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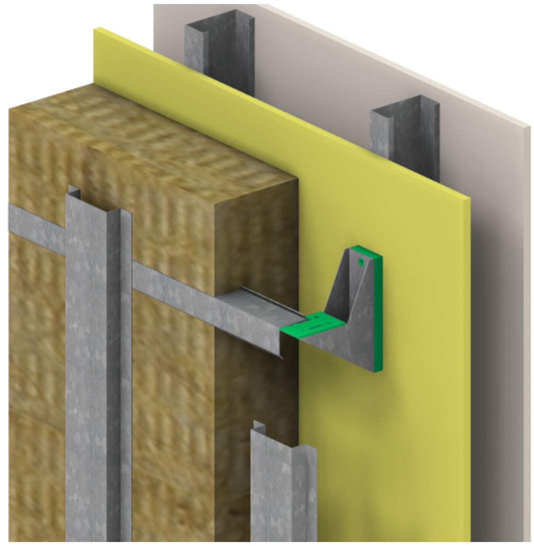
Thermal Performance of Spring Valley Architectural Innovations iCLAD Bracket System



Presented to:

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1. INTRODUCTION AND BACKGROUND

Spring Valley Architectural Innovations (Spring Valley) has developed a proprietary cladding attachment system for use with exterior insulation. Morrison Hershfield (MH) was contracted by Spring Valley to evaluate the structural and thermal performance of their iCLAD bracket system for a variety of assembly scenarios, including insulation thickness, girt spacing and backup wall configuration. This report is a summary of that analysis.

The iCLAD bracket system, shown in Figures 1.1 and 1.2, consists of a bracket supporting a continuous horizontal girt, with optional vertical hat tracks outboard, on which the cladding can be mounted. The horizontal girt is fastened to the top flange of the iCLAD bracket, which is in turn is fastened to the substrate. The iCLAD bracket system includes a plastic isolator (shown in green) between the bracket and the substrate, and between the horizontal girt and the bracket, intended to act as a thermal break. Exterior insulation is supported by and fit between the brackets and girts.

Figure 1.1: *iCLAD Bracket*

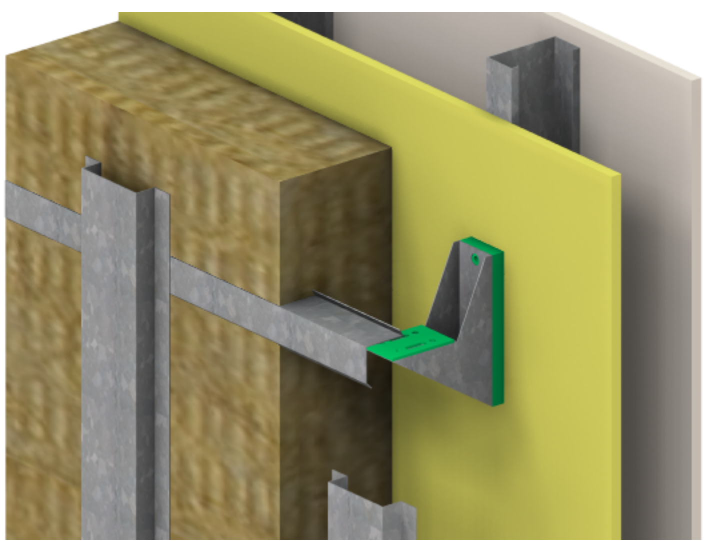


Figure 1.2: *iCLAD Bracket on Steel Stud Wall Substrate*

The iCLAD system can support multiple thicknesses of insulation by varying the depth and angle of the side flanges of the bracket as well as the depth of the horizontal girt. Figure 1.3 illustrates the bracket and girt system at varying insulation depths and the level of girt penetration into the mineral wool insulation for this analysis.

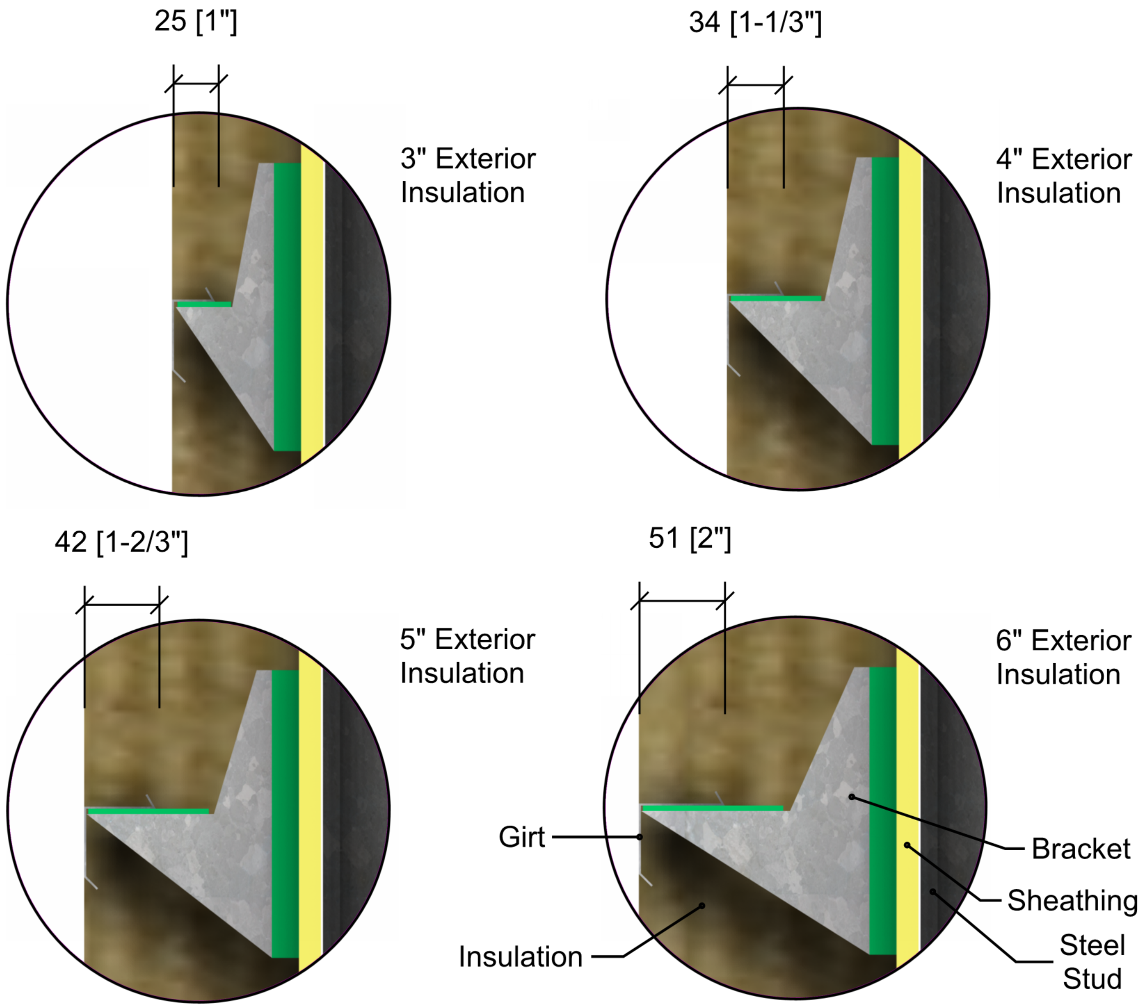
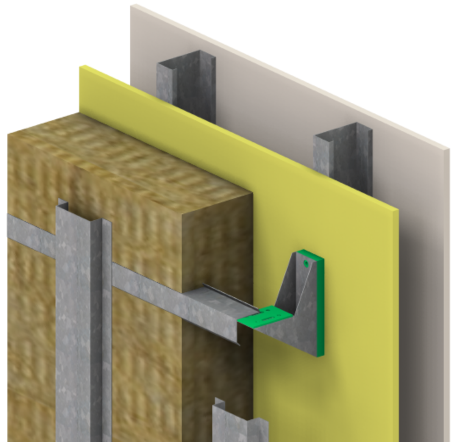


Figure 1.3: *iCLAD Bracket and Horizontal Girt Penetrations*

For this report, the iCLAD bracket system was analyzed for structural and thermal performance. The thermal analysis examined multiple levels of mineral wool insulation and vertical bracket spacings for the following three backup walls. For the structural analysis, the system was analyzed for varying wind loads and cladding weights for multiple backup walls. Further information on the structural and thermal analysis can be found in their respective sections. Material properties and additional component information can be found in Appendix A[1].

