

Deep Dive into Construction Methods & High-Performance Products and Details

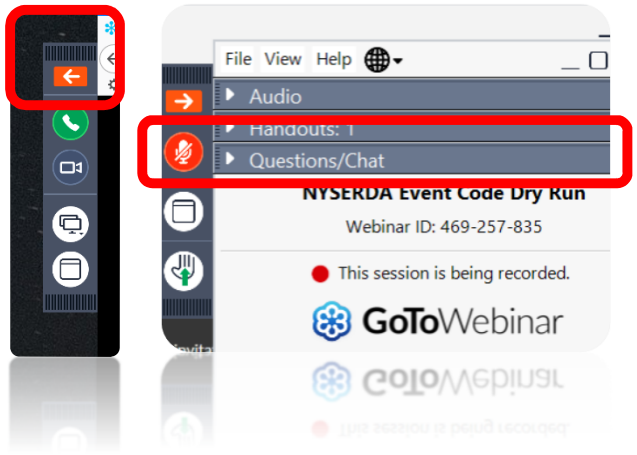
Webinar Overview

All attendees have been placed on mute.

Use the Question Section on the webinar control panel to ask a question at anytime during the presentation.

Q&A will take place at the end of the presentation.

Webinar will be recorded and sent.



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Learning Objectives



Understand the importance of thermal and moisture control in high performance buildings

List 3 different types of high performance cladding attachments

Identify critical architectural details to scrutinize during design and construction

Explain why quality assurance processes throughout construction are important

Overview of Presentation

15 min break
~10:30 AM

1. Heat & Moisture Transfer
2. Condensation Control
3. Vapor Retarders
4. Moisture & Air Flow in Buildings
5. Air Sealing

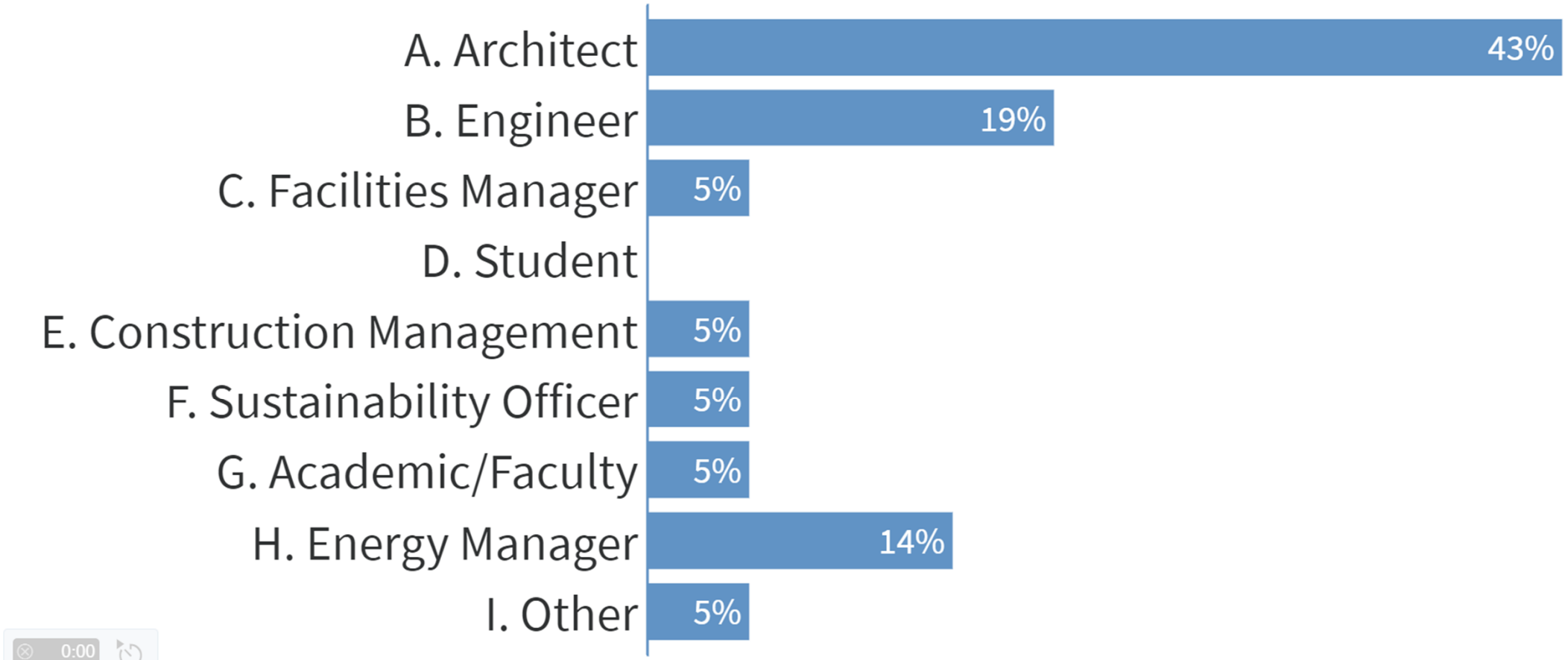
30 min break
~12:30 PM

6. Thermal Insulation
7. Innovative Materials & High Performance Assemblies
8. Thermal Bridges
9. Alternate Assemblies
10. Retrofit Solutions

15 min break
~3:00 PM

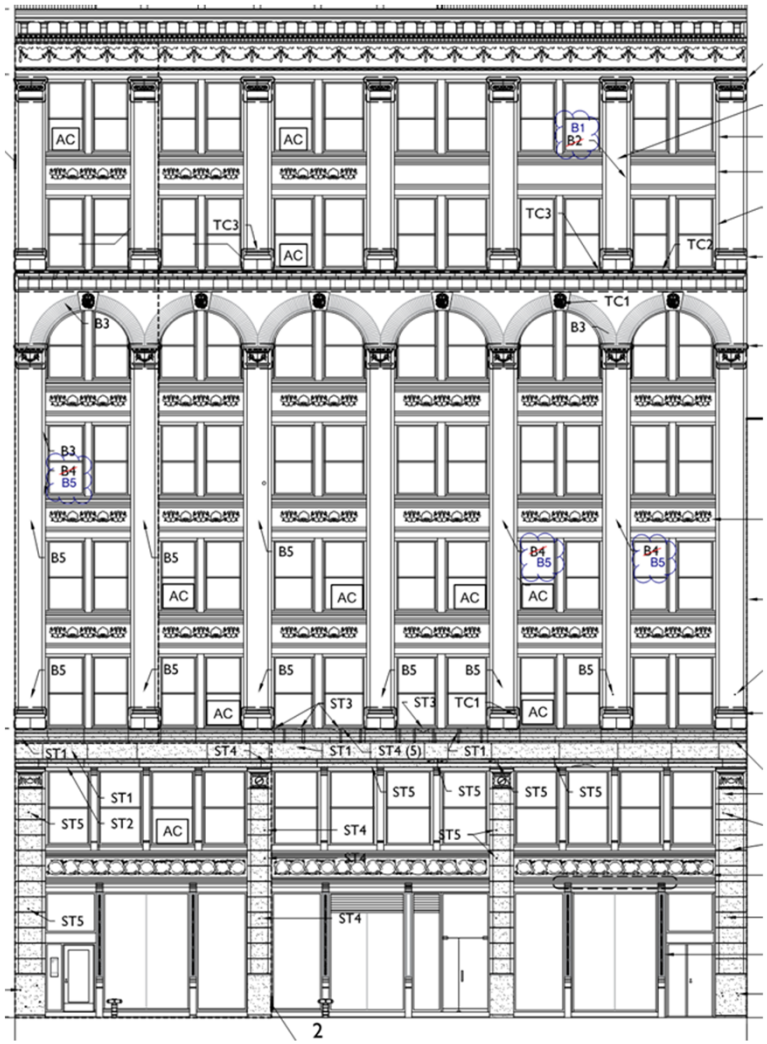
11. Windows & Doors
12. Construction Phase
13. Case Studies
14. Testing

What is your profession?



What is the one thing you were hoping to learn about today?



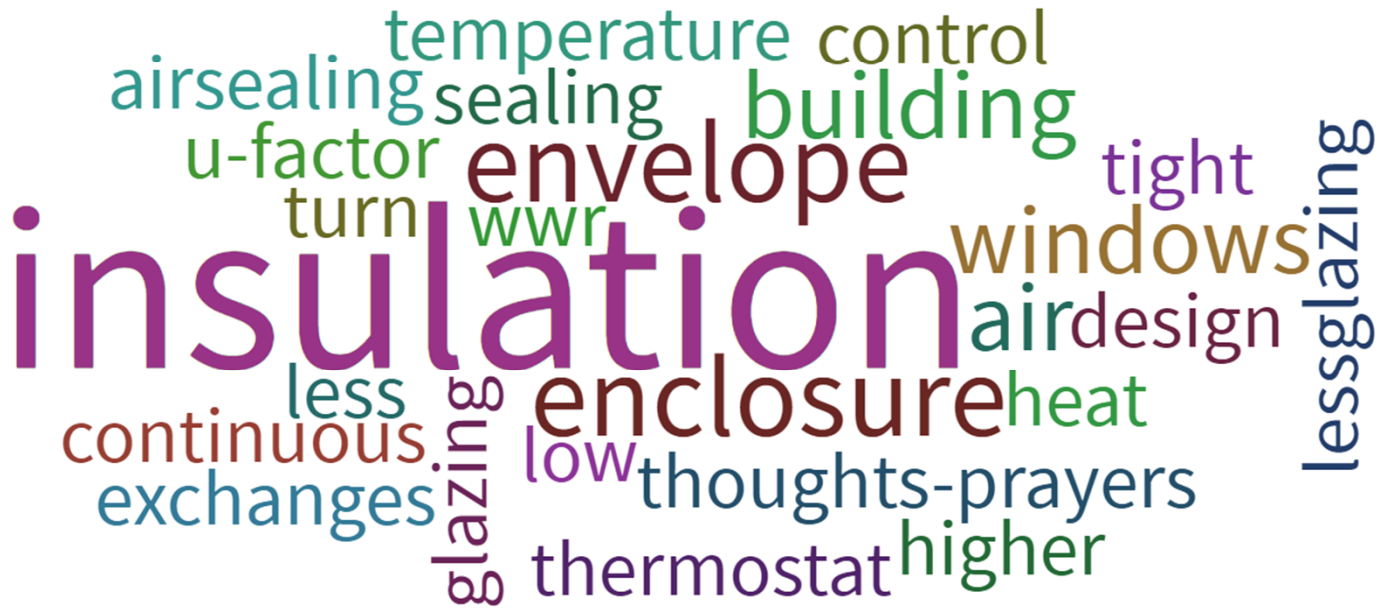


Building Enclosure Elements

- Thermal Control
  - Continuous Insulation / Thermal bridge mitigation
- Air Barrier / Pressure Boundary
- Drainage Plane
  - A predicable path for shedding water
- Water Resistive Barrier
- Vapor Control Layer
- Cladding and Attachments
- Fenestration Systems

Methods of Heat Transfer

In cold winter New Paltz, how do we ensure buildings keep warmth?



Heat Transfer

- Heat is a form of energy
- When heat moves from place to place, it is referred to as “Heat Transfer”
- Heat Transfer occurs in three ways:





Heat Transfer

- Conduction
  - Occurs when heat energy moves through a solid or fluid material
  - Energy is transferred from one molecule to the next
  - What are some examples of conduction?



Heat Transfer

- Radiation
  - Heat that passes spontaneously from a warm body to a cold body
  - The bodies must be in sight of each other but not in contact
  - Radiation does not require a “medium” to carry the heat
  - Give some examples of radiant heat transfer



Heat Transfer

- Convection
  - Convection occurs when heat is carried from one place to another
  - Convection requires a “fluid medium” (i.e. a gas or liquid) in which the thermal disparately creates bouyancy

What device, common in older buildings, utilizes the three energy transfer mechanisms described?



Example: Convection

- Convection in buildings usually occurs when air in the inside migrates due to temperature gradients.
- Warm air is lighter (i.e. less dense) than cold air
- Cold air falls, warm air rises

Convective Loops

- When convection occurs in an enclosed space, the air (or fluid) will circulate around the space as it is heated and cooled, this is referred to as a convective loop
- What are some examples of places where convective loops could be found?



Thermal Boundary

- Location of insulation in the building shell
- Type of insulation
- Amount of insulation (thickness and area)
- Quality of installation (good, fair, poor)
- Is insulation protected from wind-washing?
- Is insulation protected from moisture?

Moisture Transfer

Some Basic Physics:

1ST LAW OF THERMODYNAMICS:

ENERGY CANNOT BE CREATED OR DESTROYED

Some Basic Physics:

2ND LAW OF THERMODYNAMICS:

THE TOTAL ENTROPY OF AN ISOLATED SYSTEM CAN ONLY INCREASE OVER TIME

The introduction of thermal insulation into an assembly has the effect of slowing the increase of entropy.



Why do we care about the 2nd law?

- It applies to:
  - How air moves
  - How heat is transferred
  - How moisture migrates
  - The rate at which drying occurs

WHAT?

What we need to know about the 2nd law

- Heat moves to cold
- Air moves from high pressure to low pressure
- Moisture moves from higher to lower concentrations.

What are some consequences of poor moisture mitigation?



Beware the Unintended Consequences

Blocking the flow of **thermal energy** has consequences; some good, and some bad.

Drying requires energy, so blocking the flow of thermal energy also reduces drying potential

Understand the mechanisms or wetting and drying. Begin with a review of **moisture management** and **air-barrier completeness**, and resolve any specific issues.

Water is the enemy!



Moisture Management

- Bulk Moisture Control
- Moisture Vapor Control
- Relative Humidity and Condensation
- Vapor Retarders: What, Where, Why
- Air-barriers, infiltration, & moisture transport

Building Enclosure Attributes

Thermal Insulation	Air Barrier	Water Resistive Barrier	Drainage Plane	Vapor Retarder
Slows the transfer of thermal energy (heat)	Slows the movement of air through an assembly	Part of the assembly that protects the enclosure from water penetration	Provides a predicable path for shedding water	Slows the rate of vapor diffusion



Making Decisions

WUFI: Heat and Moisture Transiency

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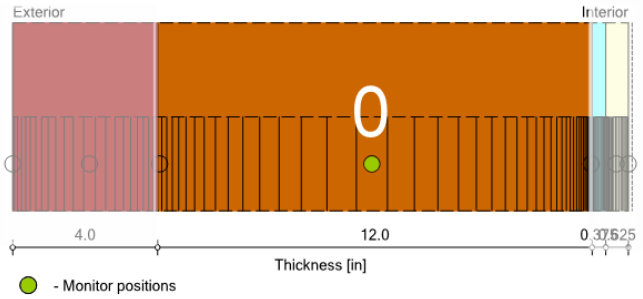
MS - 01

25 WEST 4TH_ Existing exterior wall assembly MS - 01
NO Insulation

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



Materials:

	- *Buff Matt Clay Brick - old	4.0 in
	- Brick (old)	12.0 in
	- Air Layer 10 mm; without additional moisture capacity	0.375 in
	- Interior Plaster (Gypsum Plaster)	0.625 in

Total Thickness: 17.0 in
R-Value: 6.79 h ft² °F/Btu

Temperature/ Relative Humidity @ monitor position (■ temperature/ ■ relative humidity)

the walls has a tendency to drying



Temperature/ Dew-point @ monitor position(■ temperature / ■ dew point)

the dew point temperature remains below the actual temperature in the three year period



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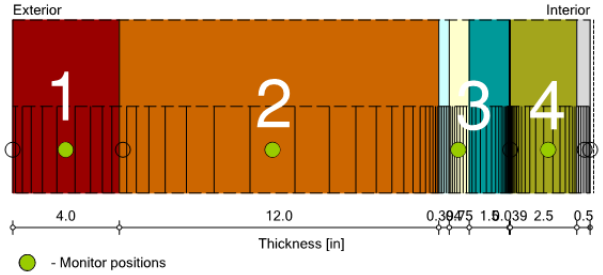
MS-01

25 WEST 4TH_ Exterior wall assembly MS-01 + 1.5" polyiso board + AP foil facer + 2.5" Mwool

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude

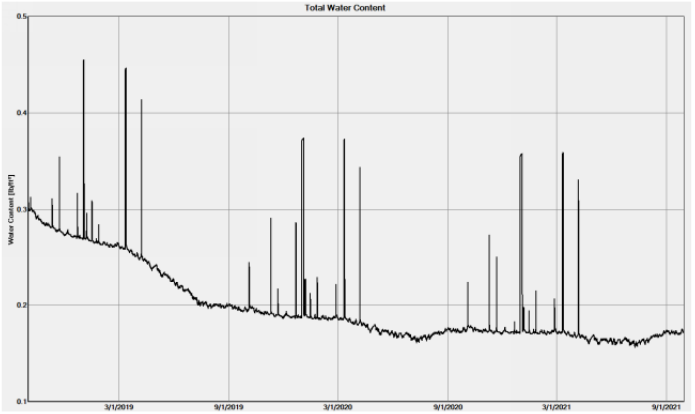


Materials:

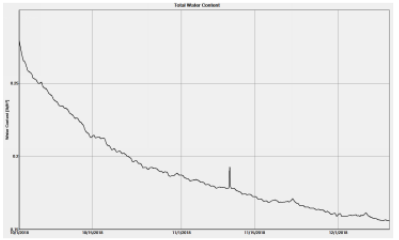
- *Buff Matt Clay Brick - old	4.0 in
- Brick (old)	12.0 in
- Air Layer 10 mm	0.394 in
- Interior Plaster (Gypsum Plaster)	0.75 in
- Polyisocyanurate Insulation	1.5 in
- AP Foil Facer	0.039 in
- Roxul ComfortBatt	2.5 in
- Interior Gypsum Board	0.5 in

Total Thickness: 21.683 in
R-Value: 26.39 h ft² °F/Btu

total water content of the wall assembly with insulation



total water content of the wall assembly NO insulation



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Date 03/18/ 2019

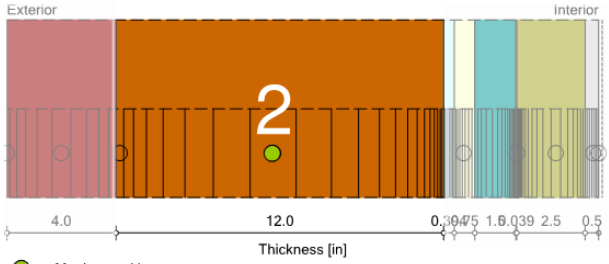
MS - 01

25 WEST 4TH ST _ MS - 01: Center of Back Bricks

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



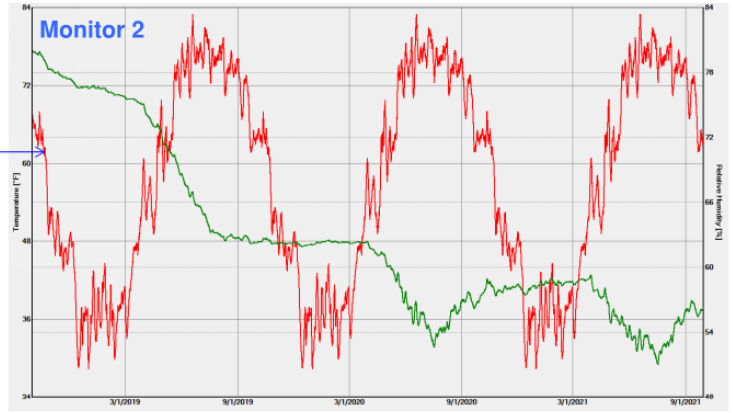
Materials:

- *Buff Matt Clay Brick - old	4.0 in
- Brick (old)	12.0 in
- Air Layer 10 mm	0.394 in
- Interior Plaster (Gypsum Plaster)	0.75 in
- Polyisocyanurate Insulation	1.5 in
- AP Foil Facer	0.039 in
- Roxul ComfortBatt	2.5 in
- Interior Gypsum Board	0.5 in

Total Thickness: 21.683 in
R-Value: 26.39 h ft² °F/Btu

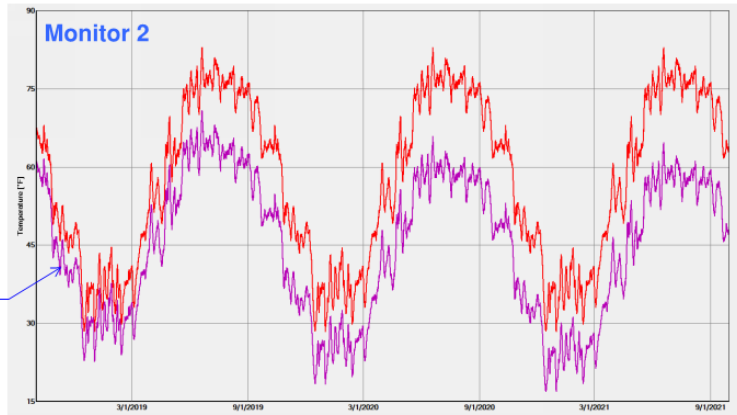
there is a seasonal regular pattern in temperatures repeating throughout the three years modeled/ moisture drops and remains between 49oF and 59oF after the second winter

Temperature/ Relative Humidity @ monitor position (■ temperature/ ■ relative humidity)



the dew point temperature remains bellow the actual temperature in the three year period

Temperature/ Dew-point @ monitor position(■ temperature / ■ dew point)



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Date 03/18/ 2019

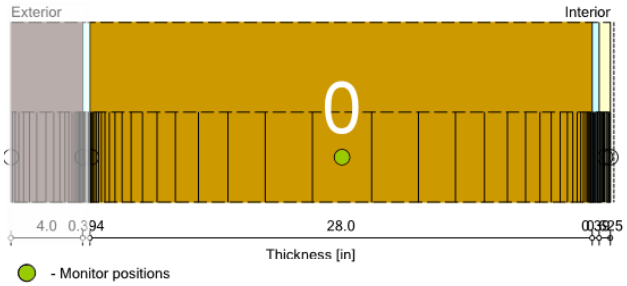
MS-03

25 WEST 4TH_ Existing exterior wall assembly MS - 03 NO Insulation

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



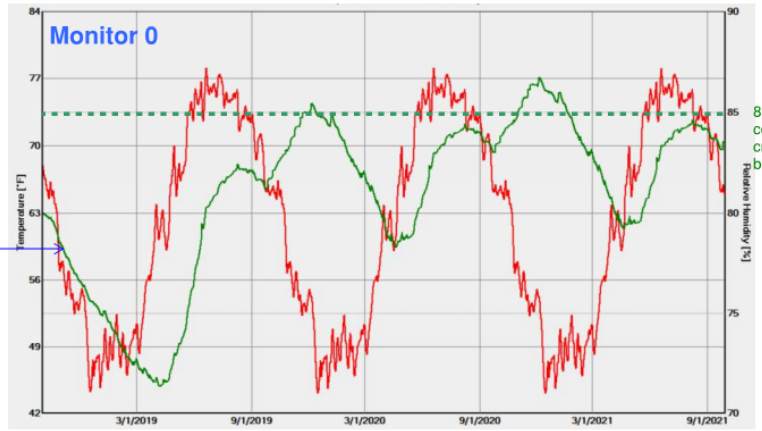
Materials:

- Granite	4.0 in
- Air Layer 10 mm	0.394 in
- Brick (old)	28.0 in
- Air Layer 10 mm	0.39 in
- Interior Plaster (Gypsum Plaster)	0.625 in

Total Thickness: 33.409 in
R-Value: 12.29 h ft² °F/Btu

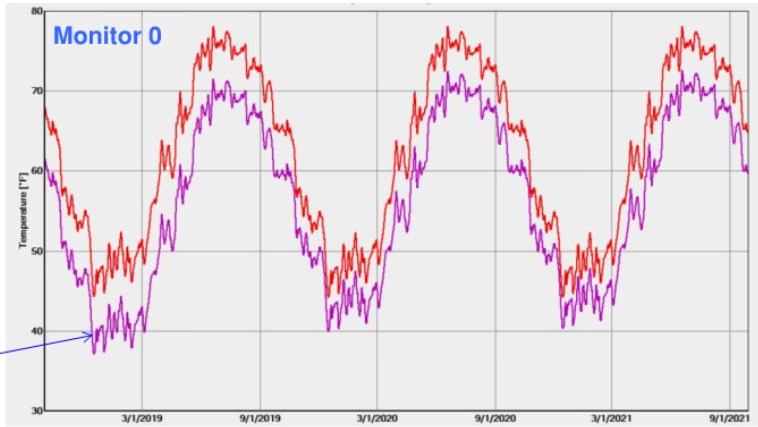
there is a seasonal regular pattern in temperatures repeating throughout the three years modeled/ the model shows a wall will a clear tendency to store water and never dry.

Temperature/ Relative Humidity @ monitor position (■ temperature/ ■ relative humidity)



85% RH could be critical for brick

Temperature/ Dew-point @ monitor position(■ temperature / ■ dew point)



the dew point temperature remains below the actual temperature in the three year period but the wall is not drying out

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Date 03/18/ 2019

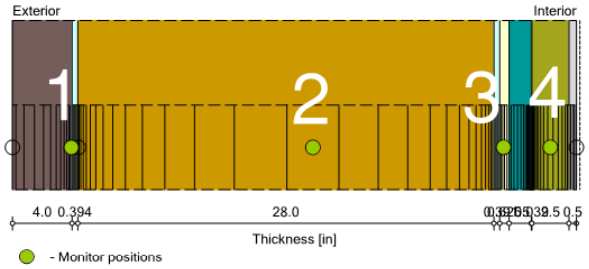
MS-03

25 WEST 4TH_ Exterior wall assembly MS - 03 + 1.5" polyiso board + AP foil facer + 2.5" Mwool

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



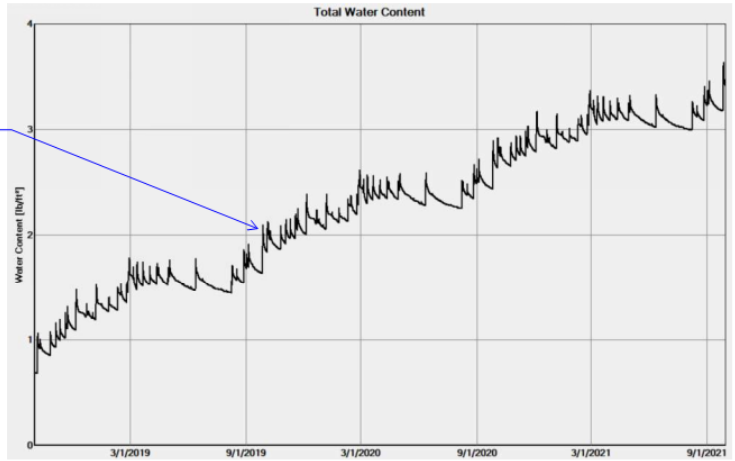
Materials:

- Granite	4.0 in
- Air Layer 10 mm	0.394 in
- Brick (old)	28.0 in
- Air Layer 10 mm	0.39 in
- Interior Plaster (Gypsum Plaster)	0.625 in
- Polyisocyanurate Board	1.5 in
- vapor retarder (0.1perm)	0.039 in
- AP Foil Facer	2.5 in
- Interior Gypsum Board	0.5 in

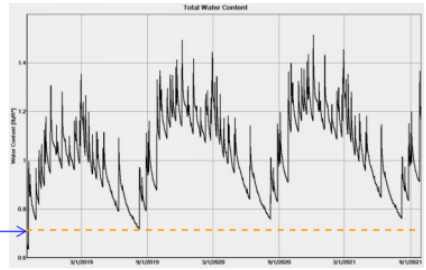
R-Value: 31.55 h ft² °F/Btu
U-Value: 0.031 Btu/h ft²°F

when we added insulation we reduced the possibilities of the wall drying to the interior and increased the moisture storage inside the wall assembly.

total water content of the wall assembly with insulation



total water content of the wall assembly NO insulation



with no insulation the wall shows a regular seasonal pattern with a slight tendency to increasingly store more moisture throughout time.

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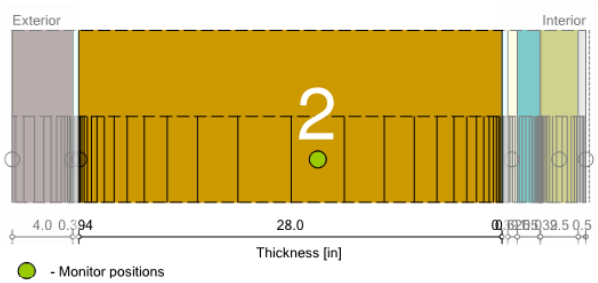
MS-03

25 WEST 4TH ST _ MS - 03: Center of Back Bricks

Boundary Conditions

Exterior (left side) New York, NY; cold year

Interior (right side) 70o F with fluctuation of 5o F; and 35% RH with a 10% amplitude



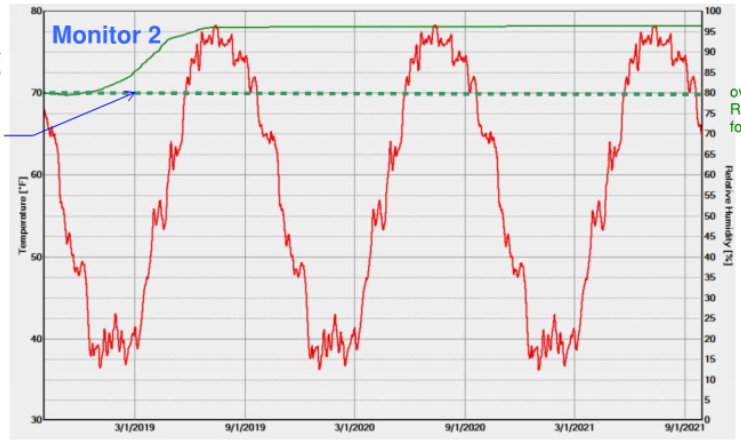
Materials:

- Granite	4.0 in
- Air Layer 10 mm	0.394 in
- Brick (old)	28.0 in
- Air Layer 10 mm	0.39 in
- Interior Plaster (Gypsum Plaster)	0.625 in
- Polyisocyanurate Board	1.5 in
- vapor retarder (0.1perm)	0.039 in
- AP Foil Facer	2.5 in
- Interior Gypsum Board	0.5 in

Total Thickness: 37.948 in
R-Value: 31.55 h ft² °F/Btu

Temperature/ Relative Humidity @ monitor position (■ temperature/ ■ relative humidity)

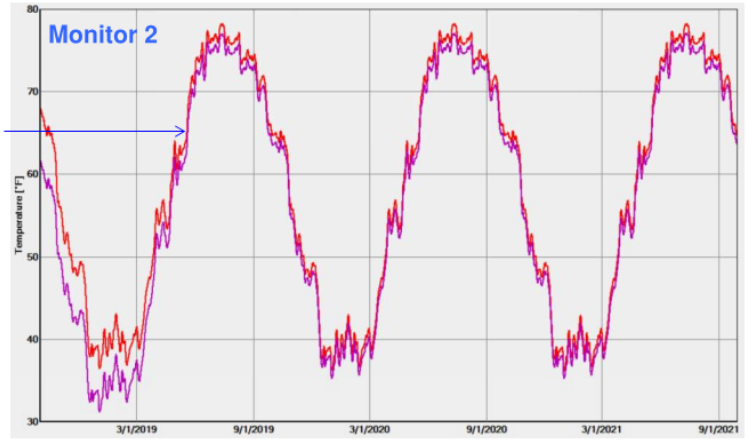
relative humidity in brick masonry remains above critical levels putting on danger the integrity of the brick



over 85% RH critical for brick

Temperature/ Dew-point @ monitor position(■ temperature / ■ dew point)

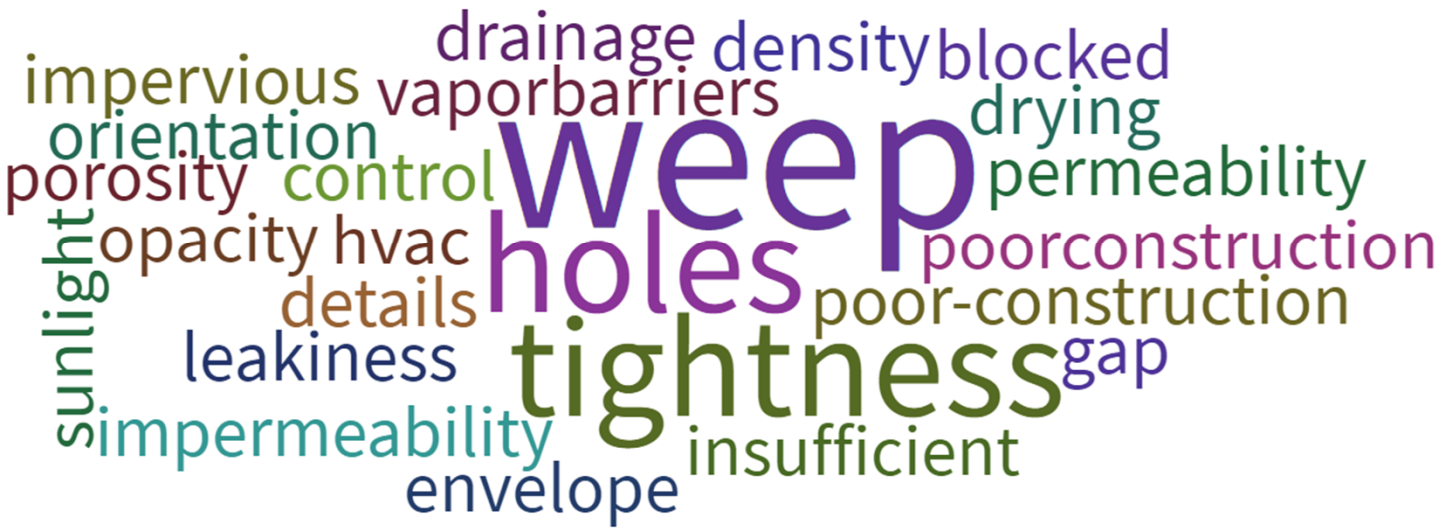
the dew point and temperature overlap in the three year period



Questions?



What are some of the attributes that can make wall assemblies more prone to moisture damage?



Condensation control



Moisture Condensation

- Why does condensation form on the outside of a cold drink in the summer?
- Dew point!



Detail Moisture Vapor Control Strategy

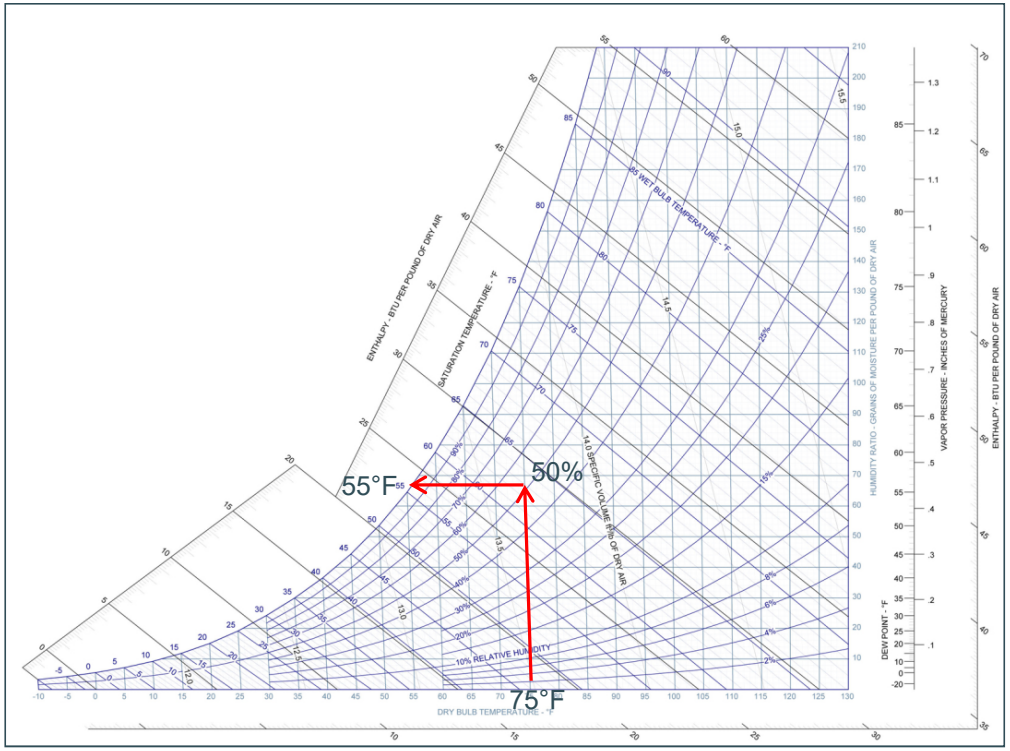
- First condensing surface must be kept above the dew-point temperature of the ambient air
  - Thermally broken windows
- Control indoor humidity conditions, specify:
  - Proper local ventilation
- Construction moisture!

Construction Moisture





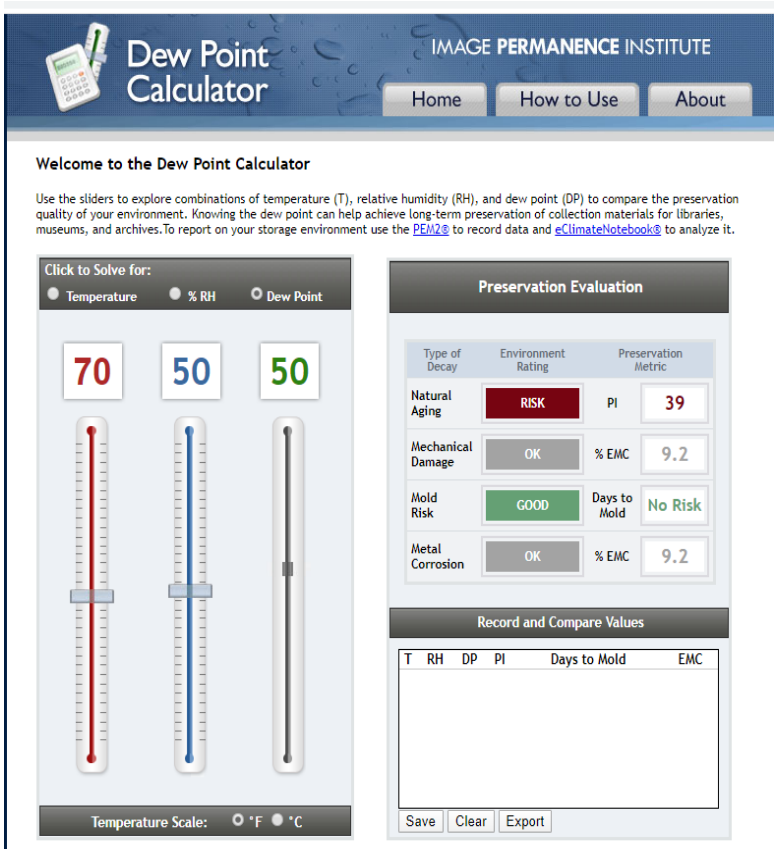
Construction moisture in “tight” new construction can cause significant problems

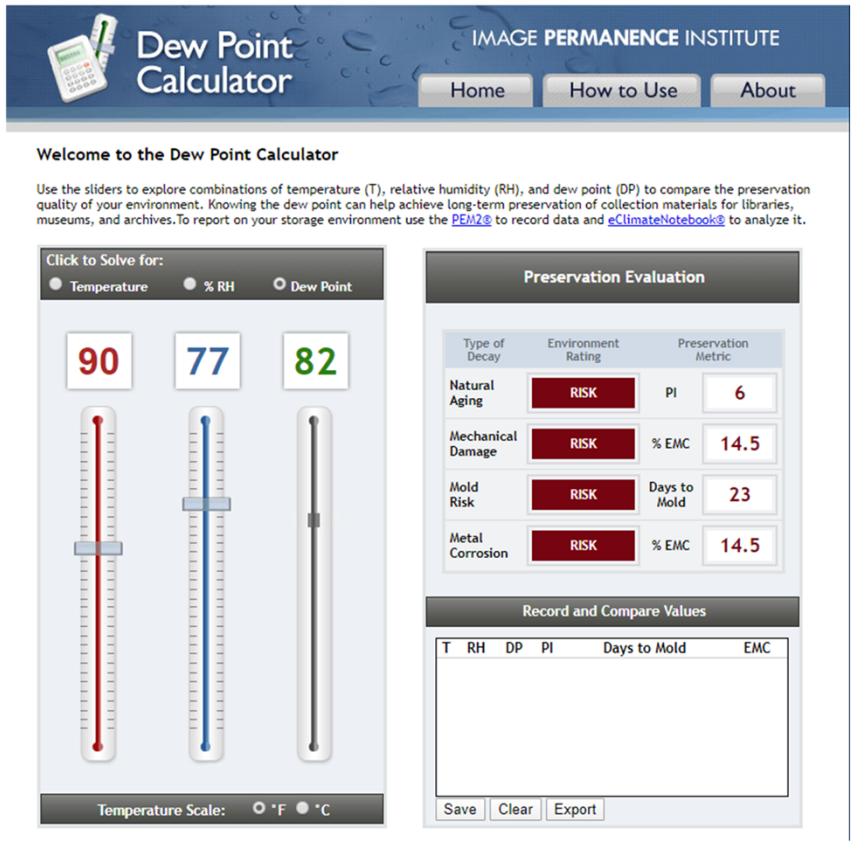


What is Dew Point?

