# R-22 Walls & Insulating for the Future

BCBEC LUNCHEON

March 17, 2016

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RDH

## Outline

- The Building Enclosure & Energy Codes
- Highly Insulated Assemblies
- Exterior Insulation – How To?
- R-22 Walls Guide & Other Resources

## The Building Enclosure

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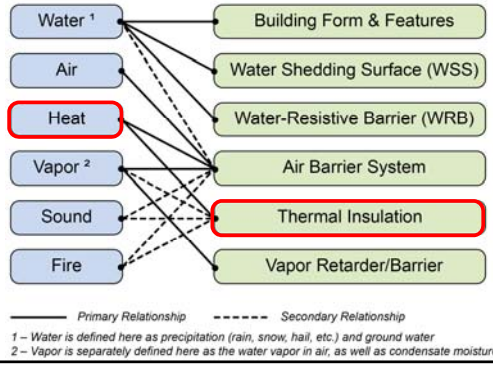
- The building enclosure separates indoors from outdoors by controlling:
  - Water penetration
  - Air flow
  - Heat flow
  - Vapor diffusion (wetting & drying)
  - Sound
  - Fire
- While at the same time:
  - Transferring structural loads
  - Being durable and maintainable
  - Being economical & constructible
  - Looking good!

## Building Enclosure Control Functions

RDH




1 – Water is defined here as precipitation (rain, snow, hail, etc.) and ground water
2 – Vapor is separately defined here as the water vapor in air, as well as condensate moisture

## Thermal Control

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- Thermal Control = Insulation

## Code Shift to Effective R-values

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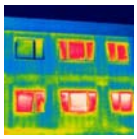
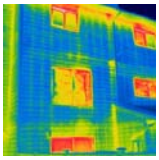
- We are now seeing an industry wide shift to **Effective R-values**
- **Nominal R-values** are the rated R-values of insulation materials which do not include impacts of how they are installed
  - For example 5.5" R-20 batt insulation or 2" R-10 rigid foam insulation
- **Effective R-values** are the actual R-values of assemblies which include for the impacts thermal bridging through the insulation
  - For example nominal R-20 batts within 6" steel studs 16" o.c. becoming ~R-9 effective, or in wood studs ~R-15

## Understanding Thermal Bridging

- **Thermal Bridging** occurs when a conductive material (e.g. aluminum, steel, concrete, wood etc.) provides a path for heat to bypass or short-circuit the installed insulation – reducing overall effectiveness of the entire system
  - Heat flow finds the path of least resistance
  - A disproportionate amount of heat flow occurs through thermal bridges even if small in area
  - Often adding more/thicker insulation to assemblies doesn't help much as a result
- **Effective R-values** account for the additional heat loss due to thermal bridges and represent actual heat flow through enclosure assemblies and details



## Understanding Thermal Bridging



- Examples of Thermal Bridges in Buildings:
  - Wood framing or steel framing (studs, plates) in insulated wall
  - Conductive cladding attachments through insulation (metal girts, clips, anchors, screws etc.)
  - Concrete slab edge (balcony, exposed slab edge) through a wall
  - Windows & installation details through insulated walls
- Energy code compliance has historically focused on assembly R-values – however more importance is now being placed on details and interfaces
- Energy, comfort, & durabiility implications

8 of 75

## The World of Energy Codes

| | | British Columbia | Vancouver |
|---|---|---|---|
| New Construction | All Other | ASHRAE 90.1 or NECB | |
| | Part 9 <4 Storeys | BCBC 9.36 | VBBL Part 10 |
| Renewal or Rehabilitation | All Other | ASHRAE 90.1 or AHJ | VBBL Part 11 (ASHRAE 90.1) |
| | Part 9 <4 Storeys | BCBC 9.36* or AHJ | VBBL Part 11 |

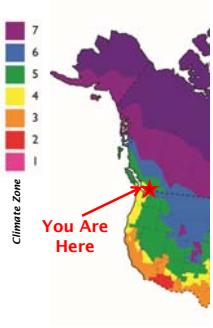
*Only for the parts of the building being impacted.

Enclosure work "voluntary upgrade" and is omitted. Also omitted if ASHRAE 90.1-2007.

## From Code Minimum to Super Insulation

- In BC, minimum effective R-value targets in energy codes are in range of:
  - R-15 to R-30 effective for walls
  - R-25 to R-50 effective for roofs
  - R-2 to R-4 for windows
- Green or more energy efficient building programs (i.e. Passive House), have more aggressive R-value targets in range of:
  - R-25 to R-50+ effective for walls
  - R-40 to R-80+ effective for roofs
  - R-5 to R-6+ for windows

## Energy Code for Part 3 Residential Buildings




**ASHRAE 90.1-2010**

| Climate Zone | Above Grade Walls: Mass, Steel, Wood *Min. Eff. R-value* | Roofs: Attic, Flat *Min. Eff. R-value* |
|---|---|---|
| 7 | 14.1, 23.8, 19.6 | 37.0, 20.8 |
| 6 | 14.1, 15.6, 19.6 | 37.0, 20.8 |
| 5 | 12.5, 15.6, 19.6 | 37.0, 20.8 |
| 4 | 11.1, 15.6, 15.6 | 37.0, 20.8 |
| 3 | 9.6, 15.6, 11.2 | 37.0, 20.8 |
| 2 | 8.1, 15.6, 11.2 | 37.0, 20.8 |
| 1 | 6.6, 8.0, 11.2 | 37.0, 20.8 |