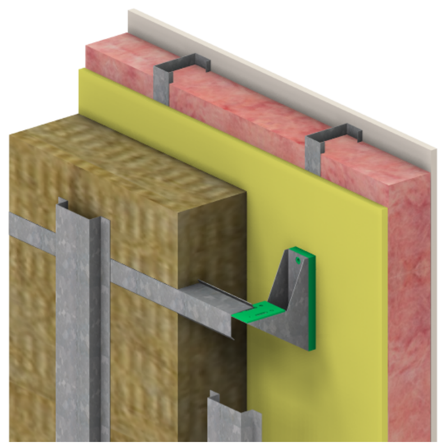
Scenario 1: Steel Stud Backup Wall

- ½" Gypsum
- Air space with 18 Ga 3 5/8" Steel Studs, 16" (406 mm) o.c.
- ½" Sheathing
- Exterior Insulation
- iCLAD Bracket
- Horizontal Girt
- Lightweight Cladding



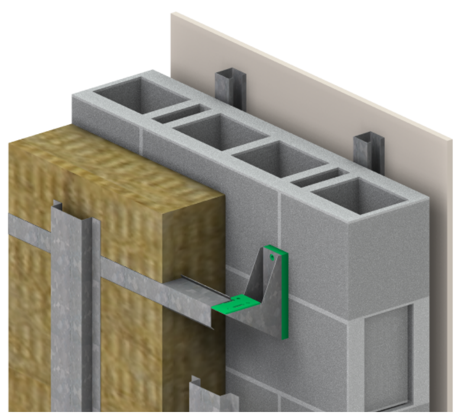
Scenario 2: Steel Stud Backup Wall with R-12 Batt in the insulation cavity

- ½" Gypsum
- R-12 Batt Insulation with 18 Ga 3 5/8" Steel Studs, 16" (406 mm) o.c.
- ½" Sheathing
- Exterior Insulation
- iCLAD Bracket
- Horizontal Girt
- Lightweight Cladding



Scenario 3: Hollow Masonry Block[2]

- ½" Gypsum
- Air Space with 18 Ga 1 5/8" Steel Studs, 16" (406mm) o.c.
- 8" Hollow Concrete Block Wall
- Exterior Insulation
- iCLAD Bracket
- Horizontal Girt
- Lightweight Cladding



[1] Fasteners were assumed to be carbon steel with zinc coating. See structural analysis in Section 3 for specific screw information
[2] A poured-in-place concrete wall was also examined, in addition to the hollow masonry block, for this assembly in the structural analysis. See Section 3.

2. MODELING OUTLINE

The structural and thermal modeling for this report was performed using the Nx software package from Siemens, which is a general purpose computer aided design (CAD) and finite element analysis (FEA) software suite, as well as manual calculations and examination. The thermal solver and modeling 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 (1365-RP)[3]. This methodology was also used to determine the thermal performance of an extensive amount of building details, including various bracket and masonry anchor attachment methods, with comprehensive results presented in the Building Envelope Thermal Bridging Guide[4]. The modeling assumptions for the structural and thermal analyses are summarized in Appendix B.

The modelled iCLAD bracket system, including dimensioning, was based on discussions and shop drawings provided by Spring Valley.

[3] http://www.morrisonhershfield.com/ashrae1365research/Pages/Insights-Publications.aspx

[4] http://www.bchydro.com/thermalguide

3. STRUTCTURAL ANALYSIS FOR iCLAD BRACKET SYSTEM

The structural analysis of the iCLAD bracket strength involved manual calculations and various in-house software tools related to strength of cold-formed steel structural components. In order to substantiate these results, the iCLAD bracket was additionally analyzed using finite element analysis (FEA).

The iCLAD brackets were examined for four wind loads and two horizontal bracket spacings, 16"o.c. and 32"o.c., which represents at bracket at every stud or every other stud. **Two cladding weights of 5 psf (0.24 kPa) and 10 psf (0.48 kPa) were assumed in the evaluation[5]**. This weight includes the cladding itself and the weight of all framing support elements outboard of the wall substrate. The analysis was performed on the backup walls described in Section 1, as well as a poured-in-place concrete wall with the same stud furring as Scenario 3.

Three aspects of the structural performance of the bracket system were examined. The first was the capacity of the clip, including the fastener pull out strength. The second was the maximum spacing of the brackets for the given wind and dead loads. Finally, the system was examined for its limiting factors, including the horizontal girt strength.

3.1 Fastener and iCLAD Bracket Capacity

For the analysis of the bracket and fastener capacity, the following fasteners were assumed with ¾" (19 mm) diameter round washers:

- Scenario 1 and 2, Steel Stud Wall: iCLAD brackets are assumed to be fastened through the sheathing to the wall studs with two ¼" diameter self-drilling screws (Teks, or equivalent published pull-out strength). Applies to both air filled and batt filled stud cavities.
- Scenario 3a, Hollow Masonry Block Wall: iCLAD brackets fastened with two ¼" diameter Hilti Kwik-Con II fasteners, with a minimum embedment into the block wall of 25 mm (1").
- Scenario 3b, Poured-In-Place Concrete Wall: iCLAD brackets fastened with two ¼" diameter Hilti Kwik-Con II fasteners, with a minimum embedment into the concrete of 44 mm (1.75").

Principal stress profile images from the FEA model are shown in Appendix C. The system was examined for 3" and 6" depths. The resulting stresses in the iCLAD bracket from the FEA analysis were generally in line with the results derived from simplified calculation methods. From the analysis, two locations of stress concentrations within the iCLAD bracket were of note, as shown in Figure 3.1. The first area found with the highest stress concentration for the bracket was at the inner corner joint between the horizontal "shelf" of the bracket and the upper "web" elements. The other areas of high stress were around the fastener holes in the back of the iCLAD bracket.

Sufficient corrosion protection of the fasteners must be specified by the end user to suit the application. For example, proprietary coating systems (Leland Industries DT2000 or equivalent performance), are recommended for fasteners exposed to exterior conditions, such as within the exterior cavity of rain-screen wall assemblies.

[5] The values and discussion in this structural analysis are intended to apply to cladding weights less than 10psf only

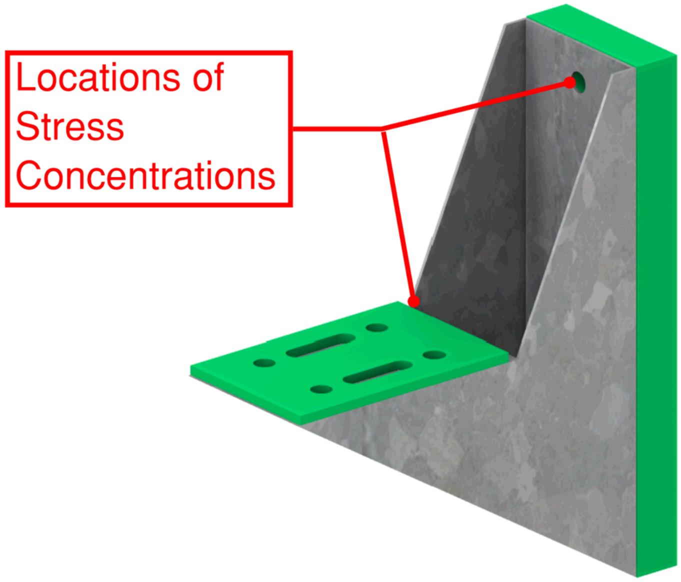


Figure 3.1: *iCLAD Bracket Stress Concentration Points*

3.2 Maximum Spacing of iCLAD Brackets

The structural analysis assumed the iCLAD brackets are arranged in a consistent and uniform grid pattern. The maximum spacing results from the structural analysis are shown in Table 3.1. Based on the fasteners described above, the spans in Table 3.1 can apply to all the analyzed backup walls and 3”-6” bracket depths, however see section 3.3 for limitations.

Table 3.1: *Vertical Spacing of iCLAD Brackets by Wind Load and Horizontal Bracket Spacing*

Applied Wind Load psf (kPa)	**Applied Dead Load** psf (kPa)	**Maximum Vertical Bracket Spacing** in (mm)		**Equivalent Maximum Tributary Wall Area per Bracket** Sq Ft (m^2)
		16” horizontal spacing o/c	32” horizontal spacing o/c	
20 (0.96)	5 (0.24)	60 (1524)	48 (1219)	10.7 (0.99)
30 (1.44)	5 (0.24)	48 (1219)	34 (864)	7.5 (0.70)
40 (1.92)	5 (0.24)	34 (864)	24 (610)	5.3 (0.50)
60 (2.87)	5 (0.24)	28 (711)	16 (406)	3.5 (0.33)
20 (0.96)	10 (0.48)	60 (1524)	44 (1118)	9.8 (0.91)
30 (1.44)	10 (0.48)	48 (1219)	30 (762)	6.7 (0.62)
40 (1.92)	10 (0.48)	34 (864)	22 (559)	4.9 (0.45)
60 (2.87)	10 (0.48)	28 (711)	15 (381)	3.3 (0.31)

3.3 Limiting Factors

The baseline structural analysis was performed on the 3" and 6" brackets and results were found to be similar. Differences in structural capacity are not expected for smaller bracket sizes since brackets with a reduced horizontal dimension will be stronger and will have less horizontal eccentricity from the supporting wall structure. For wall cavities 4" (102 mm) deep and less, the strength of the horizontal girt may become the governing factor. As defined in the thermal section of this report, a typical limit on the depth of this girt would be 1/3 of the insulation thickness. For the purposes of this report, it is assumed that this girt will be properly sized by the end user for the application. The girt is assumed not to govern the spans for the iCLAD bracket system otherwise. For lighter wind loads, as the vertical spacing of the iCLAD brackets increase, the strength of the system may tend to be governed more by the horizontal girt and vertical hat channel that support the cladding.

