MORRISON HERSHFIELD

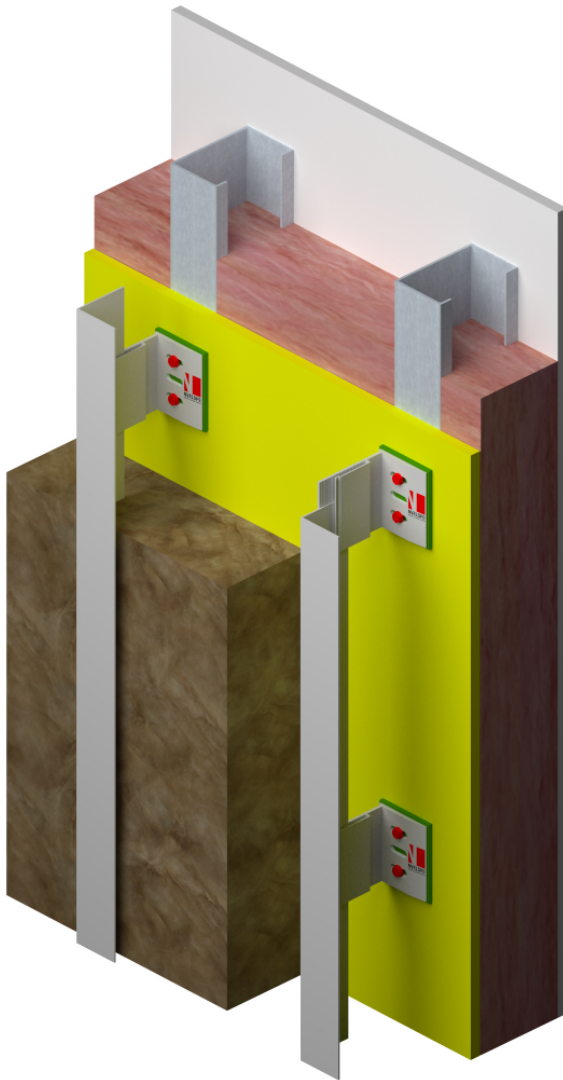## Thermal Performance of Nvelope – NV1 Clip System

Presented to:

Nvelope USA, LLC
16904 164th Way S.E.
Renton, WA 98058

TABLE OF CONTENTS

- 1 -

1. INTRODUCTION

The Nvelope NV1 Thermal Clip System is an aluminum clip system for attaching exterior cladding to various types of exterior insulated wall assemblies. Morrison Hershfield was contracted by Nvelope USA to evaluate the thermal performance of their clip system for several scenarios.

The NV1 clip provides an intermittent structural attachment for claddings of exterior insulated wall assemblies. The clip is fabricated from extruded 6005A Aluminum alloy and includes a plastic isolator that reduces thermal bridging between the clip and the back-up wall. The vertical flange of the clip has a slot that allows sub-girts to be fastened to and adjusted to level the cladding as seen in Figure 1 and 2. For steel stud assemblies, the clips are fastened through the exterior sheathing directly to the steel studs using self-drilling screws.

Several construction scenarios were evaluated for the NV1 Clip System, including varying insulation levels, clip spacing, and types of insulation.
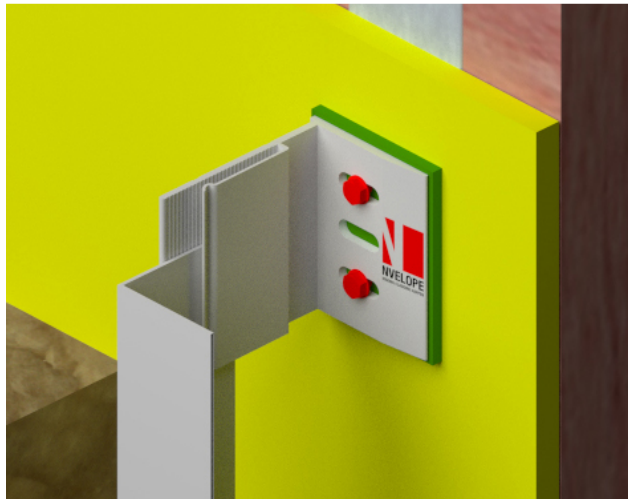

Figure 1: NV1 with Girt attachment for 4" insulation and steel stud back-up wall
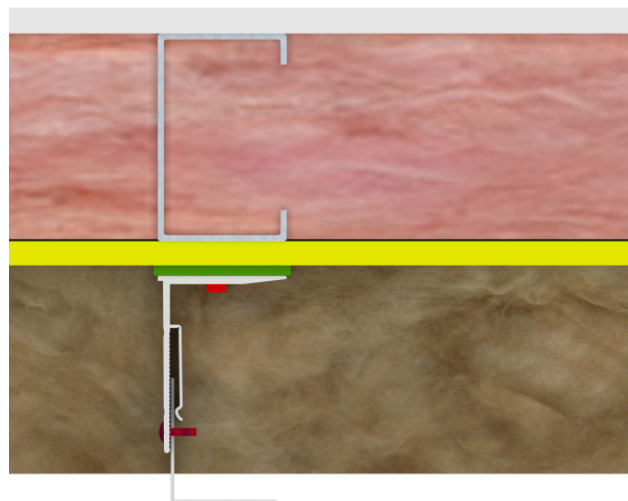

