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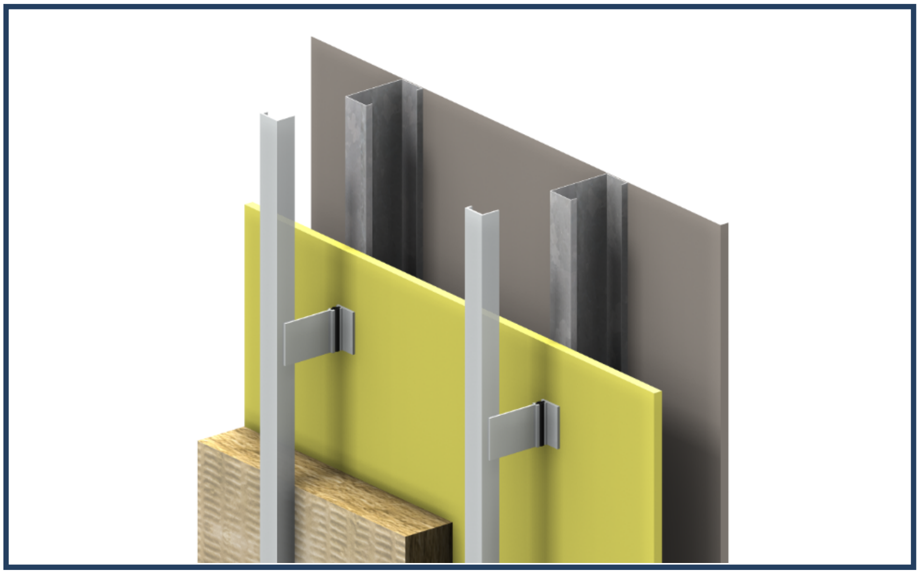
Morrison Hershfield

Thermal Performance Analysis of Longboard Architectural Sub-Girt System



Presented to:

Mayne Coatings Corp.
27575-50th Avenue
Langley, BC, V4W 0A2

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1. INTRODUCTION AND BACKGROUND

The Longboard Architectural L-Clip System is an aluminum thermal clip system for attaching exterior cladding to different types of backup walls. Morrison Hershfield was contracted by Mayne Coatings Corp. (Mayne) to evaluate the thermal performance of their revised thermal L-clip system for various scenarios. The Longboard thermally broken clip is L-shaped with a polyamide thermal break (similar to a window wall system) at the corner, separating each flange. The aluminum L-clips can be connected to vertical or horizontal sub girts that support exterior cladding.

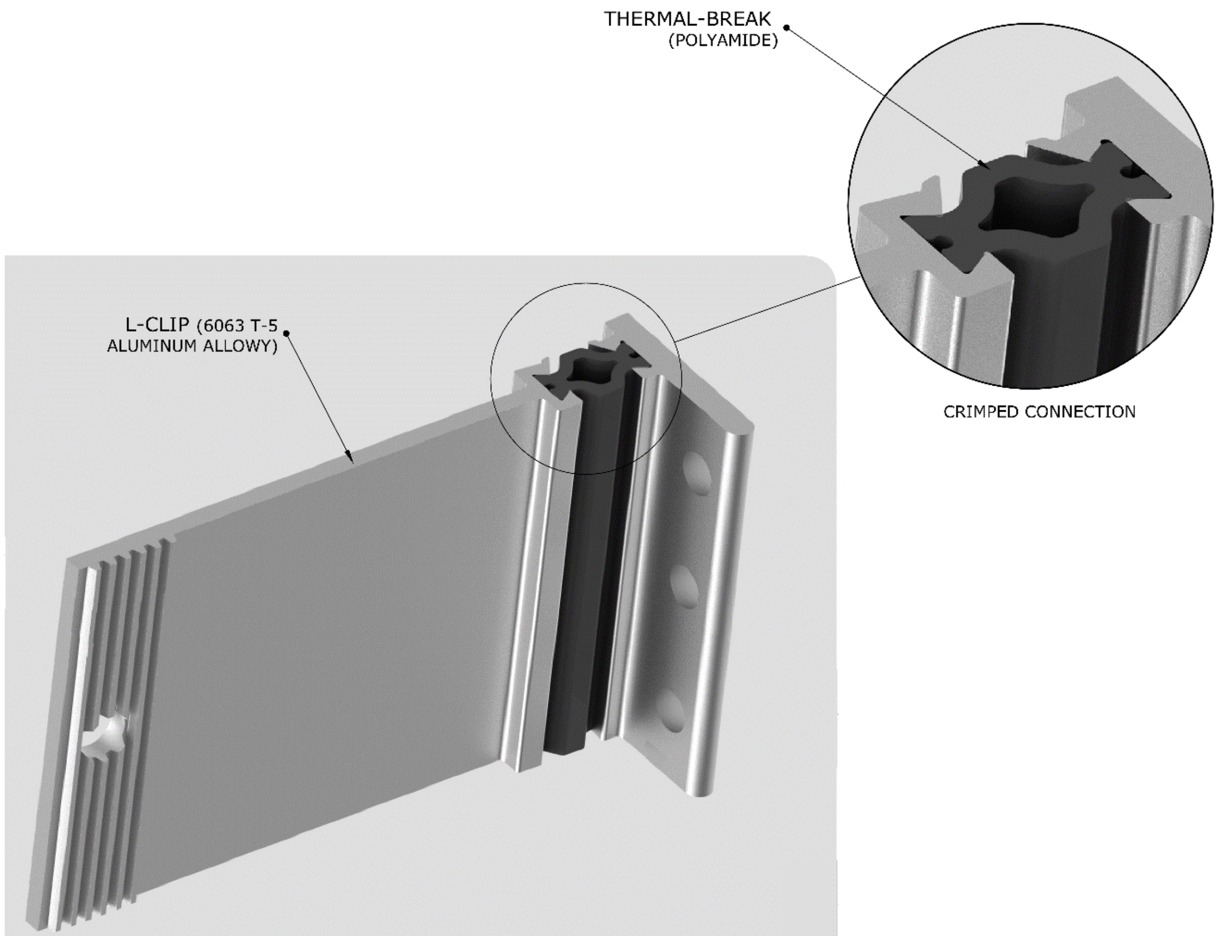

Figure1.1: Simplified Rendering of Clip from Longboard Documentation

For this analysis, the L-Clip system was analyzed for use with the following assemblies:

- Exterior Insulated 3 5/8" Steel Stud Backup Wall
- Split Insulated 3 5/8" Steel Stud Backup Wall with Interior R-12 Batt
- Exterior Insulated 2"x6" Wood Framed Wall
- 8" Reinforced Concrete Backup Wall with 1 5/8" Steel Stud Backup Wall
- Exterior Insulated Concrete Masonry Block Wall with 1 5/8" Steel Stud Backup Wall

A summary of the components for the evaluated system follows and detailed drawings can be found in Appendix A. Images of each assembly can be found with their respective results tables in Part 3 of this report.

2. MODELING PROCEDURES

The thermal performance of the Longboard assemblies 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*[1] and for the *Building Envelope Thermal Bridging Guide*[2]. The thermal transmittance (U-Value) or "effective R-value" was determined using the methodology presented in these two documents. The modeling assumptions for the thermal analyses are summarized in Appendix B.