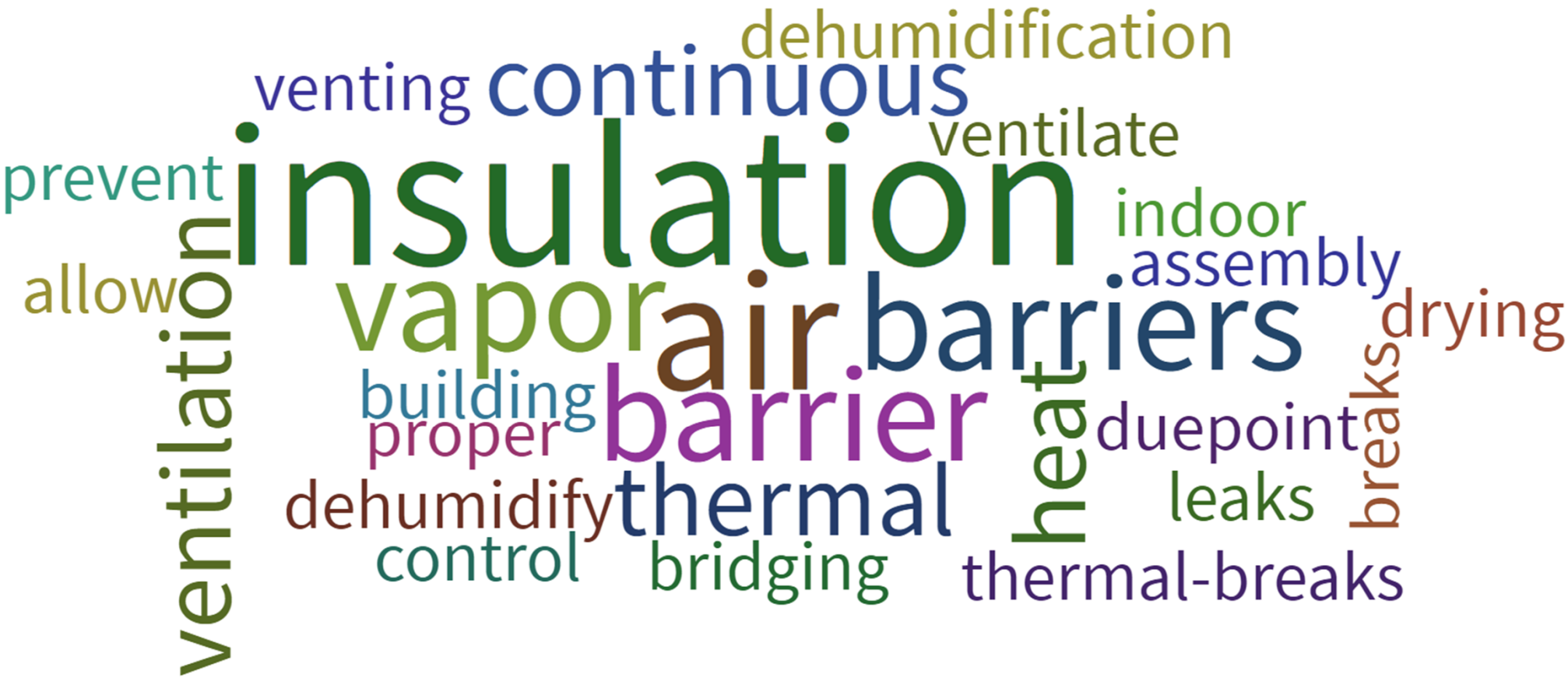
- Warm air can hold more moisture than cold air.
- The dew point is reached when the air is cooled to the point of saturation (100% Relative Humidity).
- When this occurs we call it condensation

Dew Point Calculator (DPCALC.org)





How can we prevent cold weather condensation?





Cold Weather Condensation

- Can occur when warm moist interior air contacts cooler surfaces such as windows.
- Condensation forms when the surface temperature is below the dew point temperature for the ambient interior air

HOW?

How do we Prevent Condensation?

- Raise the temperature of the condensing surfaces
- Add a vapor retarder to inhibit the moisture from reaching the condensing surface
- Lower the interior space relative humidity
  - Reduce the interior “moisture loading”

What Can Possibly Go Wrong?



Fogg Museum, Werner Otto Hall



THE WALL STREET JOURNAL.

Pardon Us, But Our Museum Is Falling Apart

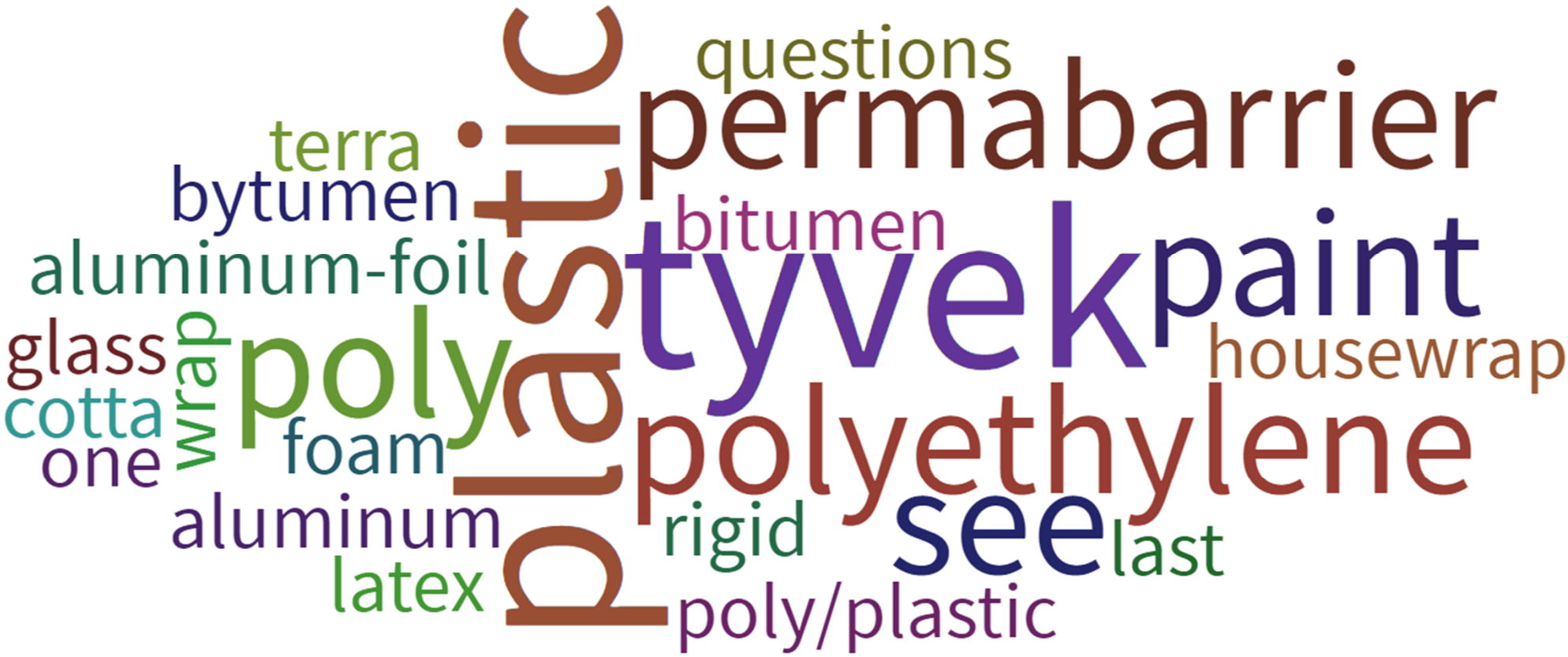
In May, the London-based architectural engineering firm Ove Arup & Partners collected an award from the International Association of Lighting Designers for their work on the addition to the Art Institute of Chicago's Modern Wing. The year before, the company's engineering work on that same Renzo Piano-designed building earned an award of merit in an international Excellence in Structural Engineering competition.

This week the company found itself getting some rather less flattering attention for the project. The Art Institute of Chicago filed suit

Questions?

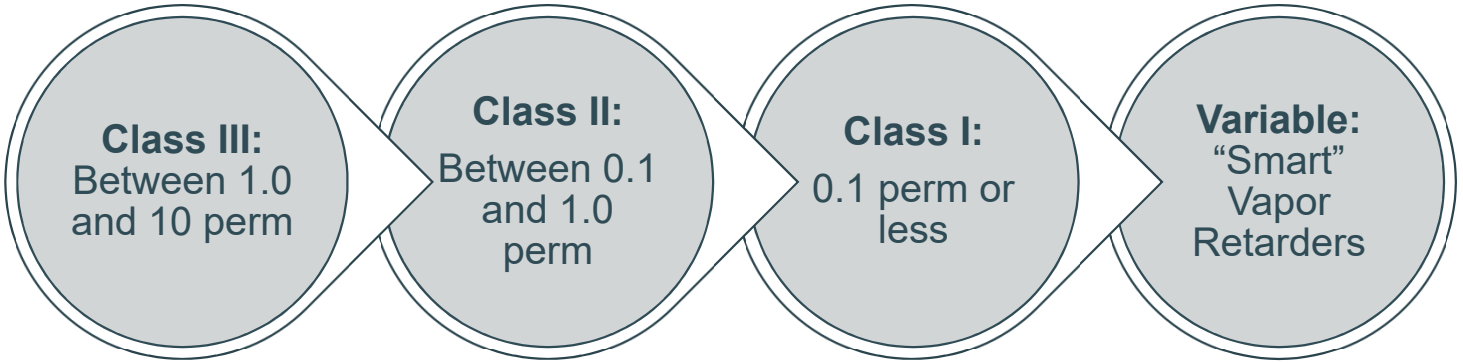


Name some vapor retarder materials?



Vapor Retarders

Vapor Retarder Classifications



Vapor Retarder Definitions

- **permeance [perm]:** the rate that moisture vapor moves through a given construction *layer* for the given thickness
- **permeability [perm in]:** the rate that moisture vapor moves through a given construction *material* at a standard thickness (1 in or 1 cm)

Permeance = permeability ÷ layer thickness

Vapor Retarder Definitions

Example:

A certain type of SPF has a permeability of 1.2 perm per inch

A) What is the perm rating of 1.5 inches of SPFA?

B) What vapor retarder class does this fall under?

Answer:

Permeance = permeability ÷ layer thickness = 1.2 perm in/1.5 in = 0.8 perm

- Class III: 10 perm or less and greater than 1.0 perm
- **Class II: 1.0 perm or less and greater than 0.1 perm**
- Class I: less than 0.1 perm

Vapor Retarders

Class I or Class II vapor retarders are required on the **interior side** of frame walls in Zones 5,6,7,8 and Marine 4 except for:

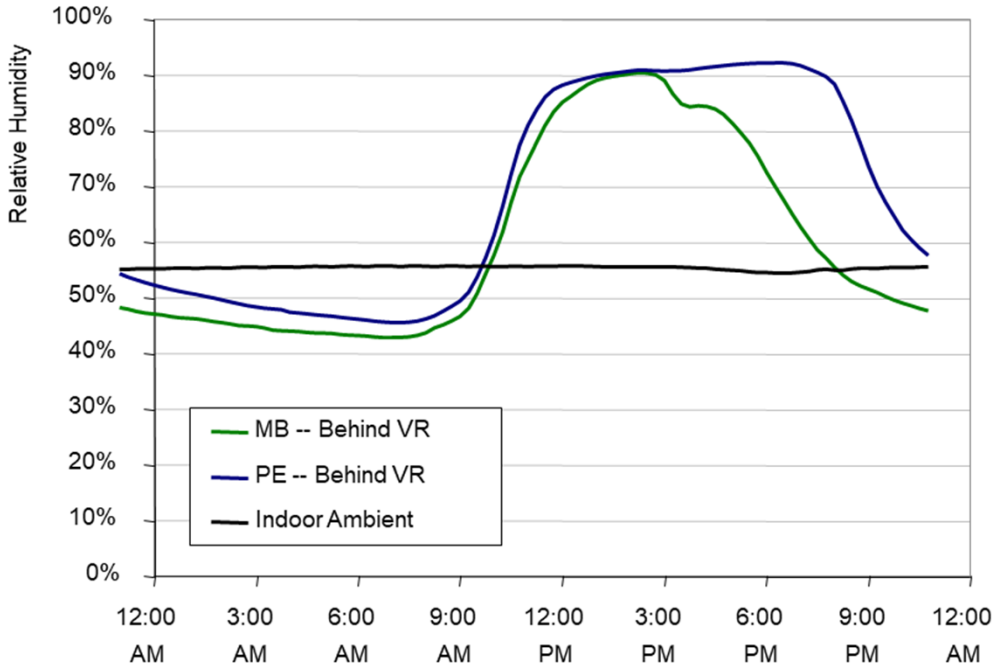
- Basements
- Below grade portions of any wall
- Construction where moisture/freezing won't damage materials

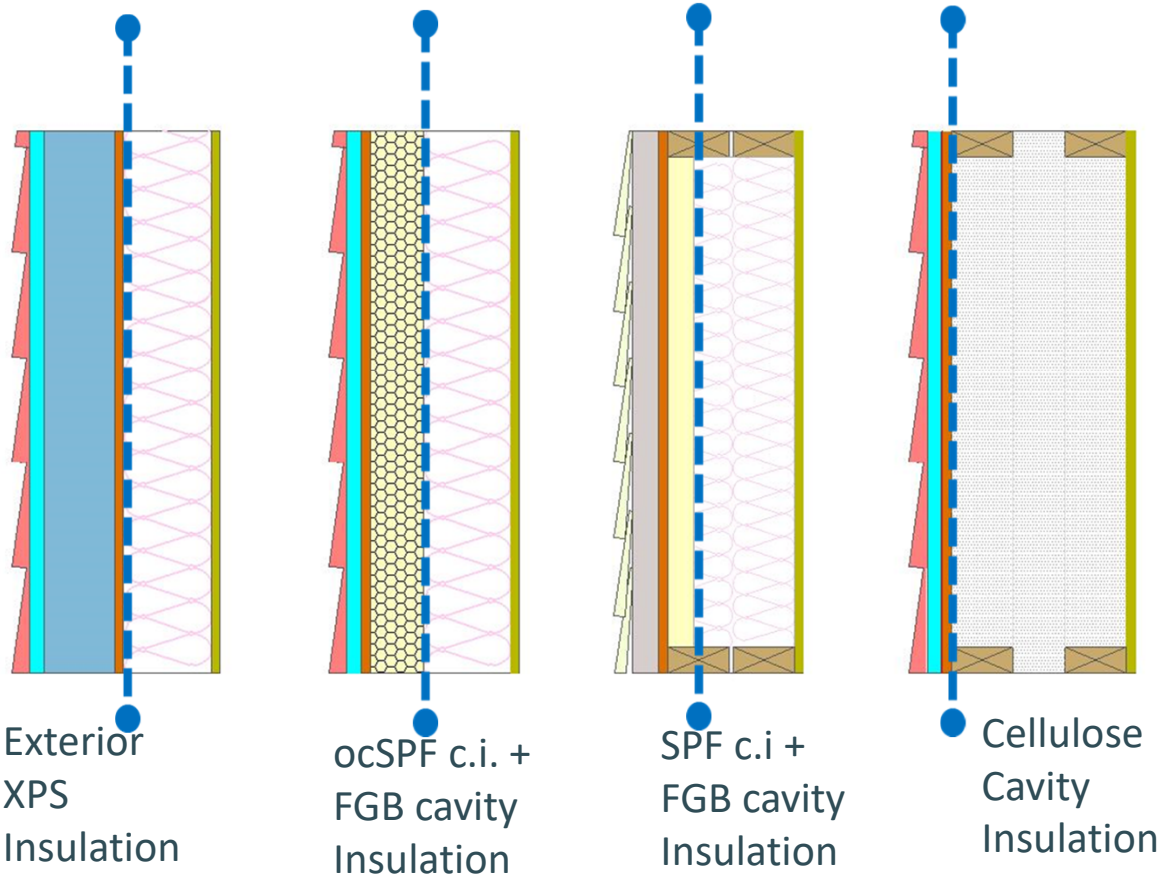
Or

- Where Class III is permitted: Table 1404.3.2

"Smart" Vapor Retarders

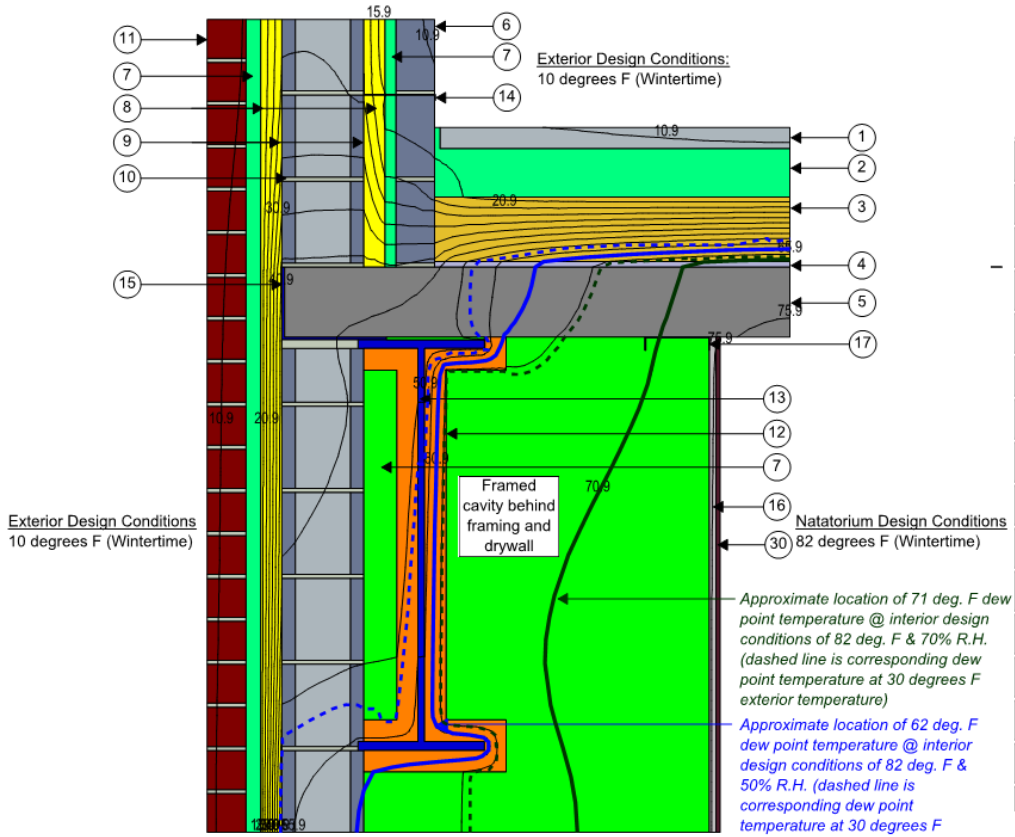




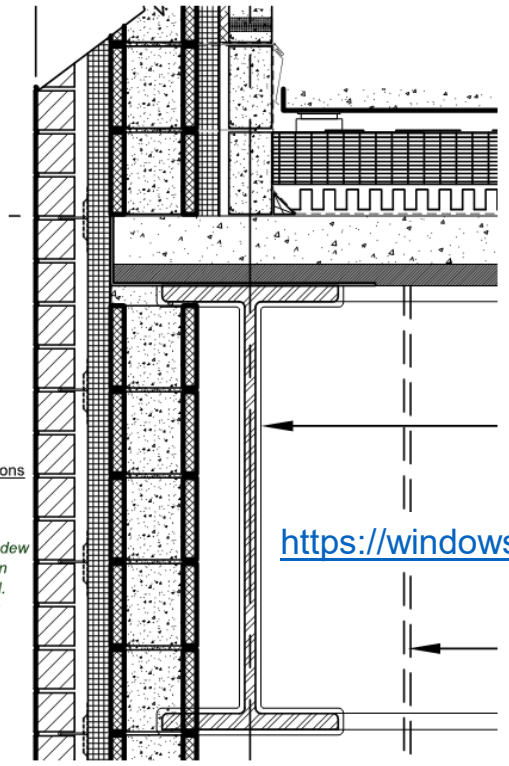


First Condensing Plane

Tools You Can Use: THERM



1) THERM Model - Exterior Wall to Roof Transition



1A) Architectural Detail (29/A-503.00) - Exterior Wall to Roof Transition

https://windows.lbl.gov/software/therm

Assembly Recommendations

- Do NOT use code minimums for exterior rigid or spray foam for high R-walls
- Use WUFI and THERM to evaluate your projects on a case by case basis
- Evaluate the climate conditions for your project carefully and compare to software assumptions
- Must prevent interior moisture from getting into the walls

Questions?



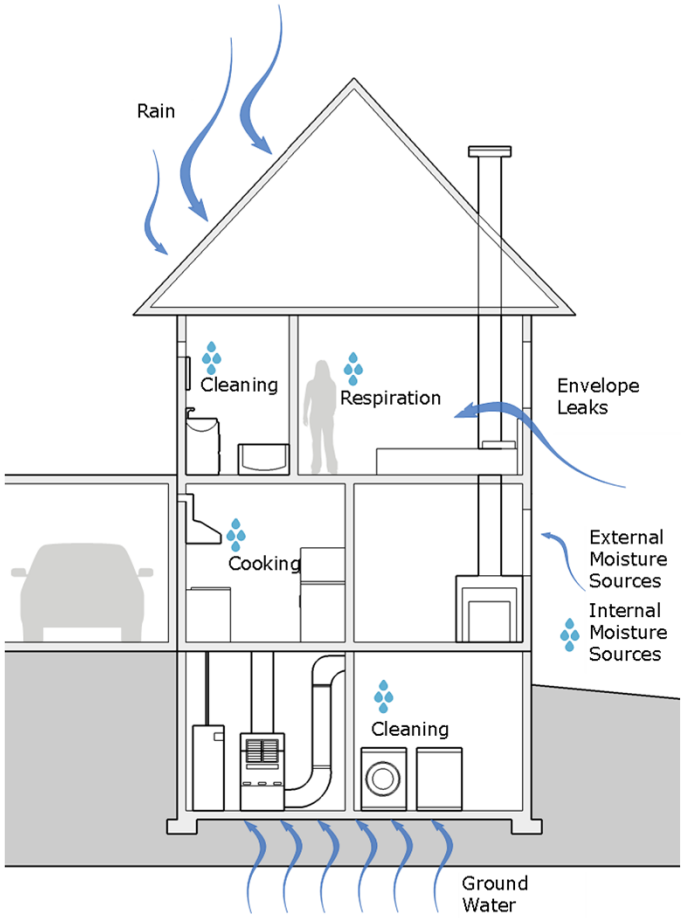
Where does moisture in buildings come from?



Moisture in Buildings

Moisture In Buildings

- Common Moisture Sources
  - Bulk Moisture (leaks)
  - Diffusion
  - Infiltration
  - Capillary Action
  - Water Vapor
    - Cooking
    - Cleaning
    - Respiration
  - Ground Water (through basement floors and walls)
  - Water in a basement, is water in a building



Moisture Damage





Airborne Moisture

- #1 moisture-related problem for building science professionals
- Moisture moves vertically through stack effect
- Moisture gets into walls by:
  - Pressurization in heating season
  - Depressurization in cooling season

Airborne Moisture - Control

- Reduce/eliminate sources – fix drainage around building, fix leaks into building
- Properly ventilate high moisture spaces – kitchens, baths, laundry
- Use whole-house mechanical ventilation – eliminate moisture from people, pets, etc.

Air Flow in Buildings

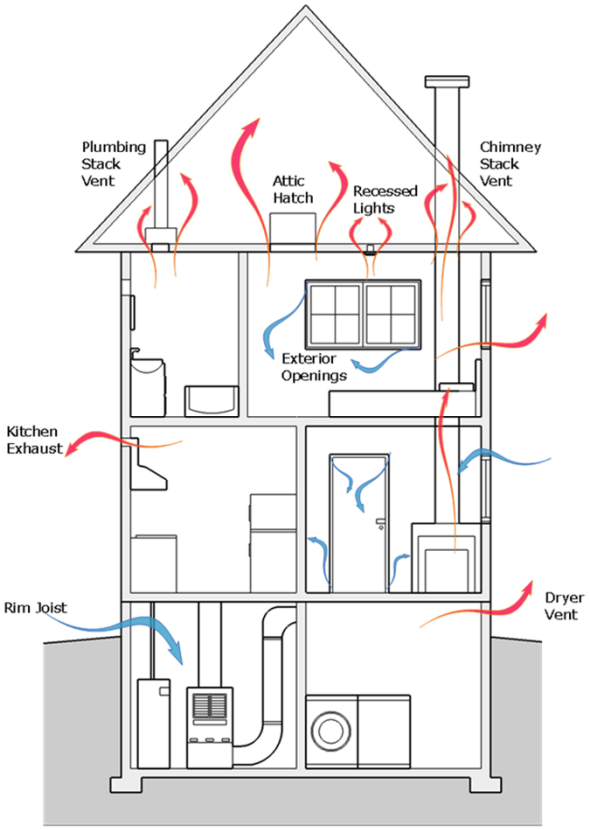
Air Flow in Buildings

Infiltration: air movement into the building

Occurs in areas of negative pressure inside the building

Exfiltration: air movement out of the building

Occurs in areas of positive pressure inside the building



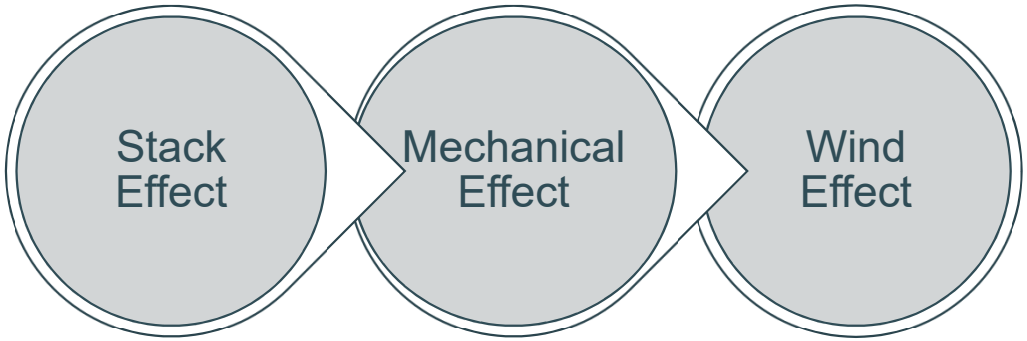
Exfiltration
Air Leakage from Inside to Outside

Infiltration
Air Leakage from Outside to Inside

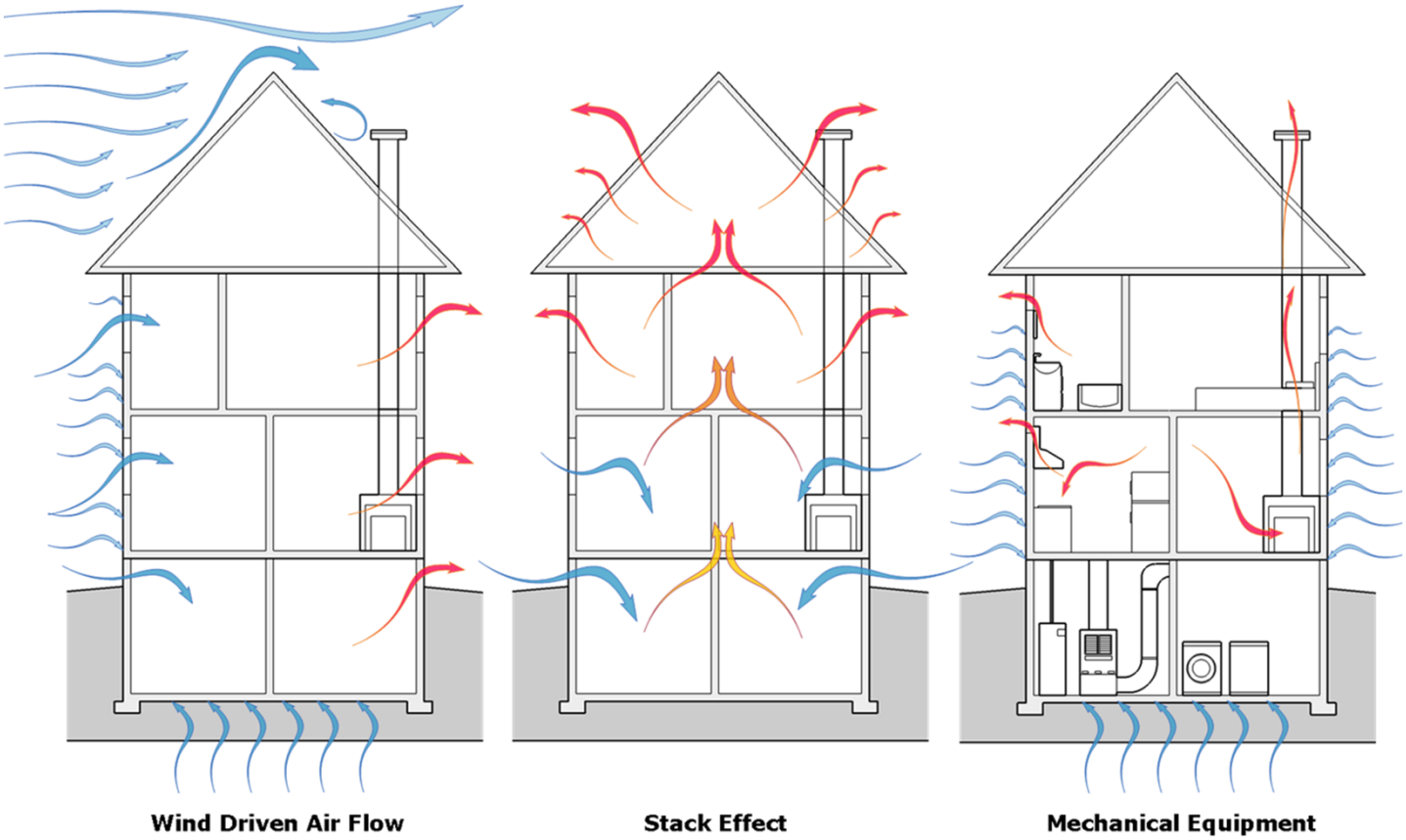
Copyright Steven Winter Associates, Inc. 2011

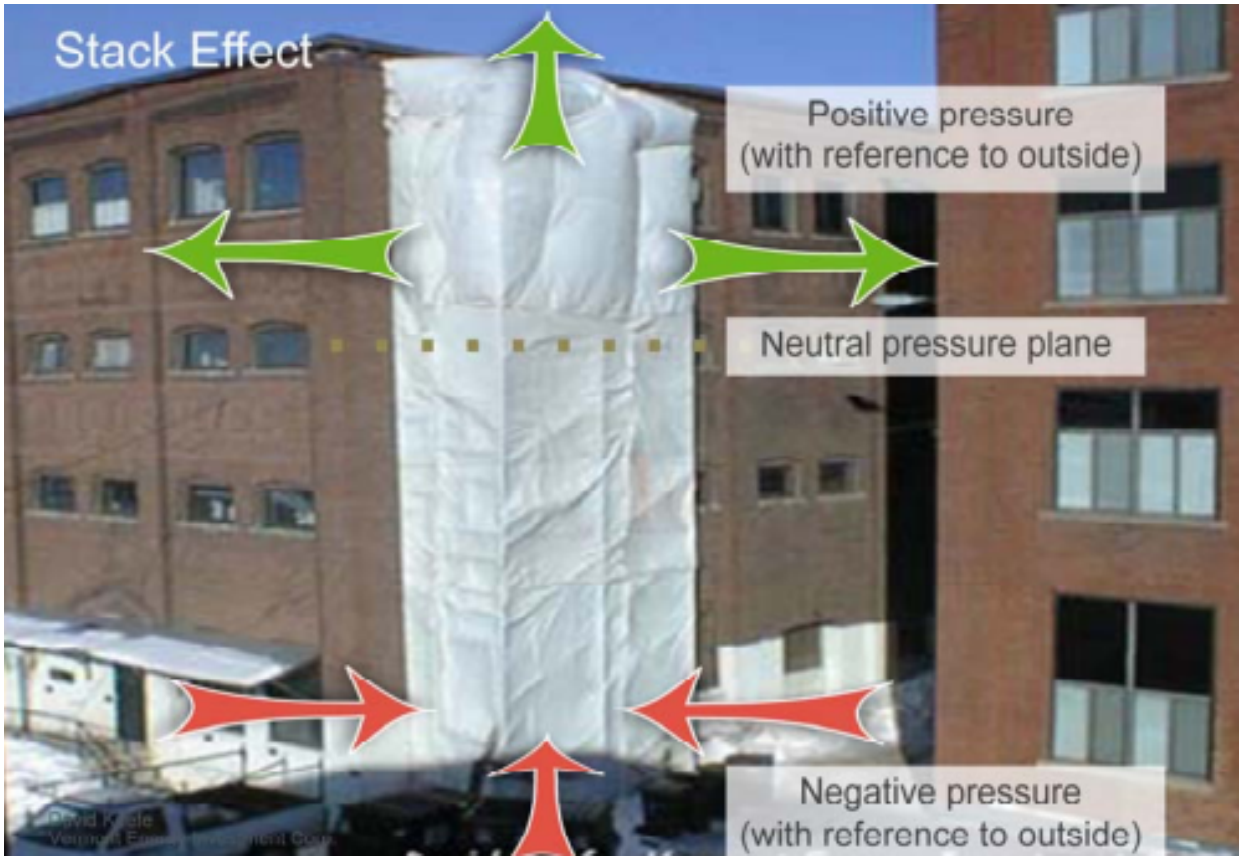
Air Flow in Buildings

3 Main Driving Forces



Air Flow in Buildings





Stack Effect

Air Sealing Priorities

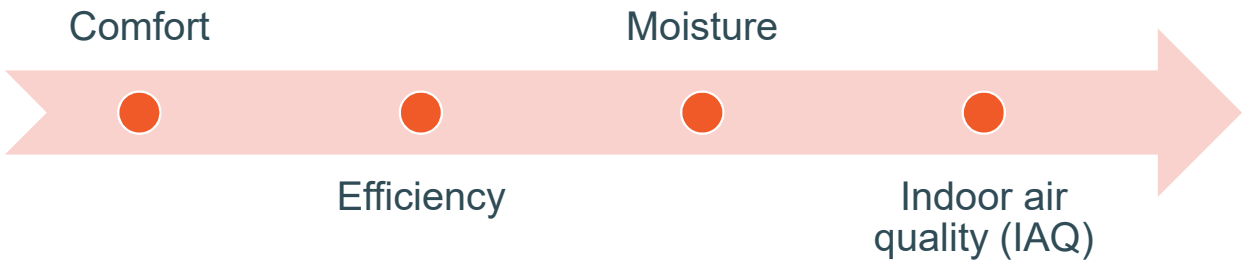
- Stop the Stack Effect!!
- Resolve the biggest holes first
- Top of the building is typically first priority
- Base of the building is next
- Center of the building after that

Questions?



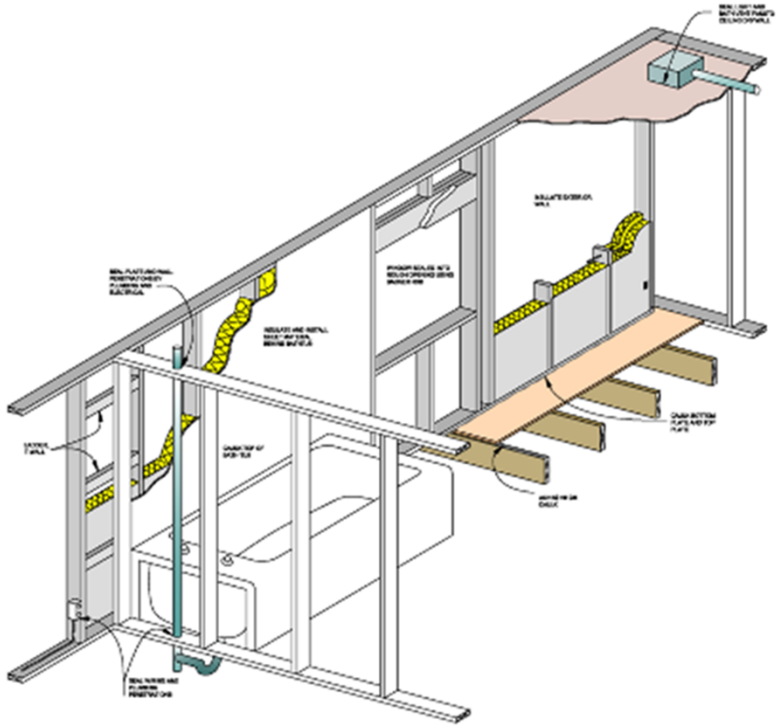
Air Sealing

Why Air Seal?



Air Barriers

- 90% of Moisture transport is (was) by air-movement, not diffusion
- Insulation is ineffective without air-sealing
- Leakage primarily at edges, corners, joints and penetrations, transitions, and terminations



Where is the air barrier in the houses on the next slide?



Find the Air Barrier

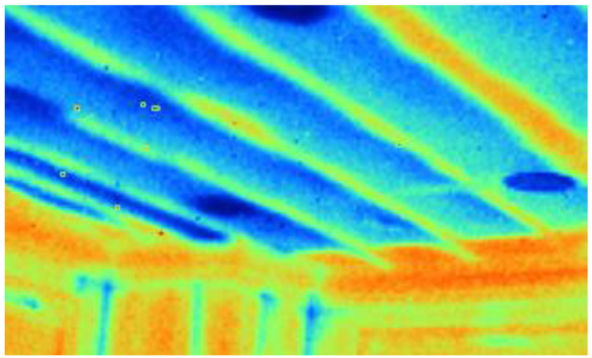


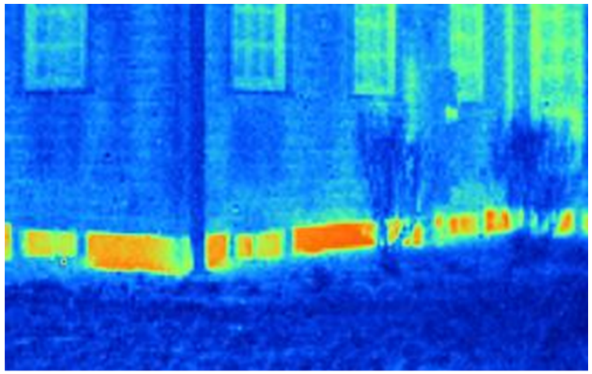


How do you air seal?









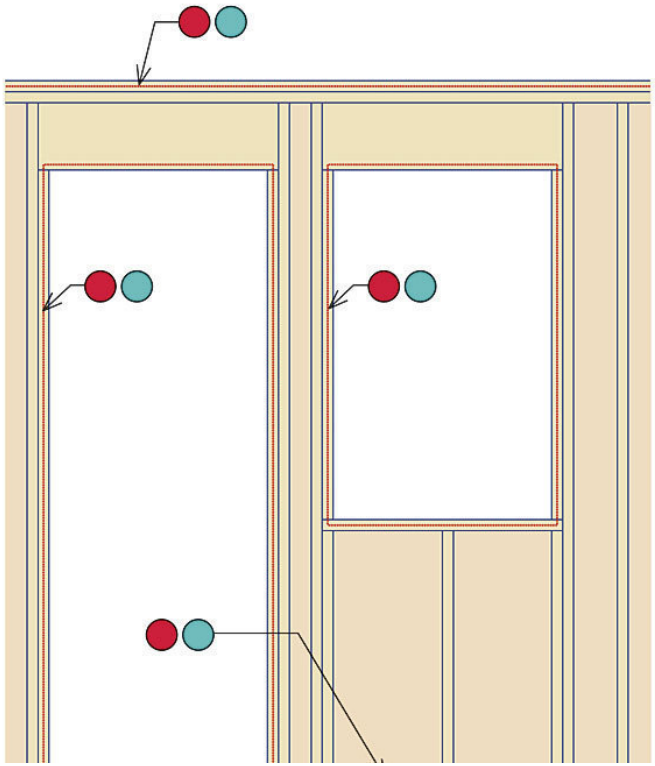
Finding and Measuring Leaks

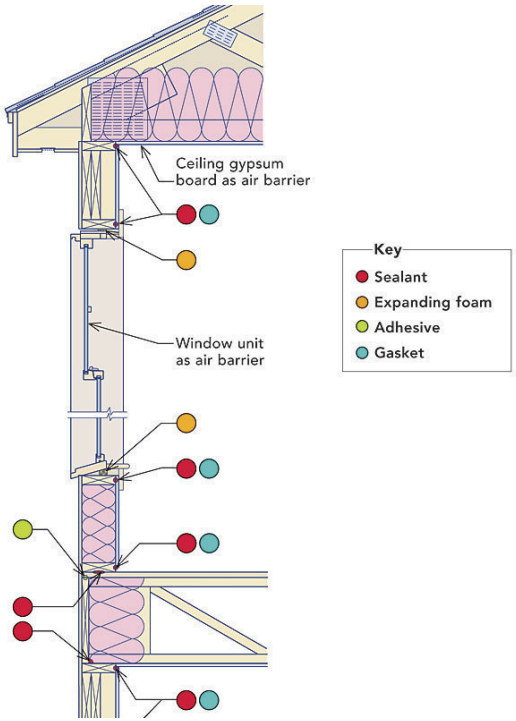




Caulking your way to Air-tight?

