

TO **Mr. Michael Bousfield**
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3565.030
Cascadia Windows Ltd.
Thermal and Structural
Modelling

DATE April 27, 2015

REGARDING **Cascadia Clip® Thermal Modelling**

Dear Mr. Bousfield,

As requested, RDH Building Engineering Ltd. (RDH) has performed thermal modelling of the Cascadia Clip® fiberglass cladding support. Over 700 three dimensional thermal models were developed to populate a comprehensive R-value calculator spreadsheet which is provided as companion to this letter. The thermal modelling and R-Value calculations determine the thermal performance of the wall assemblies described in Table 1.

TABLE 1: BACKUP WALL ASSEMBLY AND EXTERIOR INSULATION ARRANGEMENTS						
BackUp Wall		Cavity Insulation	Exterior Insulation Depth	Exterior Insulation Type	Clip Fastener Type	Clip Spacing
3 5/8" Steel Stud	20ga 18ga 16ga	With & Without R-12 Batt Insulation	2" 2.5" 3" 3.5" 4"	R-4.2/in Mineral Wool	2x Galv. Steel	16" 24" 32" Horiz. 26" 36" 48" Vert.
6" Concrete		N/A			2x Stainless Steel	
2x4 Wood Stud		R-12 Batt Insulation			1x Stainless Steel & 1x Anti Rotation Screws	
2x6 Wood Stud		R-19 Batt Insulation				
			5" 6" 8"	R-6.2/in Spray Foam		

All of the thermal modelling was completed using HEAT3 version 6.0. HEAT3 is a three-dimensional finite element thermal analysis software tool commonly used by the building industry to analyze building assemblies in three dimensions which two-dimensional analysis tools (such as THERM) cannot accurately analyze. It allows for the more detailed analysis of building assemblies including the impact of fasteners, discrete clips, and other construction realities. For each different wall assembly, a model was created in HEAT3 and the software was then used to calculate the heat flow through the assembly. Figure 1 shows a thermal gradient of the 4 different backup wall assemblies with 2" of R-4.2/inch exterior insulation, illustrating the heat flow through the clip.

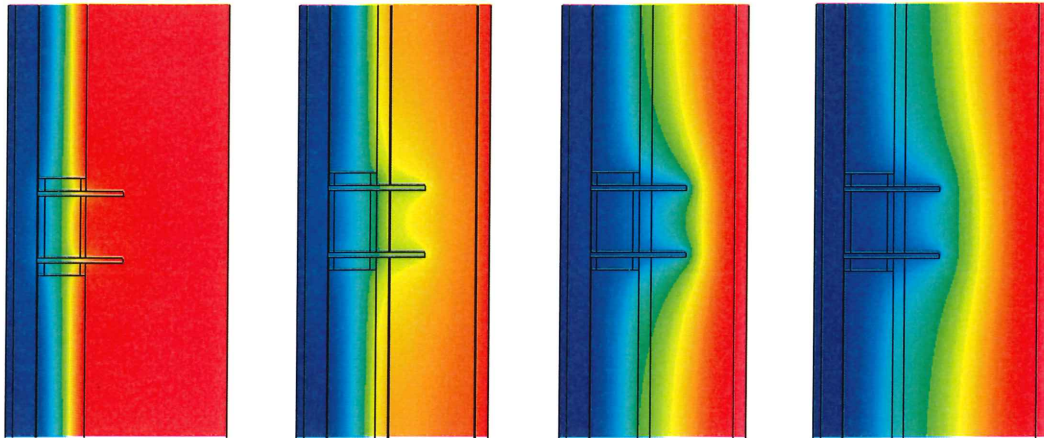


Figure 1: Thermal gradients at the mid-section cut through various backup walls (left to right, 6" concrete, 3 5/8" steel stud, 2X4 wood stud, 2X6 wood stud, all with 2" R-4.2/inch exterior insulation)

The boundary conditions used for this modelling are industry standard ASHRAE winter exterior and interior boundary conditions with temperatures of -17.8°C and 21°C and surface films 0.029 m²·K/W and 0.120 m²·K/W respectively. The material conductivities used for the modelling are provided in Table 2.