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

[2] https://www.bchydro.com/powersmart/business/programs/new-construction.html

3. LONGBOARD L-CLIP THERMAL ANALYSIS RESULTS

The thermal performance of the L-Clip with the four clear field assemblies was evaluated for three depths of the L-Clip System to support 3”, 4” and 5” of exterior insulation. Various vertical bracket spacings of the system were also examined and were based on previous structural analysis of the Longboard system, as well as typical clip spacings. In each of these cases a vented, non-masonry cladding was assumed outboard of the exterior insulation.

The following sections present the thermal performance results (U-values and effective R-values that include thermal bridging) for each of the evaluated Longboard assemblies in table format. The tables provide the spacing of clip 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, air films also all contribute towards the R-value of the assembly.

Further assembly information, including dimensions and materials are given in Appendix A. Example temperature profiles for each system are provided in Appendix C.

The following thermal analysis was performed specifically with the vertical girt orientation, however the values shown here can also be reasonably utilized with horizontal girts as long as the horizontal girt does not significantly penetrate into the insulation.

This analysis used exterior mineral wool as the base exterior insulation type. See the sensitivity analysis in Part 4 for using these tables with other insulation types.

3.1 Exterior Insulated Steel Stud Backup Wall

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

Figure 3.1: Exterior Insulated Steel Stud Backup Wall with L-Clip System

Table 3.1: Clear Field Thermal Transmittance for Steel Stud Backup Wall

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	3	R-12.6 (2.22)	0.067 (0.378)	R-15.0 (2.65)
	4	R-16.8 (2.96)	0.054 (0.306)	R-18.5 (3.26)
	5	R-21.0 (3.70)	0.046 (0.260)	R-21.8 (3.84)
36	3	R-12.6 (2.22)	0.066 (0.372)	R-15.2 (2.69)
	4	R-16.8 (2.96)	0.053 (0.299)	R-19.0 (3.34)
	5	R-21.0 (3.70)	0.044 (0.252)	R-22.5 (3.96)
42	3	R-12.6 (2.22)	0.065 (0.370)	R-15.3 (2.70)
	4	R-16.8 (2.96)	0.052 (0.297)	R-19.1 (3.37)
	5	R-21.0 (3.70)	0.044 (0.250)	R-22.7 (4.01)

3.2 Split Insulated Steel Stud Backup Wall

3 5/8" Steel Studs, 16"o.c. with ½" Gypsum Sheathing and Drywall and R-12 Batt Insulation in the Stud Cavity

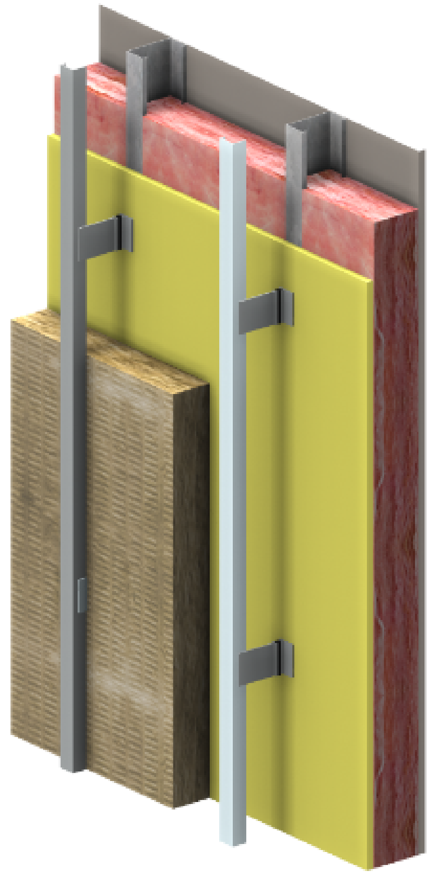


Figure 3.2: Split Insulated Steel Stud Backup Wall with L-Clip System

Table 2: Clear Field Thermal Transmittance with Batt Insulation in the Steel Stud Cavity

Vertical Spacing **in**	Exterior Insulation Thickness **in**	Exterior Insulation Nominal R-Value **hr°Fft^2/BTU (m^{2}K/W)**	Assembly U-Value **BTU/ hr°Fft^2 (W/m^{2}K)**	Assembly Effective R-Value **hr°Fft^2/BTU (m^{2}K/W)**
24	3	R-12.6 (2.22)	0.048 (0.270)	R-21.0 (3.70)
	4	R-16.8 (2.96)	0.041 (0.232)	R-24.5 (4.32)
	5	R-21.0 (3.70)	0.036 (0.205)	R-27.7 (4.89)
36	3	R-12.6 (2.22)	0.047 (0.267)	R-21.3 (3.74)
	4	R-16.8 (2.96)	0.040 (0.228)	R-24.9 (4.39)
	5	R-21.0 (3.70)	0.035 (0.199)	R-28.5 (5.01)
42	3	R-12.6 (2.22)	0.047 (0.266)	R-21.4 (3.76)
	4	R-16.8 (2.96)	0.040 (0.226)	R-25.1 (4.42)
	5	R-21.0 (3.70)	0.035 (0.198)	R-28.7 (5.06)

3.3 Exterior Insulated Wood Frame Backup Wall

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

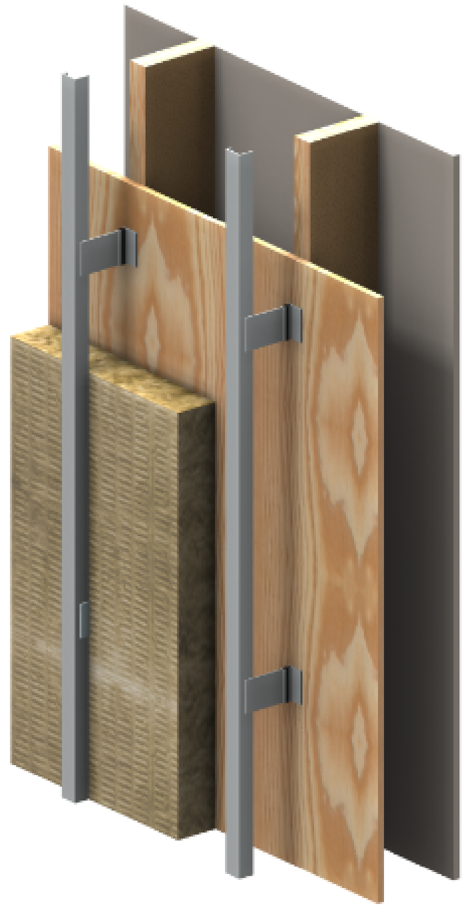


Figure 3.3: Exterior Insulated Wood Framed Wall with L-Clip System

Table 3.3: Clear Field Thermal Transmittance with 2x6 Wood Stud Wall

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	3	R-12.6 (2.22)	0.064 (0.361)	R-15.7 (2.77)
	4	R-16.8 (2.96)	0.052 (0.294)	R-19.3 (3.40)
	5	R-21.0 (3.70)	0.044 (0.251)	R-22.6 (3.98)
36	3	R-12.6 (2.22)	0.063 (0.356)	R-15.9 (2.81)
	4	R-16.8 (2.96)	0.051 (0.289)	R-19.7 (3.47)
	5	R-21.0 (3.70)	0.043 (0.246)	R-23.1 (4.06)
42	3	R-12.6 (2.22)	0.063 (0.355)	R-16.0 (2.82)
	4	R-16.8 (2.96)	0.050 (0.287)	R-19.8 (3.49)
	5	R-21.0 (3.70)	0.043 (0.242)	R-23.5 (4.13)

