CLADDING ATTACHMENT SOLUTIONS FOR EXTERIOR-INSULATED COMMERCIAL WALLS

RDH BUILDING SCIENCE

APRIL 2018 | V4

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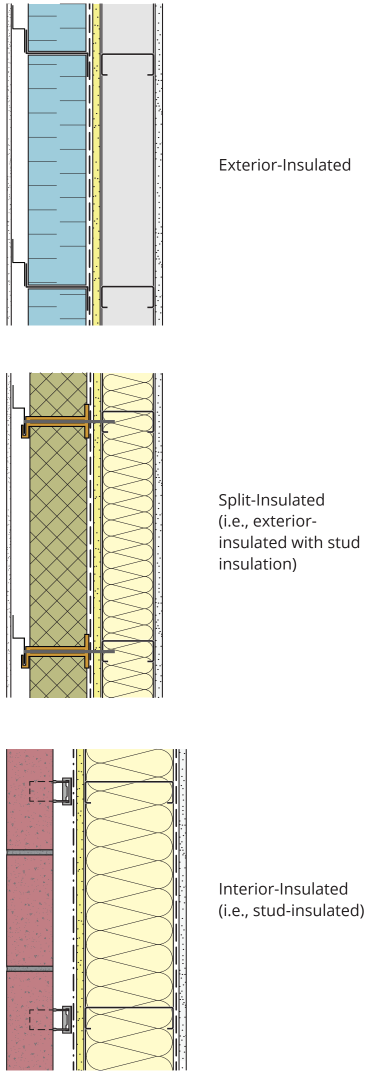
INTRODUCTION

In order to meet more stringent energy code requirements, the use of exterior insulation installed outboard of wall sheathing is becoming increasingly common across North America. Commonly referred to as exterior insulation, this insulation is installed continuously on the outside of the primary structure and—provided that thermally efficient cladding attachments are used—is more thermally efficient than insulation placed between studs or inboard of the structural system. As a result, greater attention is being paid to the design of thermally efficient cladding attachment solutions, and in recent years, several proprietary systems have been introduced into the market to meet this demand.

Designers and contractors face several challenges in selecting an appropriate cladding attachment strategy for their project. The implications that these decisions have on effective thermal performance, installation methods, sequencing, and project costs all need to be considered.

The thermal infrared image presented on the following page shows a stucco-clad wall with two cladding attachment systems. On the left of the wall is a thermally inefficient continuous vertical Z-girt cladding attachment system, and on the right is a thermally efficient low-conductivity clip and rail cladding attachment system. The exterior insulation utilizing the continuous girts is less than 25% effective, whereas the exterior insulation utilizing the clip and rail system is approximately 80% effective—significantly improving the thermal performance of the wall for roughly the same construction cost.

This bulletin provides guidance regarding different cladding attachment systems for exterior-insulated commercial wall applications.

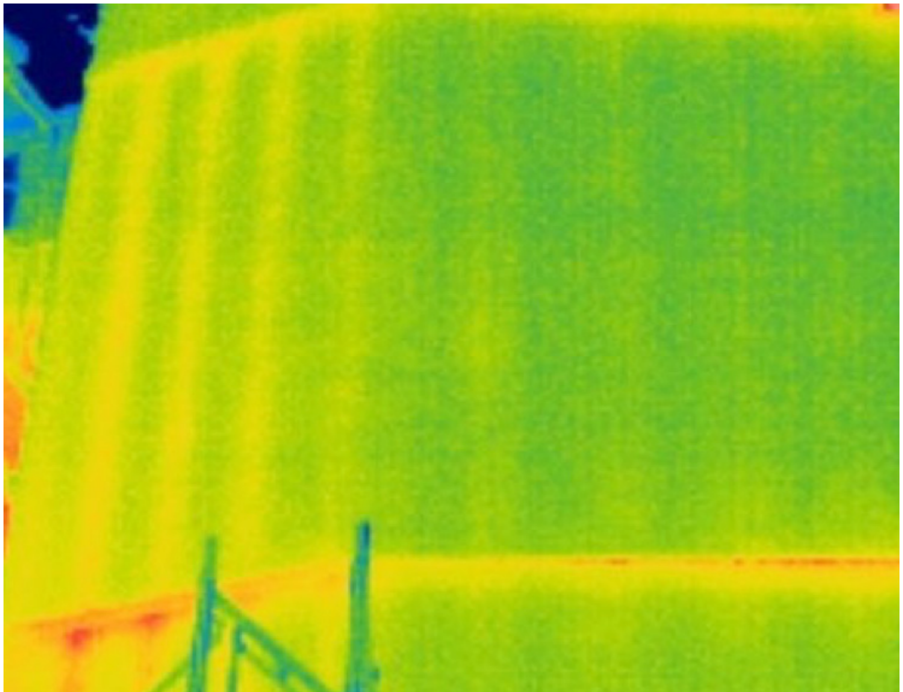


Standard approaches to insulating steel-framed wall assemblies

ENERGY CODES AND EXTERIOR INSULATION

Various energy codes and standards are used across North America. 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 applied 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 codes and standards are in effect across Canada and the US.

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 codes and standards; however, the effectiveness of this approach is highly dependent on the use of a thermally efficient cladding attachment strategy. Cladding attachment systems can reduce exterior insulation performance by as much as 80% for low-performance systems and as little as 2–10% for high-performance systems.



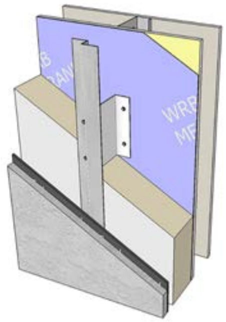
Thermal infrared image of two different cladding attachment systems: continuous vertical steel z-girts on the left and improved clip and rail used on the right

REQUIREMENTS FOR CLADDING ATTACHMENT

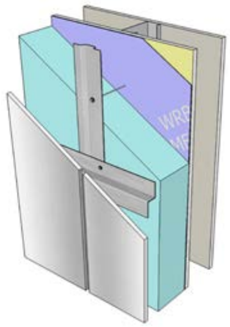
There are many factors that must be considered when choosing the type of exterior insulation and the cladding attachment strategy for a building. These include:

- → Cladding weight
- → Wind loads
- → Seismic loads
- → Fire performance and combustibility requirements
- → Back-up wall construction (wood, concrete, concrete block, or steel framing)
- → Allowable wall thickness
- → 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
- → Effective R-value target and thermal efficiency loss from attachment system
- → Orientation and required attachment location for cladding system (panel, vertical, horizontal)
- → Details for attachment of cladding at corners, returns, and penetrations
- → Ease of installation for the cladding
- → Accommodation of dimensional tolerance

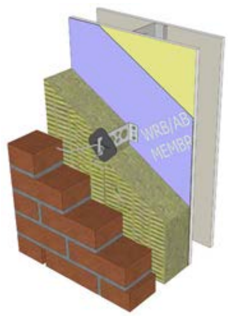
The design of the cladding attachment system will typically be undertaken by a structural or façade engineer working for the architect or cladding manufacturer. Some cladding attachment systems have been pre-engineered and designed using load tables developed by the manufacturer. It is important that the cladding attachment 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. See Structural Optimization for Thermal Performance on page 27 for more information.



Discrete clip and rail type cladding attachment 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 attachment 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).

Examples of various cladding attachment strategies through exterior insulation


SOPREMA
sopraSEAL

CLADDING ATTACHMENT SYSTEMS

There are numerous cladding attachment systems designed for use with exterior insulation. 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 generically be classified as: continuous framing, intermittent clip and rail, long fasteners, masonry ties/anchors, or other engineered systems.

Attachment systems can 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 impacting the effective thermal performance. Attachment systems should be optimized structurally and thermally for the needs of the specific project.

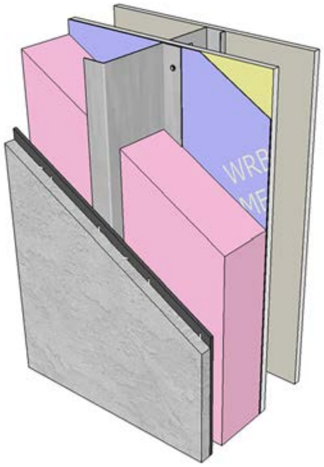
An overview of several different cladding attachment systems is provided in the sections that follow. For each system, a relative cost ($-$$$), thermal efficiency (e.g., percent effectiveness of the exterior insulation), and ease of installation ranking is provided. All of the systems readily accomodate exterior insulation except where noted.

All of the attachment 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.

The primary focus of this guide is on the thermal performance attributes of each system. Structural, fire, and constructability considerations are discussed briefly; however, further information regarding performance and testing data should be obtained from product manufacturers.