4. THERMAL ANALYSIS FOR iCLAD BRACKET SYSTEM

The thermal analysis was performed on four depths of the iCLAD bracket system, for varying insulation thickness, vertical bracket spacings and for the three backup walls, Scenarios 1-3, as described in Section 1. The following sections provide the U-value and R-value results in tabular form for the evaluated iCLAD bracket system configurations. The tables provide the exterior insulation thickness, nominal R-value of the insulation and the nominal resistance of the assembly (R_{1D} value)[6] for reference. Each table shows the determined assembly U- and effective R-Value that includes the impact of thermal bridging by the structural components, including studs and cladding attachments. Example temperature profiles for each scenario are presented in Appendix D.

[6] The R_{1D} value is the nominal thermal resistance of the assembly without any thermal bridging. This includes the resistance of planar components in the backup wall, such as sheathings, rain screen cavity, cladding and air films. See appendix A for components.

4.1 Scenario 1: iCLAD Bracket with Steel Stud Backup Wall

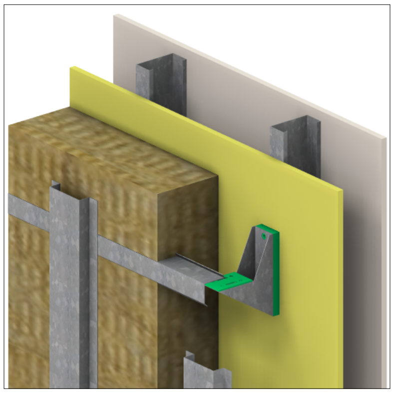


Figure 4.1: *iCLAD Bracket w/ Steel Stud Backup Wall*

The iCLAD bracket system with a steel stud backup wall is shown in Figure 4.1. Clear field U- and R-Values for this scenario are provided below in Table 4.1. The scenario was analyzed for three vertical spacing's of the horizontal girt and for four thicknesses of mineral wool insulation.

Table 4.1: *Thermal Transmittance and Resistance values for Exterior Insulated Steel Stud Wall Assembly with iCLAD Bracket System*

Vertical Spacing in	Exterior Insulation Thickness in	Exterior Insulation Nominal R-Value hr°Fft²/BTU (m²K/W)	Assembly R_{1D} Value hr°Fft²/BTU (m²K/W)	Assembly U-Value BTU/ hr°Fft² (W/m²K)	Assembly Effective R-Value hr°Fft²/BTU (m²K/W)
24	3	R-12.6 (2.22)	R-15.8 (2.78)	0.075 (0.427)	**R-13.3** (2.34)
	4	R-16.8 (2.96)	R-20.0 (3.52)	0.064 (0.364)	**R-15.6** (2.74)
	5	R-21.0 (3.70)	R-24.2 (4.26)	0.057 (0.323)	**R-17.6** (3.10)
	6	R-25.2 (4.44)	R-28.4 (5.00)	0.052 (0.293)	**R-19.4** (3.42)
36	3	R-12.6 (2.22)	R-15.8 (2.78)	0.071 (0.404)	**R-14.0** (2.47)
	4	R-16.8 (2.96)	R-20.0 (3.52)	0.059 (0.338)	**R-16.8** (2.96)
	5	R-21.0 (3.70)	R-24.2 (4.26)	0.052 (0.293)	**R-19.4** (3.41)
	6	R-25.2 (4.44)	R-28.4 (5.00)	0.046 (0.262)	**R-21.6** (3.81)
48	3	R-12.6 (2.22)	R-15.8 (2.78)	0.069 (0.392)	**R-14.5** (2.55)
	4	R-16.8 (2.96)	R-20.0 (3.52)	0.057 (0.323)	**R-17.6** (3.10)
	5	R-21.0 (3.70)	R-24.2 (4.26)	0.049 (0.277)	**R-20.5** (3.61)
	6	R-25.2 (4.44)	R-28.4 (5.00)	0.043 (0.245)	**R-23.2** (4.08)

4.2 Scenario 2: iCLAD Bracket with R-12 Interior Insulated Steel Stud Wall

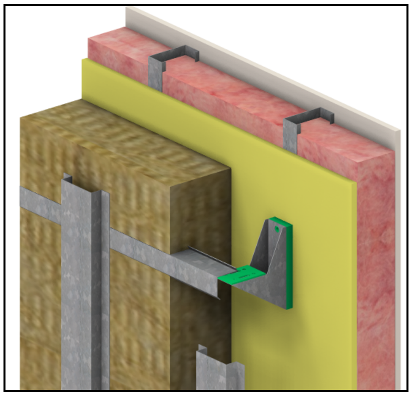


Figure 4.2: *iCLAD Bracket w/ R-12 Batt Steel Stud Backup Wall*

The iCLAD bracket with a steel stud backup wall and R-12 Interior Batt is shown in Figure 4.2. Clear field U- and R-Values for this scenario are provided below in Table 4.2. The scenario was analyzed for three vertical spacings of the horizontal girt and for four thicknesses of mineral wool insulation.

Table 4.2: *Thermal Transmittance and Resistance values for Exterior Insulated Steel Stud Wall with R-12 Interior Batt Assembly with iCLAD Bracket System*

Vertical Spacing in	Exterior Insulation Thickness in	Exterior Insulation Nominal R-Value hr°Fft²/BTU (m²K/W)	Assembly R_{1D} Value hr°Fft²/BTU (m²K/W)	Assembly U-Value BTU/ hr°Fft² (W/m²K)	Assembly Effective R-Value hr°Fft²/BTU (m²K/W)
24	3	R-12.6 (2.22)	R-26.9 (4.74)	0.052 (0.298)	**R-19.1** (3.36)
	4	R-16.8 (2.96)	R-31.1 (5.48)	0.047 (0.267)	**R-21.3** (3.74)
	5	R-21.0 (3.70)	R-35.3 (6.22)	0.043 (0.245)	**R-23.2** (4.09)
	6	R-25.2 (4.44)	R-39.5 (6.96)	0.040 (0.227)	**R-25.0** (4.40)
36	3	R-12.6 (2.22)	R-26.9 (4.74)	0.050 (0.284)	**R-20.0** (3.52)
	4	R-16.8 (2.96)	R-31.1 (5.48)	0.044 (0.250)	**R-22.7** (4.00)
	5	R-21.0 (3.70)	R-35.3 (6.22)	0.040 (0.225)	**R-25.2** (4.44)
	6	R-25.2 (4.44)	R-39.5 (6.96)	0.036 (0.207)	**R-27.5** (4.84)
48	3	R-12.6 (2.22)	R-26.9 (4.74)	0.049 (0.276)	**R-20.6** (3.62)
	4	R-16.8 (2.96)	R-31.1 (5.48)	0.042 (0.241)	**R-23.6** (4.16)
	5	R-21.0 (3.70)	R-35.3 (6.22)	0.038 (0.214)	**R-26.5** (4.67)
	6	R-25.2 (4.44)	R-39.5 (6.96)	0.034 (0.195)	**R-29.2** (5.14)

4.3 Scenario 3: iCLAD with Hollow Concrete Block Wall

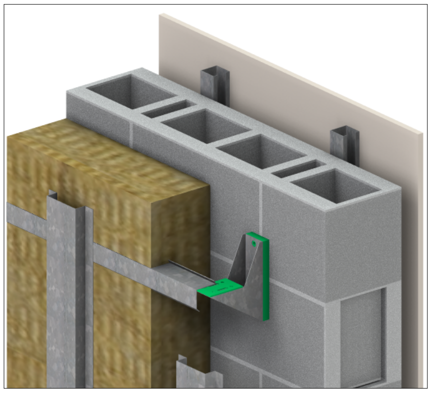


Figure 4.3: *iCLAD Bracket w/ Hollow Concrete Block Backup Wall*

The iCLAD bracket system with a Hollow Concrete Block Wall is shown in Figure 4.3. Clear field U- and R-Values for this scenario are provided below in Table 4.3. The scenario was analyzed for three vertical spacings of the horizontal girt and for four thicknesses of mineral wool insulation.

