Technical Bulletin

No. 011

Cladding Attachment Solutions for Exterior Insulated Commercial Walls

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Introduction

The use of exterior insulation installed outboard of wall sheathing is becoming increasingly common across North America in order to meet more stringent energy code requirements. Commonly referred to as exterior insulation, this insulation is installed continuously on the outside of the primary structure and is more thermally efficient than insulation placed between studs or inboard of the structural system, provided that thermally efficient cladding attachments are used. As a result, greater attention is being paid to the design of thermally efficient structural attachment systems, and several proprietary systems have been introduced into the market in recent years to meet this demand. Cladding attachment options include continuous girts, intermittent clip & rail systems, long screws, masonry ties, and other engineered supports.

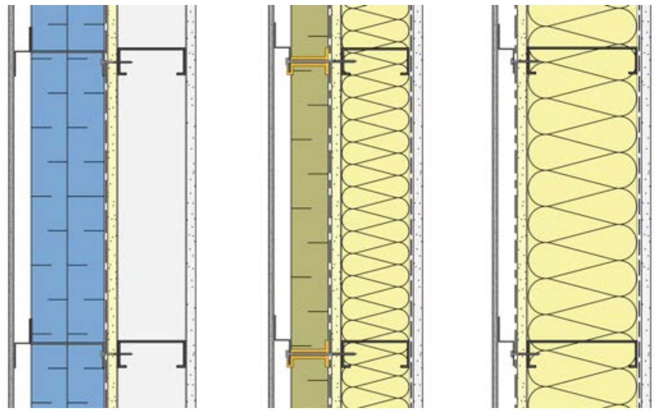


Figure 1: Standard approaches to insulating steel-framed wall assemblies

The challenge designers and contractors face is selecting and evaluating an appropriate cladding attachment strategy for their project and understanding the implications that these decisions have on effective thermal performance, installation methods, sequencing, and system costs.

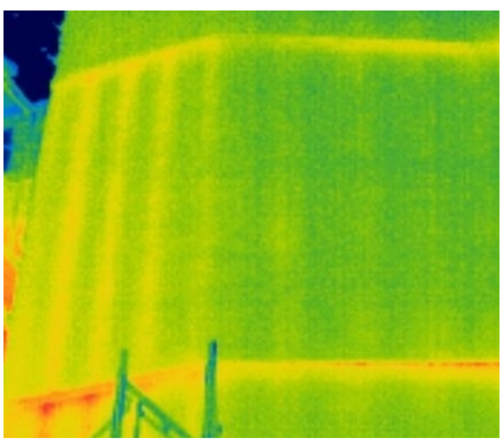


Figure 2: Thermal infrared image of two different cladding support systems, to the left - continuous vertical steel Z-girts, and the to the right - intermittent low-conductivity clips.

The thermal infrared image at left shows a stucco-clad wall with thermally inefficient continuous vertical Z-girt cladding support system to left side of wall and thermally efficient low-conductivity clip and rail cladding support system to the right side. The insulation utilizing the continuous girts is less than 25% effective, whereas the insulation utilizing the intermittent clips is over 80% effective—significantly improving the thermal performance of the wall for the same construction cost.

This bulletin clarifies and provides guidance regarding different cladding attachment systems through exterior insulation for commercial wall applications.

Energy Codes & Exterior Insulation

There are various energy codes and standards in force across North America for commercial buildings. The two most widely applicable energy codes are the International Energy Conservation Code (IECC) in the United States, and the National Energy Code for Buildings (NECB) in Canada. The most commonly referenced energy standard is ASHRAE Standard 90.1, which is referenced by building and energy codes in the majority of American States and by some Canadian Provinces. Different versions and adaptations of these standards and codes are in effect in the Provinces and States.

While different versions and adaptations of these regulations are enforced in different jurisdictions, each requires consideration of thermal bridging and effectiveness of installed insulation. Exterior insulation presents an efficient and cost-effective method to provide improved thermal performance and meet the requirements of these regulations; however, the effectiveness of this approach hinges on the selection of a thermally efficient cladding attachment strategy. The cladding attachment can be a significant thermal bridge and reduce exterior insulation performance by as much as 80% for poor systems and as little as 5-10% for high-performance systems. Requirements for Cladding Attachment

Requirements for Cladding Attachment

There are several factors that must be considered when choosing the type of exterior insulation and the cladding attachment strategy for a building. These include:

→ Cladding weight

→ Wind loads

→ Seismic loads

→ Back-up wall construction (wood, concrete, concrete block, or steel framing)

→ Attachment point back into the structure (through studs, sheathing, or slab edge)

→ Thickness of exterior insulation

→ Use of rigid, semi-rigid or spray-applied insulation material

→ Ability to fasten cladding supports directly through the face of rigid insulation boards

→ Ability to fit semi-rigid or sprayed insulation tightly around discrete supports and ease of installation

→ Effective R-value target and thermal efficiency loss from supports

→ Orientation and required attachment location for cladding system (panel, vertical, horizontal)

→ Details for attachment of cladding at corners, returns and penetrations.

