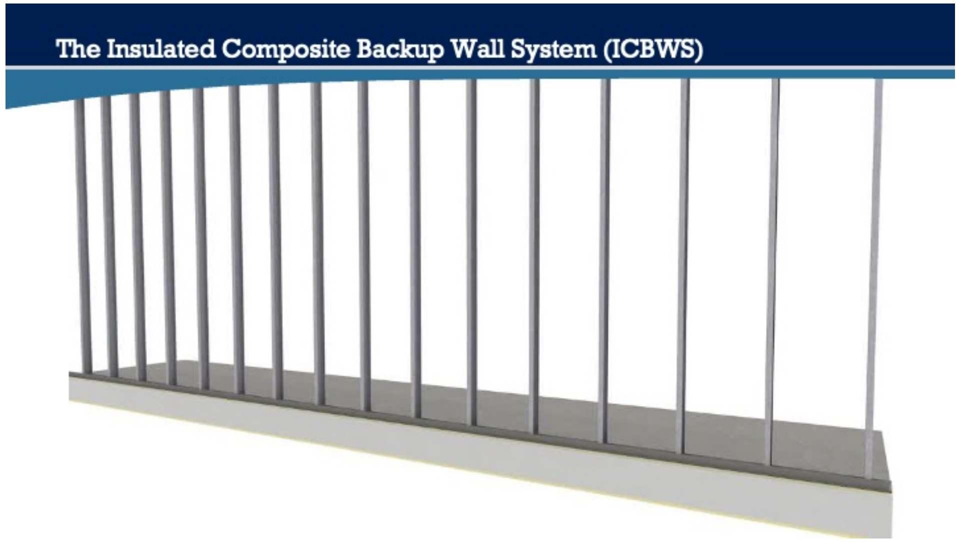
Another major benefit of the insulated composite backup wall system is available integrated window systems. While use of insulated composite backup wall-integrated windows is not a requirement in any way, this all aluminum widow system features joinery that has been engineered to integrate quickly and efficiently with insulated composite backup wall system panel joinery. This feature ensures that critical hygrothermal controls are maintained at windows. It also eliminates the the need for receptor extrusions at window head and sill as well as any exposed sealants. The windows feature thermally isolated framing as well. They are available in 9’4” heights and accept 1” IGUs. Use of a widow that integrated to marry with the insulated composite backup wall also helps to speed completion of the overall wall installation.

The Insulated Composite Backup Wall System (ICBWS)

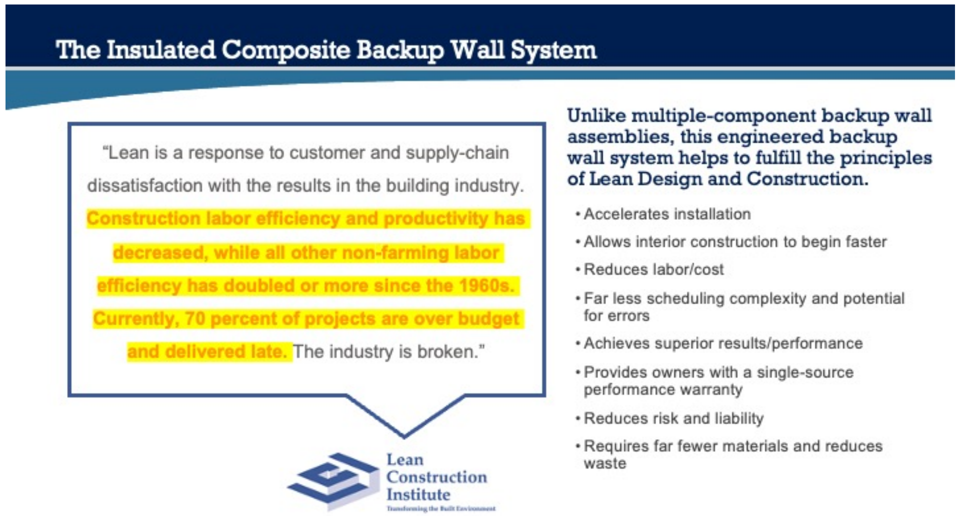
Blank Off Louver Panels

- Developed in conjunction with US-leading manufacturer of louvers
- Designed for large wall expanses where louvers are an architectural feature
- Creates a seamless appearance between active and inactive louvers
- Features storm-resistant blades over black-painted ICBWS panels
- Blade attachment rails are also painted black

