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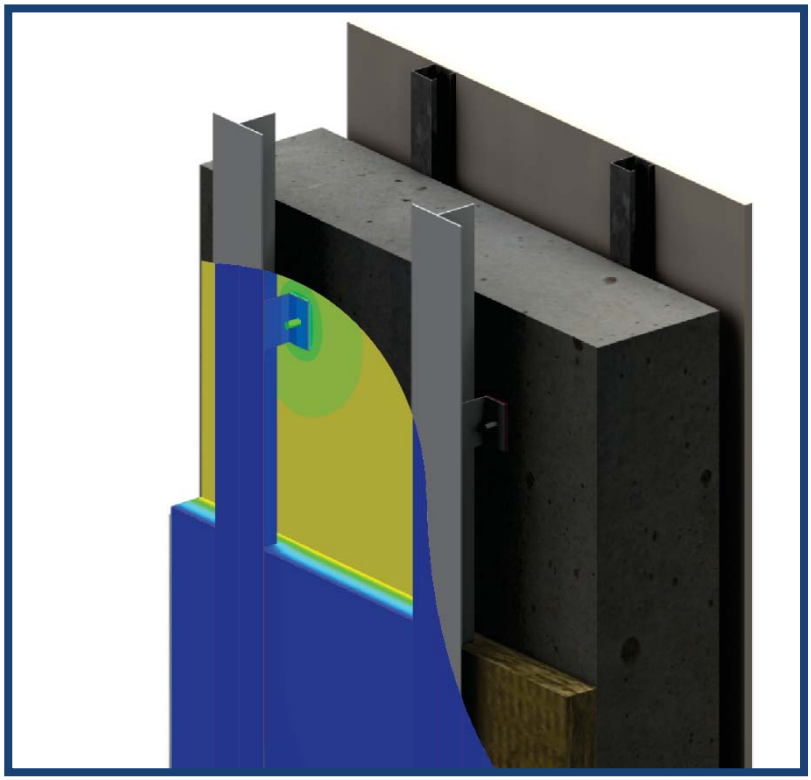
MORRISON HERSHFIELD

Thermal Analysis of Porcelanosa Cladding Attachment System



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1. INTRODUCTION AND BACKGROUND

The Porcelanosa cladding attachment system is an aluminum bracket system for attaching exterior cladding to different types of backup walls. Morrison Hershfield was contracted by Porven Ltd. d/b/a Porcelanosa USA to evaluate the thermal performance of their cladding attachment system for various scenarios. This report is a summary of the analysis.

The Porcelanosa cladding attachment system consists of an intermittent aluminum L-bracket with a plastic thermal isolator placed behind the back flange. A continuous vertical L or T sub-girt is attached to the L-brackets, which in turn support the cladding. The exterior insulation is fit between the brackets and sub-girts. Different levels of insulation are accommodated by providing varying depths of the L-bracket. The L-bracket and thermal isolator are fastened directly to the substrate or to a continuous horizontal *Omega Bar* hat channel, which is in turn fastened to the substrate. The L-brackets and sub-girts are typically spaced 24 inches on center, not necessarily in line with the backup wall studs which are spaced 16 inches on center. The arrangements of the components are shown with and without the omega bar below in Figure 1.

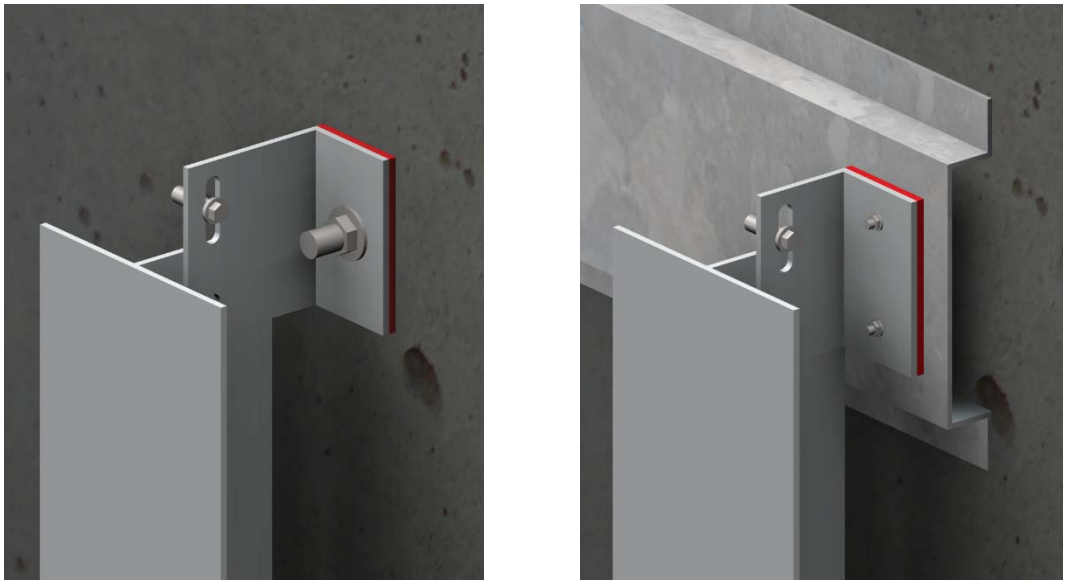
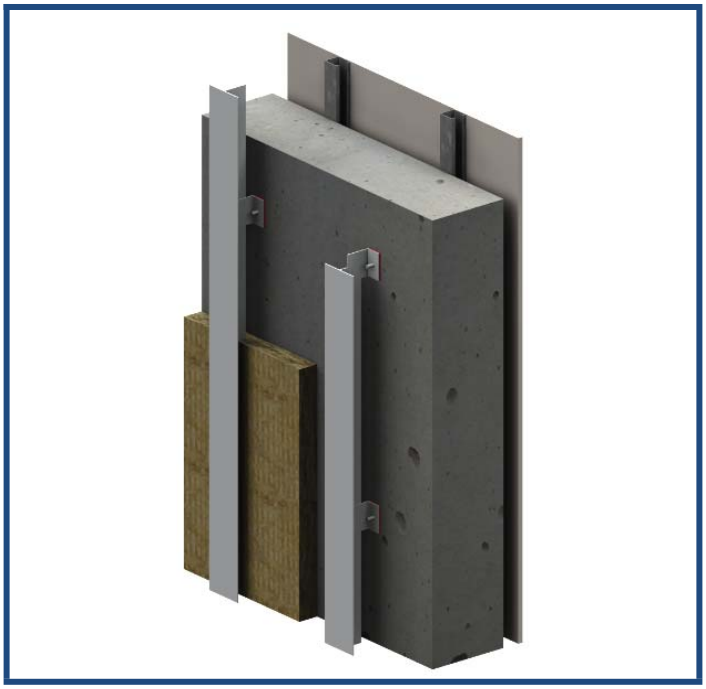


Figure1.1: Simplified Rendering of Porcelanosa Cladding Attachment

For this analysis, the Porcelanosa cladding attachment system was analyzed for use with the following assemblies:

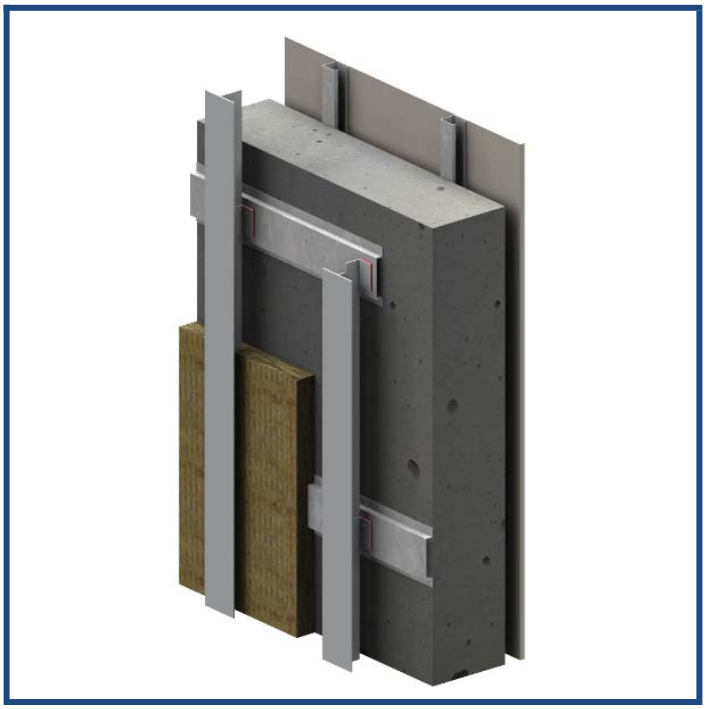
Exterior Insulated Concrete Mass Wall

- 1/2” Gypsum
- 1 5/8” Steel Stud Cavity, 16” o.c., Air Filled
- 8” Concrete Mass Wall
- Varying Mineral Wool Insulation
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)



