INTRODUCTION

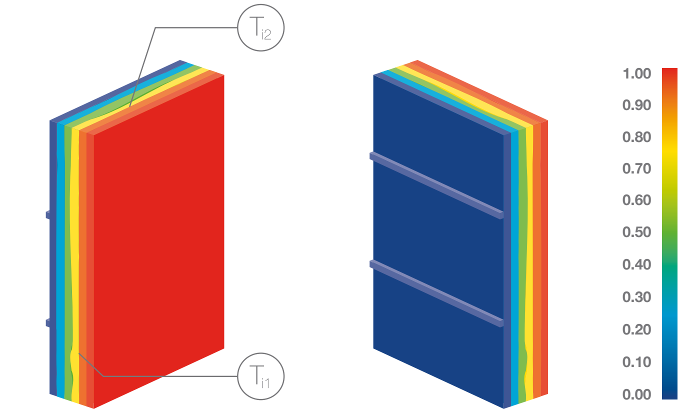
Thermal bridging is recognized as a significant factor in building envelope heat loss. It has been determined that the total heat flow through typical wall assemblies is underestimated by as much as 70% due to thermal bridging, yet simply adding insulation to walls has been proven to not necessarily decrease the energy use of a building. Heat flow paths (thermal bridges) allow heat to by-pass the insulation, negating any benefit of installing more insulation in the wall.

Metal, cement and laminate wall claddings are supported by and attached to continuous girts or clips that penetrate the exterior insulation layer, creating thermal bridges. These fastening systems are normally made of highly conductive steel or aluminum, creating significant energy (heat) loss. It has been demonstrated that these thermal bridges in conventional steel stud wall assembly construction reduce insulation effectiveness (R value) by as much as 50%, resulting in wall assemblies and interface details that do not meet current energy code requirements for minimum U value.

When thermal bridging is ignored, the unaccounted for heat flow creates higher heating and cooling costs, oversizing of HVAC equipment, operational inefficiencies and higher energy consumption.

A thermal model of a steel stud wall assembly with horizontal steel girts and exterior insulation. Note the heat flow path created by the steel girts passing through the exterior insulation.

The temperature scale can be used as a temperature index to predict whether condensation will likely be a problem or not in the local area of the girts on the internal sheathing.



VIEW FROM INTERIOR **VIEW FROM EXTERIOR**

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CONTINUOUS INSULATION

In standard construction details, wall cladding panels and rain screens are attached and secured to back-up steel stud walls, using girts or clips for support that bypass the exterior insulation. The insulation is installed around the clips or in-between the Z girts, preventing the insulation from being continuous. But what about the ASHRAE code requirement for continuous insulation?

ASHRAE 90.1 provides effective wall assembly U values for steel stud walls that do take into account the thermal bridging effect of the steel studs in the wall cavity. However, these U values assume continuous exterior insulation using the nominal R value for the insulation. ASHRAE 90.1 defines continuous insulation as “insulation that is uncompressed and that is continuous across all structural members without thermal bridges other than fasteners and service openings.

NOTE

Highly conductive Z girts and aluminum clips do create a thermal bridge and therefore must be thermally broken in order to meet the definition of “continuous insulation”. Consider this: Assume a steel stud wall assembly is insulated on its exterior by 5” of insulation with a nominal R value of R 20. The interior steel studs, sheathing and air film add an additional R 3.3 for a total R value of 23.3. The U value of this “continuous insulation” is 0.042. However, the effective R value do to the z girts is actually R 13.1 with a corresponding U value of 0.076. An increase in U value of 0.034. The thermal impact of the girts is then 0.034/0.076 or 0.447. **The z girts are responsible for 45% of the total heat flow through this wall assembly.**

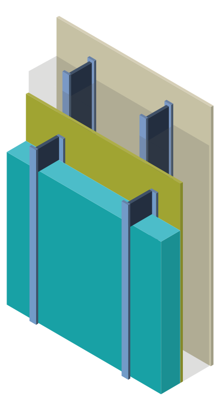
Exterior insulation installed in-between steel z girt cladding support attachment resulting in exterior insulation that is not continuous and does not meet energy codes (Source: Roxul, Inc.)

