# Thermal Bridging From Cladding Attachment Strategies Through Exterior Insulation

PHIUS 9TH ANNUAL NAPHC, SAN FRANCISCO BAY AREA
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## Learning Objectives / Overview

RDH

- → Gain an understanding of the impacts of thermal bridging from cladding attachments on thermal performance
- → Discover multiple different types of cladding attachment systems through exterior insulation and which systems perform well thermally
- → Understand two thermal performance metrics especially useful for assessing the effectiveness of assemblies with exterior insulation
- → Learn about where exterior insulation with discrete fasteners is appropriate as well as its limitations

## Building Enclosure Design Fundamentals

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- Control of exterior moisture/rainwater & detailing
- Thermal insulation continuity & effectiveness
- Airflow control/airtightness
- Control of condensation and vapor diffusion
- **More insulation = less heat flow to dry out moisture**
  - Amount, type and placement of insulations matters, for vapor, air and moisture control
  - Greater need to more robust and better detailed assemblies

## What do you See?

RDH

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## Thermal Bridging

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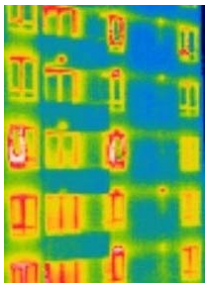
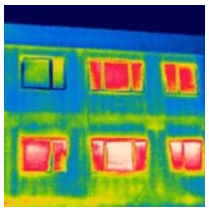
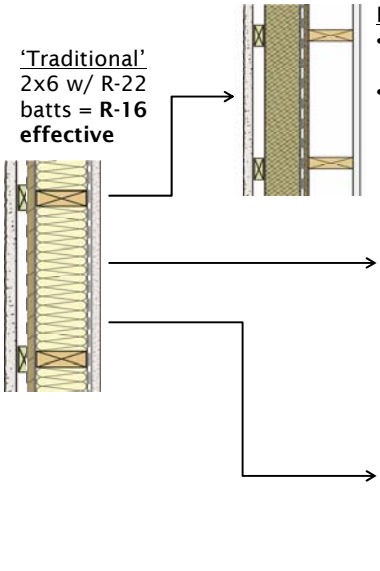
- Thermal bridging occurs when a more conductive material (e.g. metal, concrete, wood etc.) bypasses a less conductive material (insulation)
- Minimizing thermal bridging is key to passive building design
  - Use of exterior continuous insulation with thermally improved cladding attachments
  - Minimizing the big thermal bridges
- Have historically focused on *assembly R-values*, however more attention is now being placed on *interface and detail R-values,* and cladding attachments





## Getting to Higher R-values - Walls



'Traditional' 2x6 w/ R-22 batts = **R-16 effective**

Exterior Insulation: **R-20 to R-60+ effective**
- Constraints: cladding attachment, wall thickness
- Good for wood/steel/concrete

Deep/Double Stud: **R-20 to R-40+ effective**
- Constraints: wall thickness
- Good for wood, wasted for steel

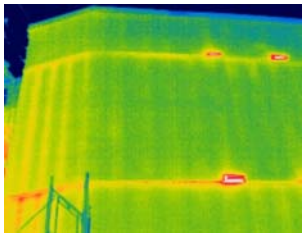
Split Insulation: **R-20 to R-60+ effective**
- Constraints: cladding attachment
- Good for wood, palatable for steel

## Building Enclosure & Passive Design

→ Building enclosure is key element in passive design

→ Exterior insulation is only as good as the cladding attachment strategy

→ What attachment system works best?



## Exterior Insulation – Meeting Passive House

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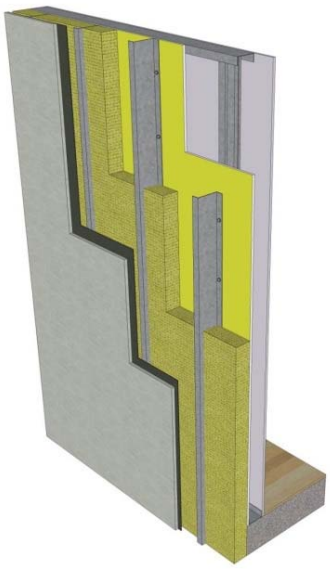

## Cladding Attachment Considerations

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- Cladding weight & gravity loads
- Wind loads
- Seismic loads
- Back-up wall construction (wood, concrete, steel)
  - Attachment from clip/girt back into structure (studs, sheathing, or slab edge)
- Exterior insulation thickness
- Rigid vs semi-rigid insulation
- R-value target, tolerable thermal loss?
- Ease of attachment of cladding – returns, corners
- Combustibility requirements

## Thermal Analysis of Effective R-values

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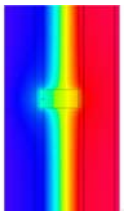
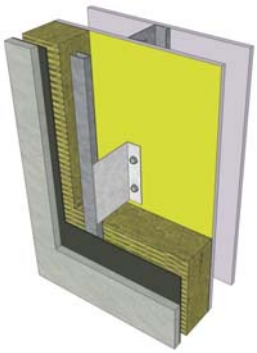
- Effective R-values of building enclosure assemblies & details can be determined by:
  - Hand methods – simple wood frame walls, not suitable for many assemblies/details
  - Laboratory (Guarded hot-box testing) – good for confirmation, expensive and not efficient for design/analysis purposes
  - Two-dimensional finite element thermal modeling – not accurate for modeling discrete or intermittent elements such as clips, ties, or fasteners
  - Three-dimensional finite element thermal modeling – most accurate and cost effective. Calibrated with laboratory testing to improve accuracy.