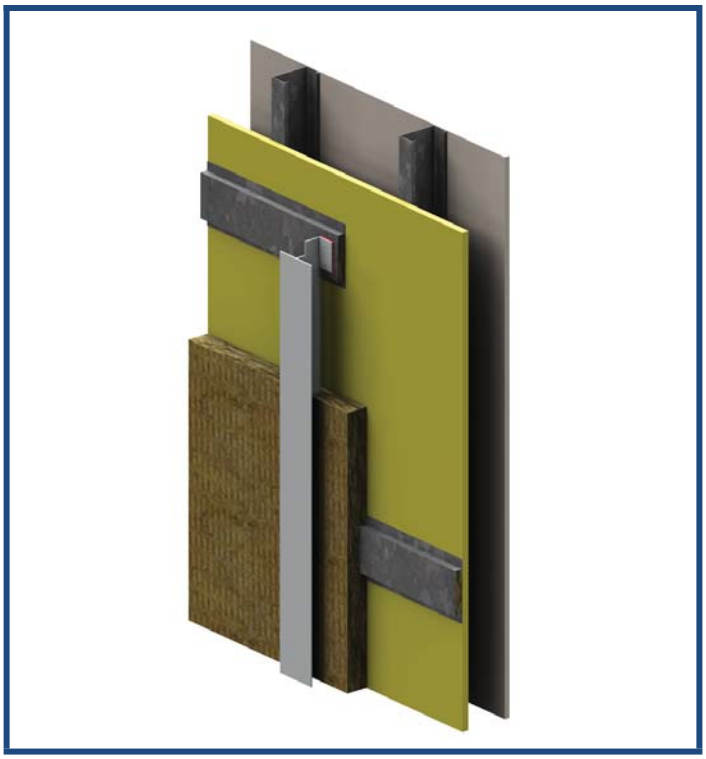
Exterior Insulated Concrete Mass Wall with Omega Bar

- 1/2” Gypsum
- 1 5/8” Steel Stud Cavity, 16” o.c., Air Filled
- 8” Concrete Mass Wall
- Varying Mineral Wool Insulation
- Omega Bar Hat Channel with Stainless Steel Fasteners
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)



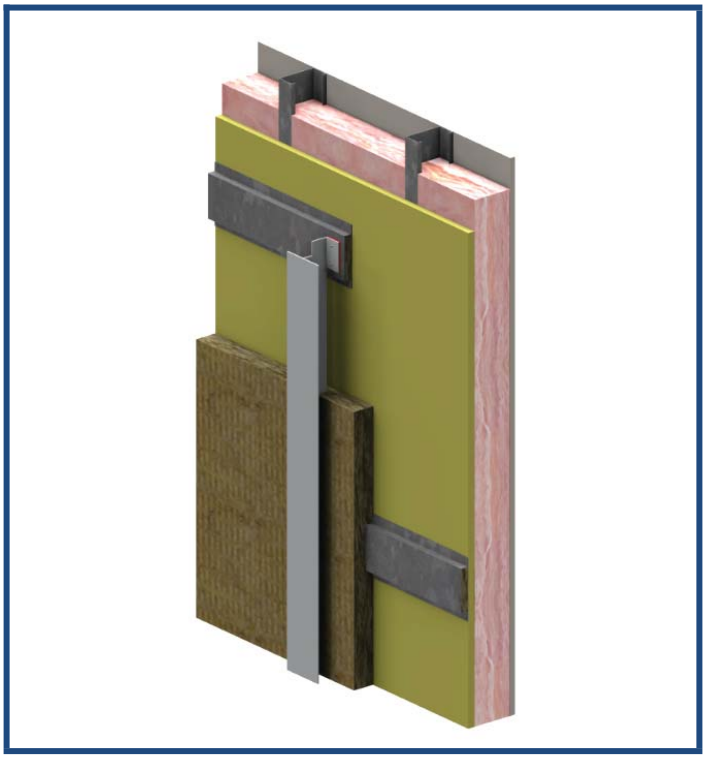
Exterior Insulated Steel Stud Wall with Omega Bar

- 1/2” Gypsum
- 3 5/8” Steel Stud Cavity, 16” o.c., Air Filled
- 1/2” Gypsum Sheathing
- Varying Mineral Wool Insulation
- Omega Bar Hat Channel with Stainless Steel Fasteners
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)



Split Insulated Steel Stud Wall with Omega Bar

- 1/2” Gypsum
- 3 5/8” Steel Stud Cavity, 16” o.c., with R-13 Batt
- 1/2” Gypsum Sheathing
- Varying Mineral Wool Insulation
- Omega Bar Hat Channel with Stainless Steel Fasteners
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)

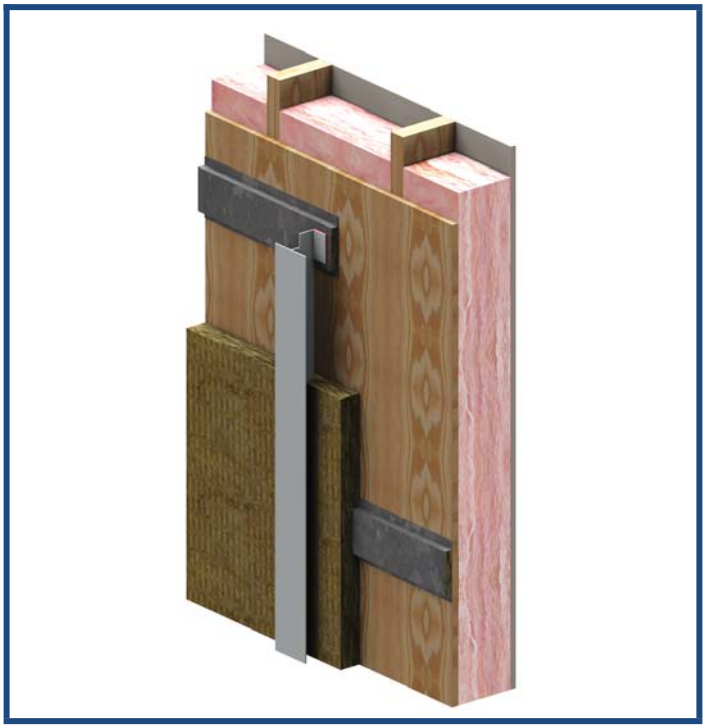


Exterior Insulated Wood Framed Wall

- 1/2” Gypsum
- 2x6 Wood Framed Cavity, 16” o.c., Air Filled
- 1/2” Plywood Sheathing
- Varying Mineral Wool Insulation
- Omega Bar Hat Channel with Stainless Steel Fasteners
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)

Split Insulated Wood Framed Wall

- 1/2” Gypsum
- 2x6 Wood Framed Cavity, 16” o.c., with R-19 Batt
- 1/2” Plywood Sheathing
- Varying Mineral Wool Insulation
- Omega Bar Hat Channel with Stainless Steel Fasteners
- Porcelanosa L-Brackets, 24” o.c. horizontally, with Stainless Steel Fasteners
- Vertical T-Girt
- Porcelain Cladding (not shown)



Further information for each assembly can be found with their respective results tables in Part 3 of this report.

2. MODELING PROCEDURES

The thermal performance of the assemblies with Porcelanosa cladding attachments were evaluated by 3D thermal modelling using the Nx software package from Siemens, which is a general purpose computer aided design (CAD) and finite element analysis (FEA) package. The thermal solver and modelling procedures utilized for this study were extensively calibrated and validated for *ASHRAE Research Project 1365-RP Thermal Performance of Building Envelope Details for Mid- and High-Rise Construction* and for the *Building Envelope Thermal Bridging Guide*[1].

The thermal analysis utilized steady-state conditions, published thermal properties of materials and information provided by Porcelanosa. Additional modeling assumptions for the thermal analyses are summarized in Appendix A.

[1] https://www.bchydro.com/thermalguide

3. PORCELANOSA CLADDING ATTACHMENT SYSTEM THERMAL RESULTS

The following sections present the thermal performance results (U-values and effective R-values that include thermal bridging) for each of the evaluated assemblies described in Section 1. The thermal performance of the Porcelanosa cladding attachment system with different backup wall types was evaluated at **24" o.c. horizontal spacing** and varying vertical spacing of the L-brackets, from 24"o.c. to 48" o.c. Four depths of the L-brackets were evaluated to support 2", 4", 6" and 8" of exterior mineral wool insulation. The variation in configuration of the L-brackets for varying depths is summarized below in Figure 3.1. Additional dimensions for each variation is presented in Appendix B.

