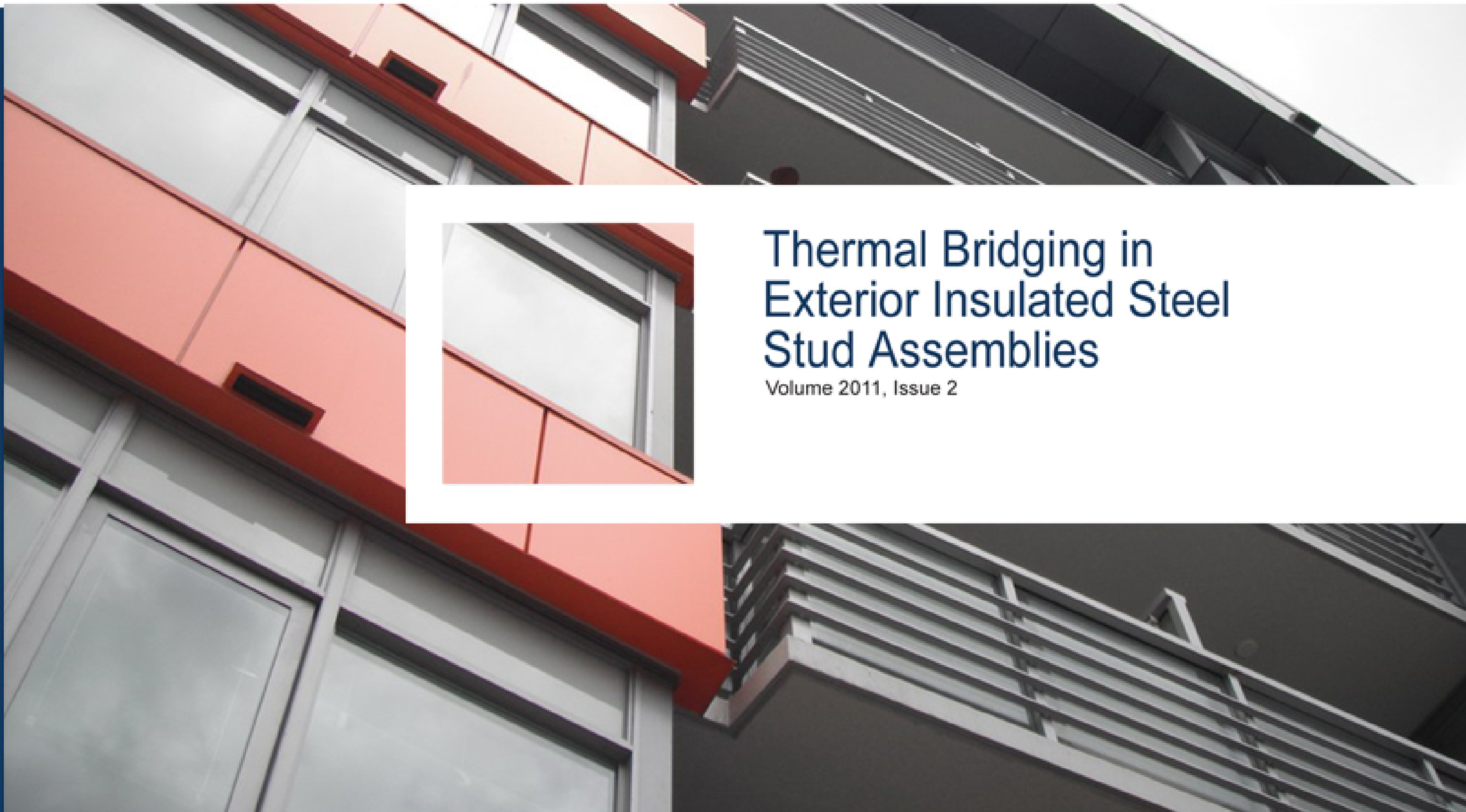
MORRISON HERSHFIELD

SOLUTIONS

BUILDINGS



Thermal Bridging in Exterior Insulated Steel Stud Assemblies

Volume 2011, Issue 2

With a continued focus of sustainable and energy efficient building design, more attention is being paid to the thermal performance of building enclosure assemblies. Providing a higher level of thermal resistance in the building enclosure may seem as straightforward as just adding insulation, but when building with conductive elements like steel, achieving higher thermal performance levels can be elusive.