Figure 2: NV1 with Girt attachment for 4" insulation and steel stud back-up wall (section view)

2. MODELING OUTLINE

The 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. The thermal transmittance (U-Value) or "effective" R-value" was determined using the methodology presented in 1365-RP. The methodology, along with modeling assumptions is summarized in Appendix B.

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)[1]. In addition, an extensive study has been performed for several construction scenarios including various clip attachment methods, with comprehensive results presented in the Building Envelope Thermal Bridging Guide[2].

3.   THERMAL ANALYSIS

The following section provides the U-Value results for several configurations using the NV1 Clip System. The base case scenario, Case 1, is an exterior insulated steel stud wall assembly with mineral wool insulation ranging from 3 to 6 inches, and vertical sub-girts (See Figure 3).
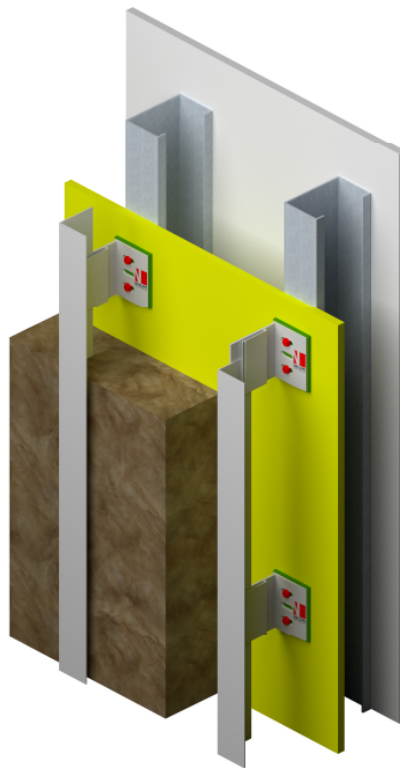

Figure 3: Case 1: Exterior Insulated Steel Stud Wall Assembly
with Vertical Girts

---

[1] http://www.morrisonhershfield.com/ashrae1365research/Pages/Insights-Publications.aspx
[2] http://www.bchydro.com/powersmart/business/programs/new-construction.html?WT.mc_id=rd_construction

Case 2 is a split insulated steel stud assembly with R-12 fiberglass batt insulation in the stud cavity (See Figure 4).
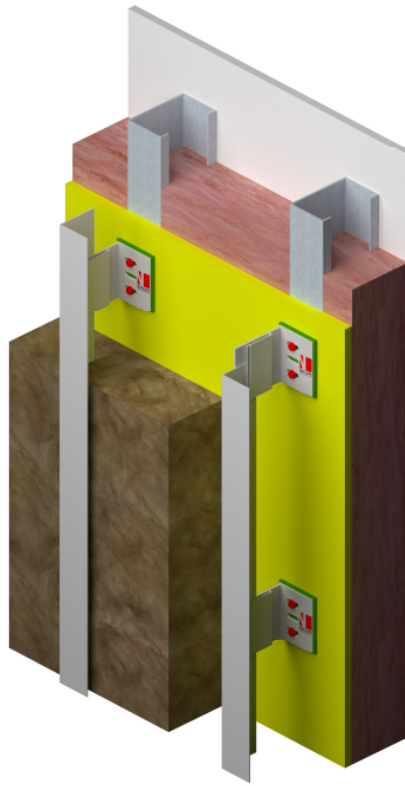
Figure 4: Case 2: Split Insulated Steel Stud Wall Assembly with Vertical Girts and R-12 batt insulation

Assembly images for these systems, outlining the components and material properties are found in Appendix A. Temperature profiles for the evaluated scenarios are given in Appendix D. "Effective" R-values are presented in Appendix C. Cases one and two are discussed further in the following sections.

A sensitivity analysis was performed to demonstrate that the conductivity of exterior insulation, and thickness, does not have a significant impact on the results and generic insulation levels can be used for any type of exterior insulation.