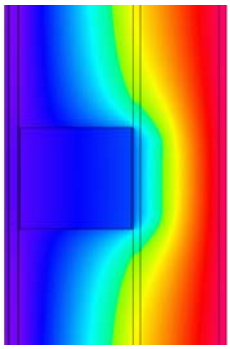


## Overview

RDH

- Cladding Attachment Strategies
- 3D Thermal Finite Element Analysis
- Results
- Testing / Examples





## Many Cladding Attachment Options

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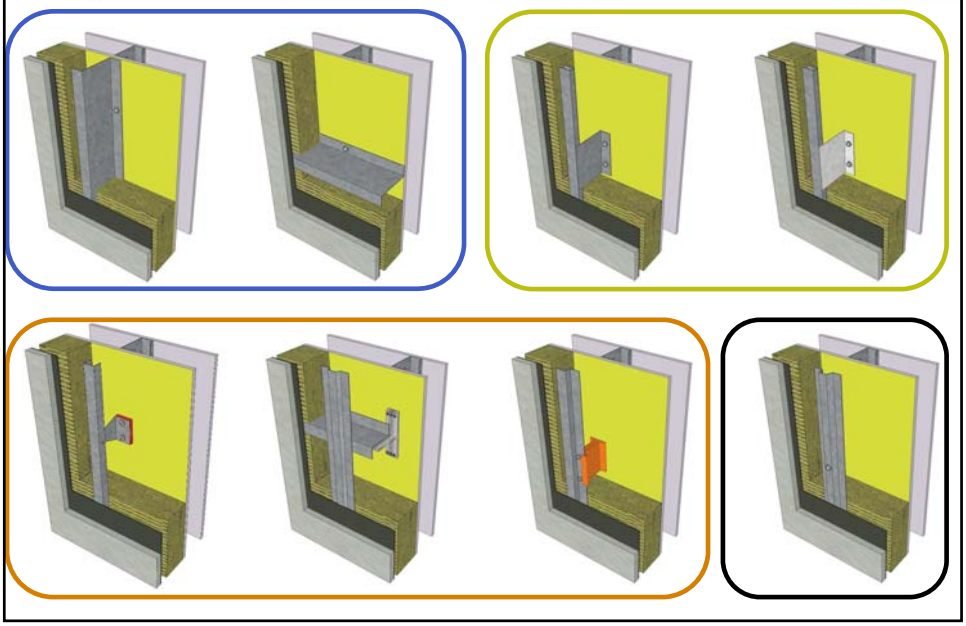
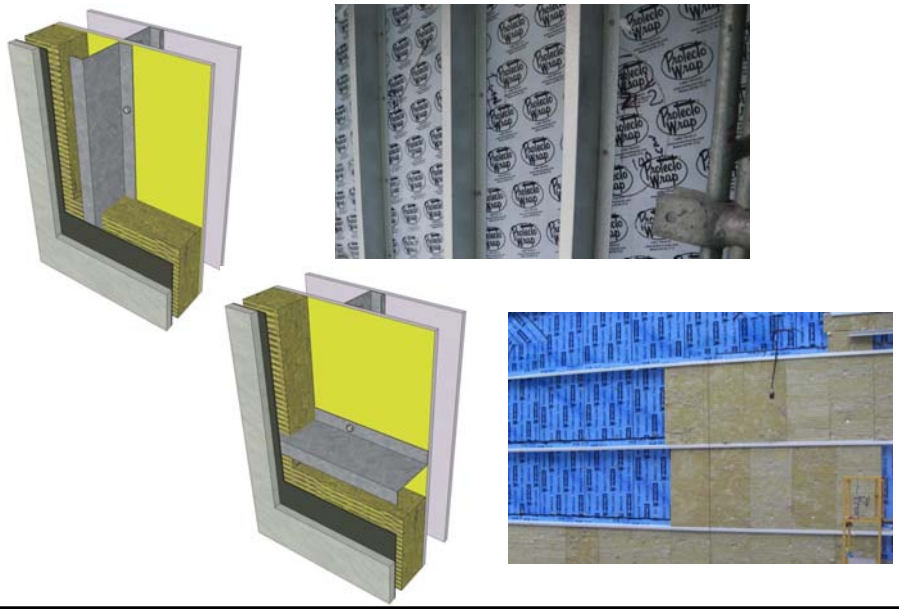


## Vertical & Horizontal Continuous Z-Girts

RDH



## Intermittent Metal Clips

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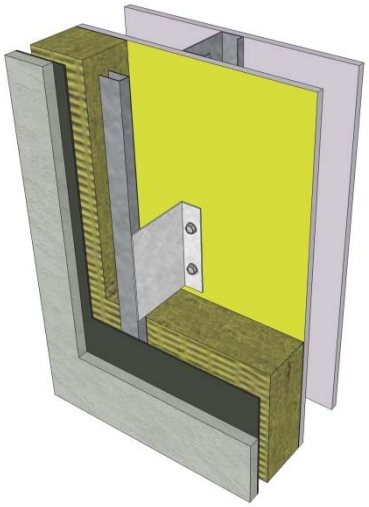
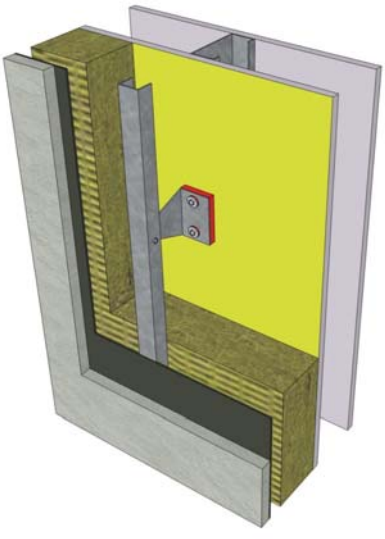


## Thermally Improved Clip – Isolated Galvanized Clip

RDH



## Thermally Improved Clip – Aluminium T-Clip

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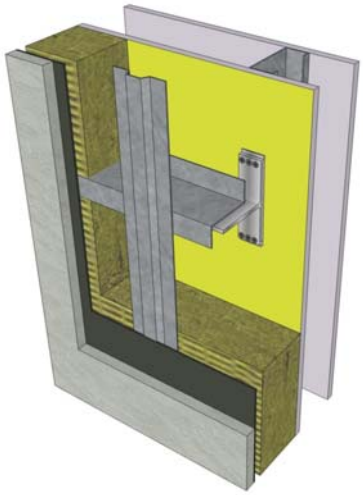