Table 4.3: *Thermal Transmittance and Resistance values for Hollow Concrete Backup Wall Assembly with iCLAD Bracket System*

Vertical Spacing in	Exterior Insulation Thickness in	Exterior Insulation Nominal R-Value hr°Fft²/BTU (m²K/W)	Assembly R_{1D} Value hr°Fft²/BTU (m²K/W)	Assembly U-Value BTU/ hr°Fft² (W/m²K)	Assembly Effective R-Value hr°Fft²/BTU (m²K/W)
24	3	R-12.6 (2.22)	R-16.6 (2.91)	0.074 (0.422)	**R-13.5** (2.37)
	4	R-16.8 (2.96)	R-20.8 (3.66)	0.064 (0.363)	**R-15.6** (2.75)
	5	R-21.0 (3.70)	R-25.0 (4.40)	0.057 (0.324)	**R-17.5** (3.08)
	6	R-25.2 (4.44)	R-29.2 (5.14)	0.052 (0.296)	**R-19.2** (3.38)
36	3	R-12.6 (2.22)	R-16.6 (2.91)	0.070 (0.398)	**R-14.3** (2.51)
	4	R-16.8 (2.96)	R-20.8 (3.66)	0.059 (0.335)	**R-17.0** (2.99)
	5	R-21.0 (3.70)	R-25.0 (4.40)	0.052 (0.293)	**R-19.4** (3.42)
	6	R-25.2 (4.44)	R-29.2 (5.14)	0.046 (0.263)	**R-21.6** (3.80)
48	3	R-12.6 (2.22)	R-16.6 (2.91)	0.068 (0.385)	**R-14.7** (2.59)
	4	R-16.8 (2.96)	R-20.8 (3.66)	0.056 (0.320)	**R-17.8** (3.13)
	5	R-21.0 (3.70)	R-25.0 (4.40)	0.049 (0.276)	**R-20.6** (3.62)
	6	R-25.2 (4.44)	R-29.2 (5.14)	0.043 (0.245)	**R-23.2** (4.08)

4.4 Insulation Type Sensitivity Analysis

A sensitivity analysis was performed on the system in order to determine if the thermal performance of the system is impacted by insulation type. This analysis used the exterior insulated steel stud backup wall, Scenario 1, at 24” vertical bracket spacing. This was done for 3”,4”, 5” and 6” of the following insulation types:

- Mineral Wool (R-4.2/inch)
- Foam Board (R-5/inch)
- Sprayfoam Insulation (R-6/inch)

The results of the sensitivity results are shown in Table 4.4. and in graphical form in Figure 4.4.

Table 4.4: *Thermal Transmittance and Resistance values for Steel Stud Backup Wall Assembly with iCLAD Bracket System and R-4.2/inch, R-5/inch, and R-6/inch Exterior Insulation*

Insulation Type	Exterior Insulation Thickness in	Exterior Insulation Nominal R-Value hr°Fft²/BTU (m²K/W)	Assembly R_{1D} Value hr°Fft²/BTU (m²K/W)	Assembly U-Value BTU/hr°Fft² (W/m²K)	Assembly Effective R-Value hr°Fft²/BTU (m²K/W)
R4.2/in Mineral Wool	3	R-12.6 (2.22)	R-17.5 (3.09)	0.074 (0.422)	**R-13.5** (2.37)
	4	R-16.8 (2.96)	R-21.7 (3.83)	0.064 (0.363)	**R-15.6** (2.75)
	5	R-21.0 (3.70)	R-25.9 (4.57)	0.057 (0.324)	**R-17.5** (3.08)
	6	R-25.2 (4.44)	R-30.1 (5.31)	0.052 (0.296)	**R-19.2** (3.38)
R5/in Foam Board	3	R-15.0 (2.64)	R-18.2 (3.20)	0.068 (0.384)	**R-14.8** (2.61)
	4	R-20.0 (3.52)	R-23.2 (4.08)	0.058 (0.329)	**R-17.3** (3.04)
	5	R-25.0 (4.40)	R-28.2 (4.96)	0.051 (0.292)	**R-19.4** (3.42)
	6	R-30.0 (5.28)	R-33.2 (5.85)	0.047 (0.266)	**R-21.4** (3.76)
R6/in Spray foam	3	R-18.0 (3.17)	R-21.2 (3.73)	0.060 (0.343)	**R-16.5** (2.91)
	4	R-24.0 (4.23)	R-27.2 (4.79)	0.052 (0.296)	**R-19.2** (3.38)
	5	R-30.0 (5.28)	R-33.2 (5.85)	0.047 (0.265)	**R-21.5** (3.78)
	6	R-36.0 (6.34)	R-39.2 (6.90)	0.043 (0.242)	**R-23.5** (4.14)

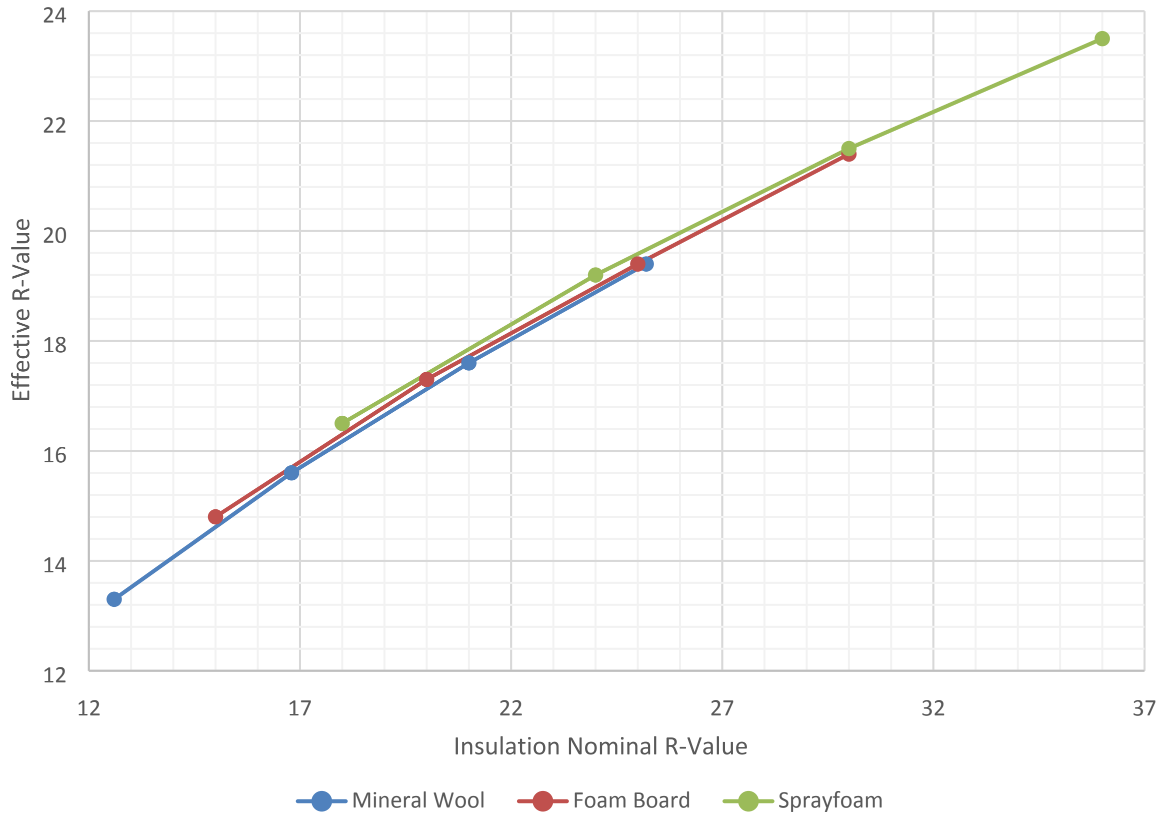


Figure 4.4: *iCLAD Bracket Effective R-Value by Insulation Type*

The results show good agreement as the effective R-values vary by less than 1% between insulation types. This indicates that the iCLAD system U- and Effective R-Values are largely independent of insulation type and thickness and are characterized more so by the nominal R-value of the insulation. Therefore, the values found in this report can reasonably apply to any typical insulation product based on that insulation's nominally rated R-value and performance values can be interpolated for between the reported values.

5. CONCLUSIONS

In summary, the following information can be gathered from this report regarding the analyzed iCLAD bracket system:

- From Table 3.1 in Section 3, the iCLAD system can vary in vertical spacing between 15"o.c. and 60"o.c. depending on the horizontal spacing of the brackets and wind loads for cladding weights upto 10 psf.

- From Section 4.1, for an exterior insulated steel stud backup wall, the assembly U-Value varies between U-0.075 (USI-0.427) and U-0.043 (USI-0.245) depending on the amount of exterior insulation and bracket spacing.

- From Section 4.2, for a split insulated steel stud backup wall with R-12 Batt insulation, the assembly U-Value varies between U-0.052 (USI-0.298) and U-0.034 (USI-0.195) depending on the amount of exterior insulation and bracket spacing.

- From Section 4.3, for an exterior insulated hollow concrete block backup wall, the assembly U-Value varies between U-0.074 (USI-0.422) and U-0.043 (USI-0.245) depending on the amount of exterior insulation and bracket spacing.

- The sensitivity analysis indicated that the performance of the iCLAD system are dependent on the nominal rated value of the insulation, not the insulation type. Therefore the U- and Effective R-Values shown in this report can reasonably apply to any typical insulation. Additionally, thermal performance values can be interpolated between the reported values for nominal insulation levels not explicitly modelled in this report.