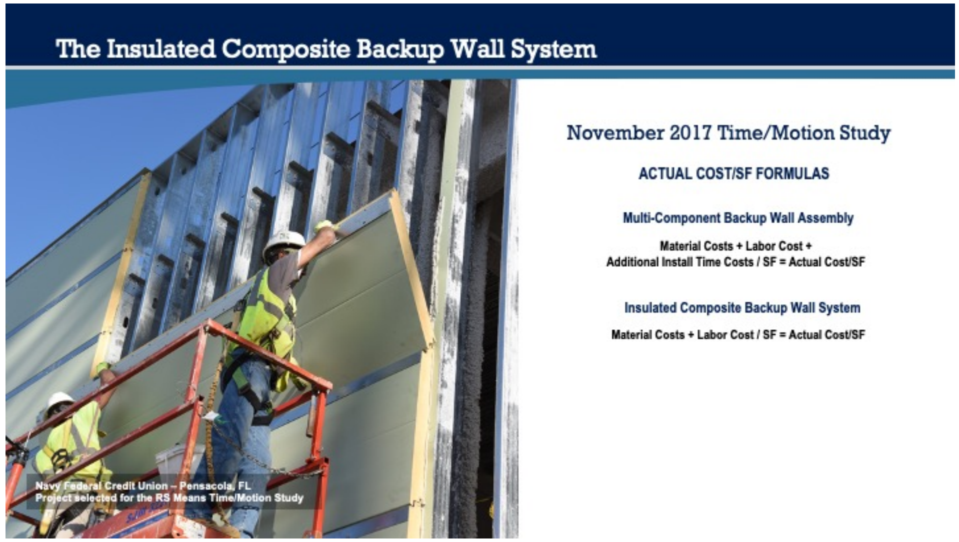
Another design option is the insulated composite backup wall blank off louver, developed in conjunction with the U.S. leading manufacturer of louvers. Since louvers are a requirement of the building envelope, some designers are incorporating the look of louvers as an architectural feature. The blank off panel helps achieve a seamless appearance between the building's active and inactive louvers. To achieve this, the panel skins are painted black and special black-painted vertical attachments are installed to accept storm-resistant louver blades. No let's watch a short video that demonstrates how the ICBWS system installs.



Here’s a short video that describes the easy installation procedure of the insulated composite backup wall system.



Now that we've examined the many performance benefits of the insulated composite backup wall system and have looked at how easily and efficiently it installs, let's discuss some of the industry issues that it solves. This dramatic quote from the Lean Construction Institute captures a major problem with the current state of the construction industry. "Lean is a response to customer and supply chain dissatisfaction with the results in the building industry. Construction labor efficiency and productivity has decreased, while all other non-farming labor efficiency has doubled or more since the 1960s. Currently, 70% of projects are over budget and delivered late. The industry is broken." Clearly, construction labor efficiency is a big problem. With the current labor shortage, especially in the construction industry, this problem has only been compounded. When you consider that only 30% of construction projects are completed on time and on budget, it's hard to argue against the LCI's assertion that the industry is indeed broken. The insulated composite backup wall system is just one response to these issues, but it's a response that fulfills many of the key principles of lean design and construction. The insulated composite backup wall system does, in fact, speed construction to completion. We'll look at this in just a moment. It vastly reduces the amount of skilled and unskilled labor required. It greatly reduces staging and scheduling complexities for the GC. There is far less potential for installation error and achieves a building envelope with superior hygrothermal performance. Risk is vastly reduced as the backup wall is provided and installed by a single source. Because of this, owners benefit from a performance warranty. Additionally, it requires far less materials and produces far less waste.