CONTINUOUS FRAMING

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



VERTICAL Z-GIRTS

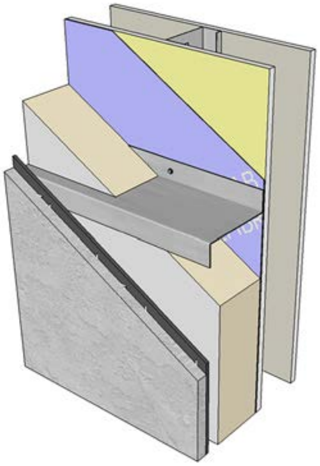
Relative Cost	Thermal Efficiency	Constructability
$ $ $	 20–40%	

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. Girts are spaced to line up with the stud framing behind (every 16” to 24” o.c.). Cladding is 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 attachment system and are not typically recommended 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 and/or washers at the sheathing can be beneficial (approximately 5–10% improvement), the insulation is still largely bridged, making the improvement mostly to surface temperature rather than the effective R-value. Continuous girts often don’t meet prescriptive code requirements and are very difficult to use in achieving necessary effective R-value performance in a trade-off or modeled approach.

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.

HORIZONTAL Z-GIRTS



Relative Cost

Thermal Efficiency

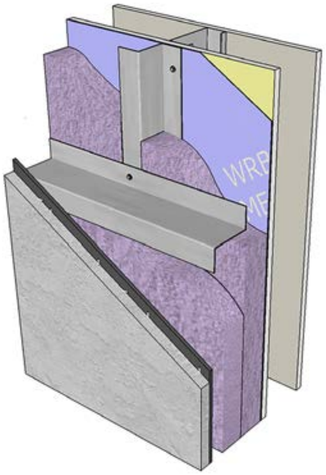
30–50%

Constructability

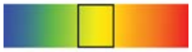
This cladding attachment system consists of continuous galvanized steel framing members, typically 18- to 20-gauge Z-girt profiles attached horizontally to steel studs or a concrete back-up wall. Girts are attached to the back-up wall every 24" to 48" o.c. depending on cladding loads. Cladding systems 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.

Similar to continuous vertical z-girts, horizontal Z-girts are not a thermally efficient attachment system and not typically recommended due to the excessive amount of thermal bridging. Exterior insulation installed between horizontal Z-girts is degraded significantly and only 30–50% effective for typical applications. The horizontal configuration has slightly improved thermal performance over vertical Z-girts because of the increased spacing between the girts and reduced metal cutting through the insulation. This system can be improved slightly (approximately 5–10%) with the use of low-conductivity isolation thermal breaks/ washers between the framing and back-up wall.

Horizontal Z-girts over a steel stud wall assembly. Girts are fastened every 36" o.c. to reduce the thermal bridging as compared to typical vertical arrangements at 16" o.c.

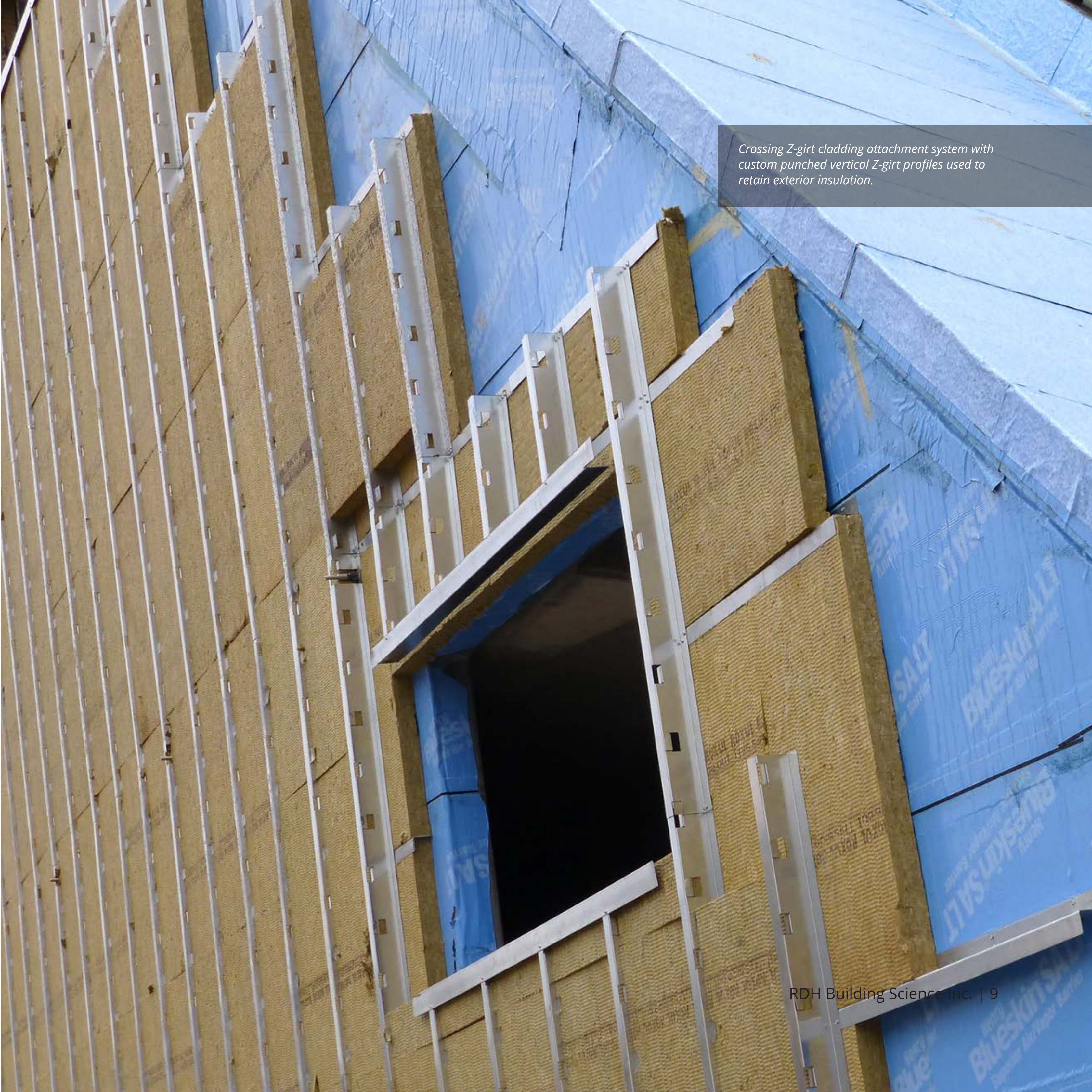


CROSSING Z-GIRTS

Relative Cost	Thermal Efficiency	Constructability
$ $ $	 40–60%	

This cladding attachment system 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.

Like vertical or horizontal Z-girts, crossing Z-girts are not a very thermally efficient attachment system and not typically recommended 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 is only 40–60% effective for typical 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.



Crossing Z-girt cladding attachment system with custom punched vertical Z-girt profiles used to retain exterior insulation.


CASCADIA CLIP™
FIBERGLASS
THERMAL SPACER

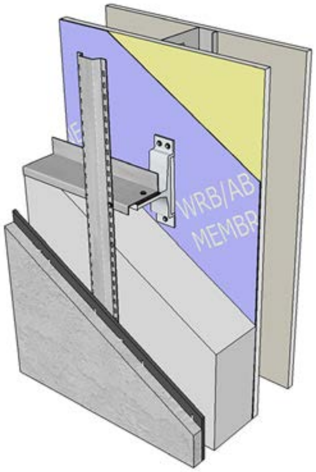
CLIP AND RAIL SYSTEMS

Clip and rail systems are a more thermally efficient approach to cladding attachment than continuous framing and can support all types of cladding. This includes board and lap cladding 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 and/or horizontal girts (rails) attached to or through intermittent clips that are 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. It is important to note that dissimilar metals (i.e., aluminum and steel) are typically isolated to prevent galvanic corrosion. 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 can perform better than galvanized steel or aluminum, and why stainless steel fasteners may be beneficial compared to galvanized steel fasteners.

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

ALUMINUM T-CLIPS



Aluminum T-clip with horizontal Z-girt and vertical hat-track for cladding attachment

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

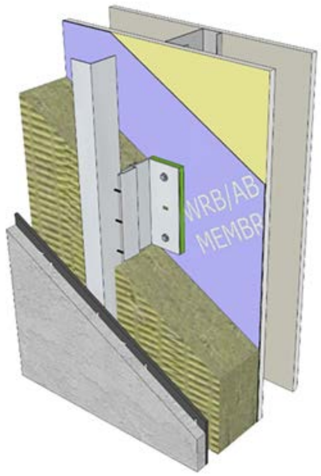
This clip and rail attachment system utilizes clips made of a thick, aluminum, T-shaped extrusion with horizontal girts attached on top of the clips. The horizontal girts cut through a portion of the exterior insulation to allow for adjustability and longer spans between clips; unfortunately, this reduces the thermal performance of the system. Where needed, vertical rails are attached to the horizontal girts.

As aluminum is more than four times as conductive as galvanized steel, the key to this system's performance 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 that also integrates other thermal break and material isolation components into the clip.

The thermal performance of this system is dependent on the spacing of the horizontal girts that penetrate the exterior insulation and on the spacing of the intermittent aluminum clips. The thermal efficiency of the system ranges from a low of 40% up to approximately 70%. Where the horizontal girt is entirely outboard of the exterior insulation the performance is greater.