TABLE 2: MATERIAL THERMAL CONDUCTIVITY			
MATERIAL	THERMAL CONDUCTIVITY [W/m·K]	MATERIAL	THERMAL CONDUCTIVITY [W/m·K]
Cement board (cladding)	0.3	Fiberglass batts 3.5" R-12	0.0421
Galvanized steel Z-Girts/fasteners/studs	62	Fiberglass batts 3.625" R-12	0.0431
Exterior mineral wool insulation (R-4.2/in)	0.0343	Fiberglass batts 5.5" R-19	0.0418
Fiberglass clip	0.3	Stainless steel fasteners	14.3
Exterior gypsum	0.129	Spray foam	0.0233
Interior gypsum	0.16	Wood (SPF)	0.14
Air cavities at varying thicknesses	Varies*	Concrete (including reinforcing)	2

*Thermal conductivity assigned using the 2013 ASHRAE Handbook of Fundamentals values for different air cavity thicknesses

The modelling configurations were based on the Cascadia Clip® Specifications Insert (Canada) from the Cascadia Windows Ltd. (Cascadia) website dated October 23rd, 2013, with additional input and direction provided directly by Cascadia. The thermal models include the following constraints:

- Thermal modelling and R-Value calculations were completed for centre-of-wall assemblies that do not account for additional framing and resulting heat flow at floors and around penetrations such as windows and doors.
- All wall assemblies use 5/16" (8 mm) fibre cement board cladding installed directly onto the Z-girts.

- Clips were modelled with vertical Z-Girts for all cases. Initial testing showed there is a negligible difference between the thermal performances of the clip with a vertical Z-girt compared to the clip with a horizontal hat-track.
- All Z-girts were modelled at 18ga (1.2mm) thickness with 1" (25mm) deep air space.
- The anti-rotation screw was modelled as a #6 (4mm diameter) by 3/4" (19mm) length stainless steel screw through the Z-girt into the front face of the clip.
- Steel studs were not modelled with conduit cut-outs in the web of the stud.
- Steel stud and wood stud backup walls were modelled with studs at 16" on centre where the clip is spaced at 16" and 32" horizontally, and 24" on centre where the clip is spaced 24" horizontally.

The determined R-values are based on both wall assembly thermal models and calculated R-values using determined point transmittance Chi values (χ -values) for the Cascadia Clip®. The χ -value is the additional amount of heat flow through the wall assembly due to the clip, compared to the wall assembly without the clip. An illustration of χ -value is shown in Figure 2. The χ -value can be used to determine the thermal performance of wall assemblies using different clip spacings in addition to what is directly determined by the thermal modelling. It is important to recognize that the calculated χ -values for the clips will change depending on the backup wall assembly. Clip χ -values were only used to determine R-values for assemblies with the same backup wall types as those modelled.

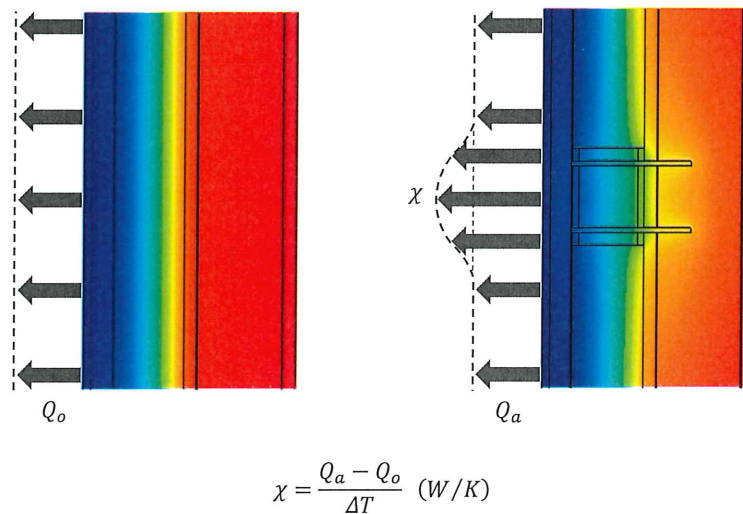


Figure 2: Thermal gradients showing the difference in heat flow through the wall assemblies due to the clip, and the corresponding χ -value calculation