When cladding is attached to back up steel stud walls, the attachments bypass the exterior insulation. These attachments, usually made of steel, can create significant heat flow paths. While there are some systems that minimize the bridging effect, many of the common attachment methods are not very efficient from a thermal perspective.

The Questions

Building energy standards, such as ASHRAE 90.1, force recognition of the impact of thermal bridging. Table A3.3 in ASHRAE 90.1 provides effective assembly U values for stud walls that consider the effects of the steel studs through the stud cavity. These values, however, are for assemblies with different levels of continuous insulation outboard of the studs (basically assuming you have the full nominal value of the exterior insulation). The table does not provide guidance in addressing the thermal impact of the cladding support elements passing through the exterior insulation. This raises some critical questions:

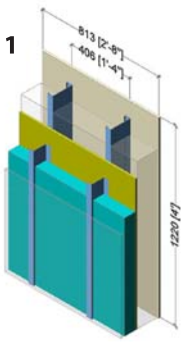
1. **What are the effective R- and U-values of your steel stud assembly walls and do they meet code requirements?**

2. **What is the difference in thermal performance of different cladding attachment arrangements?**

The SOLUTION

Morrison Hershfield approached these questions as part of the ASHRAE Research Project 1365 “Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings”[1]. Four different cladding attachment arrangements for exterior insulated steel stud cavities were investigated[2], using a well calibrated 3D thermal model[3]. These details are shown below:

1



VERICAL Z-GRITS

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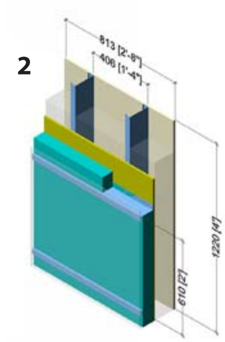

HORIONTAL Z-GRITS

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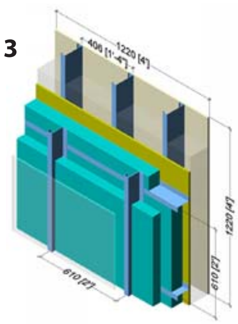
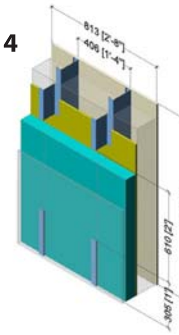


VERTICAL and HORIZONTAL Z-GRITS

4



INTERMITTENT Z-GRITS SPACED 12”, 24” and 36” APART

Table 1: Effective U-Values for Exterior Insulated Steel Stud Assemblies with Various Girt Attachments

Exterior Insulation R-Value (RSI)	Assembly U-Value BTU/hr ft^2 °F(W/m^{2}K)						
	Vertical	Horizontal	Vertical/ Horizontal	Intermittent			ASHRAE 90.1-2007 Continuous Insulation
				12” apart	24” apart	36” apart	
5 (0.88)	0.157 (0.89)	0.146 (0.83)	n.a.[5]	0.142 (0.81)	0.136 (0.77)	0.132 (0.75)	0.128 (0.73)
10 (1.76)	0.120 (0.68)	0.106 (0.60)	0.097 (0.55)	0.101 (0.57)	0.093 (0.53)	0.089 (0.50)	0.078 (0.44)
15 (2.64)	0.103 (0.59)	0.088 (0.50)	0.076 (0.43)	0.082 (0.47)	0.073 (0.41)	0.068 (0.39)	0.056 (0.32)
20 (3.52)	0.091 (0.52)	0.076 (0.43)	0.065 (0.37)	0.070 (0.40)	0.061 (0.35)	0.057 (0.32)	0.044 (0.25)
25 (4.40)	0.084 (0.47)	0.069 (0.39)	0.058 (0.33)	0.062 (0.35)	0.053 (0.30)	0.049 (0.28)	0.036 (0.20)

