BUILDINGENERGY BOSTON

Exterior Wall Insulation: Don't Eat Your Sweater!

Peter Baker and Kohta Ueno,
Building Science Corporation

Curated by Mark Schow

Northeast Sustainable Energy Association (NESEA) | March 20, 2025

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Peter Baker & Kohta Ueno
March 20, 2025

Exterior Wall Insulation: Don't Eat Your Sweater!

bsc Building Science Corporation

BUILDINGENERGY® BOSTON

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Conference + Trade Show of the Northeast Sustainable Energy Association (NESEA)

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Course Description

The use of continuous exterior wall insulation is critical in high performance buildings to address thermal bridging through stud framing and other structural elements, and to increase wall R-values beyond cavity fill levels. Exterior insulation also has durability benefits in cold climates by improving condensation control. The speakers, as building enclosure consultants, regularly advise their clients on implementing continuous exterior insulation. They will use their experience to talk through the "why and how" of continuous exterior insulation assemblies, including variations used in residential vs. commercial construction. They will also explain the mechanics of cladding attachment through thick exterior insulation, based on Department of Energy Building America research projects that they led. They will also discuss problem areas that they encounter regularly, such as sequencing wall penetrations, balconies and decks, cementitious stucco, open-joint rainscreens, and material selection.

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Learning Objectives

At the end of this course, participants will be able to answer:

1. Justify the value of continuous exterior insulation in terms of wall thermal performance.
2. Illustrate the durability benefits of continuous exterior insulation.
3. Analyze requirements for cladding attachment of various weights through continuous exterior insulation.
4. Appraise the sequencing of penetrations with various wall assemblies.

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Housekeeping

- Slides will be available on website (https://www.buildingscience.com/past-events)
- Resources: list of links at end of presentation
- Questions—reserved Q&A time at end preferred

Apologies in Advance

- Likely review for many of you
- Possibly useful "nuggets"
- Arguments and struggles with architectural and builder teams
- "It's 2025… and this is new to you?"
- "The future is already here – it's just not evenly distributed."
  - William Gibson

What We're Not Covering Today…

- High R value roofs, foundations—just above grade walls
- Double stud walls
- TJI outrigger walls/Klingenberg walls
- Carbon impacts of materials—talk to Jacob, Chris, etc.
- All the details and conditions—deck ledgers, window details
- Only a one-hour presentation!

Why Continuous Wall Insulation?

Thermal Bridging/Thermal Performance

Continuous Insulation and Thermal Bridging

"You have done a good job if the whole building has an average R-Value of R-10, and no component is less than R-5"

- Dr. John Straube

Continuous Insulation and Thermal Bridging

UA Analysis Worksheet				
Building Info				
Length	150	ft		
Width	100	ft		
Height	150	ft		
Number of stories	10			
Number of windows	200			
Window height	10	ft		
Window to Wall Ratio	35%			
Building perimeter	500	ft		
Window perimeter	9250	ft		
Roof Area	15000	ft2		
Wall Area	48750	ft2		
Window Area	26250	ft2		
Total Area	90000	ft2		
	R-Value	U-Value	UA	% of total
Roof	40	0.025	375	5%
Wall	20	0.050	2438	30%
Window	5.0	0.200	5250	65%
Total UA			8063	
Total equivalent R-Value			**11.2**	

1. Convert the component R-Values to U-Values (Uc = 1/Rc)
2. Find areas of each component (Ac)
3. Multiply the U-value of each component by the component area (UAc = Uc x Ac)
4. Sum all the component UA values (UAt = UAc1 + UAc2 + …)
5. Divide the total UA by the total area to get an equivalent whole building U-value (Ut = UAt/At)
6. Convert U-Value to R-Value (Rt = 1/Ut)

Continuous Insulation and Thermal Bridging

UA Analysis Worksheet

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Height	150	ft		
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Window to Wall Ratio	35%			
Building perimeter	500	ft		
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Wall	20	0.050	2438	30%
Window	5.0	0.200	5250	65%
Total UA			8063	
Total equivalent R-Value			**11.2**	

"You have done a good job if the whole building has an average R-Value of R-10, and no component is less than R-5"

Step	R-Value
Base building	11.2

\- Dr. John Straube

Continuous Insulation and Thermal Bridging

UA Analysis Worksheet

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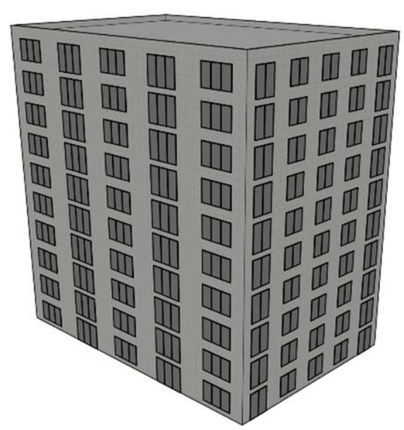
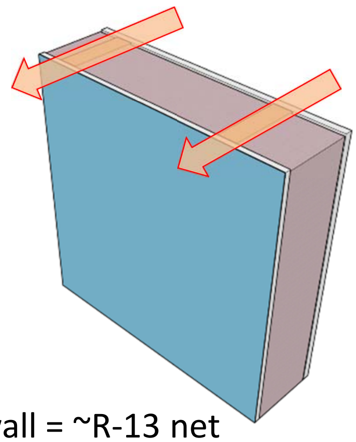
Width	100	ft		
Height	150	ft		
Number of stories	10			
Number of windows	200			
Window height	10	ft		
Window to Wall Ratio	45%			
Building perimeter	500	ft		
Window perimeter	10750	ft		
Roof Area	15000	ft2		
Wall Area	41250	ft2		
Window Area	33750	ft2		
Total Area	90000	ft2		
	R-Value	**U-Value**	**UA**	**% of total**
Roof	40	0.025	375	3%
Wall	20	0.050	2063	16%
Window	3.3	0.300	10125	81%
Total UA			12563	
Total equivalent R-Value			**7.2**	

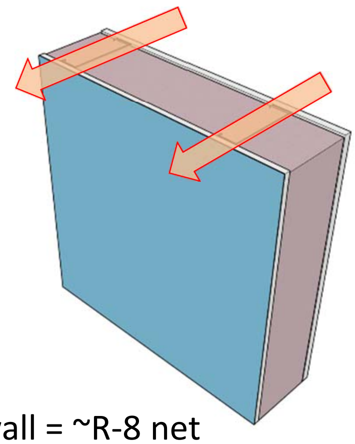
Step	R-Value
Base building	11.2
Double glazed	7.2



Continuous Insulation and Thermal Bridging



2x6 “R-20” wall = ~R-13 net
(assuming no steel)



2x6 “R-20” wall = ~R-8 net
(with steel)

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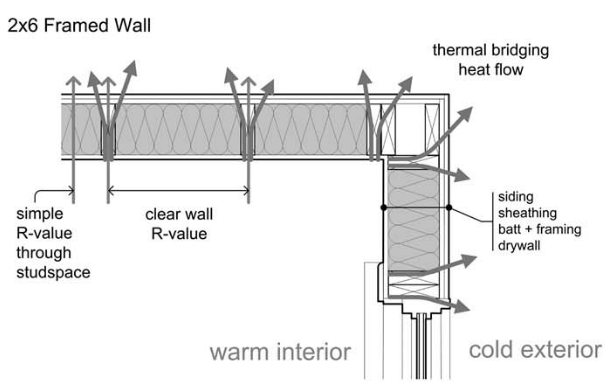
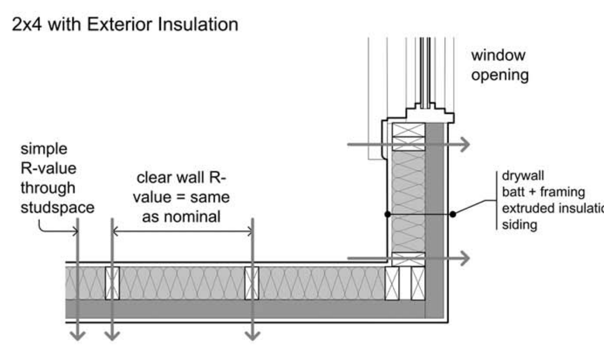
Continuous Insulation and Thermal Bridging

- Reduces effect of thermal bridging through framing
- “A sweater for your building”





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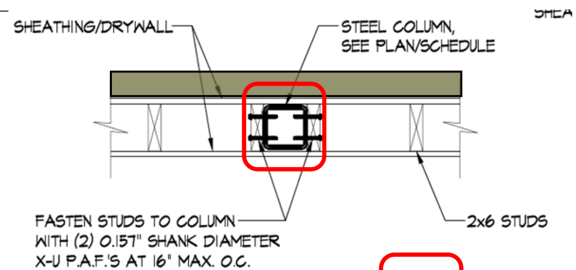
Thermal Bridging Through Framing



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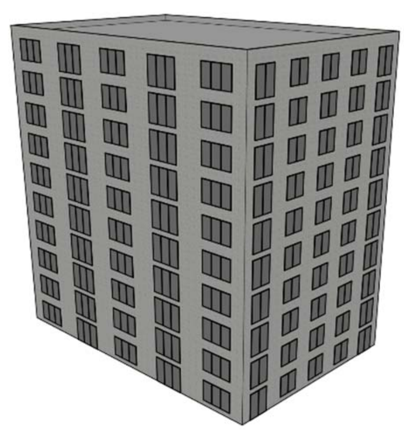
Continuous Insulation and Thermal Bridging

UA Analysis Worksheet

Building Info				
Length	150 ft			
Width	100 ft			
Height	150 ft			
Number of stories	10			
Number of windows	200			
Window height	10 ft			
Window to Wall Ratio	45%			
Building perimeter	500 ft			
Window perimeter	10750 ft			
Roof Area	15000 ft2			
Wall Area	41250 ft2			
Window Area	33750 ft2			
Total Area	90000 ft2			
	R-Value	U-Value	UA	% of total
Roof	40	0.025	375	2%
Wall	8	0.125	5156	33%
Window	3.3	0.300	10125	65%
Total UA			15656	
Total equivalent R-Value			**5.7**	