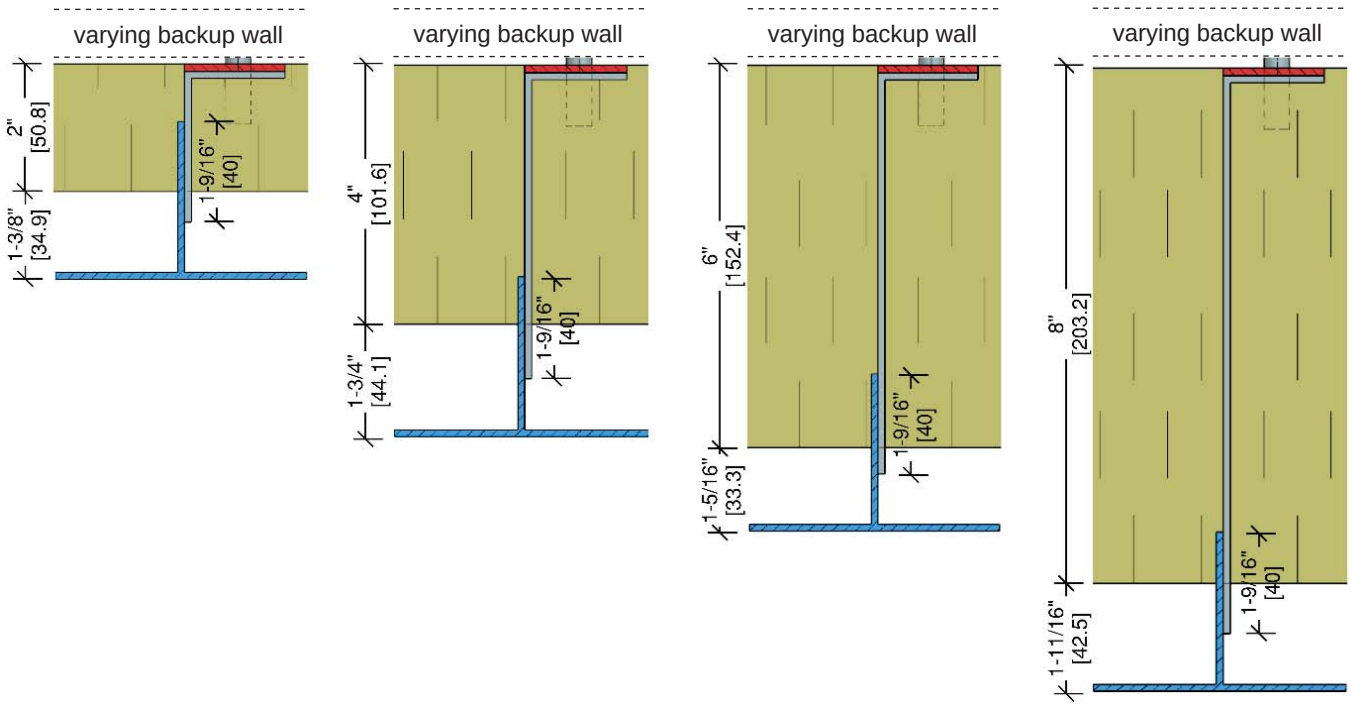


Figure 3.1: Component Arrangement for Varying Insulation Thicknesses

The results tables in the following sections provide the spacing of components, exterior insulation thickness, nominal R-value of the insulation and the determined assembly U- and effective R-Value that includes the impact of thermal bridging by the structural components, including studs and cladding attachments.

Note, the tables list the nominal R-value of the exterior insulation, however the sheathings, airspaces, and air films also all contribute towards the R-value of the assembly. Further assembly information, including dimensions and materials are given in Appendix B. Example temperature profiles for each system are provided in Appendix C.

3.1 Exterior Insulated Concrete Mass Wall

8” Concrete, with 1 5/8” Steel Studs and ½” Interior Drywall

Figure 3.2: Concrete Configuration

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System with a concrete mass wall are presented in Table 3.1.

The results include spacing of the L-brackets ranging from 24” to 48” o.c. vertically and 24” o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The concrete mass wall includes 1 5/8” steel stud cavity with studs spaced 16” o.c., and ½” gypsum inboard of the assembly. The L-brackets with a thermal isolator pad are fastened with a single concrete anchor penetrating 3 3/8” into the concrete mass wall.

Table 3.1: Clear Field Thermal Transmittance for Concrete Mass Wall Configuration

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Assembly U-Value **BTU/ hr°Fft² (W/m²K)**	Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)**
24	2	R-8.4 (1.48)	0.105 (0.598)	R-9.5 (1.67)
	4	R-16.8 (2.96)	0.071 (0.402)	R-14.1 (2.49)
	6	R-25.2 (4.44)	0.056 (0.320)	R-17.7 (3.13)
	8	R-33.6 (5.92)	0.047 (0.268)	R-21.2 (3.73)
36	2	R-8.4 (1.48)	0.099 (0.564)	R-10.1 (1.77)
	4	R-16.8 (2.96)	0.064 (0.363)	R-15.6 (2.76)
	6	R-25.2 (4.44)	0.049 (0.280)	R-20.2 (3.57)
	8	R-33.6 (5.92)	0.041 (0.230)	R-24.7 (4.34)
48	2	R-8.4 (1.48)	0.096 (0.547)	R-10.4 (1.83)
	4	R-16.8 (2.96)	0.060 (0.343)	R-16.5 (2.91)
	6	R-25.2 (4.44)	0.046 (0.261)	R-21.8 (3.84)
	8	R-33.6 (5.92)	0.037 (0.211)	R-26.9 (4.73)

3.2 Exterior Insulated Concrete Mass Wall with Omega Bar

8” Concrete, with 1 5/8” Steel Studs and ½” Interior Drywall

Figure 3.3: Concrete Configuration with Omega

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System and Omega Bar with a concrete mass wall are presented in Table 3.2.

The results include spacing of the L-brackets and omega bar ranging from 24” to 48” o.c. vertically and 24” o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The concrete mass wall includes 1 5/8” steel stud cavity with studs spaced 16” o.c., and ½” gypsum inboard of the assembly. The L-brackets with thermal isolator pad are fastened with two steel screws into the horizontal omega bar. The omega bar is fastened with two anchors into the concrete mass wall.

Table 3.2: Clear Field Thermal Transmittance for Concrete Mass Wall Configuration with Omega Bar Hat Channel

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr^oFft^2/BTU (m^2K/W)**	Assembly U-Value **$BTU/\ hr^oFft^2$ (W/m^2K)**	Assembly Effective R-Value **hr^oFft^2/BTU (m^2K/W)**
24	2	R-8.4 (1.48)	0.110 (0.625)	R-9.1 (1.60)
	4	R-16.8 (2.96)	0.074 (0.423)	R-13.4 (2.37)
	6	R-25.2 (4.44)	0.059 (0.336)	R-16.9 (2.98)
	8	R-33.6 (5.92)	0.049 (0.281)	R-20.2 (3.56)
36	2	R-8.4 (1.48)	0.103 (0.582)	R-9.7 (1.72)
	4	R-16.8 (2.96)	0.066 (0.376)	R-15.1 (2.66)
	6	R-25.2 (4.44)	0.051 (0.291)	R-19.5 (3.44)
	8	R-33.6 (5.92)	0.042 (0.239)	R-23.8 (4.19)
48	2	R-8.4 (1.48)	0.099 (0.561)	R-10.1 (1.78)
	4	R-16.8 (2.96)	0.062 (0.353)	R-16.1 (2.83)
	6	R-25.2 (4.44)	0.047 (0.269)	R-21.1 (3.72)
	8	R-33.6 (5.92)	0.038 (0.218)	R-26.1 (4.59)

3.3 Exterior Insulated Steel Stud Wall with Omega Bar

3 5/8" Steel Studs, 16"o.c. with ½" Gypsum Sheathing and Drywall

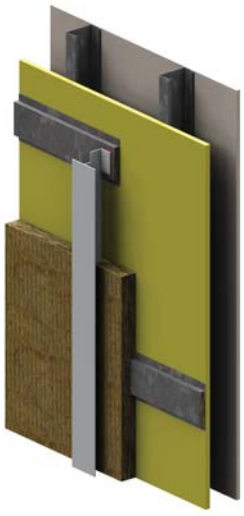


Figure 3.4: Exterior Insulated Steel Frame Configuration with Omega

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System and Omega Bar with an exterior insulated steel stud wall are presented in Table 3.3.

The results include spacing of the L-brackets and omega bar ranging from 24" to 48" o.c. vertically and 24" o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The steel stud backup wall includes an air-filled 3 5/8" steel stud cavity with studs spaced 16" o.c., and ½" exterior sheathing and interior gypsum. The L-brackets with thermal isolator pad are fastened with two steel screws into the horizontal omega bar. The omega bar is fastened with two steel screws through the exterior sheathing back to the studs.

Table 3.3: Clear Field Thermal Transmittance for Exterior Insulated Steel Stud System with Omega Bar Hat Channel

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Assembly U-Value **BTU/ hr°Fft² (W/m²K)**	Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)**
24	2	R-8.4 (1.48)	0.106 (0.600)	R-9.5 (1.67)
	4	R-16.8 (2.96)	0.071 (0.403)	R-14.1 (2.48)
	6	R-25.2 (4.44)	0.056 (0.319)	R-17.8 (3.14)
	8	R-33.6 (5.92)	0.047 (0.267)	R-21.3 (3.74)
36	2	R-8.4 (1.48)	0.100 (0.568)	R-10.0 (1.76)
	4	R-16.8 (2.96)	0.064 (0.364)	R-15.6 (2.75)
	6	R-25.2 (4.44)	0.049 (0.280)	R-20.3 (3.57)
	8	R-33.6 (5.92)	0.040 (0.230)	R-24.7 (4.35)
48	2	R-8.4 (1.48)	0.097 (0.552)	R-10.3 (1.81)
	4	R-16.8 (2.96)	0.061 (0.344)	R-16.5 (2.90)
	6	R-25.2 (4.44)	0.046 (0.261)	R-21.8 (3.83)
	8	R-33.6 (5.92)	0.037 (0.211)	R-26.9 (4.74)

3.4 Split Insulated Steel Stud Wall with Omega Bar

3 5/8" Steel Studs, 16"o.c. with ½" Gypsum Sheathing and Drywall and R-13 Batt

Figure 3.5: Split Insulated Steel Frame Configuration with Omega

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System and Omega Bar with a split insulated steel stud wall are presented in Table 3.4.