3.4 Exterior Insulated Concrete Mass Wall

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

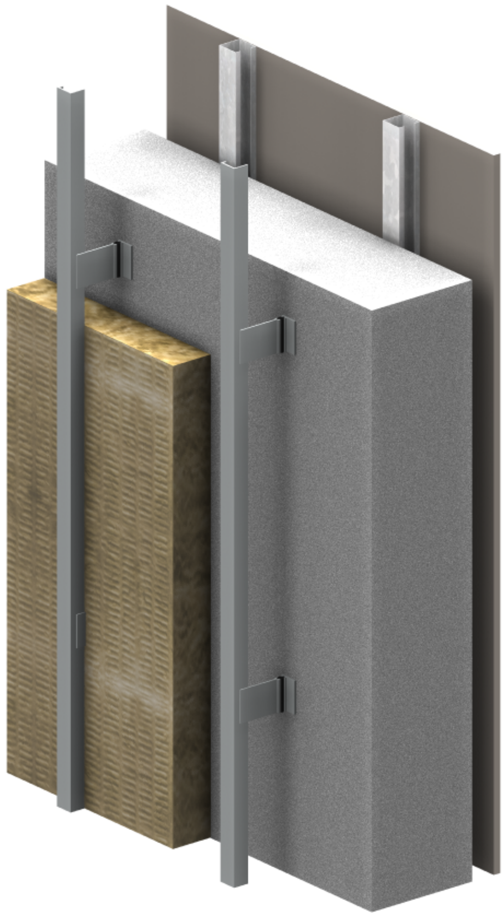


Figure 3.4: Exterior Insulated Concrete Mass Wall with L-Clip System

Table 3.4: Clear Field Thermal Transmittance with Concrete Mass Wall

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	3	R-12.6 (2.22)	0.066 (0.373)	R-15.2 (2.68)
	4	R-16.8 (2.96)	0.053 (0.302)	R-18.8 (3.31)
	5	R-21.0 (3.70)	0.045 (0.258)	R-22.0 (3.88)
36	3	R-12.6 (2.22)	0.065 (0.367)	R-15.5 (2.72)
	4	R-16.8 (2.96)	0.052 (0.296)	R-19.2 (3.38)
	5	R-21.0 (3.70)	0.044 (0.250)	R-22.7 (4.00)
42	3	R-12.6 (2.22)	0.064 (0.365)	R-15.6 (2.74)
	4	R-16.8 (2.96)	0.052 (0.294)	R-19.3 (3.41)
	5	R-21.0 (3.70)	0.044 (0.247)	R-23.0 (4.05)

3.5 Exterior Insulated Concrete Block Wall

7 5/8" Concrete Block, with 1 5/8" Steel Studs and ½" Interior Drywall

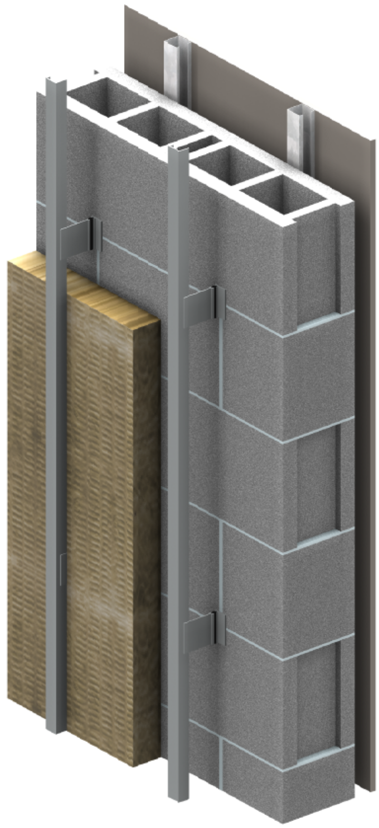


Figure 3.5: Exterior Insulated Concrete Block Wall with L-Clip System

Table 3.5: Clear Field Thermal Transmittance with Concrete Block Wall

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	3	R-12.6 (2.22)	0.063 (0.357)	R-15.9 (2.80)
	4	R-16.8 (2.96)	0.052 (0.293)	R-19.4 (3.41)
	5	R-21.0 (3.70)	0.044 (0.251)	R-22.6 (3.99)
36	3	R-12.6 (2.22)	0.062 (0.353)	R-16.1 (2.83)
	4	R-16.8 (2.96)	0.050 (0.287)	R-19.8 (3.49)
	5	R-21.0 (3.70)	0.043 (0.243)	R-23.3 (4.11)
42	3	R-12.6 (2.22)	0.062 (0.351)	R-16.2 (2.85)
	4	R-16.8 (2.96)	0.050 (0.285)	R-19.9 (3.51)
	5	R-21.0 (3.70)	0.042 (0.241)	R-23.6 (4.15)

4. INSULATION SENSITIVITY ANALYSIS

The previous tables in section 3 of this report used exterior mineral wool (at R-4.2/inch) as the basis for the evaluation. A sensitivity analysis was conducted to determine if the thermal performance of the system is impacted by insulation type. This analysis evaluated an exterior insulated steel stud backup wall with 24" vertical bracket spacing and three insulation thicknesses with the following insulation types:

- EPS (R-3.5/inch)
- Mineral Wool (R-4.2/inch)
- Polyiso (R-5.5/inch)

The results from the sensitivity analysis are shown in Table 4.1 and in graphical form in Figure 4.1.

Table 3.7: Thermal Transmittance and Resistance values for Steel Stud Backup Wall Assembly with different Insulation Types

Insulation Type	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)**
R3.5/in EPS	3	R-10.5 (1.85)	0.077 (0.434)	R-13.1 (2.30)
	4	R-14.0 (2.47)	0.062 (0.354)	R-16.0 (2.82)
	5	R-17.5 (3.08)	0.053 (0.302)	R-18.8 (3.31)
R4.2/in Mineral Wool	3	R-12.6 (2.22)	0.067 (0.378)	R-15.0 (2.65)
	4	R-16.8 (2.96)	0.054 (0.306)	R-18.5 (3.26)
	5	R-21.0 (3.70)	0.046 (0.260)	R-21.8 (3.84)
R5.5/in Polyiso	3	R-16.5 (2.91)	0.054 (0.306)	R-18.6 (3.27)
	4	R-22.0 (3.87)	0.043 (0.246)	R-23.1 (4.06)
	5	R-27.5 (4.84)	0.037 (0.208)	R-27.2 (4.80)