3.1 Case 1: Clear Field Thermal Performance of Exterior Insulated Steel Stud Assemblies with NV1 Clip System

Thermal performance results of the NV1 Clip System with vertical sub-girts are presented in Table 1. The results include spacing of the clips ranging from 24" to 48" vertically and 16" o.c. horizontally to line up with the steel studs. Varying levels of exterior mineral wool insulation (R-4.2 per inch) are presented. The results include all the components of the steel stud assembly, including 3 5/8" (90 mm) steel studs spaced at 16 o.c. and exterior sheathing and interior drywall. The exterior cladding and cavity was not explicitly modelled, but the effects of the cladding and air space were simulated by adjusting the exterior air film coefficient accordingly. "Effective" R-values are given in Table C.1 in Appendix C. Temperature profiles are presented in Appendix D.

The overall effectiveness of the thermal insulation for the vertical sub-girt system ranges from 65% to 84% depending on the vertical clip spacing and insulation level. In comparison, the effectiveness of insulation in typical continuous vertical girt systems ranges from 43% to 58% over the same range of insulation levels[3].

Table 1: Thermal Transmittance U-values for Exterior Insulated Steel Stud Wall Assemblies with NV1 Clip System (Case 1)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[4] hr·ft^2·°F/BTU (m^{2}K/W)	Effective Assembly U-Value BTU/hr·ft^2·°F (W/m^{2}K)		
		24" Vertical Clip Spacing	36" Vertical Clip Spacing	48" Vertical Clip Spacing
3	12.6 (2.22)	0.082 (0.463)	0.077 (0.440)	0.075 (0.429)
4	16.8 (2.96)	0.068 (0.386)	0.063 (0.359)	0.061 (0.346)
5	21.0 (3.70)	0.060 (0.340)	0.055 (0.310)	0.052 (0.295)
6	25.2 (4.44)	0.050 (0.308)	0.049 (0.276)	0.046 (0.260)

[3]Results in ASHRAE 1365-RP Final Report and Building Envelope Thermal Bridging Guide
[4]This is only the exterior insulation nominal R-value. Without taking into account thermal bridging, the steel stud wall, cladding cavity and interior air films add an approximate nominal R-3.2 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

3.2   Case 2: Thermal Performance of Split Insulated Steel Stud Assemblies with NV1 Clip System

For Case 2, the wall assemblies were simulated with R-12 fiberglass batt insulation in the steel stud cavity. The thermal transmittance U-values for these split insulated assemblies are summarized in Table 2 ("effective" R-values are given in Table C.2). Temperature profiles are given in Appendix D.

Table 2: Thermal Transmittance U-values for Split Insulated Steel Stud Wall with NV1 Clip System and R-12 Batt Insulation in Stud Cavity (Case 2)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[5] hr·ft^2·°F/BTU (m^{2}K/W)	Effective Assembly U-Value BTU/hr·ft^2·°F (W/m^{2}K)		
		24" Vertical Clip Spacing	36" Vertical Clip Spacing	48" Vertical Clip Spacing
2	8.4 (1.48)	0.063 (0.360)	0.062 (0.350)	0.061 (0.345)
3	12.6 (2.22)	0.055 (0.314)	0.053 (0.300)	0.052 (0.293)
4	16.8 (2.96)	0.049 (0.277)	0.046 (0.260)	0.044 (0.252)
5	21.0 (3.70)	0.044 (0.252)	0.041 (0.233)	0.039 (0.223)
6	25.2 (4.44)	0.041 (0.234)	0.037 (0.213)	0.036 (0.202)

Adding batt insulation to the steel stud cavity is often considered during design to meet specific building envelope thermal transmittance targets and to minimize the thickness of the exterior wall depth. With batt insulation, the U-value of the assembly is improved but the effectiveness of the insulation is reduced. This is due to the thermal bridging of the steel studs. For the NV1 Clip System, adding R-12 batt reduces the overall effectiveness of the insulation to a range of 61% to 73% depending on the spacing and amount of insulation. The addition of R-12 batt insulation results, on average, in an R-6 increase in the effective insulation value of the wall.

---

[5]This is only the exterior insulation nominal R-value. Without taking into account thermal bridging, the steel stud wall, cladding cavity and interior air films add an approximate nominal R-14.3 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

4.   EXTERIOR INSULATION SENSITIVITY ANALYSIS

A sensitivity analysis was performed for the thermal performance of the system to different assumptions for insulation conductivity:

- R-3.5/in exterior insulation
- R-6.5/in exterior insulation

The previous analysis assumed semi-rigid (R 4.2/inch) for the exterior insulation. Other conductivities were evaluated to allow the thermal transmittance values for the thermal clip system to be utilized for other types of insulation (see Table 3). In order to characterize the range of exterior insulation values, the modeled assemblies in section 3.1 were re-calculated using a low end of R-3.5 per inch (RSI - 0.62 per inch) to a high end of R-6.5 per inch (RSI - 1.14 per inch).