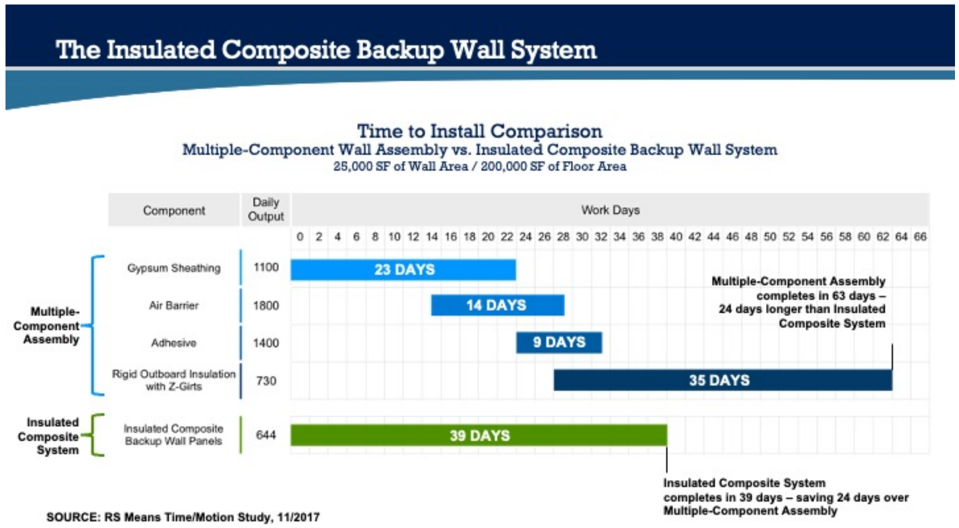


In November 2017, a detailed time/motion study was conducted by RS Means. The purpose: to determine the actual cost difference of choosing the insulated composite backup wall system over the multi-component backup wall assembly. Actual cost goes beyond simply materials and labor to account for construction savings realized from the construction site costs that are eliminated by compressing the construction schedule, a phenomenon that occurs by choosing the insulated composite backup wall system. The insulated composite backup wall system time/motion study was conducted at an actual installation of the system. The project was a headquarters facility for Navy Federal Credit Union in Pensacola Florida. Data collected during this installation was compared to longstanding known data related to materials, labor, and time for multiple-component backup wall assemblies. The formula for calculating actual cost of the multiple-component backup wall assembly per square foot is material cost, plus labor cost, plus costs realized during the additional time it takes to install a multiple-component backup wall assembly in addition to other infrastructure required to install a multiple-component backup wall assembly compared to the insulated composite backup wall system, divided by total square feet. The formula for actual cost of the insulated composite backup wall system per square foot is material cost, plus installation cost, divided by total square feet.

The methodology for the study was to measure the average time to install the insulated composite backup wall system and to compare this time to multiple-component backup wall assembly; then to calculate construction cost savings that are realized by the insulated composite backup wall system through time savings. These construction costs were threefold. First, general conditions cost savings. Second, variable general conditions cost savings. And third, temporary heating cost savings. We will take a closer look a tall three types of savings.

Measure average time to install the insulated composite backup wall system.

Compare to average time to install to a multiple-component backup wall assembly.



This chart illustrates the time to install differences between the multiple-component backup wall assembly and the insulated composite backup wall system for a 25,000-square-foot installation. For the multiple-component assembly, the first component – exterior sheathing takes 23 days to install. On the 14th day, a 14-day installation of the air barrier commences. On the 23rd day, a nine-day application of adhesives begins. And finally, on the 27th day, a 35-day installation of rigid outboard installation with Z-girts may commence. In total, the 25,000-square-foot installation of the multiple-component assembly takes 63 days to complete. In contrast, on average, the single-component insulated composite system takes just 39 days. This is a savings of 24 days of construction. So let us look at what costs are directly associated during this additional 24 days.

The Insulated Composite Backup Wall System

Fixed General Condition Costs
25,000 SF of Wall Area / 200,000 SF of Floor Area

Cost Per	Week	Month
Project Manager*	$3,600	$14,400
Superintendent*	$3,350	$13,400
Other Labor* (Laborer, Clerk)	$3,035	$12,140
Trailer (Equipment/Phone/HVAC)		$1,500
Power for the whole jobsite		$10,000
Protection/Fencing		$5,000
Waste & Site Maintenance		$2,000
	Totals	$58,440

* Includes 40% Fringes

Per Week	$14,610
Per Day	$2,851

24 Day Savings from use of insulated composite system = $68,424

SOURCE: RS Means Time/Motion Study, 11/2017

Type (Temporary Heat)	Coverage	Cost Per SF	Cost
Temporary Heat ****	200,000	$.239	$47,800
With ICBWS cut cost in Half		@50%	$23,900
Daily Heating Cost			$797

**** Needed for curing concrete and initial interior work. Costs per month.

24 Day Savings from use of insulated composite system = $19,128

SOURCE: RS Means Time/Motion Study, 11/2017

Variable General Condition Costs - ENCLOSURE
25,000 SF of Wall Area / 200,000 SF of Floor Area

Type (Enclosure)	Coverage	Cost Per SF	Cost	*** Usage @ 25%
Scaffold 26' x 1000 LF for Temp Enclosure	26,000	$2.23	$57,980	$14,495
Temp Enclosure – Plastic Sheeting	26,000	$3.42	$88,920	$22,230
			Totals	$36,725