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

Morrison Hershfield

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30 MAY 2016

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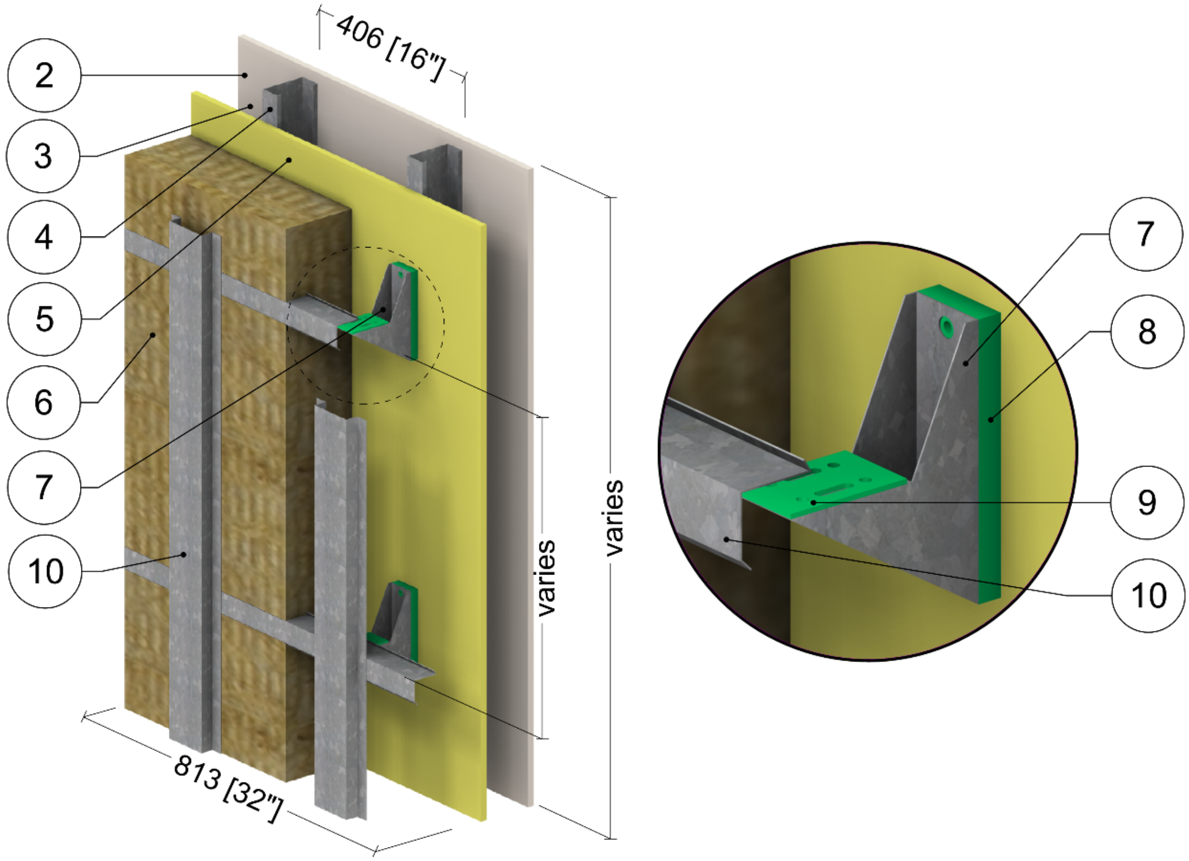
APPENDIX A– ASSEMBLY INFORMATION AND MATERIAL PROPERTIES

Scenario 1

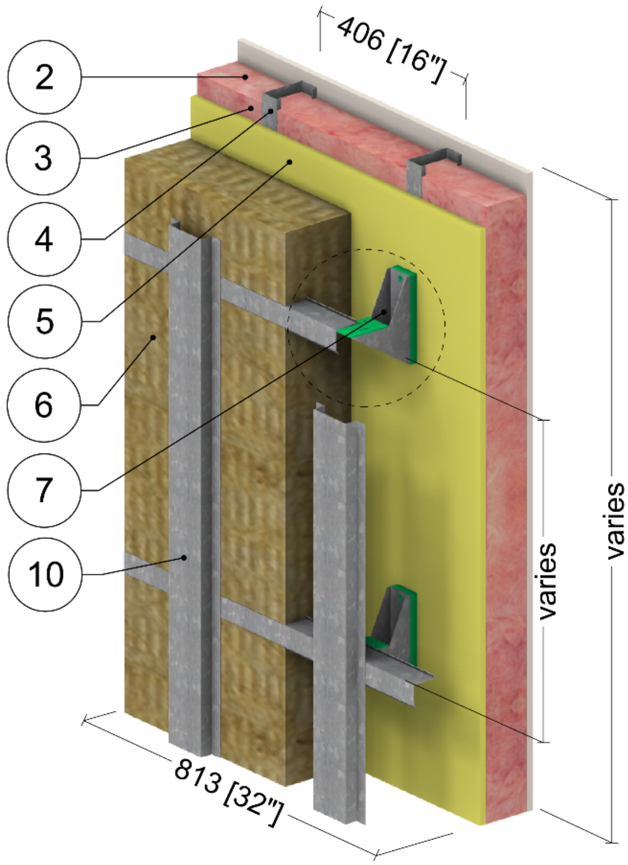
Spring Valley iCLAD Bracket System with Steel Stud Backup Wall

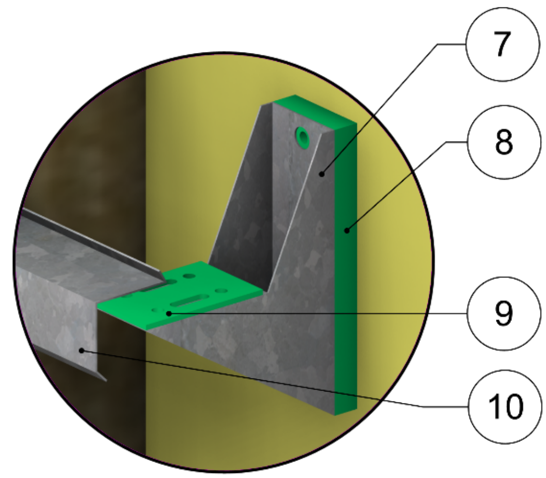


	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	3 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Mineral Wool Insulation	3" to 6" (76 to 152)	0.24 (0.034)	R-12.6 to R-25.2 (2.22 RSI to 4.44 RSI)	1.8 (28)	0.29 (1220)
7	iCLAD Bracket	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Insulation Block	5/8" (16)	3.5 (0.5)	-	59 (950)	0.48 (2000)
9	Thermal Spacer	-	1.7 (0.25)	-	137 (2200)	0.31 (1300)
10	Girt and Hat Channel	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
11	Zinc Plated Steel Fasteners	¼" D	344 (50)	-	489 (7830)	0.12 (500)
12	Cladding with 1/2" (13mm) vented airspace incorporated into exterior heat transfer coefficient					
13	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

Scenario 2

Spring Valley iCLAD Bracket System with Steel Stud Backup Wall and R-12 Interior Batt Insulation