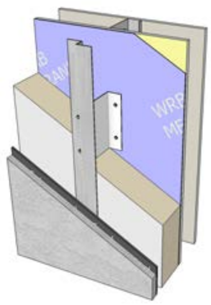
→ Combustibility requirements

→ Accommodation of dimensional tolerance

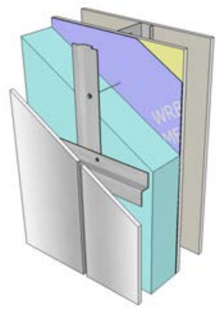
→ Allowable wall thickness

The design of the cladding attachment system will typically be performed by a structural or façade engineer working for the architect or cladding manufacturer. Many cladding support systems have been pre-engineered and designed using load tables developed by the manufacturer.

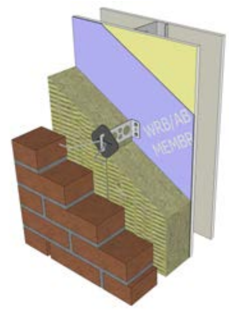
It is important that the cladding support designer understands the requirements of the project including the thermal requirement, so that the system and spacing of supports can be optimized to make the best use of the exterior insulation.



Discrete clip and rail type cladding support with rigid insulation placed between clip supports inboard of the continuous vertical rail. Cladding attached back to vertical rails on exterior of insulation.



Long screws through rigid insulation utilizing continuous vertical strapping to create a truss cladding support system. Cladding attached to strapping on exterior of insulation.



Masonry ties with semi-rigid insulation. The tie supports here provide only lateral resistance support, not gravity load (supported at the base of the veneer).

Figure 3: Examples of various cladding attachment stategies through exterior insulation

Cladding Attachment Systems

There are numerous generic and proprietary cladding support systems designed for use with exterior insulation available on the market today, and many different materials are used to make these systems including galvanized steel, stainless steel, aluminum, fiberglass, composites and plastic. While each system is unique, the approaches can generally be classified as: continuous framing, intermittent clip and rail, long fasteners and masonry or other engineered systems.

Systems are available to accommodate a wide range of claddings for buildings of all heights and exposures. Typically, the heavier the cladding or more extreme the wind load the tighter the spacing of the supports—thereby compromising the effective thermal performance. The best system is one that is optimized structurally and thermally for the cladding support needs of the specific project.

An overview of several different cladding support systems are provided in the sections below. For each of the systems a relative cost ($ - $$$), thermal efficiency (e.g. percent effectiveness of the exterior insulation), and ease of installation ranking is provided. Within all of the systems, exterior insulation is typically appropriate except where noted.

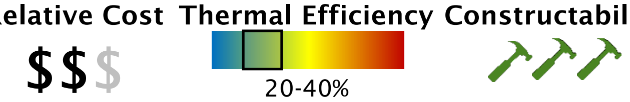
All of the cladding systems can be installed with wood, steel stud, or concrete/concrete block back-up walls, with most systems lending themselves better to commercial wall cladding rather than residential cladding.

Continuous Framing

Continuous girt cladding support systems are the predecessors to the more thermally efficient clip and rail systems that have been developed. While continuous framing systems do not perform nearly as well thermally, they still used in some applications.

Continuous Framing - Vertical Z-Girts

Relative Cost Thermal Efficiency Constructability



This cladding attachment system consists of continuous galvanized steel framing members, typically 18- to 20-gauge Z-girt or C-channel profiles attached vertically to the back-up wall. Typically girts are spaced to line up with stud framing behind (every 16” to 24” o.c.). Cladding systems are attached directly to the outer flange of the Z-girts. Where vertically oriented cladding is used, additional horizontal sub-girts may be applied to the exterior of the verticals.

Vertical Z-girts are not a thermally efficient cladding system and are not recommended in typical applications due to the excessive amount of thermal bridging. Exterior insulation installed between vertical Z-girts is degraded significantly and is only 20-40% effective for typical applications. While thermal breaks at the sheathing level can be beneficial, the insulation is still largely bridged, making the improvement mostly to surface temperature rather than U-value. In terms of prescriptive code compliance, it is very difficult to meet effective R-value requirements with this system.

Figure 4: Vertical Z-girt over steel stud wall assembly. Girts are fastened to studs behind at every 16” o.c. resulting in significant thermal bridging through the exterior insulation.

Continuous Framing - Horizontal Z-Girts

Relative Cost $$$

Thermal Efficiency

30-50%

Constructability

This cladding attachment system consists of continuous galvanized steel framing members, typically 18- to 20-gauge Z-girt profiles attached horizontally to steel studs or a concrete back-up wall. Typically girts are attached to the back-up wall every 24" to 48" o.c. depending on cladding loads. Cladding systems are attached directly to the outer flange of the girts. Where horizontally oriented cladding is used, additional vertical sub-girts may be applied to the exterior of the horizontals.