*** Based on a conservative approach of need for amount of enclosure is based on building type and construction schedule

This cost is eliminated by using the insulated composite system

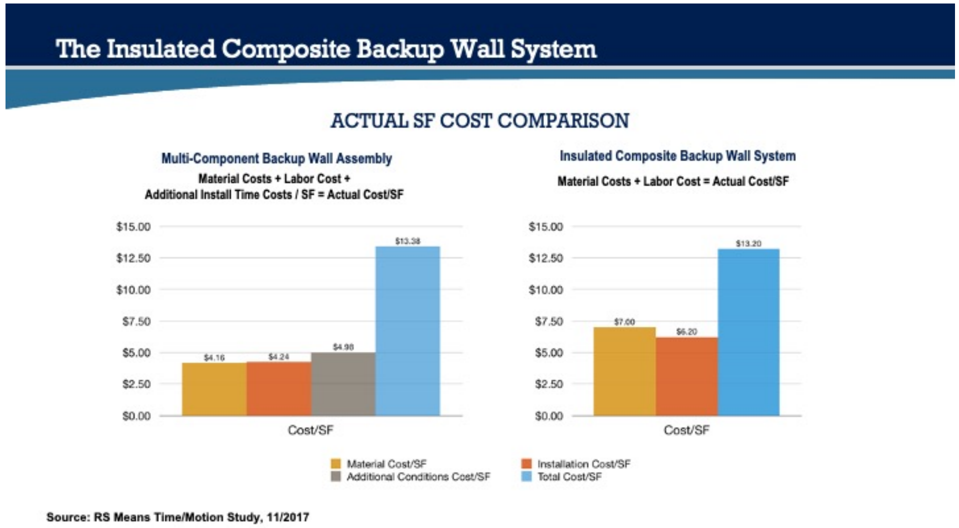
SOURCE: RS Means Time/Motion Study, 11/2017

	Fixed Conditions	Enclosure	Heating	TOTALS
Savings	$68,418	$36,725	$19,128	$124,271
$/SF Savings	$2.74	$1.47	$.77	$4.98

Additional cost per SF to use a multi-component assembly

SOURCE: RS Means Time/Motion Study, 11/2017

The first category of costs are general conditions costs. This includes a project manager, a superintendent, an additional laborer or clerk, a construction trailer, power for the jobsite, temporary fencing, and waste and site maintenance. These costs total $2,851/per day. Over the course of 24 days this totals a savings of $68,424.



When all of the costs are tabulated and compared according to the established formula, the actual cost per square foot between the multiple-component assembly and insulated composite system are virtually identical at $13.38 for the multi-component assembly and $13.20 for the insulated composite system. The actual cost of the multi-component assembly is the material cost, plus labor cost, plus the additional $4.98/square foot cost that were calculated in the time motion study. The important takeaway for this study is that despite a higher “on the wall” cost, the insulated composite system provides time efficiency that more than compensates for its higher on the wall cost. As more GCs experience this powerful benefit of the insulated composite backup wall system, the greater the adoption. However, it is important that architects understand this “actual-square-foot” cost benefit when they specify the system so that higher “on-the-wall” cost is understood in the right context of significantly faster building completion.

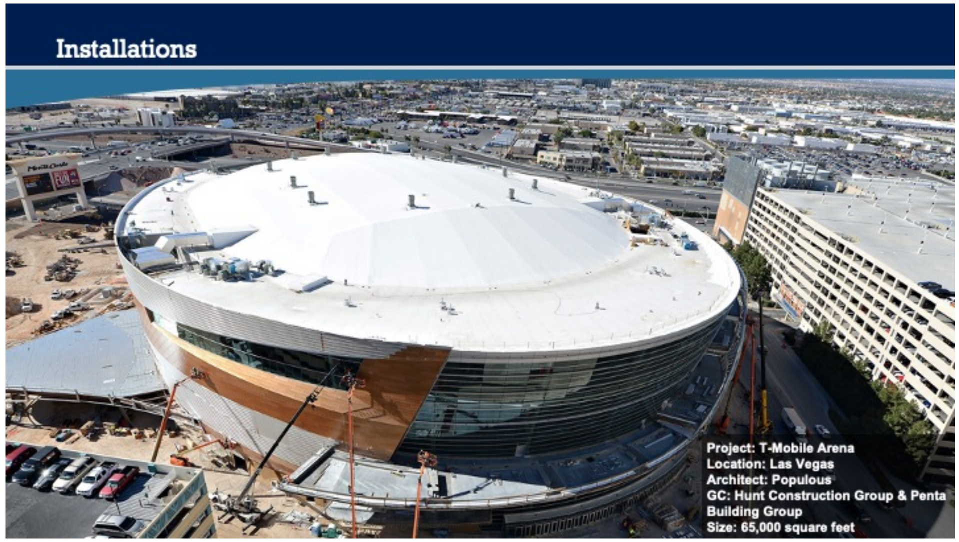
PART 3:
Installations of the Insulated Composite Backup Wall System

