The Effective Thermal Performance of the Building Enclosure: Exterior Walls
Introduction

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

- Manufacturing plant located in Langley, BC
- In operation since 2008
- Current client base:
  - BC, Alberta, Yukon, NWT, Washington, Oregon, Alaska
- Expanding to:
  - Saskatchewan, Manitoba, Ontario,
  - California, other central US States
Background – Maddy Parrott, EIT

- Queen’s University Civil Engineering, Sci ‘13
  - Oil and gas: not for me
  - Loved sustainable architecture, green engineering

- BCIT Masters of Applied Science in Building Science, 2014- now
  - Originally MEng, research project got too big

- Cascadia Windows – 2015 and onwards
  - Technical Representative - Cascadia Clip
Agenda

- Energy conservation – big picture
- Importance of limiting heat flow in buildings
  - Basic physics refresher & heat flow.
  - Types of wall insulation and uses.
- Thermal Bridging
  - Insulated construction assemblies.
- Identify code changes and their application
  - Building Code requirements for R-values of exterior walls.
  - If conventional assemblies no longer meet code requirements, what does work?
- The Cascadia Clip
The energy supply side is limited, dirty, and increasingly expensive.

Across Canada and the US, national, regional, and local governments have shifted their focus to optimizing utilization.

Going forward, increased demand is going to be met by conserving how much we use.

- **Demand Side Management**
Effective Thermal Performance
Of The Building Enclosure

→ Exterior Walls

Let's resolve to use less energy!
Importance of Limiting Heat Flow in Buildings
Importance of Limiting Heat Flow in Buildings

- Thermal Comfort
- Condensation control
- Energy
  - 40% of all energy in Canada is used in Buildings
  - In residential buildings, 30-60% energy is used for space-heating
  - Reducing space-heating is one of primary building enclosure considerations
  - Building enclosure must manage all mechanisms of heat-flow

- Building codes require that heat flow be controlled
Physics Refresher

• Fast physics refresher on heat flow.
Heat Flow

- Fundamental Rule #1:
  
  Heat Flows from HOT to COLD

- There are no exceptions

- You **cannot prevent** heat flow with insulation, you can only **slow it down**
Mechanisms of Heat Flow

- **Conduction**  
  (Heat flow by touch)

- **Convection**  
  (Heat flow by air)  
  - **Within** Closed Air-spaces  
  - **Through** air, i.e. air-leakage

- **Radiation**  
  (Heat flow by waves)

* The focus of this presentation is on **conduction** and related thermal bridging.
Conduction

- **Conduction** is the transfer of energy through a solid material, and between materials that are in contact.

- Practical Examples:
  - Heating of a pot on an electric stove
  - Heat flow through a metal window frame
  - Heat flow through a concrete balcony slab
  - Heat flow through a steel Z-girt in a conventional exterior insulated wall assembly
Conduction

- The rate of heat flow through a material is dependent on its conductivity \((k)\).
  - Metric units are \(\text{W/m} \cdot \text{K}\)
  - Imperial units are \(\text{Btu/hr} \cdot \text{ft} \cdot \text{F}°\)

- For example:
  - Aluminum \(\sim 160\ \text{W/mK}\)
  - Steel \(\sim 60\ \text{W/mK}\)
  - Stainless Steel \(\sim 14\ \text{W/mK}\)
  - Fiberglass \(- 0.15\) to \(0.30\ \text{W/mK}\)
  - Wood \(\sim 0.10\) to \(0.15\ \text{W/mK}\)
  - Insulation Materials \(0.022\) to \(0.080\ \text{W/mK}\)

- For building enclosure components to be thermally efficient – must **minimize highly conductive materials** extending through the insulation.
Conductivity Calculations

- The term, **Conductance** (C) is simply the conductivity (k) divided by the thickness of the material (t).
  - \( C = \frac{k}{t} \)
  - This is the “U-value” for a specific material

- The inverse of a material’s conductance (U-value) is its thermal resistance: **R-value**.
  - \( \frac{1}{U} = R \) and \( \frac{1}{R} = U \)
How Building Insulation Works

- Heat flow is slowed down through insulation by reducing conduction, convection, and radiation.
- Insulation is low-conductivity compared to other construction materials.
- Insulation reduces or stops convection vs an empty air space.
- Radiation is prevented across an open space by filling it, or by using a low-emissivity coating/finish (radiation barrier).