Horizontal Z-girts are not a thermally efficient cladding system and not recommended in typical applications due to the excessive amount of thermal bridging. Exterior insulation installed between vertical Z-girts is degraded significantly and only 30-50% effective for typical exterior insulation applications. The horizontal configuration has slightly improved thermal performance over vertical Z-girts because of the increased spacing between the girts.

Figure 5: Horizontal Z-girts over a steel stud wall assembly. Girts are fastened every 36" o.c. (middle) to reduce the thermal bridging somewhat compared to typical vertical arrangements at 16" o.c.

Continuous Framing - Crossing Z-Girts

Relative Cost **Thermal Efficiency** **Constructability**

$$$


40-60%

This cladding attachment consists of two continuous galvanized steel framing members, typically 18- to 20-gauge Z-girt profiles attached in a crossing pattern to steel studs or a concrete back-up wall. Typically girts are spaced every 16” to 24” o.c. or more depending on the back-up framing and cladding loads. Cladding systems are attached directly to the outer flange of the exterior girts.

Crossing Z-girts are not a very thermally efficient cladding system and not recommended in typical applications due to the excessive amount of thermal bridging. Exterior insulation installed between crossing Z-girts is degraded significantly even though the attachment occurs intermittently and only 40-60% effective for typical exterior insulation applications. This system can be improved slightly (approximately 5-10%) with the use of low conductivity isolation thermal breaks/washers between framing and back-up wall, or between the crossing girts.

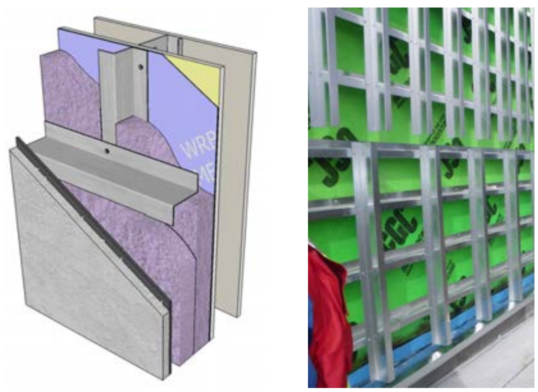


Figure 6: Crossing Z-girt assembly consisting of horizontal and vertical Z-girts attached at crossing points.

Figure 7: Crossing Z-girt cladding support system with custom punched vertical Z-girt profiles used to retain exterior insulation.

Clip and Rail Systems

Clip and rail systems are becoming an increasingly popular approach for a more thermally efficient cladding support system and can support all types of cladding. This includes board and lap cladding that is installed using standard nail/screw fasteners, stucco/adhered veneers, stone veneers, and a wide range of metal, glass, and composite cladding systems each with unique support conditions.

Clip and rail systems consist of vertical or horizontal girts (rails) attached to or through intermittent clips which are then attached back to the structure through the exterior insulation. Typically, only the clips penetrate the exterior insulation, however in some designs, the web of the rail may also cut through part of the insulation. In such cases, the web degrades the thermal performance of the system similar to the continuous vertical/horizontal girt systems and should be avoided as much as possible. The rails are typically made from galvanized steel Z-girt or hat-channel sections or aluminum extrusions. The clips are made from a range of materials including galvanized steel, stainless steel, aluminum, fiberglass, plastic or some combination of these materials together. The less conductive the clip material and the fasteners that penetrate the insulation, the more thermally efficient the system will be. This is why stainless steel or fiberglass systems perform better than galvanized steel or aluminum, and why stainless steel fasteners may beneficial compared to galvanized steel fasteners.

The overarching strategy with still clip systems is to maximize the spacing and use as few clips as possible while meeting the structural requirements. This maximum clip spacing is typically governed by the cladding wind loads and stiffness of the rail section. Low conductivity clips are also beneficial since inevitably more clips are needed at detail locations. While this is not necessarily accounted for in current energy codes, it will likely become a consideration in the future, as thermal bridging at such locations becomes a central concern.

Clip and Rail – Aluminum T-Clips

Relative Cost	Thermal Efficiency	Constructability
$$$	40-70%	

This clip and rail system is similar to the galvanized steel clip option described previously, but instead of galvanized steel the clips are made of a thick aluminum T-shaped extrusion with horizontal girts attached on top of the clips. The horizontal girts cut through the majority of the exterior insulation reducing the performance. Where needed, vertical rails are attached to the horizontal girts.

As aluminum is over four-times more conductive than galvanized steel, the key with this system is to minimize the number of clips and maximize the structural efficiency of the exterior rails. Currently there is one manufacturer of this proprietary system which also integrates other thermal break materials into the clip. The performance of this system is heavily dependent on the spacing of the horizontal girts that penetrate the insulation and on the spacing of the intermittent aluminum clips. The thermal efficiency of the system ranges from a low of 40% up to 70%.