Table 3: Sensitivity Analysis for Exterior Insulated Steel Stud Wall with Vertical Girts, Clips 24" o.c., and Studs Spaced 16" o.c. with alternate insulation types

Insulation Conductivity	Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[4] hr·ft^2·°F/BTU (m^{2}K/W)	Effective Assembly U-Value BTU/hr·ft^2·°F (W/m^{2}K)
			24" Vertical Clip Spacing
R-3.5/inch	3	10.5 (1.85)	0.091 (0.516)
	4	14.0 (2.47)	0.076 (0.431)
	5	17.5 (3.08)	0.067 (0.379)
	6	21.0 (3.70)	0.060 (0.342)
R-6.5/inch	3	19.5 (3.43)	0.063 (0.357)
	4	26.0 (4.58)	0.053 (0.300)
	5	32.5 (5.72)	0.047 (0.266)
	6	39.0 (6.87)	0.043 (0.243)

Figure 5 shows the graphical results for effective assembly R-values with a clip spacing of 24" vertically and 16" horizontally with no batt insulation when varying the exterior insulation materials. The results show that the thickness of the insulation (and the length of the clip) for a given nominal thermal resistance is largely independent of the effective R-value. Therefore, the results can be characterized by the R-value of the exterior insulation and can be applied to any material.

The results from Table 3 can be re-arranged and additional R-values can be interpolated with results from the sensitivity analysis. The U-value results are presented in Table 3 and R-value results are found in Appendix C.

As an example, 3 inches of R-5 exterior (R-15) insulation will yield an "effective" R-value of approximately R-13.5 as shown with the red arrows in Figure 5.
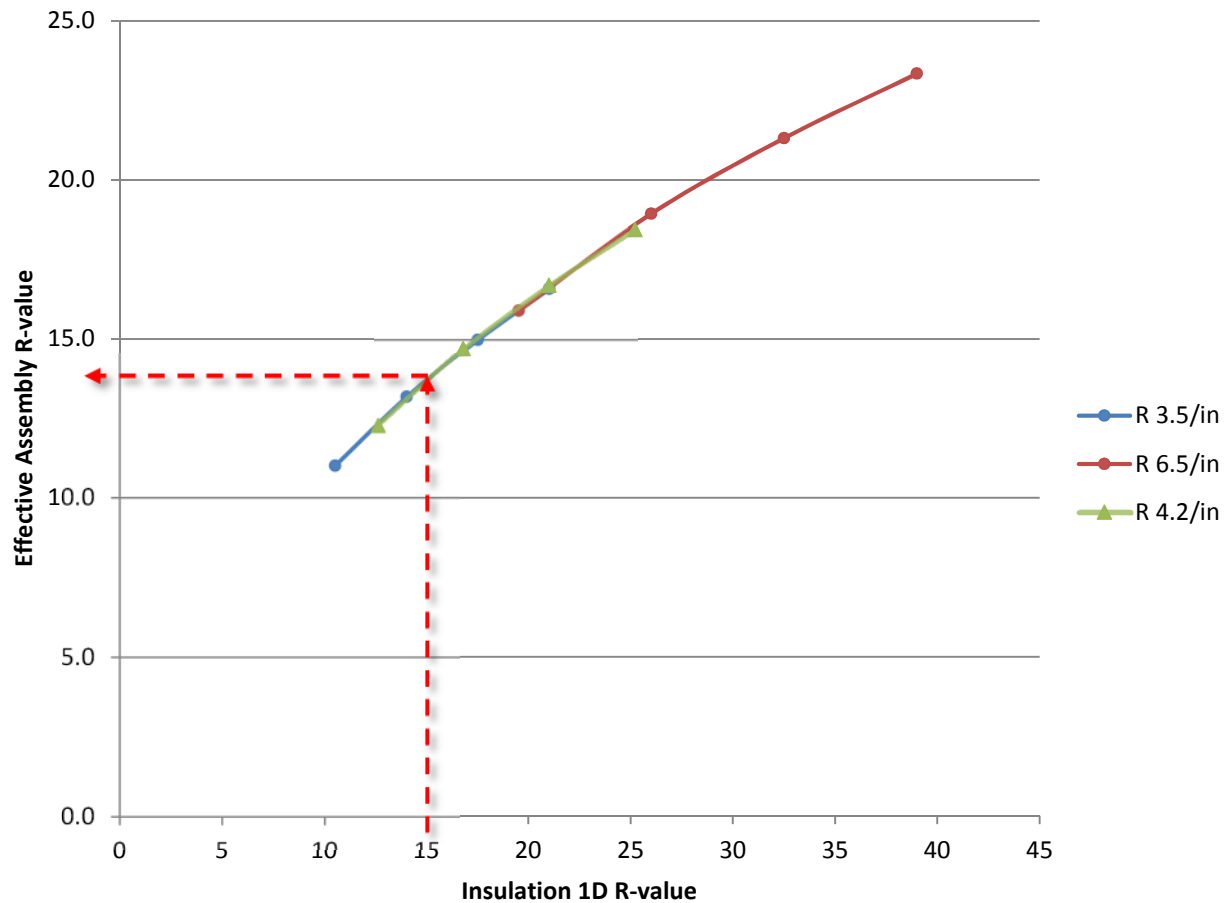

Figure 5: Case 2: Exterior Insulated Steel Stud Wall Assembly with Alternate Insulation

5.   CONCLUSIONS

Overall, the NV1 System provides an effective means of reducing thermal bridging in wall assemblies compared to traditional continuous girt systems.