- How much insulation do you need?
Temperature - Heating Degree Day

- How much insulation you need depends on *where* you are...

- Heating Degree Day is a measure of the number of hours in a year, below a certain set-point:
  - For each 24-hours: average temp
  - Below threshold of 18°C (or 65°F)
  - If the temp$_{avg}$ = 0°C, HDD for that day = 18
  - No negative HDD for periods warmer than 18°C
Types of Insulation and Uses

From Owens Corning
Fiberglass Insulation

R-3 to R-4 per inch

Owens Corning, Johns Manville, Certainteed and many others
Mineral Wool Insulation

R-3.5 to R-4.3/inch

Also called Rockwool or Stone wool

Roxul, Fibrex, ThermaFiber & others

Fire-resistant, Water-repellent, Semi-rigid, sag-free material
Extruded Polystyrene (XPS)

R-5 per inch

DOW – owns Trademark of Styrofoam

DOW Chemical, Owens Corning and others

DOW also has a product with R-5.6/inch
Expanded Polystyrene (EPS)

R-4 per inch

Numerous Manufacturers
Various Densities
Polyisocyanurate (Polyiso)

R-6/inch

May be advertised with an initial R-value of R-7/inch -> degrades to R-6/inch long term

DOW, Johns Manville & Other Manufacturers
Open Cell Sprayfoam

R-3.5 to R-4.0 per inch

Icynene, Demilec and others
Closed Cell Sprayfoam

R-5.0 to R-6.0 per inch

DOW, BASF, Demilec and many others
Thermal Bridging
Thermal Bridging

• Through conduction, heat flow will occur at a faster rate through conductive materials that penetrate through the insulation.
• This reduces the effective thermal resistance of a building envelope and reduces surface temperatures.
• Building Examples:
  - Wood framing in insulation
  - Steel studs in insulation
  - Concrete slab edges
  - Window & door frames
  - Cladding support framing (conventional Z-girts)
  - Brick shelf-angles and brick ties
  - Etc.
Two More 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.
Thermal Bridging

Steel Studs & Brick Shelf Angles
Thermal Bridging

Wood Frame
Identify Code Changes and Their Application
BC Building Code Compliance

Part 10 - BCBC or ASHRAE 90.1?

- Part 9 or Part 3
- 3 stories or less
  - Part 9
  - Non-residential
  - Table B in Part 10
- 4 stories or less
  - Part 9 or Part 3
  - Residential
  - Modeling
  - Table A in Part 10
  - Energuide 77
- 5 stories and more
  - Part 3
  - Non-residential
  - ASHRAE 90.1
  - Prescriptive
  - Trade-off
  - Cost budget
  - Residential
ASHRAE 90.1 offers three methods for consultants to specify wall thermal performance requirements:
- Prescriptive Path
- Building Enclosure Trade-off Path
- Energy Cost Budget Path
ASHRAE 90.1
A Novel Idea, and a Key Term

• ASHRAE 90.1 stipulates that wall R-values must consider the effect of thermal bridging, to be representative of actual thermal performance (i.e. consider effects of steel studs, girts, clips, slab-edges, balconies, eyebrows etc.).

• Continuous Insulation (CI): Well... this is what it sounds like – insulation free from thermal bridges (like structural elements).
  - The exceptions are “fasteners and service openings”. Service openings... ducts.
# ASHRAE 90.1 – Climate Zone 5