Step	R-Value
Base building	11.2
Double glazed	7.2
Derated wall	5.7



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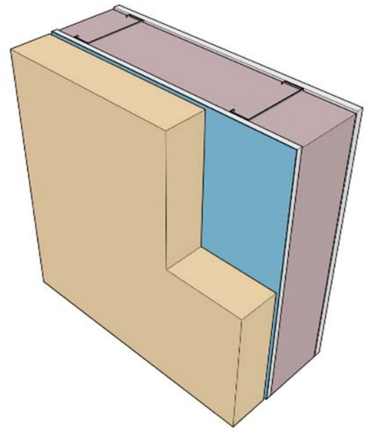
Continuous Insulation and Thermal Bridging

UA Analysis Worksheet

Building Info					
Length	150	ft			
Width	100	ft			
Height	150	ft			
Number of stories	10				
Number of windows	200				
Window height	10	ft			
Window to Wall Ratio	45%				
Building perimeter	500	ft			
Window perimeter	10750	ft			
Roof Area	15000	ft2			
Wall Area	41250	ft2			
Window Area	33750	ft2			
Total Area	90000	ft2			
	R-Value		U-Value	UA	% of total
Roof	40		0.025	375	3%
Wall	24		0.042	1719	14%
Window	3.3		0.300	10125	83%
Total UA				12219	
Total equivalent R-Value				**7.4**	

Step	R-Value
Base building	11.2
Double glazed	7.2
Derated wall	5.7
Exterior Insulation	7.4



Continuous Insulation and Thermal Bridging

Wall insulation derating per C402.7 Derating and Thermal Bridges

	R-Value	U-Value
Base Wall	24	0.042

(Equation C402.7.2.1)

$R_{derated} = R_o$ x Derating Factor

Where

$R_{derated}$: R value after derating, to be used when showing compliance R402.7.2
R_o: R value of the continuous insulation prior to derating
Derating Factor: Derating factor From C402.7.2.1.1, C402.7.2.1.2, or C402.7.2.1.3

	Derating Factor	R derated	U derated
Cladding Bad	0.382	9.2	0.109
Cladding Good	0.8	19.2	0.052
Brick	0.7	16.8	0.060

C402.7.2.1.1 Brick Veneer Systems. Wall systems comprised of brick veneer anchored to the building with fasteners shall use a Derating Factor of 0.7 to account for the *clear field thermal bridge* derating effect of the fasteners. In addition, brick shelf angles shall be derated according to Section C402.7.3 to account for the *linear thermal bridge* derating effect of any brick shelf angles.

C402.7.2.1.2 Cladding Systems. Wall systems comprised of cladding systems shall use a derating factor per Table 402.7.2.1.2

Table 402.7.2.1.2 Cladding System Derating Factors

Thickness of R_o	Derating Factor
R_o is less than or equal to R-15	Derating Factor = 0.74 – 0.021 x R_o
R_o is greater than R-15	Derating Factor = 0.55 – 0.007 x R_o

C402.7.2.1.3 Cladding Systems with Qualifying Thermal Breaks. If plastic or fiberglass fasteners entirely comprised of material having thermal conductivity of 3 Btu-in/hr-ft2-F or less are used to support external cladding; or, if fasteners having thermal breaks which have a conductivity of 3 Btu-in/hr-ft2-F or less on both ends of the fastener are used to support external cladding, use Derating Factor of 0.8.

Continuous Insulation and Thermal Bridging

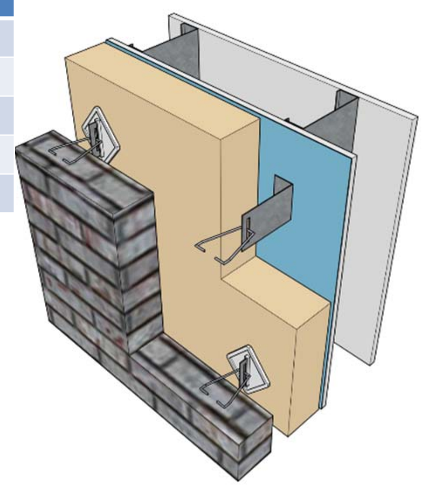
UA Analysis Worksheet

Building Info		
Length	**150**	ft
Width	**100**	ft
Height	**150**	ft
Number of stories	**10**	
Number of windows	**200**	
Window height	**10**	ft
Window to Wall Ratio	**45%**	
Building perimeter	500	ft
Window perimeter	10750	ft
Roof Area	15000	ft2
Wall Area	41250	ft2
Window Area	33750	ft2
Total Area	90000	ft2

	R-Value	U-Value	UA	% of total
Roof	~~40~~	0.025	375	3%
Wall	**16.8**	0.060	2455	19%
Window	~~3.3~~	**0.300**	10125	78%
Total UA			12955	

Total equivalent R-Value **6.9**

Step	R-Value
Base building	11.2
Double glazed	7.2
Derated wall	5.7
Exterior Insulation	7.4
Brick ties	6.9



Continuous Insulation and Thermal Bridging

C402.7.2.1.1 Brick Veneer Systems. Wall systems comprised of brick veneer anchored to the building with fasteners shall use a Derating Factor of 0.7 to account for the *clear field thermal bridge* derating effect of the fasteners. In addition, brick shelf angles shall be derated according to Section C402.7.3 to account for the *linear thermal bridge* derating effect of any brick shelf angles.

C402.7.3.1 Prescriptive PSI Values. Use PSI values from Table C402.7.3.1

Table C402.7.3.1 Linear Thermal Bridge Prescriptive PSI values.

Type of Linear Thermal Bridge	PSI-value (Btu/hr - ft – F)
Balcony to exterior vertical wall intersection	1.00
Intermediate floor to exterior vertical wall intersection	0.60
Interior vertical wall to exterior vertical wall intersection	0.50
Fenestration to exterior vertical wall intersection	0.32
Parapet (vertical wall to roof intersection)	0.60
Brick shelf angle	0.35
Vertical wall to grade intersection	0.52
Vertical wall plane transition (building corners and other changes in vertical wall plane)	0.25

(Equation C402.7.3)

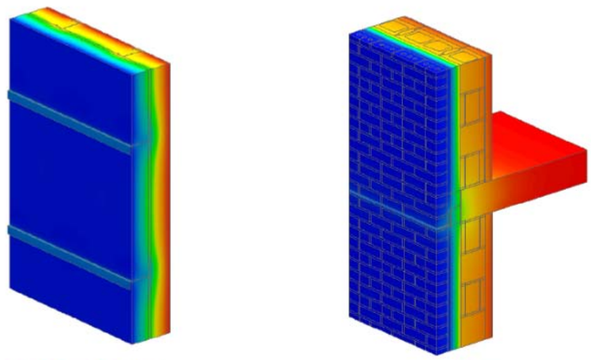
$$U_{derated} = \frac{PSI * Length}{A_{total}} + U_o$$

Where

- $U_{derated}$ Derated wall U value (Btu/hr-ft^2-F)
- PSI Value from Section C402.7.3.1, C402.7.3.2, or C402.7.3.3 (Btu/hr-ft-F)
- Length Length of linear *thermal bridge* (ft)
- A_{total} Area of derated wall (ft^2)
- U_o Wall or roof U value prior to *linear thermal bridge* derating

1. Derate the clear wall
2. Calculate the impact of the linear element (shelf angle)
3. Add it to the clear wall for the new effective U-Value

Psi (Linear) and Chi (Point) Thermal Bridges



Morrison Hershfield

Continuous Insulation and Thermal Bridging

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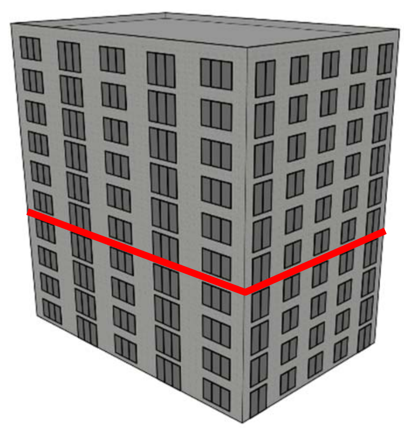
Width	100	ft		
Height	150	ft		
Number of stories	10			
Number of windows	200			
Window height	10	ft		
Window to Wall Ratio	45%			
Building perimeter	500	ft		
Window perimeter	10750	ft		
Roof Area	15000	ft2		
Wall Area	41250	ft2		
Window Area	33750	ft2		
Total Area	90000	ft2		
	R-Value	U-Value	UA	% of total
Roof	40	0.025	375	3%
Wall	9.8	0.102	4209	29%
Window	3.3	0.300	10125	69%
Total UA			14709	
Total equivalent R-Value			**6.1**	

Step	R-Value
Base building	11.2
Brick ties	6.9
Shelf angle	6.1



Continuous Insulation and Thermal Bridging

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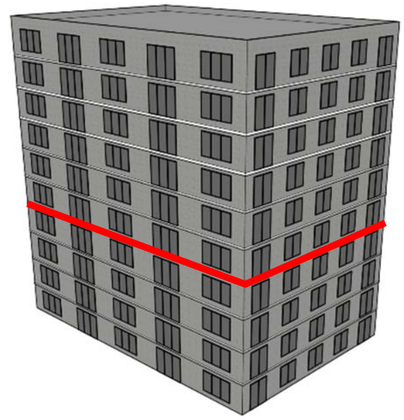
Wall Area	41250	ft2		
Window Area	33750	ft2		
Total Area	90000	ft2		
	R-Value	**U-Value**	**UA**	**% of total**
Roof	**40**	0.025	375	2%
Wall	**7.6**	0.132	5428	34%
Window	3.3	**0.300**	10125	64%
Total UA			15928	
Total equivalent R-Value			**5.7**	