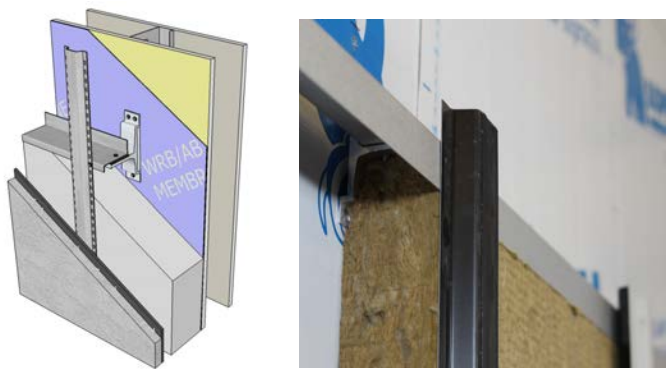


Figure 8: Aluminum T-clip with horizontal Z-girt and vertical hat-track for cladding attachment.

Clip and Rail – Galvanized Steel Clips

Relative Cost **Thermal Efficiency** **Constructability**

$$$

50-75%

This clip and rail support system utilizes intermittent generic metal clips made of cold formed galvanized steel. The clips typically take the form of 16- to 18-gauge Z-girts, C-channels, or L-angles in 4-8" lengths with depth to suite the insulation and/or cladding cavity. Dimensional adjustability can come from the use of back to back L-brackets screwed together as they are installed or shims behind the clips. The clips are attached to vertical or horizontal rails which are most often Z-girts, hat-channels or C-channels. Cladding is attached directly to these rails with short screws. The rail sections should not penetrate the insulation as it will degrade the effective thermal performance.

The thermal efficiency of a clip and rail system with galvanized steel is predominantly affected by the spacing, gauge, and length of the clips. Typically clips are spaced every 16" horizontally and 24-48" vertically depending on the cladding loads. Given the variables, the thermal efficiency of galvanized steel clip and rail system can range considerably from less than 50% to as high as 75%.

In addition to the generic options available, there are some manufacturers who now produce pre-made engineered galvanized steel clips.

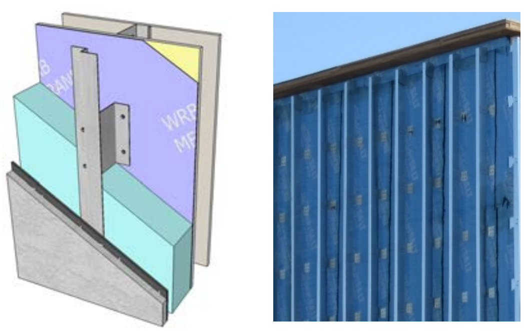


Figure 9: Intermittent galvanized steel clips with vertical girts

Figure 10: Generic adjustible back to back L-angle clips

Clip and Rail – Stainless Steel Clips

Relative Cost	Thermal Efficiency	Constructability
$$$	65-85%	

This clip and rail system is very similar to the galvanized steel clip option described previously, but instead the clips are made of stainless steel profiles (rails remain as galvanized steel). Stainless steel is over four-times less conductive than galvanized steel, and therefore more thermally efficient. Because of the lower conductivity of the clips, this system performs quite well with thermal efficiencies in the 65 to 85% range depending on spacing and clip dimensions.

In terms of installation, pre-drilling/punching the stainless components can help with fastening onsite. In addition to the generic options available, there are a few manufacturers who now produce and sell stainless steel clips including a pre-punched back to back L-bracket allowing for site adjustability.

Figure 11: Intermittent stainless steel clips with vertical girts.

Clip and Rail – Thermally Isolated Galvanized Clips

Relative Cost $$$ **Thermal Efficiency** 60-90% **Constructability**

This clip and rail system consists of proprietary heavier gauge galvanized steel clips with 1/8” to 1/2” plastic pads/washers installed between the clip and backup structure. Plastic washers may also be used at fasteners to reduce the heat transfer. Vertical or horizontal girts are attached to the clips using screws and the cladding is attached to these girts. There are currently multiple manufacturers of similar products in the market with varying thermal and structural performance.

In terms of thermal performance, the plastic components reduce the heat flow through the clip to performance levels similar to stainless steel clip systems. Again the key to maximizing the thermal performance of this system is to reduce the number of clips required. The thermal performance of this system varies between 60% and 90% depending on the manufacturer’s details and spacing.