**TABLE 5.5-5  Building Envelope Requirements For Climate Zone 5 (A,B,C)***

<table>
<thead>
<tr>
<th>Opaque Elements</th>
<th>Nonresidential</th>
<th>Residential</th>
<th>Semileathed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Assembly</td>
<td>Insulation Min. R-Value</td>
<td>Assembly</td>
</tr>
<tr>
<td>Roofs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation Entirely above Deck</td>
<td>U-0.063</td>
<td>R-15.0 ci</td>
<td>U-0.063</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.065</td>
<td>R-19.0</td>
<td>U-0.065</td>
</tr>
<tr>
<td>Attic and Other</td>
<td>U-0.034</td>
<td>R-30.0</td>
<td>U-0.027</td>
</tr>
<tr>
<td>Walls, Above-Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.123</td>
<td>R-7.6 ci</td>
<td>U-0.090</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.113</td>
<td>R-13.0</td>
<td>U-0.057</td>
</tr>
<tr>
<td>Steel-Framed</td>
<td>U-0.084</td>
<td>R-13.0 + R-3.3 ci</td>
<td>U-0.064</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.089</td>
<td>R-13.0</td>
<td>U-0.089</td>
</tr>
<tr>
<td>Wall, Below-Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below-Grade Wall</td>
<td>C-1.140</td>
<td>NR</td>
<td>C-1.140</td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>U-0.087</td>
<td>R-8.3 ci</td>
<td>U-0.074</td>
</tr>
<tr>
<td>Siccel-Joist</td>
<td>U-0.052</td>
<td>R-19.0</td>
<td>U-0.038</td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.033</td>
<td>R-30.0</td>
<td>U-0.033</td>
</tr>
<tr>
<td>Slab-On-Grade Floors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unheated</td>
<td>F-0.730</td>
<td>NR</td>
<td>F-0.730</td>
</tr>
<tr>
<td>Heated</td>
<td>F-0.840</td>
<td>R-10 for 36 in.</td>
<td>F-0.840</td>
</tr>
</tbody>
</table>

Overall U-value (inverse of Effective R-value)

Nominal R-values
### ASHRAE 90.1 – Climate Zone 5

<table>
<thead>
<tr>
<th>Walls, Above-Grade</th>
<th>Assembly Maximum</th>
<th>Insulation Min. R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>U-0.090</td>
<td>R-11.4 ci</td>
</tr>
<tr>
<td>Metal Building</td>
<td>U-0.057</td>
<td>R-13.0 + R-13.0</td>
</tr>
<tr>
<td><strong>Steel-Framed</strong></td>
<td><strong>U-0.064</strong></td>
<td><strong>R-13.0 + R-7.5 ci</strong></td>
</tr>
<tr>
<td>Wood-Framed and Other</td>
<td>U-0.089</td>
<td>R-13.0</td>
</tr>
</tbody>
</table>

R 15.6
But why?
Figure 4.5: Effects of variations of opaque wall thermal resistance on space heating for a mid-rise high efficiency MURB
What are we doing?
Does it work?
Conventional Exterior Insulated Wall Assemblies- R14.7 Nominal

Stud Insulated
R-5.5 $ft^2 \cdot ^\circ F \cdot hr/Btu$

Vertical Z-Girts
R-7.4 $ft^2 \cdot ^\circ F \cdot hr/Btu$

Horizontal Z-Girts
R-7.8 $ft^2 \cdot ^\circ F \cdot hr/Btu$

Galvanized Clips
R-11.3 $ft^2 \cdot ^\circ F \cdot hr/Btu$
Single Continuous Z-girt

- Simulations:
  - 3.5” insulation
  - 4” insulation
  - 8” insulation
Single Continuous Z-girt

Temperature Isotherms

Temperature Isotherms at screw fastener
Single Continuous Z-girt

Effective R-values

<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>?</td>
</tr>
</tbody>
</table>

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

- How much heat is flowing through steel vs field of wall?
- Use U-values for calculation – isolate effect of steel:
  - Nominal U-value: $\frac{1}{33.6} = 0.030$
  - Effective U-value: $\frac{1}{9.8} = 0.102$
  - Effect of presence of girt: $0.102 - 0.030 = 0.0723$
  - Thermal weight of girt: $\frac{0.0723}{0.102} = 71\%$
- 71% of the total heat loss flows through the steel girt.
- Diminishing returns.

<table>
<thead>
<tr>
<th>Exterior Insulation</th>
<th>Galvanized Z-Girt</th>
</tr>
</thead>
<tbody>
<tr>
<td>8” Mineral Fiber (R-33.6)</td>
<td>9.8</td>
</tr>
</tbody>
</table>
Crossing Z-girts

- Simulations:
  - 4” total insulation
  - 4” total insulation + thermal shim
  - R-15.6 solution
Crossing Z-girts

Temperature Isotherms through horizontal cut

Temperature Isotherms through vertical cut
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/ ¼ 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

- Simulations:
  - 3.5” insulation
  - 4” insulation
  - 6” insulation

- This is laborious to build... but let’s not worry about that right now.
Steel Clips

Temperature Isotherms through horizontal cut

Temperature Isotherms through vertical cut
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
So what's the answer? How do we actually meet R-15.6? Well, if steel reduces the insulation value by half, then obviously, we just need twice as much of everything, right?
OK, let’s solve this...
Materials