The U-values provided by 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, an/or NECB.

Morrison Hershfield

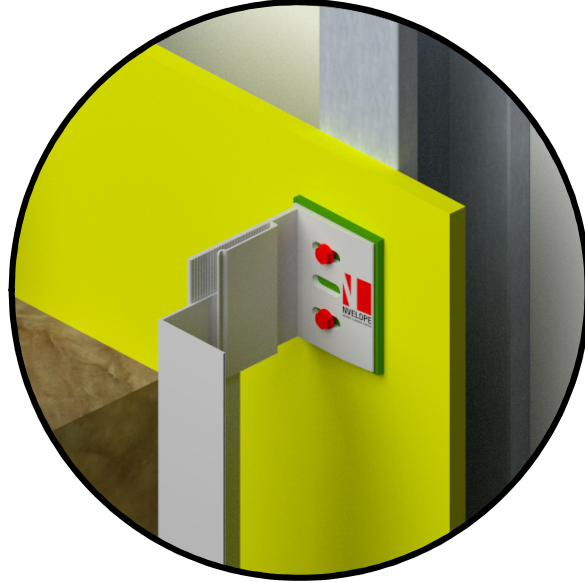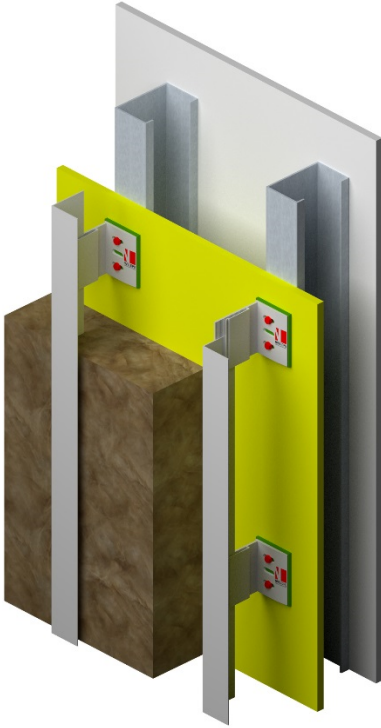**Radu Postole, BASc.**
Building Science Consultant

Patrick Roppel, P.Eng.
Building Science Specialist

APPENDIX A – CLIP SYSTEM DETAILS AND MATERIAL PROPERTIES

NV1 Clip System

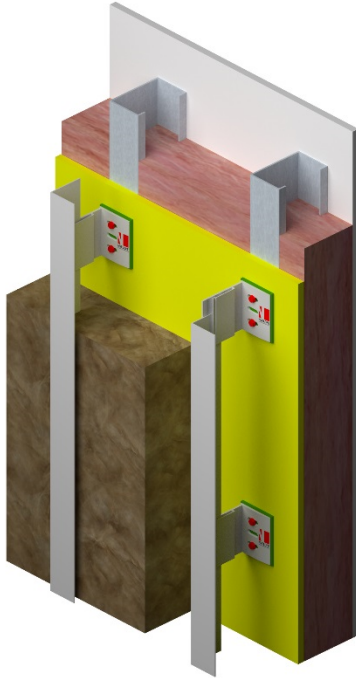# Exterior Insulated Steel Stud Assembly with Vertical Sub-girts

Clip Detail

ID	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" x 1 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	Exterior Insulation (Mineral Wool)	3 to 6 (76 to 152)	0.24 (0.034)	R-12.6 to R-25.2 (2.22 RSI to 4.44 RSI)	4 (64)	0.20 (850)
7	NV1 Clip Isolator	0.2" (5)	0.82 (0.117)	-	-	-
8	NV1 Clip Extrusion – Aluminum 6005A alloy	varies	1340 (193)	-	-	-
9	Bolts – Stainless Steel	1/4" D (6D)	118 (17)	-	-	-
10	Vertical Sub-girt	0.09" (2.2)	1340 (193)	-	-	-
11	Generic Cladding with 1/2" (13mm) vented air space is incorporated into exterior heat transfer coefficient					
12	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

* NV1 clip @ 24" spacing with 4" exterior insulation and no batt insulation is shown in images