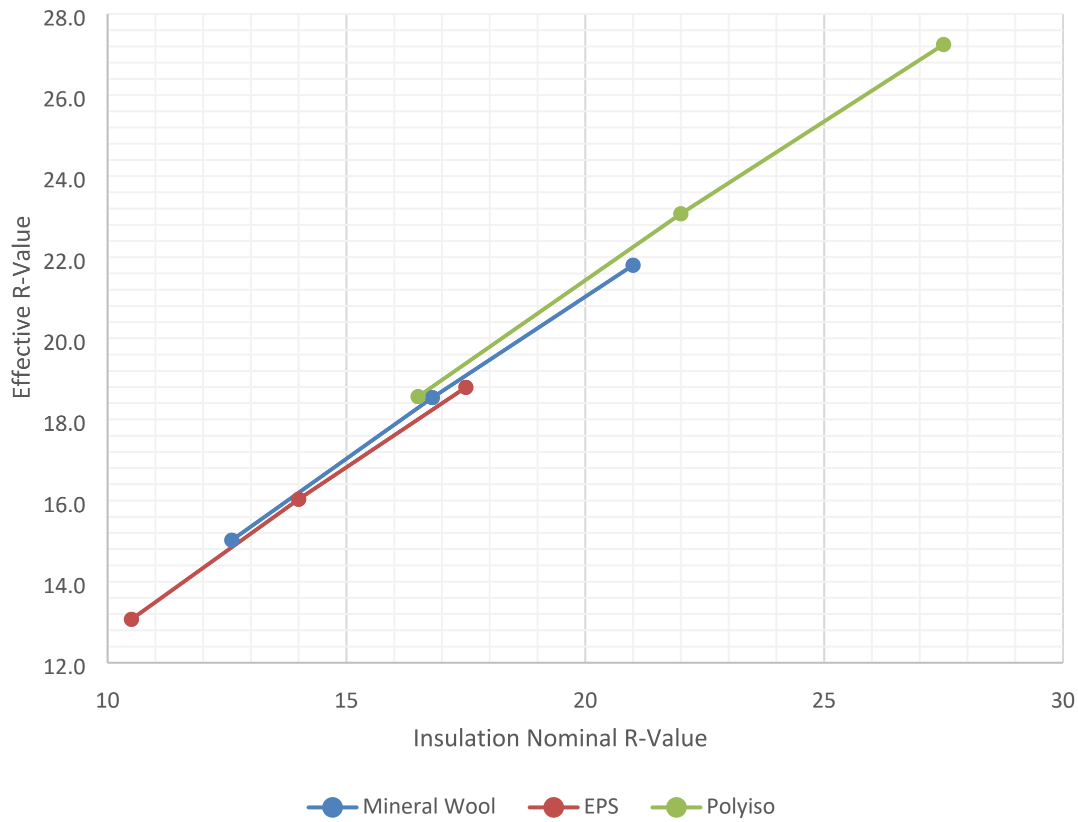


Figure 3.1: Longboard L-Clip Effective R-Value by Insulation Type

The results of the sensitivity analysis show that the effective R-Values vary by, at most, 2% for the specified insulations. This indicates that the U and Effective R-Values are reasonably dependent on the nominal R-value of the insulation, and not the insulation type. Therefore the results shown in Section 3 can apply to other insulation types. Keep in mind, using the values in Section 3 with insulations that have higher R/inch values than mineral wool will result in slightly conservative values (ie, upto 2% for Polyiso).

If the nominal R-value for the alternative insulation is known than the performance values can be interpolated from the reported values.

5. CONCLUSIONS

From this report, the following conclusions can be made:

- For an exterior insulated steel stud backup wall, the assembly U-Value varies between U-0.067 (USI-0.378) and U-0.044 (USI-0.250) depending on the amount of exterior insulation and bracket spacing.
- For an exterior insulated steel stud backup wall with R-12 batt insulation, the assembly U-Value varies between U-0.048 (USI-0.270) and U-0.035 (USI-0.198) depending on the amount of exterior insulation and bracket spacing.
- For an exterior insulated wood stud backup wall, the assembly U-Value varies between U-0.064 (USI-0.361) and U-0.043 (USI-0.242) depending on the amount of exterior insulation and bracket spacing.
- For an exterior insulated reinforced concrete backup wall, the assembly U-Value varies between U-0.066 (USI-0.373) and U-0.044 (USI-0.247) depending on the amount of exterior insulation and bracket spacing.
- For an exterior insulated hollow concrete masonry block backup wall, the assembly U-Value varies between U-0.063 (USI-0.357) and U-0.042 (USI-0.241) depending on the amount of exterior insulation and bracket spacing.
- The sensitivity analysis indicate that the U and Effective R-Values are reasonably dependent on the nominal R-value of the insulation, and not the insulation type. Therefore the results from this report can apply to other insulation types.

Morrison Hershfield Limited

PROFESSIONAL PROVINCE OF N. K. C. NORRIS # 41348 BRITISH COLUMBIA ENGINEER

Mar 28th/17

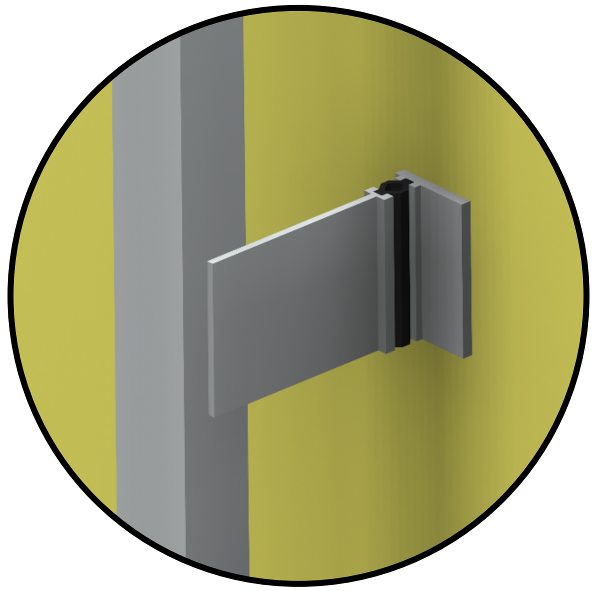
Neil Norris, M.A.Sc., P.Eng.
Building Science Engineer

Jean Tse,
Structural E.I.T.