The results include spacing of the L-brackets and omega bar ranging from 24" to 48" o.c. vertically and 24" o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The steel stud backup wall includes a 3 5/8" steel stud cavity with R-13 Batt insulation between studs spaced 16" o.c., and ½" exterior sheathing and interior gypsum. The L-brackets with thermal isolator pad are fastened with two steel screws into the horizontal omega bar. The omega bar is fastened with two steel screws through the exterior sheathing back to the studs.

Table 3.4: Clear Field Thermal Transmittance for Split Insulated Steel Stud System with Omega Bar Hat Channel and R-13 Batt

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Interior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Assembly U-Value **BTU/ hr°Fft² (W/m²K)**	Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)**
24	2	R-8.4 (1.48)	R-13.0 (2.29)	0.061 (0.344)	R-16.5 (2.90)
	4	R-16.8 (2.96)	R-13.0 (2.29)	0.047 (0.266)	R-21.4 (3.76)
	6	R-25.2 (4.44)	R-13.0 (2.29)	0.040 (0.225)	R-25.2 (4.45)
	8	R-33.6 (5.92)	R-13.0 (2.29)	0.035 (0.197)	R-28.8 (5.08)
36	2	R-8.4 (1.48)	R-13.0 (2.29)	0.058 (0.332)	R-17.1 (3.01)
	4	R-16.8 (2.96)	R-13.0 (2.29)	0.044 (0.247)	R-23.0 (4.05)
	6	R-25.2 (4.44)	R-13.0 (2.29)	0.036 (0.204)	R-27.9 (4.91)
	8	R-33.6 (5.92)	R-13.0 (2.29)	0.031 (0.174)	R-32.6 (5.74)
48	2	R-8.4 (1.48)	R-13.0 (2.29)	0.057 (0.326)	R-17.4 (3.07)
	4	R-16.8 (2.96)	R-13.0 (2.29)	0.042 (0.238)	R-23.9 (4.21)
	6	R-25.2 (4.44)	R-13.0 (2.29)	0.034 (0.193)	R-29.4 (5.18)
	8	R-33.6 (5.92)	R-13.0 (2.29)	0.029 (0.163)	R-34.8 (6.13)

3.5 Exterior Insulated Wood Framed Wall with Omega Bar

2x6" Wood Studs, 16"o.c. with ½" Wood Sheathing and Interior Drywall

Figure 3.6: Exterior Insulated Wood Frame Configuration

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System with an exterior insulated wood framed wall are presented in Table 3.5.

The results include spacing of the L-brackets and omega bar ranging from 24" to 48" o.c. vertically and 24" o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The wood framed wall includes an air-filled 2" x 6" wood stud cavity with studs spaced 16" o.c., and ½" exterior plywood sheathing and interior gypsum. The L-brackets with thermal isolator pad are fastened with two steel screws into the horizontal omega bar. The omega bar is fastened with two steel screws through the exterior sheathing back to the studs.

Table 3.5: Clear Field Thermal Transmittance for Exterior Insulated Wood Framed Wall Configuration with Omega Bar Hat Channel

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Assembly U-Value **BTU/ hr°Fft² (W/m²K)**	Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)**
24	2	R-8.4 (1.48)	0.101 (0.573)	R-9.9 (1.75)
	4	R-16.8 (2.96)	0.068 (0.385)	R-14.8 (2.60)
	6	R-25.2 (4.44)	0.054 (0.307)	R-18.5 (3.26)
	8	R-33.6 (5.92)	0.045 (0.258)	R-22.0 (3.87)
36	2	R-8.4 (1.48)	0.096 (0.543)	R-10.5 (1.84)
	4	R-16.8 (2.96)	0.062 (0.350)	R-16.2 (2.86)
	6	R-25.2 (4.44)	0.048 (0.271)	R-21.0 (3.69)
	8	R-33.6 (5.92)	0.039 (0.223)	R-25.4 (4.48)
48	2	R-8.4 (1.48)	0.093 (0.528)	R-10.8 (1.89)
	4	R-16.8 (2.96)	0.058 (0.332)	R-17.1 (3.01)
	6	R-25.2 (4.44)	0.045 (0.253)	R-22.4 (3.95)
	8	R-33.6 (5.92)	0.036 (0.206)	R-27.6 (4.86)

3.6 Split Insulated Wood Framed Wall with Omega Bar

2x6" Wood Studs, 16"o.c. with ½" Wood Sheathing and Interior Drywall and R-19 Batt

Figure 3.7: Split Insulated Wood Frame Configuration

The thermal transmittance U-value results of the Porcelanosa Cladding Attachment System with a split insulated wood framed wall are presented in Table 3.6.

The results include spacing of the L-brackets and omega bar ranging from 24" to 48" o.c. vertically and 24" o.c. horizontally. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The wood framed wall includes a 2" x 6" wood stud cavity with R-19 Batt insulation between studs spaced 16" o.c., and ½" exterior plywood sheathing and interior gypsum. The L-brackets with thermal isolator pad are fastened with two steel screws into the horizontal omega bar. The omega bar is fastened with two steel screws through the exterior sheathing back to the studs.

Table 3.6: Clear Field Thermal Transmittance for Split Insulated Wood Framed Wall Configuration with Omega Bar Hat Channel and R-19 Batt

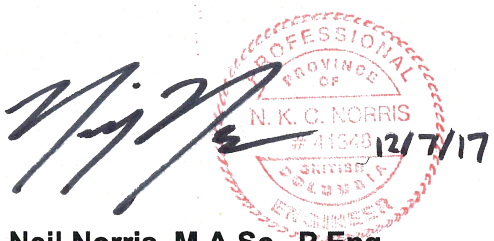
Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Interior Insulation Nominal R-Value **hr°Fft²/BTU (m²K/W)**	Assembly U-Value **BTU/ hr°Fft² (W/m²K)**	Assembly Effective R-Value **hr°Fft²/BTU (m²K/W)**
24	2	R-8.4 (1.48)	R-19.0 (3.35)	0.038 (0.216)	R-26.3 (4.63)
	4	R-16.8 (2.96)	R-19.0 (3.35)	0.032 (0.180)	R-31.5 (5.55)
	6	R-25.2 (4.44)	R-19.0 (3.35)	0.028 (0.159)	R-35.7 (6.28)
	8	R-33.6 (5.92)	R-19.0 (3.35)	0.025 (0.144)	R-39.5 (6.95)
36	2	R-8.4 (1.48)	R-19.0 (3.35)	0.037 (0.212)	R-26.8 (4.72)
	4	R-16.8 (2.96)	R-19.0 (3.35)	0.030 (0.172)	R-33.0 (5.82)
	6	R-25.2 (4.44)	R-19.0 (3.35)	0.026 (0.148)	R-38.2 (6.73)
	8	R-33.6 (5.92)	R-19.0 (3.35)	0.023 (0.131)	R-43.2 (7.61)
48	2	R-8.4 (1.48)	R-19.0 (3.35)	0.037 (0.210)	R-27.1 (4.77)
	4	R-16.8 (2.96)	R-19.0 (3.35)	0.030 (0.168)	R-33.8 (5.96)
	6	R-25.2 (4.44)	R-19.0 (3.35)	0.025 (0.143)	R-39.7 (6.99)
	8	R-33.6 (5.92)	R-19.0 (3.35)	0.022 (0.125)	R-45.3 (7.98)

4. CONCLUSIONS

This report highlights the performance for the Porcelanosa Cladding Attachment System for varying levels of insulation, component spacings and substrates.

The L -values provided in this report can be used for compliance calculations through any of the compliance paths set forth in relevant energy codes and standards such as ASHRAE 90.1, IECC, and/or NECB as of the published date of this report.

Morrison Hershfield / imited



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APPENDIX A – MODELLING PARAMETERS AND ASSUMPTIONS

A.1 General Modeling Approach

For this report, a steady-state conduction model was used. The following parameters were also assumed:

- Air cavity conductivities were taken from ISO 10077 and Table 3, p. 26.13 of 2013 ASHRAE Handbook – Fundamentals
- Interior/exterior air films were taken from Table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundamentals depending on surface orientation. The exterior air films were based on an exterior windspeed of 15mph.
- Cladding materials and secondary structures outboard of the insulation can vary widely. It has been found in ASHRAE 1365, for rainscreen cavity systems most lightweight claddings have an insignificant impact on the thermal performance other than shielding the insulation from direct wind exposure. To provide general information for the system, the cladding, secondary structure outboard of the vertical rails and rainscreen cavity were not explicitly modelled, but was incorporated into the exterior film coefficient.
- Material properties were taken from information provided by Porcelanosa, published material information from Lawrence Berkeley National Laboratory and ASHRAE Handbook – Fundamentals for common materials (such sheathings, wood studs etc). These values are typically reported at operating temperatures between 0°C and 21°C
- Materials used in this analysis were assumed to have a constant thermal conductivity.
- From the calibration in 1365-RP, contact resistances between materials were modeled. This varied between R-0.01 and R-0.2 depending on the materials and interfaces.
- The temperature difference between interior and exterior was modeled as a dimensionless temperature index between 0 and 1 (see Appendix B.3).
- As per standard U-value evaluation, no solar heating impacts were included.
- Placement of weather barriers and membranes were assumed not to impact the thermal conduction through the system and were not included in the analysis.