Maximizing Envelope Performance with IMP-Integrated Components

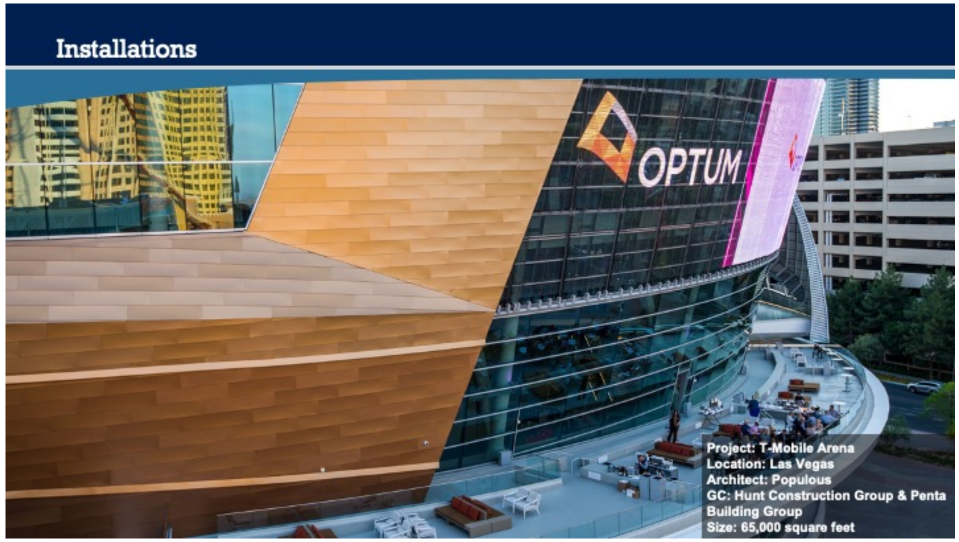
Now let's look at some installation examples of the insulated composite backup wall system.

For Unique Fitness in Holbrook, New York, the town's stringent energy code made the use of the 3" R-21 insulated composite backup wall system a natural choice. Here you see the exterior fully enclosed with the insulated composite system ready to receive exterior rainscreen cladding.

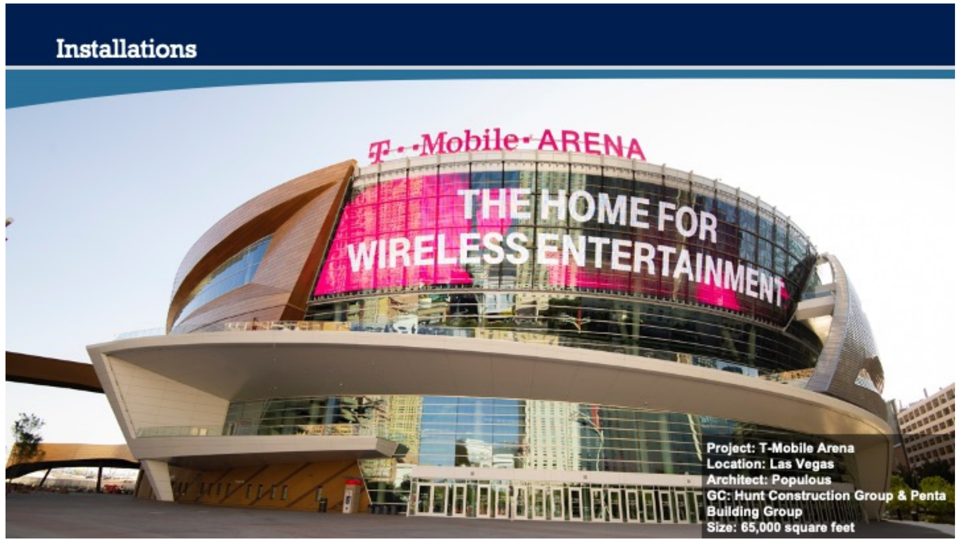
Here is the end result of the project with a good view of the blue and gray ACM panels featured prominently at the front of the building.



