Effective Thermal Performance of the Building Enclosure

*Exterior Walls*
Introduction to Cascadia

• Manufacturer of fiberglass construction products
  • Fiberglass windows
  • Fiberglass doors
  • Fiberglass cladding support systems

• Current client base:
  • Primarily along the west coast - California to Alaska
  • Projects also extending across North America

• Supported by internationally recognized building science expertise
Products

Fiberglass windows and doors

Cascadia Clip
Agenda

- Why address thermal bridging?
- How?
- Why exterior insulation?
- Prescriptive vs U-values
- PSI & CHI values

- Products
  - Testing
  - History of design
  - Insulation Issues

- Design Tools

- Choosing an approach
  - metal
  - composites
  - installation requirements
  - adjustability
  - financial advantages

- Wrap up
Why does energy conservation in buildings matter?
The importance of building science in building envelopes
Heat Flow

**Radiation:**
"Hey Duke, doesn't that fire feel good."

**Conduction:**
"Ouch! That poker's too hot to hold with my bare hands."

**Convection:**
"I'll turn on the fan. All the warmest air is up near the ceiling."
Heat flow – conduction

**Conduction**
- Heat flow through solid objects

**Conductivity**
- Rate of conductive heat flow
- Depends on material

**Conductance (U-value)**
- Layer or assembly
Heat flow – U-value and R-value

**U-value: conductance**
- How well heat moves through an assembly or material
- The lower the U-value, the better the assembly

**R-value: resistance**
- Inverse of U-value

\[
\frac{1}{R} = U \\
\frac{1}{U} = R
\]
Why address thermal bridging?
Thermal Bridging: Steel Studs, Shelf Angles
Key Terms

• Nominal R-value
  • The R-value of just the insulation itself

• Effective R-value
  • The overall value of the assembly (wall), including all components, air films, and the effect of all thermal bridging.
Conventional Insulated Wall Assemblies

- **Stud Insulated**: R-5.5 ft²·° F·hr/Btu
- **Vertical Z-Girts**: R-7.0 ft²·° F·hr/Btu
- **Horizontal Z-Girts**: R-7.8 ft²·° F·hr/Btu
- **Galvanized Clips**: R-11.0 ft²·° F·hr/Btu
Continuous Z-girt
Continuous Z-girt

- Not feasible to meet ASHRAE 90.1 minimum prescriptive requirement of R-15.6 effective with continuous girts.

<table>
<thead>
<tr>
<th>Exterior Insulation</th>
<th>Galvanized Z-Girt</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ½” Mineral Fiber (R-14.7)</td>
<td>7.4</td>
</tr>
<tr>
<td>4” Mineral Fiber (R-16.9)</td>
<td>7.8</td>
</tr>
<tr>
<td>8” Mineral Fiber (R-33.6)</td>
<td>9.8</td>
</tr>
</tbody>
</table>
Crossing Z-girts
## Crossing Z-girts

### Effective R-values

<table>
<thead>
<tr>
<th>Clip Assembly, Exterior Insulation</th>
<th>Purchased Insulation R-value</th>
<th>Effective Insulation R-value</th>
<th>% Effectiveness of Insulation</th>
<th>Effective Wall R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>4&quot; Mineral Fiber (R-16.9), Crossing Z-Girt</td>
<td>16.9</td>
<td>8.2</td>
<td>49%</td>
<td>11.4</td>
</tr>
<tr>
<td>4&quot; Mineral Fiber (R-16.9), Crossing Z-Girt (w/ 1/4 thermal shim between girts)</td>
<td>16.9</td>
<td>10.0</td>
<td>59%</td>
<td>13.1</td>
</tr>
<tr>
<td>6&quot; Sprayfoam* (~R-36), Crossing Z-Girt</td>
<td>36.0</td>
<td>12.5</td>
<td>35%</td>
<td>15.6</td>
</tr>
</tbody>
</table>

- R-36 insulation was required to achieve R-15.6 effective
Steel Clips
Steel Clips

**Effective R-values**

<table>
<thead>
<tr>
<th>Exterior Insulation</th>
<th>Galvanized Steel Clip</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ½” Mineral Fiber (R-14.7)</td>
<td>11.3</td>
</tr>
<tr>
<td>4” Mineral Fiber (R-16.9)</td>
<td>12.4</td>
</tr>
<tr>
<td>6” Mineral Fiber (R-25.1)</td>
<td>15.6 *</td>
</tr>
</tbody>
</table>

- R-25 insulation was required to achieve R-15.6 effective
Fiberglass Thermal Spacer

Fiberglass Thermal Spacer Wall
with 4” of Mineral Wool (R-4.2/in)  
\[ R_{\text{eff}} = 16 \]
How?

thermally-improved cladding supports more important than insulation type
Cladding attachment matters most

12” of Insulation

3.5” of Insulation

R-value $\text{eff}$
Metal Girt vs Thermal Spacer
Why exterior insulation?