Air Tight Drywall and Interior Membrane







Air-Barrier Placement and Material





Name some common air-barrier materials



Common Air Barrier Materials and Properties

- Gypsum Wall Board
- Plywood/OSB
- Concrete
- Housewrap products
- 6 Mil poly (unpeforated)
- Roll form Water Resistive Barriers (WRBs)
- Fluid Applied WRBs



JOE MUNROE / SAINT MARY'S COLLEGE OF CALIF./P

How Tight Do You Want To Get?

2021 IECC Residential Code
- 3.0 ACH50
- 0.3 CFM50/ft2 (individual dwelling)

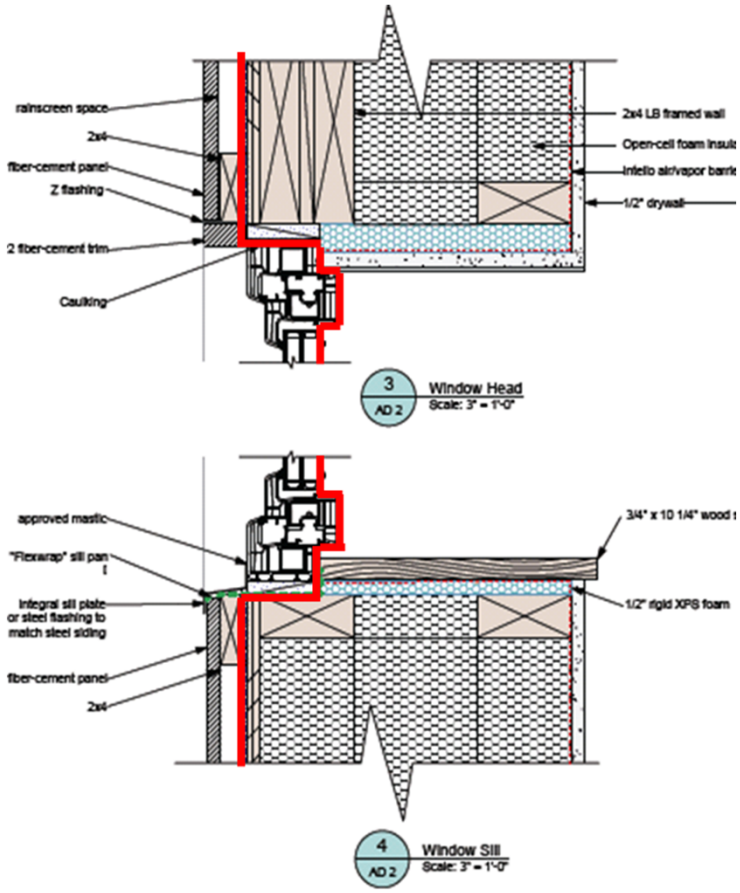
2021 IECC Commercial Code
- 0.3 CFM50/ft2 (individual dwelling)
- 0.4 CFM75/ft2 (whole-building)

Passive House
- 0.6 ACH50

Air Tightness



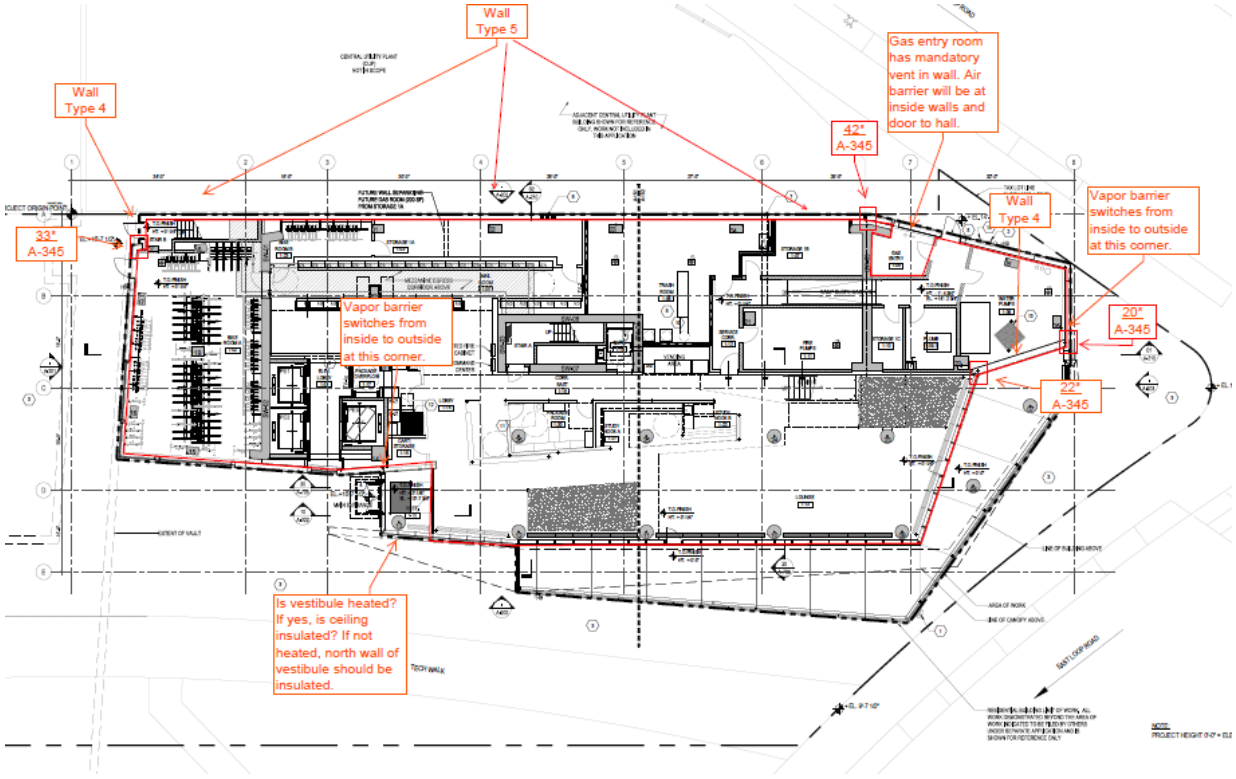
- Requirement: < 0.6 ACH@50
- What does this mean?
  - @50 refers to 50 pascals pressure difference between indoors and out during a blower door test, ≈ 20mph wind on all sides of house
  - 0.6 ACH@50 ≈ 5 times tighter than Code requirements

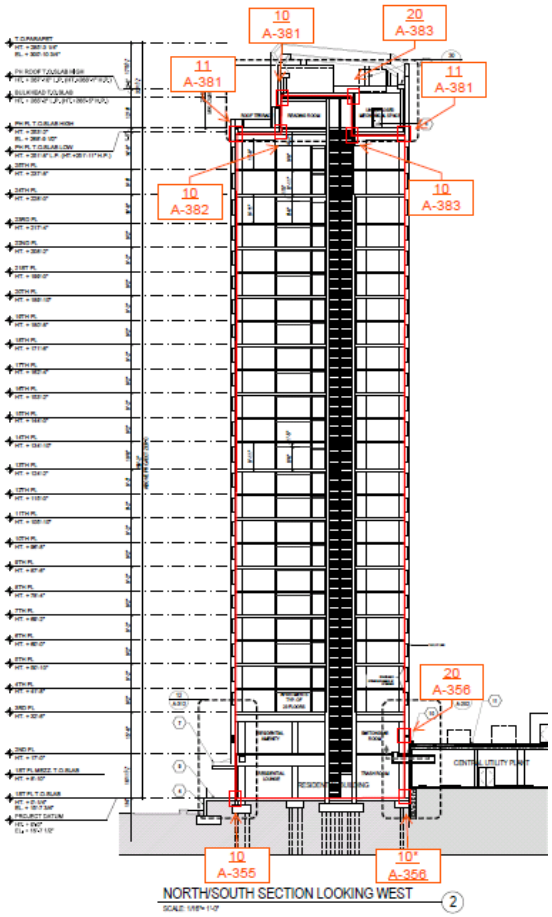


Define Air Barrier

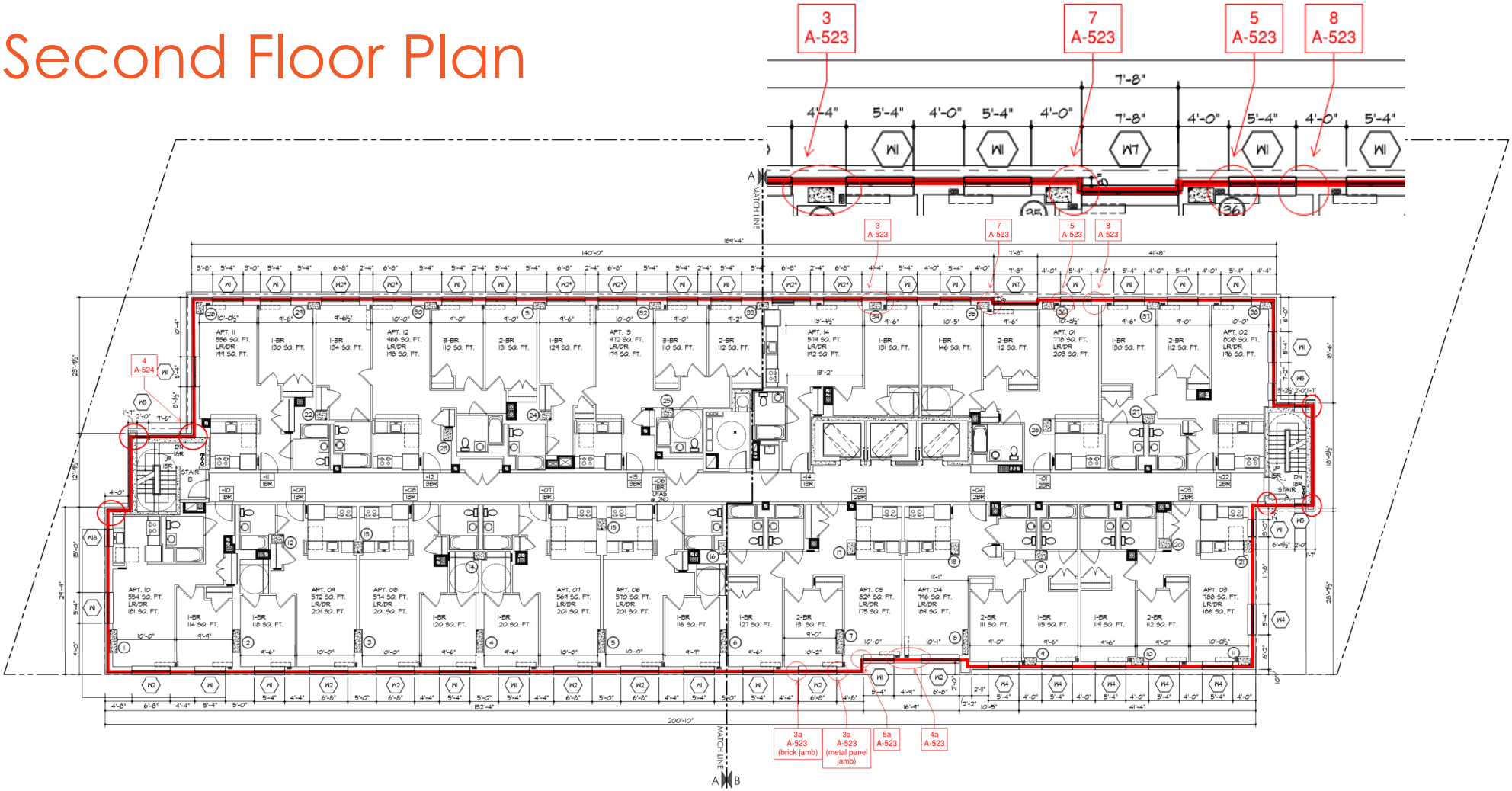
- Redline around entire perimeter indicating air sealed surface
- Both in plan view and in section
- Circle all transition points – corners, changes in components, cantilevers, wall/roof, slab/wall, etc.
- Provide details for how all these transitions will be air sealed

Define Air-Barrier

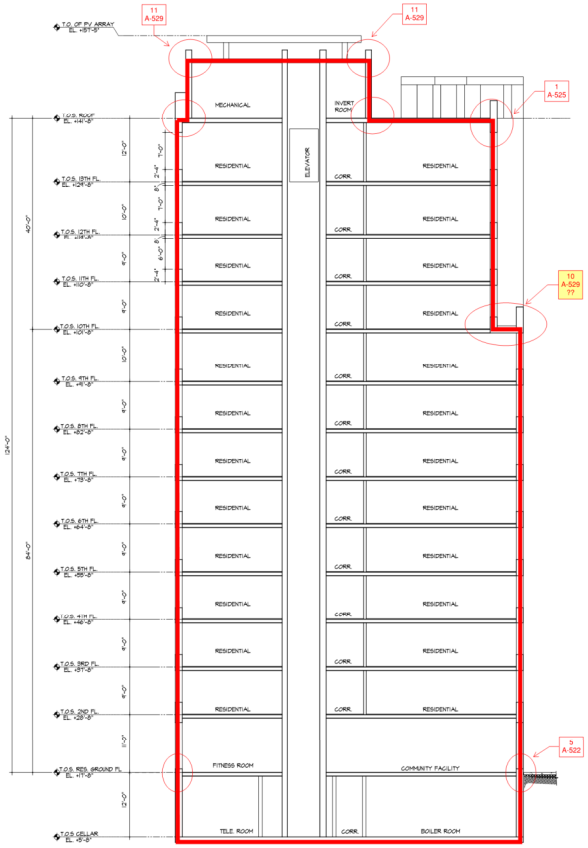


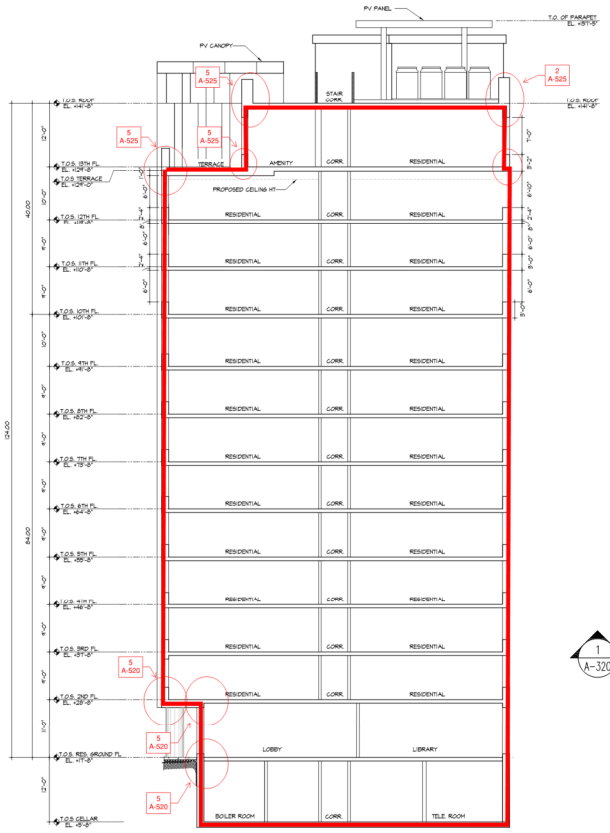


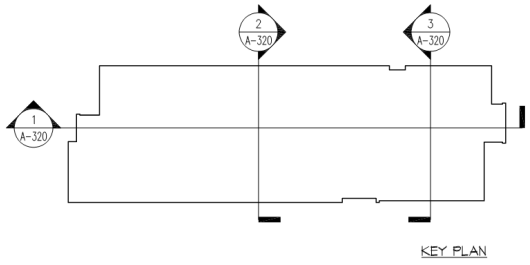
Second Floor Plan



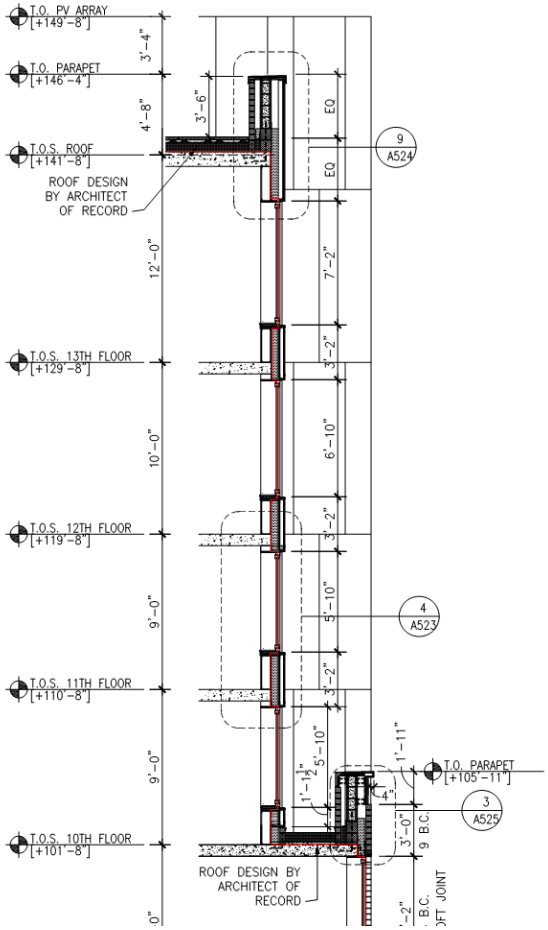
Cross Sections

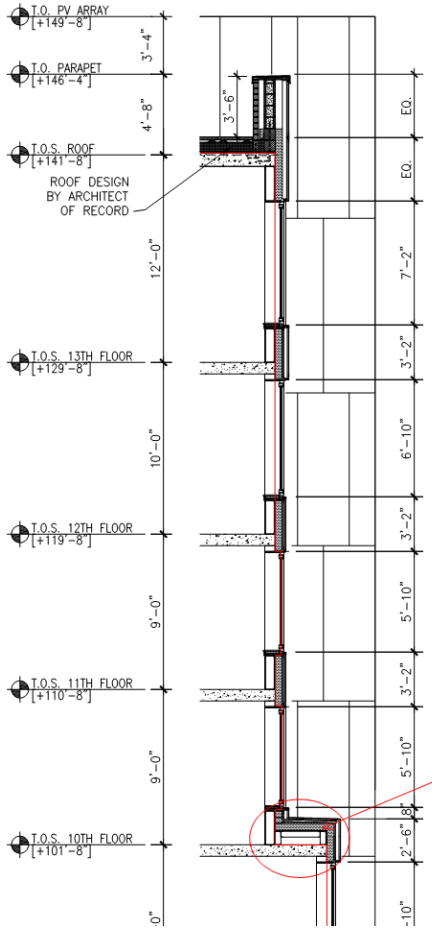


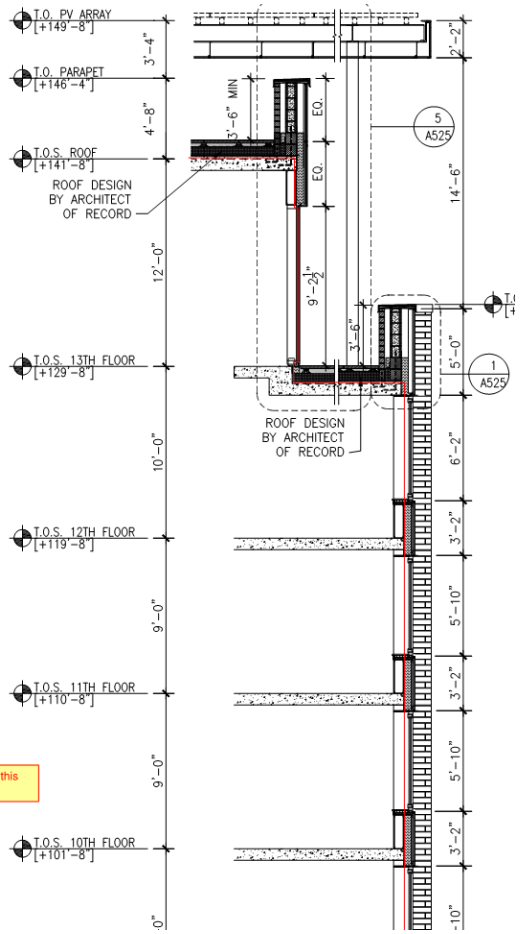




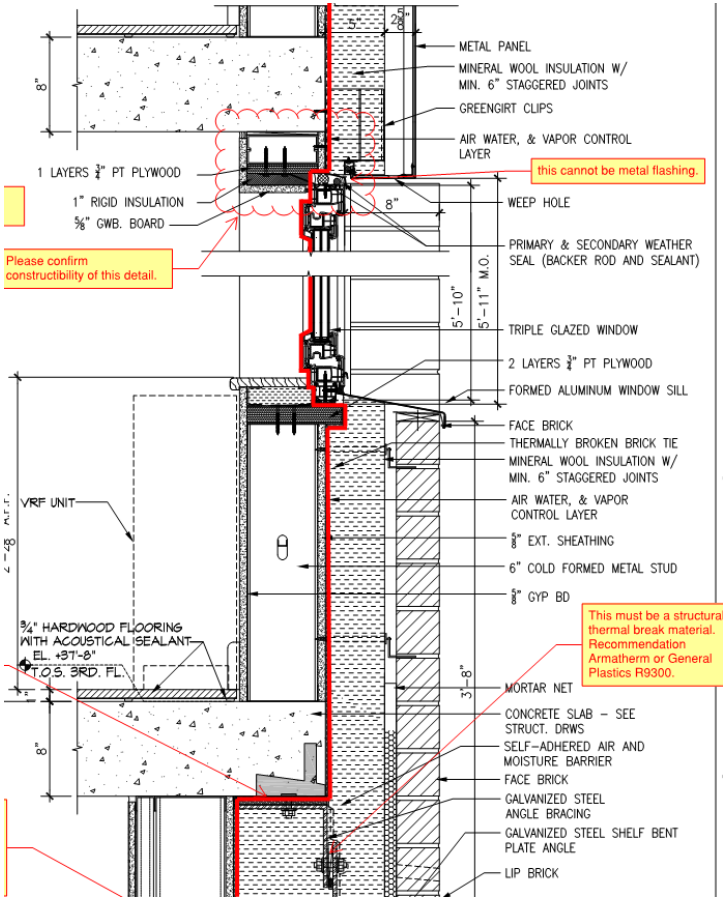
Wall Sections

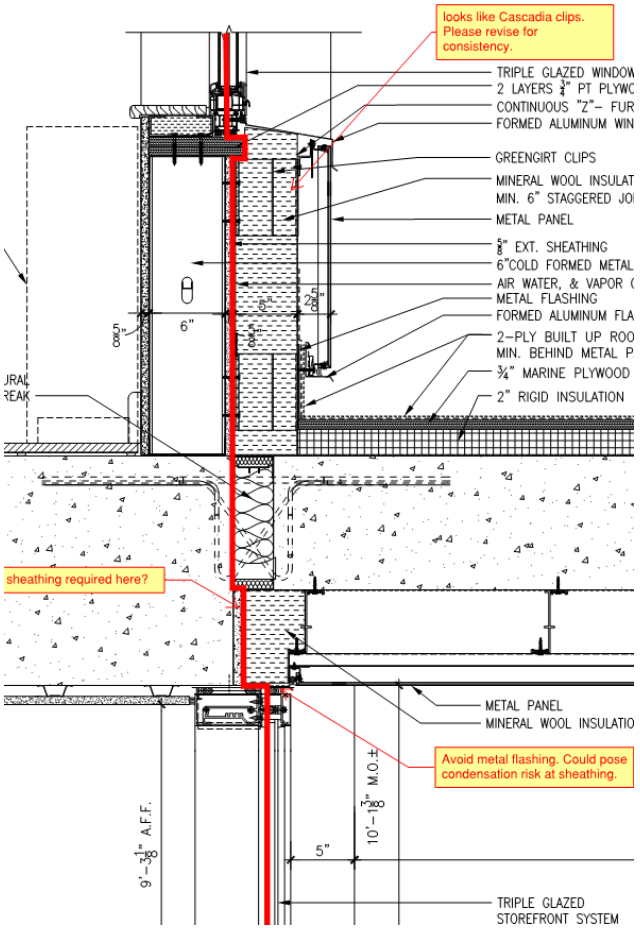




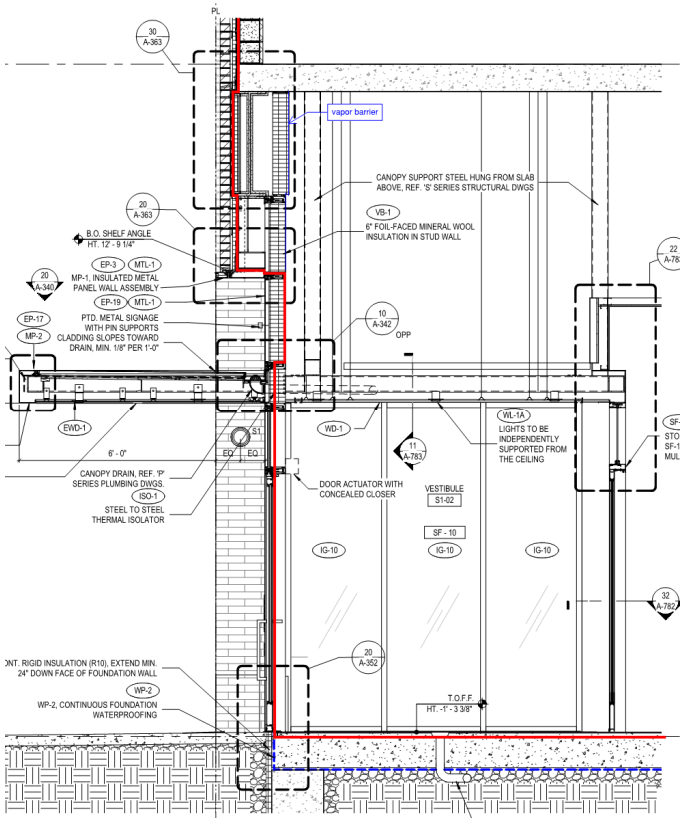


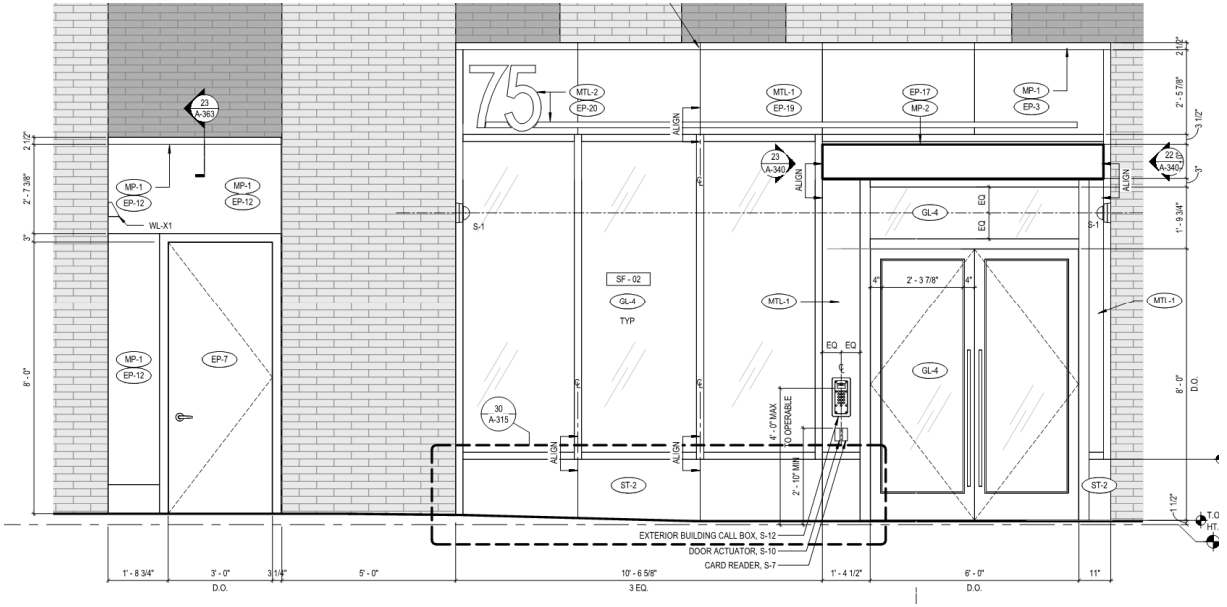
Section Details

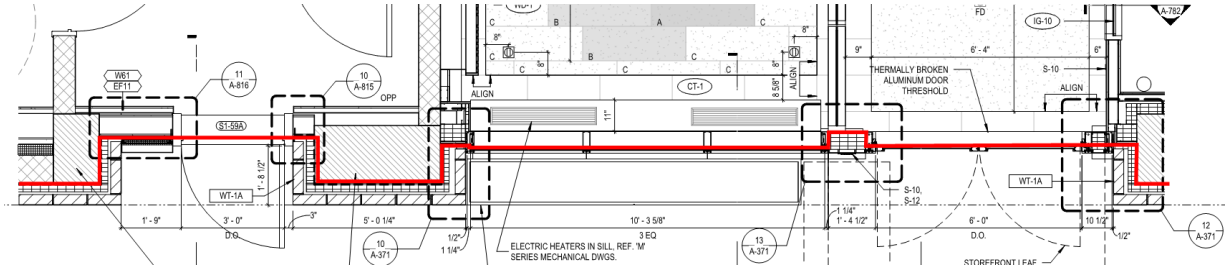




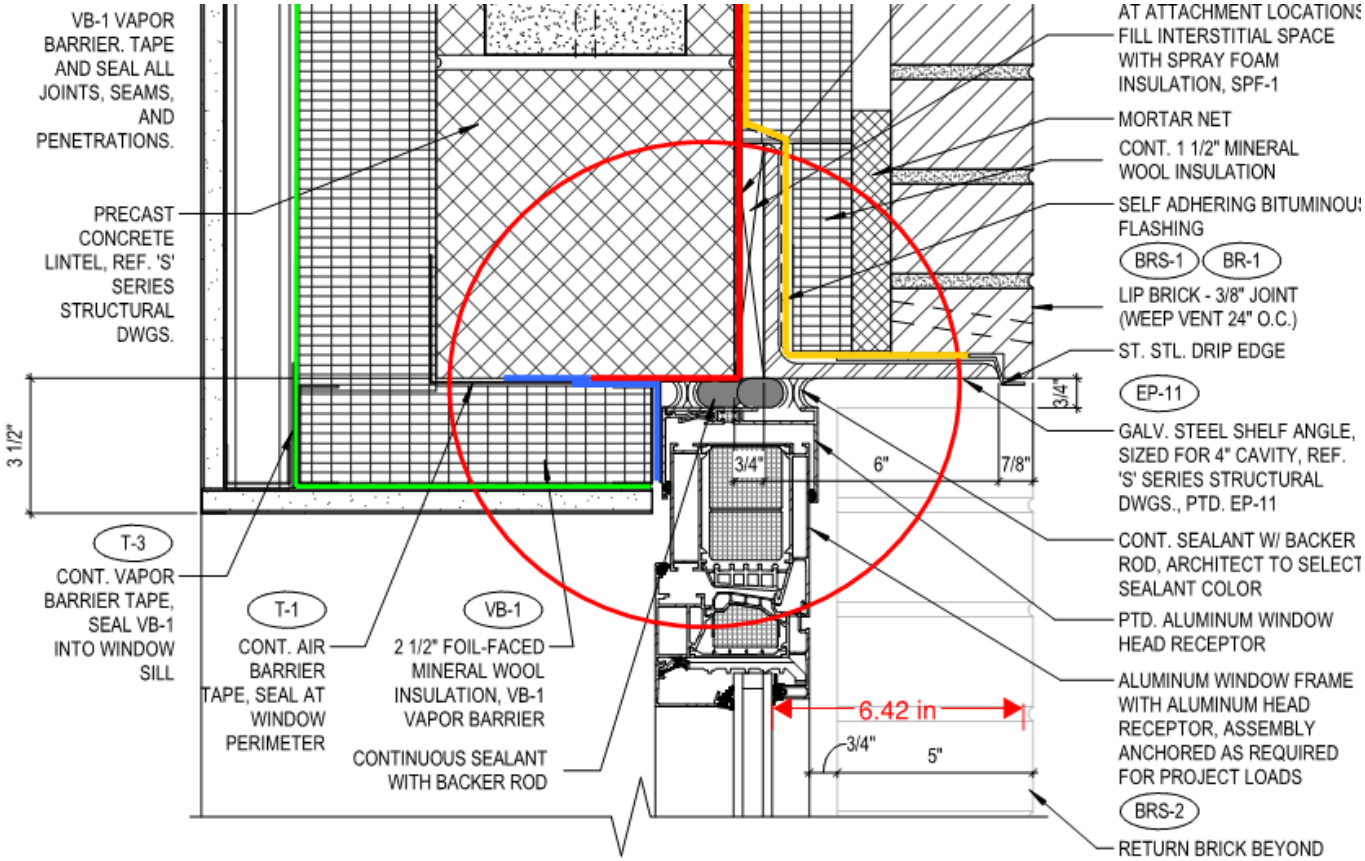
Detail Sections







Typical Window Head @ Brick Veneer



Air Barrier Materials

- Building materials that are designed and constructed to provide the principal plane of airtightness through an environmental separator, which has an ***air permeance rate no greater than 0.02 L/(s•m²) (0.004 cfm/ft²) at a pressure difference of 75 Pa when tested in accordance with ASTM E 2178.***

Air Barrier Accessories

- Products designated to maintain air tightness between air barrier materials, assemblies and components, to fasten them to the structure of the building, or both (e.g., sealants, tapes, backer rods, transition membranes, nails/washers, ties, clips, staples, strapping, primers) and which has ***an air permeance rate no greater than 0.02 L/(s•m²) at a pressure difference of 75 Pa when tested in accordance with ASTM E 2178.***
- Air barrier components are used to connect and seal air barrier materials and/or air barrier assemblies together.

Air Barrier Components

- **Air barrier components** – Pre-manufactured elements such as windows, doors and service elements that are installed in the environmental separator and sealed by air barrier accessories
- Must have an air leakage rate no greater than 0.20L/(s•m²) at a pressure difference of 75 Pa when tested in accordance with ASTM E 2357.

Air Barrier Assemblies

- Combinations of air barrier materials and air barrier accessories that are designated and designed within the environmental boundary to act as a continuous barrier to the movement of air through the environmental boundary
- Must have an air leakage rate no greater than 0.20 L/(s•m²) at a pressure difference of 75 Pa when tested in accordance with ASTM E 2357.

Air Barrier Systems

- Combinations of air barrier assemblies and air barrier components, connected by air barrier accessories, that are designed to provide a continuous barrier to the movement of air through an environmental separator, which has an ***air leakage rate no greater than 2.0 L/(s•m²) at a pressure difference of 75 Pa*** when tested in accordance with ASTM E 779.