Effective R- and U- Values

The results of our modeling are shown in Table 1[4]. Since ASHRAE 90.1 is referenced by many building codes, the data is provided in a similar format – the effective clear wall U-value for varying amounts of exterior insulation. We have also provided, for comparison, ASHRAE 90.1 data for continuous insulation.

Figure 1 shows the data from Table 1, converted to effective R-value, and presented in a graphical format. Included with this figure are the prescriptive R-value requirements for ASHRAE 90.1-2007 for all climate zones for both residential and non-residential uses.

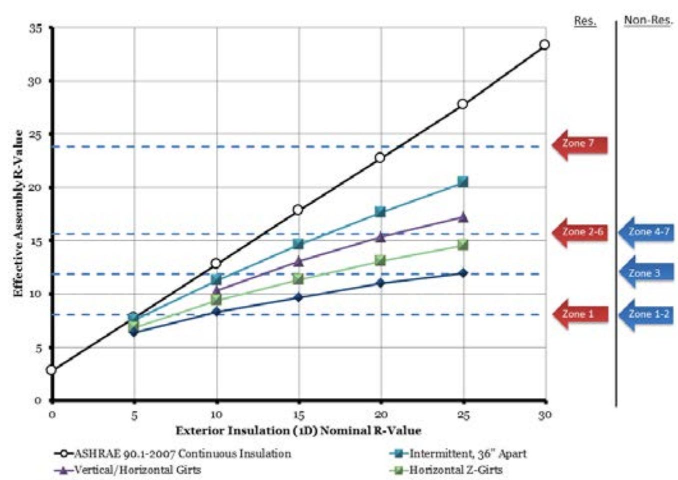


Figure 1: *Effective Assembly R-Value for Selected Cladding Attachments with ASHRAE 90.1-2007 Minimum Climate Zone requirements for Residential and Non-Residential Buildings*

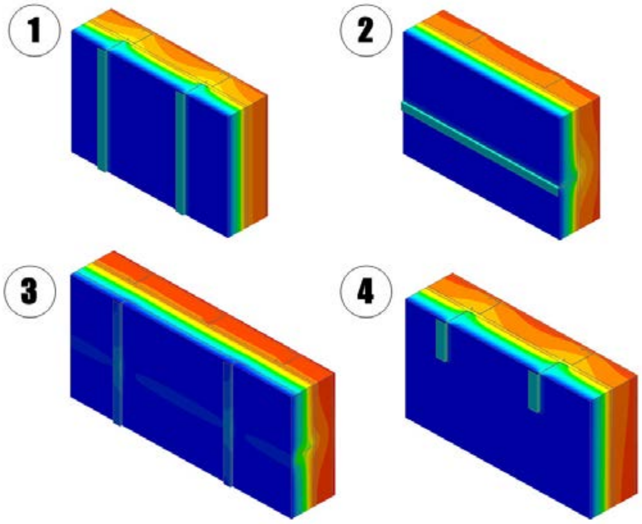


Figure 2*: Thermal Gradients and heat flow paths for the selected cladding attachments 1) Vertical, 2) Horizontal, 3) Vertical/Horizontal*

Figure 2 shows temperature profiles for the modeled steel stud assemblies[6]. These make it easier to visualize the heat flow paths created by the cladding attachments and steel studs. Comparing our modeled results and the 90.1 values for continuous exterior insulation shows that thermal bridging through the cladding attachments can have a very large effect on the overall heat loss through an assembly, particularly at higher levels of insulation. With the poorer performing systems, like vertical z-girts, the thermal bridging can result in over double the expected heat loss.