## Thermally Improved Clip – Fibreglass Clip

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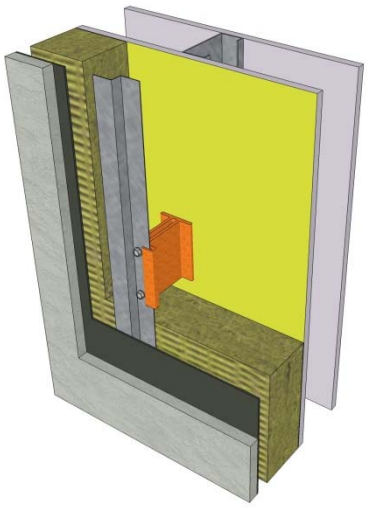

## Screws – Stainless Steel/Galvanized

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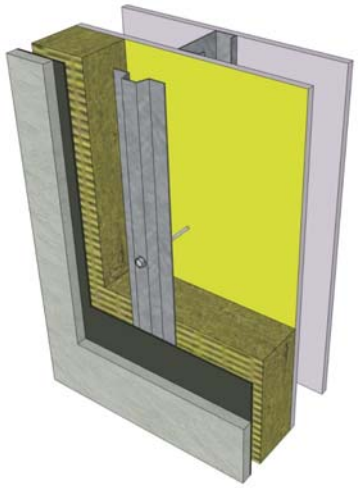

## 3D Thermal FEA

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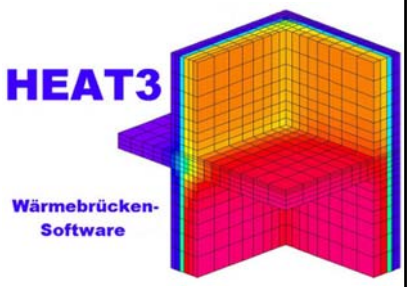
- HEAT3 5 - BuildingPhysics.com
- Finite element thermal analysis
- Boundary Conditions:
  - 0 ˚F Exterior
  - 70˚F Interior
- Surface Films
  - 0.17 $ft^2 \cdot ˚F \cdot hr/BTU$ Exterior
  - 0.68 $ft^2 \cdot ˚F \cdot hr/BTU$ Interior



## Material Thermal Conductivity

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| *Material* | *Thermal Conductivity [W/m·K]* | | *Material* | *Thermal Conductivity [W/m·K ]* |
|---|---|---|---|---|
| Fibre Cement Board | 0.3 | | PVC | 0.17 |
| Semi-Ventilated Cavity | 0.45 | | Neoprene | 0.23 |
| Galvanized Steel | 62 | | Aerogel | 0.015 |
| Stainless Steel | 14.3 | | Plywood | 0.11 |
| Aluminum | 160 | | Wood (SPF) | 0.14 |
| Fiberglass Frame | 0.3 | | Exterior Gypsum Board | 0.13 |
| Semi-Rigid Mineral Fiber Insulation (R-4.2/in) | 0.0343 | | Fiberglass Batt Insulation (R-3.3/in) | 0.0437 |
| Mineral Fiber Batt Insulation (R-4/in) | 0.0355 | | Interior Gypsum Board | 0.16 |

## Material Thermal Conductivity

RDH

| Material | Thermal Conductivity [BTU/hr·ft·F] | | Material | Thermal Conductivity [BTU/hr·ft·F] |
|---|---|---|---|---|
| Fibre Cement Board | 0.52 | | PVC | 0.29 |
| Semi-Ventilated Cavity | 0.78 | | Neoprene | 0.40 |
| Galvanized Steel | 107.30 | | Aerogel | 0.026 |
| Stainless Steel | 24.75 | | Plywood | 0.19 |
| Aluminum | 276.91 | | Wood (SPF) | 0.24 |
| Fiberglass Frame | 0.52 | | Exterior Gypsum Board | 0.22 |
| Semi-Rigid Mineral Fiber Insulation (R-4.2/in) | 0.059 | | Fiberglass Batt Insulation (R-3.3/in) | 0.076 |
| Mineral Fiber Batt Insulation (R-4/in) | 0.061 | | Interior Gypsum Board | 0.28 |

## 3D Thermal FEA

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- Clear Field Center-of-Wall modelled
- Insulation Thickness at 4", 8", 12"
- Results do not include additional thermal bridging that may occur at:
  - floors and slab edges
  - penetrations
  - interfaces
  - additional framing
  - windows
  - other details
- Apples to apples comparison

## Wood Frame Wall Assembly

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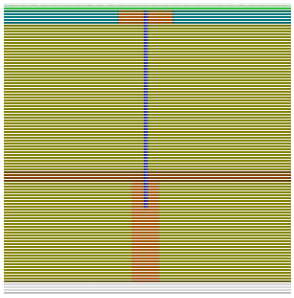
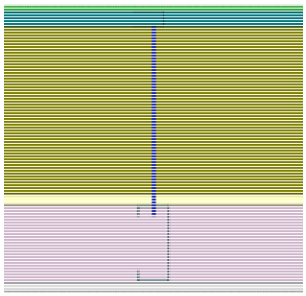


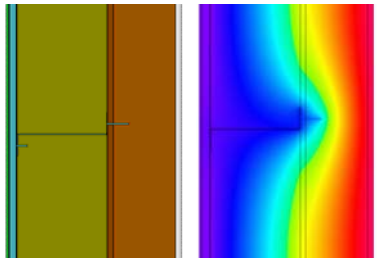
- Exterior
  - Fiber Cement Board Cladding
  - 3/4" Air Space (Rainscreen)
  - Cladding Attachment System
  - R-4.2/in Exterior MW Insulation
  - Plywood Sheathing
  - 2x6 Wood Framing @ 16" OC with
  - R-22 Batt Insulation
  - Interior Gypsum
- Interior

## Steel Stud Wall Assembly

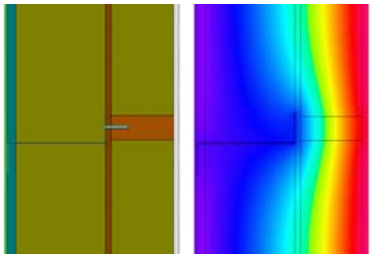


- → Exterior
  - → Fiber Cement Board Cladding
  - → 3/4" Air Space (Rainscreen)
  - → Cladding Attachment System
  - → R-4.2/in Exterior MW Insulation
  - → Gypsum Sheathing
  - → 3 5/8" Steel Studs @ 16" OC with
  - → R-12 Batt Insulation
  - → Interior Gypsum
- → Interior