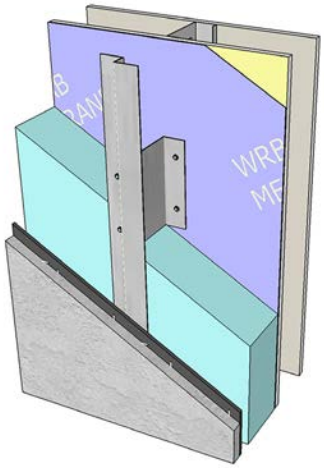
ADJUSTABLE ALUMINUM CLIPS

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



This clip and rail attachment system utilizes adjustable, aluminum, L-shaped clips with a plastic thermal break and an integrated receiver slot that allows for an L- or T-shaped steel girt to be slid into place and adjusted for dimensional tolerances. For adjustability, the exterior girts cut partially through the exterior insulation, though this reduces the overall thermal performance of the system.

As aluminum is more than four times as conductive as galvanized steel, the key to this system's performance 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 that also integrates a plastic thermal break at the clip connection to the wall. The performance of this system is dependent on the spacing of the intermittent aluminum clips. The thermal efficiency of the system ranges from a low of 40% up to approximately 70%. Where the exterior girt is entirely outboard of the exterior insulation the performance is greater.



GALVANIZED STEEL CLIPS

Relative Cost	Thermal Efficiency	Constructability
$ $ $	 50–75%	

This clip and rail attachment 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 suit 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 from 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 impacted 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. The thermal efficiency of a 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.

Generic adjustable back-to-back L-angle stainless steel clip and rail system

Stainless steel clip and rail system

STAINLESS STEEL CLIPS

Relative Cost

$ $ $

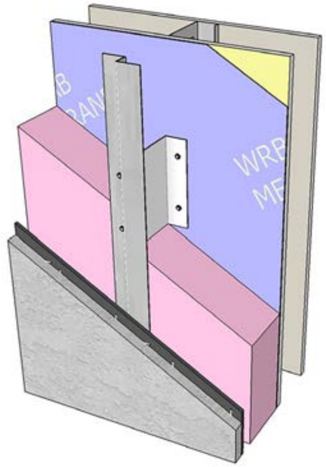
Thermal Efficiency

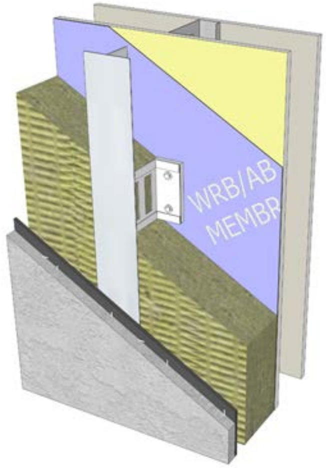
65–90%

Constructability

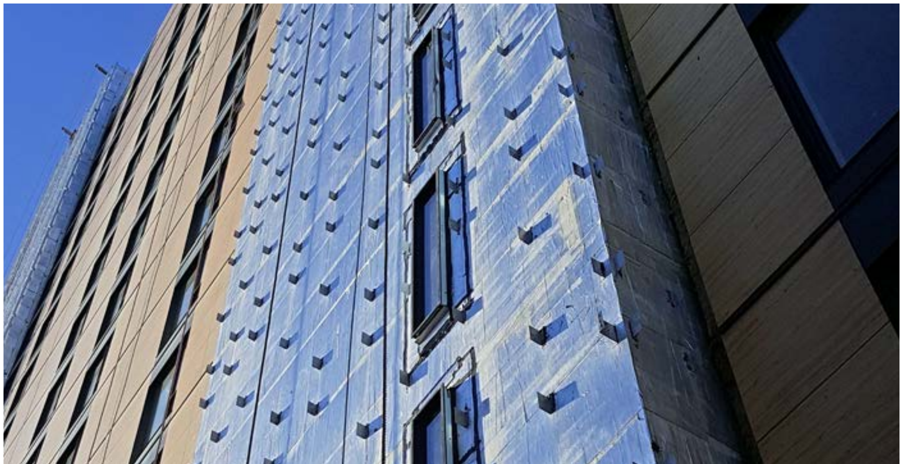
This clip and rail system is very similar to the galvanized steel clip option described previously, but utilizes clips made of stainless steel profiles (rails remain as galvanized steel). Stainless steel is over four-times less conductive than galvanized steel, and therefore more thermally efficient. Due to the lower conductivity of the clips, this system performs quite well with thermal efficiencies in the 65 to 90% range depending on spacing and clip dimensions.

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. Some manufacturers have introduced aerogel insulation or other low-conductivity thermal break materials to further improve the performance of their stainless steel clips.





Intermittent stainless steel clips with vertical girts

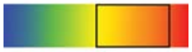


THERMALLY ISOLATED GALVANIZED CLIPS

Relative Cost

$ $ $

Thermal Efficiency

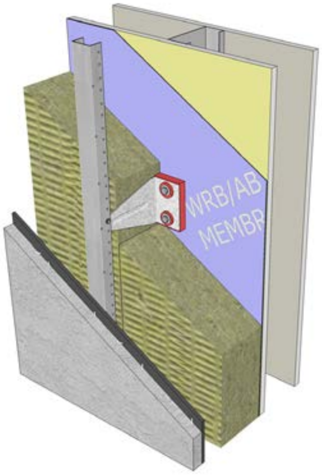


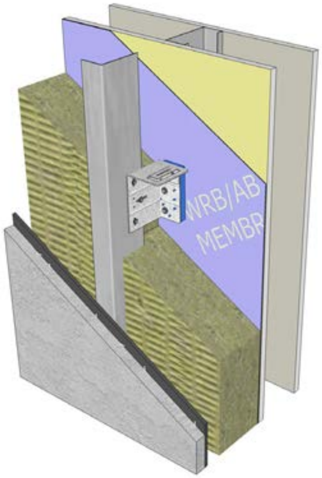
50–90%

Constructability

This clip and rail attachment system consists of proprietary heavier gauge galvanized steel clips with 1/8” to 1/2” plastic pads/washers installed between the clip and back-up structure. Plastic washers may also be used at fasteners to further 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 can reduce the heat flow through the galvanized steel 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 50% and 90% depending on the manufacturer’s details and spacing. Thermal performance is greater in systems that keep the vertical or horizontal girts entirely outboard of the insulation or minimize the partial embedment of the vertical or horizontal T- and L-angle rails, as shown in the lower image at left.





Thermally isolated galvanized steel clip attached to wall with screws through plastic isolated pad

Thermally isolated galvanized clip and rail systems

Fiberglass clips with vertical Z-girts attached with screw fasteners through the fiberglass clip into the back-up wall

Fiberglass clips with horizontal Z-girts attached with screw fasteners through the fiberglass clip into the back-up wall

FIBERGLASS CLIPS

Relative Cost

Thermal Efficiency

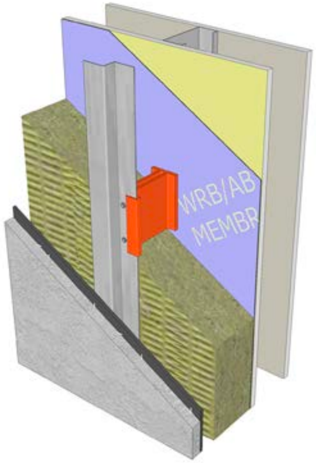
70–95%

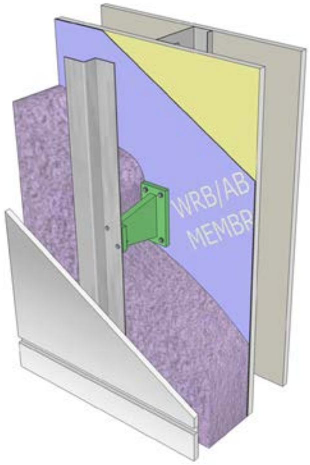
Constructability

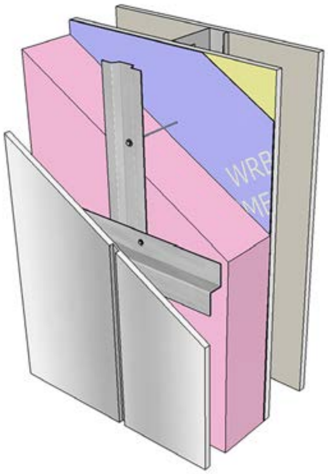
This clip and rail system utilizes low-conductivity fiberglass clips. Fiberglass is approximately 200 times less conductive than galvanized steel and its use significantly improves the thermal performance of attachment systems. In the system shown in the adjacent figures, one or two long galvanized or stainless steel screws run through each fiberglass clip directly connecting the vertical or horizontal galvanized steel rail to the structure. Other clips use two separate screws: one to attach the clip to the structure and the other to attach the rails to the clips. This latter system utilizes the clip as part of the load transfer path rather than simply as a spacer; therefore, the adequacy of the screw connection to the fiberglass is important. Fire performance of these systems should also be verified.

Metal Z-girts or hat-channels are used as the vertical or horizontal rail elements entirely on the exterior of the insulation. Some manufacturers pre-attach the rails to the fiberglass so that they can be screwed to the wall as one element, speeding up installation time.