Step	R-Value
Base building	11.2
Brick ties	6.9
Shelf angle	6.1
Slab edge	5.7



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Continuous Insulation and Thermal Bridging

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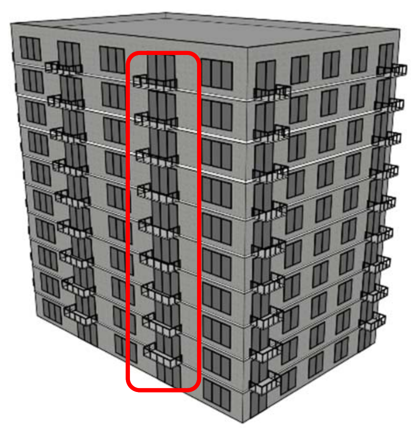
Wall Area	41250	ft2		
Window Area	33750	ft2		
Total Area	90000	ft2		
	R-Value	**U-Value**	**UA**	**% of total**
Roof	**40**	0.025	375	2%
Wall	**6.9**	0.145	5978	36%
Window	3.3	**0.300**	10125	61%
Total UA			16478	
Total equivalent R-Value			**5.5**	

Step	R-Value
Base building	11.2
Brick ties	6.9
Shelf angle	6.1
Slab edge	5.7
Balcony	5.5



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Continuous Insulation and Thermal Bridging

UA Analysis Worksheet

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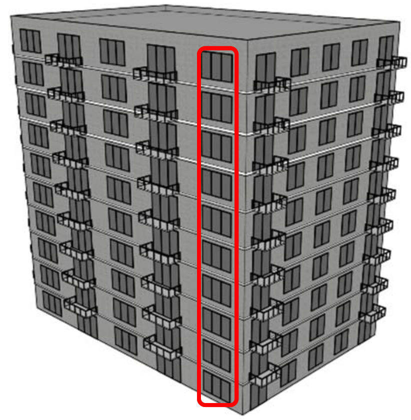
Building perimeter	500	ft		
Window perimeter	10750	ft		
Roof Area	15000	ft2		
Wall Area	41250	ft2		
Window Area	33750	ft2		
Total Area	90000	ft2		
	R-Value	U-Value	UA	% of total
Roof	40	0.025	375	2%
Wall	4.4	0.227	9375	47%
Window	3.3	0.300	10125	51%
Total UA			19875	
Total equivalent R-Value			**4.5**	

Step	R-Value
Base building	11.2
Brick ties	6.9
Shelf angle	6.1
Slab edge	5.7
Balcony	5.5
Window flanking	4.5



Continuous Insulation and Thermal Bridging

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Roof	40	0.025	375	2%
Wall	4.4	0.227	9375	47%
Window	3.3	0.300	10125	51%
Total UA			19875	
Total equivalent R-Value			**4.5**	

Why Continuous Wall Insulation?

Moisture and Condensation Risks

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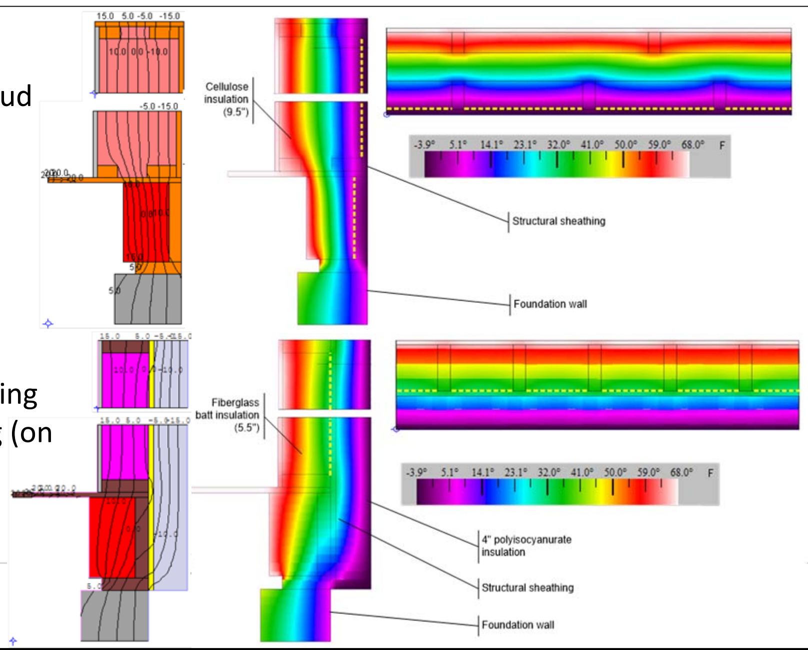
Wall Condensation Potentials

Double stud wall

4” insulating sheathing (on 2x6)



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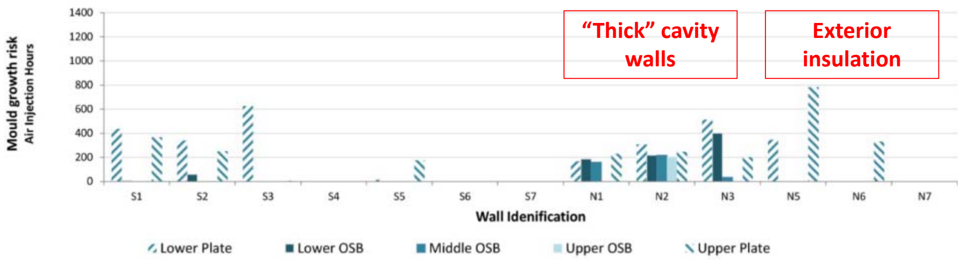
Exterior Continuous Wall Insulation

- Decades of papers: exterior insulation → drier sheathing (warm dry side)
- Fox (2014): high-R walls, air injection & drying
- Vapor-impermeable exterior rigid insulation
  - Cuts off outward drying (impermeable)
  - Reduces interior-sourced condensation risks
  - Worst case: thin vapor-impermeable foam



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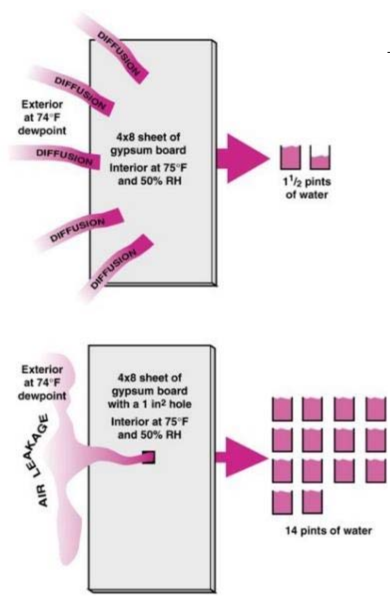
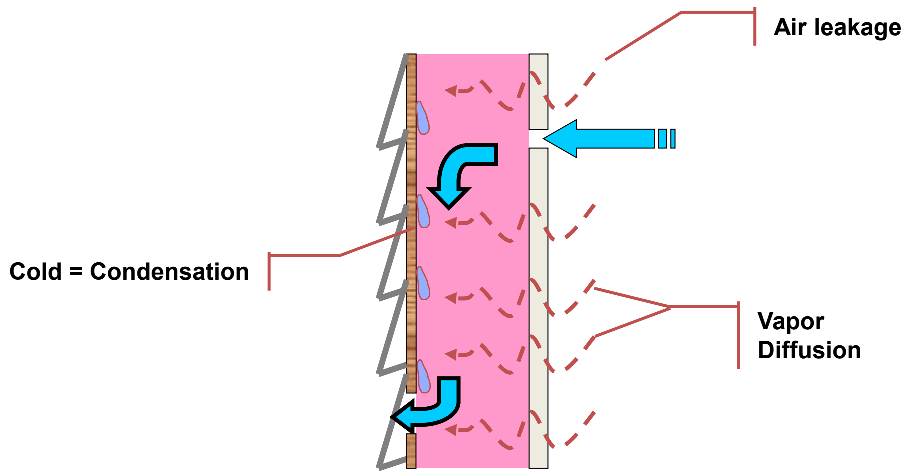
Vapor Diffusion vs. Air Leakage

- Vapor Diffusion
  - more to less vapor
  - no air flow
  - flow through tiny pores
- Air Convection
  - more to less air pressure
  - flow through visible cracks and holes
  - vapor is just along for the ride
- **A "vapor barrier" that doesn't control airflow is pointless**



Wall with Conventional Structural Sheathing



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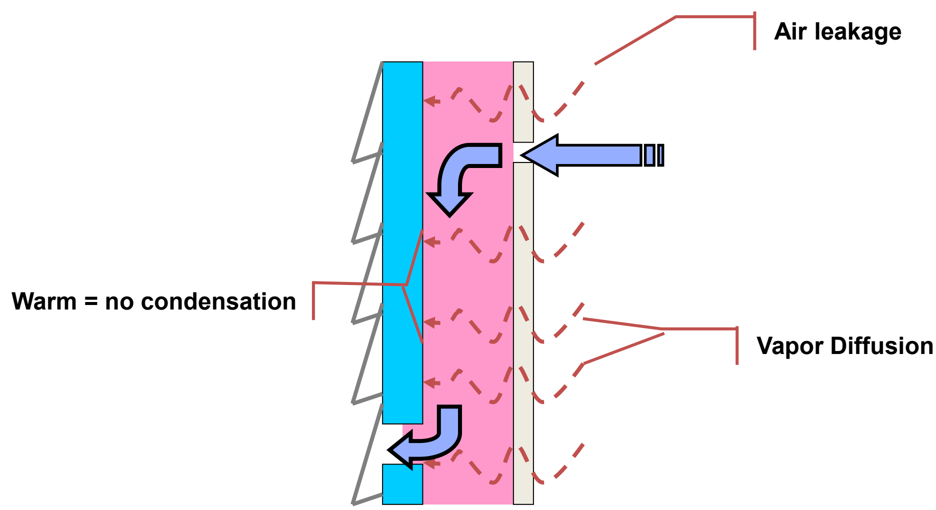
Wall with Insulated Sheathing