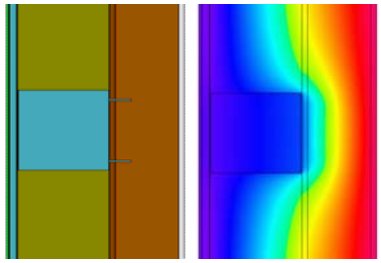
## Heat3 Modeling



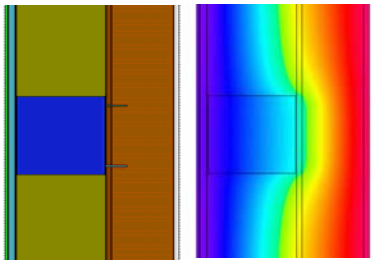
Horizontal Continuous Z-Girt



Vertical Continuous Z-Girt



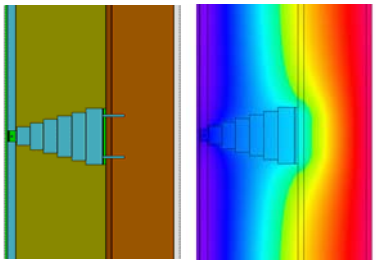
Galvanized Intermittent Z-Girt



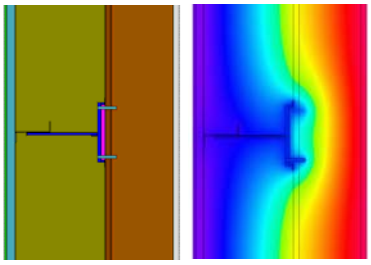
SS Intermittent Z-Girt

## Heat3 Modeling

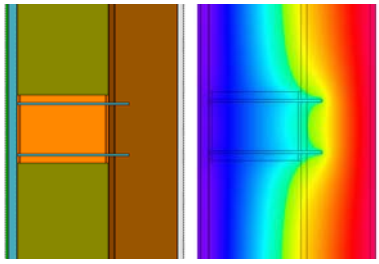
RDH



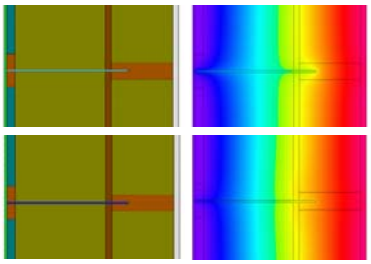
Isolated Galvanized Clip



Aluminum T-Clip



Fiberglass Clip



Galvanized/SS Screws

## Percent Thermal Degredation

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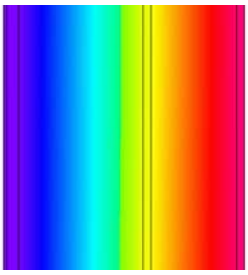
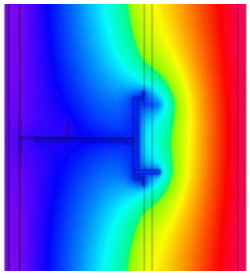
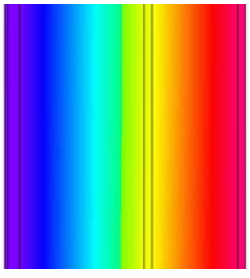


R-Value without penetrating element



R-Value with penetrating element



R-Value without penetrating element

**= % Thermal Degradation**

## Thermal Point Transmittance

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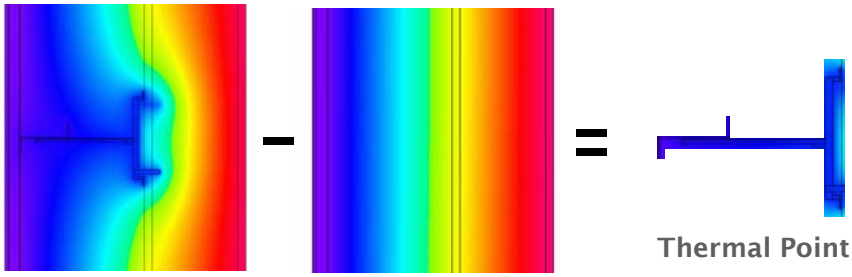