UNDERSTANDING HEAT FLOW

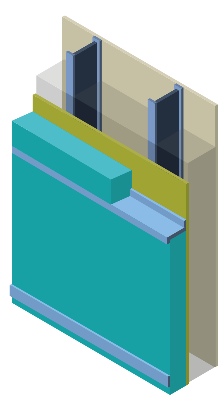
Each layer of a building wall assembly has its own thermal conductance, or rate of heat transfer. When there are multiple building elements in a layer, such as framing and internal insulation or cladding attachments and external insulation, the R and U value calculations must take into account the different heat flows and, more importantly, the lateral and multidirectional heat flows that occur due to thermal bridging.

Highly conductive building materials create lateral or multidirectional heat flows to other components that are not accounted for in parallel heat flow assumptions. Parallel heat flow path assumptions and area weighting do not accurately define the effects of a thermal bridge.

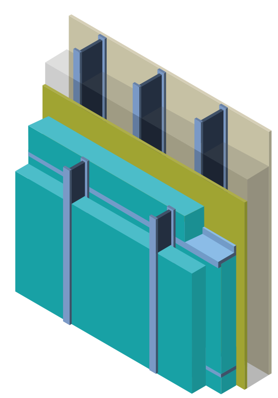
In 2011, the consulting firm Morrison Hershfield, published “Thermal Bridging in Exterior Insulated Steel Stud Assemblies” as a result of work they had done as part of the ASHRAE research project “ASHRAE RP 1365.” In this study they evaluated several steel stud wall assemblies using steel z girts and various thicknesses of exterior insulation. The results were found using three dimensional thermal analysis software to more accurately determine the effective U value of these assemblies.



VERTICAL Z-GIRTS



HORIZONTAL Z-GIRTS



VERTICAL AND HORIZONTAL Z-GIRTS

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EFFECTIVE R VALUES

Exterior Insulation R Value (RSI)	Assembly effective R Value (RSI)		
	Vertical Steel Girts	Horizontal Steel Girts	Vertical/Horizontal Steel Girts
R 10 (1.76)	8.3 (1.46)	9.4 (1.65)	10.3 (1.80)
R 15 (2.64)	9.7 (1.70)	11.4 (2.00)	13.1 (2.30)
R 20 (3.50)	11 (1.92)	13.1 (2.30)	15.4 (2.70)
R 25 (4.38)	11.9 (2.08)	14.5 (2.54)	17.2 (3.02)

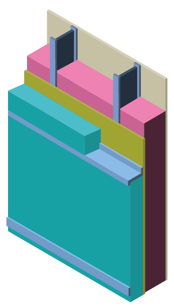
Meets ASHRAE 2013 zone 1
Meets ASHRAE 2013 zone 1 and zone 2

Those results show that when using steel z girts in the vertical orientation, aligned with the steel studs, the heat flow through the wall assembly is the greatest, resulting in the highest effective R values making the insulation only 48% efficient. In the horizontal orientation heat loss improves due to less contact area with the steel studs. However, the steel girts still pass through the insulation, preventing continuous insulation, making it 57% efficient at best. As can be seen in the chart above, adding insulation to overcome the heat loss associated with the steel girts improves the effective R value only marginally.

In an effort to improve the effective R value, the wall assembly was evaluated using both vertical and horizontal girts. (R 5 vertically with varying R values on the exterior) In this model, the girts pass through the exterior insulation only partially, making the insulation up to 68% effective, but there is additional material and labor cost involved with installing insulation and girts twice around the building. This configuration did yield the highest effective R value (R 17.2) of all the assemblies, but unfortunately only five of the wall assembly configurations meet the current ASHRAE 2013 code (three using both vertical and horizontal girts) and none meet the Canadian national energy code, NECB 2011, by geographical zone.