Air Barriers and Water-Resistive-Barriers



Sheet Materials



Fluid Applied



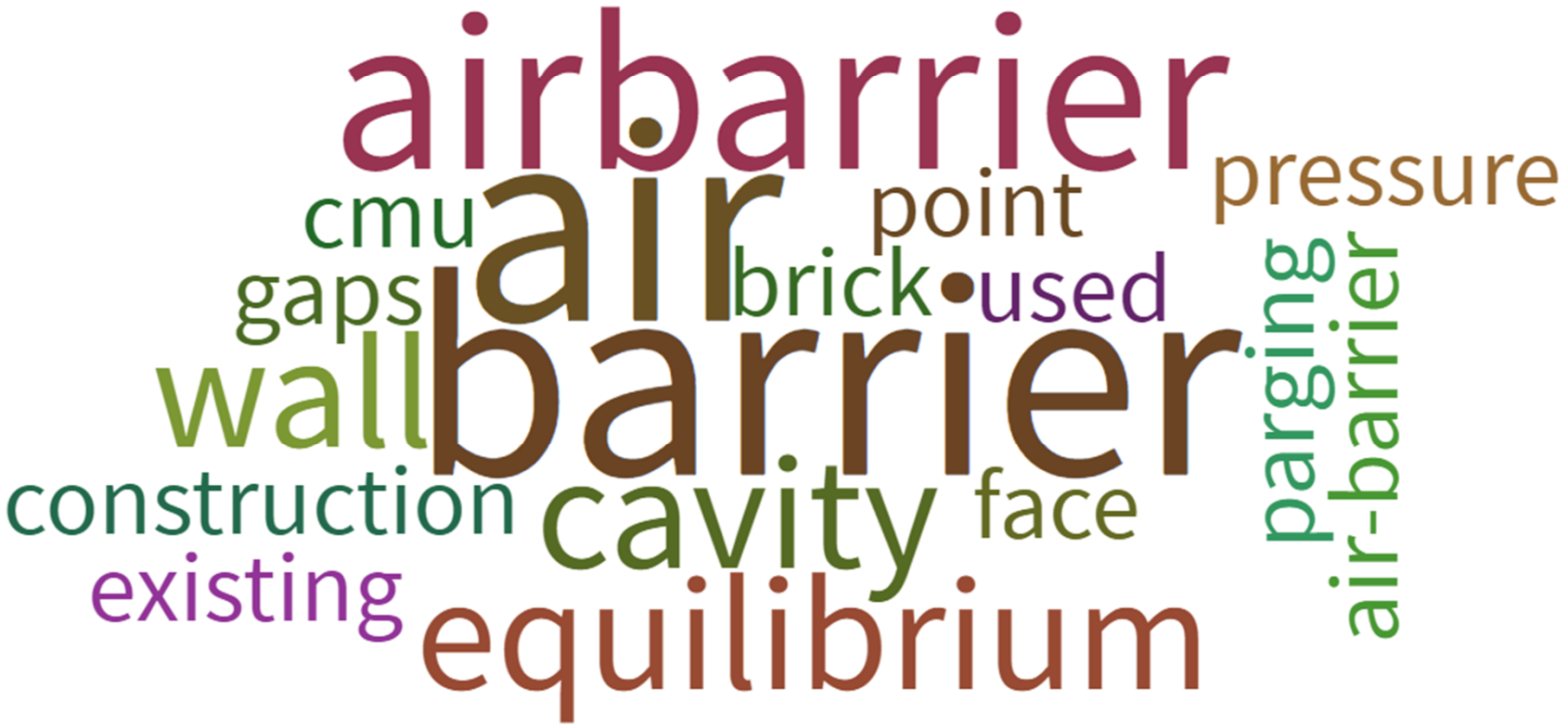
AeroBarrier Mist-Applied Air Barrier

Execute Air Barrier Correctly





What is the pressure boundary

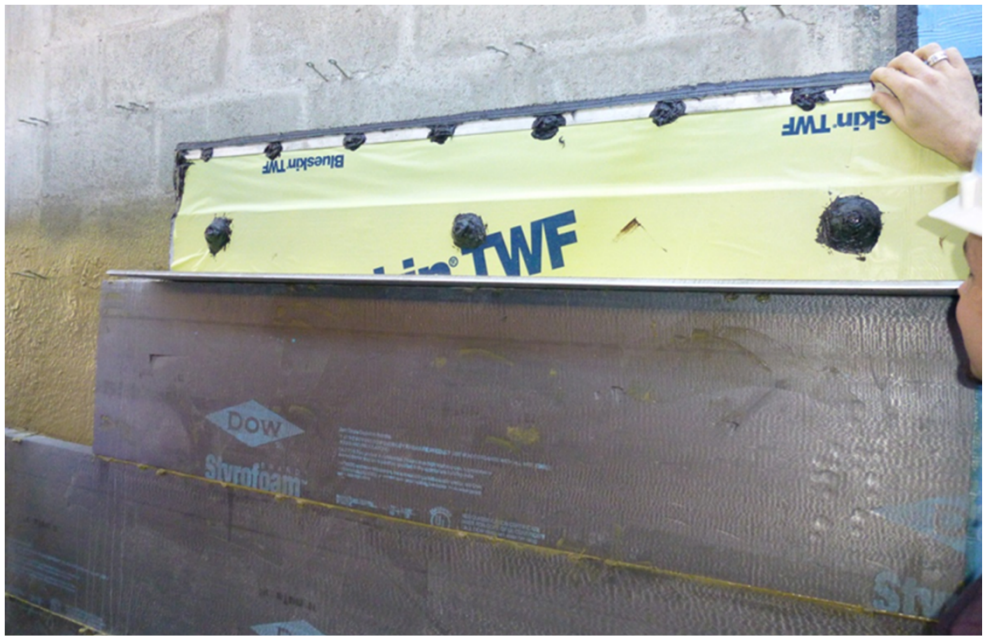


Thermal Boundary and Air Barrier Integration

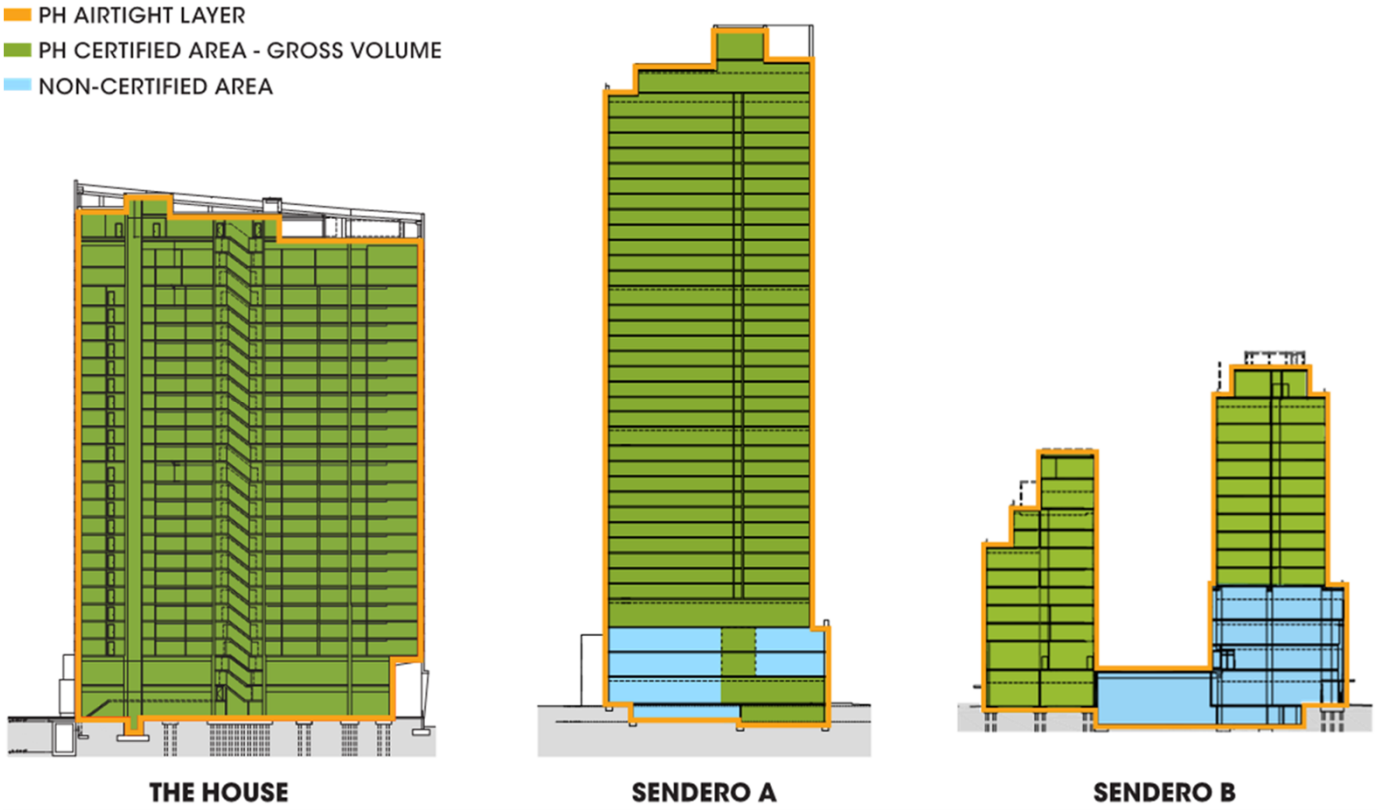
- The two boundaries work together to manage Energy, Moisture, and Increase Durability
  - Energy Control = C02 and $$$ Saved
  - Moisture Control = building durability
  - Comfort Control = happy occupants
- To Function Properly Must be:
  - Continuous (no gaps)
  - Aligned with each other

Aligned Thermal Boundary and Air Barrier

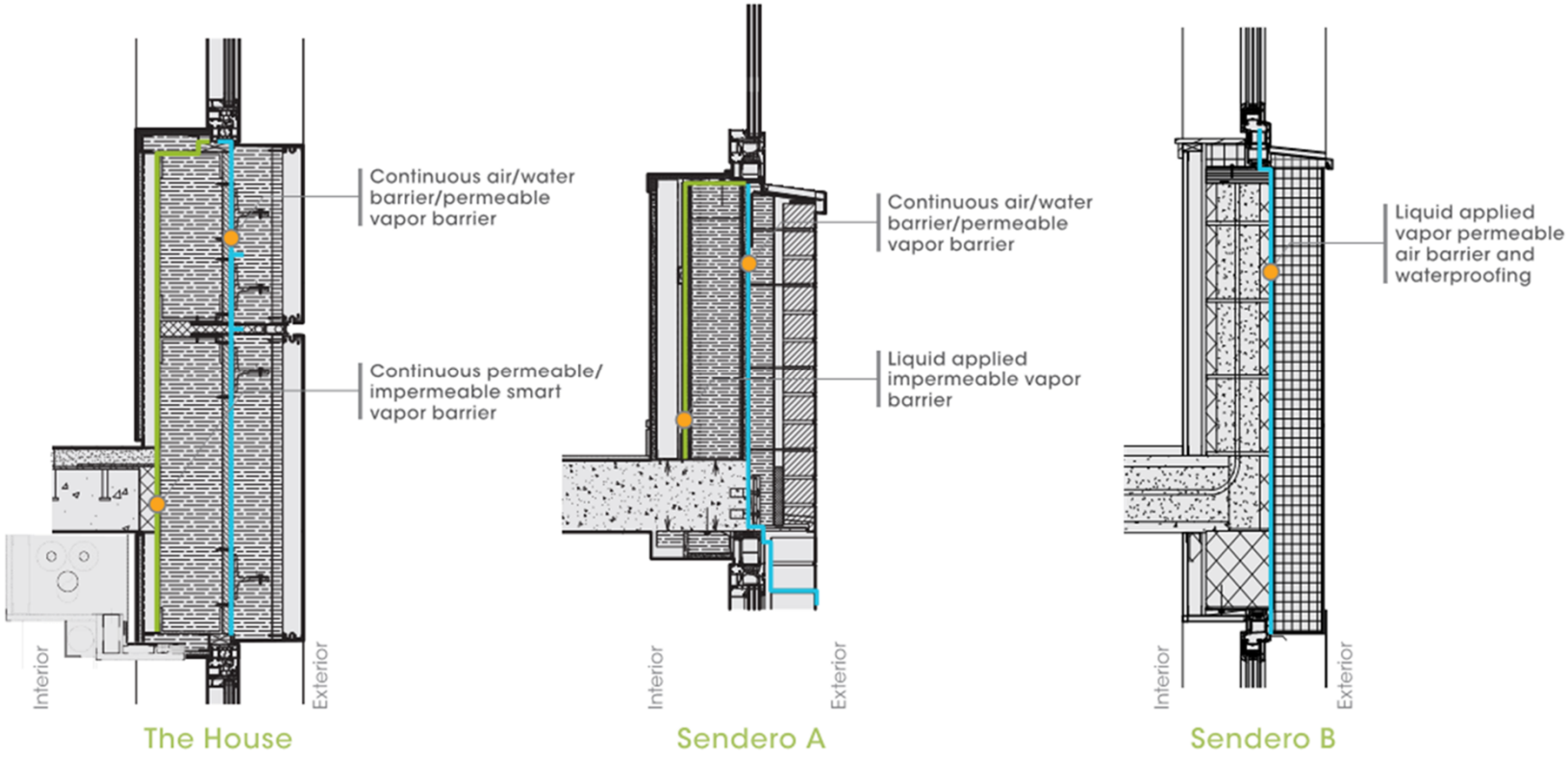




Exterior Wall Comparison: Air-Tightness



Exterior Wall Comparison: Air Tightness



Questions?



15 Minute Break

Thermal Insulation

Thermal Boundary

- Location of insulation in the building enclosure
- Type of insulation
- Amount of insulation (thickness and area)
- Quality of installation (good, fair, poor)
- Is insulation protected from wind-washing?
- Is insulation protected from moisture?

What is the conditioned boundary?!!!!



R-value
($h \cdot ft^2 \cdot °F/Btu$)

- R-value is a measurement of a material's resistance to conductive heat transfer
- The higher the R-value, the better the insulator

R-values of Common Insulations

Type	R-value/Inch
Fiberglass	2.4 – 4
Cellulose	2.4 – 3.8
Open cell SPF	3.6 – 4.5
Closed cell SPF	5.6 – 7
Mineral wool	3.5 – 4.5
Extruded Polystyrene	5 – 5.5
Polyisocyanurate	6.0 – 6.5

Factors Affecting Insulation Performance

- Compression (refer to manufacturer's compression charts)
- "Fluffing", especially blown fiberglass
- Voids and gaps, inconsistent coverage
- Moisture
- Not in contact with the surface it is insulating



Fiberglass Batts

Fiberglass Batts (R-19 to R23) *CAN* be Effective if Grade I Kraft facer is Class II vapor retarder





Blown
Cellulose

- Damp-Spray and Dense-Pack Cellulose (R-19 to R-23)
- Air and vapor permeable, will hold moisture
- Dense Pack can contribute to air-tightness

Open-Cell Foam (ocSPF)





- Approximately R-3.5 per inch (varies)
- Rated as air-impermeable, but **vapor permeable**
- Easy to rake flush with framing
- Hydrophobic but can hold water
- Respirators and safety measures required

Closed-Cell Foam (ccSPF)

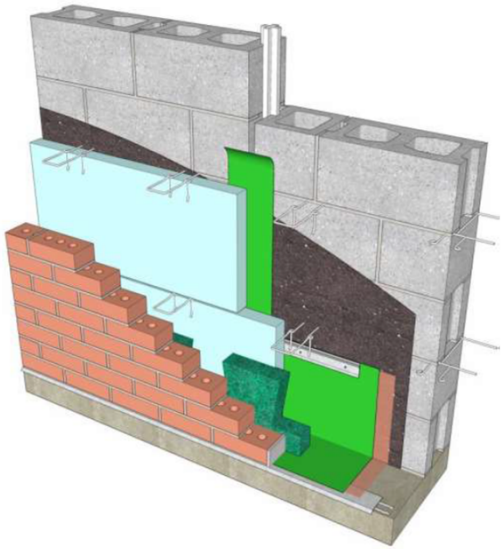




- Approximately R-6.5 per inch
- Air and vapor impermeable
- Installation QA and shrinkage can be concerns
- Respirators and worker safety measures required
- Improved blowing agents but still a GWP concern

Extruded Polystyrene (XPS)





- Can be effective WRB; joints critical
- Monolithic material with no facer
- Material is very water tolerant (below grade uses)
- R-5 per inch (5.4/inch available)
- Class II VR (thickness dependent)

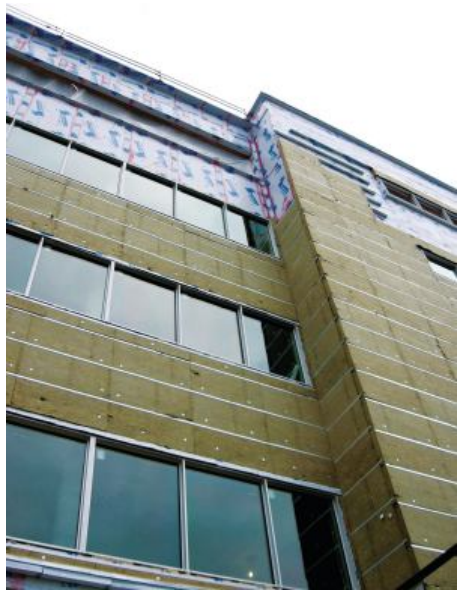




Polyisocyanurate

- R-6.5/inch
- Air and vapor impermeable if faced (other facers available)
- Can serve as air-barrier and water-resistive barrier
- Common above-deck roof insulation

Mineral Wool Insulation

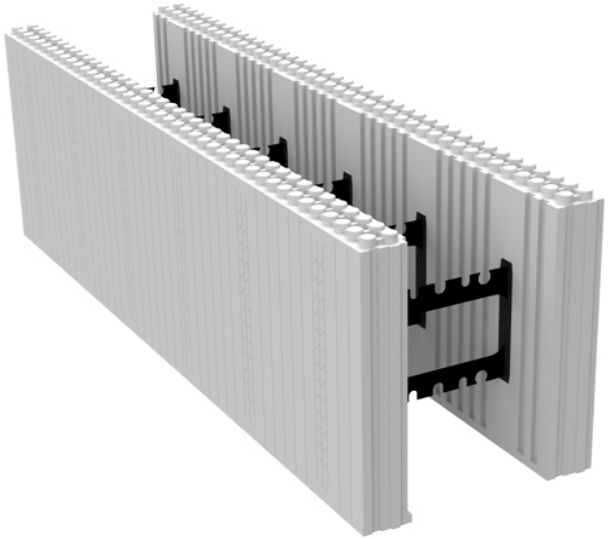


- Exterior continuous semi-rigid
- R-4.2/inch
- Air and vapor permeable
- Drainable; used in rain screens



- Interior batts
- R-14 (2 x 4); R-24 (2 x 6)
- Air and vapor permeable

Expanded Polystyrene (EPS)





- Vapor and air-permeable
- Monolithic material with no facer
- Material is very water tolerant
- R-4 per inch (R-4.7/inch available)

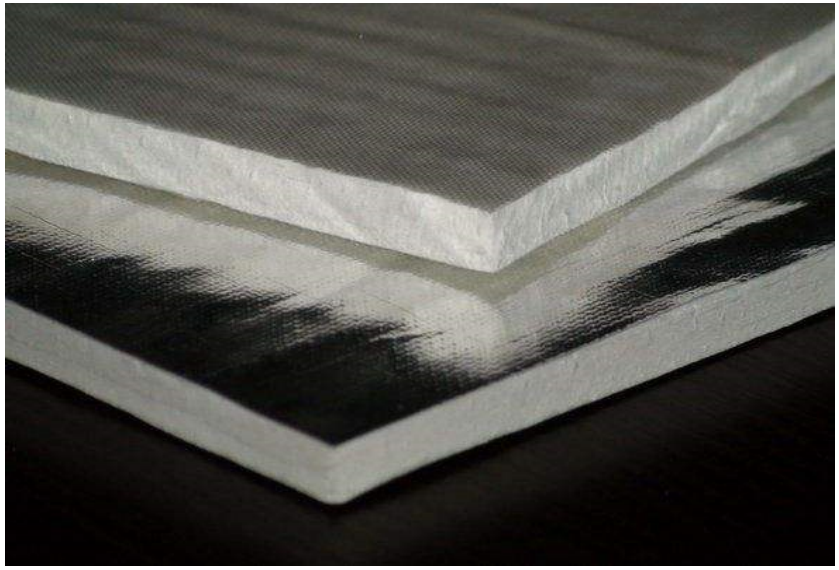
Autoclaved Aerated Concrete AAC





Specialty Insulations (Aerogel)





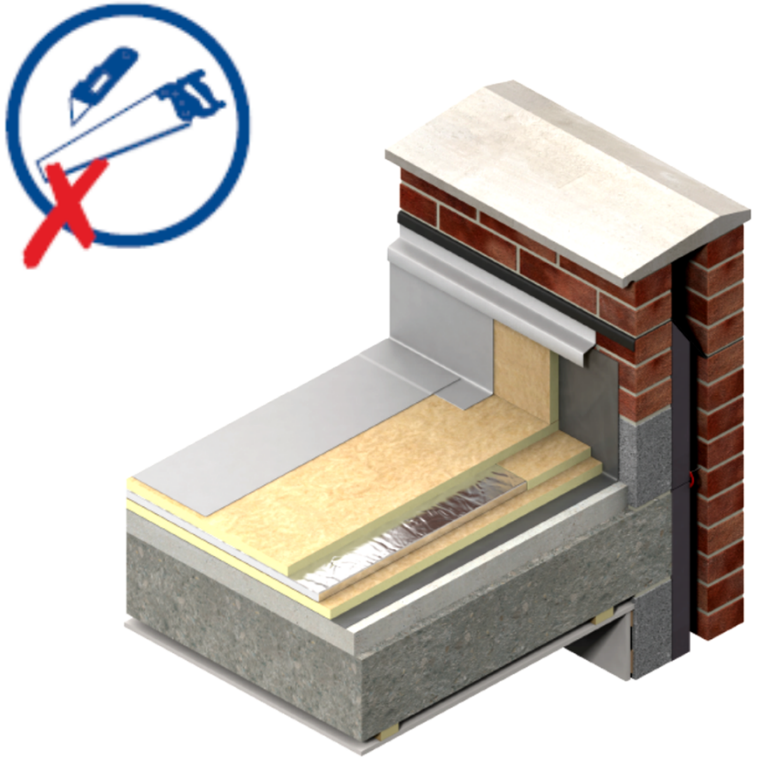
- High R Thermal break and dewpoint control
- Up to R-10 per inch; Useful in space-limited applications

Specialty Insulations Aerolon





- High R Thermal break and dewpoint control
- Effective where space is very limited and at interior to exterior structural elements

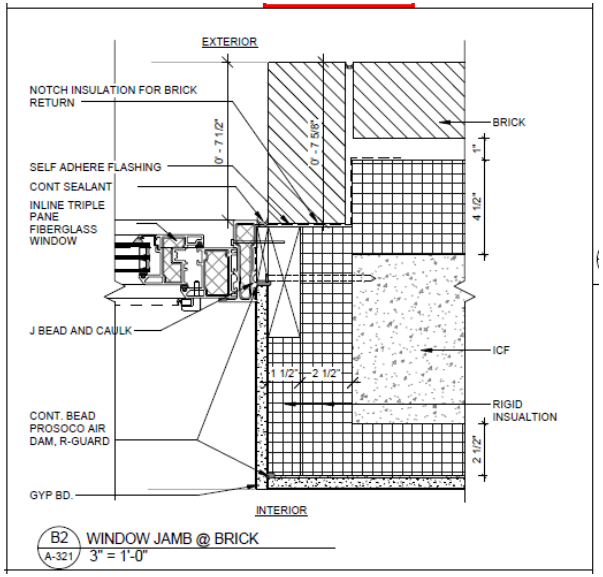


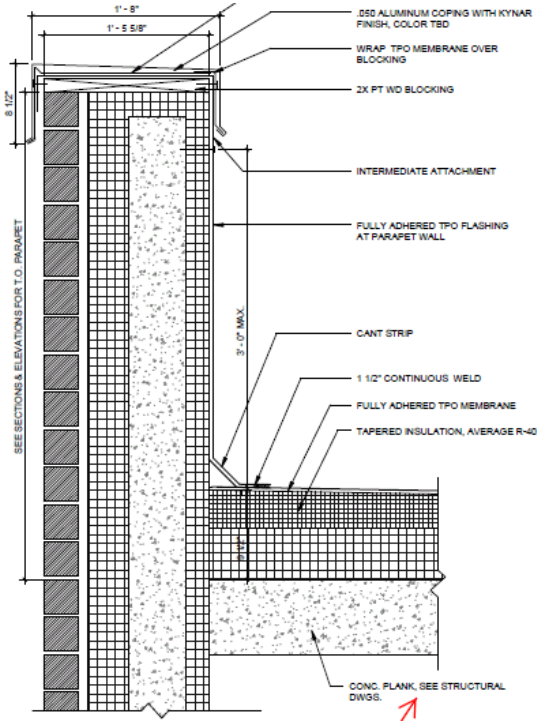
Specialty Insulations: Vacuum Insulated Panels (VIP)

- Up to R-30 per inch (field);
- Up to R-25 per inch including edge calculation de-rate
- May not be cut or punctured

Continuous Insulation







Questions?



Innovative Materials and High-Performance Assemblies

High Performance Walls Guide

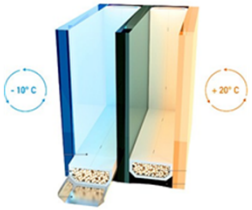
CLADDING ATTACHMENT SYSTEMS AND THEIR IMPACT ON CONTINUOUS EXTERIOR INSULATION EFFICIENCY

Document Summary: This document is meant to serve as a guide for designers and builders to compare the thermal performance of different cladding attachment systems. The first section is a catalogue of products, split into brick veneer and cladding finish systems. The second section presents thermal modeling results of these systems from a study conducted by Steven Winter Associates (SWA).

Thermal Efficiency: percentage of continuous insulation R-value that is effective.

- **100%** thermal efficiency = continuous insulation without thermal bridging
- **20%** thermal efficiency = continuous insulation derated to 20% of installed R-value

Innovative Materials Schedule

	B-1	Thermal Clip	Thermal clip assembly with thermal studs/isolators. Improves performance by 60 - 90%.
	CMU-2	Insulated CMU Block	12" Block - R22 10" Block - R20 8" Block - R6
	G-1	Vapor Permeable Gasket	Incoming conduit & pipes Install in sequence!
	GS-1	Warm Edge IGU Glass Spacers	Can lower IGU U values by approx .04 as compared to standard aluminum spacer.

Innovative Material Schedule

	ISO-1	Schock - ISO-1	Thermal isolators - Steel to Steel. Concrete to concrete available. Parapet isolators too.
	ISO-3	General Plastics	Load bearing thermal isolator. Pre-cut and pre-drilled
	T-1	Vapor Permeable/ Impermeable Tapes	1. Windows & Door openings 2. Inside face of exterior wall in contact with vapor barrier 3. Inside face of exterior wall in contact with vapor barrier 4. Interior walls adjacent to hammerhead shear walls
	V-1	Vapor Retarder	Inside face of exterior wall

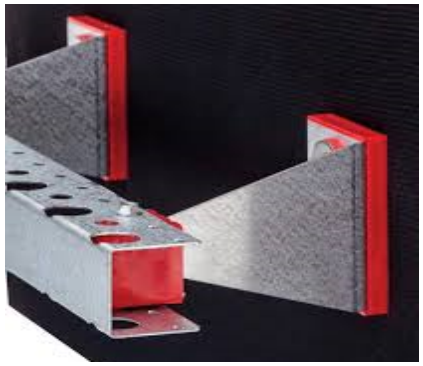
Cladding Attachment Thermal Break



Stainless Steel Clips
Thermal Efficiency
63% Steel Backup
74% CMU Backup

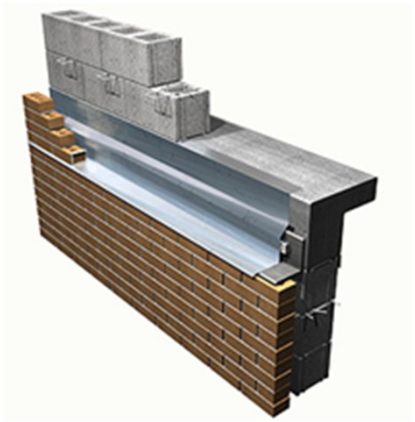


Fiberglass Clips
Thermal Efficiency
64% for Steel Backup
79% for CMU backup



Thermal Stop Clips
Thermal Efficiency
67% for Steel Backup
80% for CMU Backup

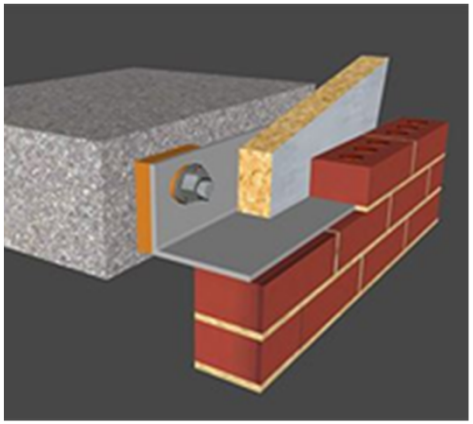
Thermal Bridging: Shelf Angle



Typical Shelf Angle
Thermal Efficiency
55% Steel Backup
67% CMU Backup

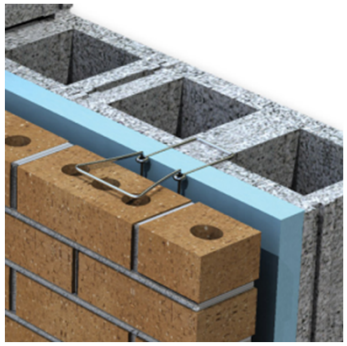


Stand-off Angle
Thermal Efficiency
72% Steel Backup
81% CMU Backup

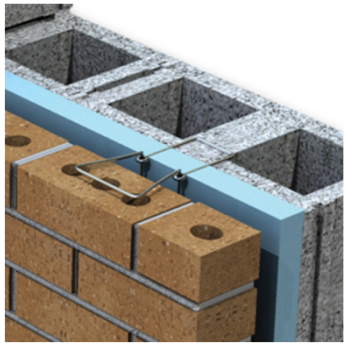


Angle with 1" Thermal Break
Thermal Efficiency
80% Steel Backup
86% CMU Backup

Brick Ties



Galvanized Steel Brick Ties
Thermal Efficiency
75% Steel Backup
84% CMU Backup



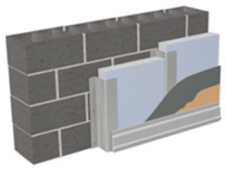
Stainless Steel Brick Ties
Thermal Efficiency
87% Steel Backup
93% CMU Backup



Thermal Break Brick Ties
Thermal Efficiency
88% Steel Backup
94% CMU Backup

Cladding
Attachments : Girts

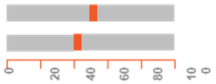
Galvanized Girts



Description

Typical z-girts are usually galvanized steel. Most projects use these to support their cladding systems.

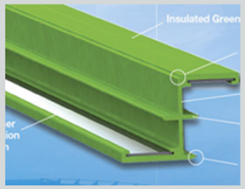
Thermal efficiency per SWA: **43%-53%**



53% for Steel backup
43% for CMU backup

Standard Product

Fiberglass Girts



Description

Fiberglass girts are installed and used the same way as typical metal z-girt. The fiberglass material reduces thermal bridging.

Thermal efficiency per SWA: **91%-95%**



91% for Steel backup
95% for CMU backup

Example Products:
Green Girt- Simple Z

Thermoset Resin Girts



Description

These girts have a low thermal conductivity. Made of fire resistant resin material. Can be spaced 16" or 24" o.c. and is very strong.

Thermal efficiency per SWA: **96%**



96% for Steel backup
96% for CMU backup

Example Products:
Armatherm Z Girt

Cladding
Attachments: Clips

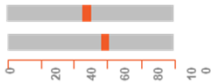
Galvanized Metal Clips



Description

These clips are usually galvanized steel and are used to support rainscreen and panel cladding systems.

Thermal efficiency per SWA: **46-59%**



46% for Steel backup
59% for CMU backup

Standard Product

Stainless Steel Clips



Description

Replacing galvanized steel clips with stainless steel ones can greatly reduce the thermal conductivity.

Thermal efficiency per SWA: **63-74%**



63% for Steel backup
74% for CMU backup

Example Products:
A-Clip. MFSSCHAN

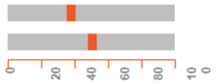
Aluminum Clips



Description

Aluminum clips are light weight and strong. They are a more elastic and non corrosive alternative to traditional metal clips.

Thermal efficiency per SWA: **38-52%**



38% for Steel backup
52% for CMU backup

Example Products:
Alpha Brackets

Fiberglass Clips



Description

Fiberglass clips have a much lower thermal transmittance coefficient than any metal equivalent.

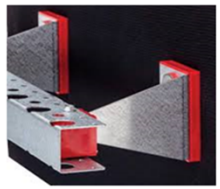
Thermal efficiency per SWA: **64-79%**



64% for Steel backup
79% for CMU backup

Example Products:
Cascada Clip

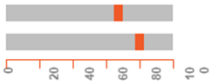
Thermal Stop Clips



Description

This clip has a plastic thermal stop at the base and head to help mitigate thermal bridging.

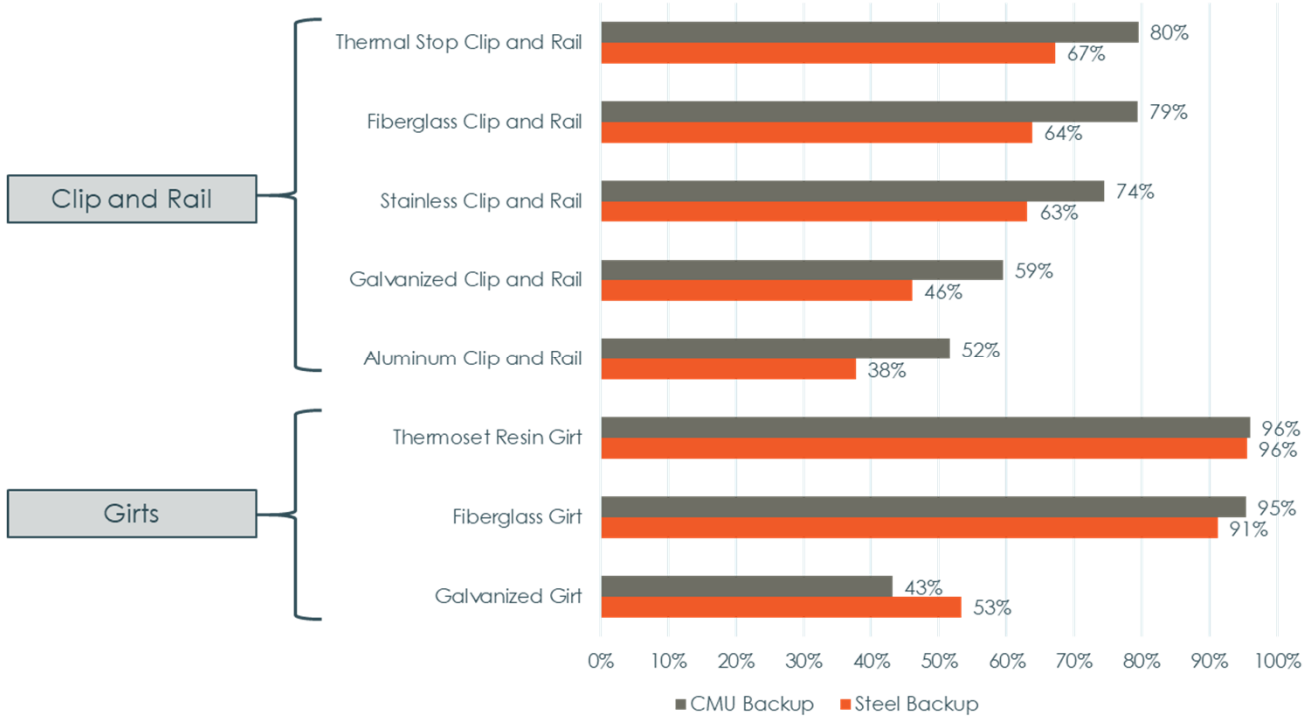
Thermal efficiency per SWA: **67-80%**



67% for Steel backup
80% for CMU backup

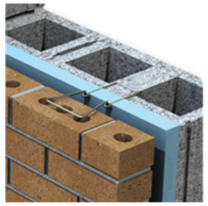
Example Products:
Pos-I-Tie Thermal Clip, Nvelope NV1 Thermal Clip

Efficiency Comparison: Panel Cladding



Brick Veneer: Ties

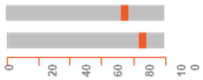
Galvanized Steel Brick Ties



Description

Typical brick ties are galvanized steel. Most brick veneer projects use this type of product.

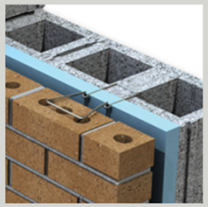
Thermal efficiency per SWA: **75-84%**



75% for Steel backup
84% for CMU backup

Standard Product

Stainless Steel Brick Ties



Description

Stainless steel ties are less conductive than galvanized steel ties.

Thermal efficiency per SWA: **87-93%**



87% for Steel backup
93% for CMU backup

Example Products:
2 Seal Tie Thermal, Original Pos-I-Tie

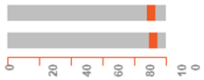
Thermal Break Brick Ties



Description

This stainless steel brick tie has a plastic coating, which reduces thermal bridging.

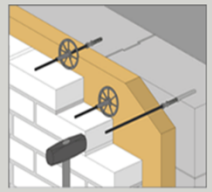
Thermal efficiency per SWA: **88-94%**



88% for Steel backup
94% for CMU backup

Example Products:
2 Seal Tie Thermal Wing Nut Anchor

Basalt Fiber Wall Ties



Description

Basalt fiber is a material made from fine fibers of basalt. They tend to be stronger and lighter than stainless steel wall ties and much less thermally conductive.

Example Products:
Teplo Ties, Galen Wall Ties

Connectors



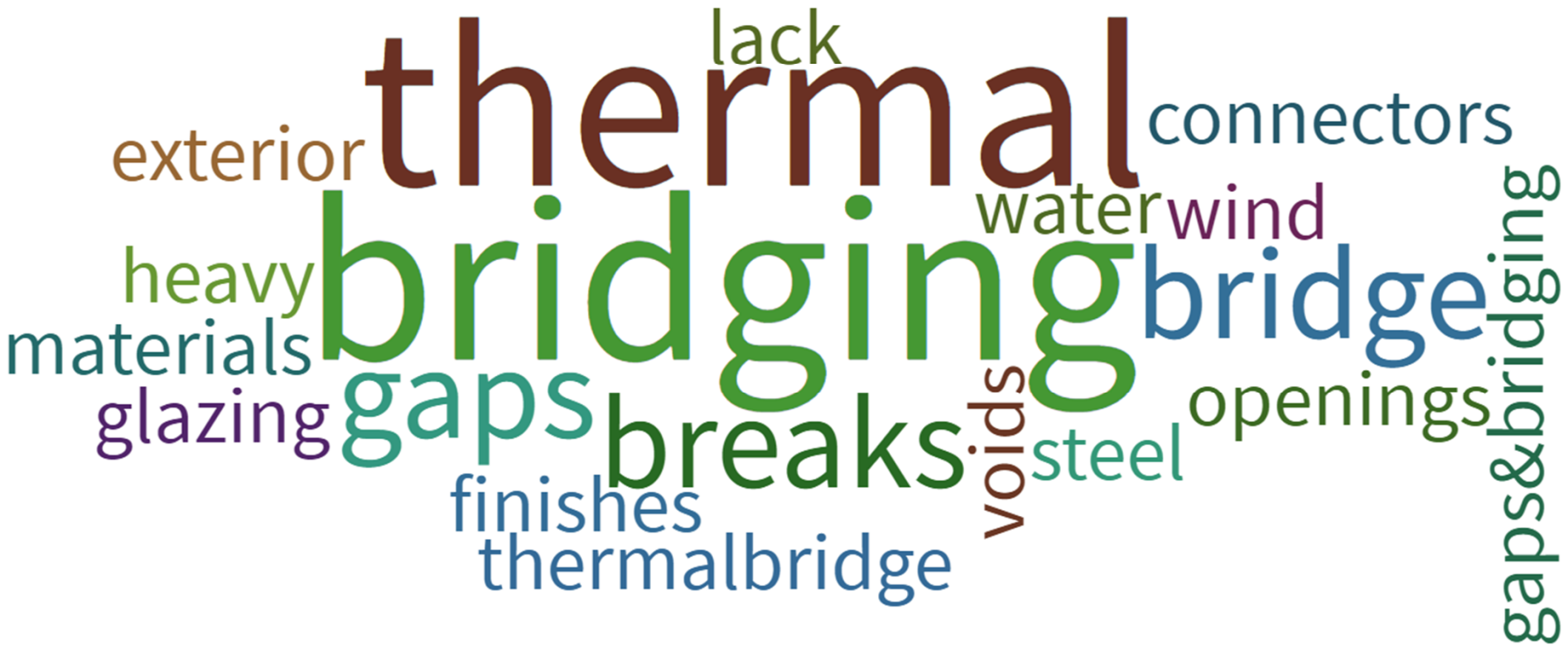
Description

These are used in place of brick ties. The combination of horizontal and vertical elements increases strength despite its small size.

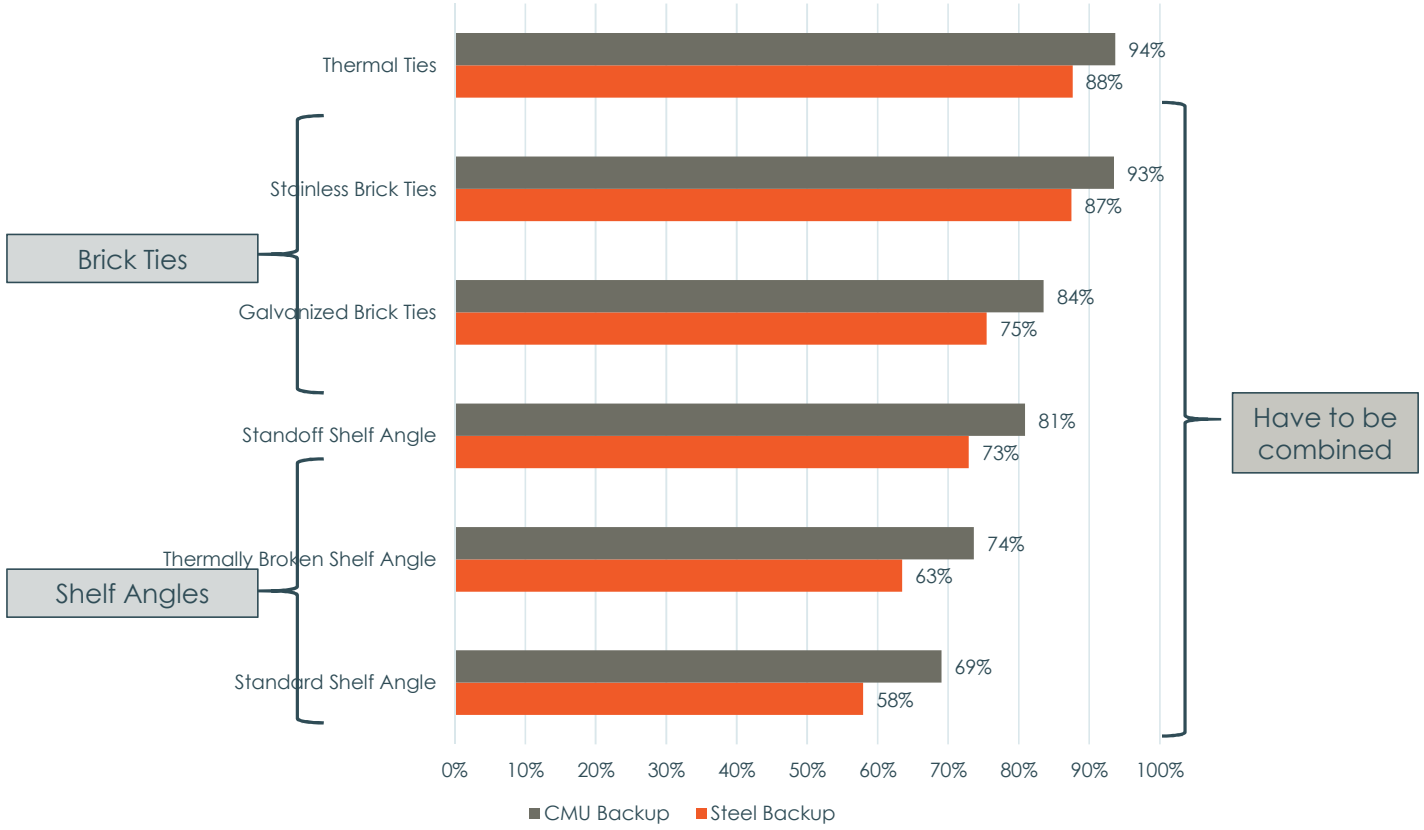
These can be applied prior to liquid applied air barrier installation, so air tightness is improved.

Example Products:
Block Shear Connector

What diminishes effective R-values in walls?



Efficiency Comparison: Brick Ties



Eff. Comparison: Shelf Angles

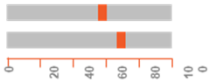
Typical Shelf Angle



Description

Typically, shelf-angles are made of galvanized steel.

Thermal efficiency per SWA: **58-69%**



58% for Steel backup
69% for CMU backup

Standard Product

Stand-off Shelf Angle



Description

This stand off shelf angle allows insulation to be installed behind it. The bracket can be used with readily available shelf angles.

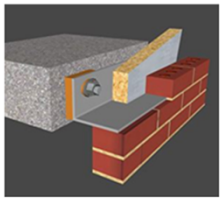
Thermal efficiency per SWA: **73-81%**



73% for Steel backup
81% for CMU backup

Example Products:
FAST (Fero Angle Support Technology),

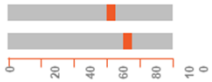
Shelf Angle with Thermal Break



Description

The thermal break plate is installed between the shelf angle and bracket to reduce the thermal bridge at those points.