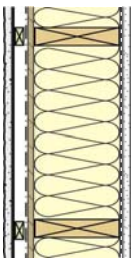
*Based on Maximum Effective Assembly U-value.*

11 of 75

## Energy Codes Targets for Part 9 Buildings

**Above Grade Wall Requirements**

- BCBC Part 9.36 Climate Zone 4
  - R-15.8
- BCBC Part 9.36 Climate Zone 5
  - R-17.5
- VBBL
  - R-22 (RSI-3.85)



12 of 75

## R-15.6 Steel Stud Wall?

*As bad (here), or as good as you can practically build – you just can't get an effective R-15.6 out of stuffing insulation between **steel studs** – no matter what depth the studs may be.*

13 of 75

## Also Not an R-15.6 Steel Framed Wall

*No matter the insulation type, also cannot practically get to >R-15.6 with continuous steel girts through exterior insulation*

## The Engineer's Solution to Thermal Bridging?!

15 of 75

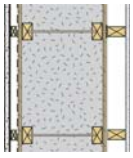
So the question is…

**How do we improve wall thermal performance, without compromising durability?**

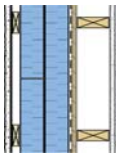
16 of 75

## Where to Add More Insulation in Walls?

Stuff It?

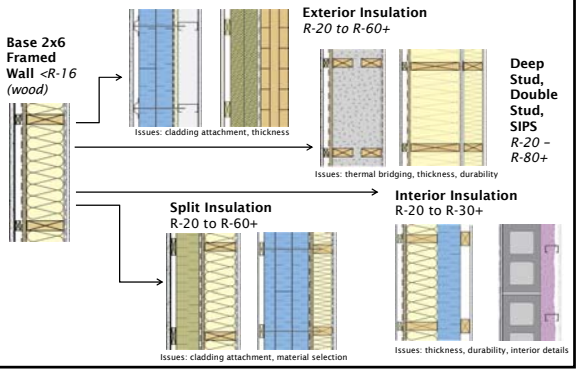


Wrap It?

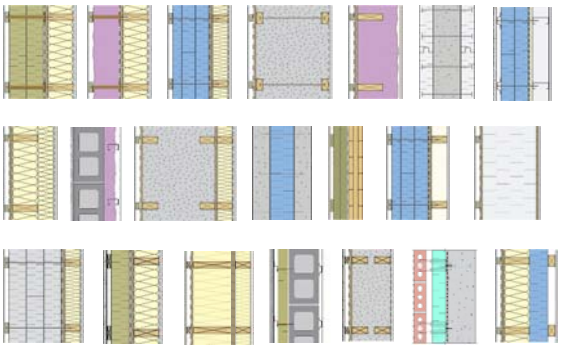


17 of 75

## Getting to Higher Insulation Levels in Exterior Walls



## There is Way More than One Way to Get There…

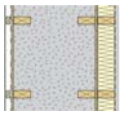


## Deep Stud & Double Stud Wall Considerations

*Double Stud*

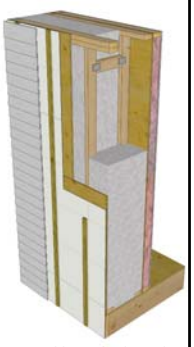
*TJI Stud*

*2x8 to 2x12 Deep Stud w/ Interior Service Wall*



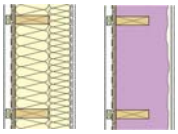
*Double Stud w/ Interior Service Wall*

**Key design considerations:** air barrier details, vapour control, overall thickness, reducing potential for wetting

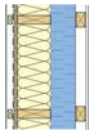


*Double Stud w/ or w/o interior service wall*

## Interior Insulated Wall Considerations

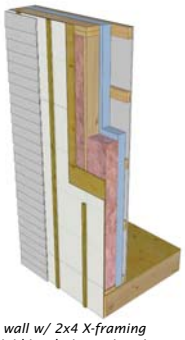


*2x6 w/ x-strapped 2x4s on interior and filled with fibrous or sprayfoam insulation*



*2x6 w/ interior rigid foam insulation*

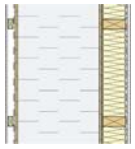
**Key design considerations:** air & vapour barrier selection, interior services details



*2x6 wall w/ 2x4 X-framing or rigid insulation at interior*

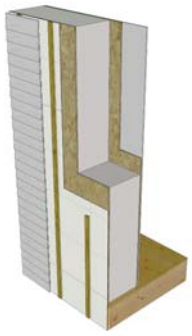
## Structurally Insulated Panels (SIPs) Considerations

*SIPs wall panel*



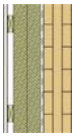
*SIPs wall panel w/ interior service wall*