ADDITIONAL INSULATION

In the same study, fiberglass batt insulation was added to the internal steel stud cavities in an effort to improve the wall heat loss. The horizontal girt configuration was chosen for this comparison adding R 12 batt insulation. The modeling results show that by adding internal insulation, the effective R value of the wall assembly can be increased by R 7.5 or 60% of the nominal value of the batt insulation. This yields a range of effective R values from R 16.4 to R 22.2 (up to35% improvement). However, there is the added material and labor cost of installing the internal batt insulation.



Exterior Insulation R Value (RSI)	Assembly effective R Value (RSI)	
	Horizontal Steel Girts Exterior Insulation Only	Horizontal Steel Girts Exterior and R 12 Interior Insulation
R 10 (1.76)	9.4 (1.65)	16.4 (2.87)
R 15 (2.64)	11.4 (2.00)	18.5 (3.24)
R 20 (3.50)	13.1 (2.30)	20.4 (3.58)
R 25 (4.38)	14.5 (2.54)	22.2 (3.89)

Meets ASHRAE 2013 zone 1
Meets ASHRAE 2013 zones 1 - 3 and NECB zone 4
Meets ASHRAE 2013 zones 1 - 4 and NECB zones 4 and 5

NOTE: In addition to creating a breach in heat flow, thermal bridging due to cladding attachments can reduce the surface temperature on local internal wall surfaces as they penetrate the thermal envelope. This can result in potential moisture problems. Moisture within the building structure can corrode metal components. Condensation occurs on cold surface areas when the temperature at the internal surface of an external wall is at or below the dew point temperature of the air. Using more efficient attachment details that incorporate a thermal break in conjunction with air vapor barriers reduces the risk of condensation by forcing the dew point *outward* of the thermal envelope.

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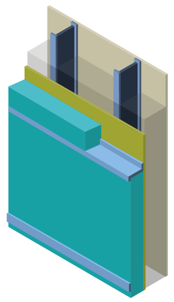
IMPROVE WALL ASSEMBLY EFFICIENCY

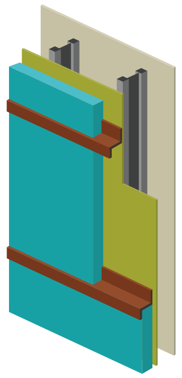
How can we improve cladding attachment details and design wall assemblies that maximize insulation values so they reduce heat loss, reduce cost and meet energy codes?

Armatherm cladding attachments significantly improve wall assembly thermal performance. Armatherm FRR Z Girt, clip and thermal break shims provide a combination of low thermal conductivity and high compressive strength transferring load and reducing heat loss. The material is made of a reinforced, thermoset resin that is fire resistant and exhibits very limited creep under load, making it the ideal material for use in structural and façade thermal break connections.

To determine the effectiveness of the Armatherm Z girt, the same wall assemblies were evaluated, substituting Armatherm, non-conductive Z girts for the steel girts. The vertical and horizontal girt orientations were compared and the results are shown below.



Wall assembly using horizontal steel girts



Wall assembly using horizontal Armatherm girts

Exterior Insulation R Value (RSI)	Assembly effective R Value (RSI)	
	Steel Girts Exterior Insulation Only	Armatherm Girts Exterior Insulation Only
R 10 (1.76)	9.4 (1.65)	13 (2.28)
R 15 (2.64)	11.4 (2.00)	17.5 (3.07)
R 20 (3.50)	13.1 (2.30)	22.2 (3.89)
R 25 (4.38)	14.5 (2.54)	27 (4.73)