NV1 Clip System

Split Insulated Steel Stud Assembly with Vertical Sub-girts

Clip Detail

ID	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)	R-12 (2.2 RSI)	0.9 (14)	0.17 (710)
4	3 5/8" x 1 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	Exterior Insulation (Mineral Wool)	2 to 6 (50 to 152)	0.24 (0.034)	R-8.4 to R-25.2 (1.48 RSI to 4.44 RSI)	4 (64)	0.20 (850)
7	NV1 Clip Isolator	0.2" (5)	0.82 (0.117)	-	-	-
8	NV1 Clip Extrusion – Aluminum 6005A alloy	varies	1340 (193)	-	-	-
9	Bolts – Stainless Steel	1/4" D (6D)	118 (17)	-	-	-
10	Vertical Sub-girt	0.09" (2.2)	1340 (193)	-	-	-
11	Generic Cladding with 1/2" (13mm) vented air space is incorporated into exterior heat transfer coefficient					
12	Exterior Film	-	-	R-0.7 (0.12 RSI)	-	-

* NV1 clip @ 24" spacing with 4" exterior insulation and batt insulation is shown in images

APPENDIX B – ASHRAE 1365-RP METHODOLOGY

B.1   General Modeling Approach

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

- Air cavities were assumed to have an effective thermal conductivity which includes the effects of cavity convection.

- Interior/exterior air films were taken from Table 1, p. 26.1 of 2009 ASHRAE Handbook – Fundments depending on surface orientation.

- Cladding and vented rainscreen cavity airspaces were not explicitly modelled and their thermal resistance was added to the exterior air film

- From the calibration in 1365-RP, contact resistances between materials were modeled.

- 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.

B.2   Thermal Transmittance

The methodology presented in ASHRAE 1365-RP separates the thermal performance of 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 details (such as slab edges), 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.

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, brick ties and cladding supports. This is treated the same as in standard practice, defined as a U-value, Uo (heat flow per area). For a specific area of opaque wall, this can be converted into an overall heat flow per temperature difference, Qo.

The linear transmittance is the additional heat flow caused by details that can be defined by a characteristic length, L. This includes slab edges, corners, parapets, and transitions between assemblies. The linear transmittance is a heat flow per length, and is represented by psi (Ψ).

The point transmittance is the heat flow caused by thermal bridges that occur only at single, infrequent locations. This includes building components such as pipe penetrations and intersections between linear details. The point transmittance is a single additive amount of heat, represented by chi (χ).

With these thermal quantities the overall heat flow can be found simple by adding all the components together, as given in equation 1.

$$Q = \Sigma\, Q_{thermalbridge} + Q_o = \Sigma\left(\Psi \cdot L\right) + \Sigma\left(\chi\right) + Q_o \qquad\qquad \text{EQ 1}$$

Equation 1 gives the overall heat flow for a given building size. For energy modeling, or comparisons to standards and codes, often it is more useful to present equation 1 as a heat flow per area. Knowing that the opaque wall area is A_{total}, and $U=Q/A_{total}$, equation 2 can be derived.

$$U = \frac{\Sigma\left(\Psi \cdot L\right) + \Sigma\left(\chi\right)}{A_{Total}} + U_o$$
EQ 2

Since the linear and point transmittances are simply added amounts of heat flow, they can be individually included or excluded depending on design requirements. For this report, no point transmittance details were analyzed.

B.2 Temperature Index

For condensation concerns, the thermal model can also provide surface temperatures of assembly components to help locate potential areas of risk. In order to be applicable for any climate (varying indoor and outdoor temperatures), the temperatures can been non-dimensionalized into a temperature index, T_i, as shown below in Equation 3.

$$T_i = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}}$$
EQ 3

The 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 3 can be rearranged for $T_{surface}$.

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

APPENDIX C – EFFECTIVE ASSEMBLY R-VALUES

C.1 Case 1: Clear Field Thermal Performance of Exterior Insulated Steel Stud Assemblies with NV1 Clip System

Table C.1: Thermal Resistance for Exterior Insulated Steel Stud Wall Assemblies with NV1 Clip System (Case 1)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[1] hr·ft$^{2\cdot o}$F/BTU (m^{2}K/W)	Assembly Effective R-Value hr·ft$^{2\cdot o}$F/BTU (m^{2}K/W)		
		24" Vertical Spacing	36" Vertical Spacing	48" Vertical Spacing
3	12.6 (2.22)	R-12.3 (2.16)	R-12.9 (2.28)	R-13.3 (2.33)
4	16.8 (2.96)	R-14.7 (2.59)	R-15.8 (2.78)	R-16.4 (2.89)
5	21.0 (3.70)	R-16.7 (2.94)	R-18.3 (3.23)	R-19.2 (3.39)
6	25.2 (4.44)	R-18.4 (3.25)	R-20.6 (3.63)	R-21.9 (3.85)

C.2 Thermal Performance of Split Insulated Steel Stud Assemblies with NV1 Clip System