**Key design considerations:** detailing & sealing of joints & interfaces, protection of panels from wetting

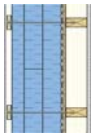


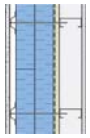
*SIPs Panel w/ EPS insulation*

## Exterior Insulated Wall Considerations



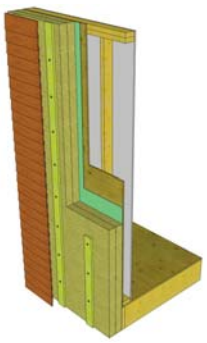
*CLT wall panel with semi-rigid exterior Insulation*





*Steel stud or wood frame wall with rigid exterior insulation*

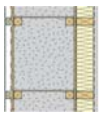
**Key design considerations:** attachment of cladding through exterior insulation, air barrier/WRB details



*Fully exterior insulated 2x4 wall with rigid insulation*

## Split Insulated Wall Considerations

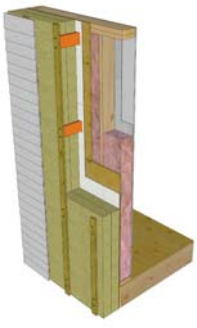
*Semi-rigid or sprayfoam insulation with intermittent thermally improved cladding attachments*



*Larsen truss over 2x4 wall*

*12" EPS over 2x4 wall*

**Key design considerations:** type of exterior insulation, cladding attachment through exterior insulation, air/vapour barrier placement



*Split insulated 2x4 wall with rigid or semi-rigid insulation*

## Split Insulated Wall

- Various exterior insulation types can be used
  - Permeable: Mineral Wool or Rigid Fiberglass
  - Impermeable: XPS, EPS, Polyiso, Closed-Cell Sprayfoam

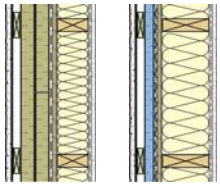
**Placement of impermeable insulations is tricky for code compliance and performance.**

25 of 75

## Split Insulated Wall

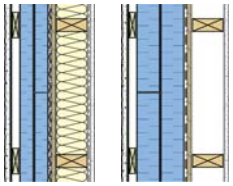
**Part 9 Code Compliance Paths for Split Insulated Wall Assemblies**

**Relatively Permeable Exterior Insulation (> 60 ng/(s • m² • Pa))**



Does not trigger code requirements for placement of impermeable materials

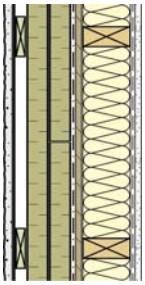
**Exterior-to-Interior Insulation Ratio**



Must meet ratio in Table 9.25.5.2 of VBBL (Ratio of Exterior Insulation to Interior Insulation)

## Split Insulated Wall

- **Split insulated walls with permeable exterior (i.e stone wool) insulation provide a lower risk than does impermeable insulation**
  - Allows outward drying
  - No double vapour barrier

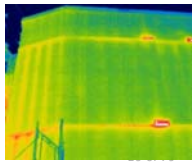


27 of 75

## Trials With Exterior Insulation

## Cladding Attachment & Exterior Insulation

- Exterior insulation is only as good as the cladding attachment strategy
- What attachment systems work best?
- What is and how to achieve true continuous insulation (ci) performance?
- What type of insulation/membrane?

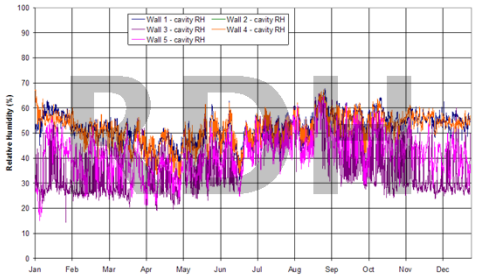


## Exterior Insulation with Continuous Girts – 1990s

30 of 75

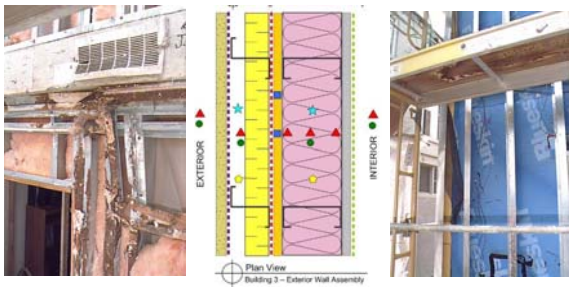
## Exterior Insulation with Continuous Girts

Nice and dry walls




31 of 75

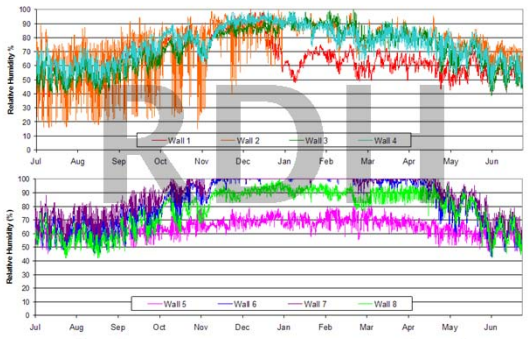
## Trial Split Insulated Assembly – Early 2000s