A.2 Thermal Transmittance

The methodology presented in the Building Envelope Thermal Bridging Guide separates the thermal performance of clear field assemblies and transition details (slabs, parapets, window interfaces) in order to simplify heat loss calculations.

For this report, only clear field transmittances for this system were evaluated, and not any transition details. The presented U-values in the Tables in Section 3 contain only uniform repeating thermal bridges, such as studs and clips, and do not include any interface details, such as slab intersections or top and bottom stud tracks.

A.3 Temperature Index

The temperature index is the ratio of the surface temperature relative to the interior and exterior temperatures. The temperature index has a value between 0 and 1, where 0 is the exterior temperature and 1 is the interior temperature. If T_i is known, Equation 1 can be rearranged for $T_{surface}$. This arrangement allows the modelled surface temperatures to be applicable to any climate.

$$T_i = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}} \qquad \text{EQ 1}$$

Note, these indices shown in the temperature profiles for this analysis are for general information only and are **not** intended to predict in-service surface temperatures subject to transient conditions, variable heating systems, and/ or interior obstructions that restrict heating of the assembly. For full limitations of this modeling approach, see ASHRAE 1365-RP

A.4 Boundary Conditions

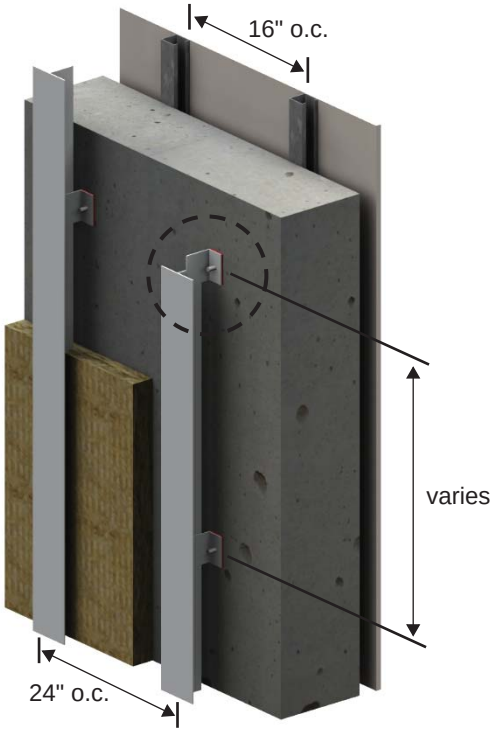
Table A-1: Boundary Conditions

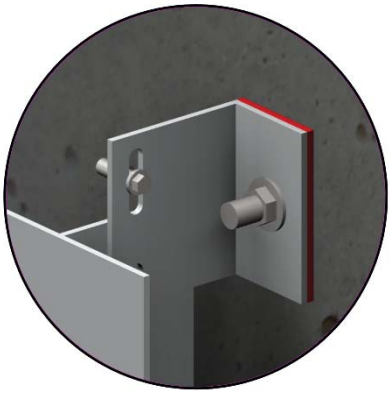
Boundary Location	**Convective and Radiation Heat Transfer Coefficient** BTU/hft^2°F (W/m^{2}K)
Exterior (15mph wind)	6.0 (34.0)
Interior Walls	1.5 (8.3)

APPENDIX B – ASSEMBLY INFORMATION AND MATERIAL PROPERTIES

Porcelanosa Cladding Attachment System

Exterior Insulated Concrete Mass Wall

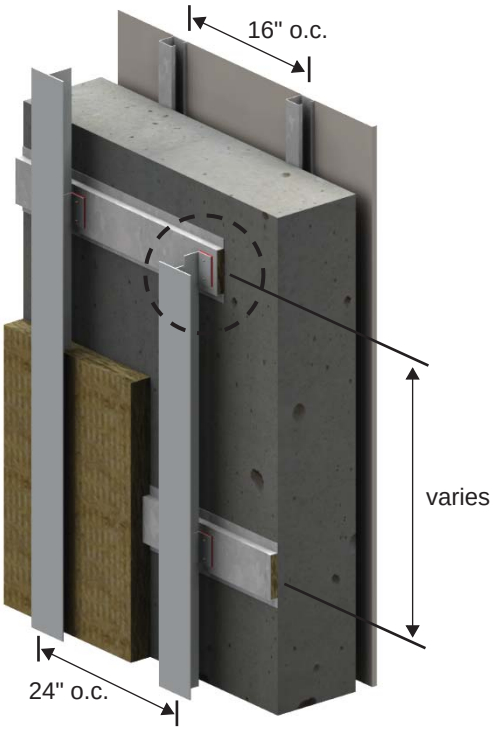


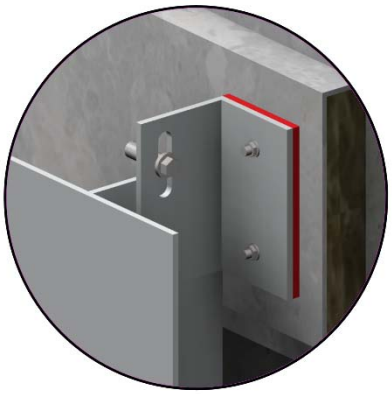


Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (RSI-0.16)
1 5/8" x 1 5/8" Steel Studs, 16" o.c.	18 gauge	430 (62)	-
Concrete Wall	8" (203)	12.5 (1.8)	-
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
Concrete Anchor	3/8" (10) ø	430 (62)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25 mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Porcelanosa Cladding Attachment System

Exterior Insulated Concrete Mass Wall with Omega Bar Hat Channel

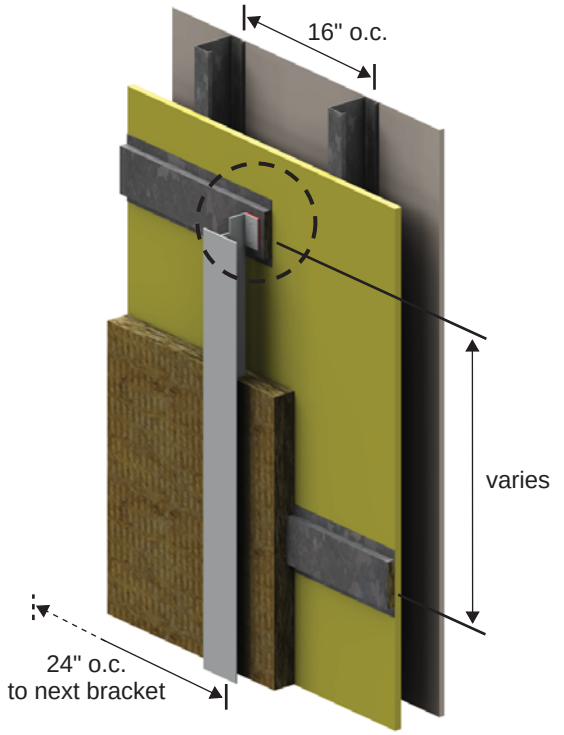




Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	1 5/8" (41)	-	R-0.9 (RSI-0.16)
1 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Concrete Wall	8" (203)	12.5 (1.8)	-
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
L-Bracket Stainless Steel Fasteners	1/4" (6) Ø	118 (17)	-
Aluminum Omega Bar	12 gauge	1109 (160)	-
Omega Bar Stainless Steel Fasteners	#12 (5.5) Ø	118 (17)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25 mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Porcelanosa Cladding Attachment System

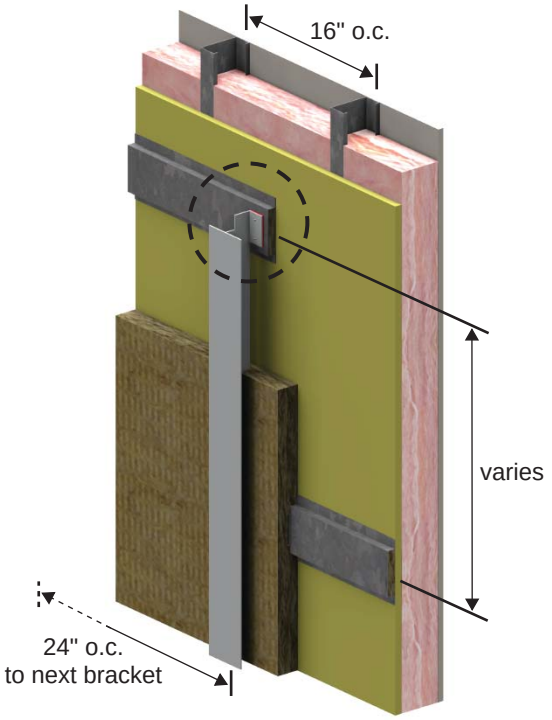
Exterior Insulated Steel Stud Wall with Omega Bar Hat Channel



Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (RSI-0.16)
3 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
L-Bracket Stainless Steel Fasteners	1/4" (6) Ø	118 (17)	-
Aluminum Omega Bar	12 gauge	1109 (160)	-
Omega Bar Stainless Steel Fasteners	#12 (5.5) Ø	118 (17)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Porcelanosa Cladding Attachment System