APPENDIX A – ASSEMBLY INFORMATION AND MATERIAL PROPERTIES

Longboard L-Clip System

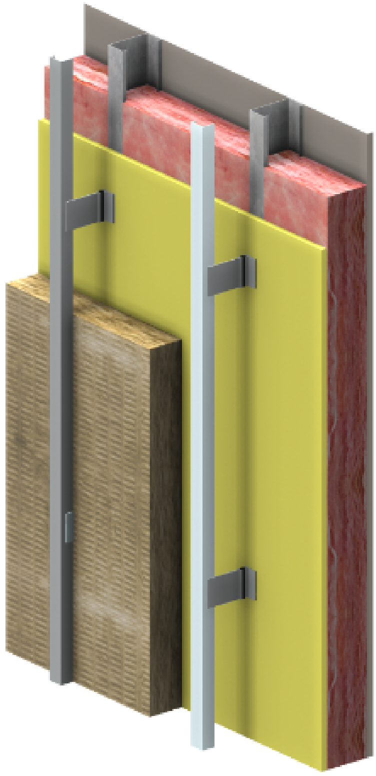
Exterior Insulated Steel Stud Backup Wall

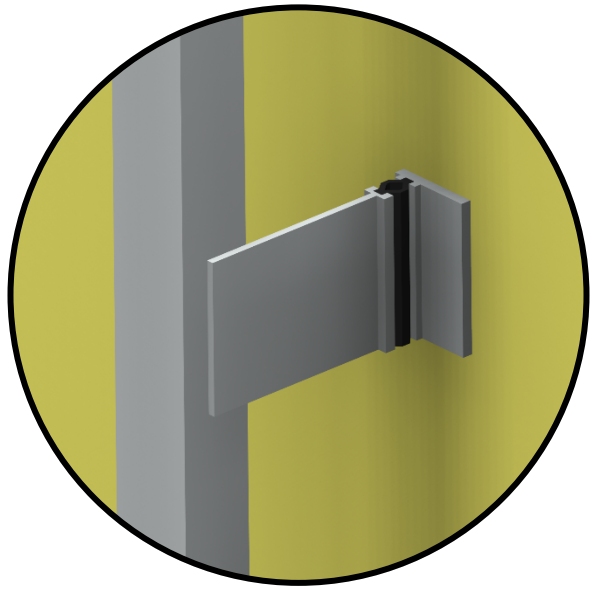


Component	Thickness Inches (mm)	Conductivity Btu·in / ft²·hr·°F (W/m K)	Nominal Resistance hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (RSI-0.16)
3 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Exterior Sheathing	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Exterior Insulation (Mineral Wool)	3" to 5" (76 to 127)	0.24 (0.034)	R-12.6 to R-21.0 (RSI-2.22 to RSI-3.70)
L-Clip	1/5" to 3/8" (5 to10)	1109 (160)	-
Vertical Girt	18 gauge	430 (62)	-
Cladding with ½" (13mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Longboard L-Clip System

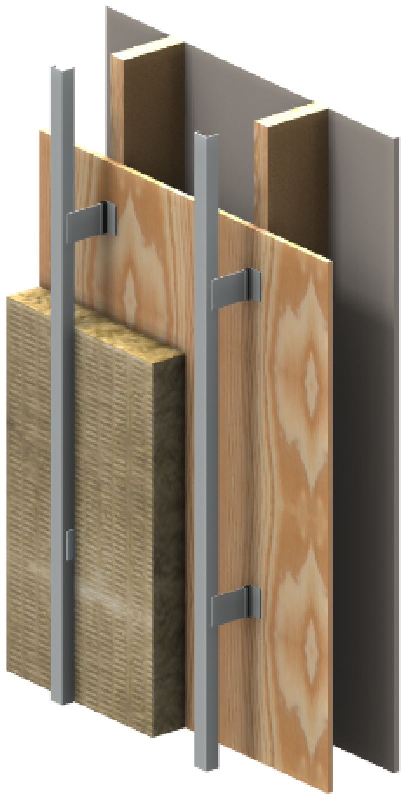
Split Insulated Steel Stud Backup Wall





Component	**Thickness** Inches (mm)	**Conductivity** Btu·in / ft²·hr·°F (W/m K)	**Nominal Resistance** hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
R-12 Batt Insulation	3 5/8" (92)	-	R-12 (RSI-2.11)
3 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Exterior Sheathing	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Exterior Insulation (Mineral Wool)	3" to 5" (76 to 127)	0.24 (0.034)	R-12.6 to R-21.0 (RSI-2.22 to RSI-3.70)
L- Clip	1/5" to 3/8" (5 to10)	1109 (160)	-
Vertical Girt	18 gauge	430 (62)	-
Cladding with ½" (13mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

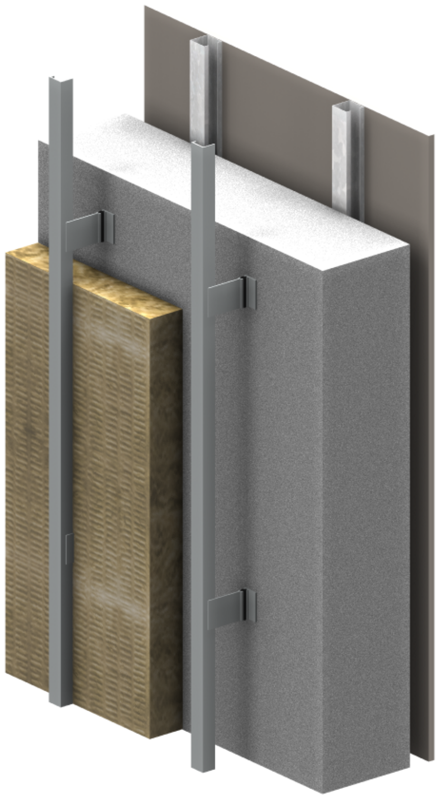
Longboard L-Clip System | **Wood Stud Backup Wall**

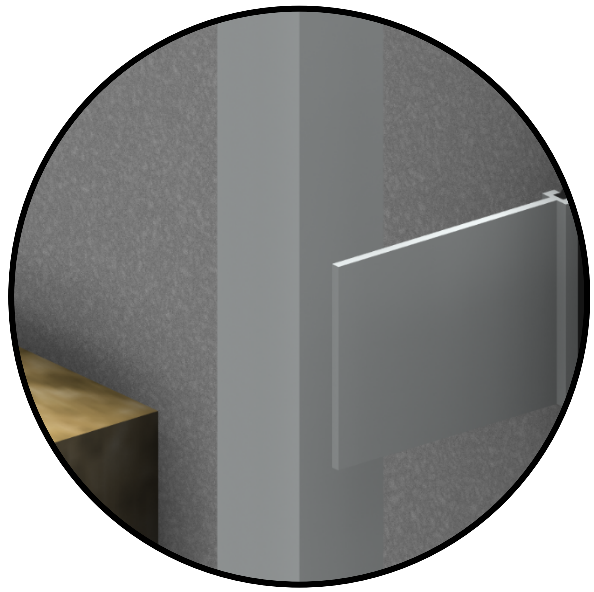


Component	**Thickness** Inches (mm)	**Conductivity** Btu·in / ft²·hr·°F (W/m K)	**Nominal Resistance** hr· ft²· °F/BTU (m^2K/W)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (RSI-0.16)
2x6 Wood Stud,16" o.c.	5 ½" (140)	0.69 (0.10)	-
Exterior Wood Sheathing	½" (13)	0.69 (0.10)	R-0.7 (RSI-0.10)
Exterior Insulation (Mineral Wool)	3" to 5" (76 to 127)	0.24 (0.034)	R-12.6 to R-21.0 (RSI-2.22 to RSI-3.70)
L-Clip	1/5" to 3/8" (5 to10)	1109 (160)	-
Vertical Girt	18 gauge	430 (62)	-
Cladding with ½" (13mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