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 versus stainless) and ranges from 70% with tightly spaced clips for heavier claddings to over 90% with optimally spaced clips for lighter claddings.







Long screws through metal girts and rigid exterior insulation

LONG SCREWS THROUGH INSULATION

Relative Cost

$ $ $

Thermal Efficiency

75–95%

Constructability

This cladding attachment system utilizes long fasteners that connect girts or strapping on the exterior of rigid insulation (including EPS, XPS, Polyiso, and rigid mineral wool) directly into the structure. The combination of the continuous exterior strapping/girts, long fasteners, and rigid insulation create a truss system consisting of the screws and struts within the insulation. This truss system is used to support light- to medium-weight cladding systems. The only thermal bridges through the exterior insulation are the long screws. Claddings are attached directly to steel girts or wood strapping on the exterior surface of the insulation. 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 galvanized steel hat-channel profiles, a minimum of ¾" plywood, or 1x3 or 1x4 dimensional lumber are used for the exterior girts/strapping. It is also typical that the fasteners consist of #10 to #14 steel screws every 12–16" o.c. in lengths to connect the exterior girt/strapping to the back-up structure (studs, sheathing, or concrete). The required screw length can often

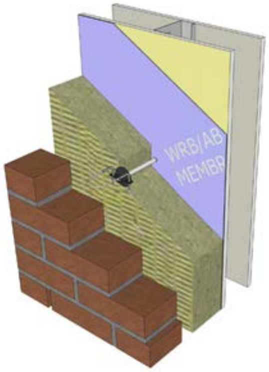
Mock-up of fasteners through plywood strapping and insulation into CLT back-up wall

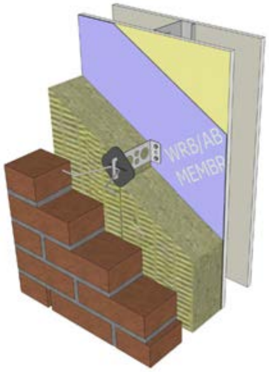
be estimated to match the thickness of exterior insulation plus 1½”–2” so as to penetrate the sheathing and back-up framing.

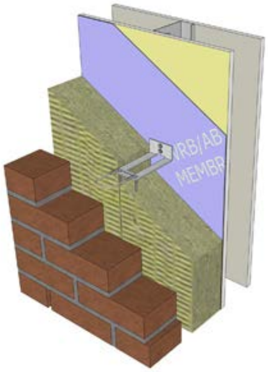
One challenge installers face with this system is the positive connection of the screw fasteners back to the structure. With wood framing, this can be achieved by either hitting the studs or designing the plywood or OSB sheathing for the required pull-out resistance. Typically, in wood frame construction, this can be achieved by upgrading to ¾” plywood or OSB depending on the fastener type and pull-out loads. 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 and, again, care not to strip the fasteners during installation.

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 frame or concrete back-up, and as high as 90% to 95% for stainless steel screws in wood frame back-up.

When using this approach, special attention should be paid to the impact of the fastener penetration through the air and watertightness of the sheathing membrane. Unlike clip and rail or girt systems installed before the insulation, which can be sealed with field-applied sealant, a long screw penetration cannot be effectively sealed after installation. For this reason, this cladding attachment system is best suited for low-rise wood frame buildings with lower rainwater exposure. For mid- to high-rise buildings with greater exposure or sloped walls/roofs, the use of a clip and rail system where the clip fasteners can be sealed before installing insulation is typically recommended.







MASONRY TIES

Relative Cost	Thermal Efficiency	Constructability
$ $ $	40–90%	

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 attachment systems and are therefore thermal bridges. There is a range of proprietary and generic masonry tie systems available in the market and the thermal efficiency spans from fair to excellent at a range of approximately 40–90% depending on the number of ties and the type and gauge of metal used (stainless steel being the optimal choice).

Masonry ties installed through exterior insulation

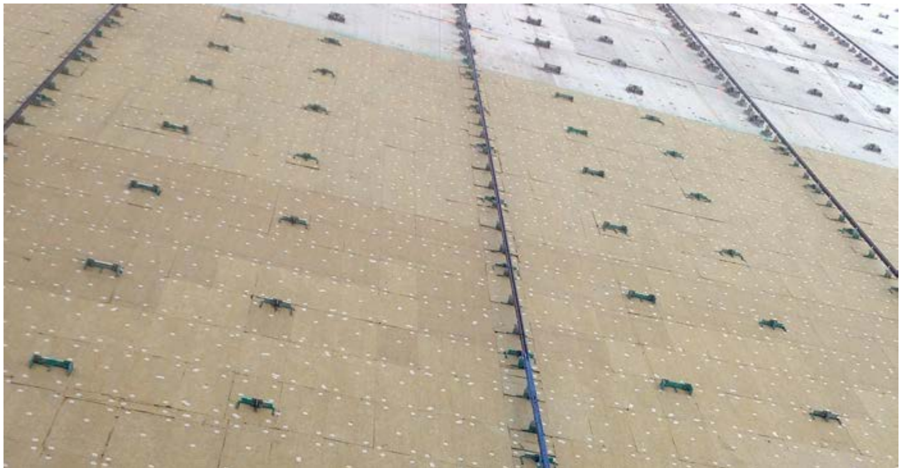
ENGINEERED ANCHORS AND OTHER SYSTEMS

In addition to the various cladding attachment systems presented 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.

Cladding manufacturers are constantly developing new and improved support systems. The list of available cladding attachment systems covered within this bulletin will continue to grow and modification 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.



Example of heavy-duty engineered anchor consisting of large welded steel plates and a vertical rail system

Examples of thermally improved discrete cladding attachments for composite metal panels

STRUCTURAL OPTIMIZATION FOR THERMAL PERFORMANCE

It is important to optimize cladding attachment systems so the thermal performance of the wall assembly can be maximized while maintaining sufficient structural strength and deflection resistance for the anticipated loads. This section provides an overview of the various structural considerations for optimization of the cladding attachment system.

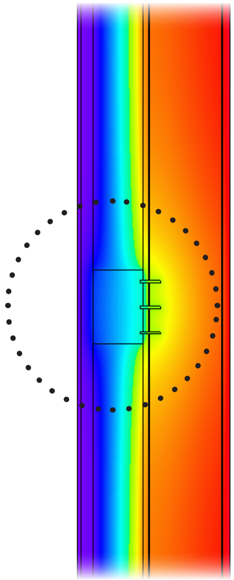
The structural design of clip and rail systems requires consideration of at least five separate components used to transfer the structural cladding load to the building structure:

- The connection between the cladding and the continuous rail/girt system
- The rail/girt system itself (in some cases multiple layers arranged in a grid)
- The connection between the rail and the primary clip/girt
- The primary clip itself (penetrating through the exterior insulation)
- The connection between the primary clip and the structure

These components must act together as a system to resist the dead, wind, and seismic loads on the cladding, and provide adequate strength to resist deflection. The primary clip is often a unique proprietary component designed to transfer loads through the exterior insulation. Since the clip is the main pathway for potential thermal bridging through the wall exterior insulation, there are several key considerations when optimizing for thermal performance:

- Size and strength of the clip for dead, wind, and seismic load resistance
- Clip height and orientation, for ease of attachment to the building structure and installation of exterior insulation
- Number of fasteners (and resulting structural strength) that can be used for the various connections
- Clip material (i.e. higher conductivity aluminum, galvanized steel, or stainless steel versus lower conductivity fiberglass or PVC)

While the other components and connections are important for the overall design of the cladding attachment system, the considerations for the design and installation of the elements which penetrate the insulation (i.e. the clips) are the most important for optimizing the thermal performance.



The clips are the primary pathway for potential thermal bridging through the exterior insulation (vertical wall section isothermal planes shown)

Fiberglass clip

OPTIMIZATION CONSIDERATIONS

Thermal performance of the attachment system is optimized by minimizing the thermal bridging through the insulation due to the clips. This is done by using as few penetrations as possible, and by using clips with low thermal transmittance. Optimizing for thermal performance must be balanced with the minimum structural requirements for the dead, seismic and wind loads, and deflection.

The primary structural loading types are the cladding dead load, acting as the downward force, and the wind and seismic load, acting to push and pull the cladding in-plane and out-of-plane from the building face. These loads impact the overall design of the cladding attachment system; the clips and rails must be robust enough to hold the weight of the cladding and resist bending or buckling, and the fastener connection at the building face must resist the pullout force.

While increasing the spacing of the clip can increase thermal efficiency, at some point it becomes impractical as it might necessitate increasing the strength and size of the rail components, or lead to constructability issues for cladding types with strict attachment requirements. The selection of one cladding attachment system over another is largely driven by:

- Orientation and attachment requirements of the cladding: horizontally oriented cladding generally favors vertical rails while vertically oriented cladding requires horizontal rails.
- The span and deflection capabilities of the cladding: some thin and brittle cladding materials require closely spaced support framing. If this spacing is less than the spacing of the primary clip (connected to the structure), adding an intermediate layer of framing may be preferred over decreasing the clip spacing.
- Out-of-plane adjustability: many systems utilize at least a 2-level system where the connection between the primary clip and the secondary girt is adjustable, or the clips can be installed with shims against the wall.
- Depth of the insulation cavity: added depth increases the structural loads on the system due to increased eccentricity.