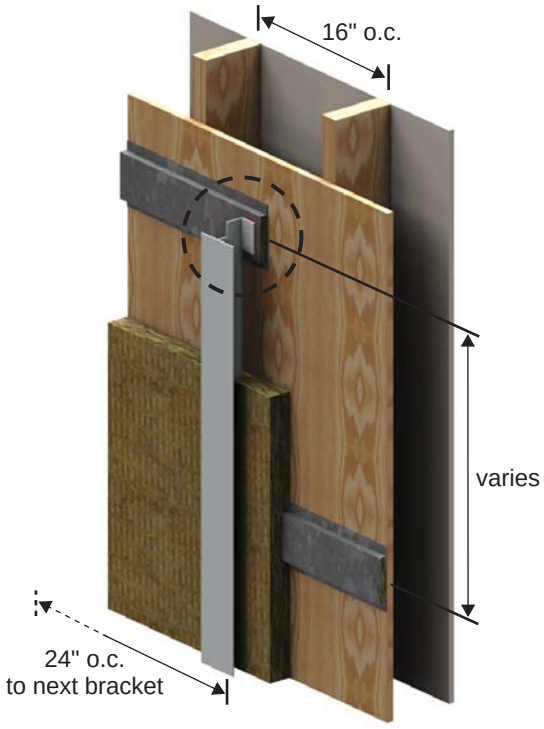
Split Insulated Steel Stud Wall with Omega Bar Hat Channel



Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Fiberglass Batt Insulation	3 5/8" (92)	0.28 (0.040)	R-13 (RSI-2.18)
3 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
L-Bracket Stainless Steel Fasteners	1/4" (6) Ø	118 (17)	-
Aluminum Omega Bar	12 gauge	1109 (160)	-
Omega Bar Stainless Steel Fasteners	#12 (5.5) Ø	118 (17)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Porcelanosa Cladding Attachment System

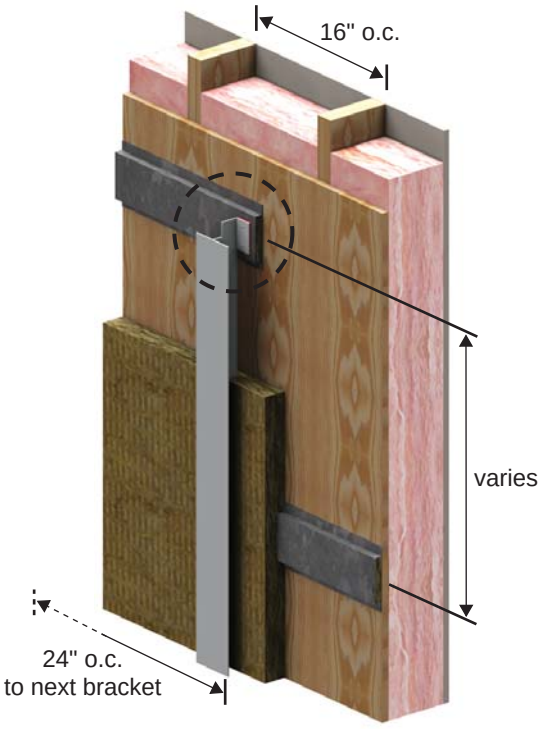
Exterior Insulated Wood Framed Wall with Omega Bar Hat Channel



Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	5 1/2" (140)	-	R-0.9 (RSI-0.16)
2x6 Wood Studs, 16"o.c.	5 1/2" (140)	0.69 (0.1)	-
Exterior Plywood Sheathing	1/2" (13)	0.69 (0.1)	R-0.7 (RSI-0.13)
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
L-Bracket Stainless Steel Fasteners	1/4" (6) Ø	118 (17)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Porcelanosa Cladding Attachment System

Split Insulated Wood Framed Wall with Omega Bar Hat Channel



Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Fiberglass Batt Insulation	5 1/2" (140)	0.29 (0.042)	R-19 (RSI-3.35)
2x6 Wood Studs, 16"o.c.	5 1/2" (140)	0.69 (0.1)	-
Exterior Plywood Sheathing	1/2" (13)	0.69 (0.1)	R-0.7 (RSI-0.13)
Exterior Insulation (Mineral Wool)	2" to 8" (51 to 203)	0.24 (0.034)	R-8.4 to R-33.6 (RSI-1.48 to RSI-5.92)
HDPE Thermal Break	-	3.5 (0.5)	-
Aluminum L-Brackets, 24" o.c. horizontally	12 gauge	1109 (160)	-
L-Bracket Stainless Steel Fasteners	1/4" (6) ø	118 (17)	-
Aluminum T-girts, 24" o.c.	12 gauge	1109 (160)	-
Cladding with min 1" (25mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