Longboard L-Clip System

Solid Concrete Backup Wall

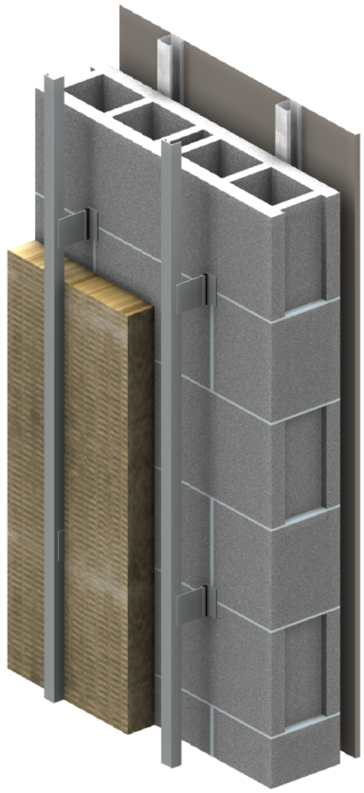


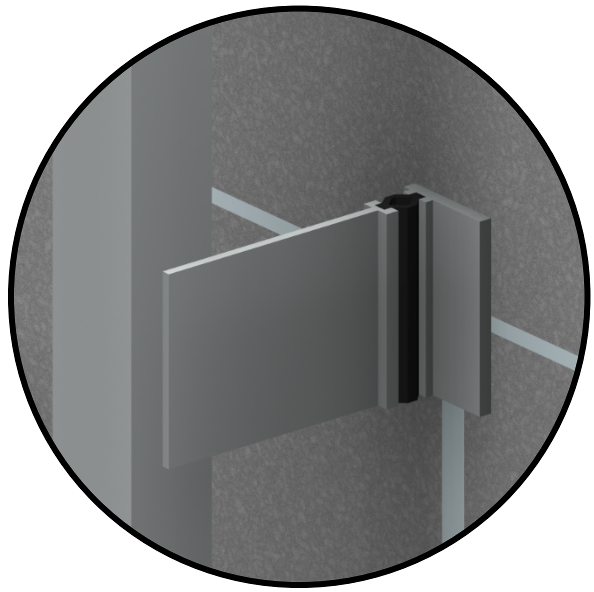


Component	**Thickness** Inches (mm)	**Conductivity** Btu·in / ft²·hr·°F (W/m K)	**Nominal Resistance** hr· ft²· °F/BTU (m²K/W)
Interior Film	-	-	R-0.6 to R-0.9 (RSI-0.11 to RSI-0.16)
Gypsum Board	½" (13)	1.1 (0.16)	R-0.5 (RSI-0.08)
Air in Stud Cavity	3 5/8" (92)	-	R-0.9 (RSI-0.16)
1 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	36 (62)	-
Exterior Insulation (Mineral Wool)	3" to 5" (76 to 127)	0.24 (0.034)	R-12.6 to R-21.0 (RSI-2.22 to RSI-3.70)
L-Clip	1/5" to 3/8" (5 to10)	1109 (160)	-
Vertical Girt	18 gauge	430 (62)	-
Cladding with ½" (13mm) vented air space is incorporated into exterior heat transfer coefficient			
8" Solid Concrete Wall	8 (203)	12.5 (1.8)	-
Exterior Film	-	-	R-0.7 (RSI-0.12)

Longboard L-Clip System

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)
Interior Film	-	-	R-0.7 (RSI-0.12)
Gypsum Board	½" (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)
1 5/8" x 1 5/8" Steel Studs, 16"o.c.	18 gauge	430 (62)	-
Standard Concrete Block	7 5/8" (190)	3.5 (0.5)	-
Cement Mortar	-	3.5 (0.5)	-
Exterior Insulation (Mineral Wool)	3" to 5" (76 to 127)	0.24 (0.034)	R-12.6 to R-21.0 (RSI-2.22 to RSI-3.70)
L-Clip	1/5" to 3/8" (5 to10)	1109 (160)	-
Vertical Girt	18 gauge	430 (62)	-
Cladding with ½" (13mm) vented air space is incorporated into exterior heat transfer coefficient			
Exterior Film	-	-	R-0.7 (RSI-0.12)

APPENDIX B – MODELLING PARAMETERS AND ASSUMPTIONS

B.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.
- Material properties were taken from information provided by Mayne Coatings and published material information from Lawrence Berkeley National Laboratory and ASHRAE Handbook – Fundamentals for common materials (such sheathings, wood studs etc)
- 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). These values, along with other modeling parameters, are given in ASHRAE 1365-RP, Chapter 5.
- 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.

B.2 Thermal Transmittance

The methodology presented in the Building Envelope Thermal Bridging Guide separates the thermal performance of clear field assemblies and details in order to simplify heat loss calculations. For the assemblies, a characteristic area is modeled and the heat flow through that area is found. To find the effects of thermal bridges in transition details (such as slab edges, parapets etc), the assembly is modeled with and without the detail. The difference in heat loss between the two models is then prescribed to that detail. This allows the thermal transmittances to be divided into three categories: clear field, linear and point transmittances.

For this report, only clear field transmittances for this system were evaluated, and not the 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 with top and bottom tracks.

B.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

B.4 Boundary Conditions

Table B-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 C – SIMULATED TEMPERATURE PROFILES