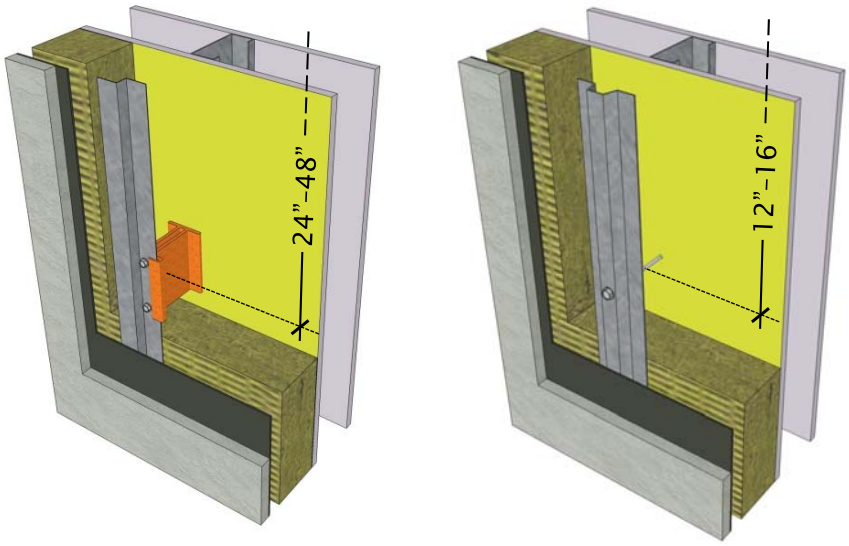
Heat Loss Through Assembly with Clip

Heat Loss Through Assembly without Clip

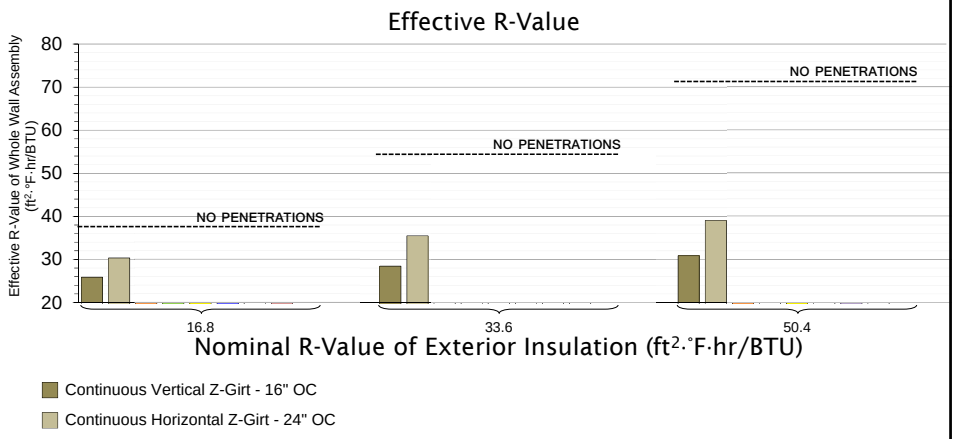
**Thermal Point Transmittance (χ-value)**

## Clip/Screw Vertical Spacing

RDH



## Results – Insulated Wood Frame Wall

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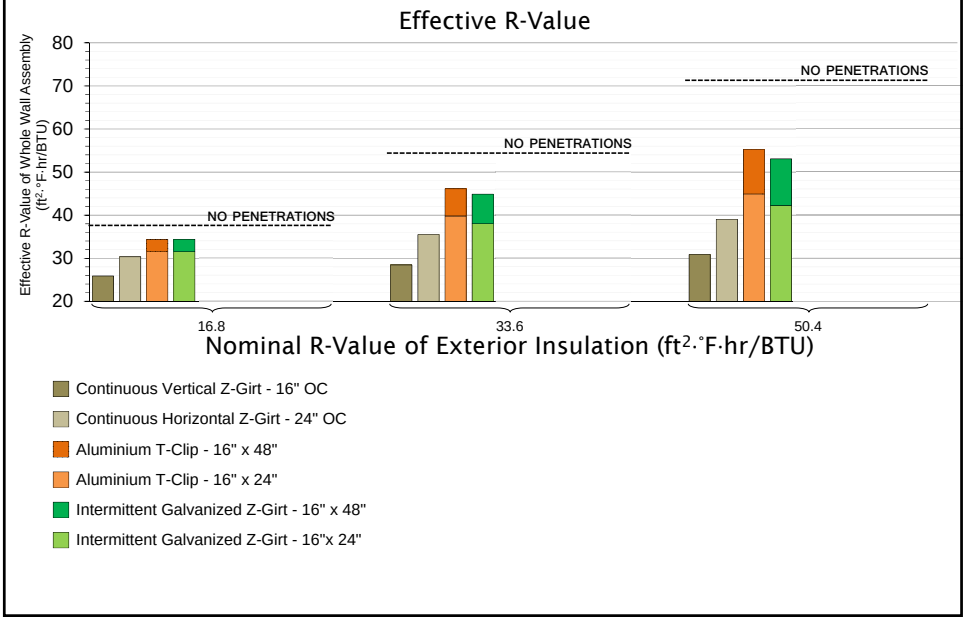

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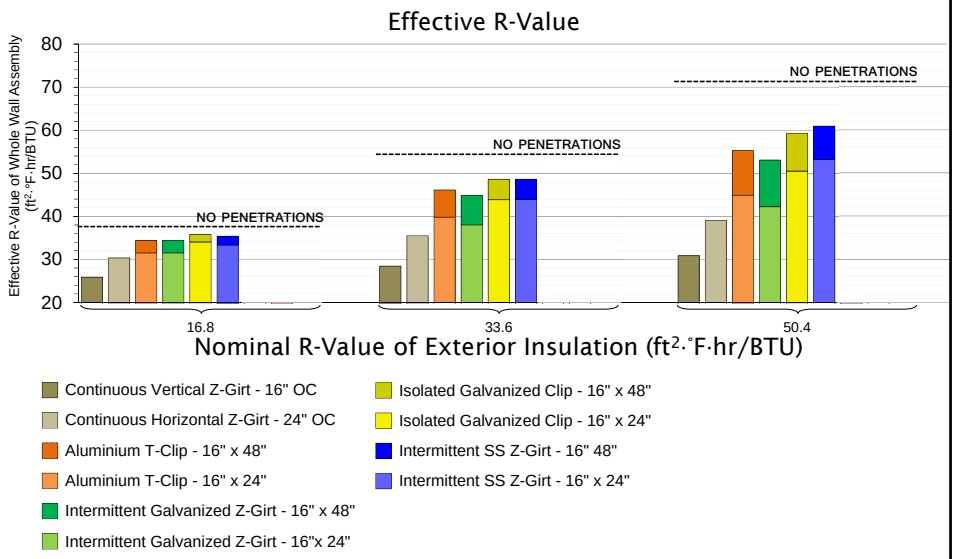


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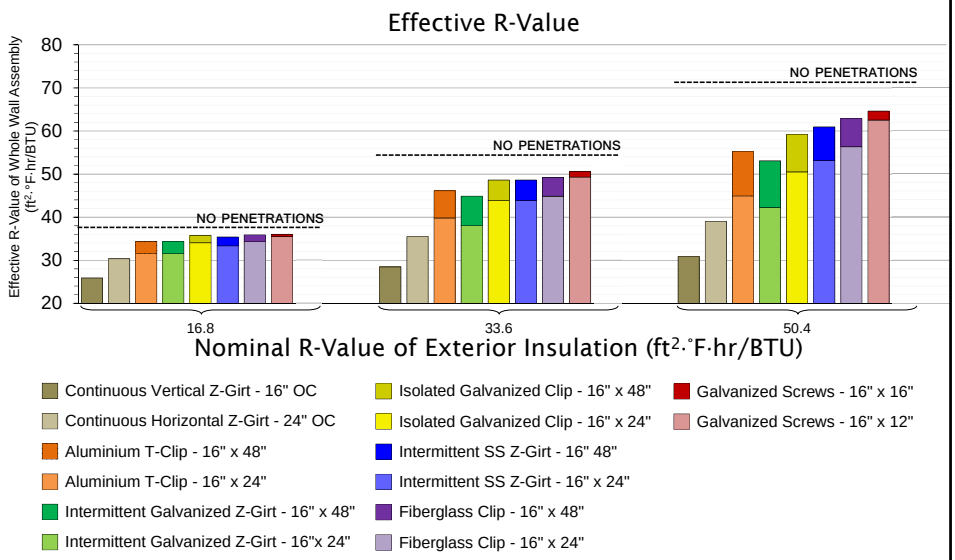