CLIP DESIGN

Clip size and shape will vary between different systems and materials. While the clip's strength in resisting vertical cladding loads and inward wind and seismic loads will be primarily governed by its size and shape, an important limiting factor is the positioning and number of fasteners used to attach the clip to the backup assembly. Often three or more fasteners can be used on larger clips like 6" long generic intermittent steel girts, while more compact proprietary clips may allow just two fasteners per clip.

Another limiting factor in the clip design is how the system transfers loads to the wall structure through the rail/girt system. Systems that use more than a single set of rails/girts (i.e. a grid pattern) to transfer the cladding load to the clip may result in uneven load distribution. This is due to the point-loading pattern between the 'outer' rail and the 'inner' rail of the grid. This can lead to additional loading of the clips nearest to the point load, while other clips do not receive a uniform distribution of the load. Clip spacing and optimization may result in large spans between clips, and uneven point-loading can cause greater loads than the assumed standard spacing calculation accounts for. The structural calculations and clip design should account for this phenomenon. Systems that use a single set of rails/girts generally result in uniform load distribution to the clips and avoid this issue.

The pullout force that acts on the system components due to wind forces are calculated based on the location, exposure, height, and expected wind speeds the building may experience. The calculations are generally completed according to the American Society of Civil Engineers (ASCE) Standard ASCE 7-10 (or ASCE 7-16 where applicable), and result in the expected wind loads for the center-of-wall and corner conditions. These forces are combined with forces from the cladding weight to determine the total loading the system must resist. **Since many cladding types are light-weight, in most cases the allowable wind load is the governing factor in the structural design of the clip system.**

Thermally isolated galvanized clip

Thermally isolated stainless steel clip

SEISMIC LOADS

The calculations for seismic loads are generally completed according to ASCE 7-10 (or ASCE 7-16 where applicable). Seismic loads can produce significant stresses on the cladding, the cladding attachment system, and its connection to the building face. Potential damage from seismic events is generally from the destruction of the cladding material itself, which may become dislodged or break around fasteners. The durability of the cladding itself is important, and potentially brittle claddings like stone may require additional fasteners or reinforcing. Seismic forces acting out-of-plane with the building face can create pullout forces at the clip and fastener, which can be significant, especially for heavy claddings. Seismic forces acting in-plane with the building face (i.e. across the clip) can cause the clips and fasteners to bend or buckle, and can also result in pullout forces.

Structural attachment requirements to accommodate wind loads usually supersede seismic requirements, but seismic loads must always be calculated. Factors that may lead to seismic forces governing the design include heavy cladding used in high-risk earthquake zones, heavy cladding used with a deeper exterior insulation depth, and buildings in high-risk earthquake zones with low wind pressures.

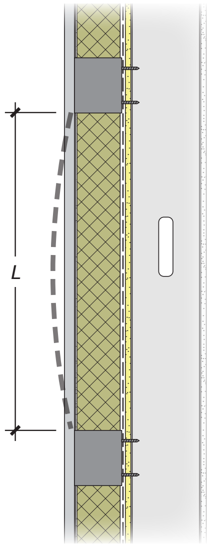
DEFLECTION

In-service deflection can also cause damage to the cladding. The secondary rails and girts that are susceptible to deflection between clips due to wind loading are the primary concern. This deflection can cause damage in-service because the cladding plane can become non-uniform. Stiffer claddings like stucco or fiber cement panels can be strained and can crack. A safe deflection limit for most cladding types is L/240 (deflection of 1/240th the length between supports).

Deflection calculations generally use the deflection resistance of the rail or girt system alone, without necessarily including any stiffening that may be provided by the cladding it supports. However, it should be confirmed with the manufacturer if this is considered in the structural calculations or load tables for the rail or girt system being used, as the cladding type will have a significant impact on deflection resistance.

The high section modulus of C-channels or Z-girts commonly used for the rails are generally adequate to meet the cladding deflection limits for most cladding types, even at larger clip spacings. If girt deflection is found to be a limiting factor in the clip attachment spacing, the girt steel thickness or depth could be increased. Most systems use 18 gauge girt/rail thickness as standard, and 16 gauge girts or rails can be used if higher deflection resistance is needed. Some systems use deeper girts/rails to increase the deflection resistance, and may be installed with part of the girt penetrating into the plane of the exterior insulation. This approach creates a risk of higher thermal bridging through the exterior insulation, especially when using high-conductivity galvanized steel girts. The thermal impact on the wall assembly should be assessed if this approach is used. (Check with the cladding manufacturer for guidance on deflection limits of the cladding attachment system and options for stiffening.)

In addition to deflection of the rails or girts, there may be more flexible clips that could be prone to deflection due to the gravity load of the cladding. However, this type of deflection is not common.



Deflection should be calculated for the rails and girts using the distance between supports

EXAMPLE CALCULATIONS

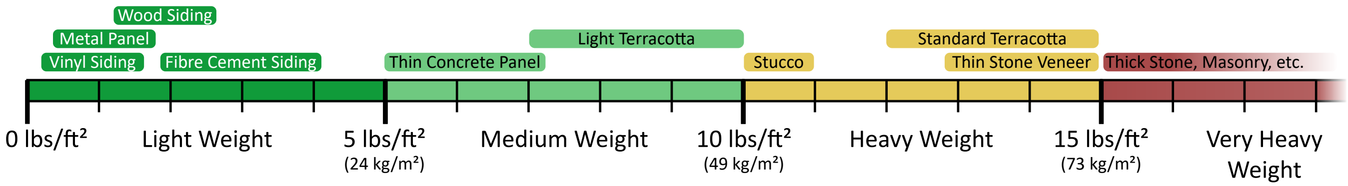
The following example calculations compare three proprietary clip systems. The following parameters were used.

4" Clip	Cladding	Clip Spacing (H x V)
Thermally Broken Aluminum Clip (4 #10 fasteners)	Cement Board (5 psf)	16" x 16"
Fiberglass Clip (2 #14 Fasteners)		16" x 24"
		16" x 32"
Thermally Isolated Galvanized Steel Clip (2 #14 Fasteners)	Stone Veneer (15 psf)	16" x 48"
		32" x 32"

The load resistances provided on the following pages are limited to cases that are published by the manufacturers. In some cases, full load tables are not available for all conditions and interpolation has been used between discrete data points to provide clear comparison between systems. The effective R-values provided are based on three-dimensional thermal modeling for the specific clip, spacing and wall assembly.

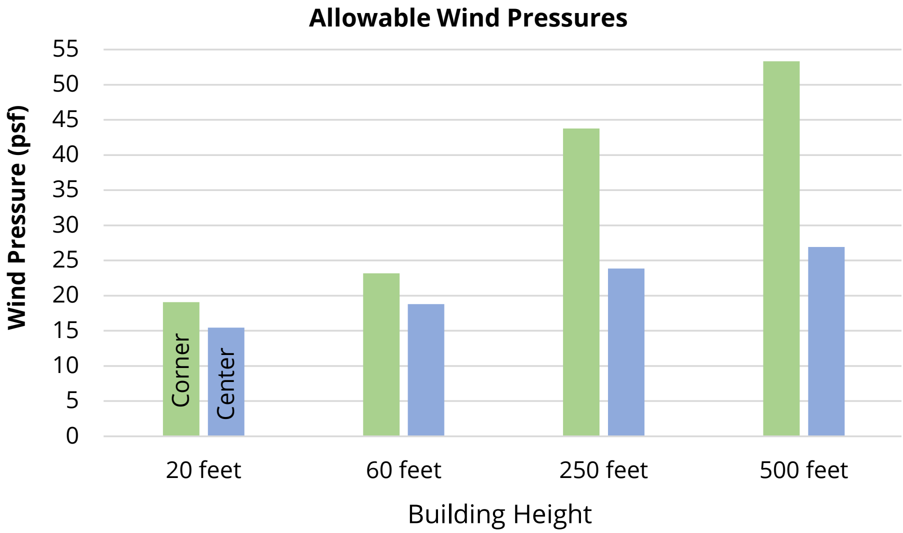
Cladding weight for the purpose of the structural calculations can be categorized as light (less than 5 lbs/ft²), medium (5 to less than 10 lbs/ft²), heavy (10–15 lbs/ft²), and very heavy (over 15 lbs/ft²) weight. The approximate weight and category for various common cladding types is shown below. The cladding types used in the structural calculations represent relatively light & heavy claddings which essentially bound the weights of common cladding types.

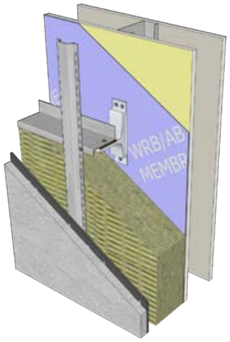
Cladding weight can be categorized as light, medium, heavy, and very heavy weight



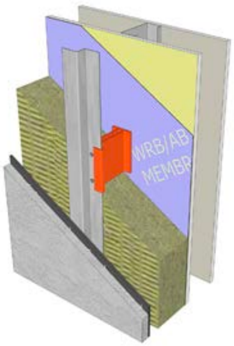
The example wind calculation variables and graph below shows the allowable wind loads on different building heights and wall areas.