Girts in horizontal orientation with 24" spacing

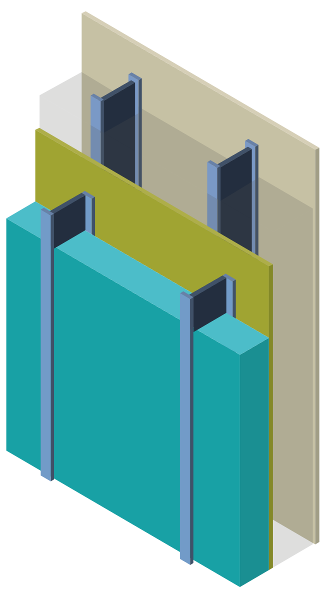
Meets ASHRAE 2013 zone 1
Meets ASHRAE 2013 zone 1 and zone 2
Meets ASHRAE 2013 zones 1 - 4 and NECB zones 4 and 5
Meets ASHRAE 2013 zones 1 - 7 and NECB zones 4 – 7b

IMPROVE WALL ASSEMBLY EFFICIENCY

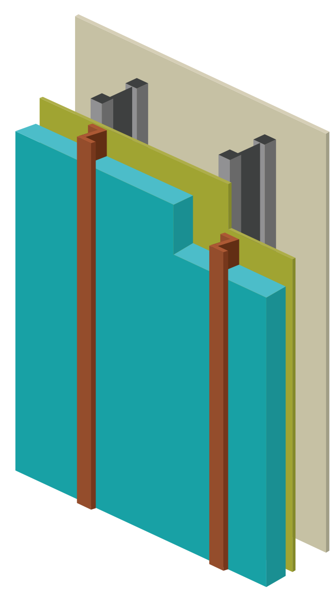
Exterior Insulation R Value (RSI)	Assembly effective R Value (RSI)	
	Steel Girts Exterior Insulation Only	Armatherm Girts Exterior Insulation Only
R 10 (1.76)	8.3 (1.46)	12.7 (2.22)
R 15 (2.64)	9.7 (1.70)	17.2 (3.01)
R 20 (3.50)	11 (1.92)	21.7 (3.80)
R 25 (4.38)	11.9 (2.98)	26.3 (4.61)

Girts in vertical orientation with 16" spacing

- **Meets ASHRAE 2013 zone 1**
- **Meets ASHRAE 2013 zone 1 and zone 2**
- **Meets ASHRAE 2013 zones 1 - 4 and NECB zones 4 and 5**
- **Meets ASHRAE 2013 zones 1 - 7 and NECB zones 4 – 7b**



Wall assembly using vertical steel girts



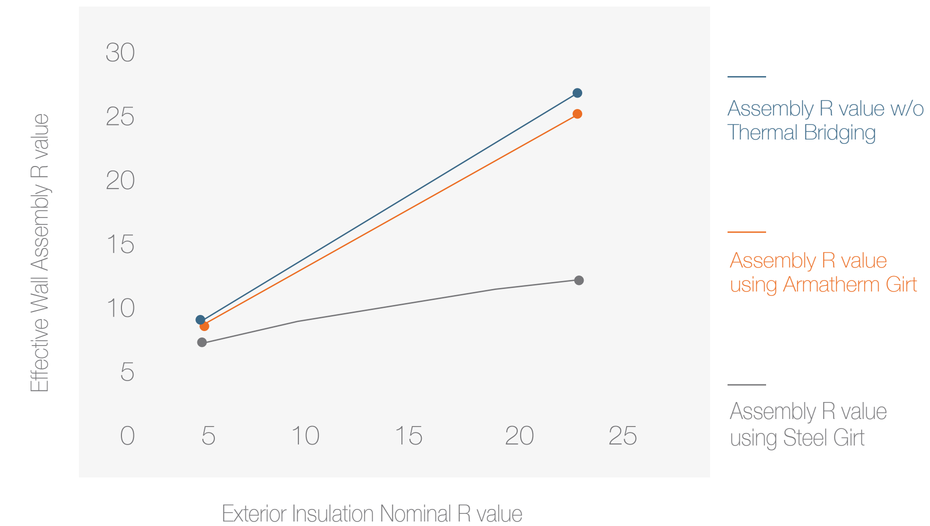
Wall assembly using vertical Armatherm girts

Material data information, thermal performance and condensation indices for the thermal modelling examples shown is available upon request. Please contact us to obtain these or the results of other modeled areas in the building envelope from our thermal modeling library.