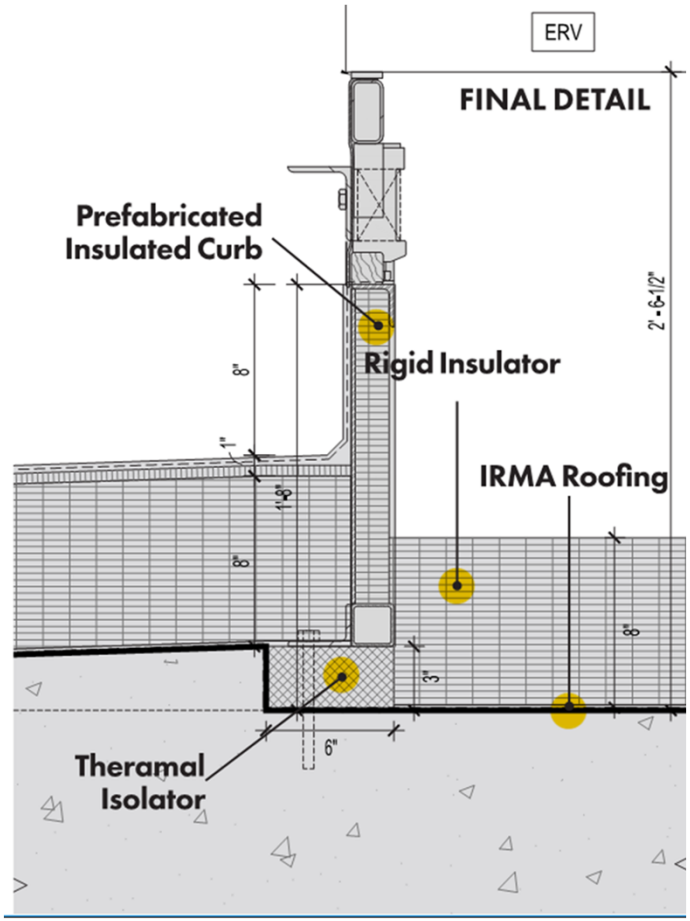
Thermal efficiency per SWA: **63-74%**



63% for Steel backup
74% for CMU backup

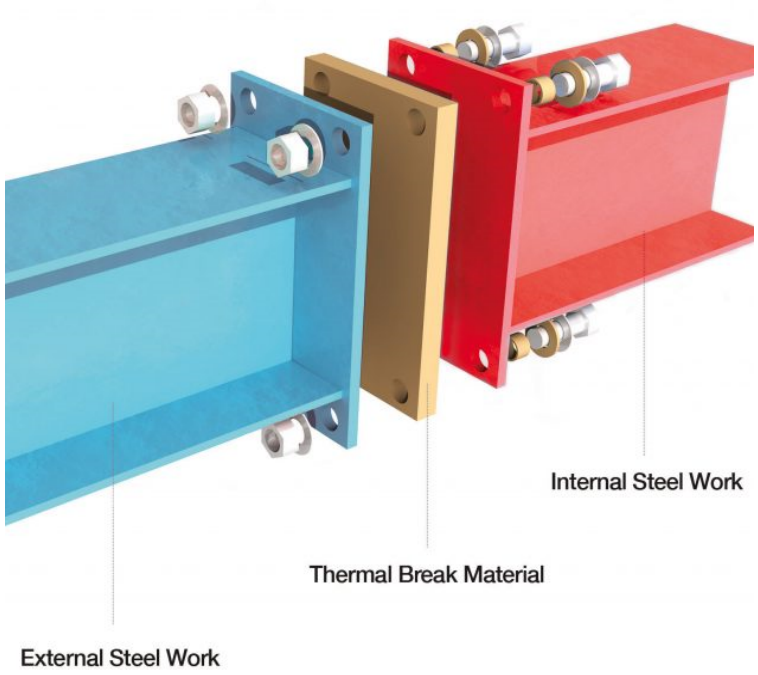
Example Products:
Armatherm Shelf Angle

Structural Thermal Breaks

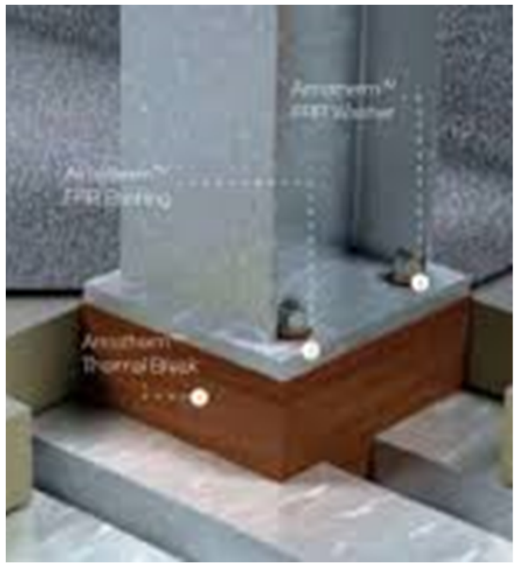




Structural Thermal Breaks

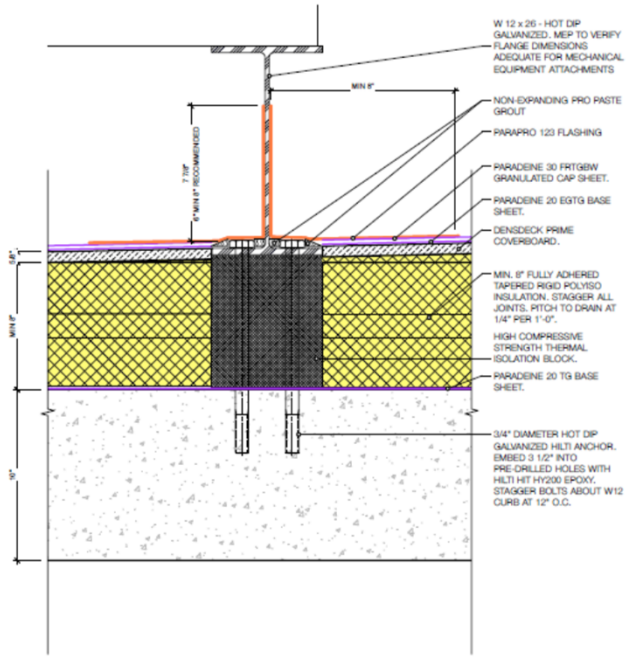






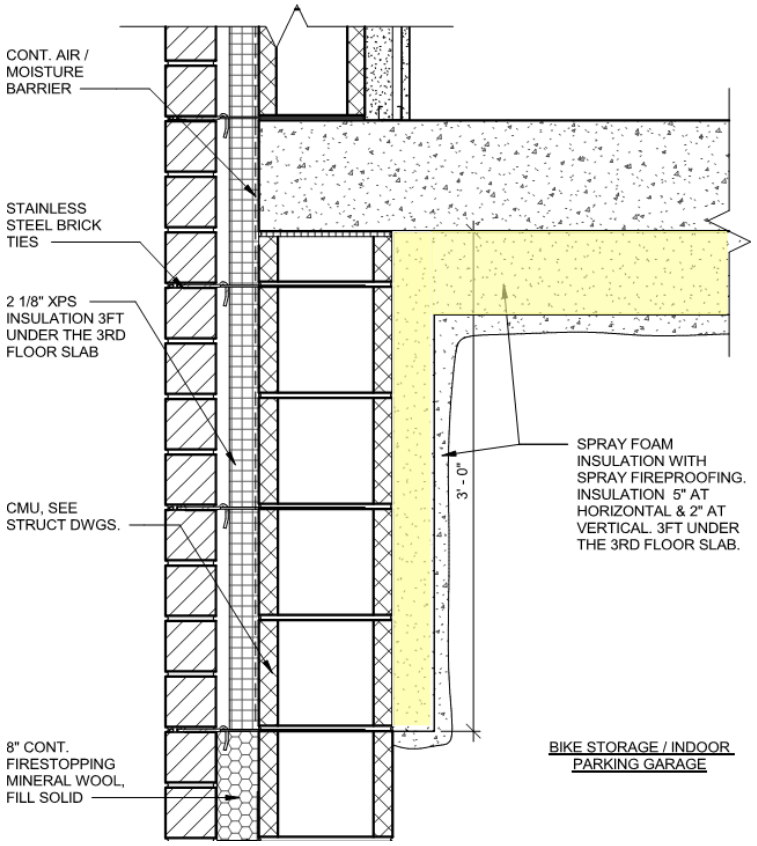
Thermal Separation at Dunnage

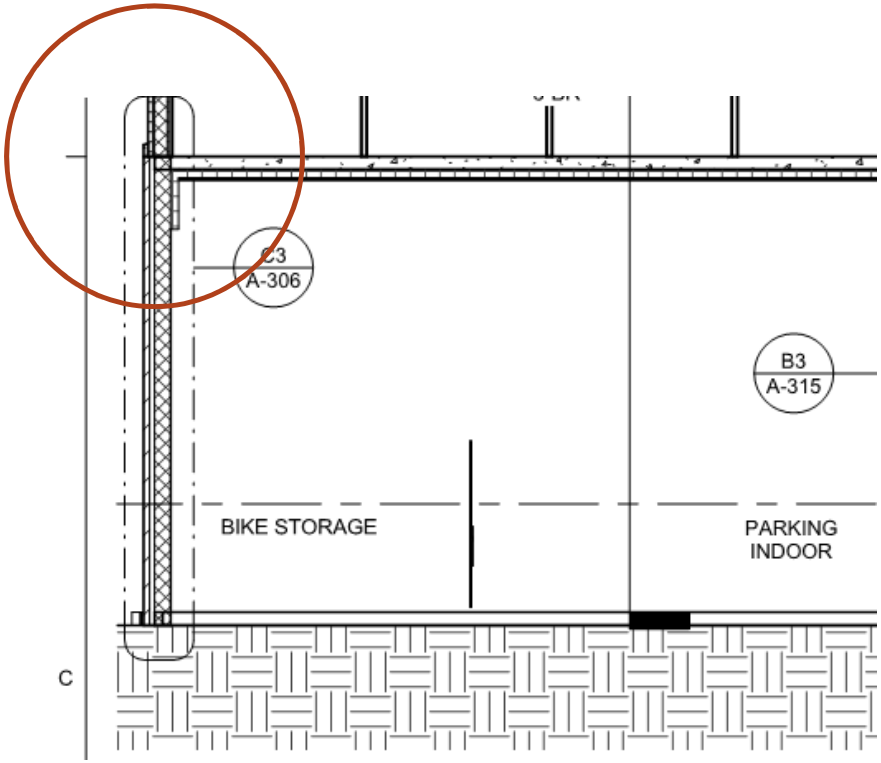




1 TYPICAL ROOF DUNNAGE UPSTAND DETAIL
Scale: 3" = 1'-0"

Thermal Separation at Structure





Questions?



Effects of Thermal Bridges on Assembly R-Value

Comparing Three Different Projects



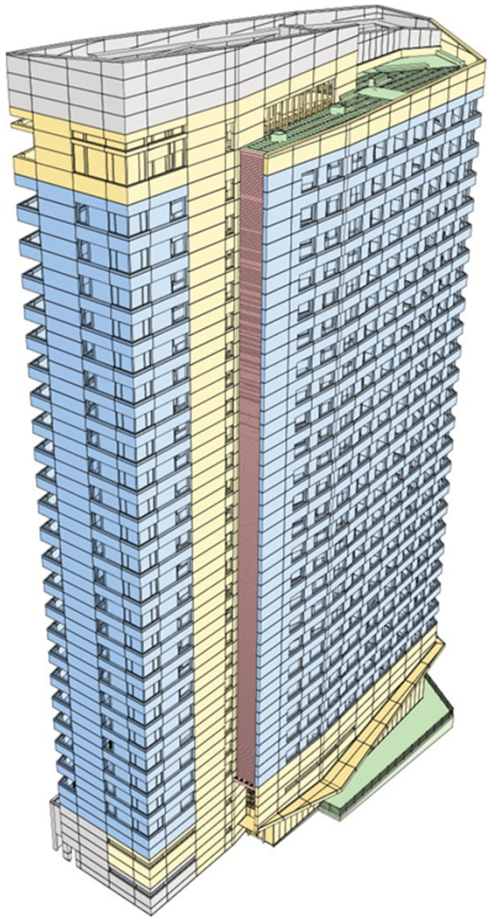
TEAM

Cornell University | Hudson Companies | Related Companies
Handel Architects | Steven Winter Associates | Buro Happold
Vidaris | Monadnock Construction



TEAM

Jonathan Rose Companies | L+M Development Partners | Acacia Network | Handel Architects | Steven Winter Associates
Cosentini | DeSimone Consulting Engineers | Vidaris



PROJECT SUMMARY

- 26 stories
- 352 units
- Lobby, fitness room, laundry, lounge, party room
- Split system VRF for heating and cooling
- Centralized ventilation using 2 Rooftop ERV's
- Gas fired boilers for domestic hot water
- 272,500 GSF, 198,338 SF TFA - the largest residential Passive House building
- 270' to roof, 285' to top of wrap

USERS

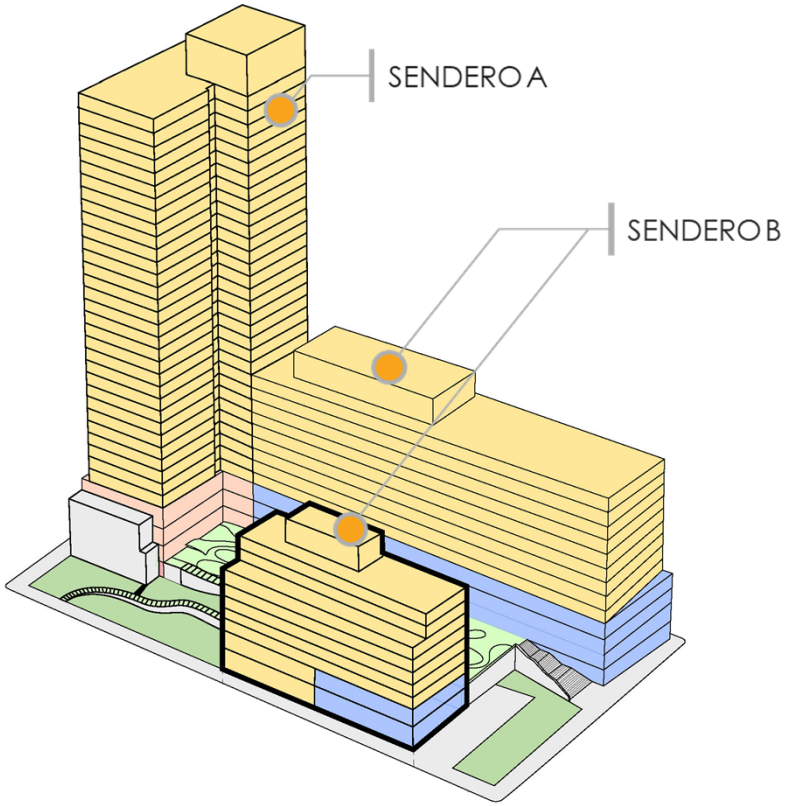

Graduate Students


PhD Candidates


Post Doctoral


Faculty

The House
Project Summary



PROJECT SUMMARY

- A: 37 stories, B: 15/9 stories
- 698 units total
- Residential amenities: lounges, fitness rooms, study rooms, roof decks
- Split system VRF for heating and cooling
- Centralized ventilation with Rooftop ERV's
- Gas Fired boilers for domestic hot water
- 650,000 GFA Residential, 249,332 SF TFA (Bldg A), 152,333 SF TFA (Bldg B North), 55,076 SF TFA (Bldg B South)
- 150,000 GFA Community Facility Spaces: High School and Supportive Services

USERS


High Shool Students

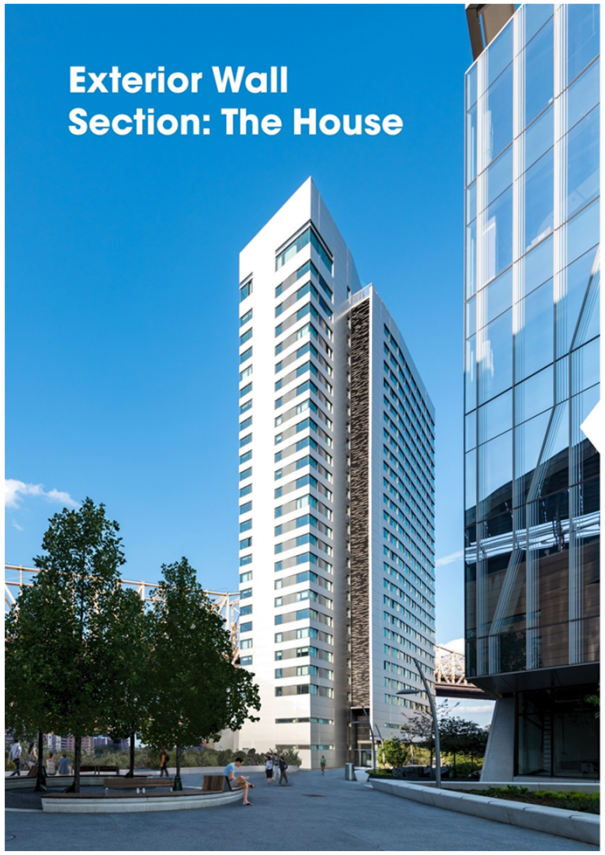

Residents

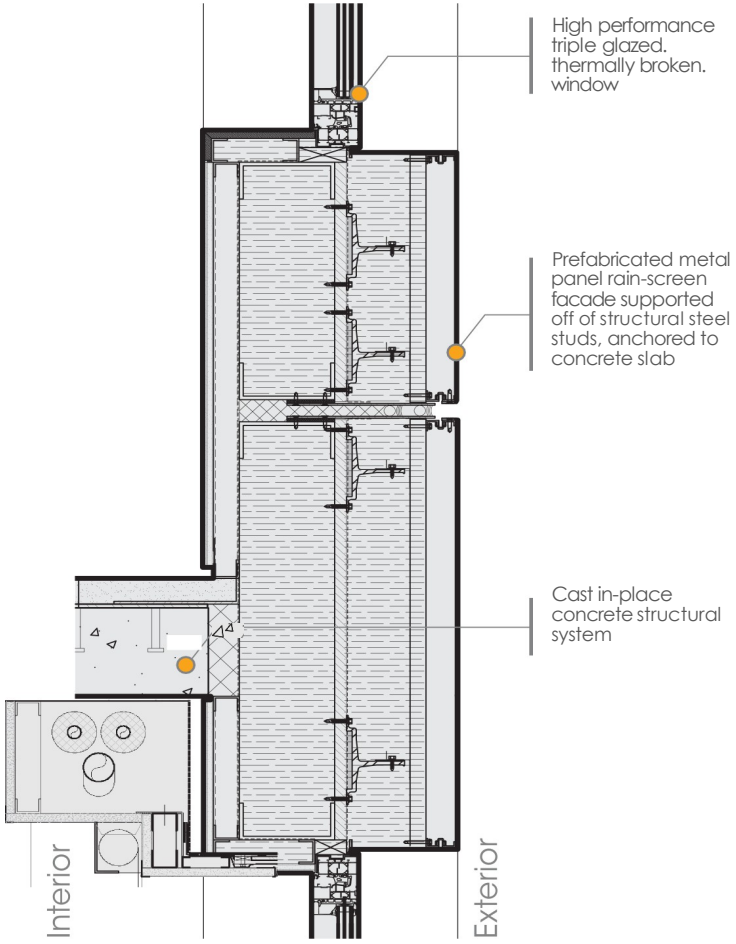

Seniors


Health Clinic Users

Sendero Project Summary

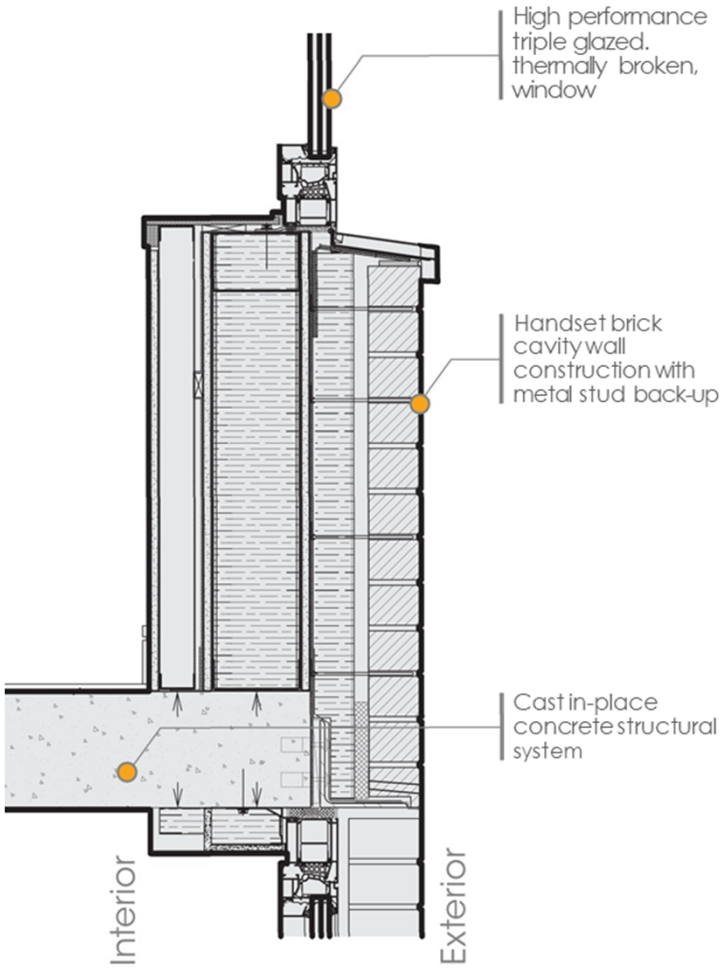
Exterior Wall Comparison





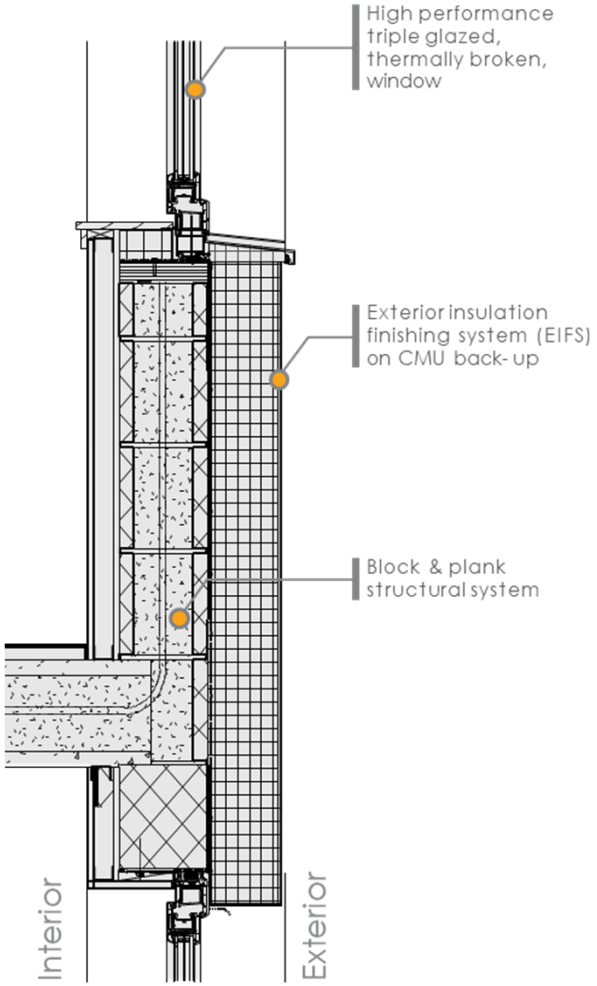
Exterior Wall Comparison





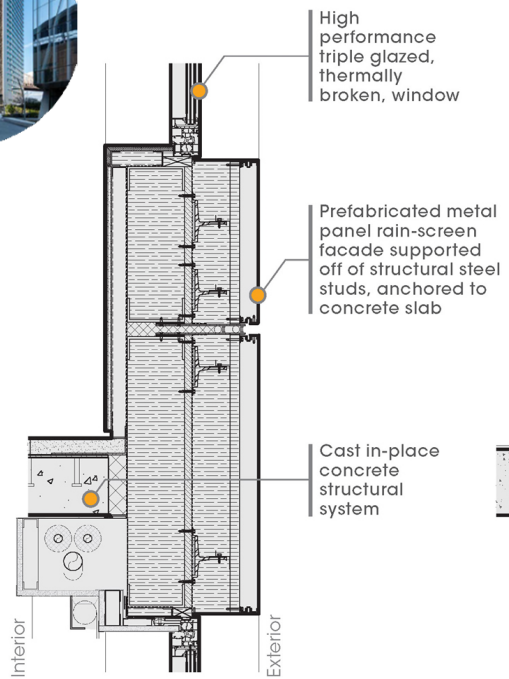
Exterior Wall Condition





EXTERIOR WALL SECTION COMPARISON

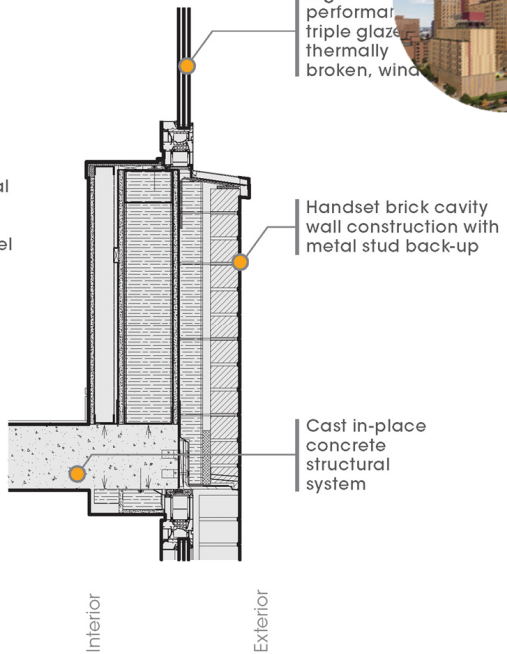




The House

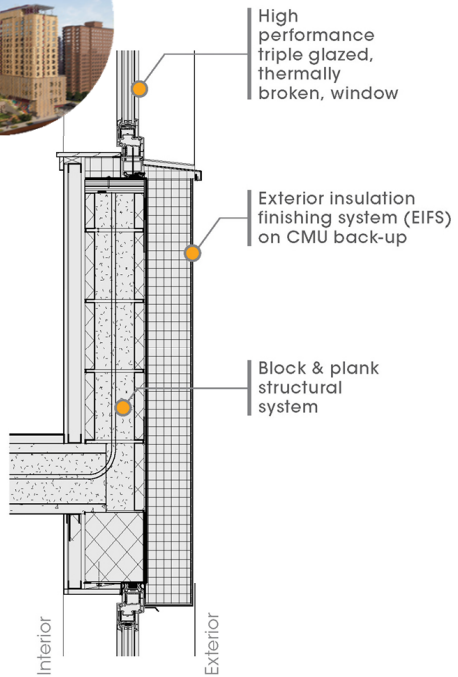
R-38





Sendero Verde Bldg. A

R-38

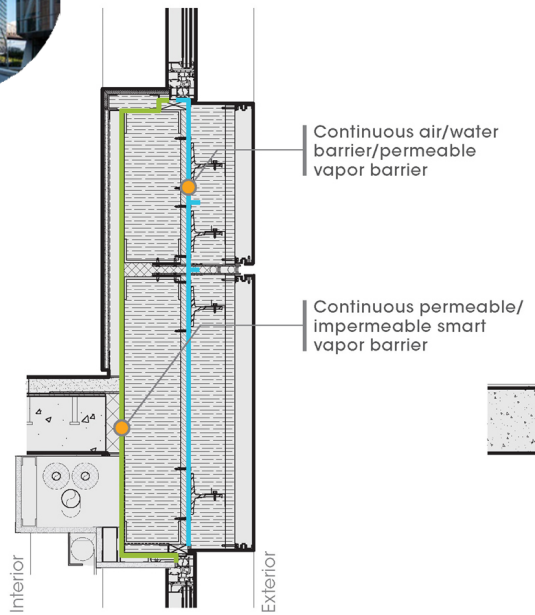


Sendero Verde Bldg. B

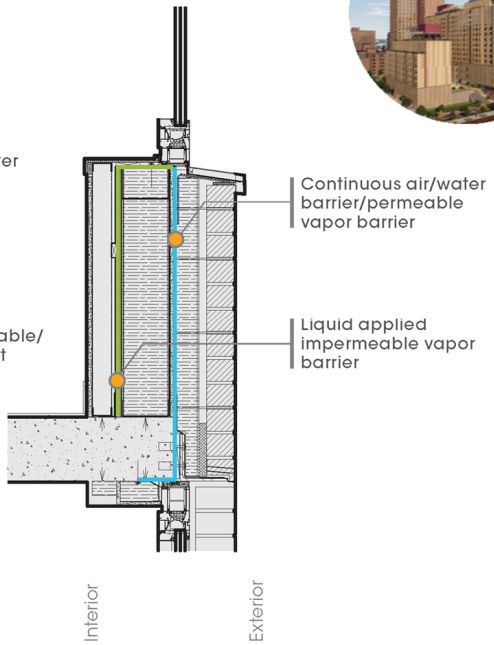
R-25

EXTERIOR WALL SECTION COMPARISON



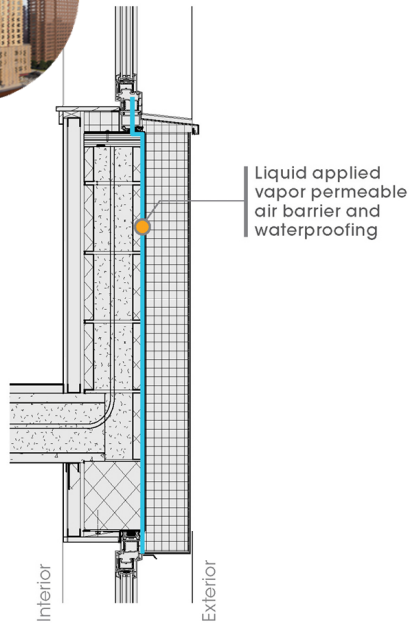


The House



Sendero Verde Bldg. A

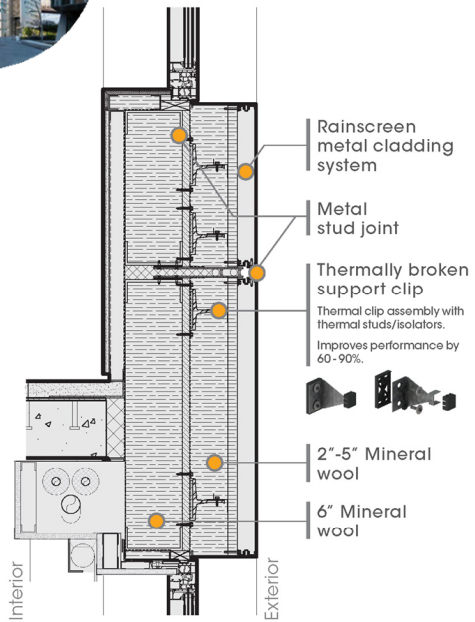




Sendero Verde Bldg. B

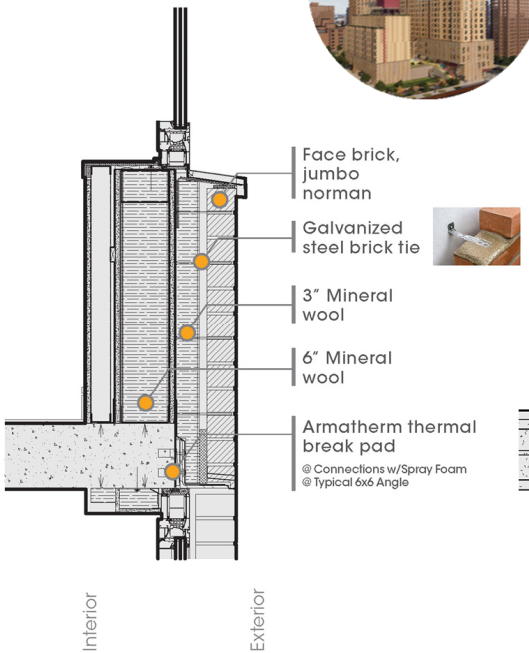
EXTERIOR WALL SECTION COMPARISON



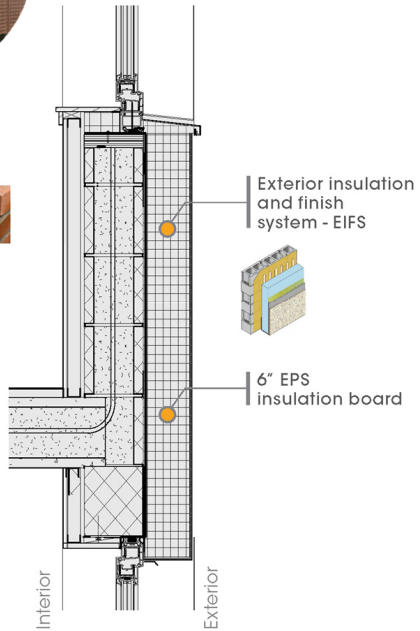


The House
R Value: R-19



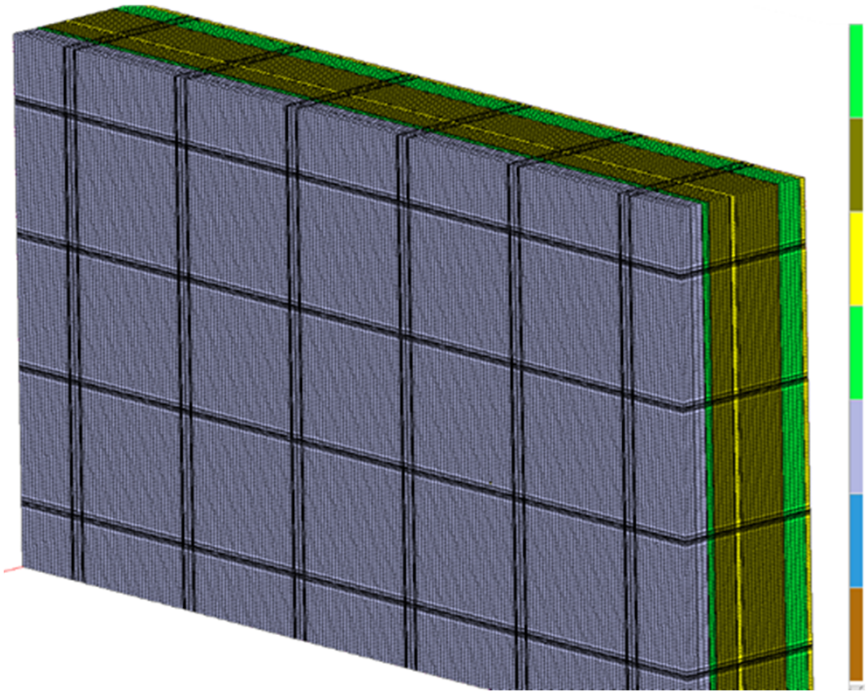


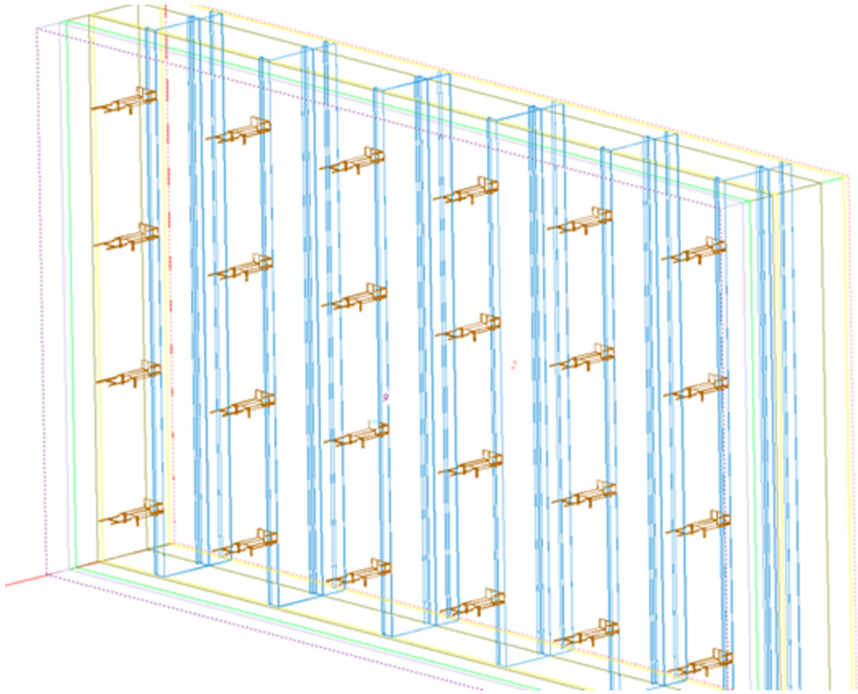
Sendero A
R Value: R-24



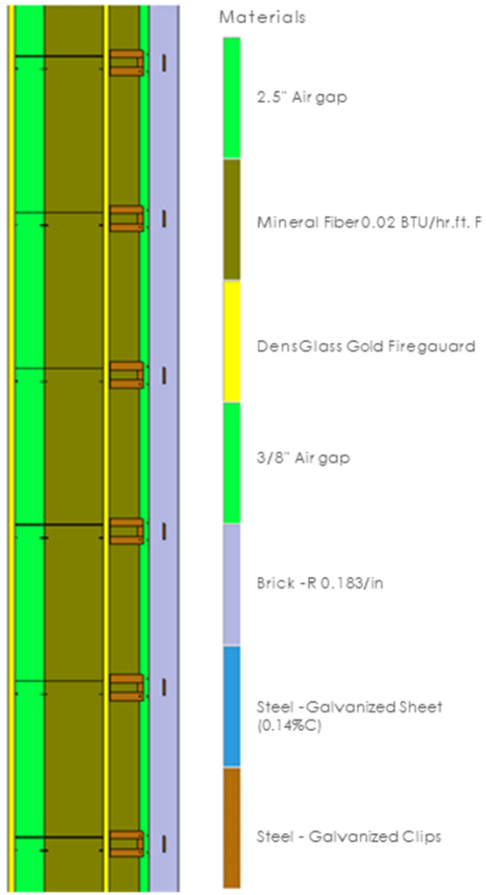
Sendero B
R Value: R-25

Exterior Wall Comparison: Heat3 Models
Sendero A





Section cut through brick ties

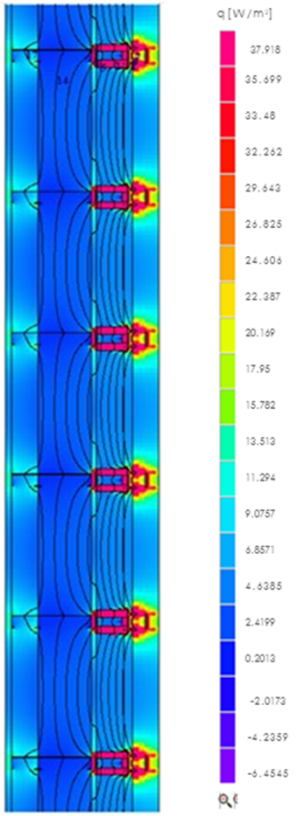


Heat flow through section

Red = more heat loss

Blue = less heat loss

Isotherm lines visible



Exterior Wall Comparison: Heat3 Models Sendero A

Which wall types do you work with mostly?

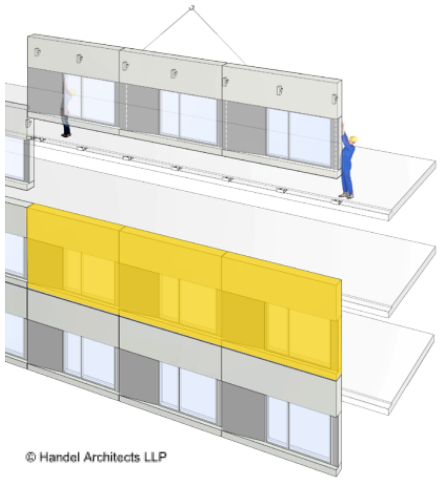


Questions?