32 of 75

## Trial Split Insulated Wall Assembly - Moisture

Uhoh…




## Lessons Learned

34 of 75

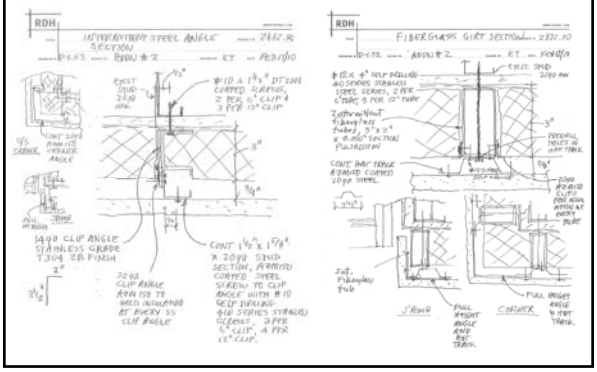
## Exterior Insulation & Cladding Attachment

## Considerations

- Cladding weight & gravity loads
- Wind & seismic loads
- Back-up wall construction (wood, concrete, steel)
  - Attachment from clip/girt back into structure (studs, sheathing, or slab edge)
- Thickness of exterior insulation
- Use of rigid, semi-rigid or spray-applied insulation
  - Ability to fasten cladding supports through face
  - Ability to fit insulation tightly around cladding supports
- R-value target, tolerable thermal loss from supports
- Cladding orientation (panel, vertical, horizontal)
- Ease of attachment of cladding – returns, corners, etc.
- Combustibility requirements