Wind Pressures per ASCE 7-10	
Input Variables	
Exposure Category	B
Surface Roughness	B
Wind Directionality Factor (Kd)	0.85
Topographic Factor (Ktz)	1.0
Internal Pressure Factor (GCpi)	0.18
Wind Velocity (V)	115 mph
Building Height	Varies (see below)

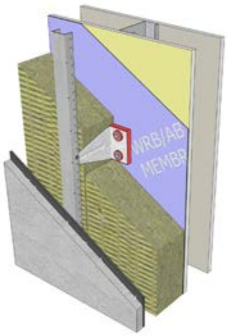




Aluminum clip

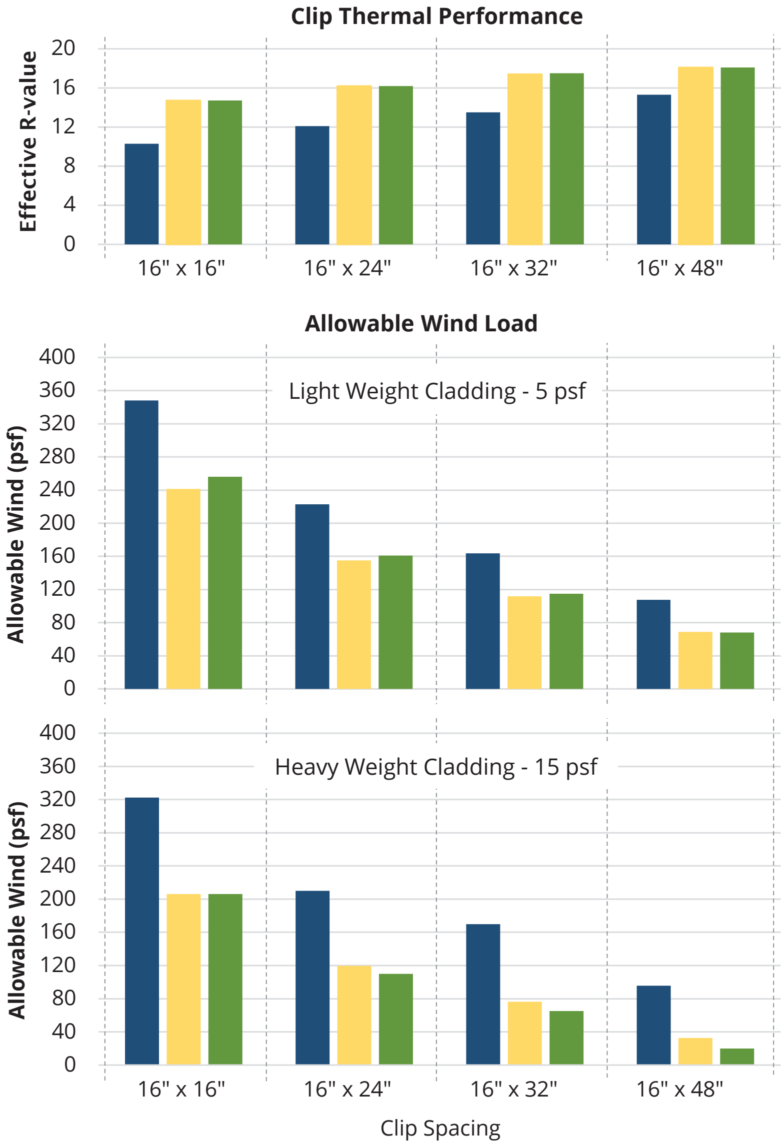


Fiberglass clip

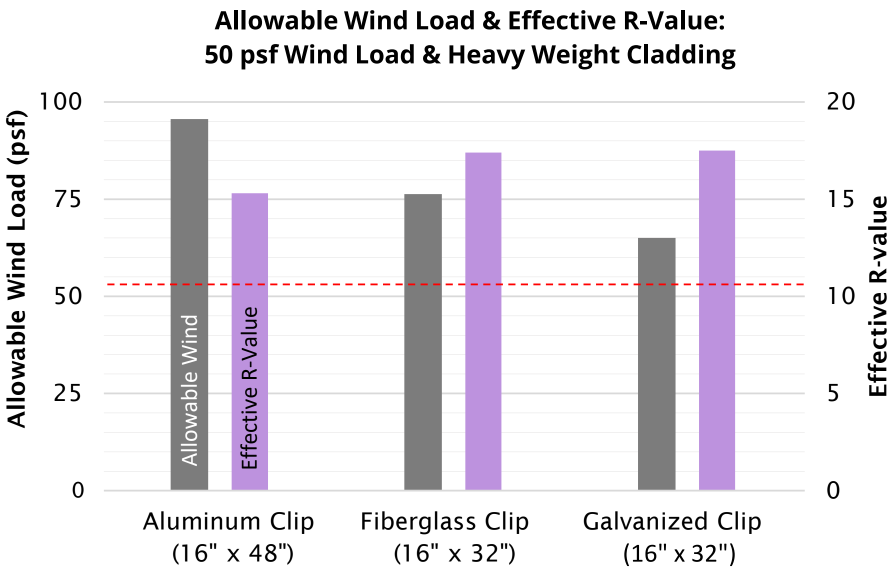


Galvanized clip

3-5/8” 18 ga Steel Stud Wall with 4” R-16.8 Exterior Stone Wool



The example wind pressure calculations (see page 33) show that in this scenario the system may have to provide up to approximately 53 psf allowable wind load. The graph below shows the allowable wind load and effective R-value of the clips at the various minimum required spacings, with heavy weight cladding.



In this example the aluminum clip provides the required allowable wind load at 48” vertically, while the fiberglass and galvanized clip must be placed at 32” on center vertically.

DISCUSSION

Since the cladding weight is set in both cases, and the pullout force from the wind load governs in this scenario, the allowable wind load is as the main design parameter. The structural capacity for each clip system in this example calculation is governed by the pullout strength of the fasteners into the backup wall assembly. Note that this value will change based on the backup wall assembly type (i.e. wood stud or concrete), but steel stud is used for comparison across systems.

Thermally isolated galvanized clip

The differences in structural capacity between systems can largely be attributed to the quantity of fasteners at the clip to back-up wall connection, the stiffness of the clip itself, and the pull-out strength of the fastener used. As cladding loads increase, the structural capacity differences between the three systems become more apparent. The aluminum clip consistently provides greater allowable wind load resistance. Higher strength levels can be attributed to additional fasteners in the aluminum clip, the increased clip height that decreases the effect of dead load, and the stiffness of the aluminum. The fiberglass clip and galvanized clip provide lower allowable wind load since they use just two fasteners and are shorter in height.

On the other hand, the fiberglass clip and galvanized clip consistently provide better thermal performance than the aluminum clip, even at closer vertical spacing, largely due to the more thermally efficient clip materials (aluminum is nearly three times as conductive as galvanized steel). This means that even if the allowable wind load is higher for the aluminum clip at a larger spacing, reducing the clip spacing of the other clips can achieve the same structural performance needed while providing better thermal performance.

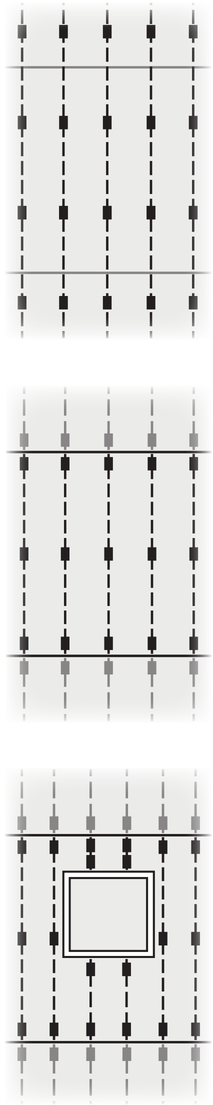
Note this analysis does not include cost optimization for any of the systems. Cost will vary significantly between the different clips and the attachment requirements, number of clips needed, as well as availability and industry familiarity. Cost has a significant impact on the selection process and its effect cannot be easily demonstrated without specific project information.

OPTIMIZATION CHALLENGES

Cladding spacing, allowable wind loads, and thermal performance provided in this section assume an unobstructed “clear-field” wall scenario. This represents a simplified and ideal model for comparing different clip systems. In reality, the cladding attachment system must accommodate various openings, penetrations, cladding joints, attachment of flashings and trims, and separations at floor lines.

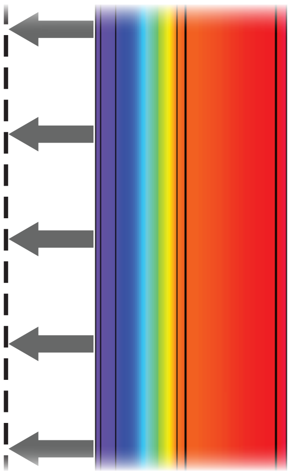
For example, while structural requirements can allow clip spacing of up to 16” x 48” or more on center, this spacing is only available at clear-field wall areas. If a window is present, clips must be placed at the outside perimeter of the window, with at least two clips above and below the window for each floor in most cases. These construction challenges apply to all clip and rail systems, regardless of the strength of the individual clips, since the cladding must be attached and supported at all sides. In this example, while the original spacing and optimization for thermal performance may have assumed one clip per 16” x 48” area, clips are instead spaced at 16” x 12” or less in some areas.