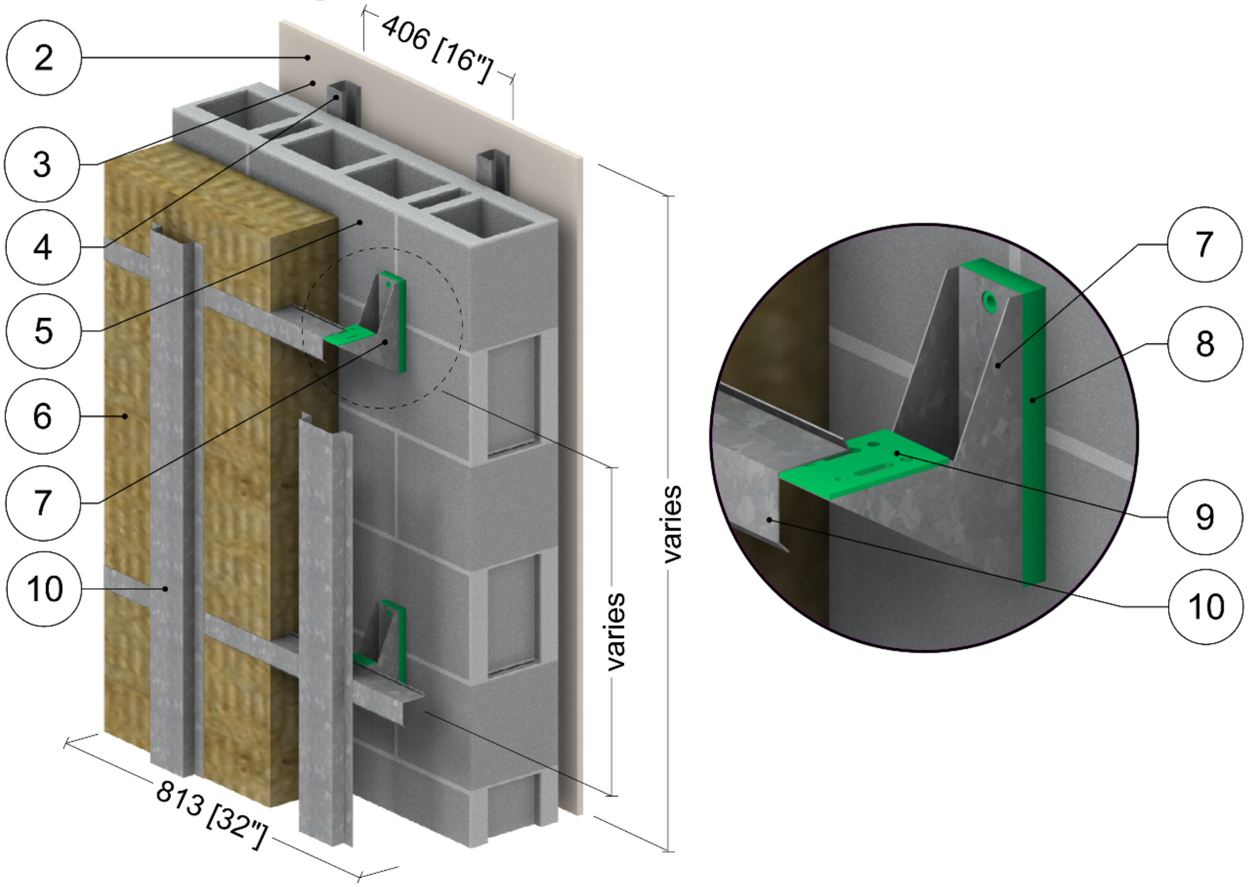




	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Fiberglass Batt Insulation	3 5/8" (92)	0.29 (0.042)	-	0.9 (14)	0.17 (710)
4	3 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Exterior Sheathing	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
6	Mineral Wool Insulation	3" to 6" (76 to 152)	0.24 (0.034)	R-12.6 to R-25.2 (2.22 RSI to 4.44 RSI)	1.8 (28)	0.29 (1220)
7	iCLAD Bracket	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Insulation Block	5/8" (16)	3.5 (0.5)	-	59 (950)	0.48 (2000)
9	Thermal Spacer	-	1.7 (0.25)	-	137 (2200)	0.31 (1300)
10	Girt and Hat Channel	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
11	Zinc Plated Steel Fasteners	¼" D	344 (50)	-	489 (7830)	0.12 (500)
12	Cladding with 1/2" (13mm) vented airspace incorporated into exterior heat transfer coefficient					
13	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

Scenario 3

Spring Valley iCLAD Bracket System with Hollow Concrete Block Backup Wall



	Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr·ft²·°F/Btu (m²K/W)	Density lb/ft³ (kg/m³)	Specific Heat Btu/lb·°F (J/kg K)
1	Interior Film	-	-	R-0.7 (0.12 RSI)	-	-
2	Gypsum Board	1/2" (13)	1.1 (0.16)	R-0.5 (0.08 RSI)	50 (800)	0.26 (1090)
3	Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (0.16 RSI)	0.075 (1.2)	0.24 (1000)
4	1 5/8" Steel Studs	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
5	Standard Concrete Block	8" (203)	-	-	119 (1900)	0.19 (800)
6	Mineral Wool Insulation	3" to 6" (76 to 152)	0.24 (0.034)	R-12.6 to R-25.2 (2.22 RSI to 4.44 RSI)	1.8 (28)	0.29 (1220)
7	iCLAD Bracket	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
8	Insulation Block	5/8" (16)	3.5 (0.5)	-	59 (950)	0.48 (2000)
9	Thermal Spacer	-	1.7 (0.25)	-	137 (2200)	0.31 (1300)
10	Girt and Hat Channel	18 Gauge	430 (62)	-	489 (7830)	0.12 (500)
11	Zinc Plated Steel Fasteners	¼" D	344 (50)	-	489 (7830)	0.12 (500)
12	Cladding with 1/2" (13mm) vented airspace incorporated into exterior heat transfer coefficient					
13	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

APPENDIX B – ASHRAE 1365-RP METHODOLOGY AND MODEL ASSUMPTIONS

B.1 General Structural Modeling Approach and Assumptions

A structural analysis for wind and dead loads was performed on the Spring Valley iCLAD. The following assumptions were made:

- The iCLAD clip dimensions were taken from the Spring Valley H150 Version 3 shop drawings, with an overall clip height of 170 mm, width 137 mm, and the horizontal shelf centered vertically between the fasteners to the wall structure. The clip is assumed to be fabricated from 18 ga steel plate with a yield strength of 230 MPa.
- Two cladding weights of 5 psf (0.24 kPa) and 10 psf (0.48 kPa) were examined in this evaluation. This weight includes the cladding itself and the weight of all framing support elements outboard of the wall sheathing.
- The wind pressures listed in Table 3.1 are assumed to act either inwards towards to the face of the wall, or outwards away from the wall (negative pressure / suction).
- Loads shown are applied loads, after all appropriate load factors have been included.
- The analysis has been performed for fastening the system to 18 ga steel wall studs spaced at 16" (406 mm) o/c. The iCLAD clips are assumed to be arranged in horizontal line fastened in to every stud, 16" (406 mm) o/c, or every other stud, 32" (812 mm) o/c. Maximum vertical spacing for the iCLAD clips were calculated for these two configurations.
- Strength values for the iCLAD clips, horizontal z-girts and vertical hat-channels have been calculated in accordance with CSA Standard S136-12 *North American Specification for Design of Cold-Formed Steel Structural Members* (Limit States Design).
- A horizontal deflection limit of L/240 has been used for the vertical metal hat-channels and horizontal metal z-girts. This value would be suitable for flexible and brittle cladding panel types such as metal or concrete panels. This deflection limit would not be suitable for materials that are highly susceptible to cracking such as masonry veneer, plaster, and stucco. The hat-channels and z-girt cold-formed sections profiles were provided by Spring Valley.
- Brackets were modeled in FEA analysis with applied horizontal and vertical point loads applied at the centroid of the outboard flange of the horizontal z-girt.

B.2 General Thermal Modeling Approach and Assumptions

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.
- Material properties were taken from information provided by Knight Wall and from ASHRAE Handbook – Fundamentals

- The cladding and air space was not explicitly modelled, but included with the exterior film coefficient.
- 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.
- This was modelled as a clear field assembly away from major details, such as slab edges or parapets. As a result, these assemblies do not include top and bottom steel stud tracks (See Appendix B.3).
- The temperature difference between interior and exterior was modeled as a dimensionless temperature index between 0 and 1 (see Appendix B.4). These values, along with other modeling parameters, are given in ASHRAE 1365-RP, Chapter 5.

B.3 Thermal Transmittance

The methodology presented in ASHRAE 1365-RP separates the thermal performance of assemblies and details in order to simplify heat loss calculations. The thermal transmittance of an assembly is divided into three categories: clear field, linear and point transmittances.

The clear field transmittance is the heat flow from the wall or roof assembly, including uniformly distributed thermal bridges that are not practical to account for on an individual basis, such as structural framing and cladding attachments shown in this report. This is defined as a U-value, U_o (heat flow per area). Linear transmittances are for details that can be accounted for in a linear nature, such as corners, slab edges, balconies etc. Point transmittances are for single areas of thermal bridging that can be practically accounted for, such as beam penetrations. Note: **THIS REPORT CONTAINS ONLY CLEAR FIELD VALUES**.

B.4 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.

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

Example temperature profiles for the assemblies and details modeled in this report are shown in Appendix D.