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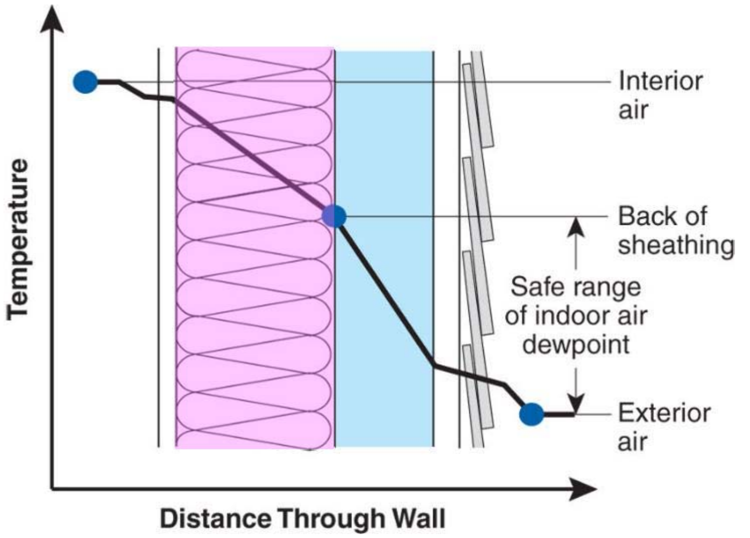
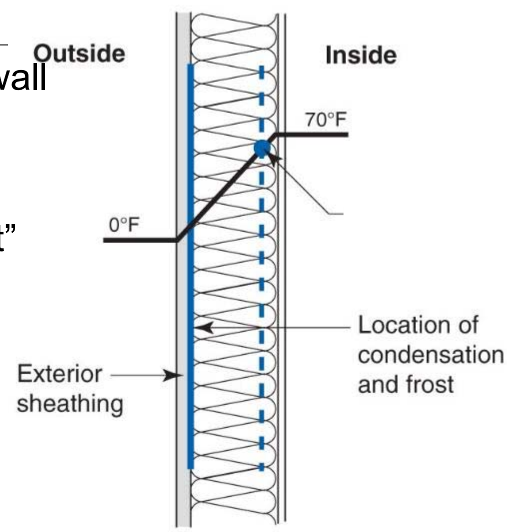
Ratio of Exterior-to-Interior Insulation



"Where's the Dewpoint?"

- "Calculating the dewpoint location" in wall
- Dewpoint = absolute air MC
- Temperature drop through assembly
- "Condensation in the middle of the batt"

- But that's not what happens…



Frosting on Sheathing

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Cladding Support Research

Building America Research Work

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Foam Sheathing Cladding Attachment

250 lbs/113 kg load (7.8 psf): <0.003” deflection

Wood siding ~2 psf
Fiber cement 2-3 psf
Stucco 8-10 psf

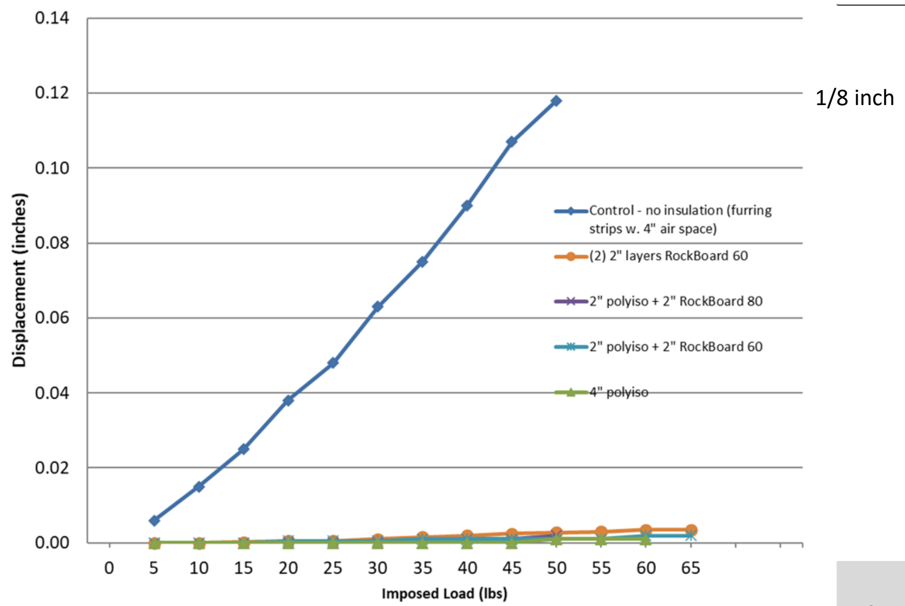
Image c/o Petersen Engineering

Benchtop Testing (Ken Neuhauser)

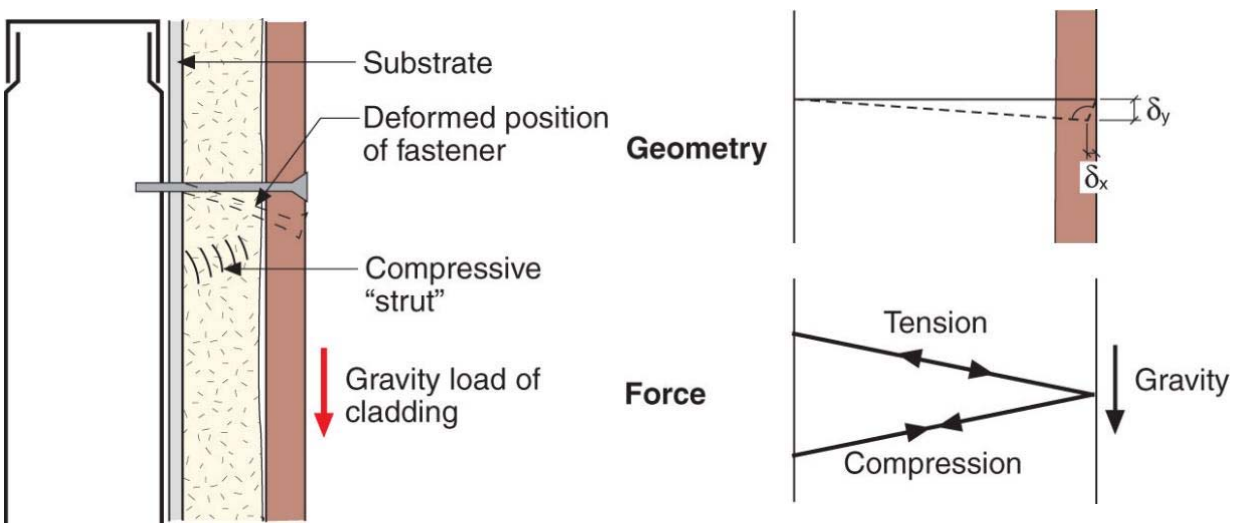
No rigid insulation (control)

Polyisocyanurate insulation

Benchtop Testing (Ken Neuhauser)

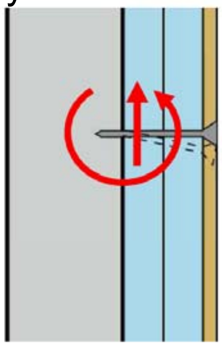


Foam Sheathing Cladding Attachment

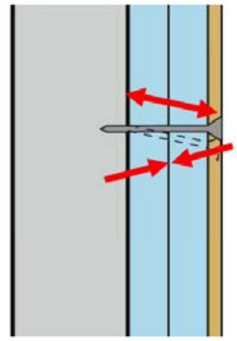


BSC Cladding Attachment Research

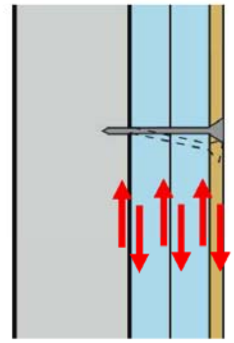
- System Mechanics



Shear and rotational resistance provided by fastener to wood connections



Rotational resistance provided by tension in fastener and compression of the insulation



Vertical movement resistance provided by friction between layers

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Full System Laboratory Tests

- Looked at initial response full system capacity as well as long term sustained loading
- Used full scale samples to limit variations in fastener installation

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Recommendations

- Based on testing, maximum load per fastener 10 lbs. each, for up to 4" of insulation

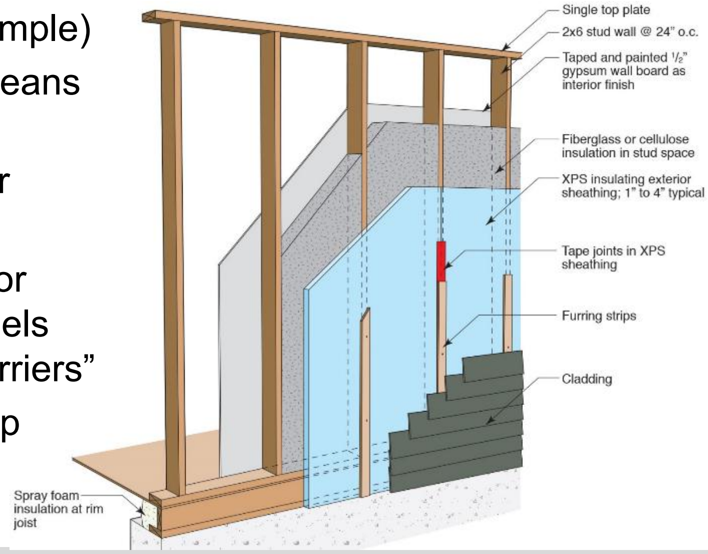
Cladding weight (psf)	16" oc Furring	24" oc Furring
5	18	12
10	9	6
15	6	4
20	4	3
25	3	2

Exterior Continuous Insulation

A Few Examples… and When to Use Them

"Habitat for Humanity Wall"

- No structural sheathing (example)
- Shear developed by other means (diagonal bracing or similar)
- Taped foam surface as water control layer/WRB
- AC71 "Acceptance Criteria for Foam Plastic Sheathing Panels Used As Water-Resistive Barriers"
- 1" foam or thinner → can skip furring strips (per VSI)
  - Habitat does up to 2"