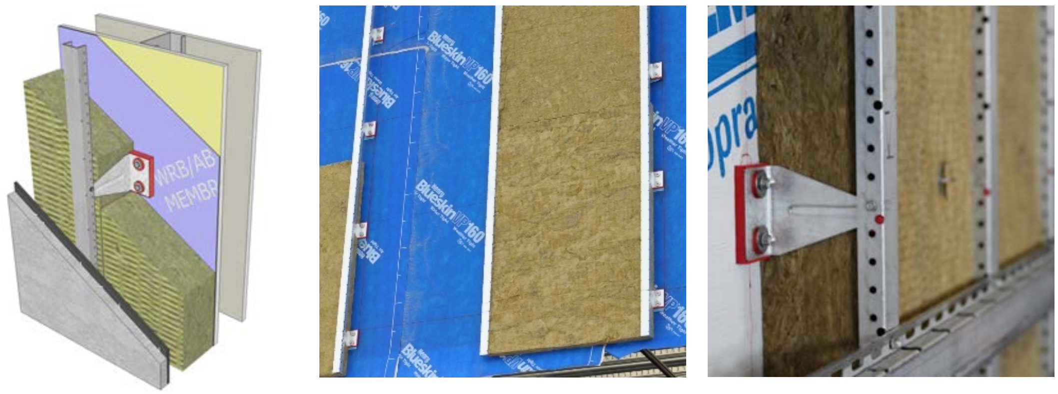


Figure 12: Thermally isolated galvanized steel clip attached to wall with screws through plastic isolation pad.

Clip and Rail – Fiberglass Clips

Relative Cost	Thermal Efficiency	Constructability
$$$	70-95%	

This clip and rail system utilizes low-conductivity fiberglass clips. Fiberglass is approximately 200 times less conductive than galvanized steel and improves the thermal performance significantly. One or two long screws (galvanized or stainless steel) through each clip connects the vertical or horizontal galvanized steel rail through the shear block clip back to the structure.

With this system, Z-girts or hat-channels are used as the vertical or horizontal rail elements entirely on the exterior of the insulation. The fiberglass clips are often pre-clipped to the metal girts and then screwed to the wall as one element, speeding up installation time.

There are two variants of the fiberglass clip in the market with varying structural, fire, and thermal performance characteristics. The thermal performance of a fiberglass clip and rail system is heavily dependent on the spacing of the clips and type of screw fasteners used (galvanized vs stainless) and ranges from 70% with tightly spaced clips for heavier claddings to over 90% with optimally spaced clips for lighter claddings.

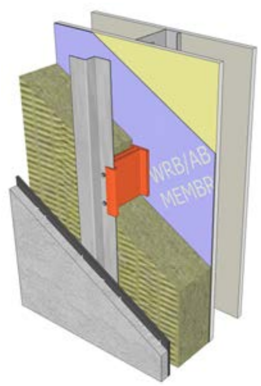


Figure 13: Fiberglass clips with vertical Z-girt attached with screw fasteners through the fiberglass clip into the back-up wall

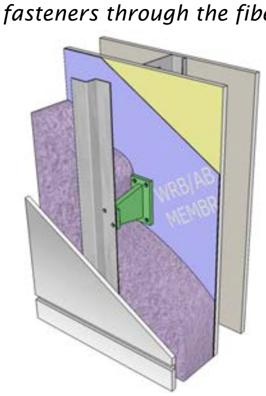


Figure 14: Fiberglass clips (spacers) attached to wall with screws, horizontal Z-girts attached to clips with screws

Long Screws Through Insulation

Relative Cost $$$ **Thermal Efficiency** **Constructability**

75–95%

This cladding attachment system utilizes long fasteners that connect girts or strapping on the exterior of rigid insulation directly into the structure. The combination of the continuous exterior strapping/girts, long fasteners, and rigid insulation create a truss system to support light to medium weight cladding systems. Deflection is limited by the truss action and can be further limited by installation of fasteners screwed in upwards at an angle through the insulation. The only thermal bridges through the exterior insulation are the long galvanized or stainless steel screws. Claddings are attached directly to steel girts or wood strapping on the exterior surface of the insulation. Typically, vertical strapping is used as it provides a vertical cavity for drainage and ventilation behind the cladding along with greater load carrying capacity; however, horizontal strapping can also be used for some claddings.

Typically, 18- to 20-gauge hat-channel profiles for galvanized steel girts or minimum ¾" plywood or dimensional lumber are used for the exterior girts/strapping. Typically, the fasteners consist of #10-#14 steel screws every 12–16" o.c. in lengths to connect the exterior girt/strapping to the backup structure (studs, sheathing, or concrete). Typically, the required screw length can be estimated by the thickness of exterior insulation plus 1 ½"–2".

One challenge installers face with this system is the positive connection of the screw fasteners back to the structure. With wood framing this can be achieved by either hitting the studs or designing the plywood or OSB sheathing for the required pull-out resistance. With steel studs this requires careful alignment to hit but not strip the studs. With concrete and concrete block back-up, this requires special concrete or masonry fasteners.

The thermal performance of this system depends on the back-up wall, type of fastener and fastener spacing. For typical conditions (fasteners every 12" vertically by 16" horizontally), the insulation effectiveness will be in the range of 75% to 85% for galvanized screws in steel/concrete backup, and up to 90-95% for stainless steel screws in wood-frame backup. Note that these values are similar to many of the high performance clip systems available.