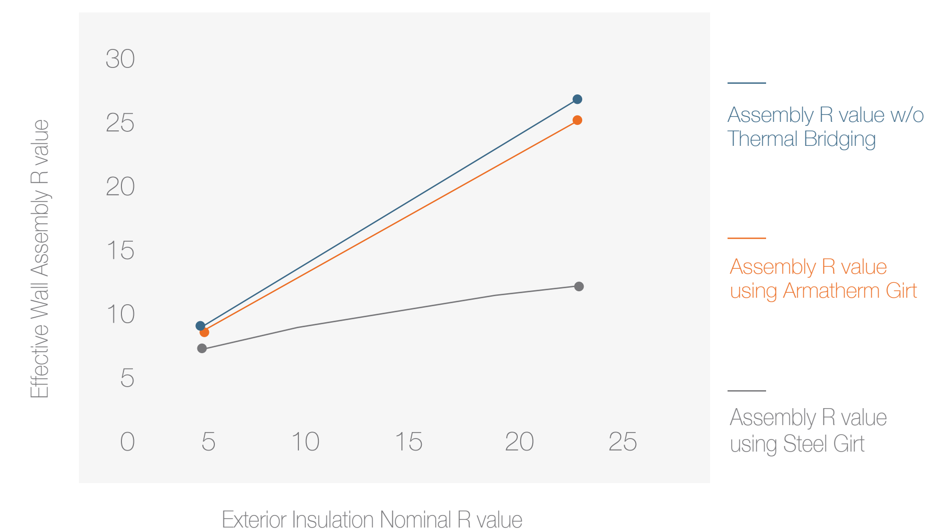
EFFICIENCY COMPARISON

The charts below show more clearly the relationship between external insulation nominal R value and effective wall assembly R value.

EFFECTIVE WALL ASSEMBLY R VALUE COMPARISON
WITH VERTICAL GIRTS AT 16" SPACING



EFFECTIVE WALL ASSEMBLY R VALUE COMPARISON
WITH HORIZONTAL GIRTS AT 24" SPACING



ARMATHERM SOLUTIONS

Armatherm thermally broken cladding support connection solutions prevent excessive heat flow and potential condensation problems otherwise associated with thermal bridging. Moreover, wall assemblies using Armatherm attachments will meet the continuous insulation requirement of ASHRAE 90.1 and the effective R value requirements of the Canadian NECB energy code.

Modeling results show that using Armatherm Z girts results in several improvements in the thermal efficiency of wall designs, reducing heat flow:

- The insulation efficiencies of the wall assemblies increase significantly. Some as high as 98%.
- Higher, effective wall assembly R values are achieved using lower values of external insulation. For example, to obtain an R value of R-13 minimum to meet ASHRAE zone 1, steel girts require and external R 20; whereas Armatherm girts require only R 10.
- Cladding wall assemblies can meet the R value requirements of ALL geographical zones for both ASHRAE 2013 and NECB 2011 energy codes using Armatherm Z girts
- Reduction in thickness and cost of insulation
- Reduces energy consumption

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"Building Envelope Thermal Analysis", Morrison Hershfield, Building Envelope Thermal Bridging Guide, August 2014.
"Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings (1365-RP)", Morrison Hershfield, July 2011
"Building Envelope Thermal Bridging Guide, Version 1.1", Morrison Hershfield, 2016
"Thermal Bridging in Exterior Insulated Steel Stud Assemblies", Morrison Hershfield, 2011, Issue 2
"Practical use of Thermal Breaks in Cladding Support Systems", L.B.B. Peer, ASHRAE, 2007