Figure C1: 3" Longboard L-Clip with Exterior Insulated Steel Stud Backup Wall

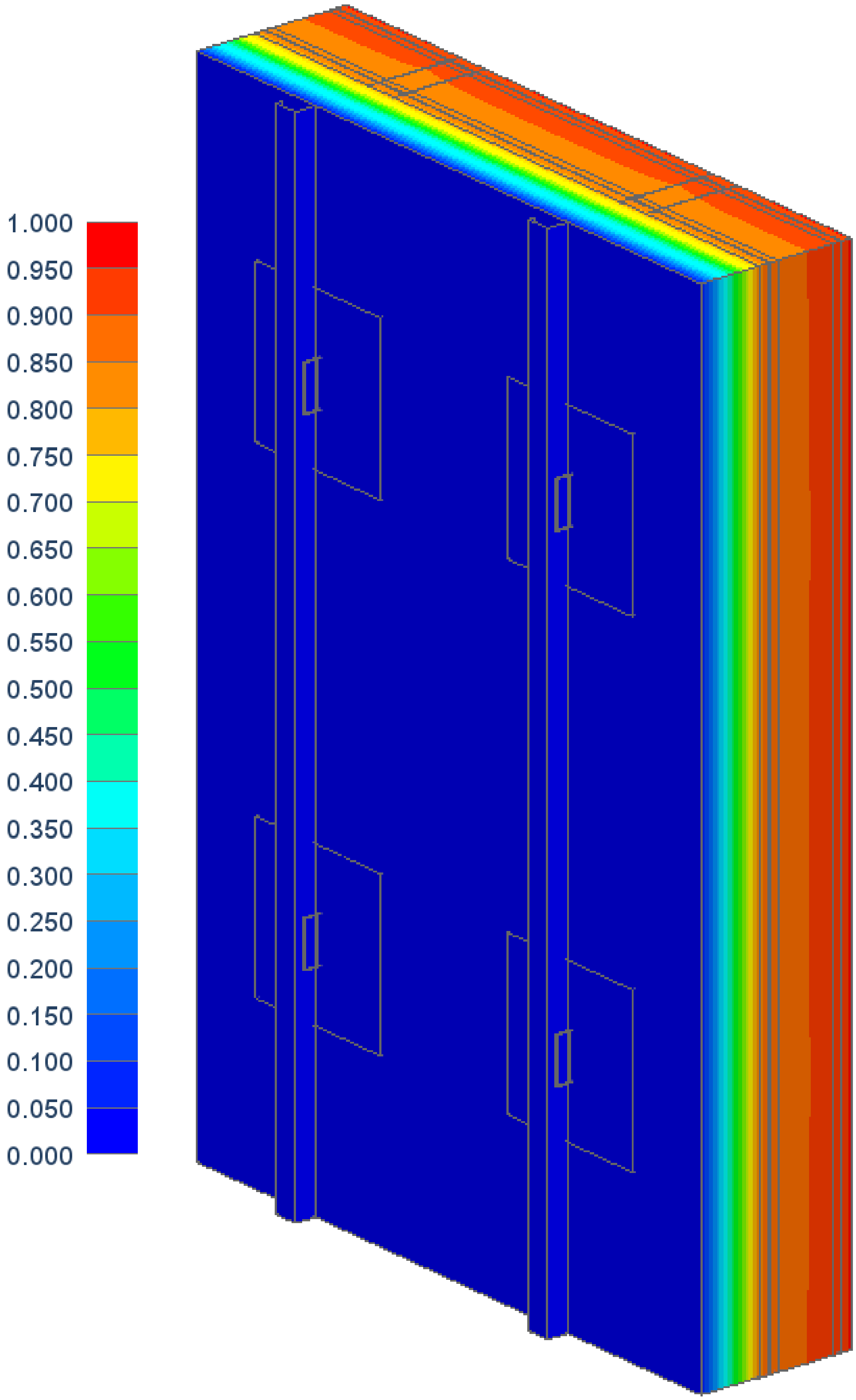


Figure C2: 3” Longboard L-Clip with Split Insulated Steel Stud Backup Wall

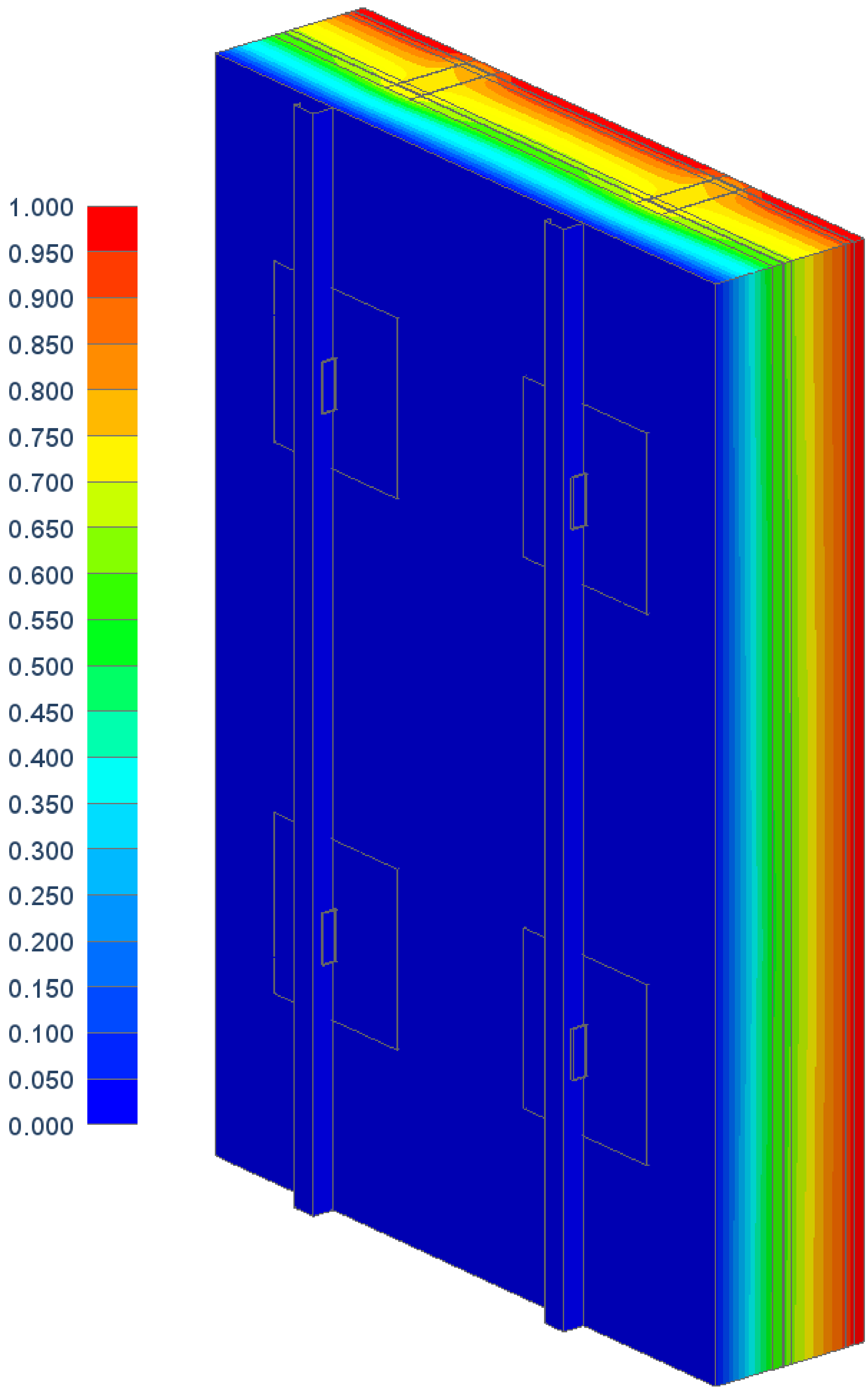


Figure C3: 3” Longboard L-Clip with Exterior Insulated Wood Stud Backup Wall