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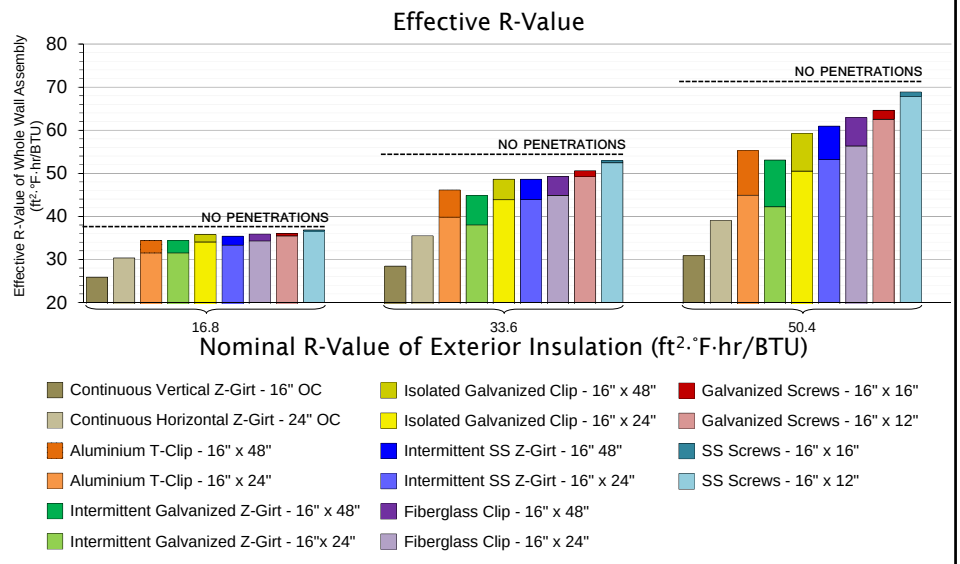


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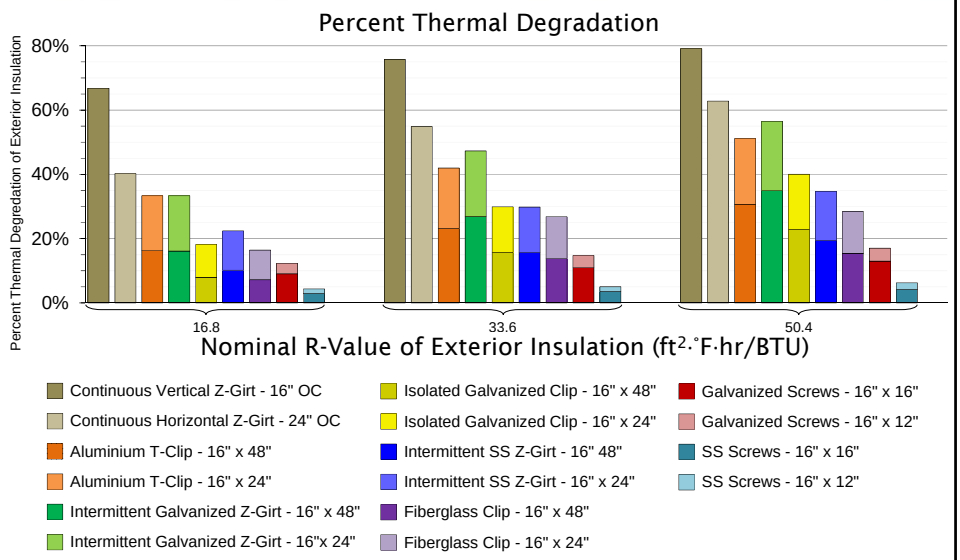

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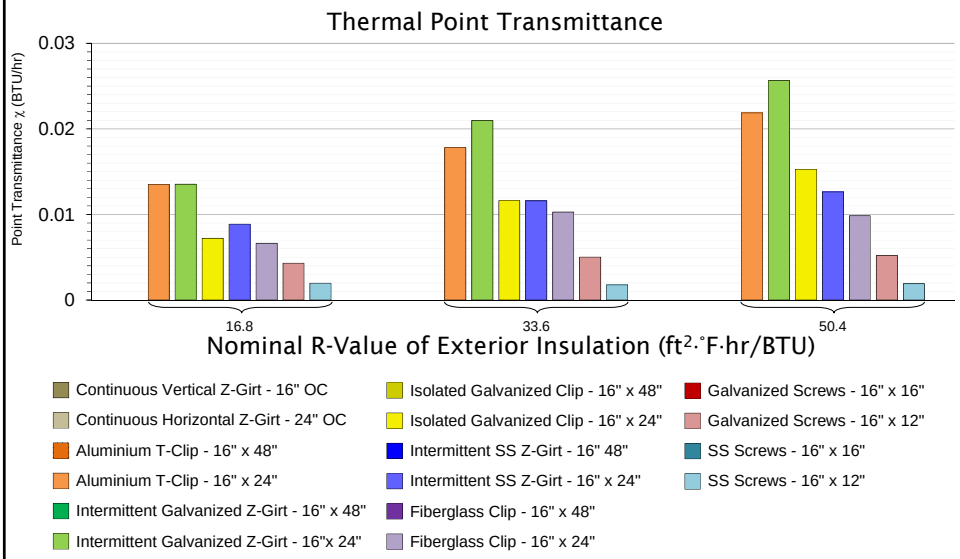
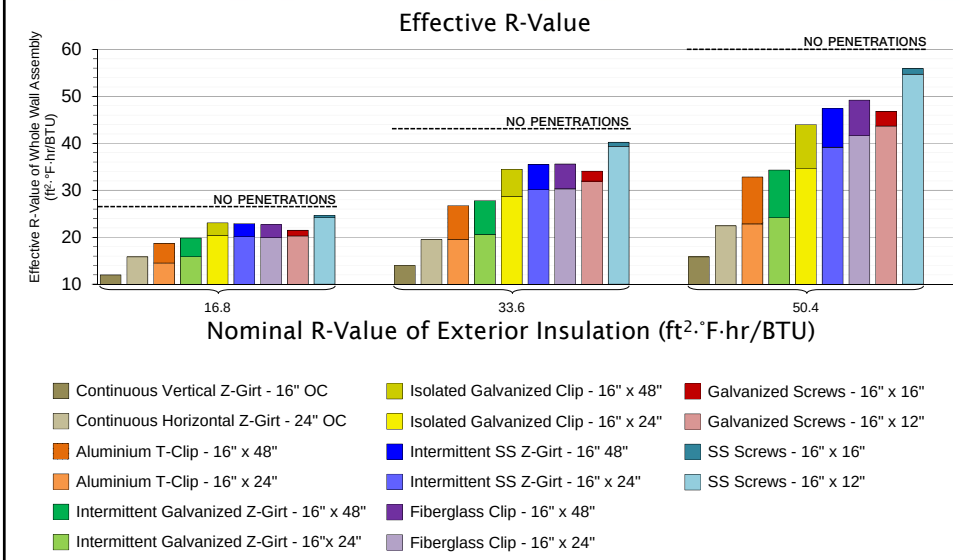