APPENDIX C – SIMULATED PRINCIPAL STRESS PROFILES

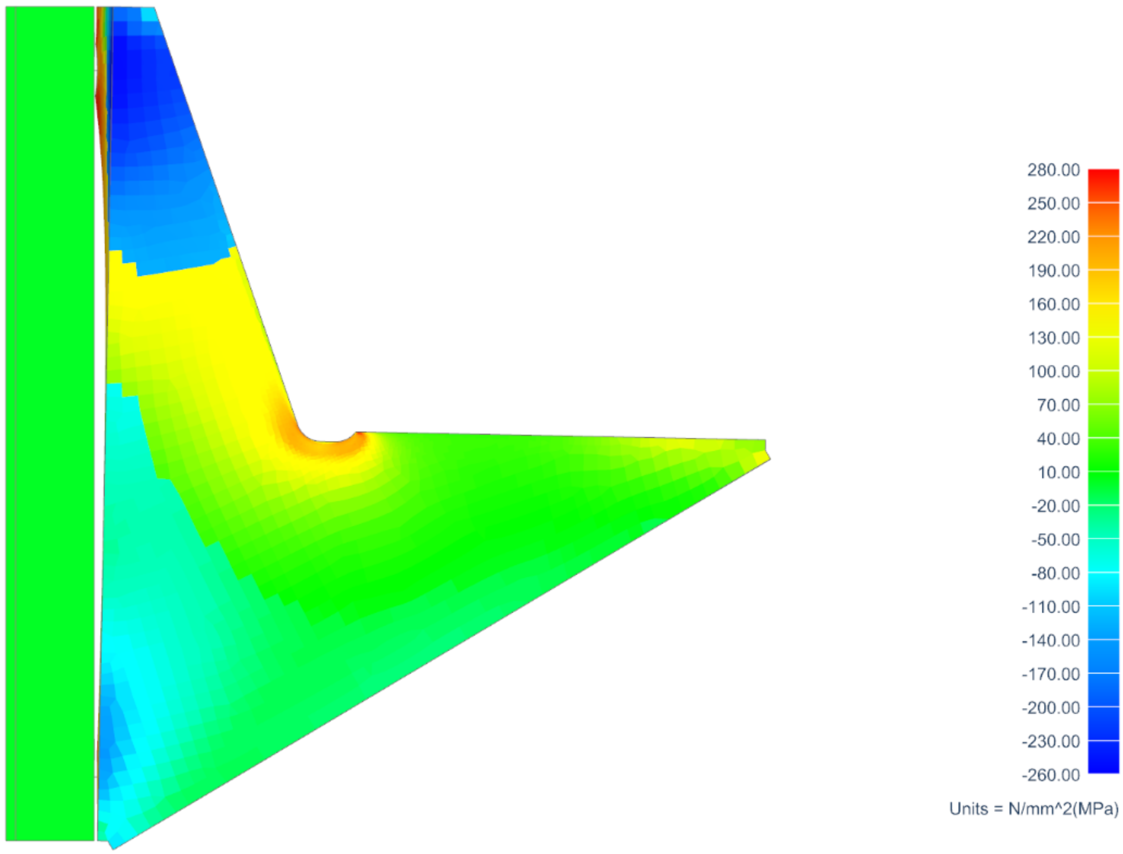


Figure C.1: 6” Spring Valley iCLAD Clip – Stress at inner corner joint

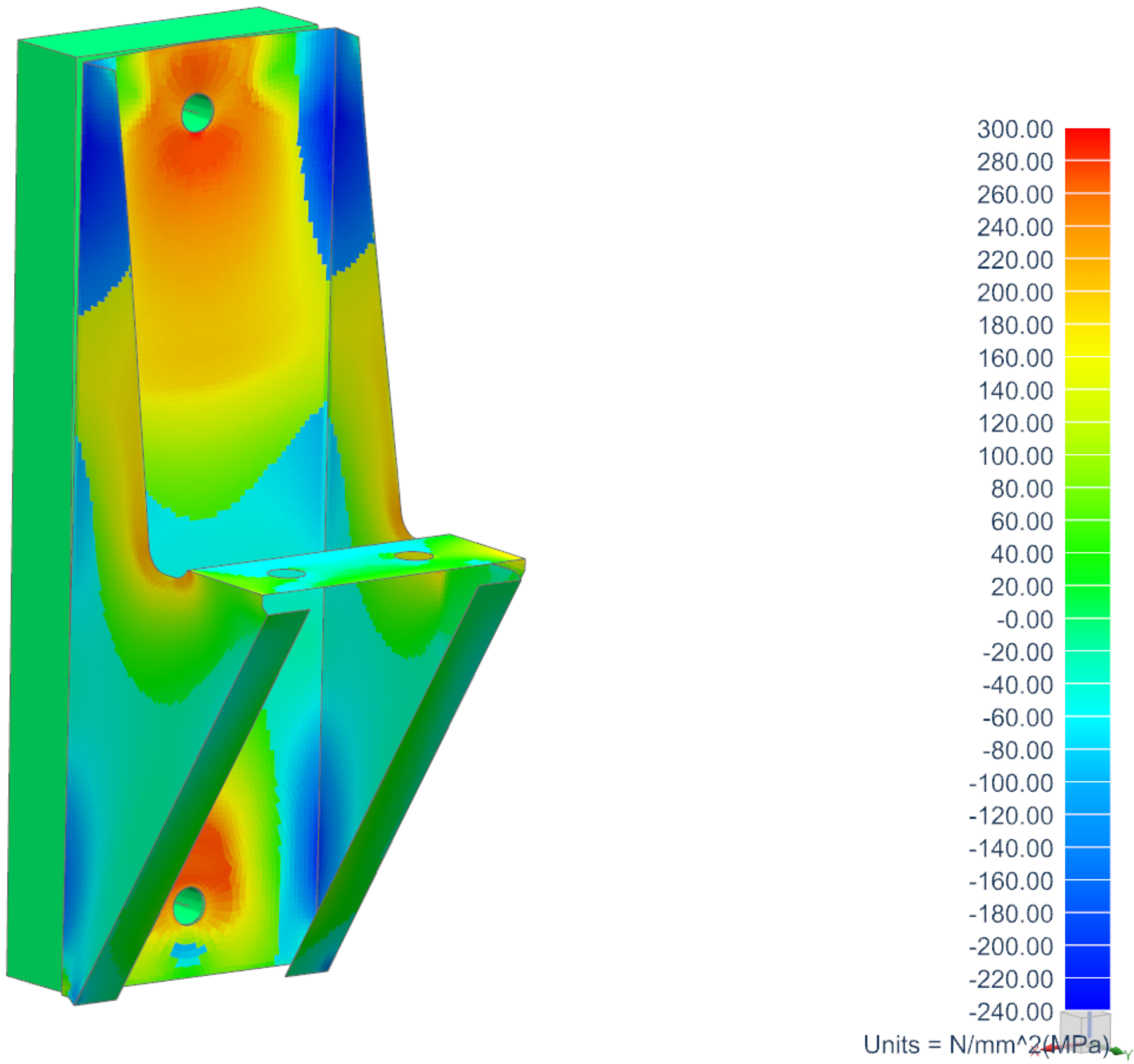


Figure C.2: 3” Spring Valley iCLAD Clip – Stress at wall fastener holes (3/4” washer)

APPENDIX D –SIMULATED TEMPERATURE PROFILES

Scenario 1: Spring Valley iCLAD Bracket with Steel Stud Backup Wall

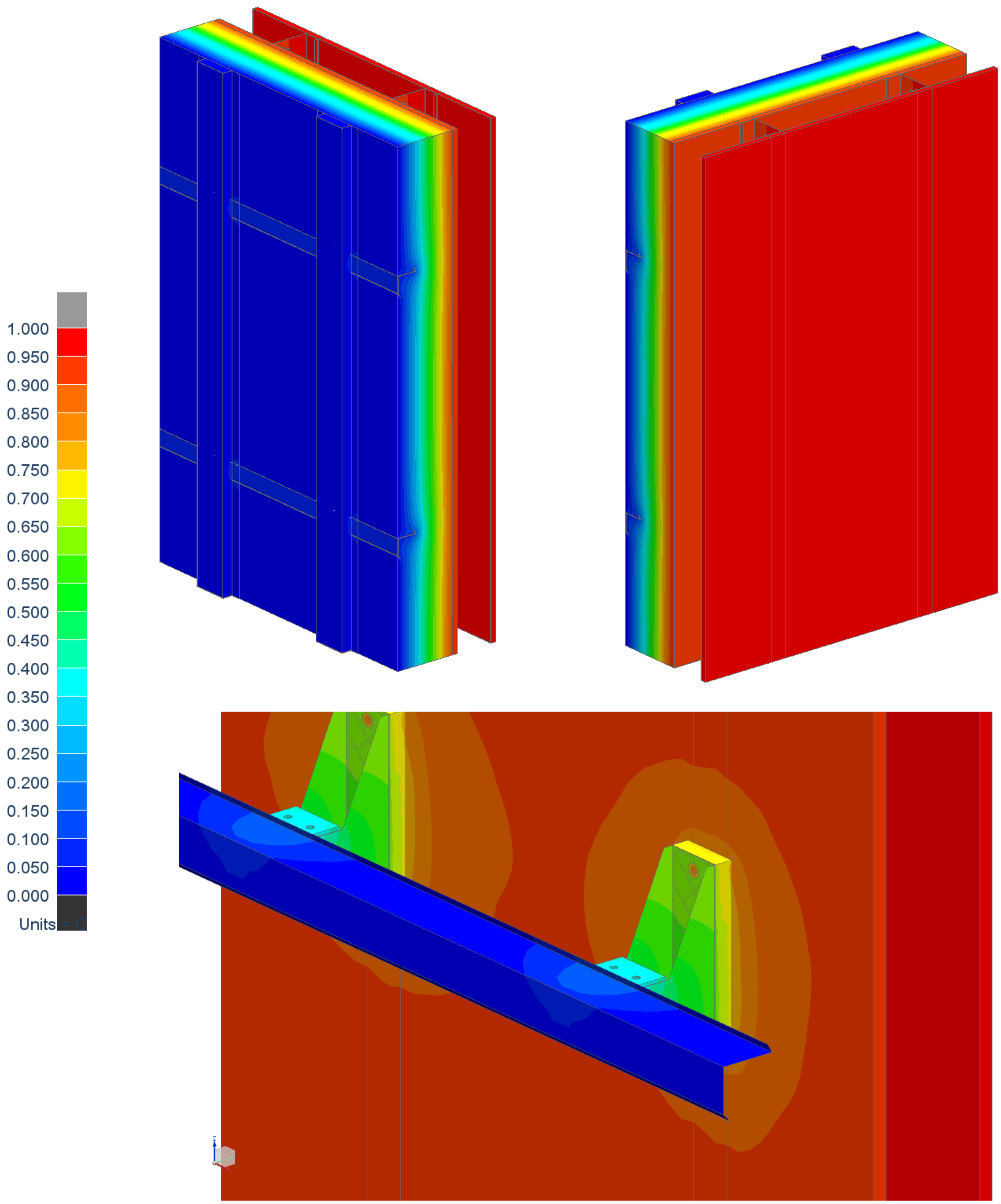


Figure D.1: Exterior Insulated Steel Stud Assembly with 6” of Mineral Wool and iCLAD Bracket System Spaced 24” O.C. Vertically