- Focus on **improving material selection and sequencing**, instead of just adding more insulation and limiting the use of existing thermally poor assemblies
  - Use lower conductivity materials in key locations to improve effective R-values
  - Careful – don’t sacrifice other essential material attributes of building components, just to use something less conductive
Must-haves list

- Need to reduce thermal bridging of cladding supports, while keeping the following characteristics:
  - Acceptable in non-combustible
  - Appropriate substrate for cladding fasteners
  - Rigid enough for cladding attachment, and other loading
  - Inorganic (won’t rot)
  - Low thermal expansion/contraction
  - Won’t creep or deform over time (this might eliminate thermoplastics)
  - Easy to construct
  - Cost effective
Step 1

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

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

- Problem:
  - Screw pull-out

Backup wall

Make this leg steel – solves pull-out issue.
Connection problem though…
Step 3

• Problem:
  - Combustibility

Use long screw to attach outer steel directly to stud
Step 4

- **Problem:**
  - Rotation at inner leg

- Make inner leg on both sides
Step 5

- Problem:
  - Interference between screws and web

Two webs allow screws in between
Step 6

- Problems:
  - Cost of continuous member too high
  - Thermal performance could be better

Backup wall

Make pieces intermittent

Section
Step 7

• Problem:
  - Installation is inconvenient – too many pieces

Backup wall

Provide retainer clip to clip pieces onto continuous steel
Step 8

• Problems:
  - Need exterior drainage cavity
  - Need steel to be more rigid for cladding attachment
This concludes the educational portion of the presentation

- Now we’re going to look at some of Cascadia’s offerings, along the lines that we’ve been discussing.
Other Systems

Clip & Rail Systems

- Adjustable rails penetrate insulation
- Thermal break is not full depth of insulation
- L-bracket not very strong
- Added clips means worse thermal performance, relying on larger spacing doesn’t always work for cladding requirements
Other Systems

Fiberglass and Composite Systems

- Combustible structural connection
- Thin webs mean lower strength
- Pull-out may be an issue
- Best thermal performance
Cascadia Clip
Fiberglass Thermal Spacer Wall

Fiberglass Thermal Spacer Wall
with 4” of Mineral Wool (R-4.2/in)
R-15.7 ft²·° F·hr/Btu

Low-conductivity fiberglass material reduces thermal bridging. This greatly improves the effective thermal performance of the wall.
Awards

- This has been getting some attention...

VRCA
Awards of Excellence 2011
Sustainable Construction and Innovation
SILVER Award

Cascadia in Top 10 Most Innovative Companies

GLOBE-Net
the GREEN innovators in B.C.

CASCADIA WINDOWS & DOORS

Award
Fleur-de-lis Interior Design Inc.

BC Business

20 Innovators

THE WTN
The World Technology Network

FORTUNE CNN

2012 EXPORT AWARDS WINNER
So.....

12” of Insulation

4” of Insulation
Fiberglass Thermal Spacer

**R-15.7**

Exceeds the ASHRAE 90.1 minimum prescriptive requirement of R-15.6 ft²·° F·hr/Btu for steel frame walls

**R-7.0**

Common wall with exterior steel girts; not ASHRAE 90.1 compliant (needs to meet R-15.6 effective)
Field Comparison of Vertical Z-Girt and Fiberglass Girt Spacer System

Vertical Z-Girt Wall System

Warm areas visible on exterior wall that correspond with the conductive Vertical Z-girts.

Fiberglass Thermal Spacer Wall System

Essentially no warm areas visible on exterior wall because fiberglass spacers limit the heat flow.