Is “continuous insulation” based on insulation or cladding connection?
Insulation
Insulation – Exterior vs. Interior

**Interior Insulation**
- Thinner overall wall
- Cheapest if only using interior insulation**

**Exterior Insulation**
- Best thermal performance
- Best use of interior space
- Cheapest option to meet thermal requirements
- Best location for vapour barrier
- Best condensation resistance
Prescriptive vs U-values
Energy Codes in the US and Canada (2018)

Individual building codes require improved energy performance by referencing various energy standards.
What is ASHRAE 90.1?

An energy standard with three ways to achieve compliance:

• Prescriptive path
• Building enclosure trade-off
• Energy cost budget path
PSI and CHI Values

A more meaningful and flexible modelling approach
Graphic credit to Morrison Hershfield

Ripped screaming from the pages of a 2012 report, authored by Neil Norris, Patrick Ropell, Mark Lawton
Framing example

$$U = \frac{W}{(\text{Square}-\text{metre} \cdot \text{K})}$$
$$\Psi = \frac{W}{(\text{Linear}-\text{metre} \cdot \text{K})}$$
Products & Components

Testing & Evaluation
History of Clip design
Insulation
Testing & Evaluation

A manufacturer’s tale
Bringing an innovative product into market
Fire Protection – Cladding

Big Picture

• To avoid this...
Analysis and Testing – Fire Performance

• Engineering Analysis – Fire Performance:
  • Spacer is acceptable for use in:
    • A wall required to be built of non-combustible construction
    • Including permitted combustible claddings (metal composite materials)
    • Also, in combustible construction (obviously)
  • Maintains the two code (and common sense) objectives, which are:
    • Cannot alter intended fire performance of non-combustible wall
    • Cladding must stay-in-place even if the component if damaged
  • No.1 is clear by analysis, and can be further supported by testing
  • No.2 is clear by observation – direct fastening
Canadian Code Evaluation / Compliance

• Burnaby
  • Code appeal process
  • BC Building and Safety Standards Branch – published approval
Canadian Code Evaluation

Minor Combustible Component
IAPMO

• “It’s a washer”
  • Oh yeah... Great!
Code Compliance: IAPMO-UES Report

- Third party certification of the Cascadia Clip
- Approves clip for use in IBC Types I, II, III, IV, and V construction
- ICC-ES equivalent
- Looks at several different aspects of design
- Only clip system with a nationally recognized third party code compliance report
Fire Performance Testing

- NFPA 285 test
- Fire Propagation in Exterior Wall
- Full-assembly test
NFPA 285 test results

• Solid pass with MCM panels
For Fire Performance

• Conclusion: The Clip does...

• nothing

• and therefore changes nothing.
Intertek Listing with Roxul

ROXUL Inc.
Design No. RI/MFF 30-01
Mineral Wool Insulation
CAVITYROCK and COMFORTBOARD 110
NFPA 285 – Meets Conditions of Acceptance

Figure 1: Construction with COMFORTBOARD 110
Figure 2: Construction with CAVITYROCK
A Lens to Judge
A History of Clip design
Step 1

• OK, so we have a conductivity problem...

• Let’s use a material with very low conductivity – like fiberglass.
Step 2

Main problem: Combustibility

Backup wall

Use long screw to attach outer steel directly to stud

Problem: rotation at inner leg

Problem: web/screw interference
Step 3

Problem: still a continuous member too expensive and poor thermal performance

Make pieces intermittent

Problem: installation is inconvenient, too many pieces

Problem: weak furring shape, does not provide drainage cavity

Backup wall

Section
Step 4

If we use a Z-girt instead… Is it done?
The Cascadia Clip

- Essentially a “thermal washer”
- Universal solution for almost any cladding (up to around 30psf)
- For non-combustible construction
Why Mineral Wool Insulation?
Mineral Wool

• R-4.2 to 4.3/inch (stable)
• Non-combustible
• Permeable to liquid water and water vapour (outdoor ok)

• Perhaps the most over-looked but critical characteristic:
  • Tolerant of substrate irregularities
Design Tools
Cascadia Clip Calculator

CASCADIA CLIP CALCULATOR

Welcome to Cascadia's Clip spacing calculator. This tool enables you to calculate the needed spacing of Clips. Use just the right amount of Clips - not more, not less - and save money.
Choosing an Approach

• Pros & cons with metal
• Pros & cons with composites (PSI/CHI values)
• Pros & cons with installation requirements
• Adjustability; when is this required vs just wasted effort
• Financial advantages
Pros & cons with metal
Why Cascadia Clip?