Comparing Assemblies

For each of the modeled cases, there was a layer of gypsum sheathing separating the z-girts and the studs. The vertical z-girt system is commonly used because of the arrangement's high structural strength. However, it is also thermally inefficient because the z-girts and steel studs are directly aligned, creating a straight path for heat to flow through the assembly.

With horizontal z-girts, the heat flow paths are less direct and the amount of steel overlap is greatly reduced when compared to the vertical z-girt system. This lowers the effective U-value; but only modestly since the z-girts still bypass the entire thickness of the exterior insulation. By using both vertical and horizontal z-girts, each z-girt only partially cuts through the insulation. With this arrangement, the heat flow paths are further reduced and result in a lower U-value than the previous two systems.

Continued on page 4 (back page)

Adding Batt Insulation

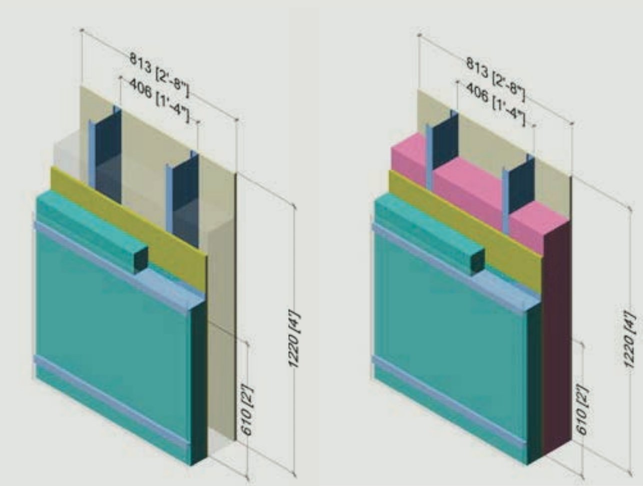
Often, fiberglass batt is added to fill the stud cavity in order to further increase the thermal resistance of an exterior insulated steel stud assembly[8]. To evaluate the benefit of adding this insulation, we modeled the horizontal z-girt arrangement with and without an R-12 batt in the stud cavity.

The results are shown in Figure 4. Adding the R-12 batt increases the assembly R-value by, on average, R-7.5.

These results will differ using other systems; but only slightly. In general, adding insulation in the stud cavity of an exterior insulated stud wall assembly will add approximately 60% of the rated nominal value of that insulation to the thermal resistance of the assembly.

This improvement may seem modest for the increased nominal R-value, but it may be important in meeting code.

Figure 4 shows that in order to meet the prescriptive requirements of ASHRAE 90.1 using exterior insulation and horizontal z-girts may require the two layers of insulation.



Horizontal Z-Girts without Batt insulation

Horizontal Z-Girts with Batt insulation

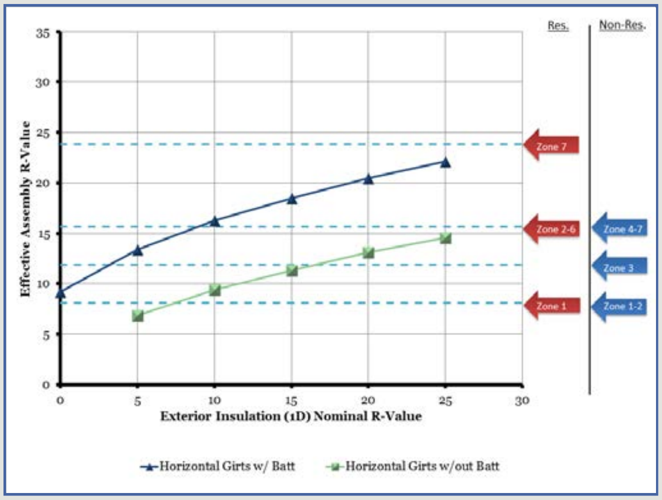


Figure 4: *Effective R-Values for Horizontal Z-Girts with and without interior Batt with ASHRAE 90.1-2007 Minimun Climate Zone requirements for Residential and Non-Residential Buildings*