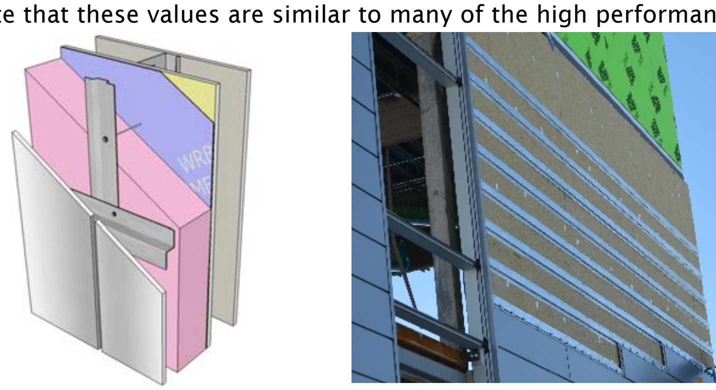


Figure 15: Long screws through metal girts and rigid exterior insulation.

Masonry Ties

Relative Cost $$$ **Thermal Efficiency** 40-90% **Constructability**

Masonry veneer systems are supported by gravity bearing supports (shelf angles, corbels etc.) and intermittent ties for lateral and out of plane support. Masonry ties bridge the exterior insulation similar to other cladding supports and therefore are thermal bridges. There are a range of proprietary and generic masonry tie systems available in the market and the thermal efficiency ranges from fair to excellent (approximately 40 to 90%) depending on the number of ties and the type and gauge of metal used (stainless steel is better).

Figure 16: Examples of some different masonry ties installed through exterior insulation.

Engineered Anchors and Other Systems

In addition to the various cladding attachment systems presented earlier in this bulletin, there exist many opportunities for engineered approaches and adaptations of existing systems.

Stone veneer systems have long used heavy gauge engineered clips to structurally support heavy claddings and have adapted configurations to support through a few inches of exterior insulation. Many of these heavier gauge steel anchors will be large thermal bridges, and thermal modeling is suggested to assess opportunities for improvement, including spacing optimization or incorporation of thermal break materials.

An example of a heavy-duty engineered cladding anchor support system is shown below where large steel plates have been bolted into the concrete structure at 10- to 12-foot spacing. A proprietary rail system spans over top of the steel plates to support the panel cladding system.

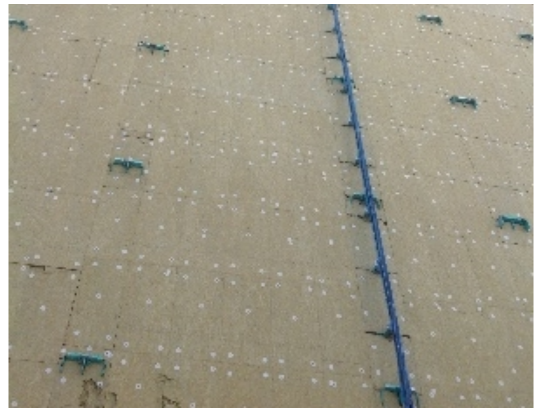


Figure 17: Example of heavy-duty engineered anchor consisting of large welded steel plates and vertical rail system.

Cladding manufacturers are constantly developing new and improved support systems. The list of available cladding support systems from that covered within this bulletin will continue to grow and modifications of existing systems will become more commonplace. Such examples include the use of discrete fiberglass clips or aluminum and plastic clips to support composite metal panels (Figure 18).

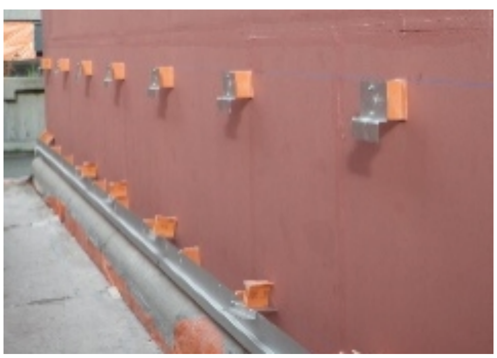


Figure 18: Examples of thermally improved discrete cladding supports for composite metal panels.

Thermal Comparison of Systems: A Summary

To summarize the thermal performance of the various cladding support strategies presented, the range of thermal effectiveness of the exterior insulation is shown below. These percentages can be multiplied by the R-value of the exterior insulation and added to the back-up wall R-value to determine an approximate overall effective R-value for the wall assembly.