Infrared Image of Exterior Wall
Installation

FAST INSTALLATION

STEP 1
Attach clips to steel girt

STEP 2
Fasten girts and clips to the wall with screws

STEP 3
Install insulation and fasten next girt
Installation – On Site

STEP 1
Layout spacers by clipping to steel girt

STEP 2
Fasten to wall with screw through spacer
Installation

STEP 3

Place insulation between spacers

COMPLETE

Finished installation of fiberglass spacer
Vertical Application
Cost Comparisons

CASCADIA CLIP® SYSTEM

R-15.7 EFFECTIVE  Easily increased to R-20+

- 5°
- 4" of insulation
- Interior
- Exterior
- Cascadia Clip®
- Z-girt
- Insulation

Cost of clips and girts
~$0.13 per ft² / per R-value

Additional indirect costs
+ One layer of insulation

VERTICAL + HORIZONTAL DOUBLE GIRT SYSTEM

R-15 EFFECTIVE  Not easily increased

- 9°
- 8" of insulation
- Interior
- Exterior
- Z-girts
- Insulation

Cost of girts
~$0.16 per ft² / per R-value

Additional indirect costs
+ Twice the insulation
+ Twice the labour
+ Twice the flashing
+ More lost floor space that the owner cannot use or sell
While fiberglass is combustible, the clip functions within non-combustible wall assemblies as a minor combustible component, in accordance with Article 3.1.5.2 of the Model National Building Code.

The clip is enclosed within the non-combustible insulation and the fasteners attach the cladding directly to the structure. Fire protection and building code professionals support the clip as a minor combustible component, in compliance with the building code.

The Building and Safety Standards Branch of the BC Ministry of Energy and Mines confirmed that the Cascadia Clip® is a minor combustible component, acceptable for use in non-combustible construction.
# Structural Information

## Screw Fastener Design Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Metric Value</th>
<th>Inch Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheathing thickness</td>
<td>12.7 mm</td>
<td>0.5 in</td>
</tr>
<tr>
<td>Vertical girt depth</td>
<td>25.4 mm</td>
<td>1 in</td>
</tr>
<tr>
<td>Cladding thickness</td>
<td>19.05 mm</td>
<td>0.75 in</td>
</tr>
</tbody>
</table>

### Cascadia Clip® Size

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Metric Value</th>
<th>Inch Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>Varies</td>
<td>Varies</td>
</tr>
<tr>
<td>Length</td>
<td>101.6 mm</td>
<td>4.0 in</td>
</tr>
<tr>
<td>Screw edge distance</td>
<td>12.7 mm</td>
<td>0.5 in</td>
</tr>
<tr>
<td>Screw spacing</td>
<td>76.2 mm</td>
<td>3.0 in</td>
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</table>

## Allowable Fastener Loads (Factor of Safety: 3.5)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>$T_{\text{ALLOW}}$</th>
<th>$V_{\text{ALLOW}}$</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>For 20 gauge studs</td>
<td>559 N</td>
<td>602 N</td>
<td>Leland Industries</td>
</tr>
<tr>
<td>For 18 gauge studs</td>
<td>851 N</td>
<td>892 N</td>
<td>Dietrich</td>
</tr>
<tr>
<td>Interpolated from Leland Industries data for 20 ga and 16 ga</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For Wood studs + plywood sheathing</td>
<td>838 N</td>
<td>560 N</td>
<td>Values from Leland Master Gripper 14 x 10 with 1&quot; effective penetration into douglas fir</td>
</tr>
</tbody>
</table>
WIND VERSUS DEAD LOAD INTERACTION DIAGRAMS: METAL STUDS

ALLOWABLE WIND LOAD VERSUS CLADDING DEAD LOAD

Cascadia Clips®

- 3.5"
- 4.0"
- 5.0"
- 6.0"

Design Parameters

- Stud spacing – horizontal = 16" [406mm]
- Clip vertical spacing = 26" [660mm]
## Cascadia Clip Calculator

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Back up Wall Structure</td>
<td>3 5/8” Steel Stud - 16ga</td>
</tr>
<tr>
<td>Batts in Cavity?</td>
<td>No</td>
</tr>
<tr>
<td>Exterior Insulation R-Value per Inch</td>
<td>R-4.2/inch</td>
</tr>
<tr>
<td>Fastener Type</td>
<td>2 x Galvanized Steel</td>
</tr>
<tr>
<td>Clip Horizontal Spacing</td>
<td>32 in</td>
</tr>
<tr>
<td>Cladding Dead Load (Weight)</td>
<td>6 psf</td>
</tr>
<tr>
<td>Exterior Insulation Depth / Clip Size</td>
<td>2 in</td>
</tr>
<tr>
<td>Clip Vertical Spacing</td>
<td>26 in</td>
</tr>
</tbody>
</table>

- I wish to specify clip size and vertical spacing
Bullitt Center
Seattle, WA
Bullitt Center
Seattle, WA

The greenest commercial building in the world.
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