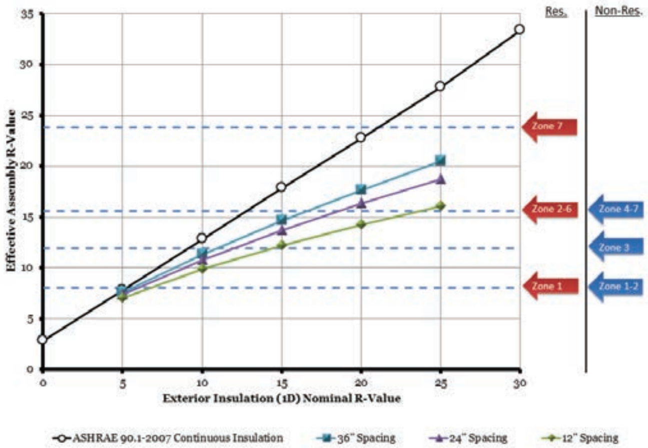


Figure 3: *Effective Assembly R-Value for Intermittently spaced girts with ASHRAE 90.1-2007 Minimum Climate Zone requirements for Residential and Non-Residential Buildings.*

The fourth system is a set of intermittent clips that were modeled as 12" inch long pieces of z-girt, aligned vertically at the studs. Figure 3 compares the effect on R-values of the increased spacing and resultant reduction in metal passing through the insulation. With a widely spaced clip, this system gave the best thermal performance out of the four analyzed assemblies[7].

For all these systems, there is a diminishing return to adding insulation, which can be seen in Figures 1 and 3. For example, going from an R-5 to an R-10 exterior insulation with the horizontal z-girt system, the thermal resistance is increased by R-2.6. If another R-5 of insulation is added, from R-10 to R-15, the thermal resistance this time is only increased by R-1.9.

Closing

One of the important lessons of this analysis is that to achieve high levels of effective thermal resistance in steel stud walls, it is more important to find ways of eliminating, or thermally breaking the metal elements passing through the insulation. A number of systems have been proposed and used that make use of:

- **structurally efficient cladding support systems**
- **non metallic structural elements**
- **low conductivity thermal breaks**

It is important to note that there are additional structural and fire resistance implications that need to be considered, as well the thermal performance, when using these systems.

This example provides understanding of the effects of 3D bridging in several 'clear wall' assemblies. In addition, there are other significant avenues of thermal bridging, including at parapets, slabs, corners etc. that were analyzed as part of the ASHRAE Research Project 1365.

As the push towards greater energy efficiency continues, 3D thermal modeling will become an increasingly useful approach in accurately analyzing the thermal performance of building envelope systems.

3D thermal modeling is one of the many tools in MH's toolbox, and combined with extensive field experience and knowledge, MH can effectively provide solutions that are relevant to the design, construction and operation of the building environment.

Supplementary Notes

1. Report is scheduled to be finalized mid 2011.

2. For these 4 assemblies, the studs were 3.5in depths at 16"o.c. and the stud cavity was un-insulated. The exterior insulation was varied from R-5 to R-25.

3. Part of MH's resources is a 3D heat transfer model that was extensively calibrated and validated as part of the ASHRAE Research Project 1365.

4. These are the 'clear wall' U-values and includes the effects of the stud wall with no top and bottom tracks. ASHRAE values were taken from ASHRAE 90.1-2007, Table A.3.3. Note that ASHRAE includes both top and bottom steel tracks

5. The vertical section of the vertical/horizontal system always contained R-5 insulation, and the horizontal section was varied between R-5 and R-25. Therefore a total value for an exterior insulation of R-5 alone was not applicable.

6. All images shown are for an exterior insulation of R15.

7. This type of intermittent system is often constrained by structural considerations since the decrease in steel offers less support.

8. Other factors, such as condensation resistance, must also be considered when using batt insulation.

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