Additionally, even at a clear-field wall area, flashing may be present at the floor lines and would confine the cladding attachment to a single floor, limiting how far clips can be spaced vertically. The clips must be spaced to attach the rails at the top and bottom of the wall, resulting in at least 3 clips per floor, and the wall areas above and below will also have at least 3 clips. In these cases where the average clip tributary area may be more useful than the assumed nominal clip spacing dimensions, it may be beneficial to use the clip Chi-value (χ-value) for calculating the thermal performance (see next page).

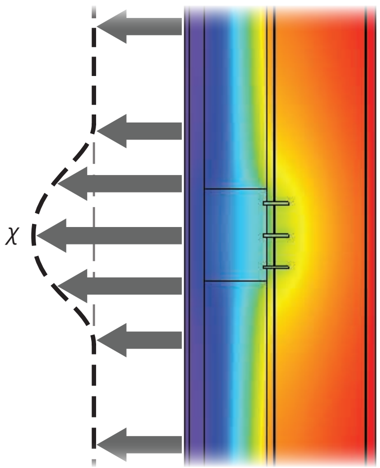


The cladding attachment system must accommodate floor lines, openings, and penetrations

Example χ-value calculation



Q_o (BTU/hr)



Q_a (BTU/hr)

$$\chi = \frac{Q_a - Q_o}{\Delta T}$$

USING THE CHI VALUE

If the effect on thermal performance due to clip spacing at openings, penetrations, and floor lines is accounted for in thermal calculations, the structural optimization calculations are likely to favor clips with lower overall thermal transmittance that can perform well at closer spacings. In these cases, the thermal performance of the wall assembly can be calculated using the Chi value (χ-value) of the clip.

The χ-value is the additional amount of point heat flow through the wall assembly due to the clip penetrating the exterior insulation, compared to the wall assembly without the clip (see right). The χ-value can be used to determine the thermal performance of the wall assembly using different clip attachment spacings given as the average tributary area, beyond what is directly calculated in thermal modeling. It is important to recognize that the calculated χ-values for the clips will change depending on the backup wall assembly. Clip χ-values can only be used to determine R-values for assemblies with the same backup wall type, exterior insulation thickness, and nominal R-value as the assembly modeled and used to determine the χ-value.

The formula to calculate the thermal performance of the assembly using the χ-value is as follows (equivalent metric units can also be used):

$$U = \frac{\chi}{A_{total}} + U_o$$

Where:

U = Assembly thermal transmittance (BTU/hr · °F · ft²)

U_o = Assembly thermal transmittance without clips (BTU/hr · °F · ft²)

A_{total} = Average tributary wall area of the clip (ft²)

χ = Heat flow due to clip (BTU/hr · °F)

By changing the value of the average tributary area, the assembly thermal transmittance can be calculated to reflect varying clip spacing, without having to use additional thermal modeling or relying on assumed consistent clip spacings.

The table below lists the χ-value for each clip type from the previous comparison, used with a clear-field wall with thermal transmittance (without clips) of U-0.048.

Clip Type	Chi Value (BTU/hr•°F)
Thermally Broken Aluminum Clip	**0.090**
Fiberglass Clip	**0.035**
Thermally Broken Galvanized Steel Clip	**0.035**

Example U-value calculations using the aluminum clip and galvanized steel clip χ-value are shown below.

Aluminum Clip

16" x 48" assumed spacing
(average 5.33 ft² tributary area):

$$U = \frac{\chi}{A_{total}} + U_o$$

$$U = \frac{0.090}{5.33} + \text{U-0.048}$$

$$\boxed{U = \text{U-0.065} = \text{R-15.4}}$$

vs.

3 clips/floor over 27 ft. (see right)
(average 4.0 ft² tributary area):

$$U = \frac{0.090}{4.0} + \text{U-0.048}$$

$$\boxed{U = \text{U-0.071} = \text{R-14.2}}$$

Galvanized Steel Clip

16" x 16" assumed spacing
(average 1.78 ft² tributary area):

$$U = \frac{\chi}{A_{total}} + U_o$$

$$U = \frac{0.035}{1.78} + \text{U-0.048}$$

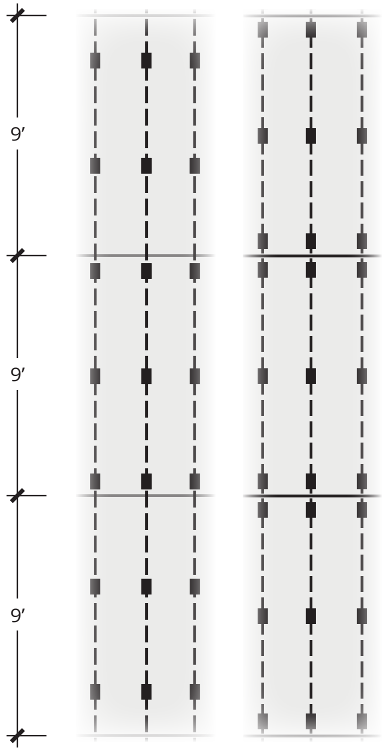
$$\boxed{U = \text{U-0.068} = \text{R-14.8}}$$

vs.

7 clips/floor over 27 ft.
(average 1.71 ft² tributary area):

$$U = \frac{0.035}{1.71} + \text{U-0.048}$$

$$\boxed{U = \text{U-0.068} = \text{R-14.6}}$$



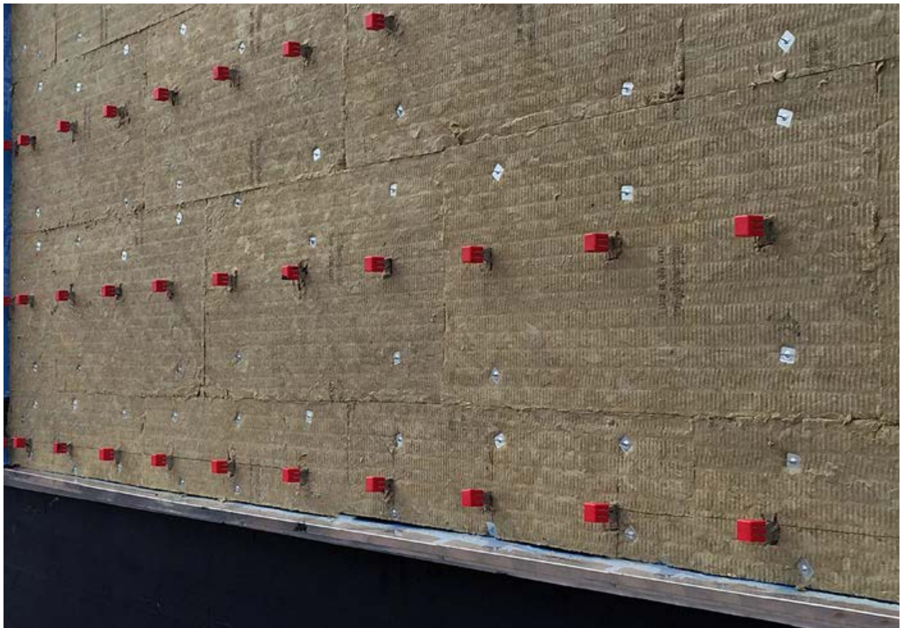
Aluminum clip 16" x 48" assumed "clear-field" spacing versus actual spacing due to flashing at floor lines (galvanized clip similar for 16" x 16")

The calculation shows how accounting for the average tributary area, rather than just using the assumed nominal spacing, can have a large impact on the calculated thermal performance of the assembly. It also shows the value of using the χ-value in the calculation rather than attempting to model the wall assembly multiple times to account for different clip spacings.

CONCLUSION

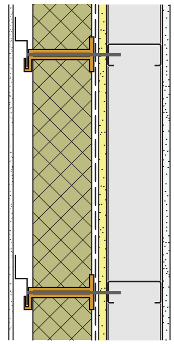
Cladding attachment optimization is generally limited to wind loads and pullout strength of the fasteners into the backup wall as the governing factor for the clip spacing. Most systems and their attachment methods are sufficient to support the gravity loads of common cladding weights. Optimizing for structural and thermal performance with large clip spacing can be challenging at areas other than clear-field unobstructed wall areas. Clips with lower structural capacity but better themal performance can allow for effective optimization.

Optimizing for thermal performance should use clip χ-values where possible to streamline the calculations and accurately account for the spacing of the clips as installed.