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Direct Nailed Vinyl Siding Retrofit

- Budget approach on triple decker
- 1" polyisocyanurate with taped seams
- Window details- brake formed metal
- Known technique for siding crews

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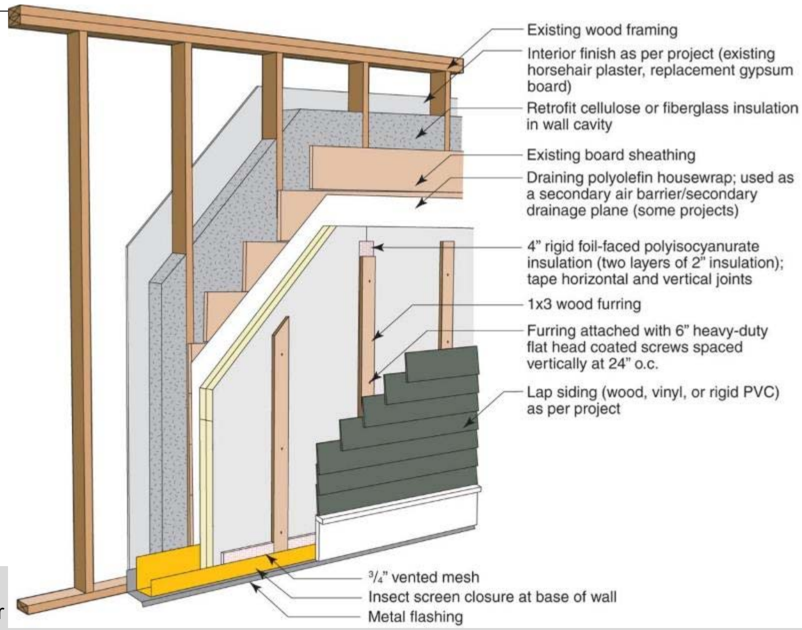
DER Wall: 4" Polyisocyanurate Foam Retrofit

- BSC's typical deep energy retrofit wall
- Housewrap common in early work; adhered membrane better air barrier performance
- Drainage gap between foam and backup wall?
  - **IF** vapor-closed stud insulation & exterior CI, (ccSPF stud bays)



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DER Wall: 4" Polyisocyanurate Foam Retrofit

- Rigid foam is taped before furring goes on
- Hold foam on walls temporarily—long screws + roofing washers

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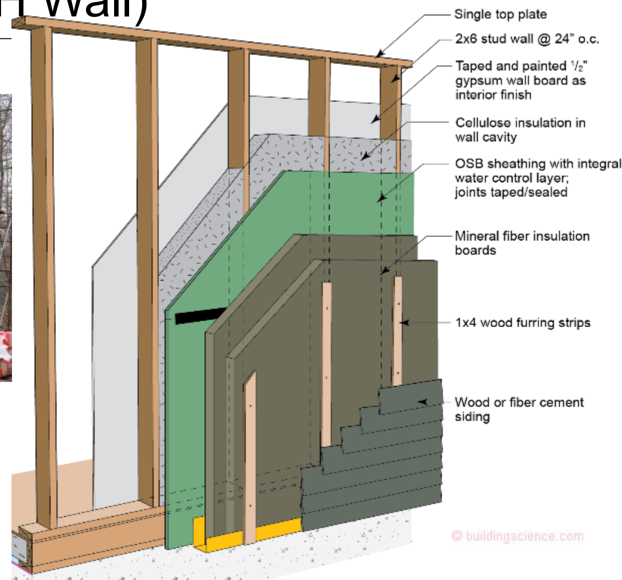
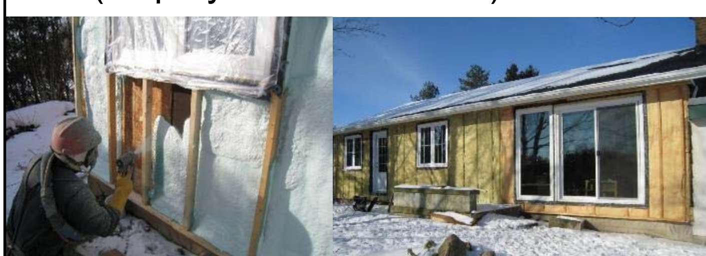
Mineral Fiber Insulation (RPH Wall)

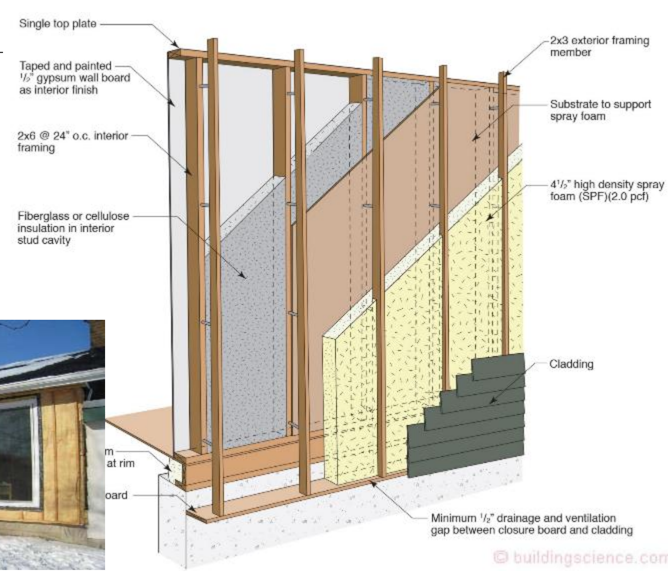


- Needs air-water control behind insulation
- Breathable (vapor open) insulation
- Wood fiber board similar

Exterior Spray Foam Wall

- Air-water-vapor control in a single layer
- Negatives of ccSPF
- Stand-off implementation (stop by InSoFast booth)





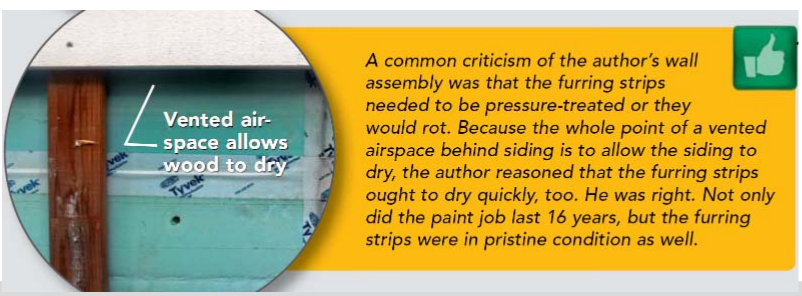
John Straube/RDH Building Science Laboratories

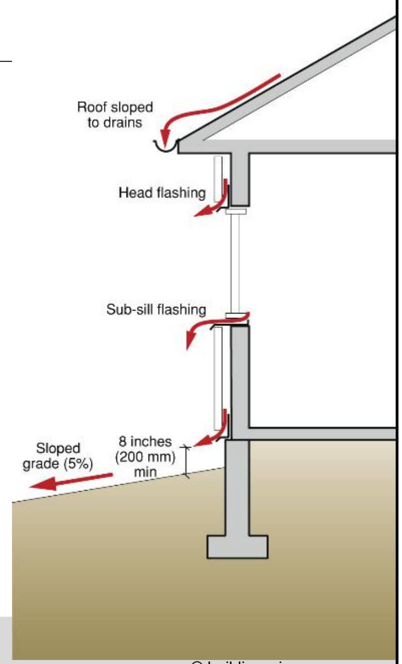
Furring Strips

A Quick Interlude

What do the Furring Strips Do?

- Cladding support
- Drainage space (water down)
- Ventilation space (air up)
- Pressure treated or not?
- Light gauge metal: see CFSEI





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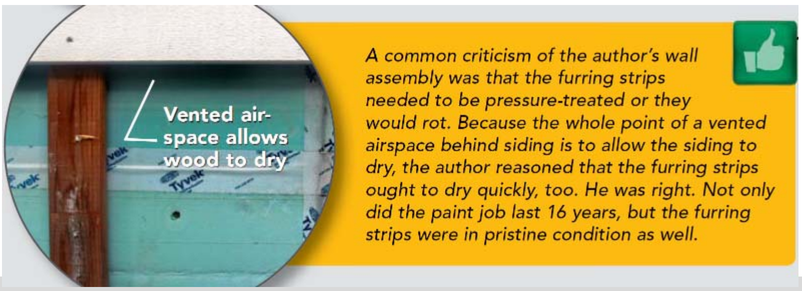
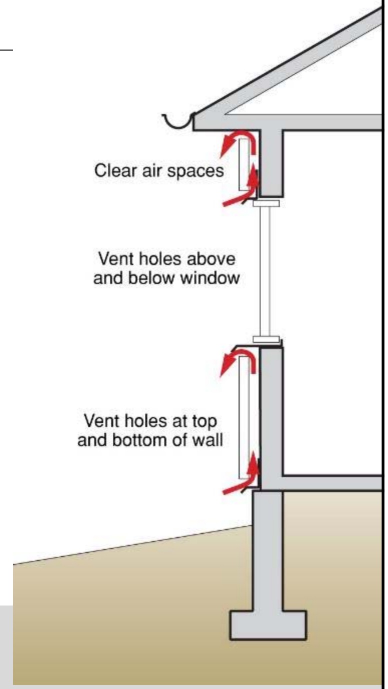
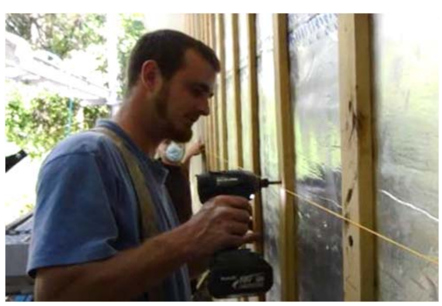