## Results – Insulated Steel Stud Wall

RDH



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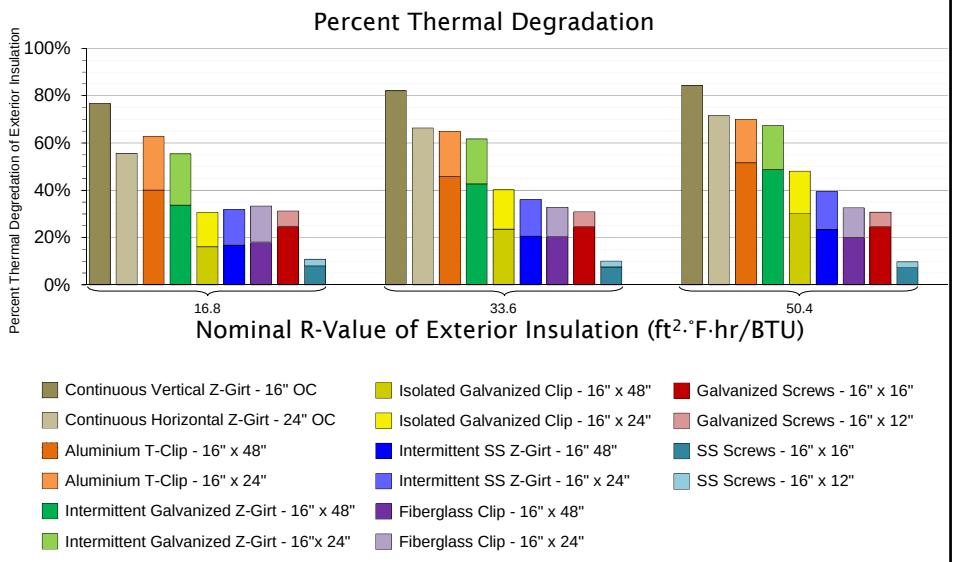


## Results – Insulated Steel Stud Wall

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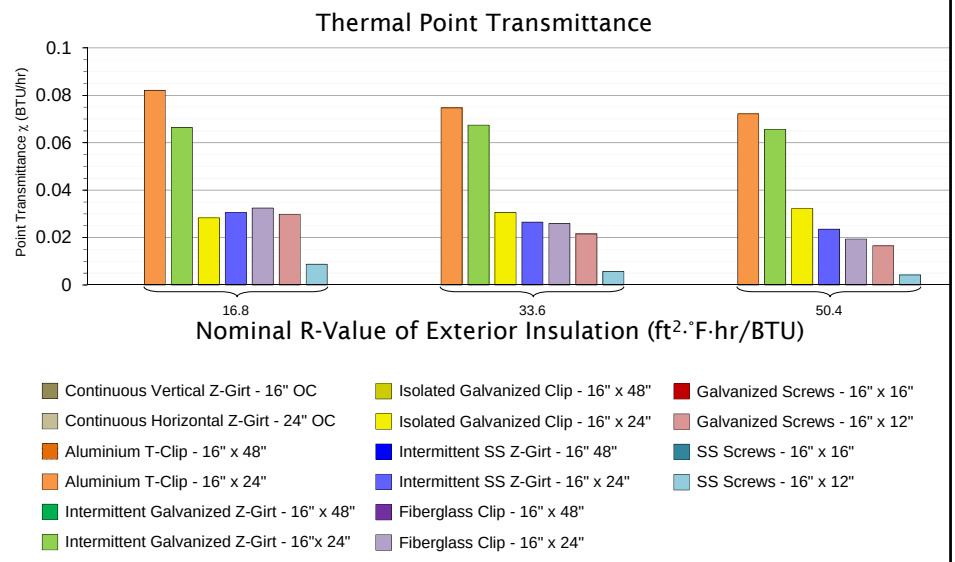
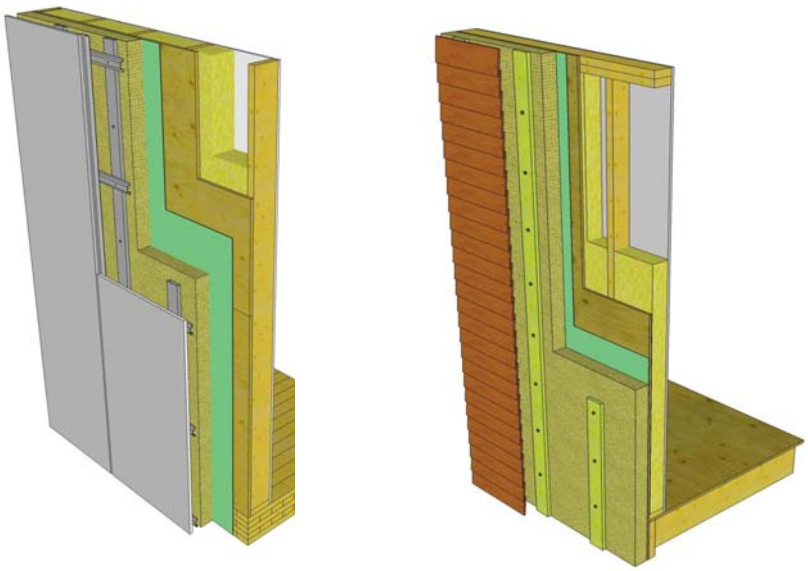