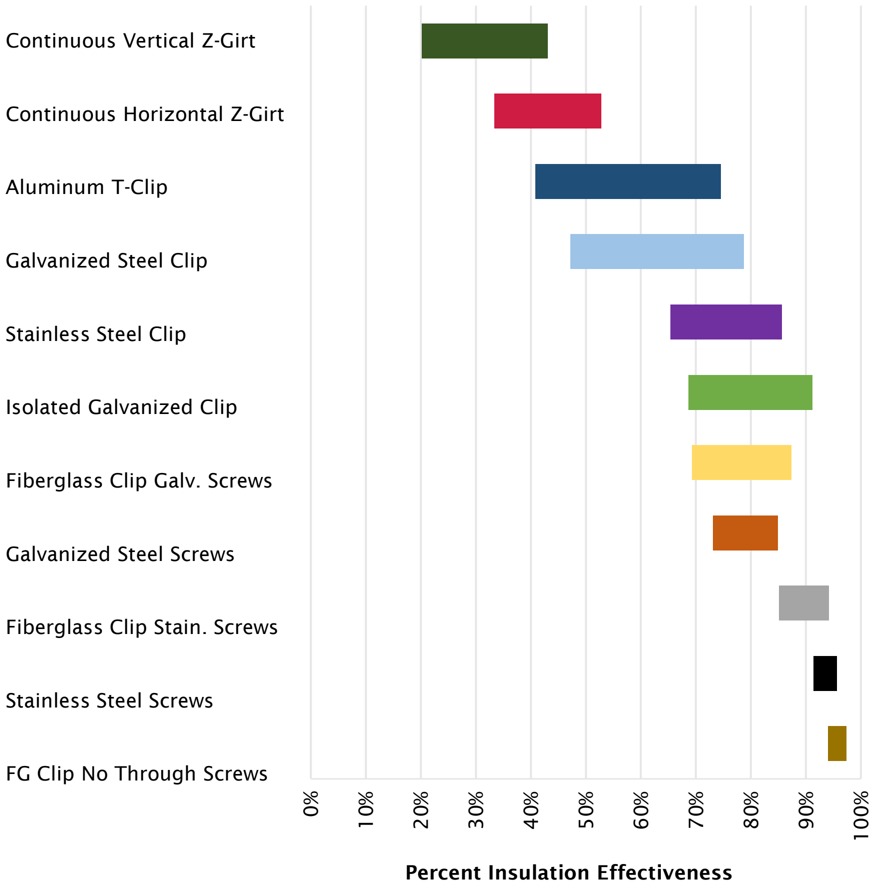


THERMAL COMPARISON OF SYSTEMS: A SUMMARY

To summarize the thermal performance of the various cladding attachment 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.



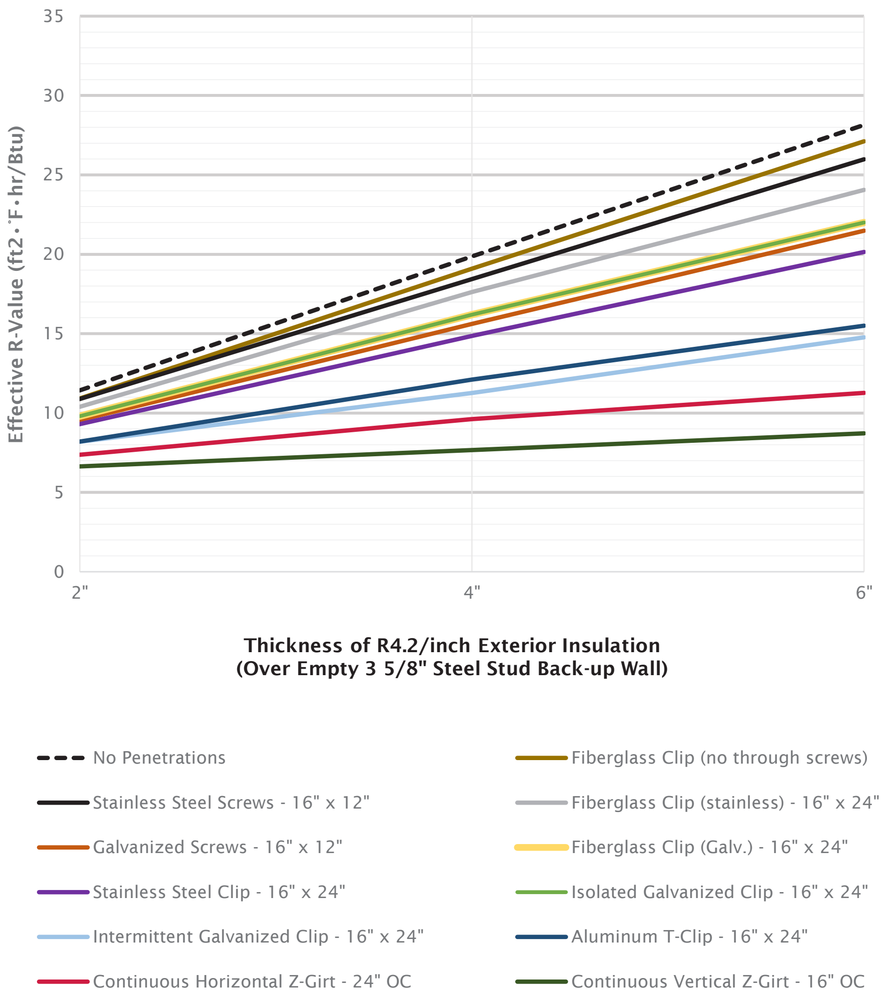
Uninsulated 3-5/8" steel stud wall with exterior insulation and cladding attachment system



Percent effectiveness of exterior insulation with various cladding attachment systems

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 presented 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 adjacent chart. For example, to get to an effective R-15 with this back-up wall, 4" exterior insulation is required for several different cladding attachment systems.



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


National Gypsum.

OTHER CONSIDERATIONS

In addition to the cladding attachment systems, mechanical attachments are also needed to support and hold the exterior insulation in place where not provided by the cladding attachment 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 and washers, proprietary insulation fasteners, impaling pins, and plastic cap nails.

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

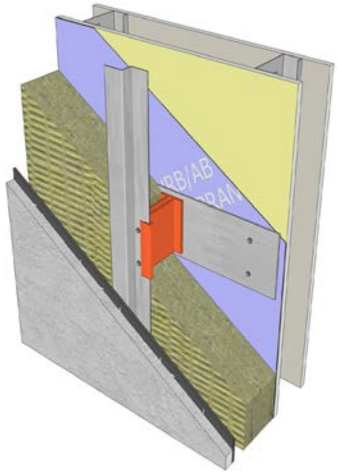
Each of the cladding attachment systems presented in this bulletin requires the supports to be attached back to the structure. This is relatively simple with concrete, concrete block, and mass timber walls. With wood frame buildings, the cladding attachments can be designed to be supported by either studs or the plywood or OSB sheathing, depending on the fastener pull-out requirements. With steel stud buildings and gypsum sheathing, the cladding attachments 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, intermediate structural support may be used to span between the studs and act as a larger target for the fasteners of the cladding attachment clip/girt. These strips may also be required around penetrations, windows, corners, and other places where steel studs cannot be installed from the interior. These additional supports will require specific structural design to be undertaken.

Example of insulation retained by intermittent cladding attachment clips behind metal panels. The metal panel attachment structure will further retain the insulation in the assembly here.*

Example of plastic fuel-cell actuated insulation fasteners installed after insulation and horizontal clip and girt system is installed to retain the insulation

SUMMARY

There are many cladding attachment systems 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. Important to consider are systems that provide the required structural support, meet the fire performance requirements, minimize thermal bridging, are easy to install, and are cost effective. As this is an emerging industry, cladding attachment systems are constantly evolving and being developed.



ADDITIONAL RESOURCES

- *Thermal Bridging From Cladding Attachment Strategies through Exterior Insulation* conference paper by RDH from the 9th North American Passive House Conference
- *Thermal Bridging of Masonry Veneer Claddings and Energy Code Compliance* conference paper by RDH from the 12th Canadian Masonry Conference
- *Guide for Designing Energy-Efficient Building Enclosures*

LEARN MORE

RDH Building Science offers a number of professional development and learning opportunities covering a diverse range of building science topics—both online and off. To learn more about current and upcoming courses, presentations, and workshops visit **learnbuildingscience.com**

SYSTEM OVERVIEW QUICKTABLE

CLADDING ATTACHMENT SYSTEM	RELATIVE COST	THERMAL EFFICIENCY	CONSTRUCTABILITY
Continuous Framing - Vertical Z-girts	**$ $** $	20–40%	
Continuous Framing - Horizontal Z-girts	**$ $** $	30–50%	
Continuous Framing - Crossing Z-girts	**$ $ $**	40–60%	
Clip and Rail - Aluminum T-Clips	**$ $** $	40–70%	
Clip and Rail - Thermally Broken Adjustable Aluminum Clips	**$ $** $	40–70%	
Clip and Rail - Galvanized Steel Clips	**$** $ $	50–75%	
Clip and Rail - Stainless Steel Clips	**$ $ $**	65–90%	
Clip and Rail - Thermally Isolated Galvanized Clips	**$ $** $	50–90%	
Clip and Rail - Fiberglass Clips	**$ $** $	70–95%	
Long Screws Through Insulation	**$** $ $	75–95%	
Masonry Ties	**$** $ $	40–90%	

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