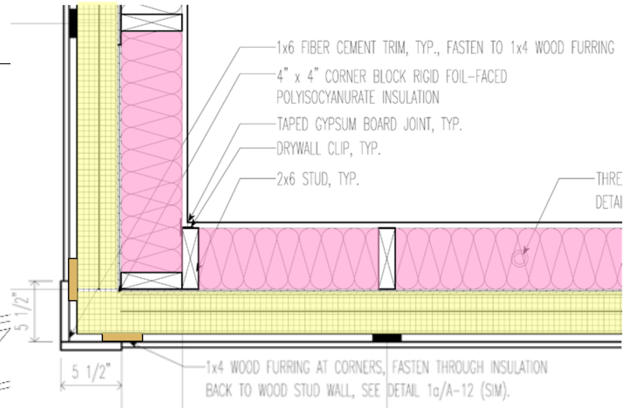
Attaching/Aligning Furring

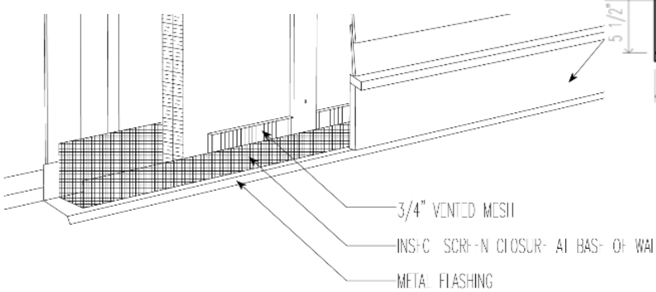
- Long screws (1-¼" embedment)
- Tweaking screws, string lines, shims, straight edges
- Adjustable screws—good but expensive!



Tricky Furring

- Outside corners
- Base of wall
- Horizontal furring?
  - “You done f’d up…”





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Wide Corner & Window/Door Furring

- Much less drying than furring
- Horizontal blocks drainage & ventilation

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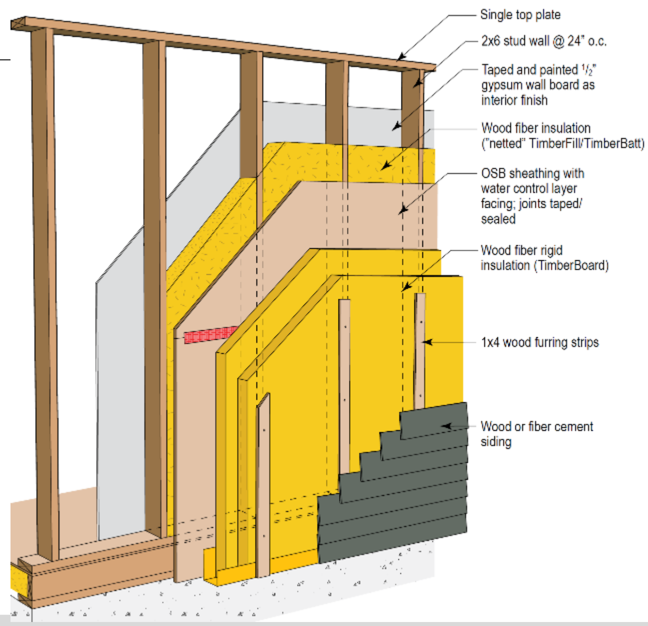
Cladding Choice and Complexity

Easy Mode, Hard Mode, Boss Mode

Horizontal Lap Siding

- "Easy mode"
- Furring strips align with studs
- Vertical drained and ventilated cavities
- Protection detail at base of wall and window heads



Shingles and Vertical Board Siding

- Batten-cross batten approach (vertical then horizontal)
- Close spacing required for shingles
- Vertical siding: wider spacing

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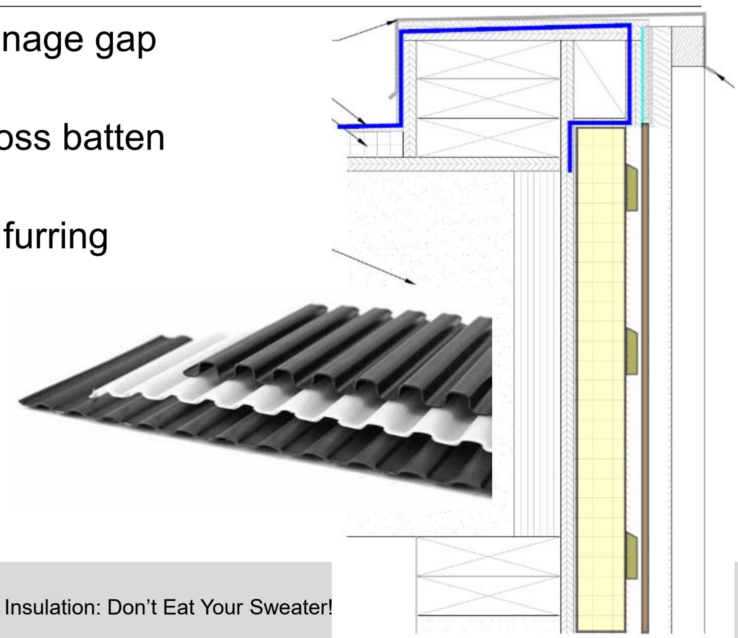
Shingles and Vertical Board Siding

- Horizontal strapping + drainage gap (corrugated lath, spacers)
- Not as robust as batten-cross batten but simpler
- Slope top of horizontal PT furring
- Water tends to stick to backside of cladding (surface tension)



Nail Base + Structural Sheathing

Dumb Mode (sometimes)

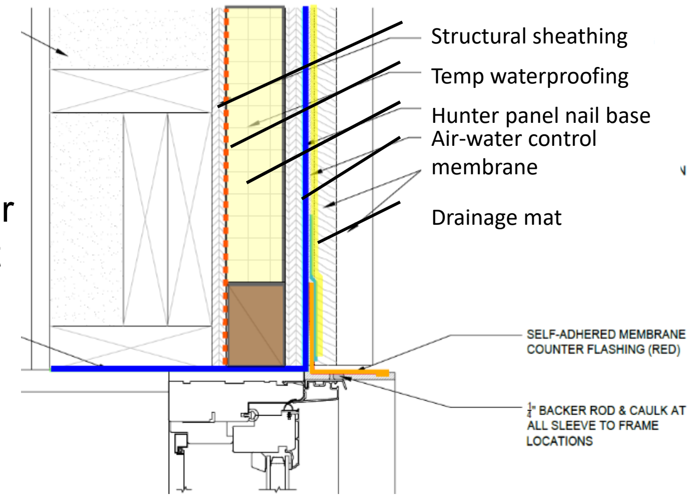
Nailbase Panels as Continuous Insulation

- Insulation inboard of structural sheathing (simpler, not as good)
- Rigid insulation no longer protects wood-based sheathing
- Vapor-closed foam directly behind sheathing
- ZIP-R vs. Hunter Panel Xci Ply, shear strength

Huber ZIP-R Sheathing

Nailbase Panels and Redundant Wall

- Structure/shear strength w. large openings, high winds
- Two layers of sheathing per structural (redundant)
- Temporary waterproofing or air barrier (**ORANGE**): redundant "wrap"?
- Drainage mat (**YELLOW**) required over Hunter Panel to create drained cavity



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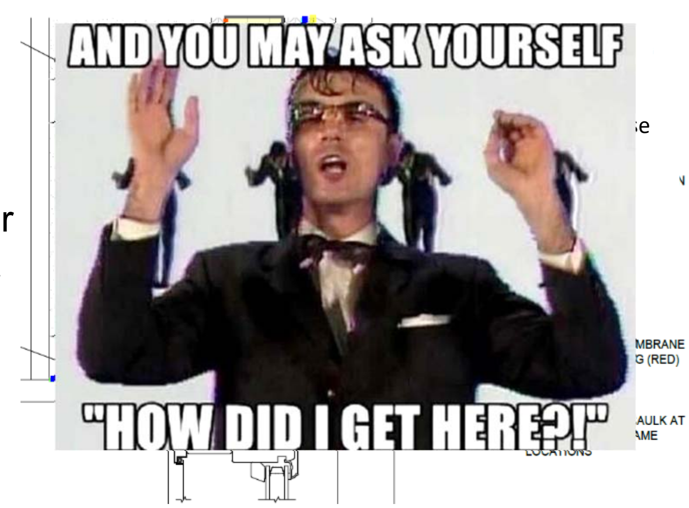
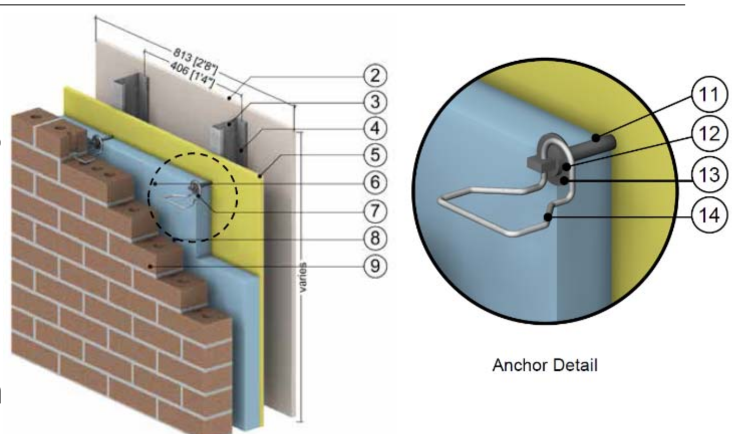