Table C.2: Thermal Resistance for Split Insulated Steel Stud Wall with NV1 Clip System and R-12 Batt Insulation in Stud Cavity (Case 2)

Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[1] hr·ft$^{2\cdot o}$F/BTU (m^{2}K/W)	Assembly Effective R-Value hr·ft$^{2\cdot o}$F/BTU (m^{2}K/W)		
		24" Vertical Spacing	36" Vertical Spacing	48" Vertical Spacing
2	8.4 (1.48)	R-15.8 (2.78)	R-16.2 (2.86)	R-16.5 (2.90)
3	12.6 (2.22)	R-18.1 (3.19)	R-18.9 (3.33)	R-19.3 (3.41)
4	16.8 (2.96)	R-20.5 (3.61)	R-21.9 (3.85)	R-22.6 (3.97)
5	21.0 (3.70)	R-22.5 (3.96)	R-24.4 (4.30)	R-25.4 (4.48)
6	25.2 (4.44)	R-24.2 (4.27)	R-26.7 (4.70)	R-28.1 (4.95)

---

[1]This is only the exterior insulation nominal R-value. Without taking into account thermal bridging, the steel stud wall, cladding cavity and interior air films add an approximate nominal R-3.2 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

[2]This is only the exterior insulation nominal R-value. Without taking into account thermal bridging, the steel stud wall with batt insulation, cladding cavity and interior air films add an approximate nominal R-14.3 to the assembly. This additional thermal resistance is included when assessing the effectiveness of the system.

C.3 Case 3: Thermal Performance of Exterior Insulated Steel Stud Assemblies with NV1 Clip System and Alternate Insulation

Table C.3: Sensitivity Analysis for Exterior Insulated Steel Stud Wall with Vertical Girts and Studs Spaced 16" o.c. with alternate insulation types

Insulation Conductivity	Exterior Insulation Thickness (in)	Exterior Insulation Nominal R-Value[1] hr·ft^2·°F/BTU (m^{2}K/W)	Assembly Effective R-Value hr·ft^2·°F/BTU (m^{2}K/W) 24" Vertical Spacing
R-3.5/inch	3	10.5 (1.85)	R-11.0 (1.94)
	4	14.0 (2.47)	R-13.2 (2.32)
	5	17.5 (3.08)	R-15.0 (2.64)
	6	21.0 (3.70)	R-16.6 (2.92)
R-6.5/inch	3	19.5 (3.43)	R-15.9 (2.80)
	4	26.0 (4.58)	R-18.9 (3.34)
	5	32.5 (5.72)	R-21.3 (3.75)
	6	39.0 (6.87)	R-23.3 (4.11)

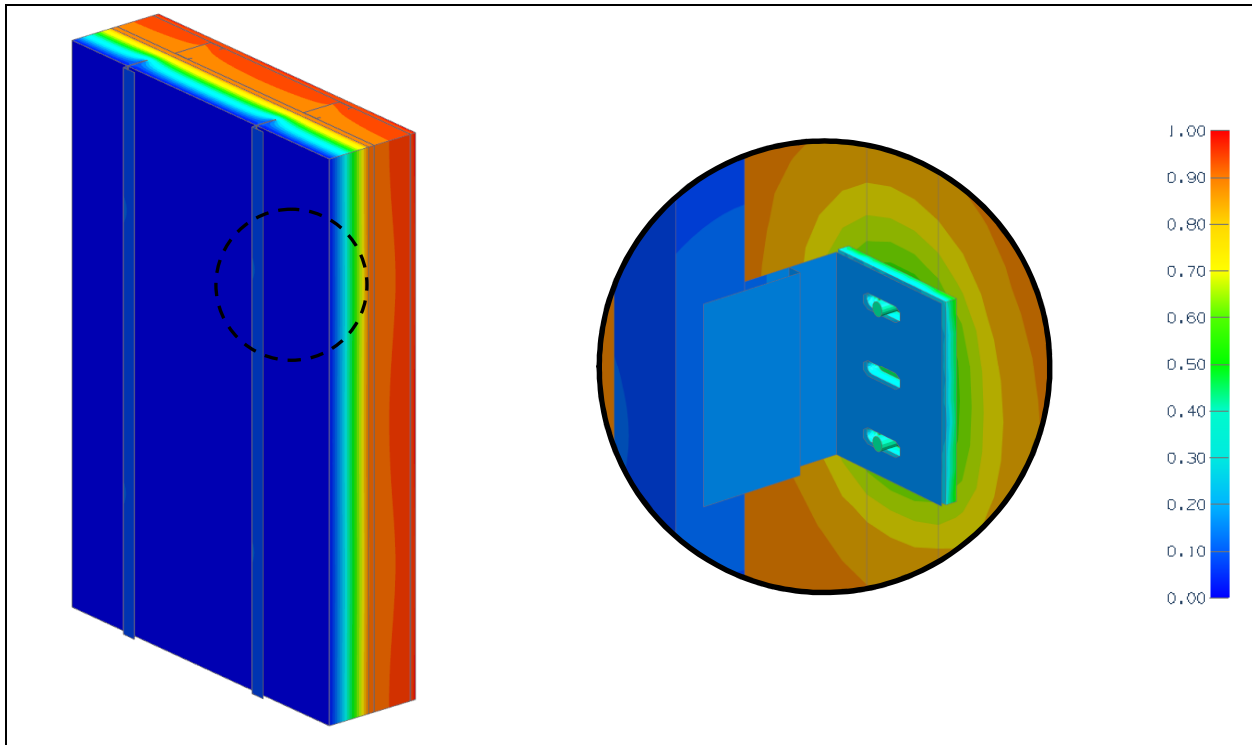# APPENDIX D – SIMULATED TEMPERATURE DISTRIBUTIONS