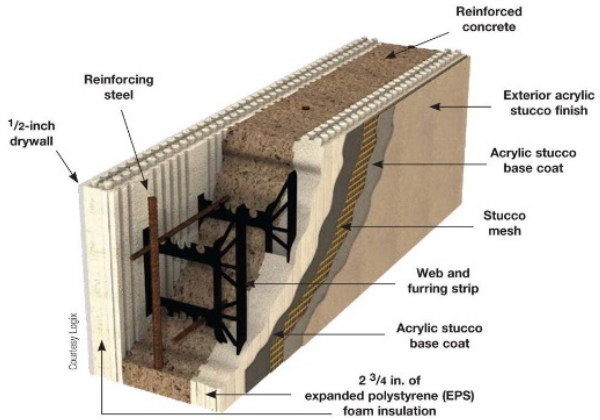


Evaluating Alternate Assemblies

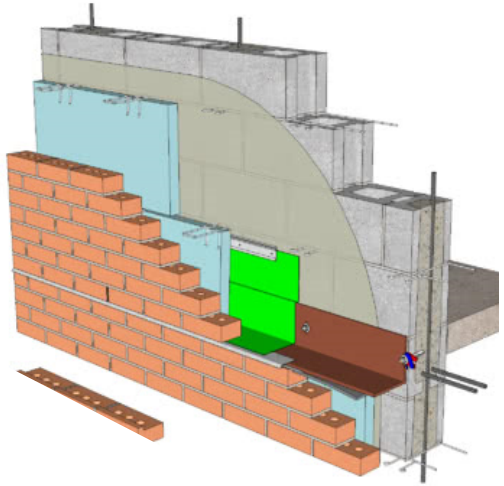
Thermal Performance / Air Barrier Pros & Cons



Prefabricated Panels
Fabricated Stud Frame Wall panel offset with water vapor barrier installed with window

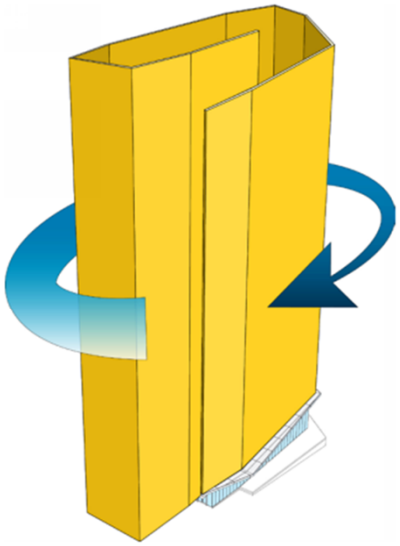


Insulated Concrete Form
Stay in place concrete form with integral straps for attachment



CMU
Concrete masonry wall with rigid insulation





© Handel Architects LLP

Prefabricated Panels Thermal Performance

Prefab Panels air-barrier and sealing

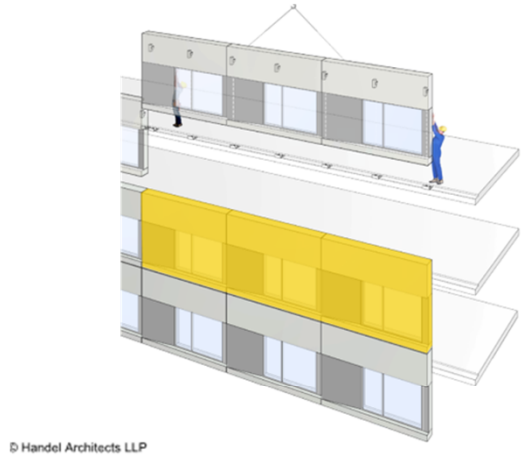
BEFORE PANEL SUPPORTS SEALED



AFTER PANEL SUPPORTS SEALED



Prefab Panels Pros and Cons





Pros

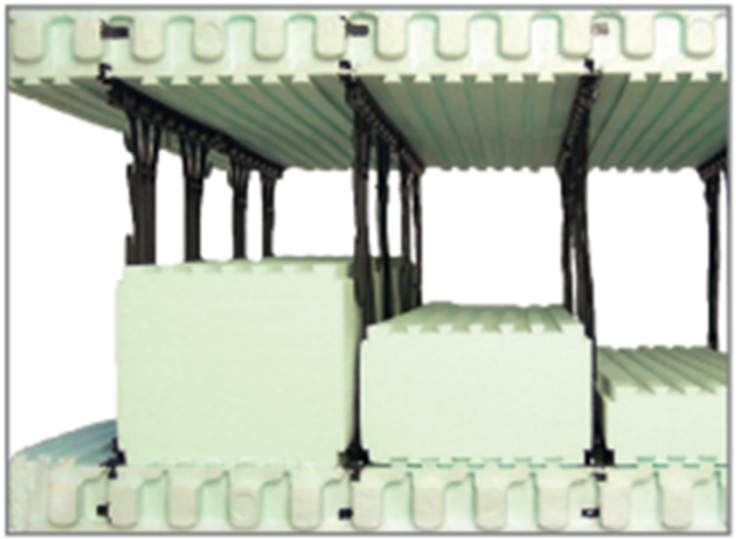
- Speed of construction
- Quality control in the factory
- Can be extremely efficient and air tight

Cons

- Cost
- Coordination and design assistance needed very early on
- Logistics/shipping to site
- Ability to perform air leakage testing on site/sequencing
- Detailing at panel edges is crucial

ICF Thermal Performance





2- 5/8” EPS each side + thermal mass of concrete for effective R-24.1
Additional insert at 2” increments up to R-48

ICF Air Barrier and Sealing



Integral cast insulated jamb are cleanest tightest detail

Avoid Panel Joint at Opening, which allow water/air infiltration

Min. Thermal bridge of Brick Angle

Coordination of Min. Penetration Sleeve

Provide reinforcement at floor edge to prevent gaps

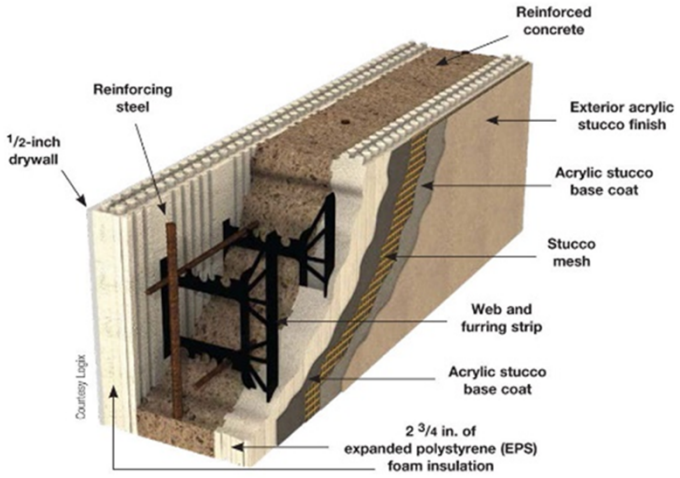
ICF Air Barrier and Sealing





Joint of ICF allow air pathway. Gyp bd finish adds to the air tightness

ICF Pros and Cons





Pros

- Reduces Trades/More done with one system
- Watertight Quickly
- Greater Design Flexibility
- Great Sound Isolation (OITC 41 to 65)
- Energy Efficiency System with high R-value and integrated air barrier

Cons

- Unfamiliar construction technology and limited sub contractor
- Implementation crucial to maintain vapor/air barrier continuity

Construction Planning and Coordination









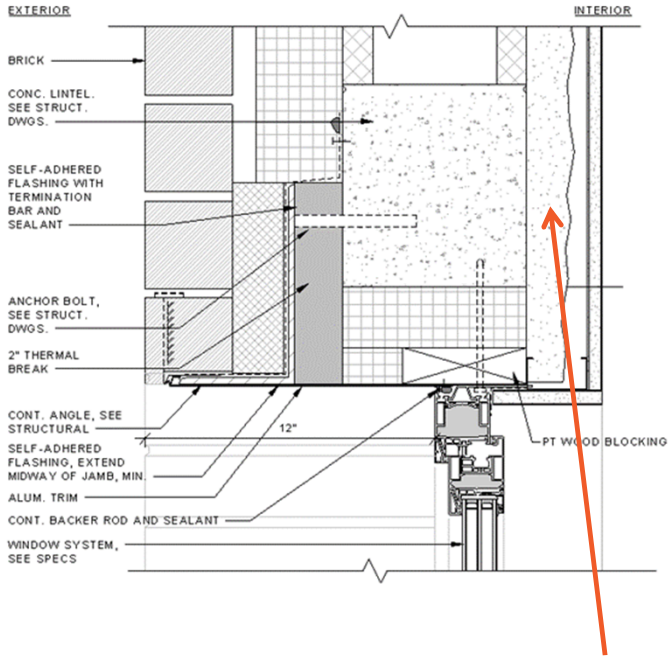
CMU Back-up Thermal Performance

Structural Thermal Break at Individual ERV opening

Exterior continuous rigid insulation + Thermal mass of grouted masonry

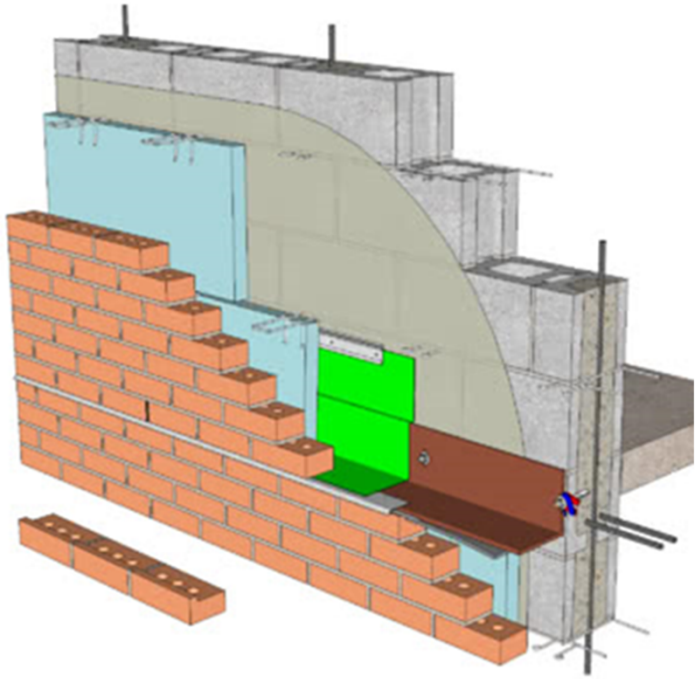
CMU Back-up Thermal Performance





Possible solution to have spray foam on the interior

CMU Back up Pros and Cons



Pros

- Ease and knowledge of construction method



Cons

- Need more diligence on air tightness
- May require more structural thermal break for façade elements

Alternate Viable Assemblies

Aerated Autoclaved Concrete



R-1.2 per inch (varies)
Compressive Strength up to 1200 psi







Exterior Cladding Options - EIFS

Exterior Cladding Options – Rainscreen







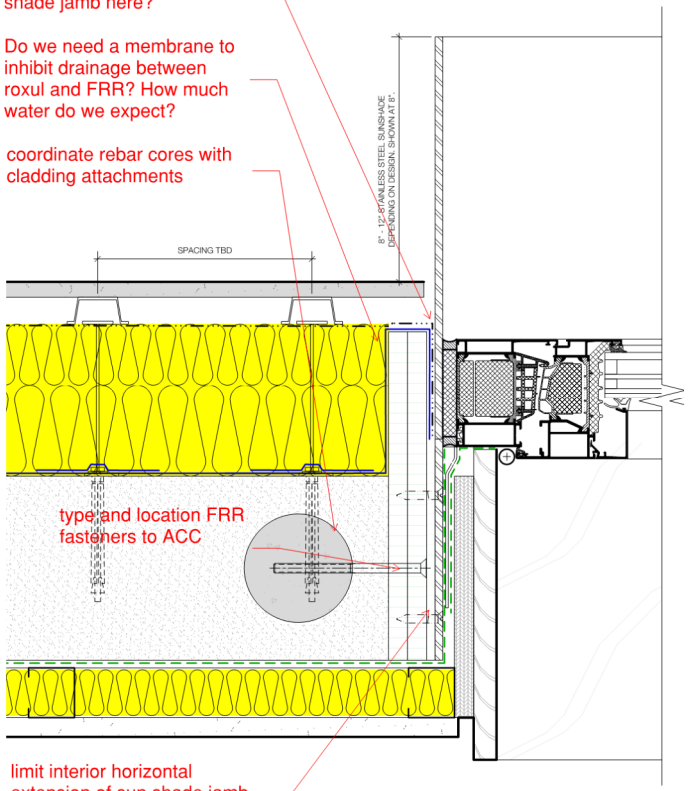
Cladding
Transitions

Detail Head and Jamb Mark Ups

How to prevent drainage between membrane and shade jamb here?

Do we need a membrane to inhibit drainage between roxul and FRR? How much water do we expect?

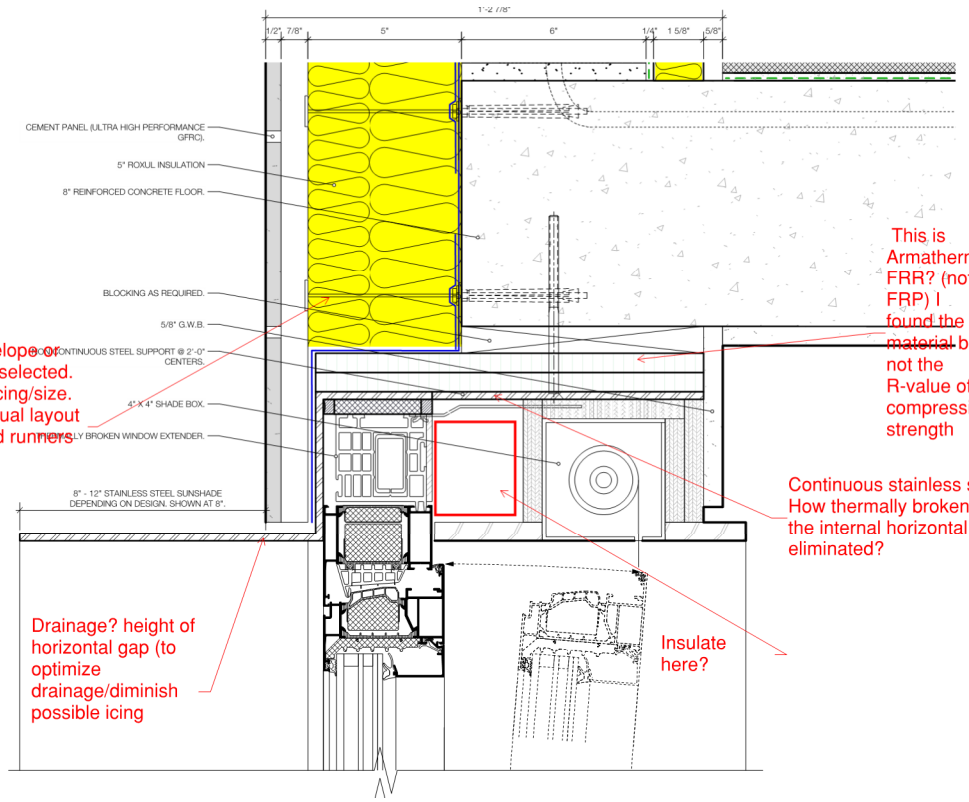
coordinate rebar cores with cladding attachments



type and location FRR fasteners to ACC

limit interior horizontal extension of sun shade jamb (thermal bridge)

Show with N-velope or Knight clips as selected. Determine spacing/size. Create conceptual layout of Zee clips and runners



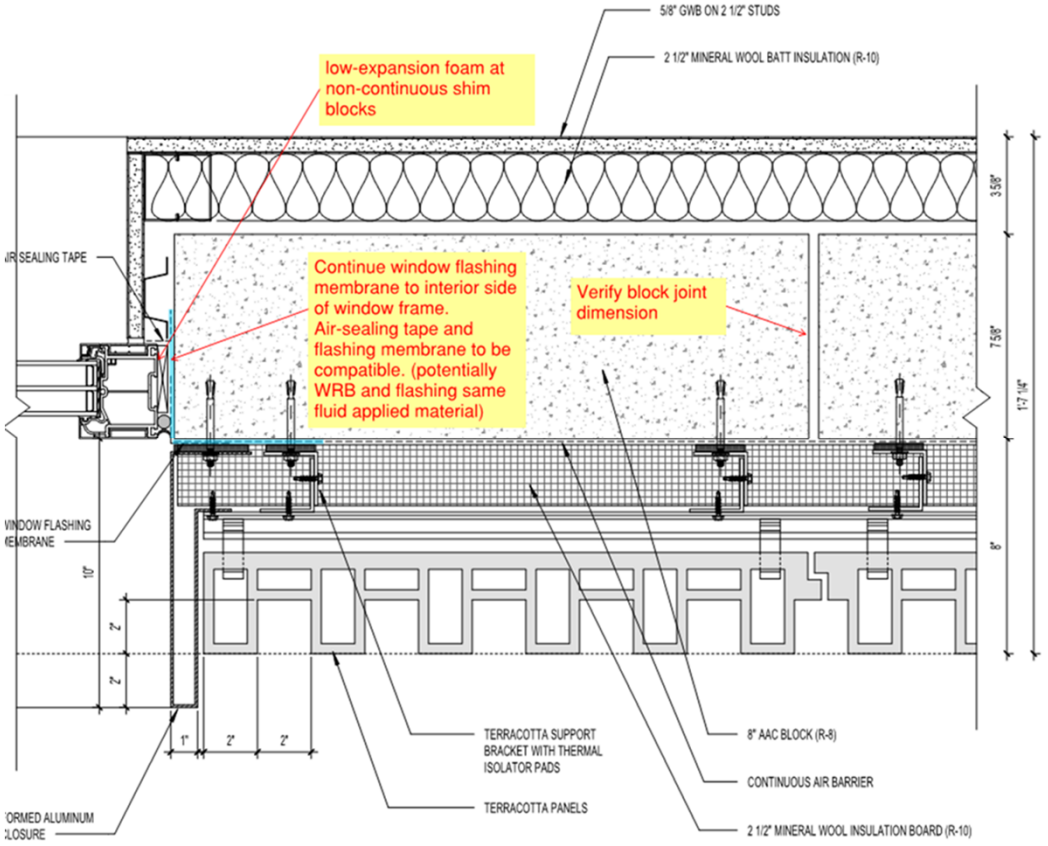
This is Armatherm FRR? (not FRP) I found the material but not the R-value of compressive strength

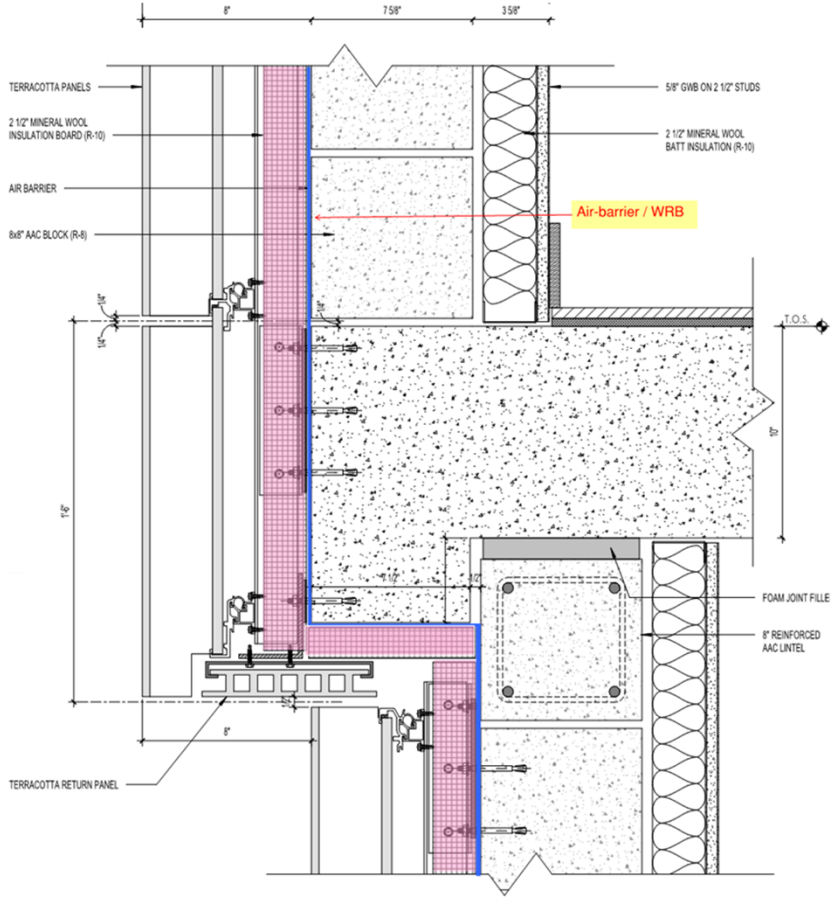
Continuous stainless steel? How thermally broken? Can the internal horizontal leg be eliminated?

Drainage? height of horizontal gap (to optimize drainage/diminish possible icing

Insulate here?

Aerated Autoclaved Concrete (AAC)





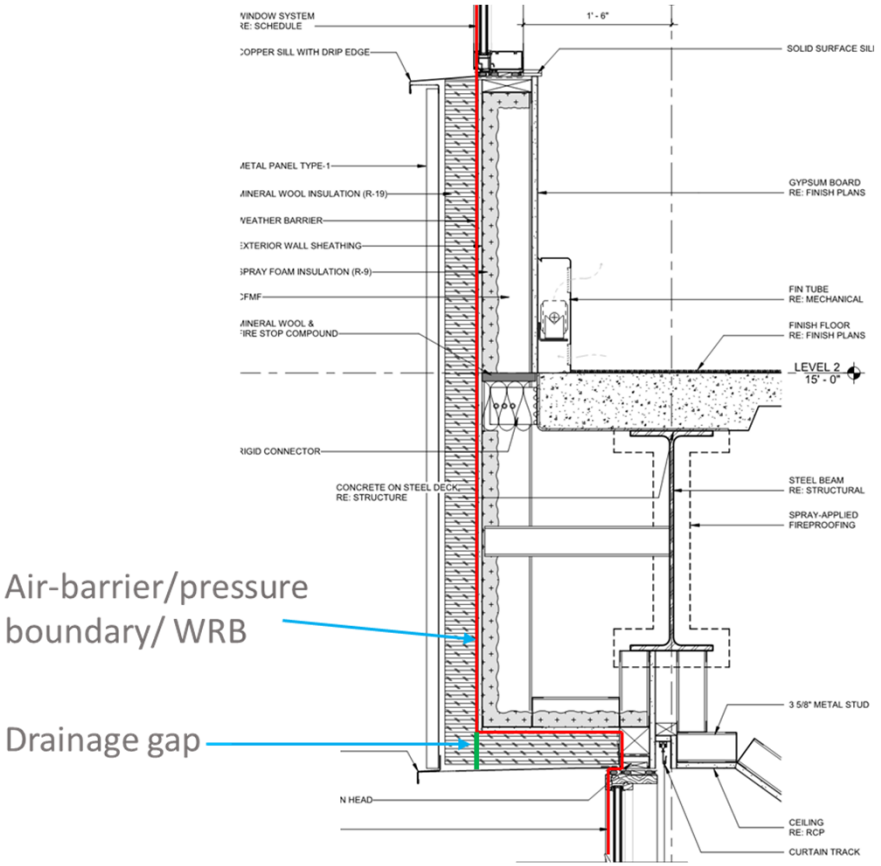
Autoclaved Concrete



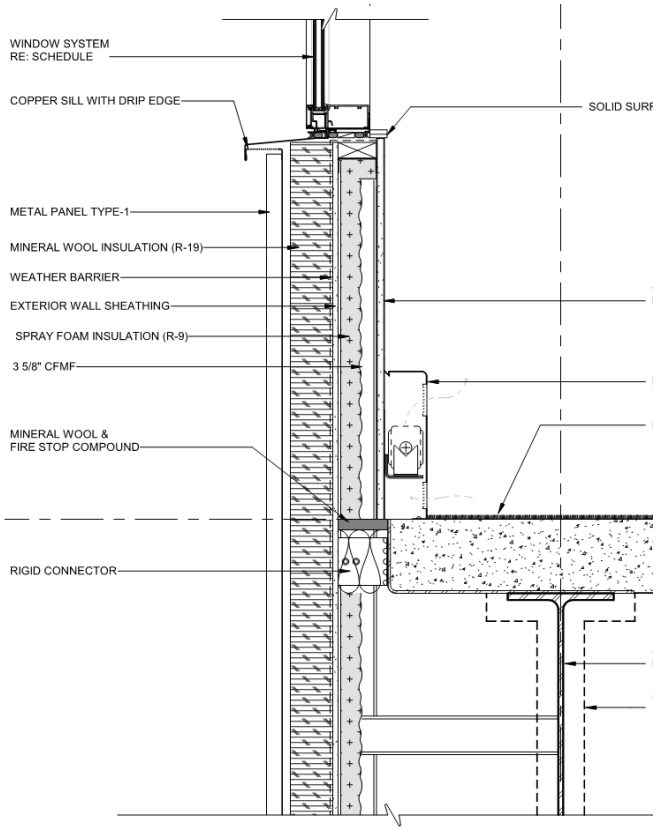


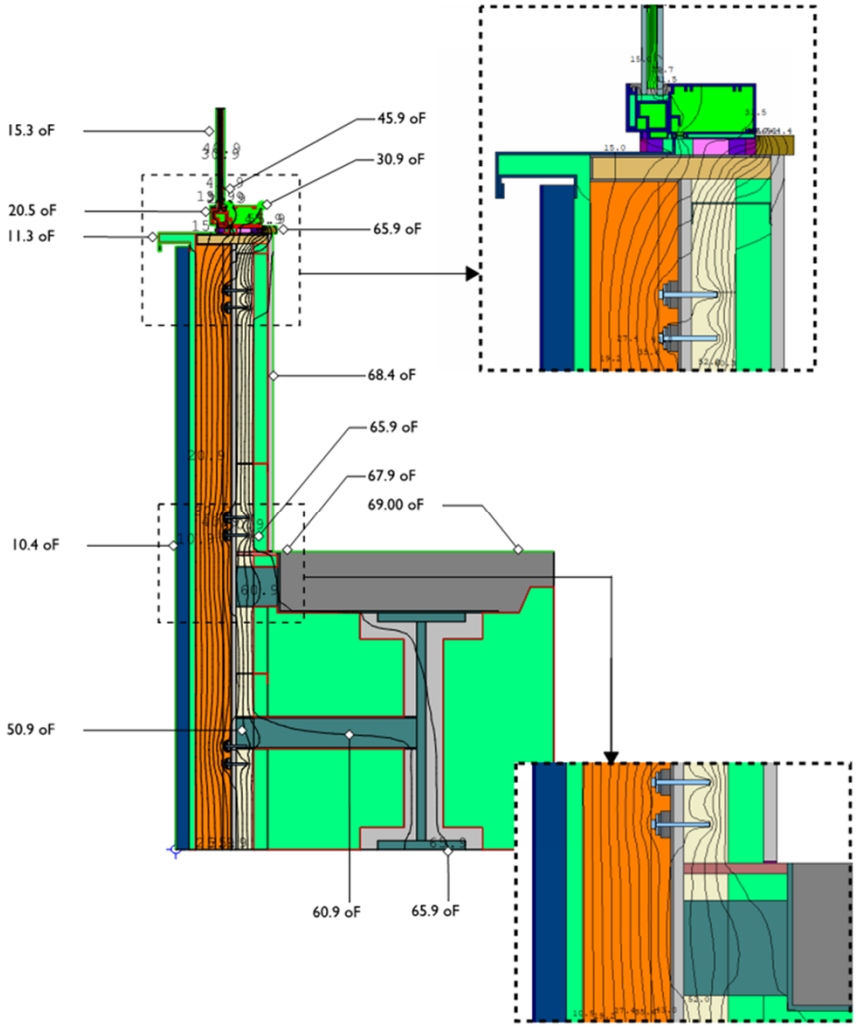
New Construction: Rain Screen





THERM Analysis





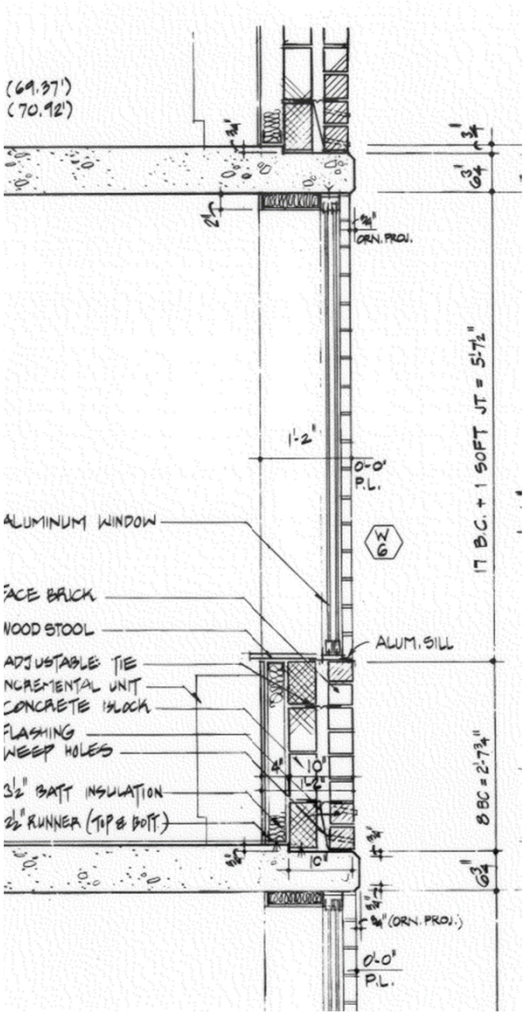
Questions?



30 Minute Break

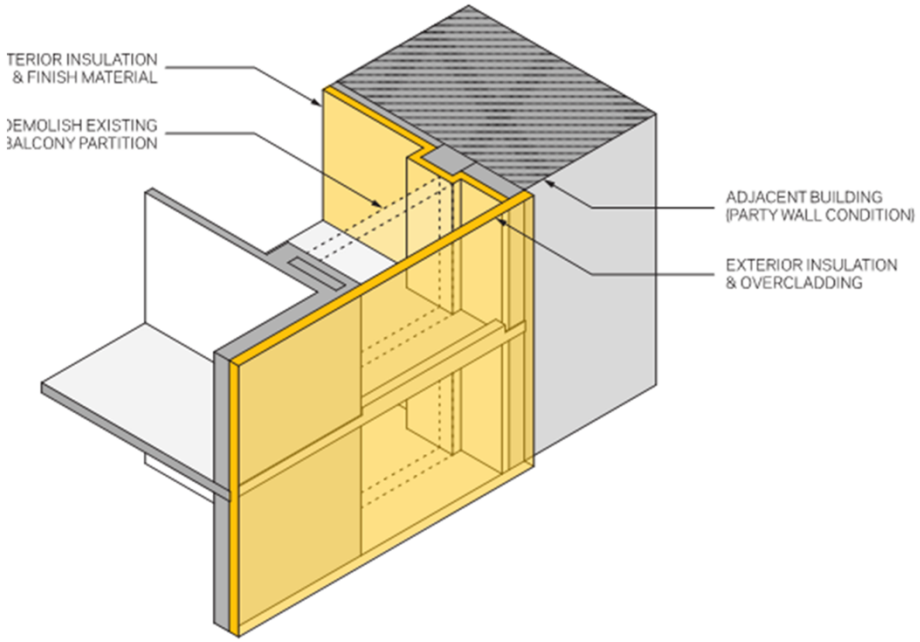
Retrofit Solutions



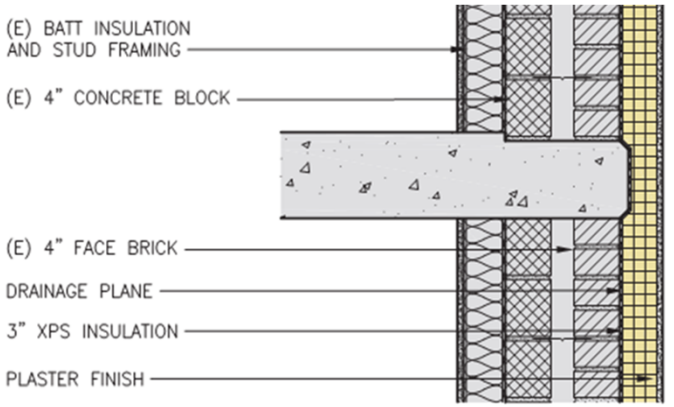


Over-Cladding Solutions

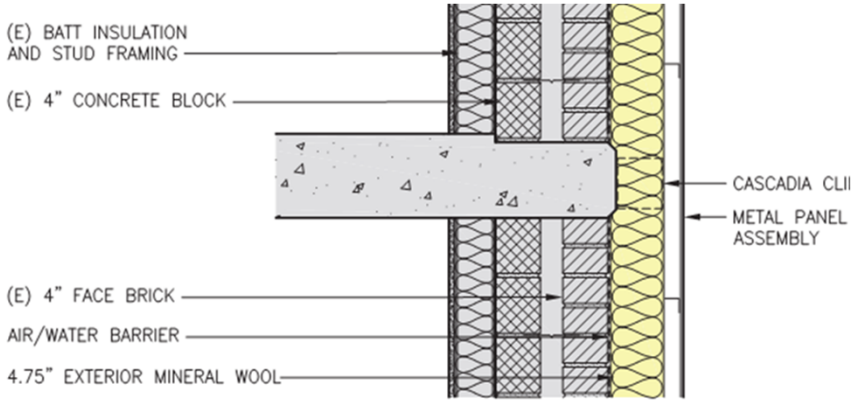
Over-Cladding
Solutions



ECM-C-EW-05: Balcony Enclosure Diagram

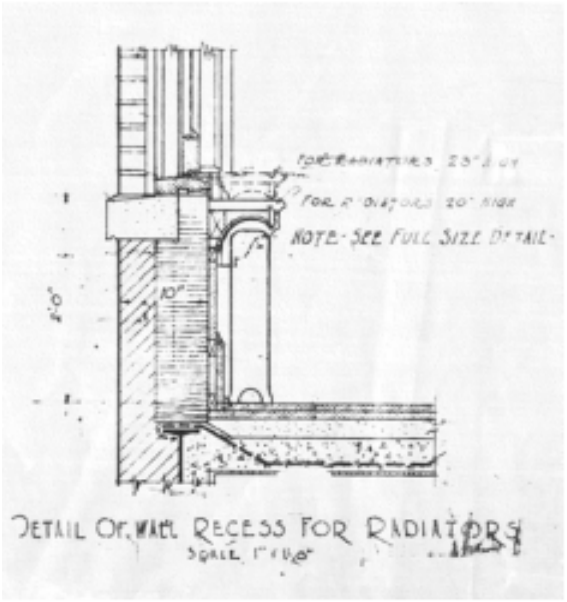


EIFS Over-cladding



Rain-Screen Over-cladding





WALL SECTION DETAIL DATED 1948

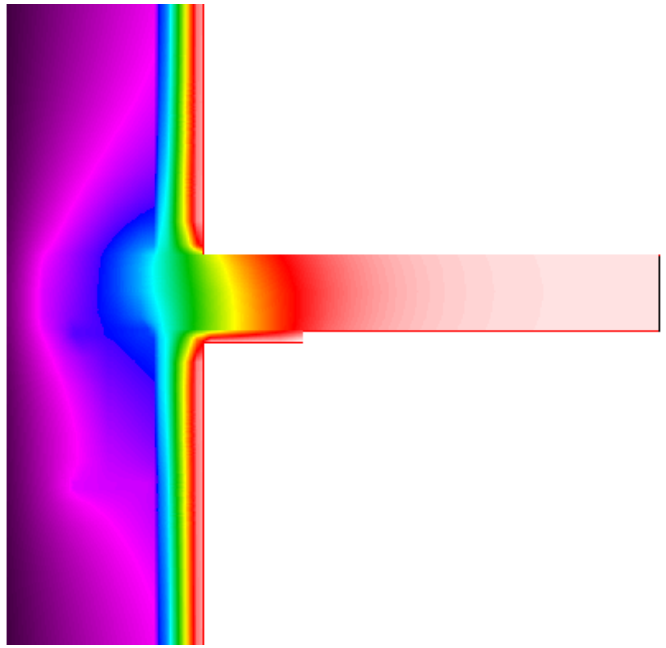
EnerPHit Study: Rubin Hall - Interior Insulation Proposed

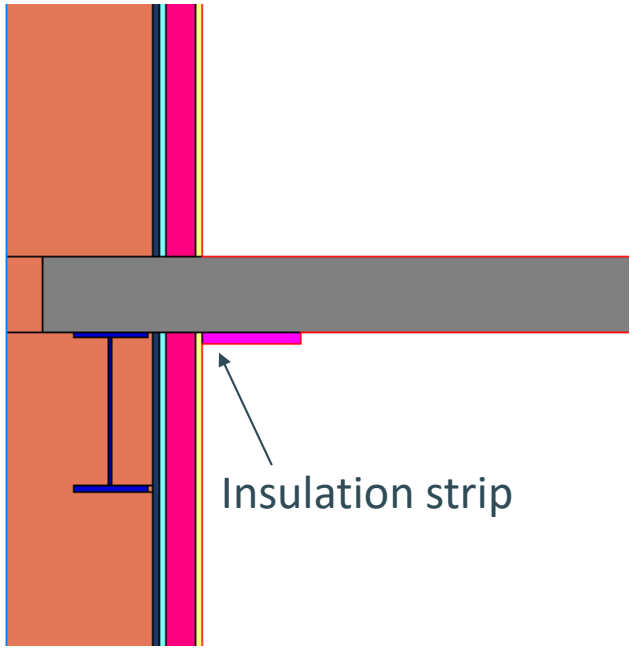
- Rubin Hall – 1925 Historic Building
- Uninsulated Walls: 4” face brick + 8” Terracotta
- Metal, Single Pane Windows

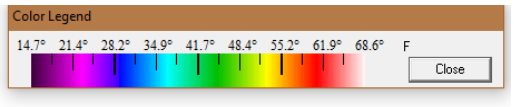
RH: Wall Assembly Recommendations

	1.5” Polyiso +2.5” Mineral Wool	**2.5” Closed Cell**
Benefits	Provides interior continuous insulation, air-barrier and dewpoint control layer. R-10 without additional mineral wool	Provides interior continuous insulation, air-barrier and dewpoint control layer. Thinner wall assembly. Even coverage is easily achieved
Issues	Thicker wall assembly - 4.5" and loss of square footage Install quality is important Can be labor intensive	Objections to spray foam and off gassing. Cost of material is higher, but labor to install may not be.