Brick or Stone Masonry with CI

‘Easy mode’… mostly…

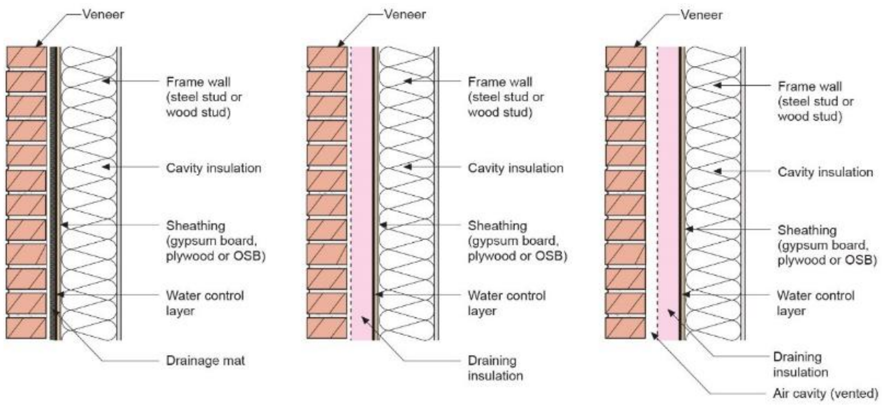
Masonry Veneer w. CI and Thermally Broken Ties

- Typical commercial wall w. off the shelf components,
- Stud frame or block backup
- Ties address wind & seismic, dead load at shelf
- Thermally broken ties compatible with CI
- Difficulty when working with residential contractors/ masons



Morrison-Hershfield 2021

Drainage Mat vs. Ventilated Cavity



- Draining insulation or mat → OK in CZ 4/warmer, or <20” rain

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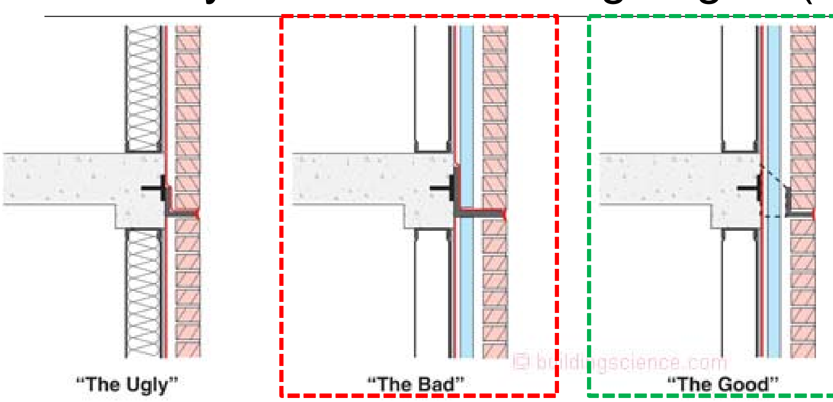
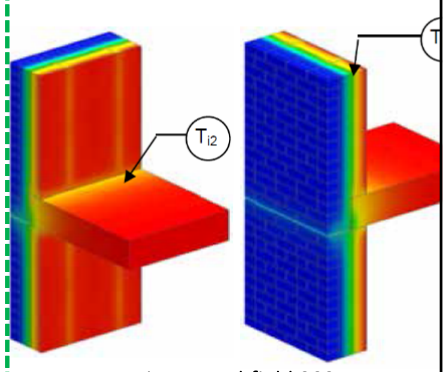
Masonry Veneers Relieving Angles (Support Angles)





Morrison-Hershfield 2021

- The Good, The Bad, The Ugly of brick shelves
- Fabricated or commercially available supports

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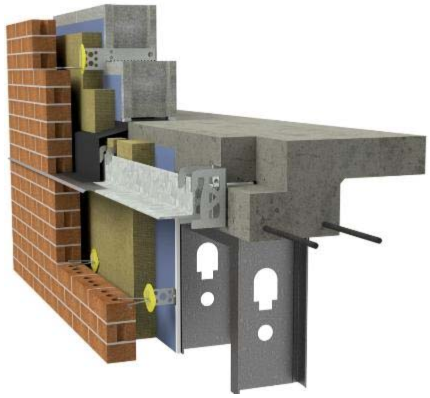
Masonry Veneers Relieving Angles (Support Angles)



FERO Corporation

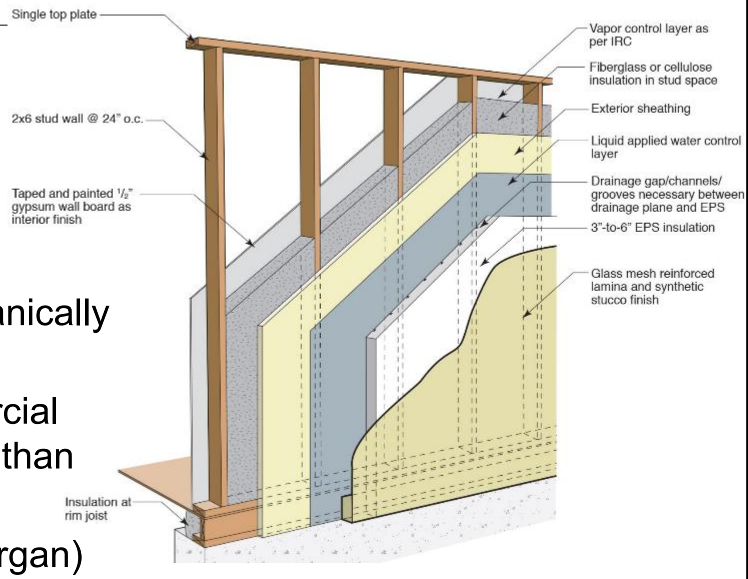
Hohmann & Barnard

Stucco

The Easy Way and the Hard Way

Drained EIFS Wall

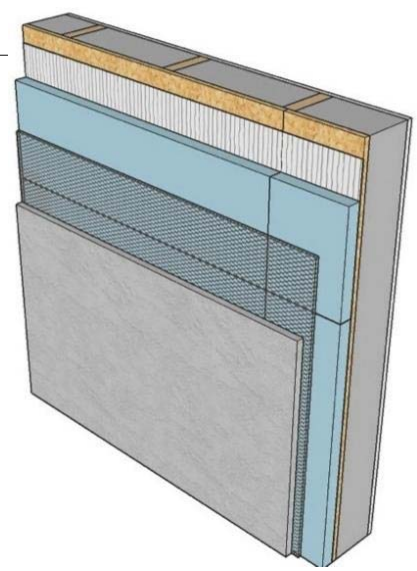
- Not the EIFS of the 1990s!
- Industry standard EPS foam (R-4/inch)
- Mineral fiber option available on market
- Adhered (typical) or mechanically fastened foam
- Potential difficulty: commercial contractors more common than residential
- Drainage behind foam (Horgan)



Stucco and Exterior Insulation

- Difficult: heavy cladding, crack-sensitive
- WRB, CI (taped seams), drainage mat, metal lath, stucco coats
- Fasten lath to backup wall per ASTM C1063, IRC 703.7.1

Journal of Light Construction, 2016



Stucco and Exterior Insulation

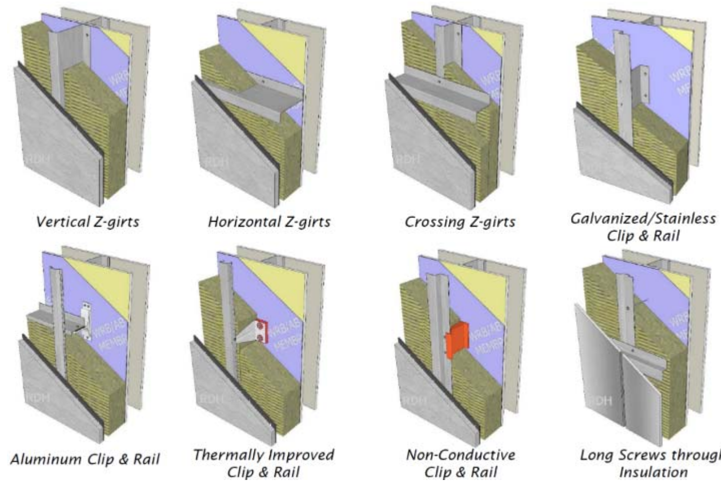
- Cement board-based stucco over Knight Wall metal furring + polyisocyanurate
- NYC job (fire codes/non-combustible)
- Joint cracking problems: thickness & reinforcement of stucco lamina

Commercial Cladding Systems

I Give You Money, You Solve My Problems

Commercial Cladding Systems

- Another solution to "We don't want to screw furring through rigid insulation"
- Use in residential projects
- Directly attaching girt system to backup wall
- Doing this without causing thermal bridging…

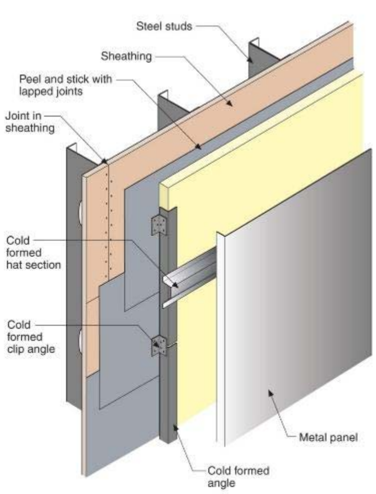


Cladding Attachment Solutions for Exterior-Insulated Commercial Walls (RDH 2017)

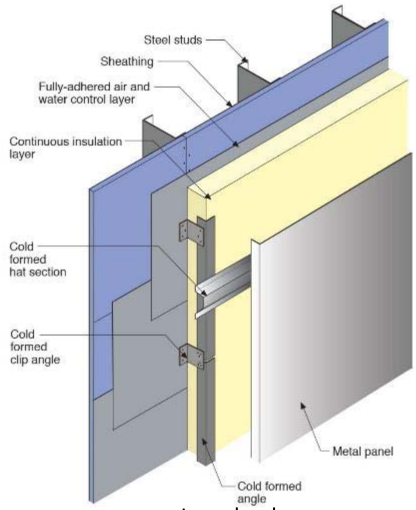
Cladding Support (Z-Furring) Thermal Bridging

- Steel Z-furring 16" o.c.
- All this effort to cover up our thermal bridges with insulation… and then we punch steel through it…