For T-Mobile Arena in Las Vegas, the insulated composite backup wall system was selected because it could accommodate all three requirements – the ease with which exterior cladding materials can be mixed, a very high R-Value, and speed of building enclosure.



Here you see the beautiful custom copper cladding installed over the system.

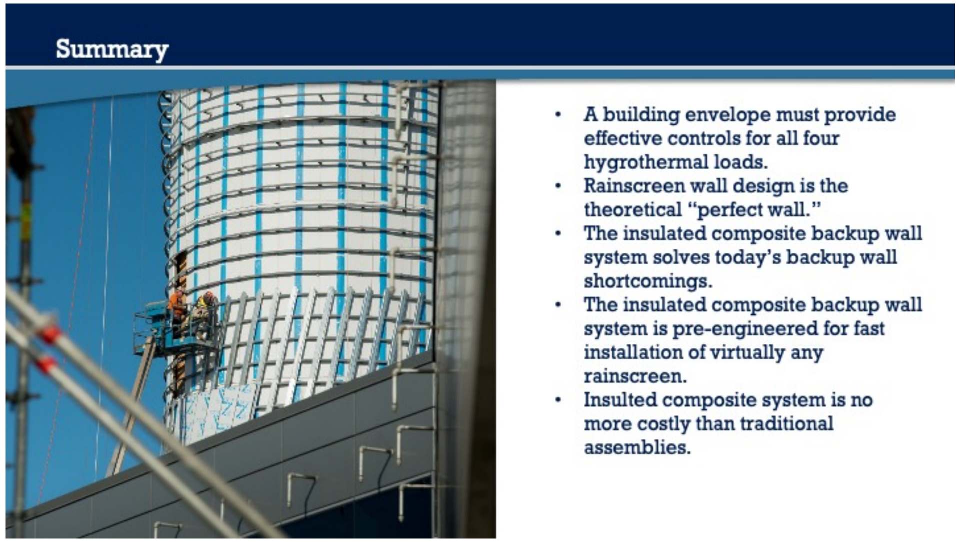


The end result is a highly energy-efficient building that Vegas can be very proud of.

In this case for Irwin Seating Company, the architect selected a single rainscreen cladding material – a single-skin profiled metal rainscreen installed horizontally.

Here are some detail shots of the cladding. Note, the sharp corners produced by the rainscreen manufacturer and the absence of any face sealant that can collect dirt and eventually stain these walls. This project will remain pristine decade after decade.

Finally, let us summarize what we have learned today.



The building envelope must control all four hygrothermal loads from the outside in and from the inside out. In the order of importance, these include rain control, air control, vapor control, and thermal control.

This rainscreen wall design is considered by one of the leading authorities in building science and envelope design as the "perfect wall." This is because the controls are in the right locations. The rainscreen is only tasked with shedding bulk water. Secondary water that passes the rainscreen is allowed to drain and exit to the exterior of the building and air freely circulates in this cavity promoting evaporation and drying. Finally, it works in all climate zones.

However, there are many shortcomings with today's version of the perfect wall one that incorporates a multi-component backup wall assembly. These shortcomings include its time and labor intensity, its reliance on multiple trades for installation, which causes staging and scheduling complexity for GCs. There is little room for error in its installation. And when a failure occurs, it is very hard to determine who the responsible party is. Finally, because it is provided by multiple manufacturers and multiple trades, there is no ability to warrant the entire system for long-term performance.

The insulated composite backup wall system solves these key shortcomings. An extensive time/motion study proves that it installs 38 percent faster than a multi-component assembly. It installs by just a single well-trained contractor. It is a far easier installation too, with far less of a chance for installation errors. The system vastly reduces staging and scheduling for the GC. It provides proven, superior hygrothermal control. It is a system that gives architects, owners, and GCs single-source responsibility. Owners receive a performance warranty. It meets and easily exceeds all required codes. And it can be used anywhere in the world.

Equally important, it is been pre-engineered to integrate easily and efficiently with virtually any rainscreen material—metal, terra cotta, high-pressure laminate, fiber cement, masonry, and more. And this allows architects to mix and match these materials freely, without concern for envelope performance issues, to create remarkable and beautiful building exteriors.

Finally, despite its higher material and installation cost, per square foot, the system's actual cost proves that it is no more costly than traditional assemblies. This is a result of its speed of installation and those items that are not required on the jobsite because of its use.

How to Achieve Superior Building Envelope Performance in Rainscreen Wall Design

1 AIA LU/HSW

This completes the course.

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