36 of 75

## Trial Thermally Improved Cladding Attachments

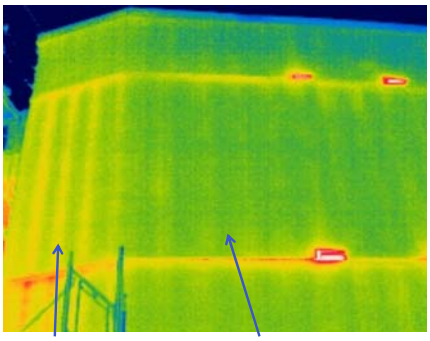


## Trial Thermally Improved Cladding Attachments

38 of 75

## Low-Conductivity Cladding Supports


## Thermally Improved Performance

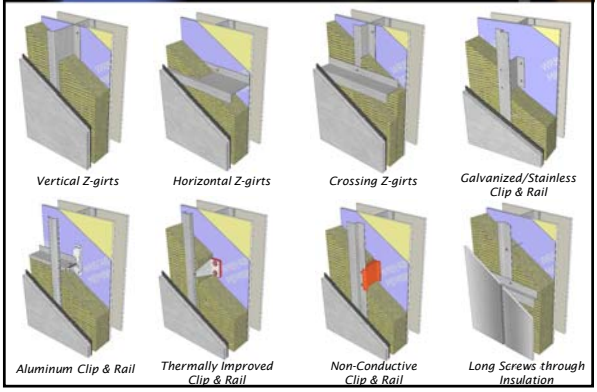


Continuous metal Z-girts

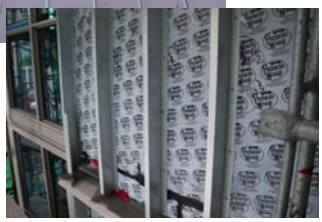
Fiberglass Clips & Hat-Tracks

40 of 75

## Many Cladding Attachment Options & Counting

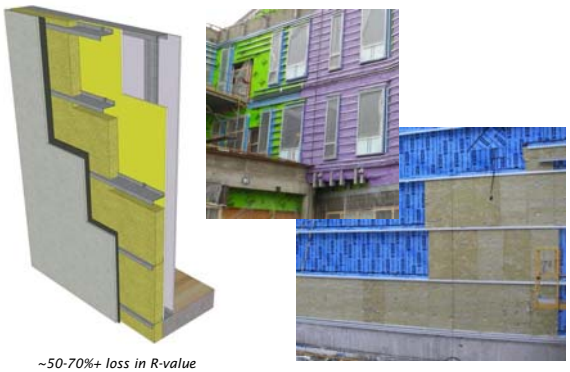



## Cladding Attachment: Vertical Steel Z-Girts



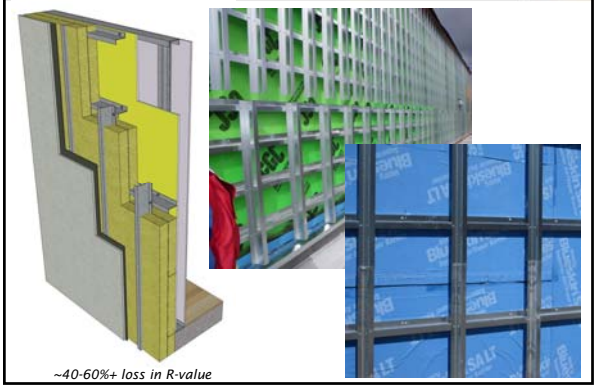
~60-80%+ loss in R-value

## Cladding Attachment: Horizontal Steel Z-Girts



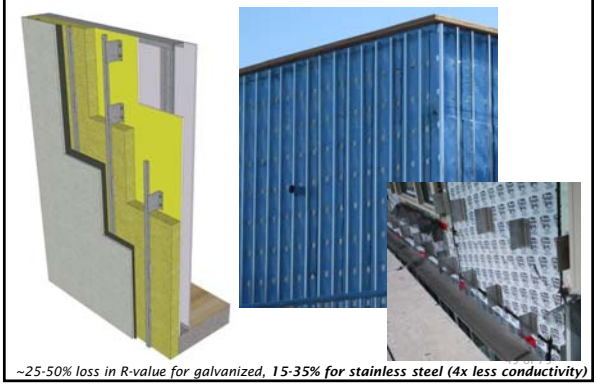
*~50-70%+ loss in R-value*

## Cladding Attachment: Crossing Steel Z-Girts



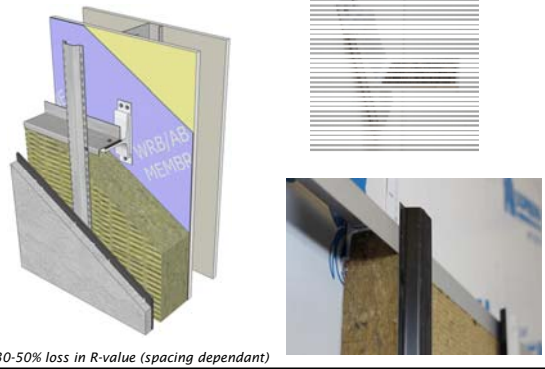
*~40-60%+ loss in R-value*

## Cladding Attachment: Clip & Rail, Steel



*~25-50% loss in R-value for galvanized,* ***15-35% for stainless steel (4x less conductivity)***

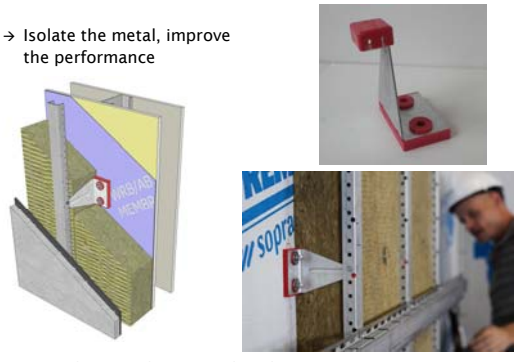
## Cladding Attachment: Aluminum Clip & Dual Girt



*~30-50% loss in R-value (spacing dependant)*

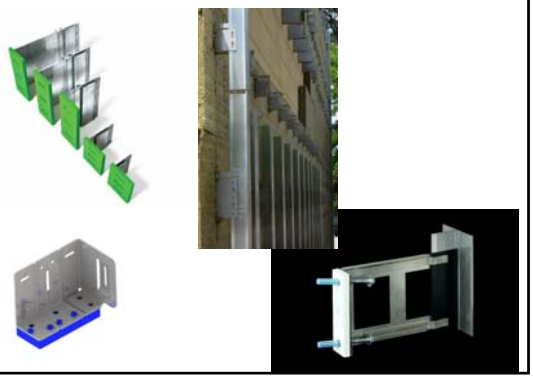
## Cladding Attachment: Clip & Rail, Isolated Galvanized

→ Isolate the metal, improve the performance



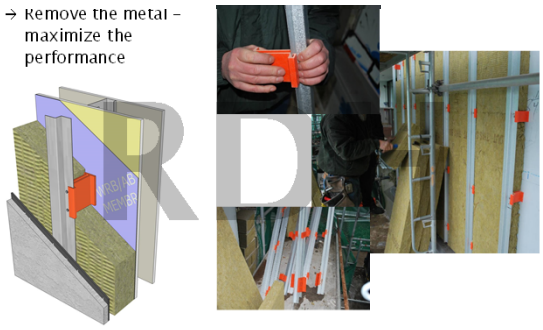
*~10-40% loss in R-value (spacing dependant)*

## Other Steel & Aluminum Cladding Clip & Rail Technologies



## Cladding Attachment: Clip & Rail, Fiberglass

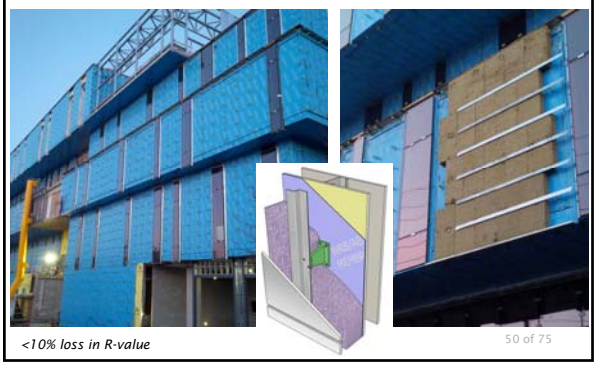
→ Remove the metal – maximize the performance