Scenario 2: Spring Valley iCLAD Bracket with R-12 Interior Insulated Steel Stud Wall

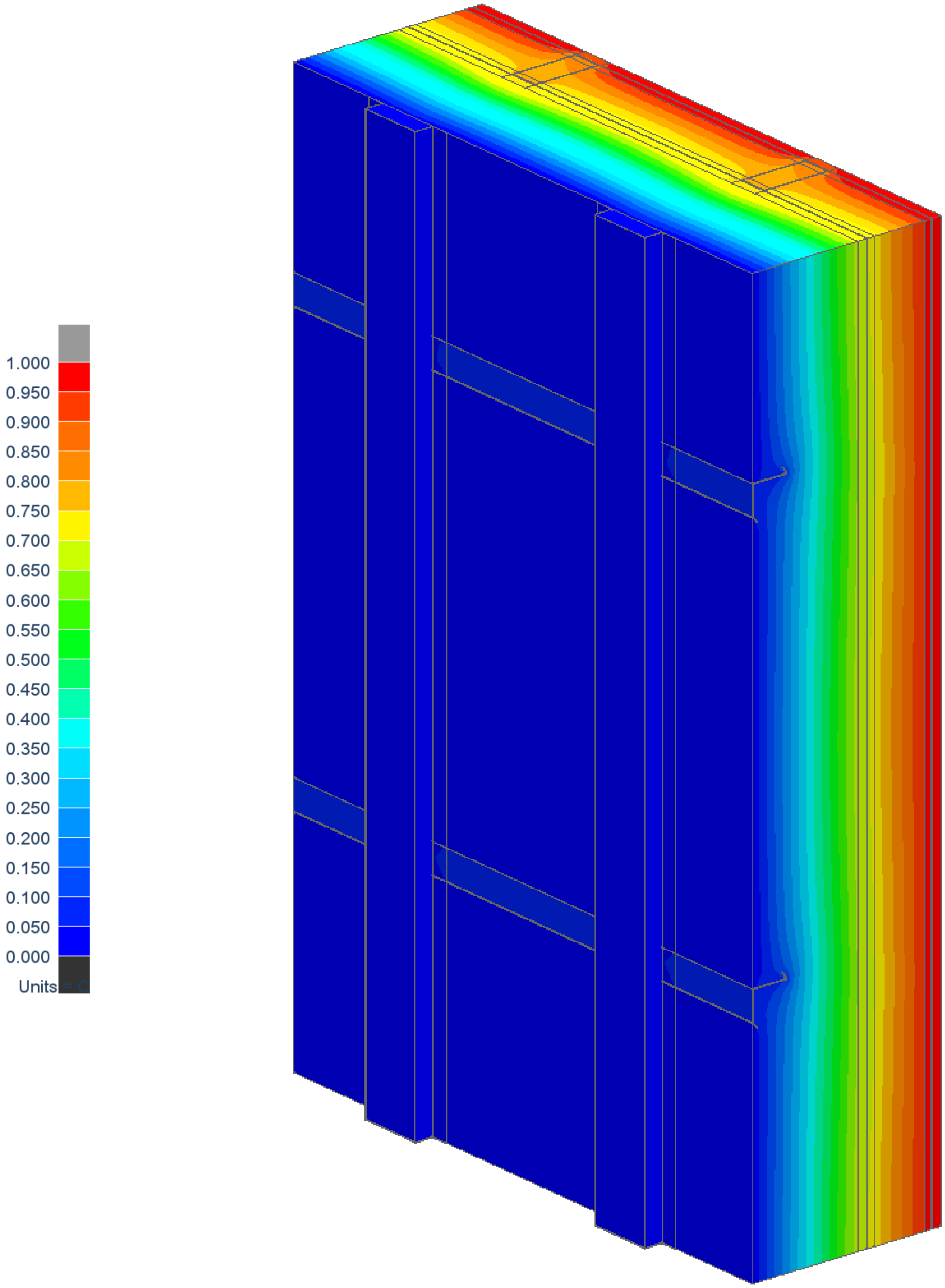


Figure D.2: Split Insulated Steel Stud Assembly with 6” of Mineral Wool with R-12 Batt and iCLAD Bracket System Spaced 24” O.C. Vertically

Scenario 3: Spring Valley iCLAD with Concrete Masonry Unit Wall

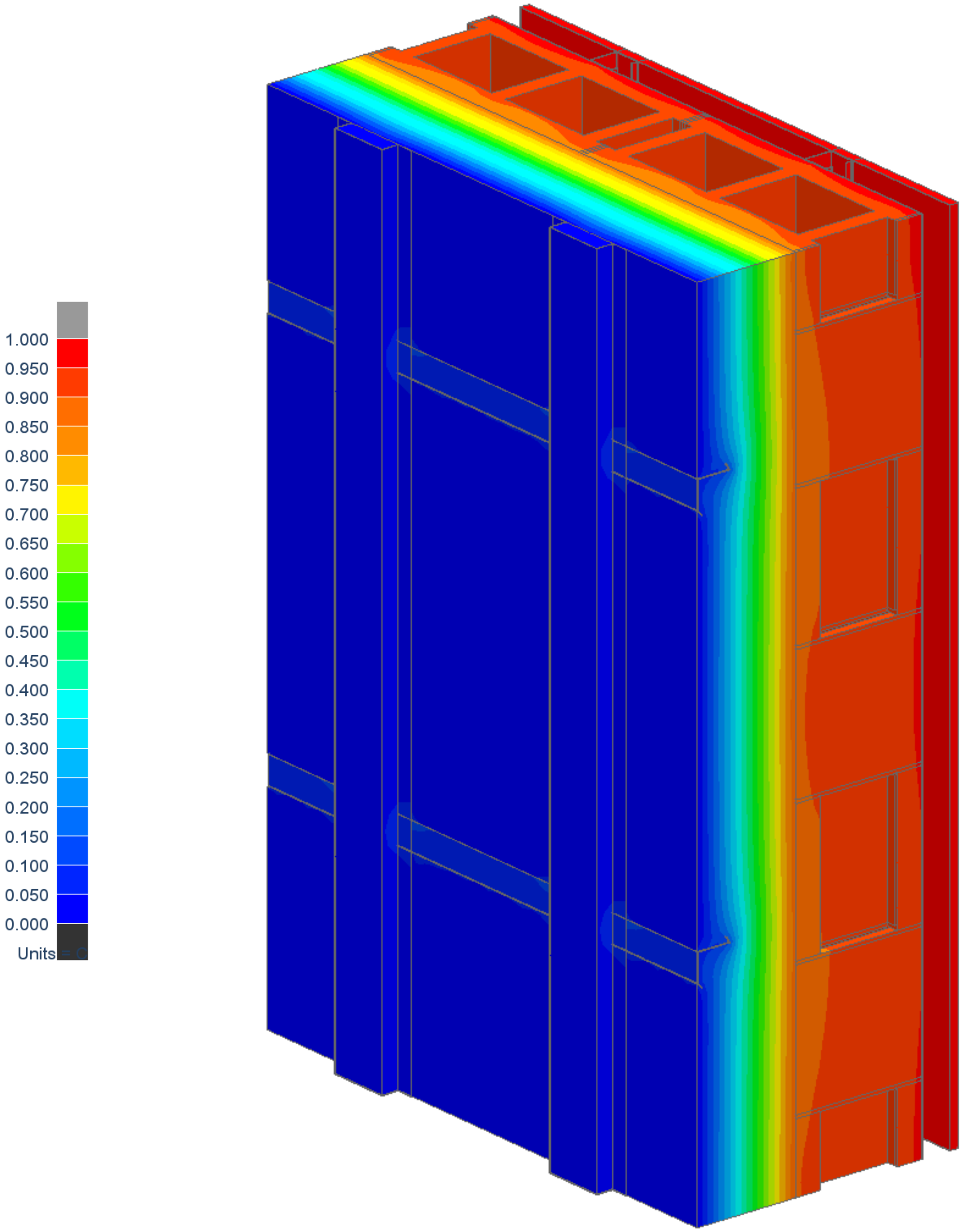


Figure D.3: Exterior Insulated CMU Assembly with 6” of Mineral Wool and iCLAD Bracket System Spaced 24” O.C. Vertically