The formula used to calculate the heat flow through assemblies that were not specifically modelled using HEAT3 is shown below.

$$U_T = \frac{\chi}{A_{total}} + U_o$$

Where:

U_T = Total effective thermal transmittance of the assembly (W/m² · K)

U_o = Effective thermal transmittance of the assembly without clips (W/m² · K)

A_{total} = Total wall area for each clip spacing (m²)

χ = Thermal point transmittance due to the clip (W/K)

The percent effectiveness of the exterior insulation is also calculated from the results of the thermal calculations. This metric is intended to show the effectiveness of the exterior insulation for each wall type and insulation configuration when using the Cascadia Clip®. The percent effectiveness calculation for the thermal performance of the exterior insulation is given for both the whole wall assembly and for the exterior insulation alone. Both calculations are shown below.

$$\%_{eff \text{ whole wall}} = \frac{R_{clip}}{R_{noclip}} \quad \%_{eff \text{ exterior insulation}} = \frac{R_{clip} - R_{backup}}{R_{noclip} - R_{backup}}$$

Where:

$\%_{eff \text{ whole wall}}$ = Percent effectiveness of the exterior insulation including backup wall (%)

$\%_{eff \text{ exterior insulation}}$ = Percent effectiveness of the exterior insulation alone (%)

R_{clip} = Effective thermal resistance of the wall assembly with clips (m² · K/W)

R_{noclip} = Effective thermal resistance of the wall assembly without clips (m² · K/W)

R_{backup} = Effective thermal resistance of the backup wall assembly (m² · K/W)

The thermal modelling results are tabulated and presented in a spreadsheet based calculator, separate from this letter report. The calculator is essentially a look-up function which works by using the reference name for each wall assembly to locate the corresponding performance from the tabulated data. On the "Calculator" tab, the results show the imperial and metric center-of-wall U-Value and R-Value and the percent effectiveness of the exterior insulation for the selected backup wall, insulation type and thickness, and clip attachment strategy and spacing. The "Table & Graph Generator" tab provides the thermal results in table and chart format to facilitate comparison of performance and to visualize the large tabulated data set. In total, the spreadsheet provides access to over 5,000 wall assembly R-values. The results of the structural modelling (see accompanying report) are also presented for each wall type selected on both tabs. Figure 3 shows an example graph for the uninsulated 18ga steel stud backup wall with R-4.2/inch exterior insulation.

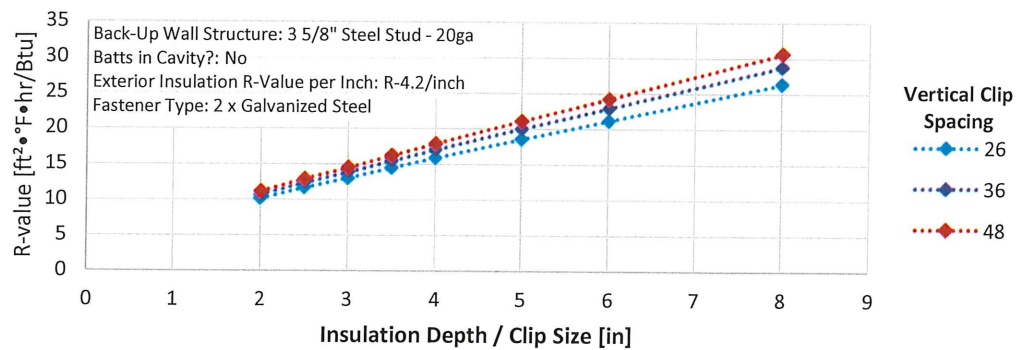


Figure 3: Graph showing the effective R-Value for the uninsulated steel stud backup wall with R-4.2/inch exterior insulation at various depths and vertical clip spacing.

We understand this spreadsheet is intended to be referenced in an online calculator for the Cascadia Clip®. All thermal modelling results, thermal and structural calculations, and relevant information, including the wall configurations naming convention, are included in separate tabs within the spreadsheet.

We trust that this letter meets your needs at this time. Please call or email us if there are any items that need further explanation or clarification regarding the thermal modelling methodology, thermal calculations, tabulated data, or spreadsheet calculator.

Yours truly,

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