*~5-30% loss in R-value (spacing & fastener type dependant)*

49 of 75

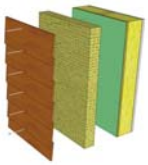
## Cladding Attachment: Clip & Rail Fiberglass (No Screws)



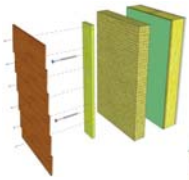
*<10% loss in R-value*

50 of 75

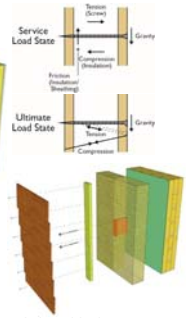
## Cladding Attachment: Screws through Insulation



Longer cladding Fasteners directly through rigid insulation (up to 2" for light claddings)



Long screws through vertical strapping and rigid insulation creates truss – short cladding fasteners into vertical strapping



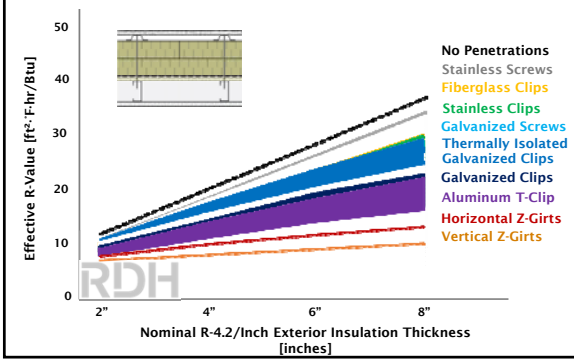

Rigid shear block type connection through insulation, short cladding fasteners into vertical strapping

## Really Thick Insulation = Really Long Screws

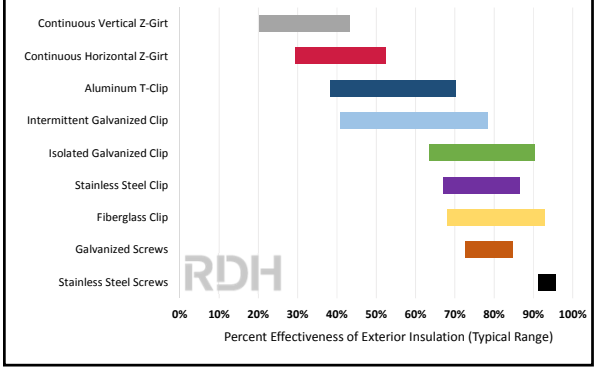

52 of 75

## Effective R-value Summary of Various Cladding Support Systems

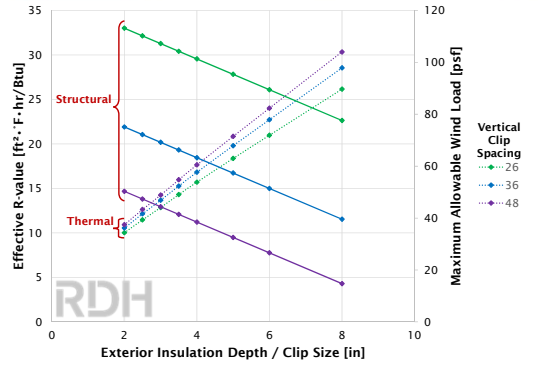
*Base backup wall is 3 5/8" steel stud (empty) + exterior insulation*




## Percent Effectiveness of Exterior Insulation with Various Cladding Support Systems



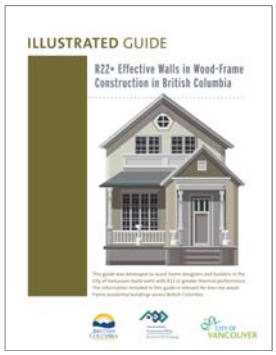
## Effective R-Value vs Structural Capacity for Clips




http://www.cascadiawindows.com/cascadia-clip-calculator

## R-22+ Wall Guide & Other Resources

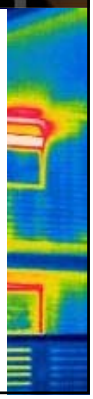
## R-22+ Wall Guide




57 of 75

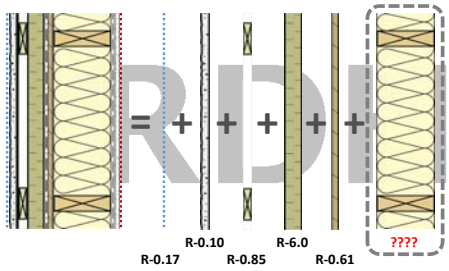
## Walls Covered in the Guide

- Above Grade Walls
  - Split Insulated Walls
  - Exterior Insulated Walls
  - Double Stud Walls
  - Deep Stud and TJI Walls
- Below Grade Walls
  - Exterior Insulated Below Grade Walls
  - Interior Insulated Below Grade Walls
- Alternatives
  - Structurally Insulated Panels (SIPs)
  - Insulated Concrete Forms (ICFs)