APPENDIX C –
SIMULATED TEMPERATURE PROFILES

Figure C1: Exterior Insulated Concrete Mass Wall

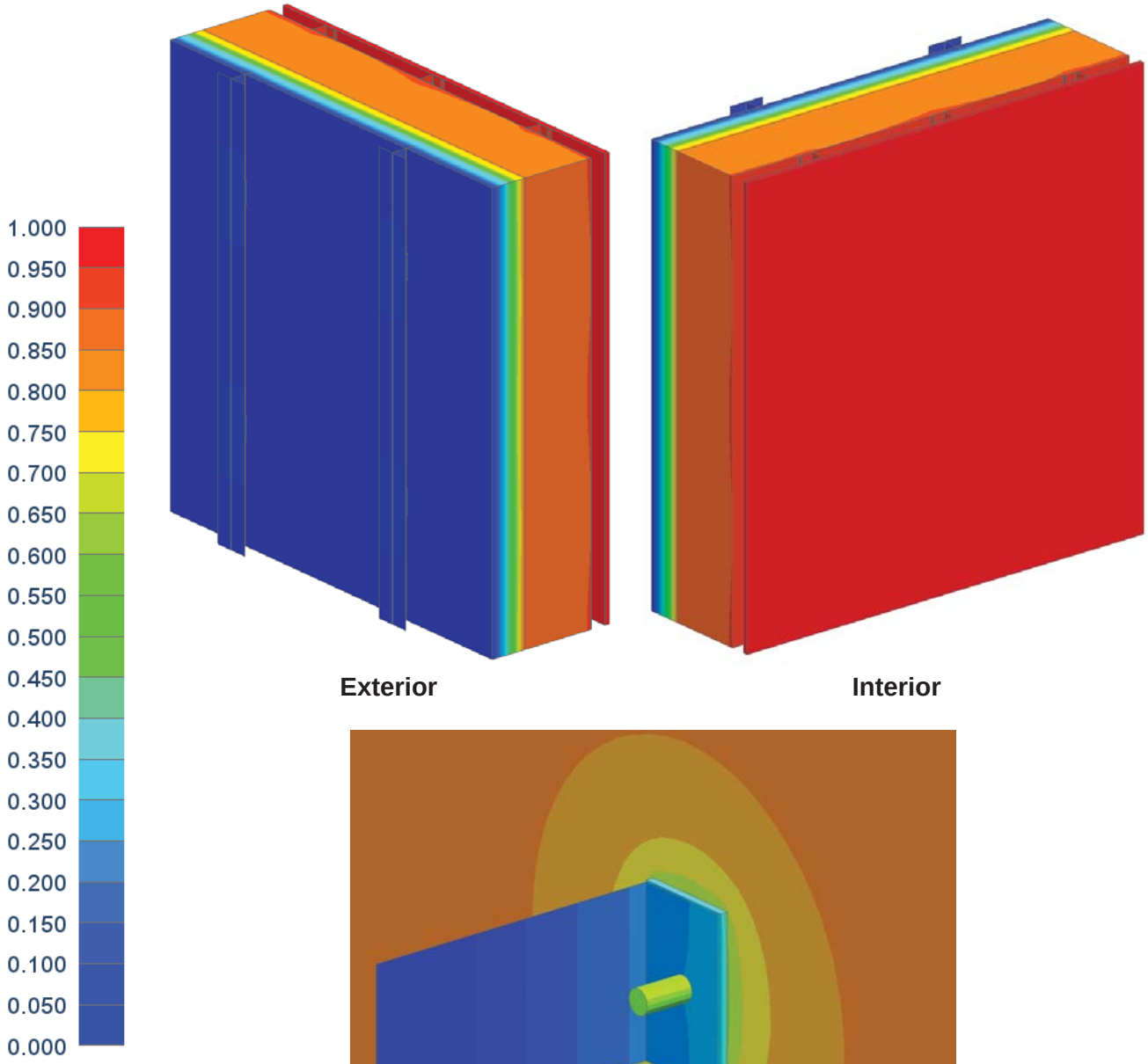
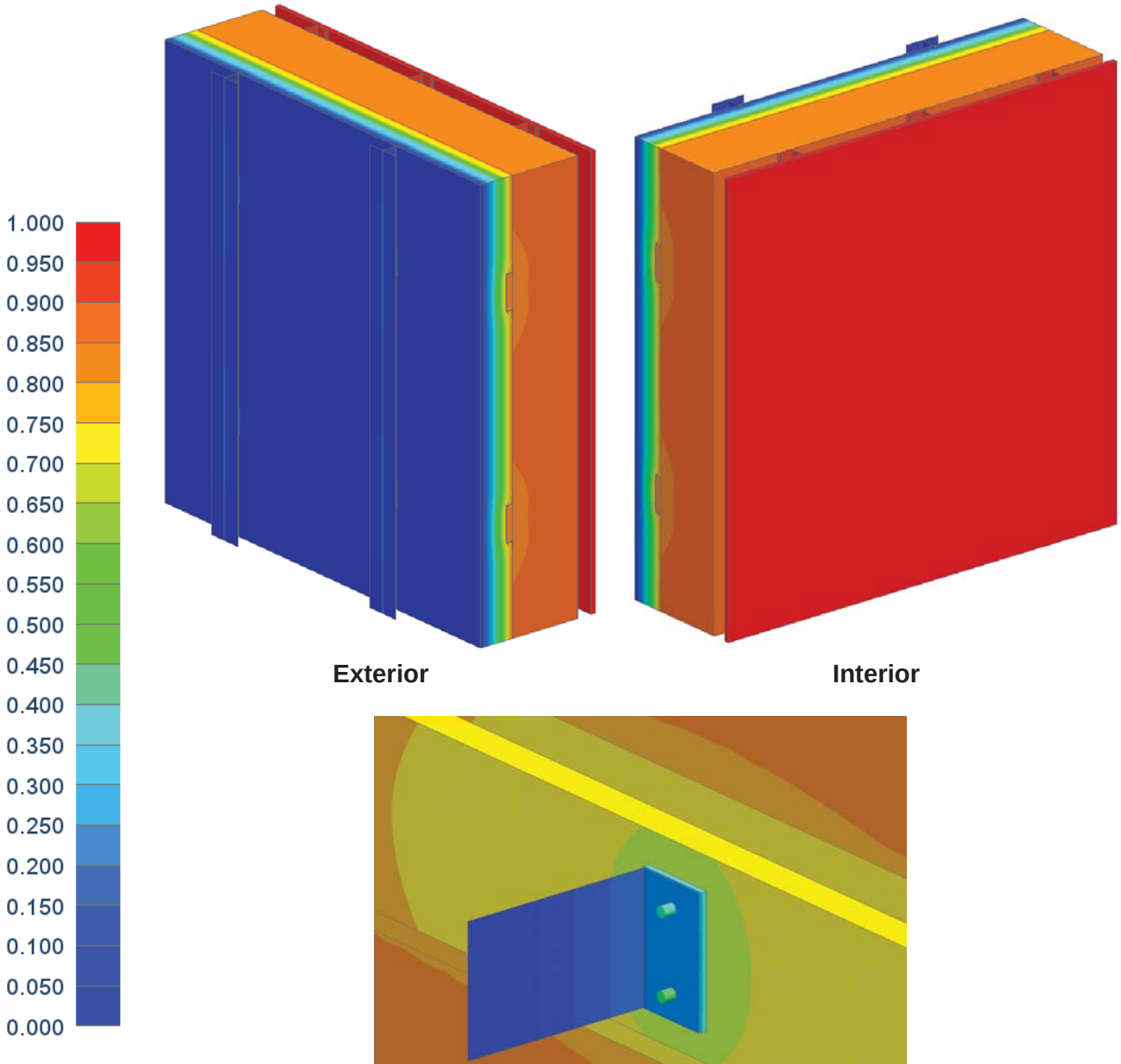
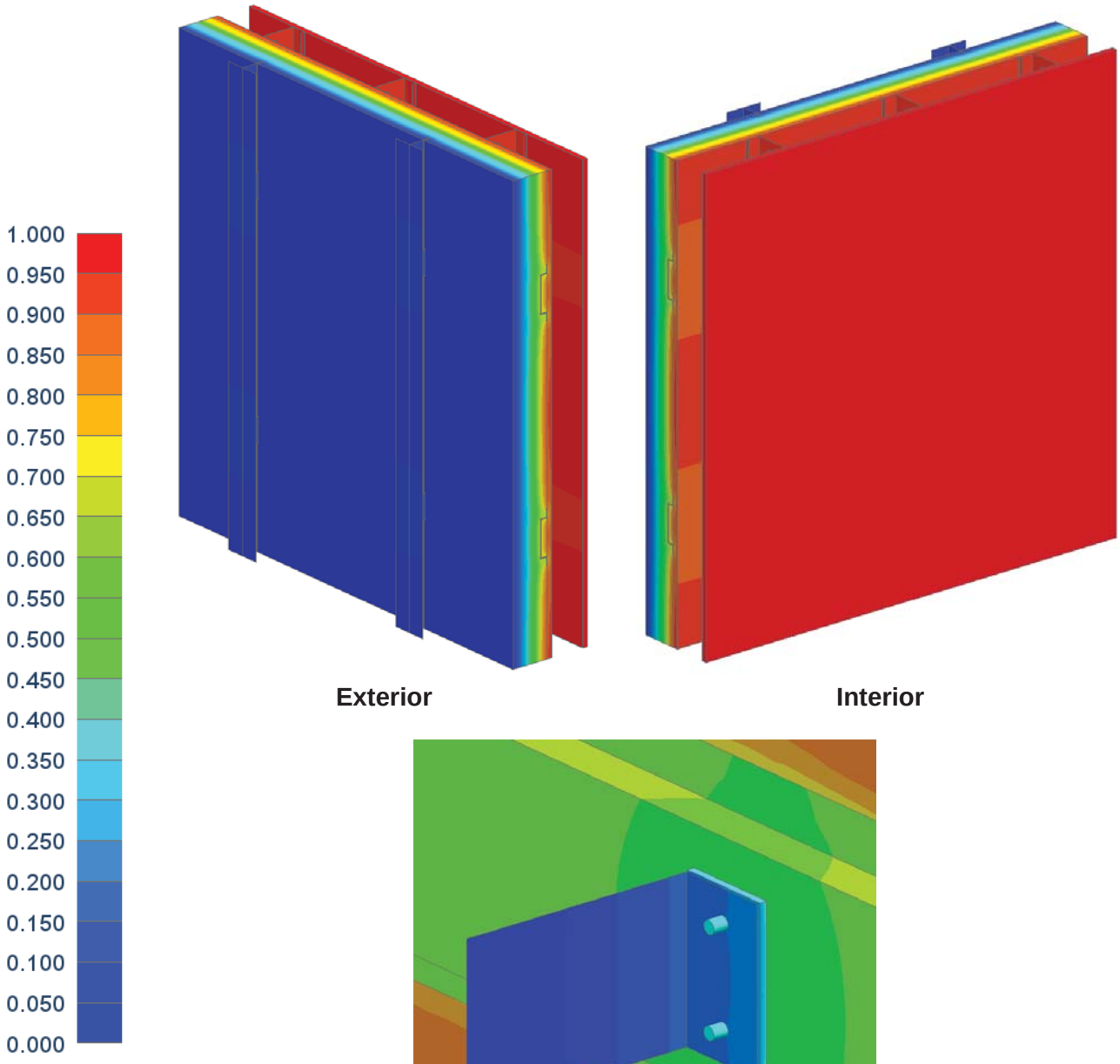