**Cascadia Clip**
- Adjustability happens entirely outboard of the insulation
- Cladding attachment is a Z or a hat, both incredibly strong shapes
- Cascadia Clip matches insulation, thermal break for entire depth of insulation
- Cascadia clip maintains thermal performance even at very tight spacing

**Metal Clip & Rail Systems**
- Adjustable rails penetrate insulation
- L-angle cladding attachment not very strong (much more likely to deflect)
- Thermal break is only a small portion of insulation depth
- Thermal performance relies on large spacing of clips: not always possible with various claddings
Pros & cons with composites

Psi & Chi values
Why composites?

• Improves PSI or CHI value effects when a building has configurations that increase Clip spacing necessarily, such as:
  • Windows
  • Doors
  • Corners
  • Balconies
  • Curves

• Take-away: Composite materials make this nearly a non-issue

• Aluminum ~160 W/mK
• Steel ~60 W/mK
• Stainless Steel ~14 W/mK
• Fiberglass – 0.15 to 0.30 W/mK
• Wood ~0.10 to 0.15 W/mK
• Insulation Materials 0.022 to 0.080 W/mK
Why Cascadia Clip?

Cascadia Clip
• Screws are directly fastened through the entire clip:
  • Screws reduce thermal performance slightly (allowably)
  • Screws allow for non-combustible construction
• Strength comes from screws, thick fiberglass allows for shear support – up to 30psf cladding

Composite Systems
• Best thermal performance
• Combustible structural connection
• Generally lower strength than metal
  • Thinner webs mean lower strength
  • Pull-out may be an issue
Pros & cons with installation

Adjustability
Adjustability - when is this required vs just wasted effort?

- Not every substrate is as irregular as concrete
- Not every cladding needs adjustability
- Some do...
Single Z-girts

- Our industry has built a lot of walls without adjustability.
- The times that you needed adjustability stick out in everyone's mind.
- It is natural to remember like this.
The cost of adjustability

- Adjustability means many pieces
- Adjustability takes extra labour
- Ideally, we would only expend this effort and cost when needed
- An on-demand solution is best
On-demand Adjustability
Financial Advantages

• For the Architect:
  • Risk management – most testing and full code-evaluation
  • Reliability of metal connections
  • Least drop in performance when spacing becomes dense

• For the Contractor:
  • Intermittent pieces save material cost
  • Pre-assembly saves labour cost
  • On-demand adjustability avoids unnecessary complexity

• Cascadia Clip combines these, and is the lower possible cost per R-value
Questions?
Cascadia Clip projects

High-profile and interesting projects across the US
State University of New York - Medical School

- 8 stories
- 540,000SF
- 2” blue & 4” red clips
- Horizontal type
- Largest building constructed in Buffalo in decades
- Designed by HOK
Bullitt Center

- 6 stories
- 52,000SF
- 3.5” orange clips
- Horizontal type
- First Living Building Challenge certified commercial building in North America
- Designed by Miller Hull Partnership
Zurich North America Headquarters

- 11 stories
- 735,000SF
- 3” purple clips
- Horizontal type
- LEED Platinum Certified
- Clips only used on soffit (middle building)
- Designed by Clayco
Portland University - Collaborative Life Sciences Building

- 12 stories
- 650,000SF
- 3.5” orange clips
- Vertical type
- LEED Platinum
- Designed by SERA Architects and CO Architects
MIT- Nanoscale Research Building

- 4 stories
- 200,000SF
- 3.5” orange clips
- Horizontal type
- Two floors of high-performance cleanrooms
- Designed by Wilson Architects
Cox Health – Medical Center South

- 10 stories
- 310,000SF
- 3.5” orange clips
- Vertical type
- Includes women’s and children’s hospital as well as neuroscience center
- Designed by Beck Group
Denver Botanic Gardens Science Pyramid

- Pyramid structure
- 5,300SF
- 4” red and 5” yellow clips
- Vertical type
- Highly unique sloped roof/wall construction
- Designed by BURKETTDESIGN
Phoenix Airport- Terminal 3 Modernization

• 3 stories
• 676,000SF
• 3.5” orange clips
• Vertical type
• New high-performing terminal in three phases to replace outdated existing terminal
• Designed by DWL Architects, Corgan, and Smithgroup JJR
Menil Drawing Institute

- 1 story
- 30,000SF
- 4" red clips
- Horizontal type
- First exhibition space of its kind
- Designed by Johnston Marklee
Fairmont State University- University Terrace

- 4 stories
- 110,000SF
- 2” blue clips
- Vertical type
- University housing project
- Designed by McKinley & Associates, AECOM and Triad Engineering