## R-Value Calculation

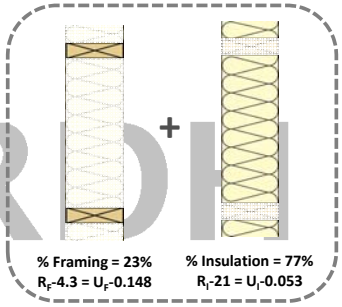
- Isothermal Planes




59 of 75

## R-Value Calculation

- Parallel Paths (i.e. UxA)

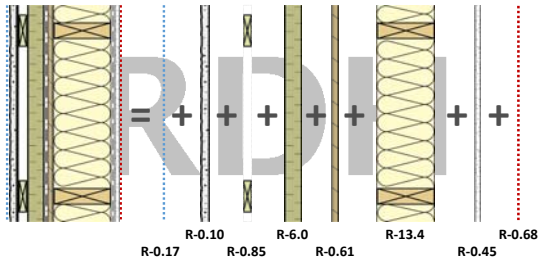



$$\text{R-Value} = \left[\frac{U_F \cdot A_F + U_I \cdot A_I}{A_F + A_I}\right]^{-1} = \left[\frac{0.148 \cdot 23 + 0.053 \cdot 77}{23 + 77}\right]^{-1} = \textbf{R-13.4}$$

60 of 75

## R-Value Calculation

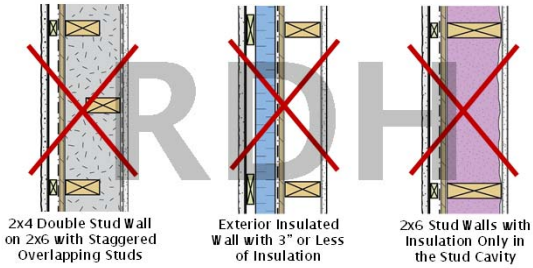
→ Isothermal Planes




= R-22.3

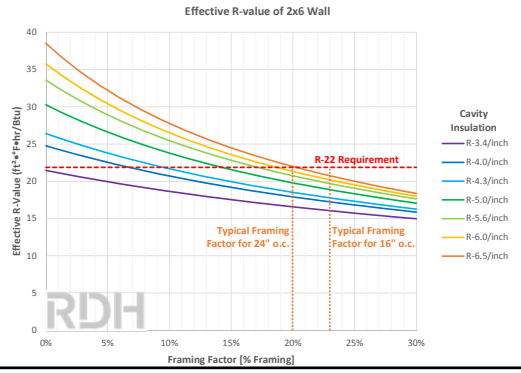
61 of 75

## Walls Less Than R-22



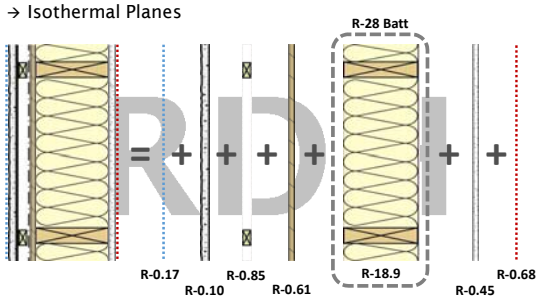

62 of 75

## 2x6 Walls & Achieving R-22




## 2x8 Wall R-Value – R-28 Batts

→ Isothermal Planes

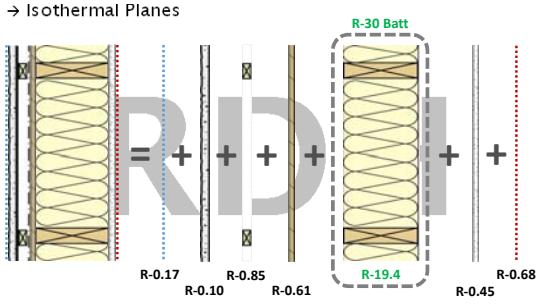



= R-21.8 < 21.9

64 of 75

## 2x8 Wall R-Value – R-30 Batts

→ Isothermal Planes




= R-22.2 < 21.9

65 of 75

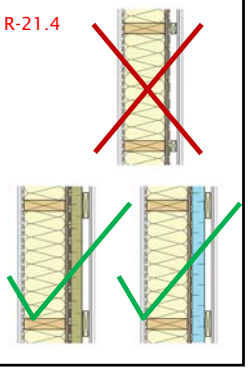
## 2x8 Wall Options for R-22 (16in o.c.)

→ 2x8 with ½ lb SPUF (R-3.75/in) = R-21.4
- → + 1" Mineral Wool = R-25.4
- → + 1" XPS = R-26.5

→ 2x8 with R-28 Batt = R-21.8
- → + 1" Mineral Wool = R-25.7
- → + 1" XPS = R-26.7

→ 2x8 with 2 lb SPUF = R-23.9

→ 2x8 with ¾ lb SPUF = R-22.0



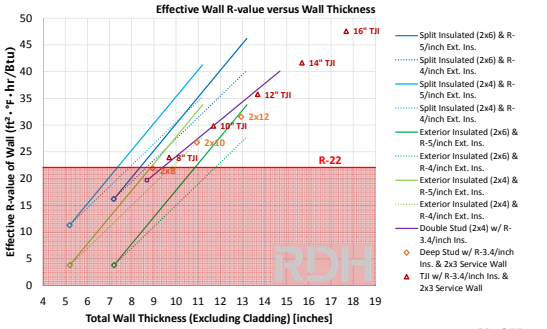
## Just Squishing It In Won't Work!