Figure C2: Exterior Insulated Concrete Mass Wall with Omega Bar



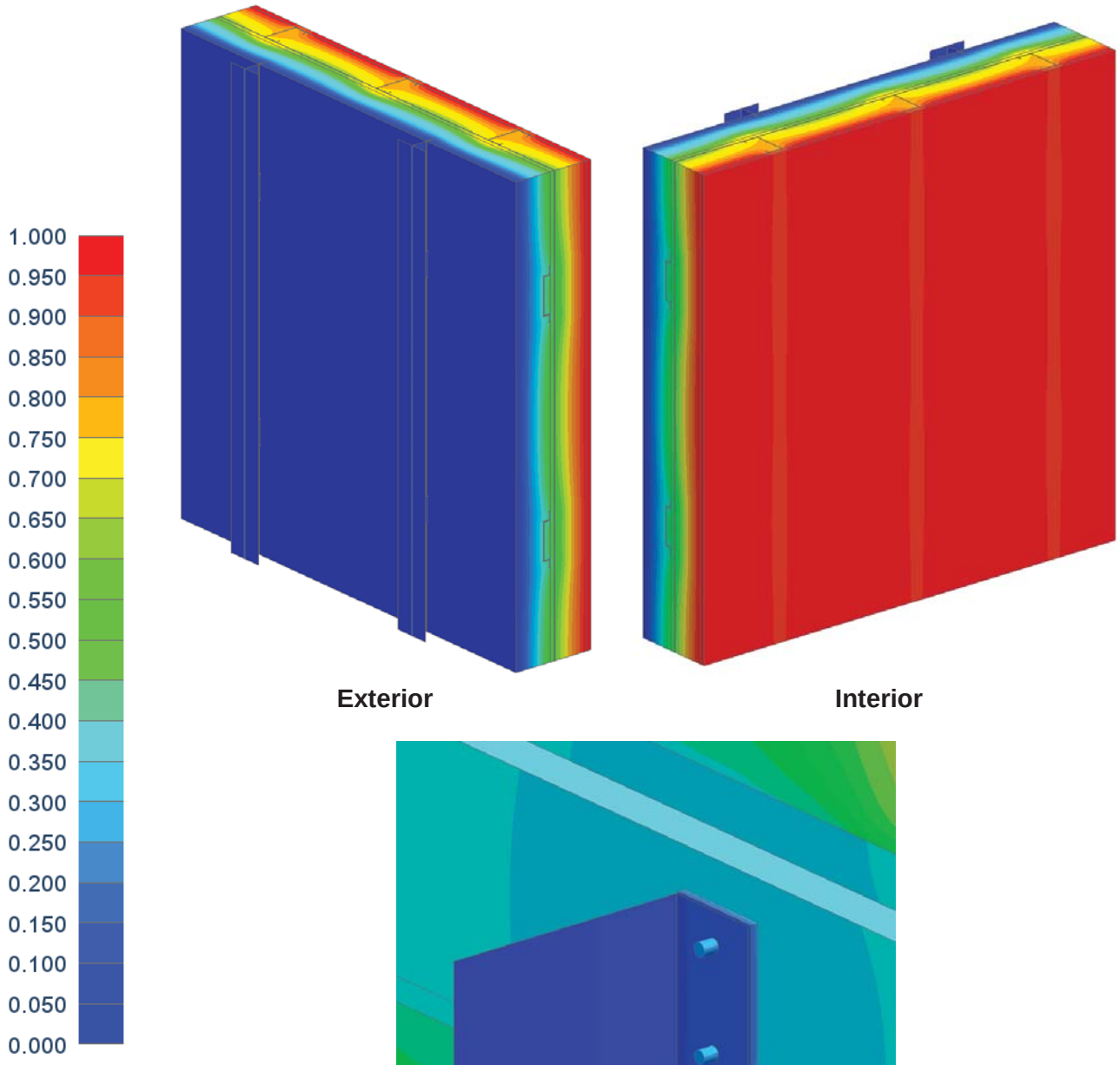
L-Angle

Figure C3: Exterior Insulated Steel Stud Wall with Omega Bar



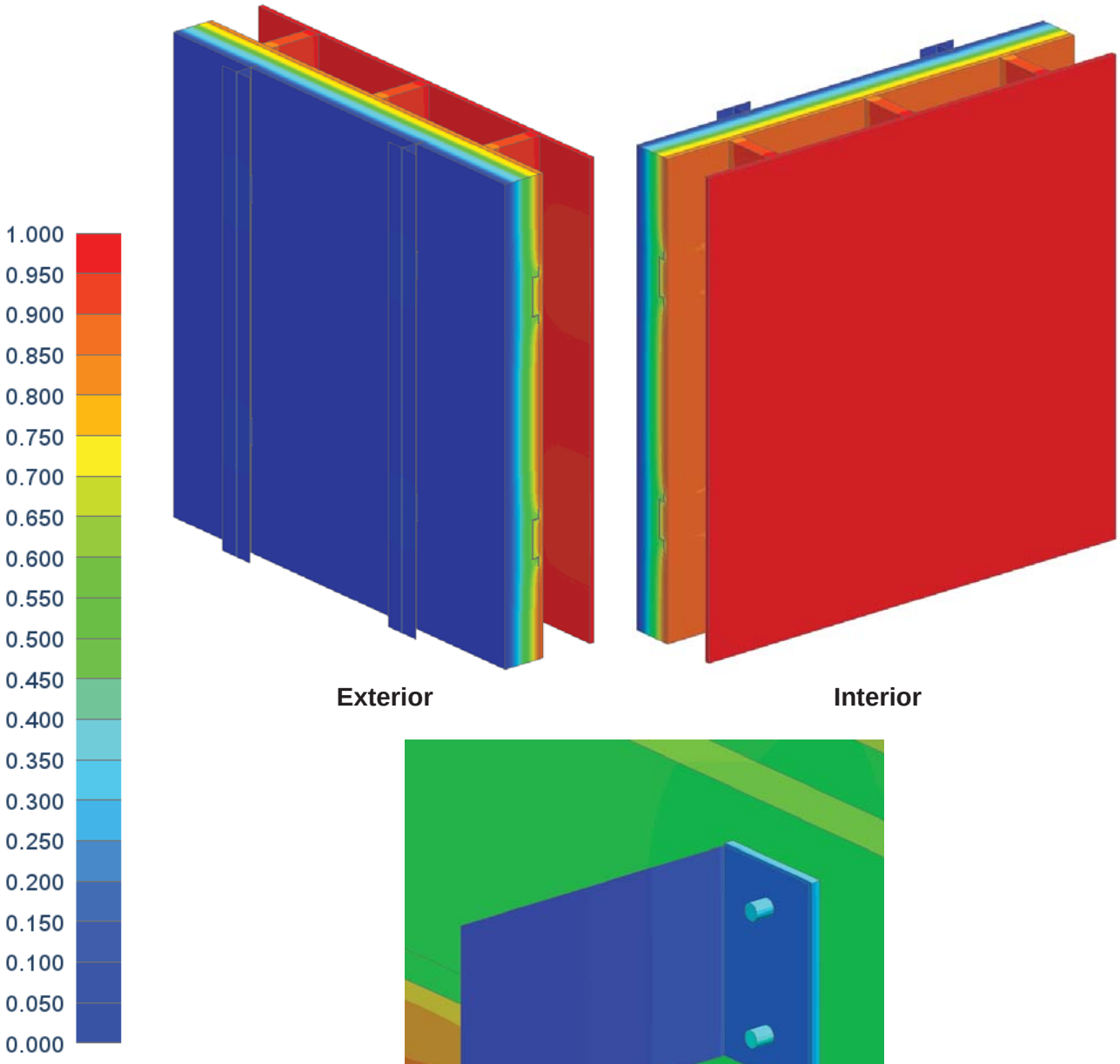
L-Angle

Figure C4: Split Insulated Steel Stud Wall with Omega Bar



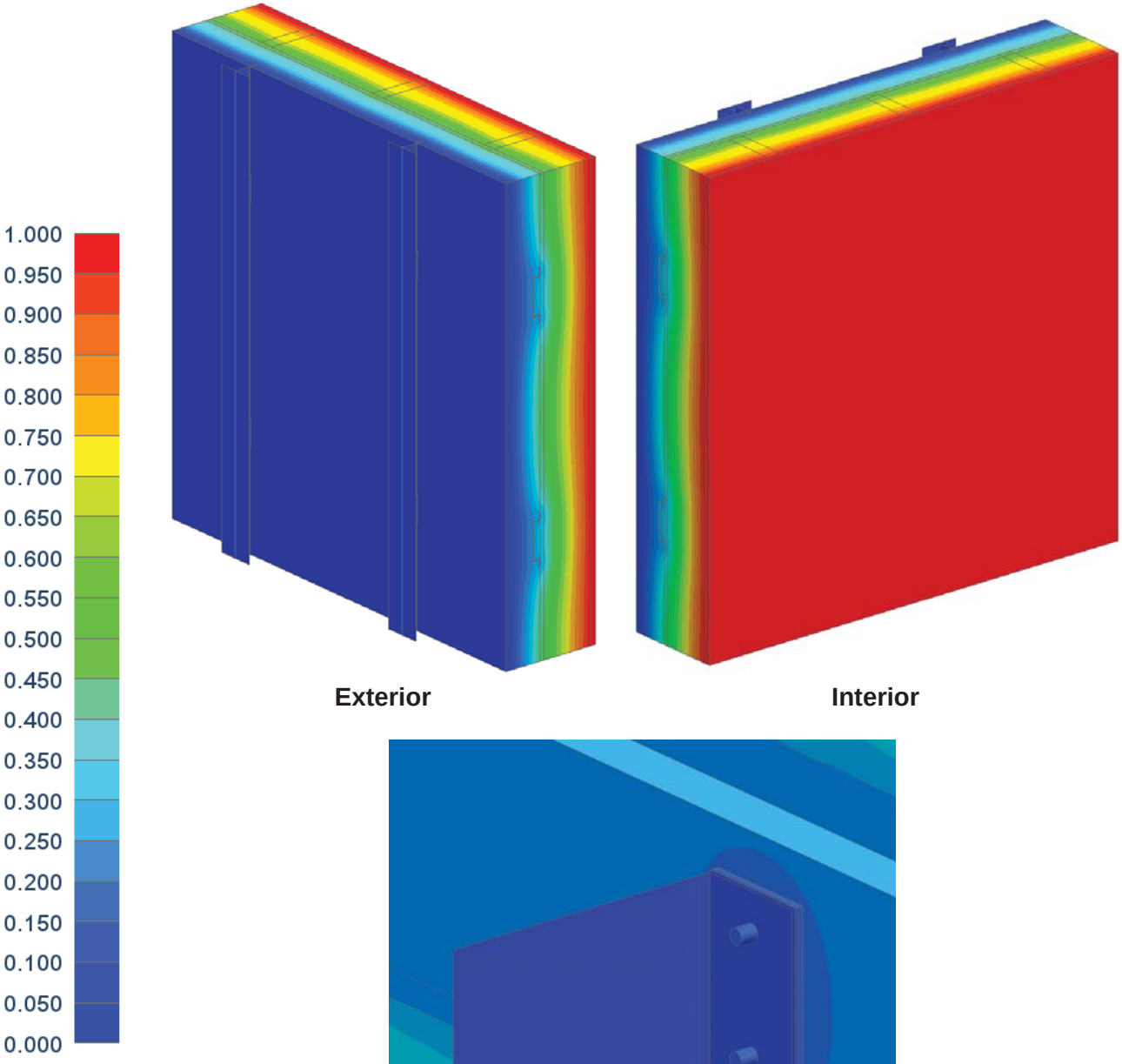
L-Angle

Figure C5: Exterior Insulated Wood Framed Wall with Omega Bar



L-Angle

Figure C6: Split Insulated Wood Framed Wall with Omega Bar



L-Angle