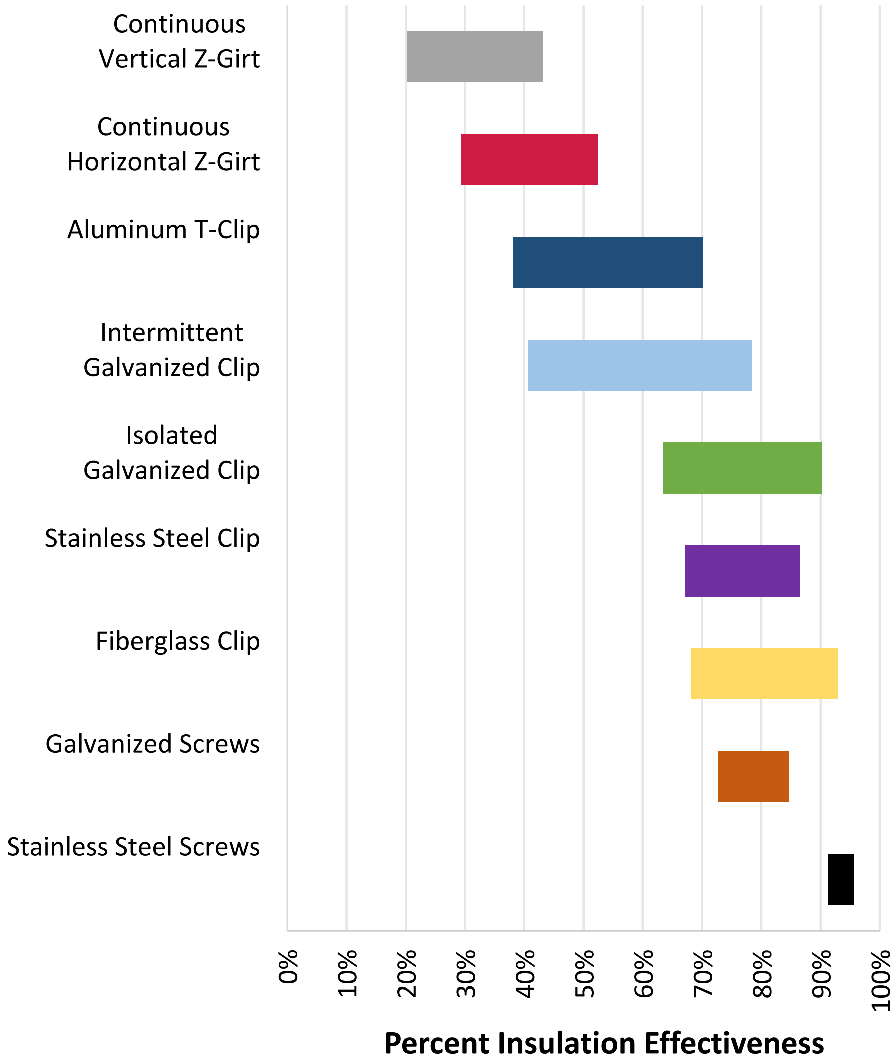


Figure 19: Percent Effectiveness of Exterior Insulation with Various Cladding Support Systems and Typical Thicknesses of Exterior Insulation (2" to 8" ranging from R-8 to over R-40)

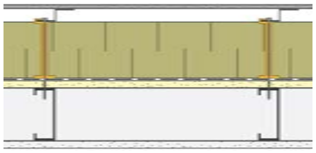


Figure 20: Uninsulated 3-5/8" steel stud wall with exterior. insulation and cladding attachment system

The range in values provided on the previous page encompasses typical support structure spacing when attached to steel stud, concrete, and wood back-up walls for a range of typical commercial claddings. The percent insulation effectiveness also decreases with thicker amounts of exterior insulation. The values were determined using calibrated three dimensional thermal modeling software. Each of the systems were modeled using the same set of assumptions, boundary conditions, and material property inputs. Manufacturers will also be able to provide their own published data, though be careful when comparing information as some manufacturers may provide misleading marketing material.

This same information can also be used to help select an appropriate thickness of exterior insulation over an uninsulated 3-5/8" steel stud frame back-up wall in the chart below. For example, to get to an effective R-20 with this back-up wall, 6" exterior insulation is required for several different cladding support systems.