| Nominal Lumber Size | Cavity Depth | Insulation R-Values When Compressed In Framing Cavity | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2x12 | 11 1/4" | 37 | 38 | 30 | | | | | | | | |
| 2x10 | 9 1/4" | 32 | 35 | 30 | 30 | 25 | | | | | | |
| 2x8 | 7 1/4" | 27 | 30 | 25 | 27 | 24 | 22 | 21 | 19 | | | |
| 2x6 | 5 1/2" | | | 21 | 22 | 20 | 19 | 21 | 18 | | | |
| 2x4 | 3 1/2" | | | | | | 14 | 15 | 13 | 15 | 13 | 11 |
| 2x3 | 2 1/2" | | | | | | | | | 11 | 10 | 8.9 |
| 2x2 | 1 1/2" | | | | | | | | | | 6.6 | 6.2 |
| 2x1 | 3/4" | | | | | | | | | | | |
| Product R-Values | | R-38 | R-38C | R-30 | R-30C | R-25 | R-22 | R-21 | R-19 | R-15 | R-13 | R-11 |
| Standard Thickness | | 12" | 10 1/4" | 9 1/2" | 8 1/4" | 8" | 6 3/4" | 5 1/2" | 6 1/4" | 3 1/2" | 3 1/2" | 3 1/2" |

Notes: 1. Minimum dressed lumber thickness per U.S. Dept. of Commerce Publication PS 20-70.
2. Above listing for information only: some products will resist compression into framing cavities.

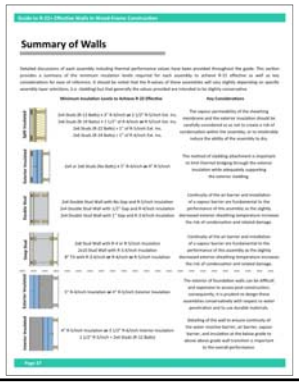


## Thinnest Walls for R-22



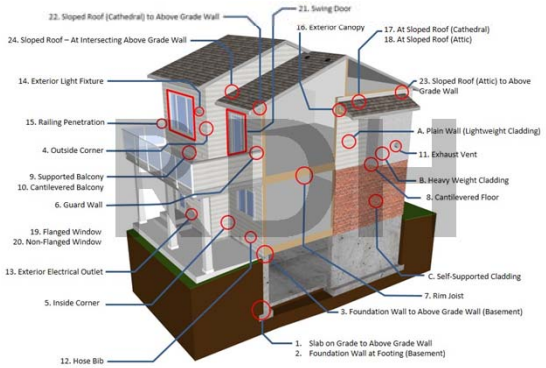



## Summary



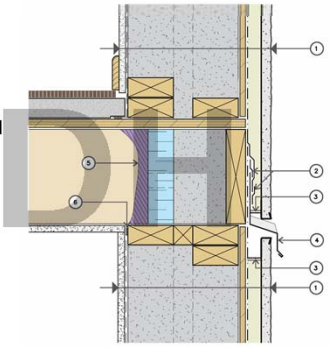



## Remember the Details

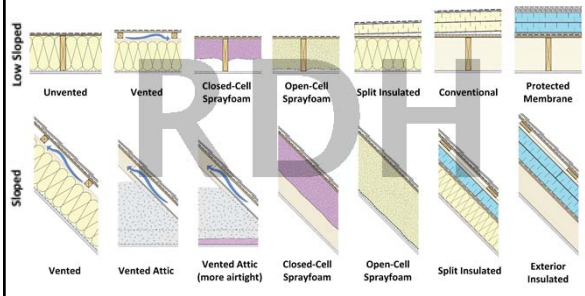



## Remember the Details

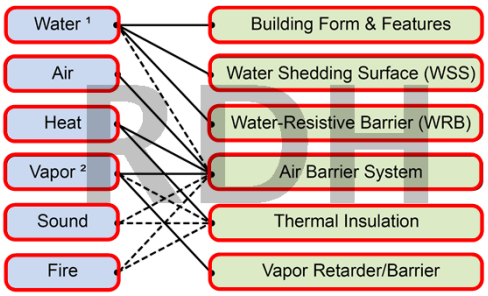
→ Important that details insulated to same level as field of wall (i.e. rim joists)



## Remember the Other Assemblies



## And Remember Everything Else!




1 – Water is defined here as precipitation (rain, snow, hail, etc.) and ground water
2 – Vapor is separately defined here as the water vapor in air, as well as condensate moisture

## Resources to Help With Part 9 Requirements


COV – Guide to R-22+ Effective Walls in Wood-Frame Construction


BCBC – Illustrated Guides to New Part 9.36 Requirements (Climate Zones 4-8)

## Resources to Help With Part 3 Requirements

Guide to Design of Energy-Efficient Building Enclosures


Building Enclosure Design Guide – *Currently Being Updated*

New HPO Builder Insights – ASHRAE/NECB – *Available Soon!*

## Discussion + Questions

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77 of 75