Figure D.1: *Temperature profile for Case 1 with 4" exterior insulation and clips spaced 24" o.c. Steel stud wall with no interior insulation.*
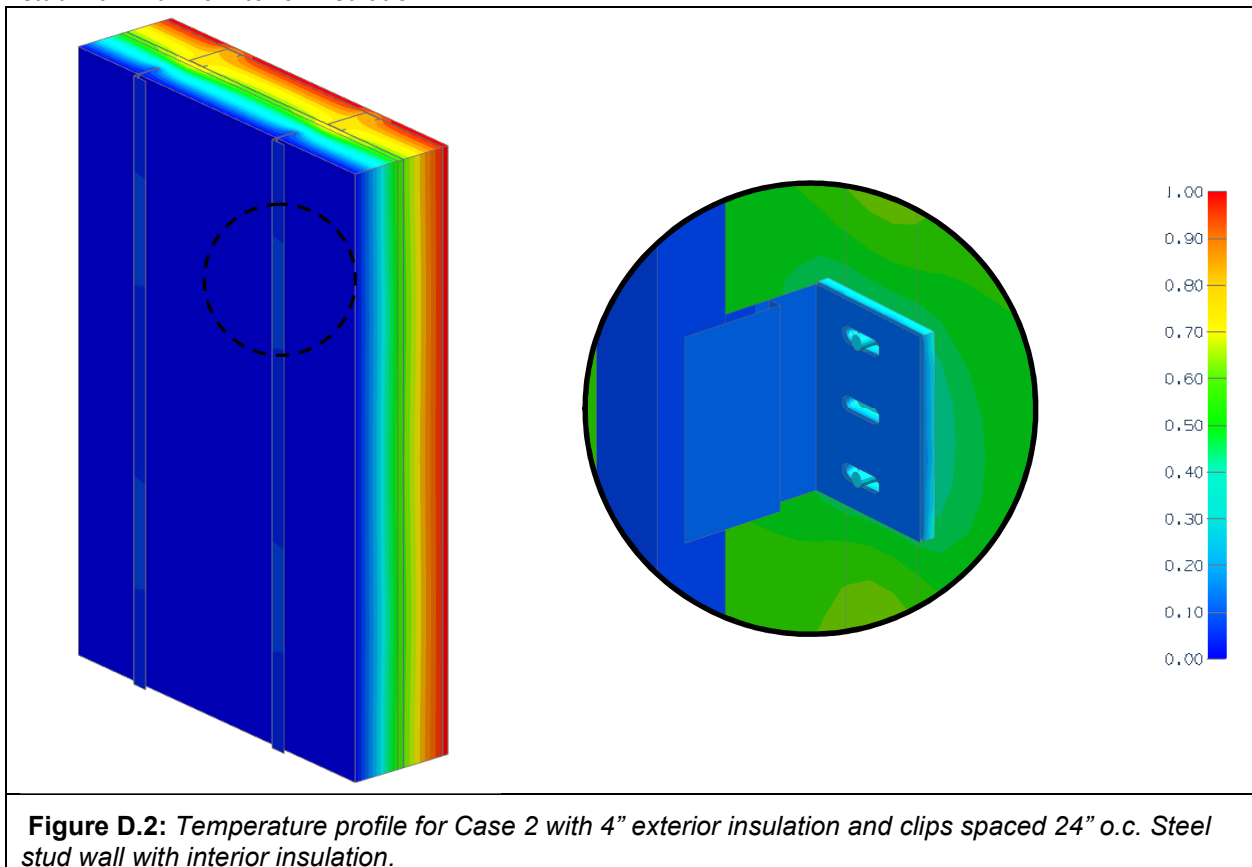

Figure D.2: *Temperature profile for Case 2 with 4" exterior insulation and clips spaced 24" o.c. Steel stud wall with interior insulation.*