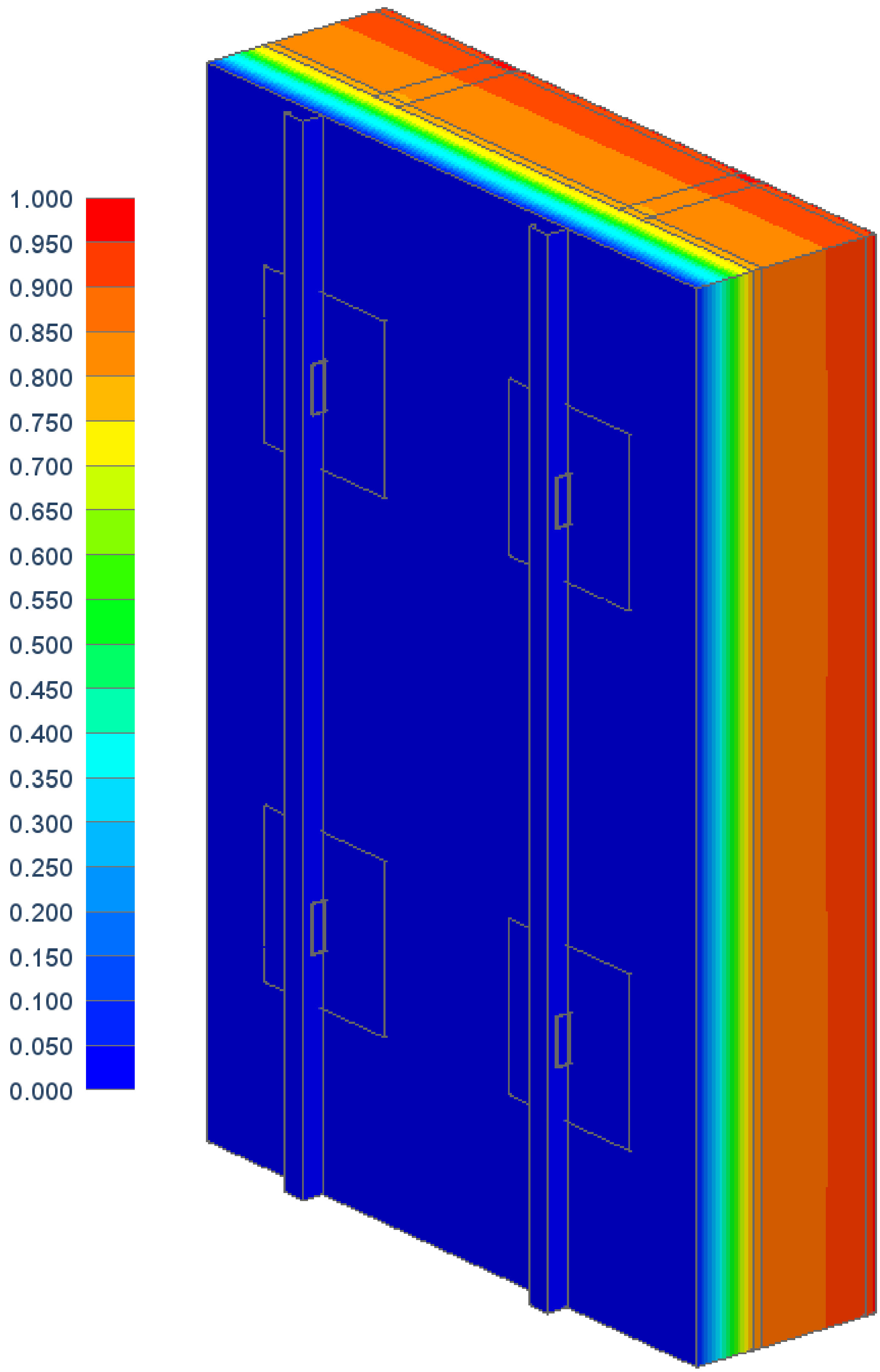


Figure C4: 3” Longboard L-Clip with Exterior Insulated Reinforced Concrete Backup Wall

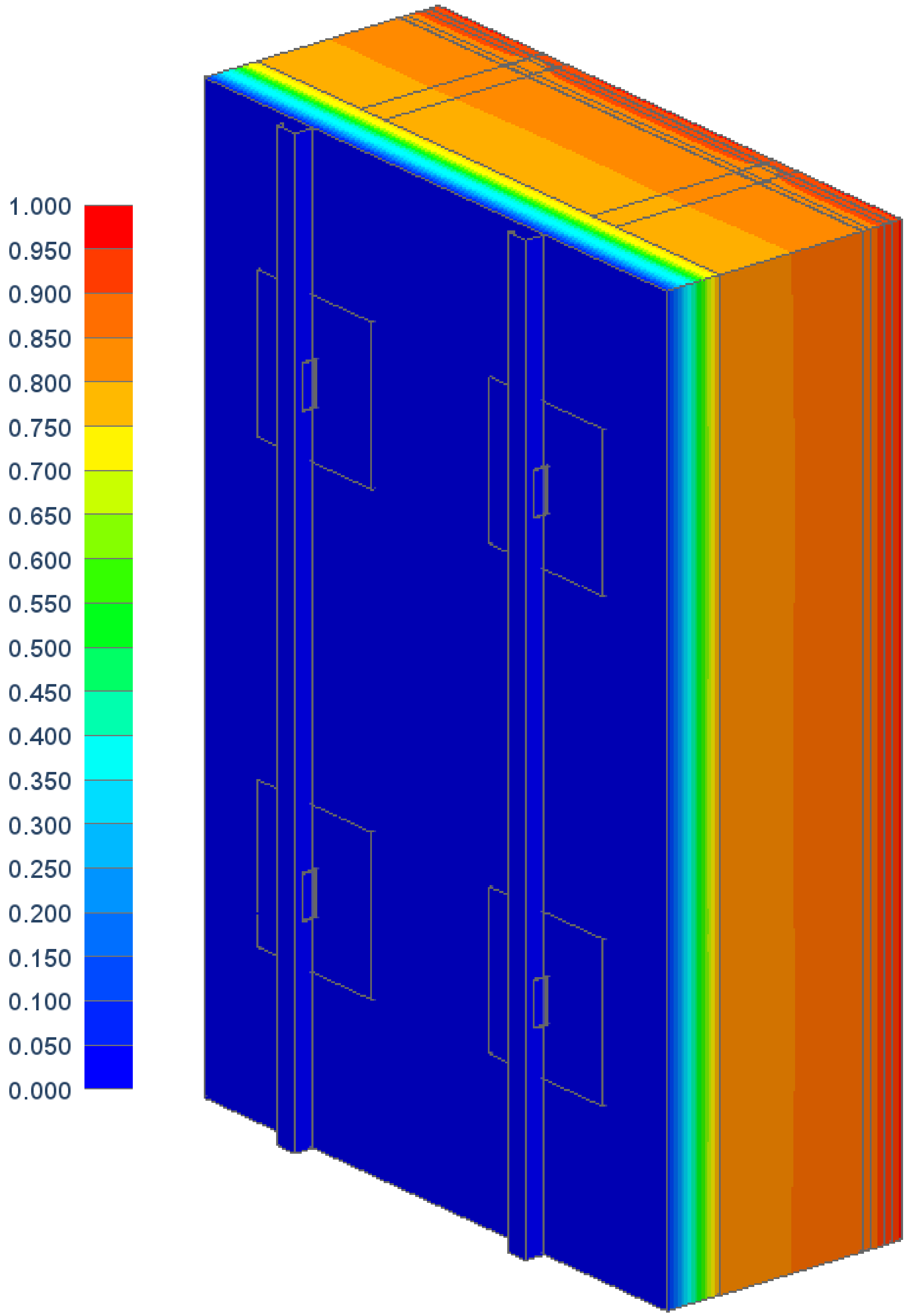


Figure C5: 3" Longboard L-Clip with Exterior Insulated Concrete Masonry Block Backup Wall