Floors & Walls as Thermal Bridges







Water-Resistive Barrier





Find the Water-Resistive Barrier

Water-Resistive Barrier







1403.2 Water-Resistive Barrier. Not fewer than one layer of No. 15 asphalt felt, complying with ASTM D226, or other approved materials……

Air Barriers and Water-Resistive-Barriers



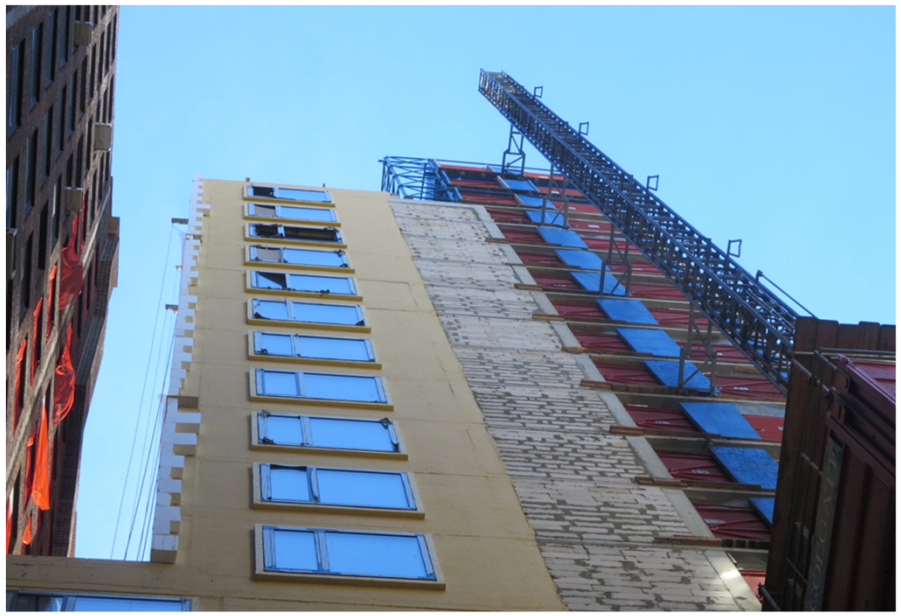
Sheet Materials



Fluid Applied

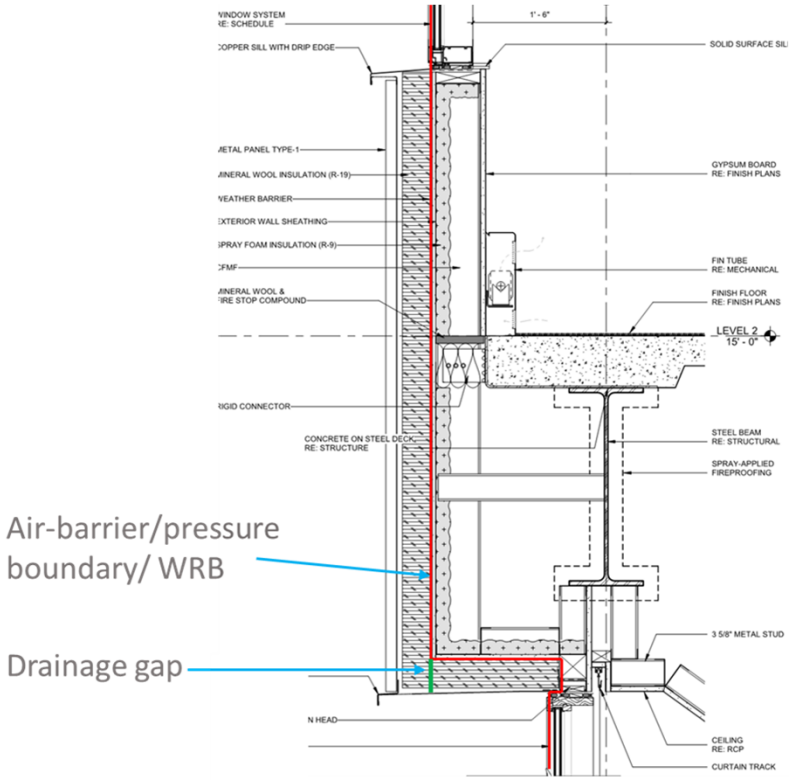
Air Barriers and Water-Resistive-Barriers

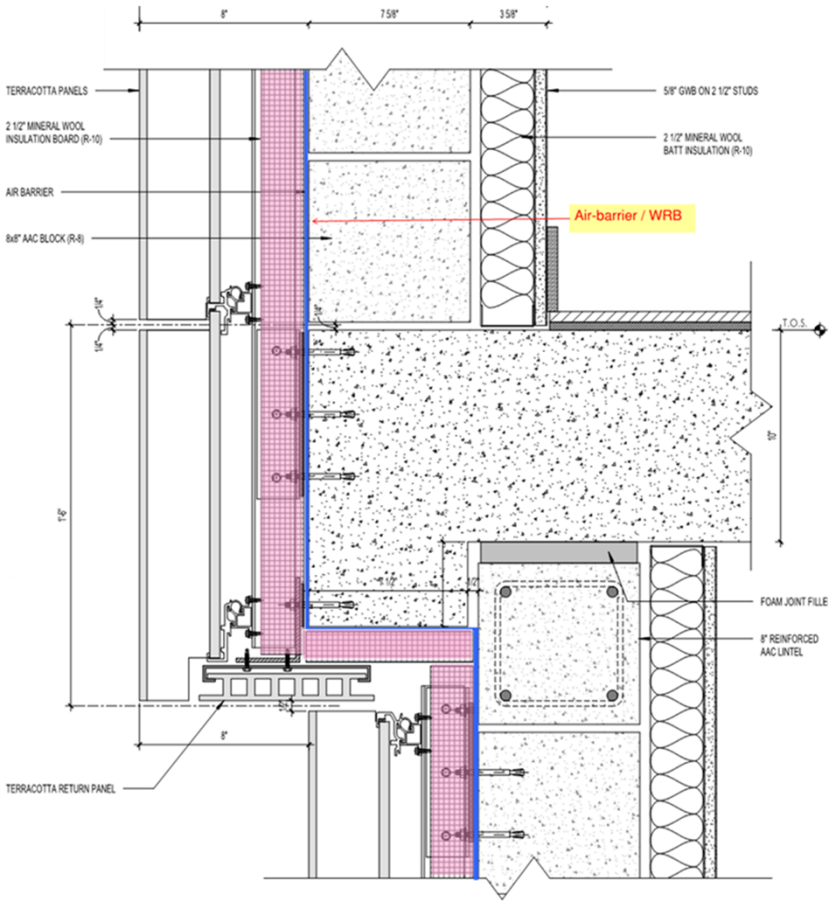




WRBs can have significantly different performance attributes. All assembly, climate, and building occupancy variables must be considered

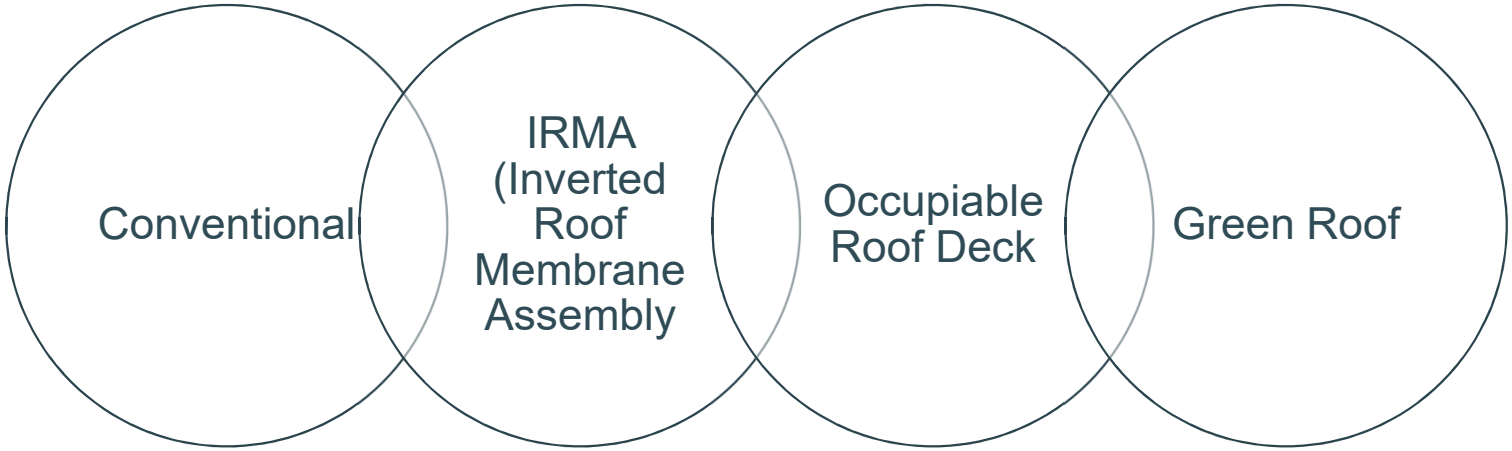
WRBs Must Be Drainable





Roof Assemblies

Roof Assemblies



Roof Deck / Board and Vapor Barriers





Low-Slope Roof Insulation



Polyisocyanurate
R-6.5 per inch (varies)
Not water tolerant



Extruded Polystyrene
R-5.0 per inch (varies)
Water tolerant

Multi-Layer Tapered Insulation





Roof Membranes



PVC / TPO
High Solar Reflective Index (SRI)
PVC - 25 years
TPO – 15 to 20 Years



EDPM
25 to 30 Years



Fluid Applied
20 + Years
Some available with High SRI

Economical Materials can be good performers







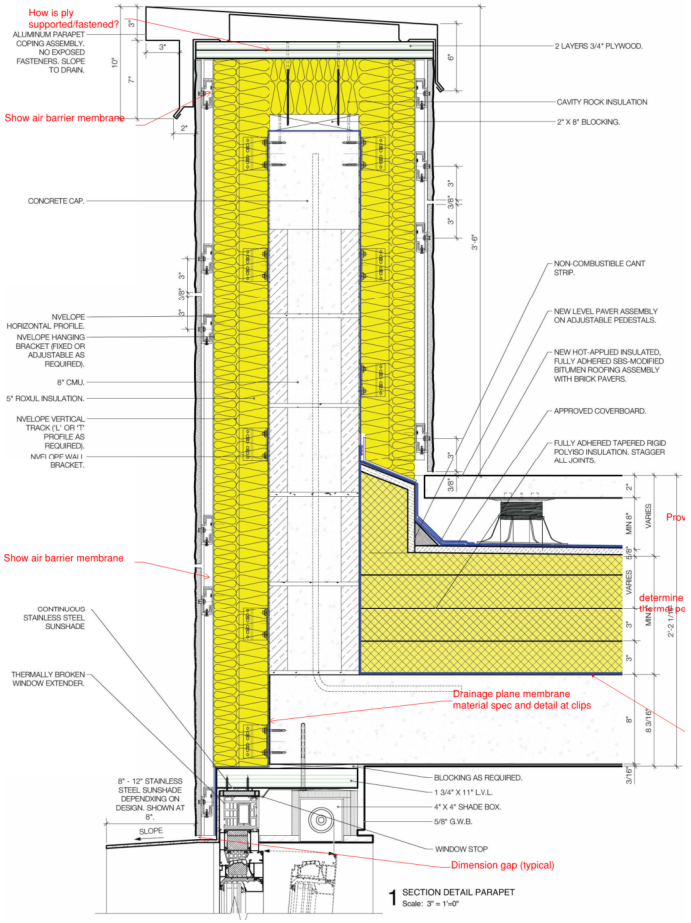
Quality
application is
critical

Flashing and Transitions



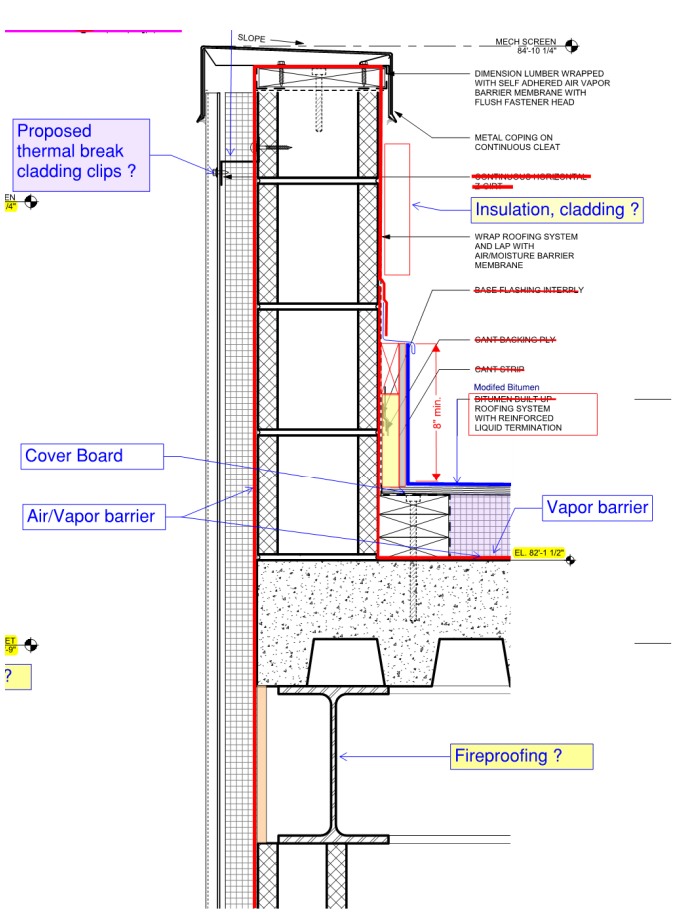


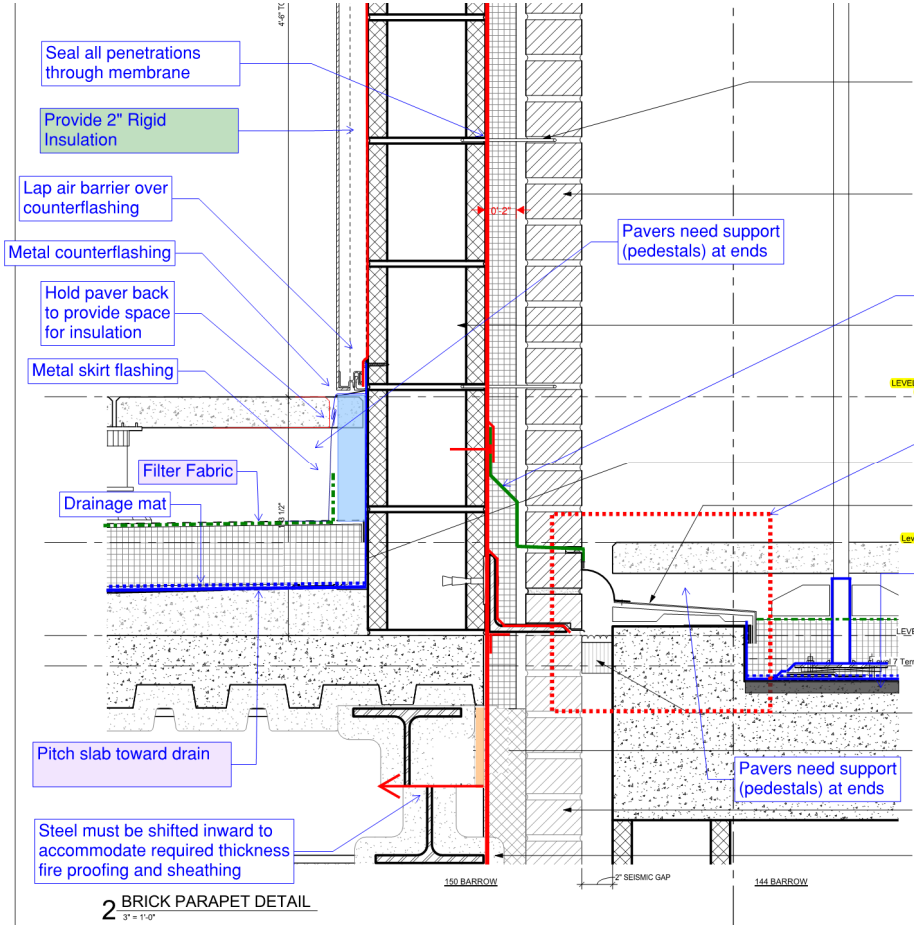




Parapet Condition

Parapet/Roof Transitions





2 BRICK PARAPET DETAIL
3" = 1'-0"



Flood Testing

Foundation Assemblies

Foundations: Waterproofing Systems



Foundation Waterproofing Facts

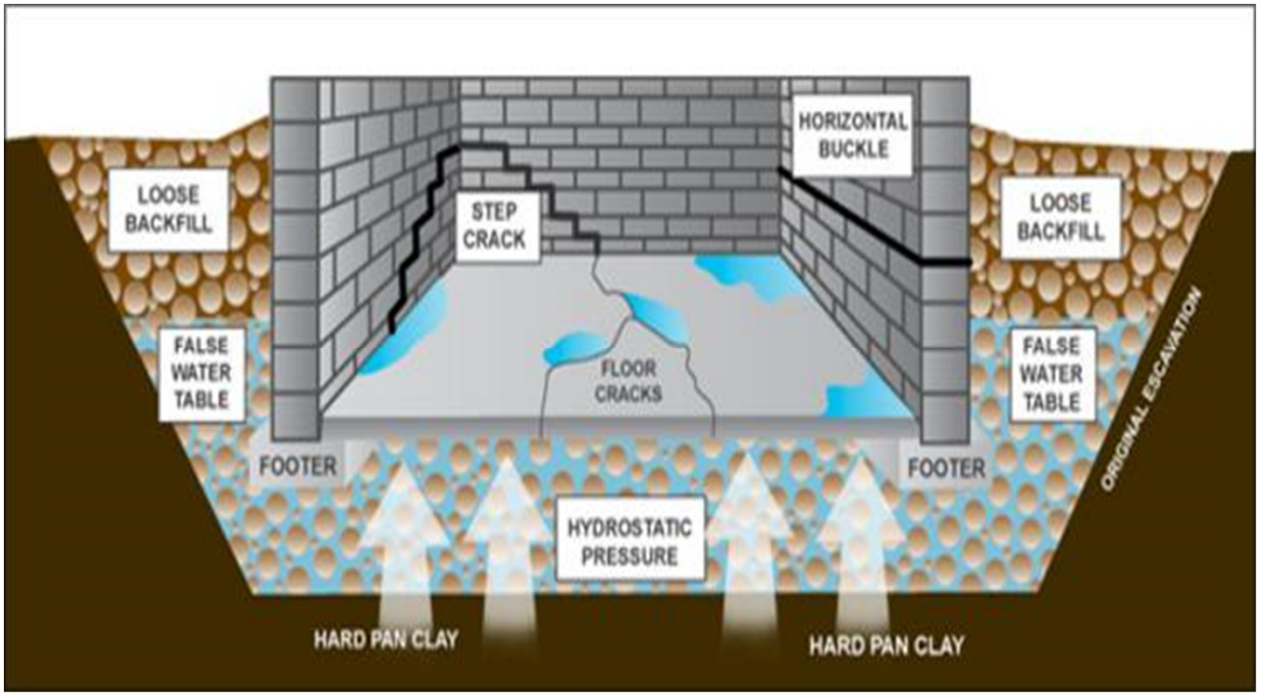
- Water intrusion makes up more than 70%* of construction litigation
- Repairing foundation leaks can be difficult and costly
- Water in basement leads to more moisture in the building, IAQ, humidity, etc.
- Most waterproofing failure is attributable to design, detailing, and execution.

*June 2011 ARCHITECT: The Journal of the American Institute of Architects

Design Considerations

- Site and Building Configuration
  - Water Table
  - Soil Characteristics
  - Grading/Surface Drainage
  - Excavation Access
- Code Requirements
  - NYS Building Code Chapter 18
  - NYS Building Code Appendix G Flood-Resistant Construction
  - NYS Energy Conservation Construction Code
- Flood Zones
  - NYC: FEMA Region II Coastal

Site and Building Configuration

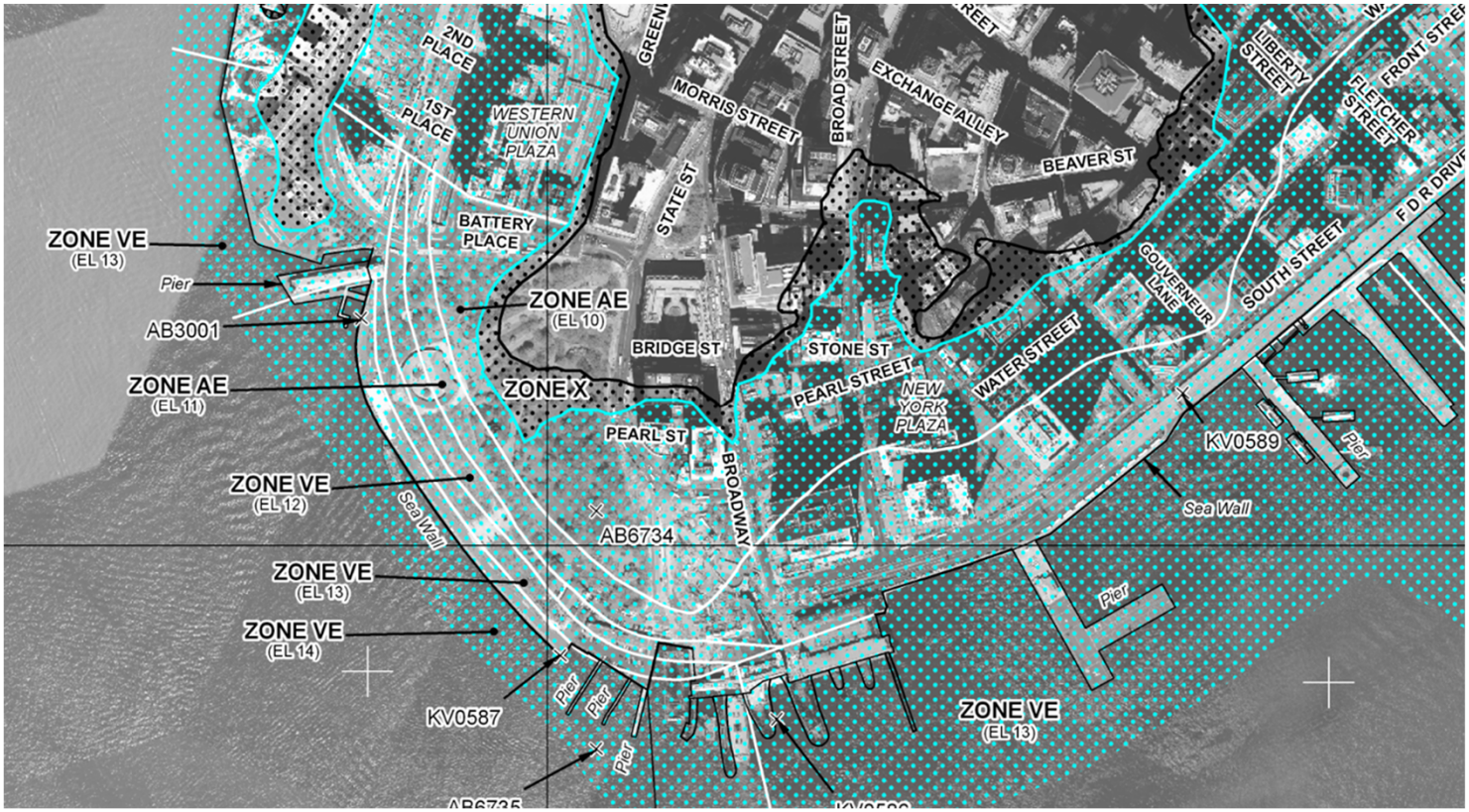


Guardian Basement Waterproofing

Code Requirements

- NYC Building Code Section BC 1807/2015 IBC Section 1805
  - Dampproofing required where hydrostatic pressure will not occur
  - Waterproofing required where a hydrostatic pressure condition exists
  - Includes both floors and walls
- Appendix G: Flood-resistant Construction

Flood Zone Map Detail



Waterproofing Types

- Blind-side Waterproofing
  - Waterproofing installed prior to concrete placement
- Positive-side Waterproofing
  - Waterproofing installed after concrete placement
- Negative-side Waterproofing
  - Waterproofing/water control methods installed on the interior
  - Existing Building Remediation/Retrofit





Blind-side Waterproofing

- Typically sheet membrane systems
- Below slab and/or footing
- Foundation at property line
- Lot line walls
- Sheeting and shoring, soldier piles and lagging
- De-watering

Blind-side Waterproofing







Positive-side Waterproofing

- Sheet membrane systems or liquid membrane systems
- Access to exterior face of foundation walls
- Tie in to blind-side waterproofing below slab/footing
- Horizontal surfaces below grade, i.e. vaults, tunnels.



Positive-side Waterproofing

Self-Adhered
Sheet Membranes

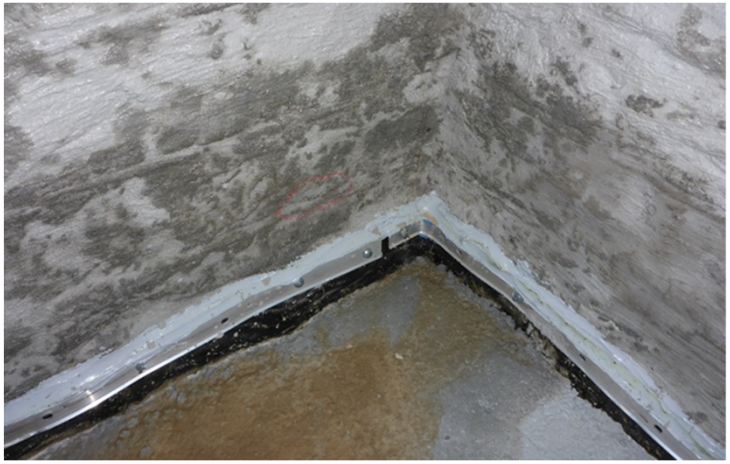
Positive-side Waterproofing



Fluid Applied Membranes

Negative-side Waterproofing





- Existing Building Remediation
- Building leaks may be discovered during construction
- Historic rubble foundation walls
- Unique strategies based on existing conditions
- Injection Grouting



Negative-side Waterproofing



Continuous Insulation

Continuous Insulation



Continuous Insulation



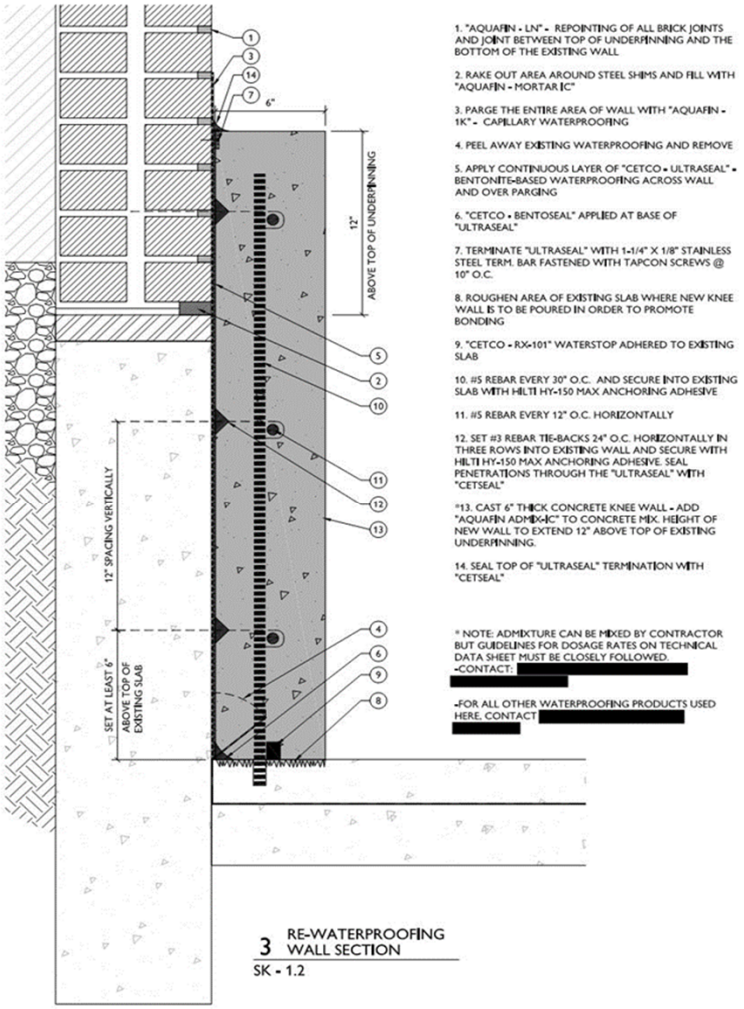
R-10 under all
R-5 perimeter



4” XPS, R-20

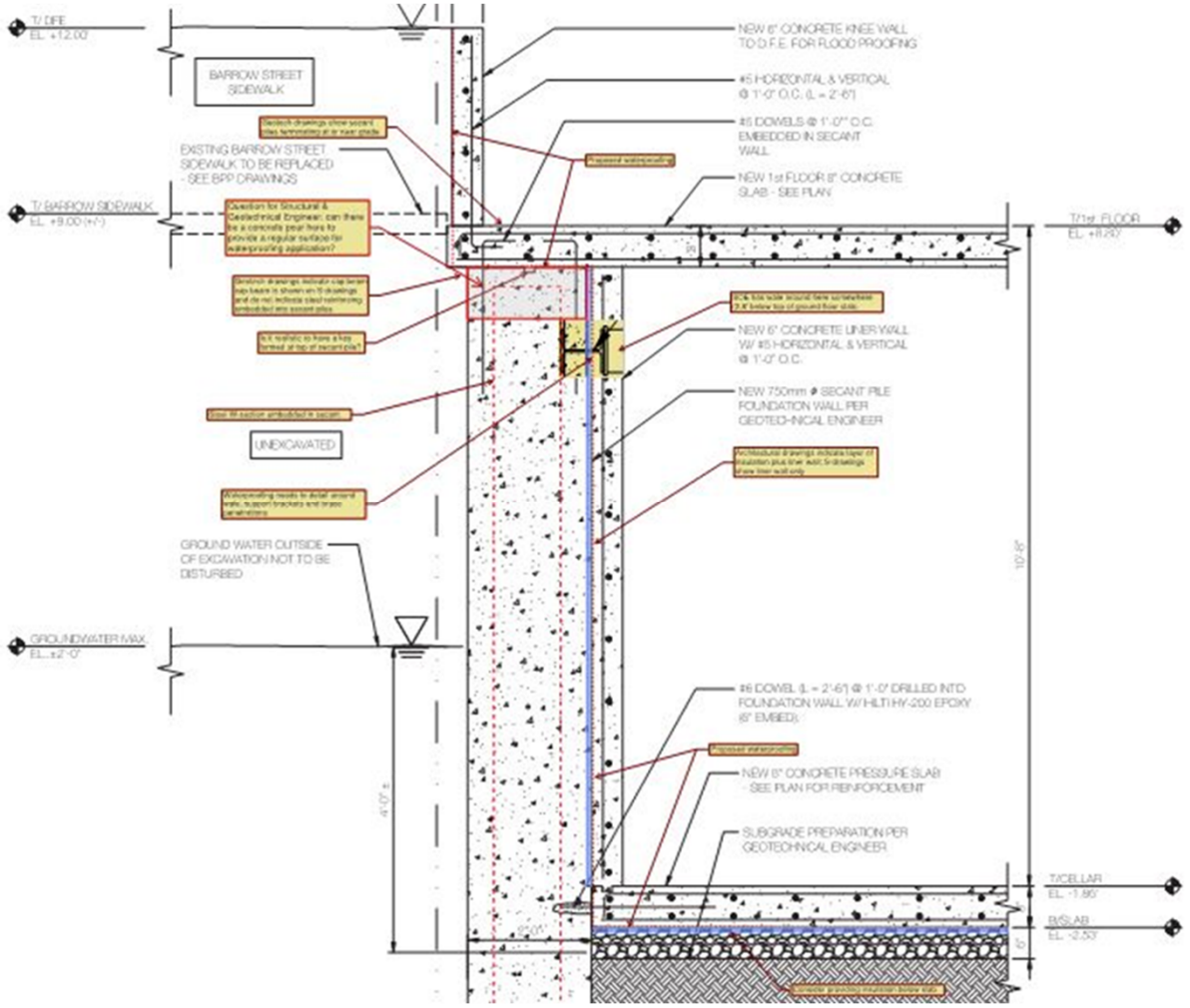


R-40 under all
R-30 perimeter

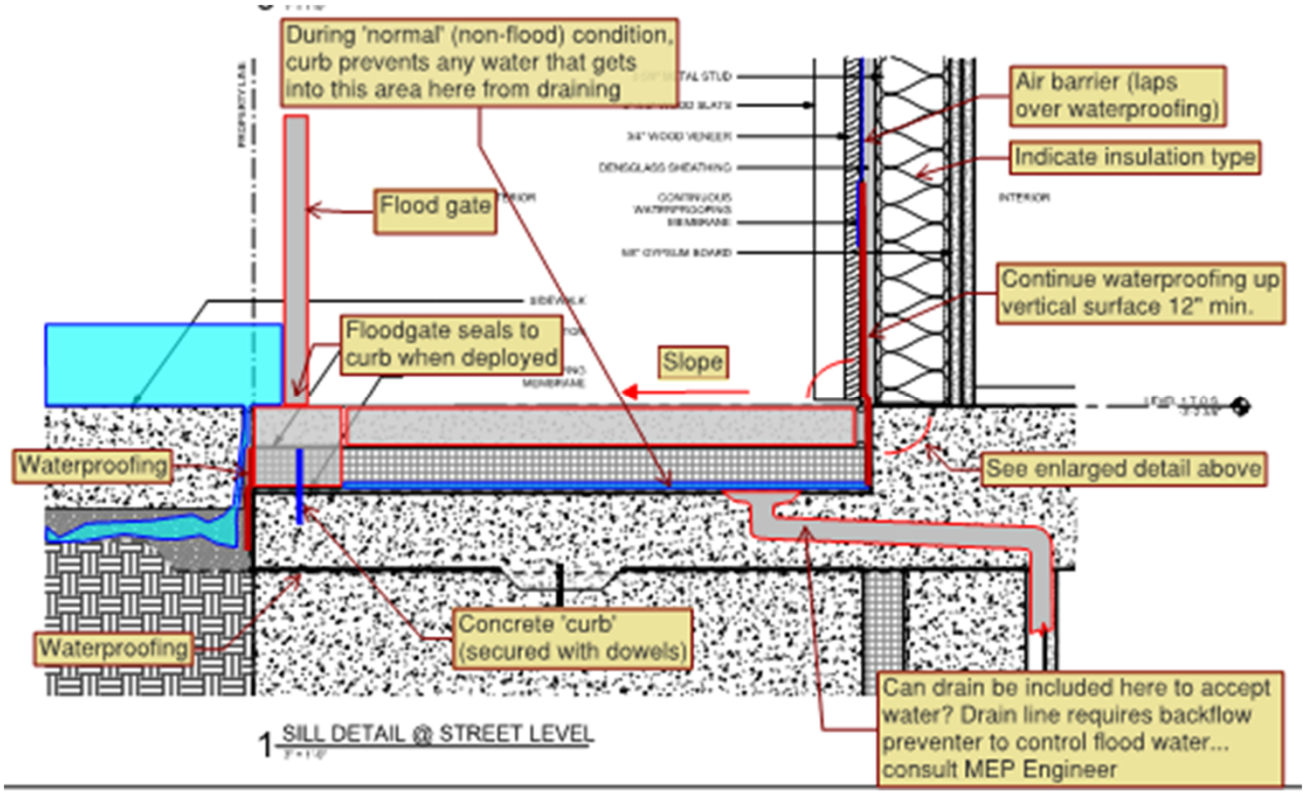


Detailing and Drawing Mark Ups

Detailing and Drawing Mark Ups



Detailing and Drawing Mark Ups



Installation Considerations

- Substrate preparation
- Seam and joint treatment
- Transition detailing
- Penetration detailing

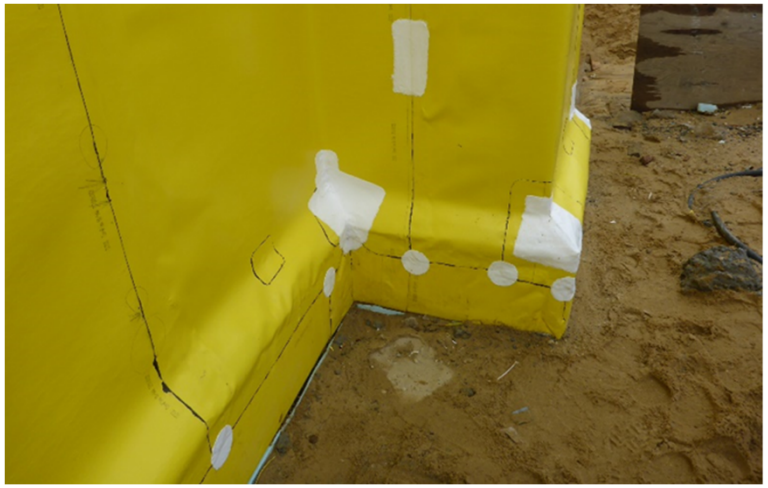




Substrate Prep

- Correction of surface irregularities
- Below slab preparation
  - Mud slab
  - Compacted gravel
  - XPS insulation
- Stayform at lot line walls
- Refer to manufacturer's installation requirements and guidelines





Seams and Joints

- Sealed continuously!!!!
- Type of seam dependent upon system specified
- Locate seams away from transitions and penetrations
- Fluid applied systems are seamless



Seams and Joints

Walking the “dog”

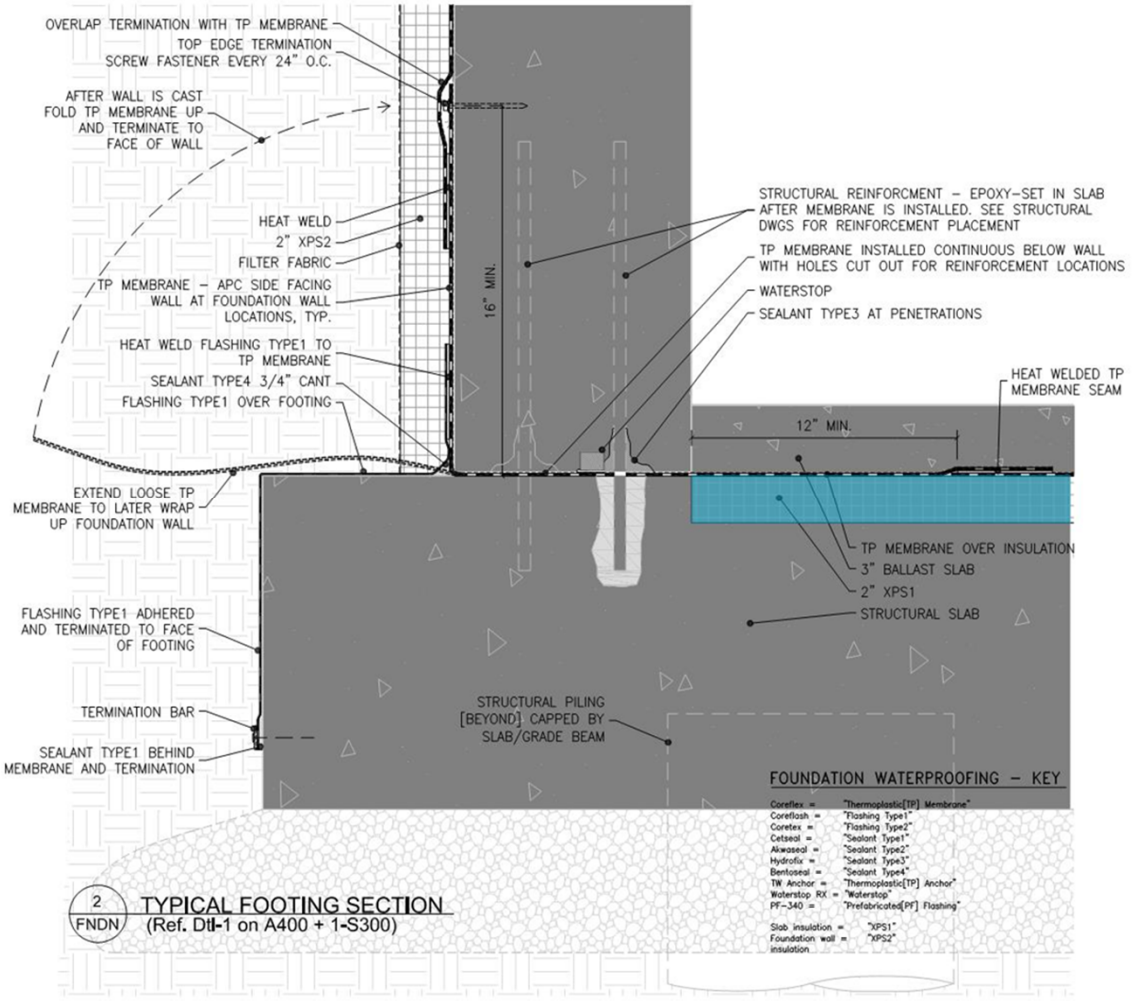




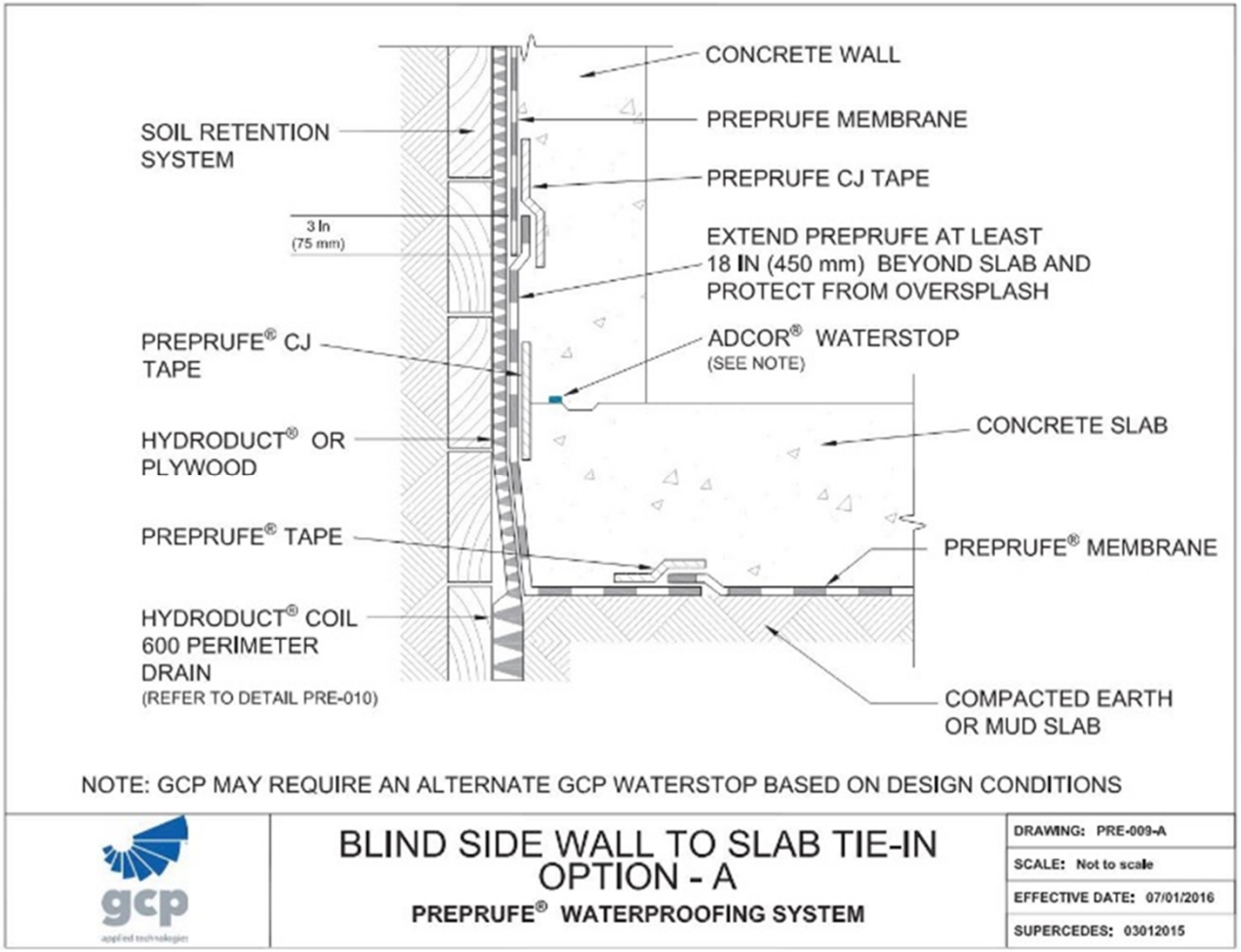
Material Transitions

- Compatibility between different materials
- Corners
- Changes in plane and substrate
- Extension above grade
- Tie-ins to air barrier