## Cladding Attachment: Screws through Insulation



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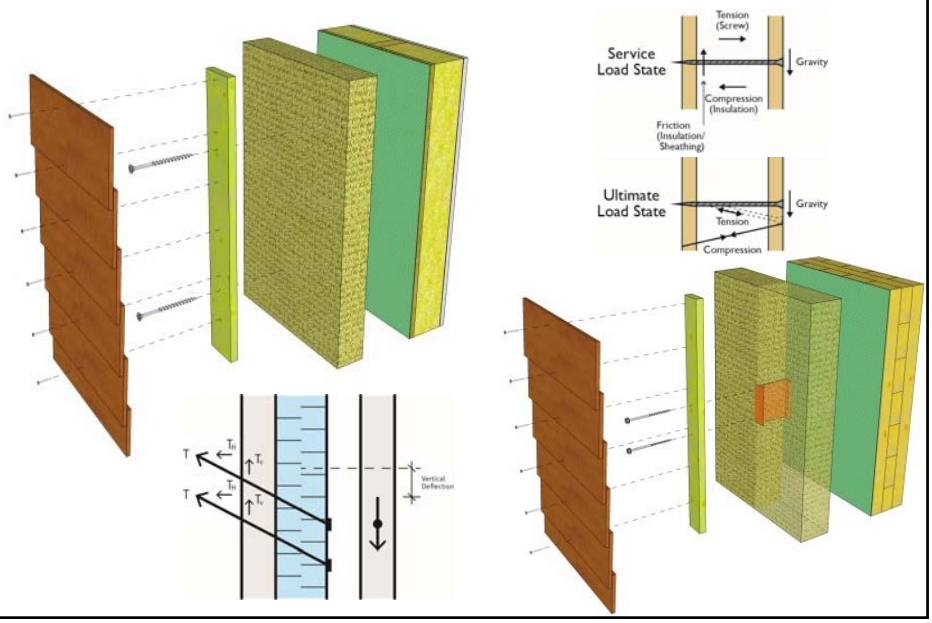

## Mockups!

RDH


## Cladding Attachment: Screws through Insulation

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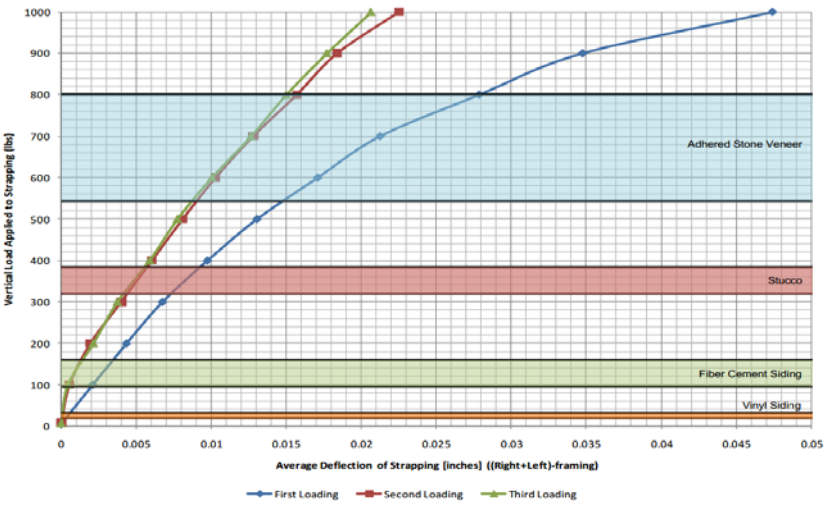
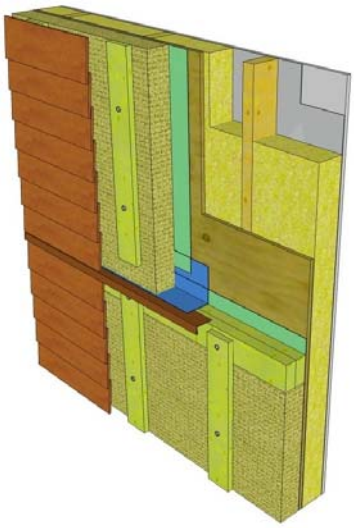



**Figure 5: Deflection Testing of 3" ComfortBoard IS**

## Cladding Attachment: Screws through Insulation

## Screws through Insulation: Shear Blocks



- With heavy or brittle claddings – may consider shear blocks to limit deflection and creep
  - Not necessary with light-weight claddings
- Shear block material:
  - Continuous or intermitted wood blocks, metal clips etc.

## What about steel studs?

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## Cladding Attachment Recommendations

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| Substrate / Cladding Type | Wood Backup (OSB/Plywood) | Steel Stud Backup | Concrete or Concrete Block Backup |
|---|---|---|---|
| Light weight *(up to fiber cement panels, <10psf)* | Clip & Rail good<br><br>Screws good | Clip & Rail good<br><br>Screws okay, but difficult to hit stud | Clip & Rail good<br><br>Screws can be difficult to install |
| Medium weight *(stucco, cultured stone, 10-25 psf)* | Clip & Rail good<br><br>Screws with shear block or engineered | Clip & Rail good<br><br>Screws with shear block or engineered | Clip & Rail good<br><br>Screws can be difficult to install |
| Heavy weight *(Masonry, Stone Panels, >25 psf)* | Gravity supports, anchors & engineered connections only | Gravity supports, anchors & engineered connections only | Gravity supports, anchors & engineered connections only |

## Conclusions

- → Exterior insulation is key to high R-value wall assemblies
- → Thermal degradation of exterior insulation from bridging varies drastically between systems
- → Clip & rail, and discrete fastener systems offer the best thermal efficiency
- → Thermal point transmittance is a useful metric to compare different systems and varying spacing
- → Discrete fasteners through rigid insulation provides high thermal efficiency and adequate strength for majority of cladding systems

## Discussion + Questions

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