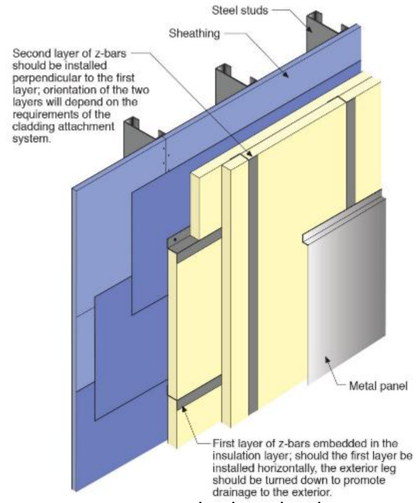
Conductivity of Metal Z Girts



Dumb



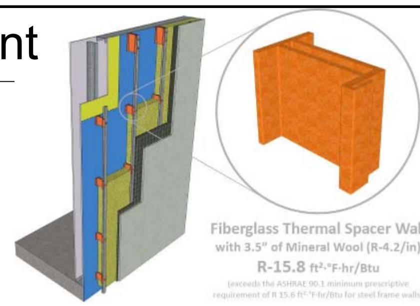
Less dumb



Also less dumb

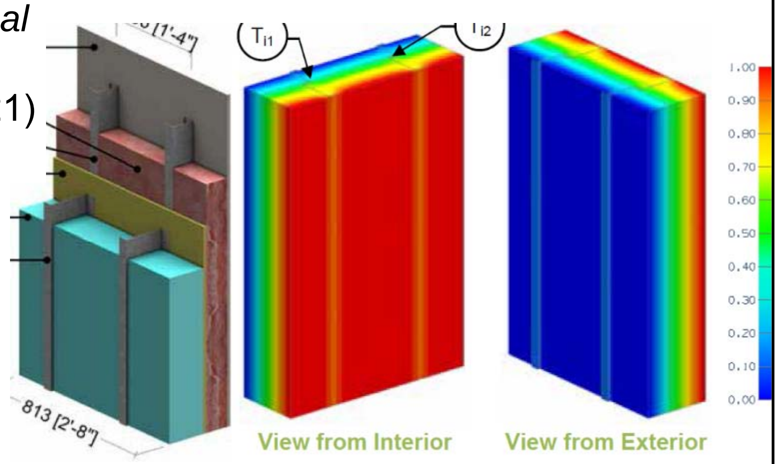
Thermally Broken Cladding Attachment

- Pultruded fiberglass clips
- Clip and rail with thermal break pads
- Non-conductive girt system
- Engineering typically by manufacturer



Thermal Bridging Guide

- *Building Envelope Thermal Bridging Guide* V.1.6 (Morrison Hershfield, 2021)
- Rosetta Stone of thermal bridging, 1400+ pages
- Huge number of conditions/assemblies
- Extrapolate from their thermal simulations



Morrison Hershfield

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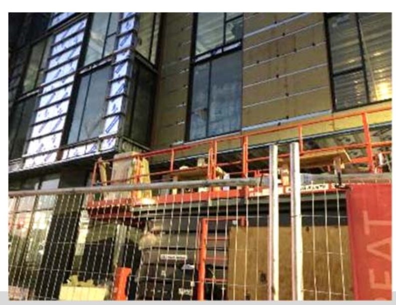
Mineral Fiber-Commercial Jobsites

- Day-to-day installations around Boston
- NFPA 285 (fire) requirements in commercial construction



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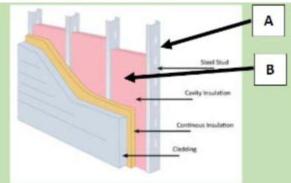
Massachusetts Enforcement

- Envelope Performance and Thermal Bridge Derating
- C402.7 Derating and thermal bridges
- “You can’t get away with the dumb anymore!”
- Annoying bunch of calculations to slog through

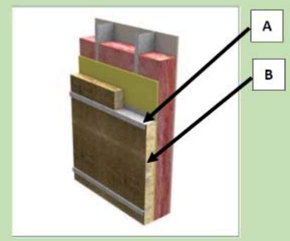
Thermal bridge 1: Cavity insulation between wall framing

Wall framing (A), which can be wood or metal, interrupt the “cavity” insulation on the inboard side of the assembly (B).



Thermal bridge 2: Fasteners which hold exterior wall cladding (paneling/rainscreen) to the framing studs

Fasteners (A) which are used to connect the exterior paneling/rainscreen (not shown) and/or support exterior insulation interrupt the exterior insulation (B)



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Questions?

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Presentation will be available at:
https://buildingscience.com/past-events

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U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Document Resources

- Building Science Digest 011: Thermal Control in Buildings
  https://buildingscience.com/documents/digests/bsd-011-thermal-control-in-buildings
- Building Science Digest 013: Rain Control in Buildings
  https://buildingscience.com/documents/digests/bsd-013-rain-control-in-buildings
- Building Science Digest 146: EIFS - Problems and Solutions
  https://buildingscience.com/documents/digests/bsd-146-eifs-problems-and-solutions
- Building Science Digest 163: Controlling Cold-Weather Condensation Using Insulation
  https://buildingscience.com/documents/digests/bsd-controlling-cold-weather-condensation-using-insulation
- BA-0903: Building America Special Research Project—High-R Walls Case Study Analysis
  https://buildingscience.com/documents/bareports/ba-0903-building-america-special-research-project-high-r-walls/view
- BA-1314: Cladding Attachment Over Thick Exterior Insulating Sheathing
  https://buildingscience.com/documents/bareports/ba-1314-cladding-attachment-over-thick-exterior-sheathing/view
- BA-1404: Initial and Long-Term Movement of Cladding Installed Over Exterior Rigid Insulation
  https://buildingscience.com/documents/bareports/ba-1404-initial-long-term-movement-cladding-installed-over-exterior-rigid-insulation/view
- BA-1406: Final Measure Guideline: Incorporating Thick Layers of Exterior Rigid Insulation on Walls
  https://www.buildingscience.com/documents/bareports/ba-1406-final-measure-guideline-incorporating-thick-layers-exterior-rigid-insulation/view
- GM-1302: Mass Save Deep Energy Retrofit Builder Guide
  https://www.buildingscience.com/documents/guides-and-manuals/gm-mass-save-der-builder-guide/view

Document Resources

- PA-1201: Foam Shrinks, and Other Lessons
  https://buildingscience.com/documents/published-articles/pa-foam-shrinks/view
- DTW: Westford, MA - Habitat for Humanity - House Plan
  https://www.buildingscience.com/documents/houseplans/hp-westford-ma-example/view
- Building Science Insight 005: A Bridge Too Far
  https://www.buildingscience.com/documents/insights/bsi-005-a-bridge-too-far
- Building Science Insight 048: Exterior Spray Foam
  https://buildingscience.com/documents/insights/bsi-048-exterior-spray-foam
- Building Science Insight 049: Confusion About Diffusion
  https://buildingscience.com/documents/insights/bsi-049-confusion-about-diffusion
- Building Science Insight 062: Thermal Bridges Redux
  https://www.buildingscience.com/documents/insights/bsi062-thermal-bridges-redux
- Building Science Insight 068: Rocks Don't Burn
  https://buildingscience.com/documents/insights/bsi068_rocks_dont_burn
- Building Science Insight 085: Windows Can Be A Pain*—Continuous Insulation and Punched Openings
  https://buildingscience.com/documents/insights/bsi-085-windows-can-be-a-pain
- Building Science Insight 086: Vitruvius Does Veneers: Drilling Into Cavities
  https://buildingscience.com/documents/insights/bsi086-vitruvius-does-veeners

Document Resources

- Building Science Insight 096: Hot and Wet but Dry
  https://www.buildingscience.com/documents/building-science-insights-newsletters/bsi-096-hot-and-wet-dry
- Building Science Insight 104: Punched Openings
  https://buildingscience.com/documents/building-science-insights-newsletters/bsi-104-punched-openings
- Building Science Insight 132: More on Continuous Exterior Insulation…
  https://buildingscience.com/documents/building-science-insights/bsi-132-more-continuous-exterior-insulation%25E2%2580%25A6
- Building Science Insight 134: High Performance Frame Walls "Hot-rod walls“
  https://buildingscience.com/documents/building-science-insights/bsi-134-high-performance-frame-walls-hot-rod-walls
- Building Science Insight 149: Slide Rules, Pocket Protectors, Cigarettes and an Iconic Building Science Image
  https://buildingscience.com/documents/building-science-insights/bsi-149-slide-rules-pocket-protectors-cigarettes-and-iconic

Document Resources

- Masonry SYSTEMS Guide (RDH)
  http://www.masonrysystemsguide.com/
- Residential Facade Retrofits Modeling: Results and Documentation (NREL)
  https://www.nrel.gov/docs/fy24osti/84930.pdf
- Installing Closed-Cell Spray Foam Between Studs is a Waste
  https://www.greenbuildingadvisor.com/article/installing-closed-cell-spray-foam-between-studs-is-a-waste
- Prepping a Vented Rainscreen for Siding
  https://www.youtube.com/watch?v=UgxgP_cRuwI&ab_channel=ProTradeCraft
- Small-Town Woodframe Retrofit Transforms Into A High-Performance Co-Working Space
  https://foursevenfive.com/blog/from-post-office-to-postcarbon-future-with-emerald-builders/
- The Guide to Cladding Attachment Solutions for Exterior-Insulated Commercial Walls
  https://www.rdh.com/blog/guide-cladding-attachment-solutions-for-exterior-insulated-commercial-walls/
- Building Envelope Thermal Bridging Guide V.1.6 (Morrison Hershfield, 2021)
  https://www.bchousing.org/publications/Building-Envelope-Thermal-Bridging-Guide-v1.6.pdf
- Three Ways to Install Drainable EIFS Wrong (and One Way to Make It Work)
  https://www.jlconline.com/how-to/exteriors/three-ways-to-install-drainable-eifs-wrong-and-one-way-to-make-itwork_
- Thin-Stone Veneer Over Rigid Foam: Installing real stone over continuous exterior insulation
  https://www.jlconline.com/how-to/exteriors/thin-stone-veneer-over-rigid-foam_o