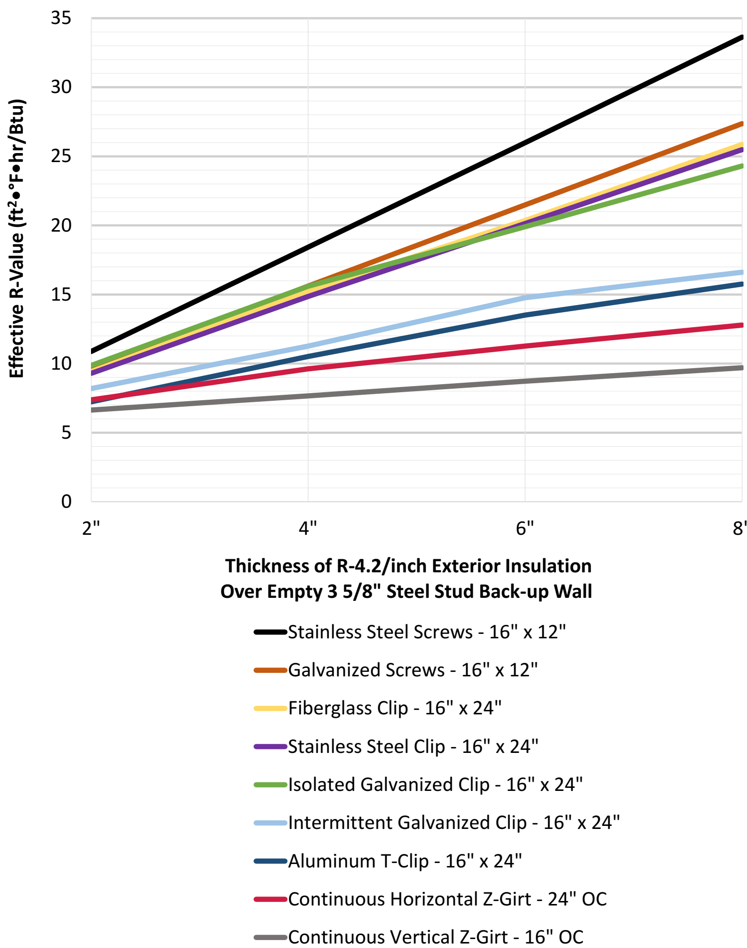


Figure 21: Effective R-value of a 3-5/8" steel stud wall (no stud cavity insulation) with varying depth of exterior insulation and different clip support systems/spacings.

Other Considerations

Figure 22: Example of insulation retained by intermittent cladding support clips behind metal panels. The metal panel support structure overtop will further retain the insulation in the assembly here.

In addition to the cladding supports, mechanical attachments are also needed to support and hold the exterior insulation in place where not provided by the cladding support system. These insulation fasteners are intended to retain the insulation tight to the back-up wall as gaps between boards of insulation or behind the insulation will degrade the thermal performance, especially if the insulation becomes dislodged behind the cladding once in-service. These fasteners are used throughout the wall area, and in particular around details where smaller pieces of insulation are cut and fit. Acceptable fasteners include screws & washers, proprietary insulation fasteners, impaling pins, and plastic cap nails. Many of the cladding systems presented in this bulletin also are designed to retain the insulation during the installation process.

Metal insulation fasteners will create additional thermal bridging through the exterior insulation, so should be used sparingly. Fasteners will typically reduce the thermal effectiveness of the exterior insulation by <1% for plastic fasteners to up to 10% for large screws, in addition to losses due to the cladding support system.

Figure 23: Example of insulation retained by mechanically attached metal impaling pins between vertical wood framing (adhesive stick-pins are not considered a long-term support strategy).

Figure 24: Example of plastic fuel-cell actuated insulation fasteners installed after insulation and girt system is installed to retain the insulation.

Each of the cladding systems presented in this bulletin requires the supports to be attached back to the structure. This is relatively simple with concrete, concrete block, and mass timber walls. With wood buildings, the cladding supports can be designed either to be supported by studs, or by the plywood or OSB sheathing, depending on the fastener pull-out requirements. With steel stud buildings and gypsum sheathing, the cladding supports must be attached back into the steel studs. This means that a steel stud needs to be positioned behind each clip or girt. This may not always be possible, especially in retrofit situations. In these scenarios 16 to 20 gauge galvanized sheet steel strips can be used to span between the studs and act as a larger target for the fasteners of the cladding support clip/girt. These strips may be required around penetrations, windows, corners, and other places where steel studs cannot be installed from the interior.

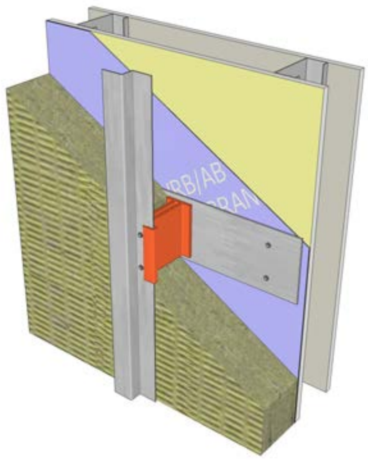


Figure 25: Example of the use of a galvanized sheet steel strips to provide structural backer for cladding support clips away from studs.

Summary

There are many cladding support systems available in the industry that can be used to support claddings of all types through exterior insulation. Energy codes including ASHRAE Standard 90.1 and NECB consider thermal bridging and insulation effectiveness, making an efficient cladding attachment strategy an important component of the enclosure design. Key attributes to look for are systems that provide the required structural support, minimize thermal bridging, are easy to install, and are cost effective. As this is an emerging industry – cladding support systems are constantly evolving and being developed.

For additional information on this and other topics, please visit our website, rdh.com, or contact us at contact@rdh.com.

Additional Resources

→ Thermal Bridging From Cladding Attachment Strategies through Exterior Insulation – Conference Paper by RDH from 9th North American Passive House Conference

→ Thermal Bridging of Masonry Veneer Claddings and Energy Code Compliance – Conference Papers by RDH from 12th Canadian Masonry Conference

→ Guide for Designing Energy-Efficient Building Enclosures