Details


OVERLAP TERMINATION WITH TP MEMBRANE
TOP EDGE TERMINATION SCREW FASTENER EVERY 24" O.C.
AFTER WALL IS CAST FOLD TP MEMBRANE UP AND TERMINATE TO FACE OF WALL
HEAT WELD
2" XPS2
FILTER FABRIC
TP MEMBRANE – APC SIDE FACING WALL AT FOUNDATION WALL LOCATIONS, TYP.
HEAT WELD FLASHING TYPE1 TO TP MEMBRANE
SEALANT TYPE4 3/4" CANT
FLASHING TYPE1 OVER FOOTING
EXTEND LOOSE TP MEMBRANE TO LATER WRAP UP FOUNDATION WALL
FLASHING TYPE1 ADHERED AND TERMINATED TO FACE OF FOOTING
TERMINATION BAR
SEALANT TYPE1 BEHIND MEMBRANE AND TERMINATION
16" MIN.
STRUCTURAL REINFORCMENT – EPOXY-SET IN SLAB AFTER MEMBRANE IS INSTALLED. SEE STRUCTURAL DWGS FOR REINFORCEMENT PLACEMENT
TP MEMBRANE INSTALLED CONTINUOUS BELOW WALL WITH HOLES CUT OUT FOR REINFORCEMENT LOCATIONS
WATERSTOP
SEALANT TYPE3 AT PENETRATIONS
HEAT WELDED TP MEMBRANE SEAM
12" MIN.
TP MEMBRANE OVER INSULATION
3" BALLAST SLAB
2" XPS1
STRUCTURAL SLAB
STRUCTURAL PILING [BEYOND] CAPPED BY SLAB/GRADE BEAM
FOUNDATION WATERPROOFING – KEY
Coreflex = "Thermoplastic[TP] Membrane"
Coreflash = "Flashing Type1"
Coretex = "Flashing Type2"
Cetseal = "Sealant Type1"
Akwaseal = "Sealant Type2"
Hydrofix = "Sealant Type3"
Bentoseal = "Sealant Type4"
TW Anchor = "Thermoplastic[TP] Anchor"
Waterstop RX = "Waterstop"
PF-340 = "Prefabricated[PF] Flashing"
Slab insulation = "XPS1"
Foundation wall insulation = "XPS2"
2 FNDN TYPICAL FOOTING SECTION
(Ref. Dtl-1 on A400 + 1-S300)

Details


CONCRETE WALL
SOIL RETENTION SYSTEM
PREPRUFE MEMBRANE
PREPRUFE CJ TAPE
3 In (75 mm)
EXTEND PREPRUFE AT LEAST 18 IN (450 mm) BEYOND SLAB AND PROTECT FROM OVERSPLASH
PREPRUFE® CJ TAPE
ADCOR® WATERSTOP (SEE NOTE)
CONCRETE SLAB
HYDRODUCT® OR PLYWOOD
PREPRUFE® TAPE
PREPRUFE® MEMBRANE
HYDRODUCT® COIL 600 PERIMETER DRAIN (REFER TO DETAIL PRE-010)
COMPACTED EARTH OR MUD SLAB
NOTE: GCP MAY REQUIRE AN ALTERNATE GCP WATERSTOP BASED ON DESIGN CONDITIONS
gcp
BLIND SIDE WALL TO SLAB TIE-IN OPTION - A
PREPRUFE® WATERPROOFING SYSTEM
DRAWING: PRE-009-A
SCALE: Not to scale
EFFECTIVE DATE: 07/01/2016
SUPERCEDES: 03012015

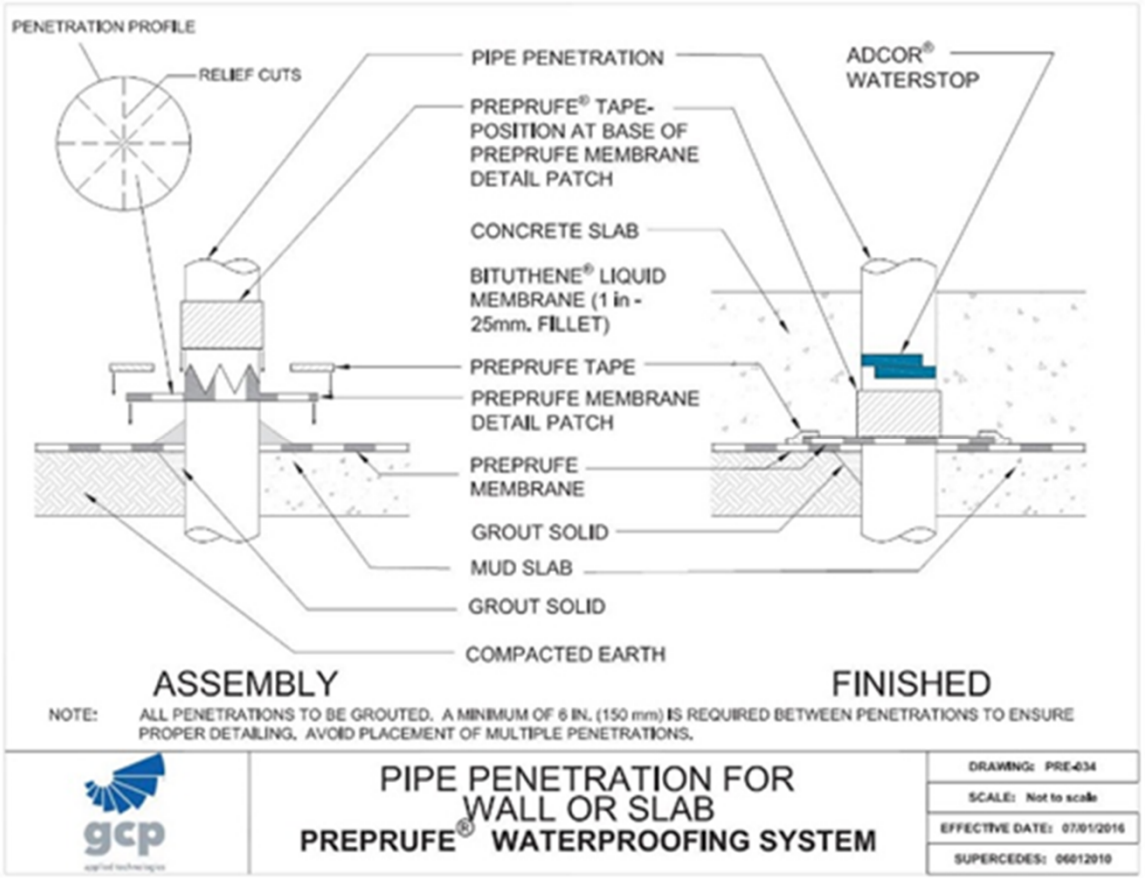




Penetrations

- Must be sealed and flashed continuously
- Surface preparation
- Location/spacing
- Shape/complexity
- Prefabricated components
- Flashing options
- Follow manufacturer's requirements

Penetration
Details





Failures:
What NOT to do!

Typical Failures



Fish-mouths



Impossible/Possible penetrations



Over-heating the seam



Insufficient tie-in between systems

Typical Failures



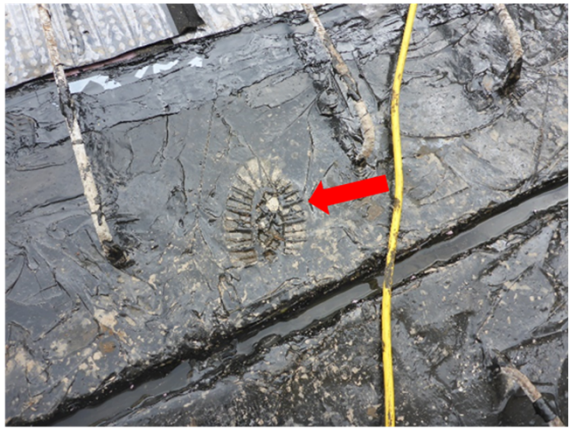
Hydrostatic Pressure



Inadequate surface preparation



Waterfall feature? Definitely not….



Cure time and protection

Typical Failures



Inaccessible repairs



Rebar rips and punctures



Substrate prep



Substrate with bug holes/honeycombing

Quality Assurance

- Design Considerations and Decisions must be Made Early in the Process
- Evaluate and specify appropriate systems
- Warranties
- Third Party Inspections
- Installer Certification
- Contractor Training

Questions?



Windows and Doors

- Target efficiencies for durability and comfort
- Punched openings
- Curtain wall and storefront systems
- High performance windows and doors
- Code and accessibility limitations

Punched Openings

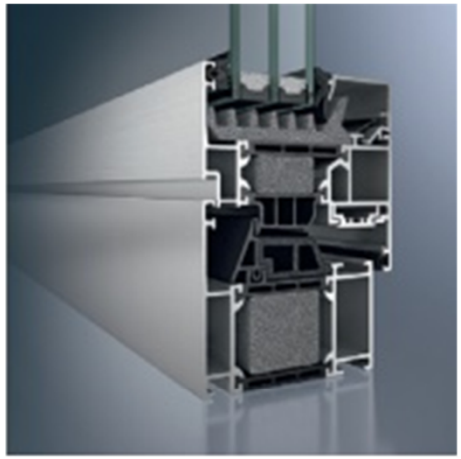
R-value vs. U-factor (Btu/h · ft2·°F)

U-factor = 1 ÷ R-value

Typically:

- U-factors are used to rate window performance
- U-factors are also used in heat loss calculations

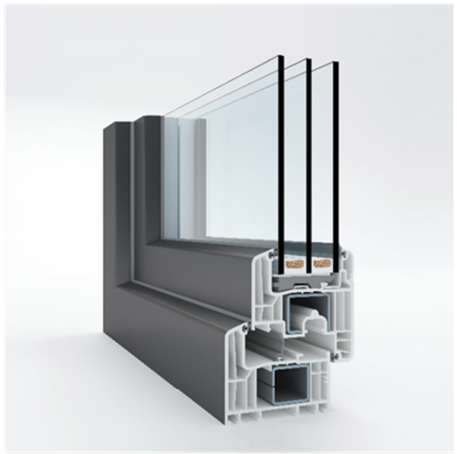
Evaluating Alternate High-Perf Windows



Thermally Broken Aluminum
U-value:~.14
U-Frame: ~.211
Greatest Structural Capacity
$$$



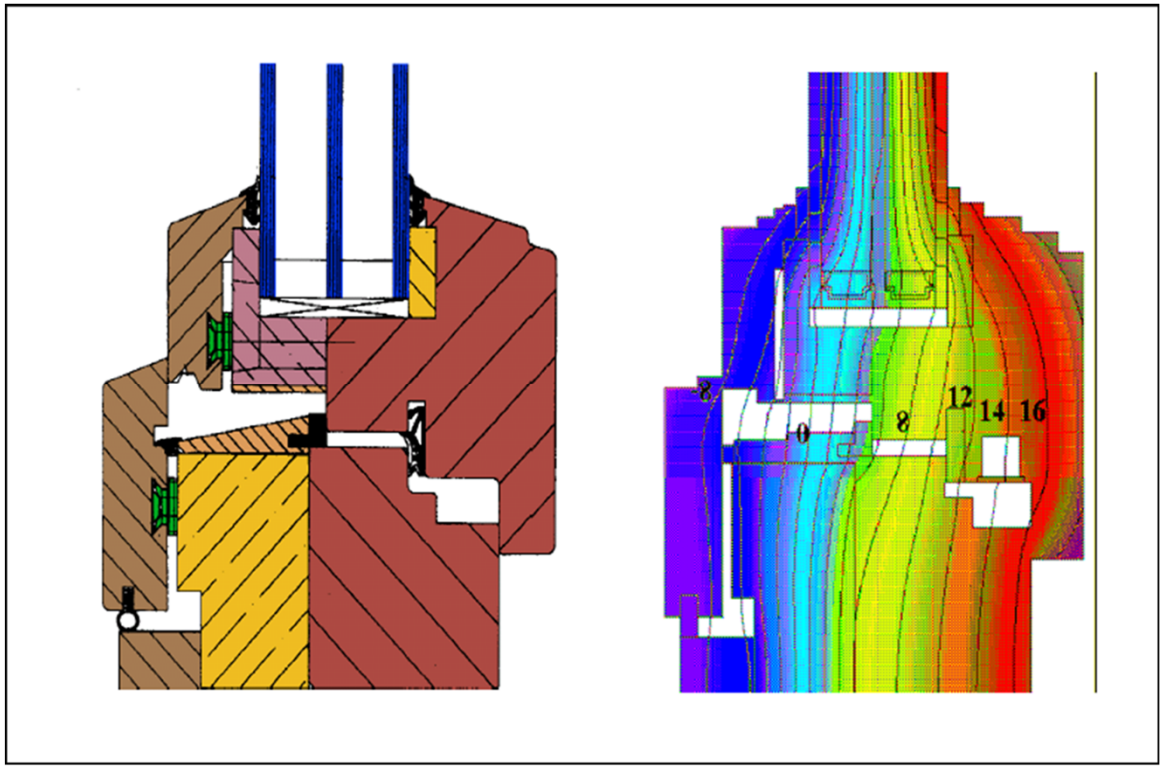
Fiberglass
U-value: ~.17
U-Frame: ~.2
$$



uPVC
U-value: ~.12
U-Frame:~.167
Reinforced with Steel
$

Passive House Windows

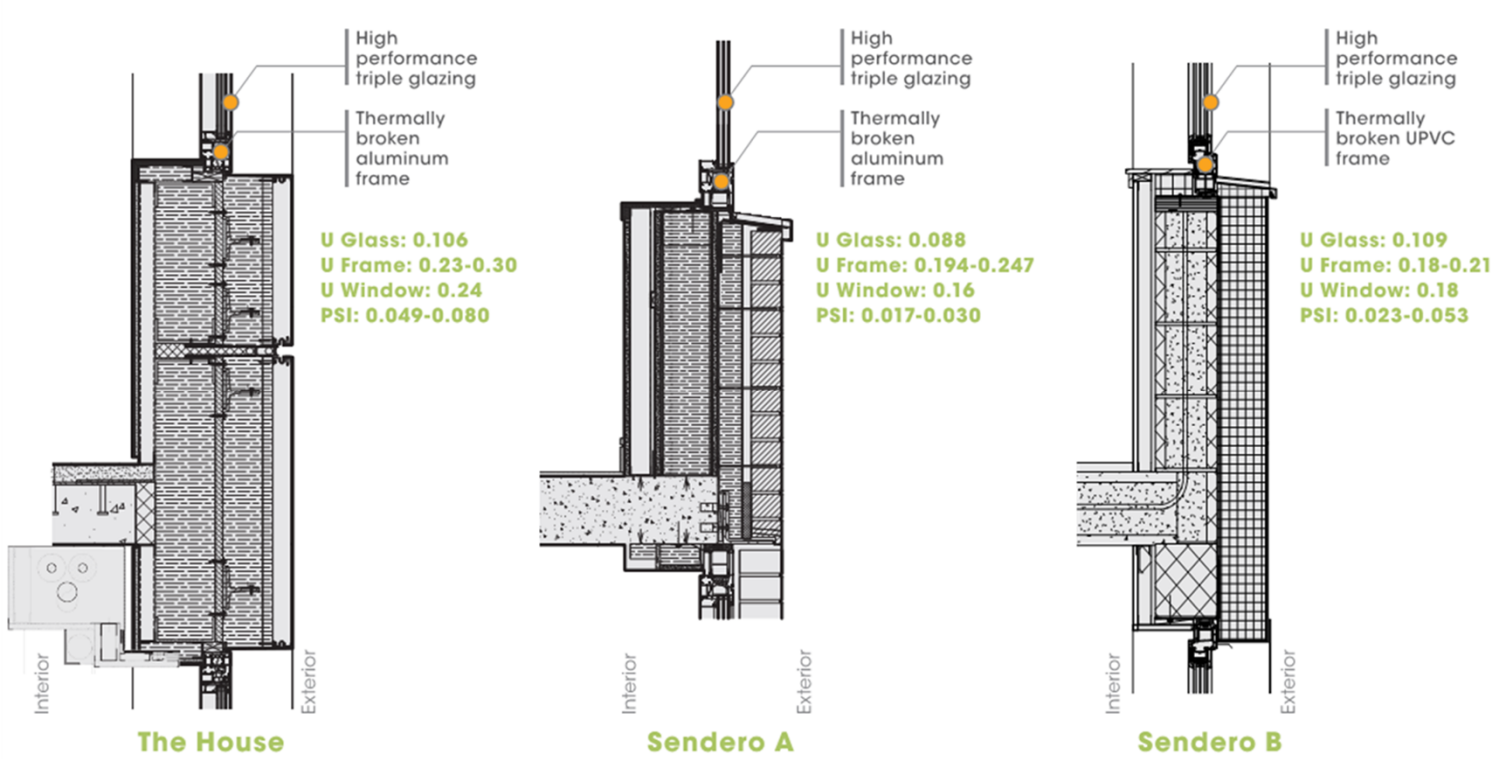
- Window install detailing is extremely important
- Must meet comfort criteria – sort of
- Flashing details can ruin install





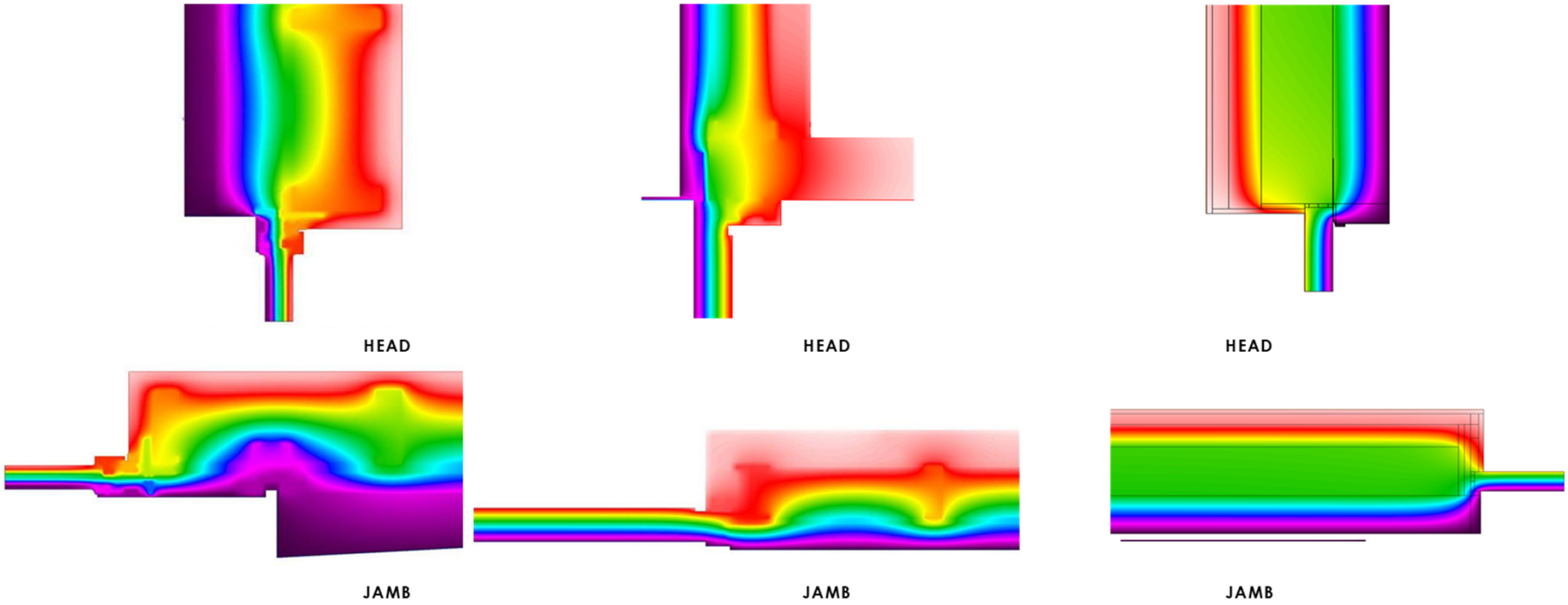
Continuous
Insulation

Exterior Wall Comparison: Windows

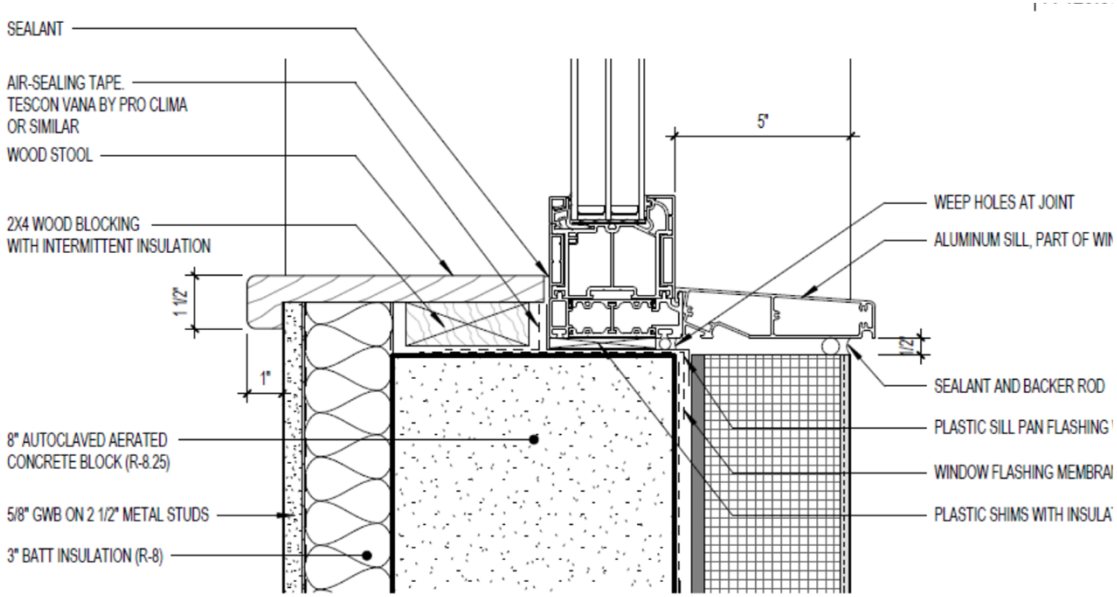


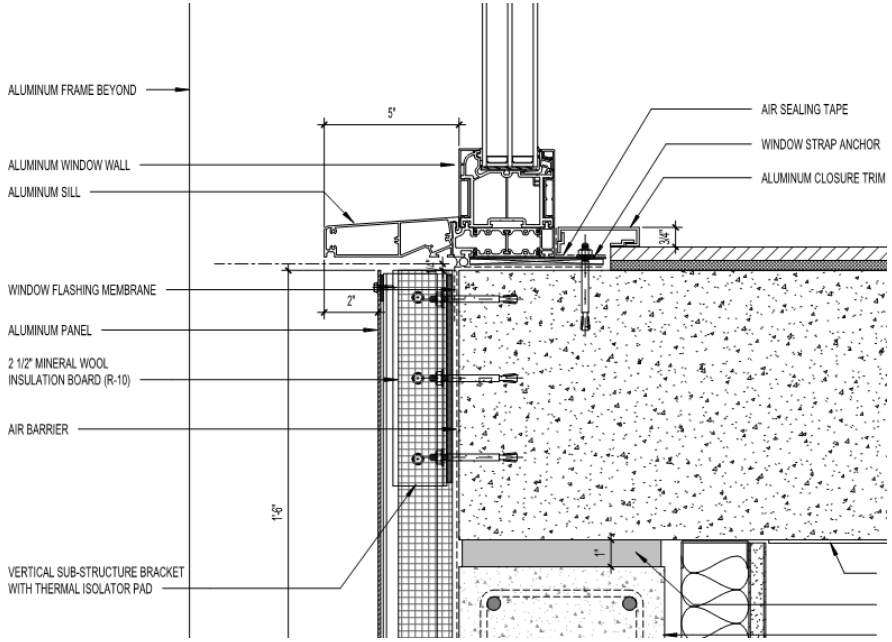
Exterior Wall Comparison: Windows

Therm Models

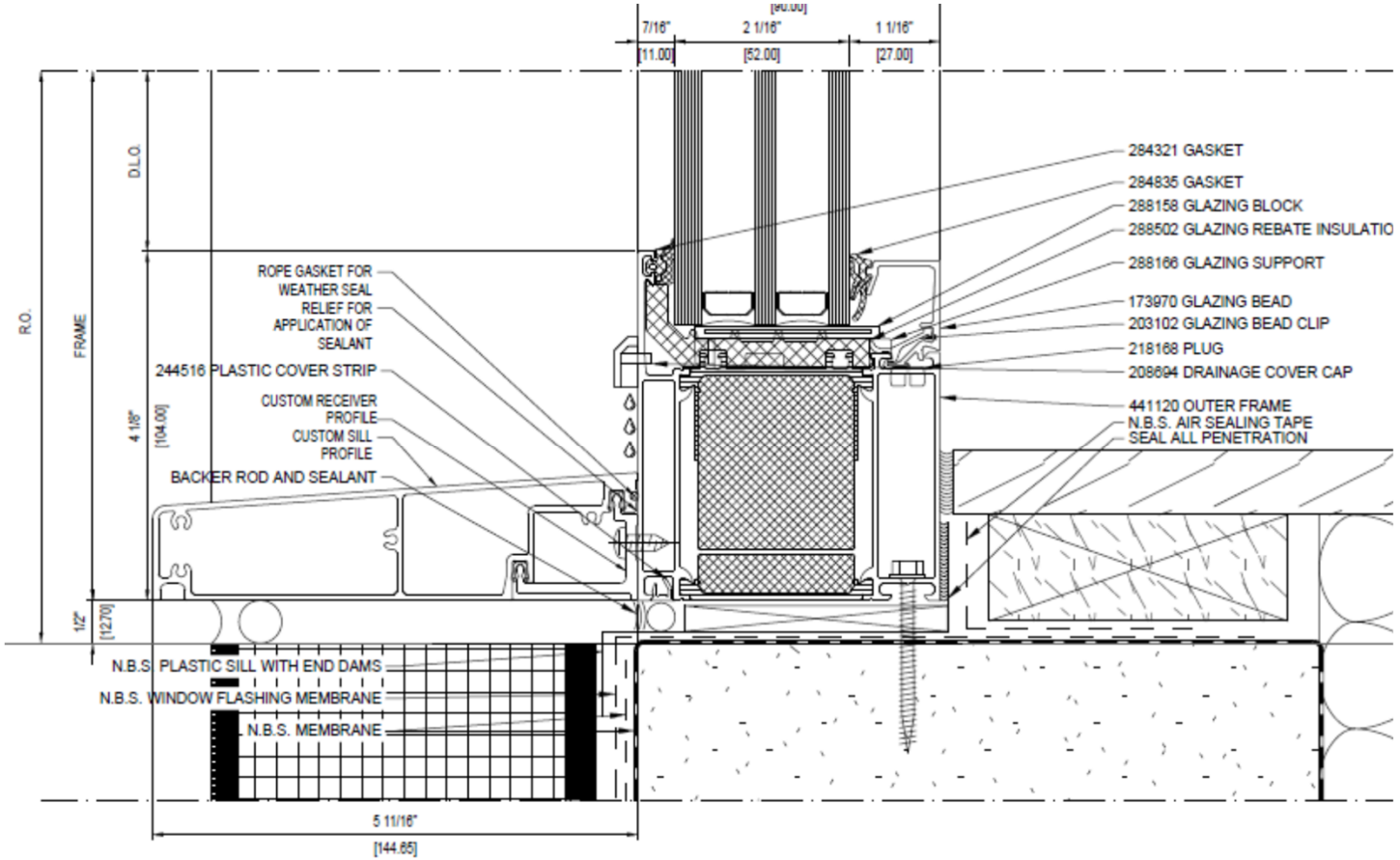


Importance of Continuous Insulation





Very High Performance Frame



NFRC Label


Andersen
Frenchwood Outswing
Fiberglass to Wood Frame, Dual-Pane Low-E Temp
Glazing with Argon
Product Type: Swing Door with Frame
CERTIFIED
ENERGY PERFORMANCE RATINGS
0.32
0.26
ADDITIONAL PERFORMANCE RATINGS
Visible Transmittance
0.41
-

Curtain wall and storefront systems

Curtain Wall Solutions

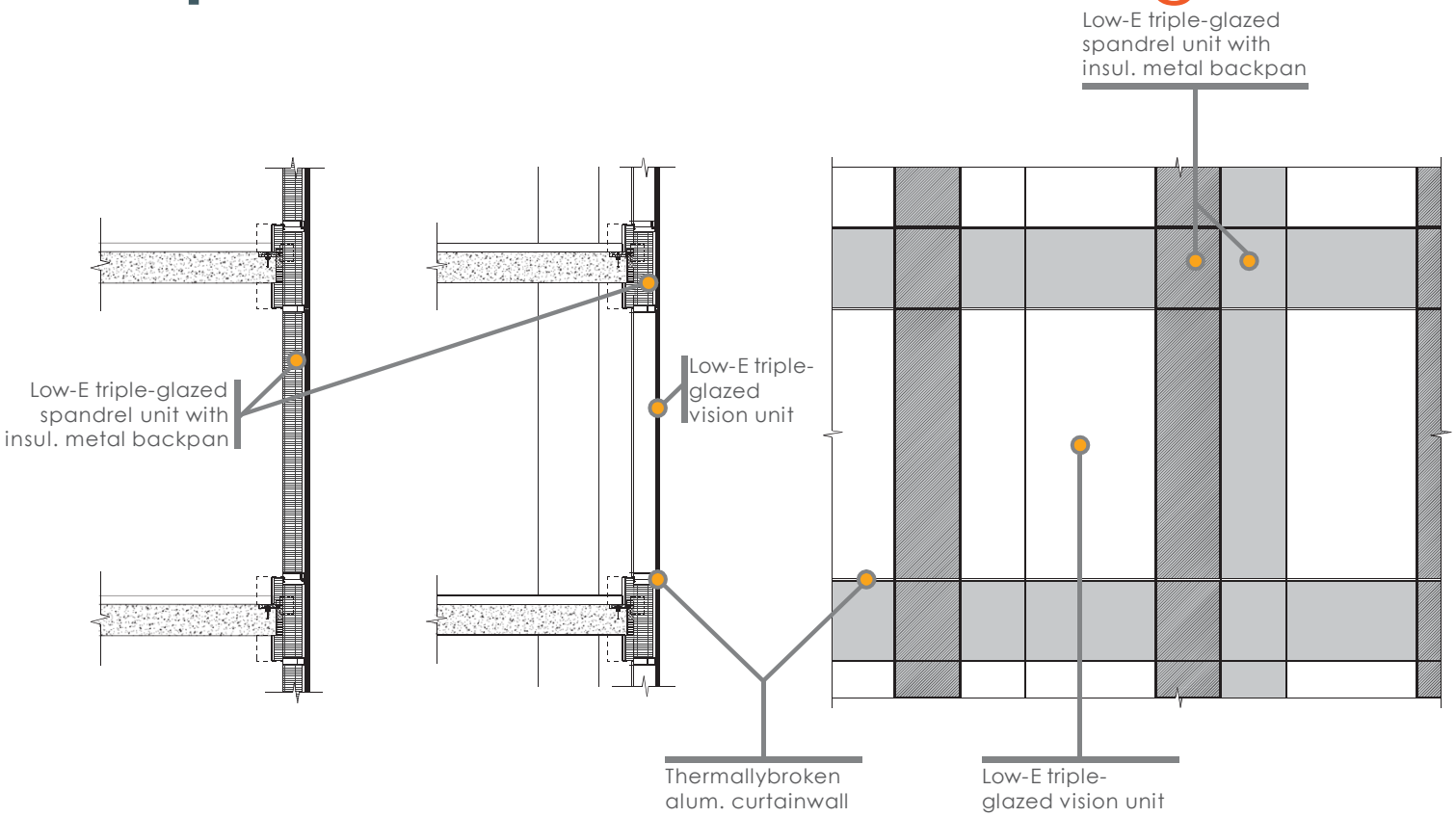


Winthrop Square

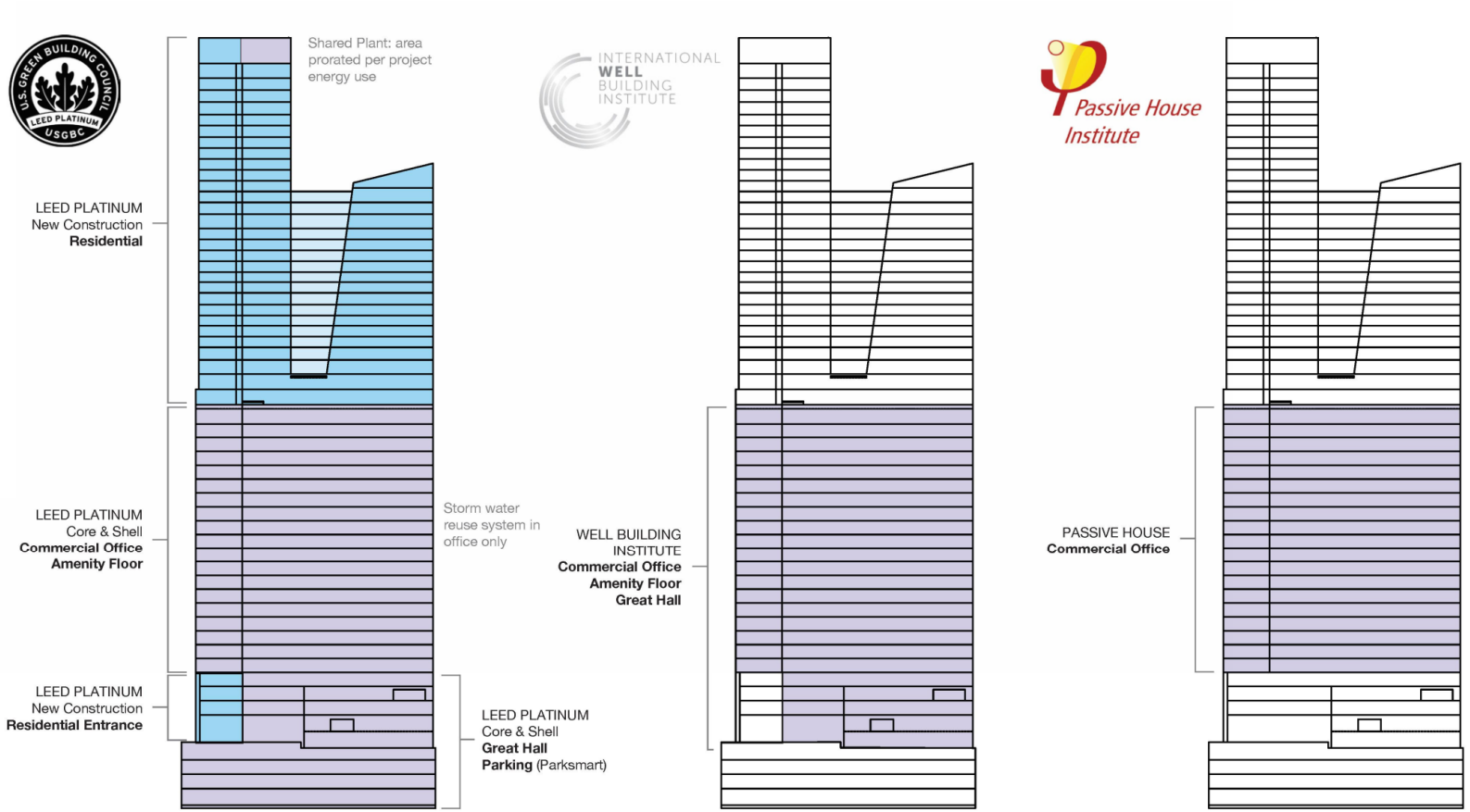
- Downtown Boston
- (Very) high-rise mixed use
- Numerous sustainability goals
- Office portion → **PH Pilot Project**



Winthrop Center: Facade Challenges

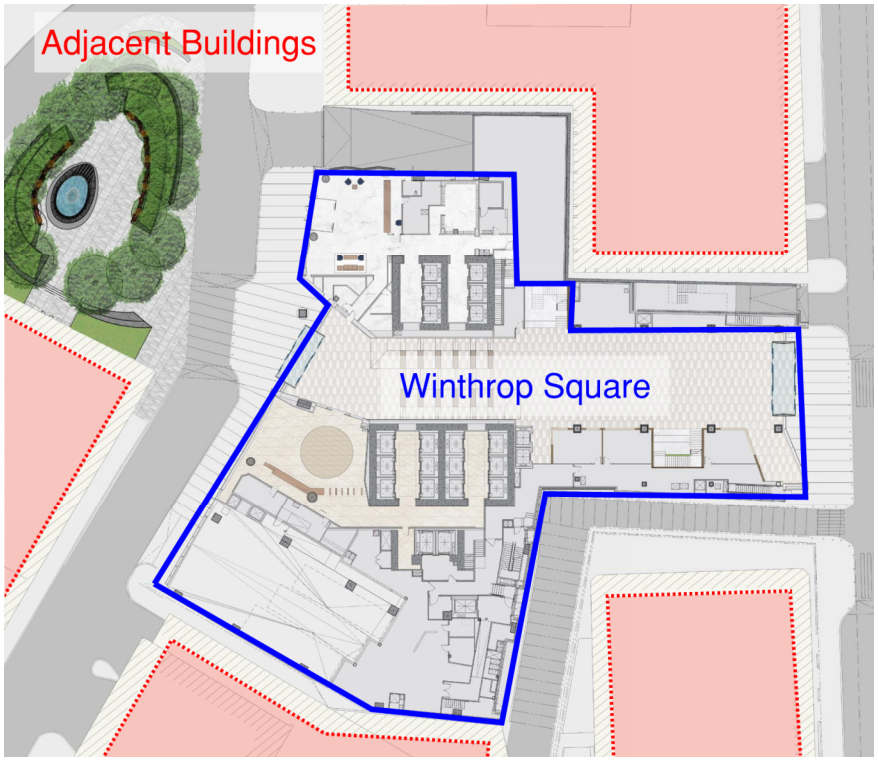


Winthrop Square

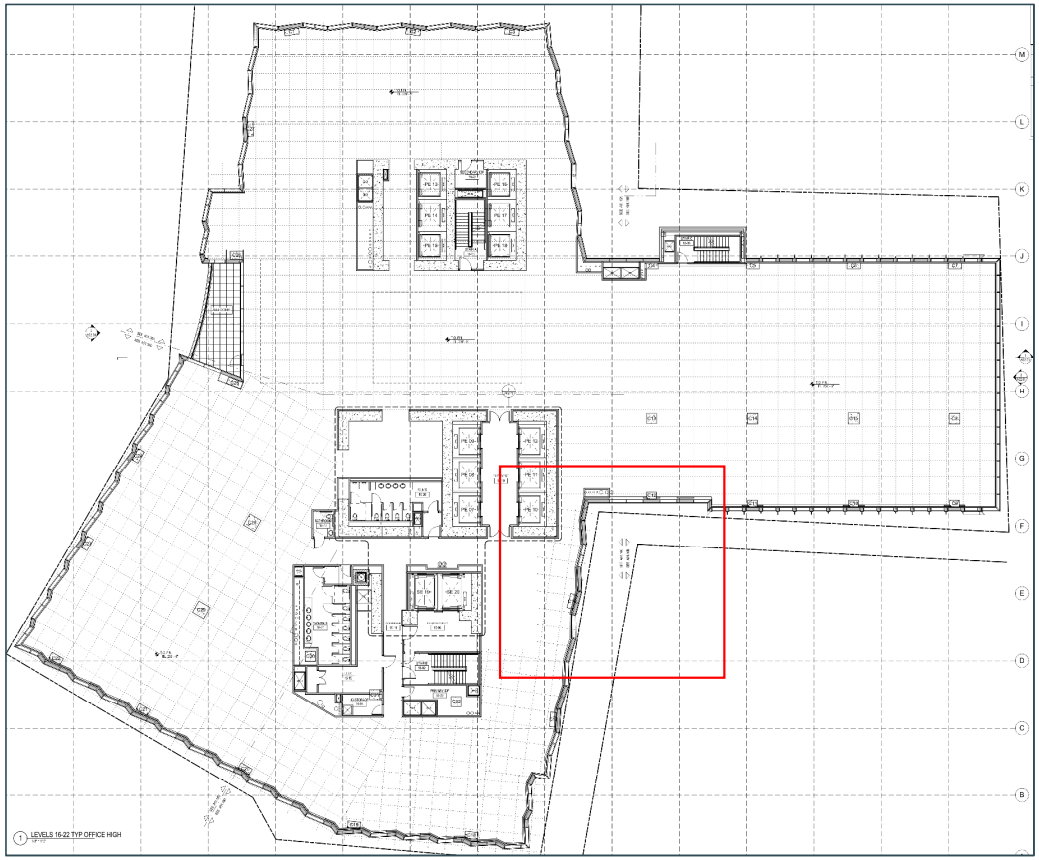


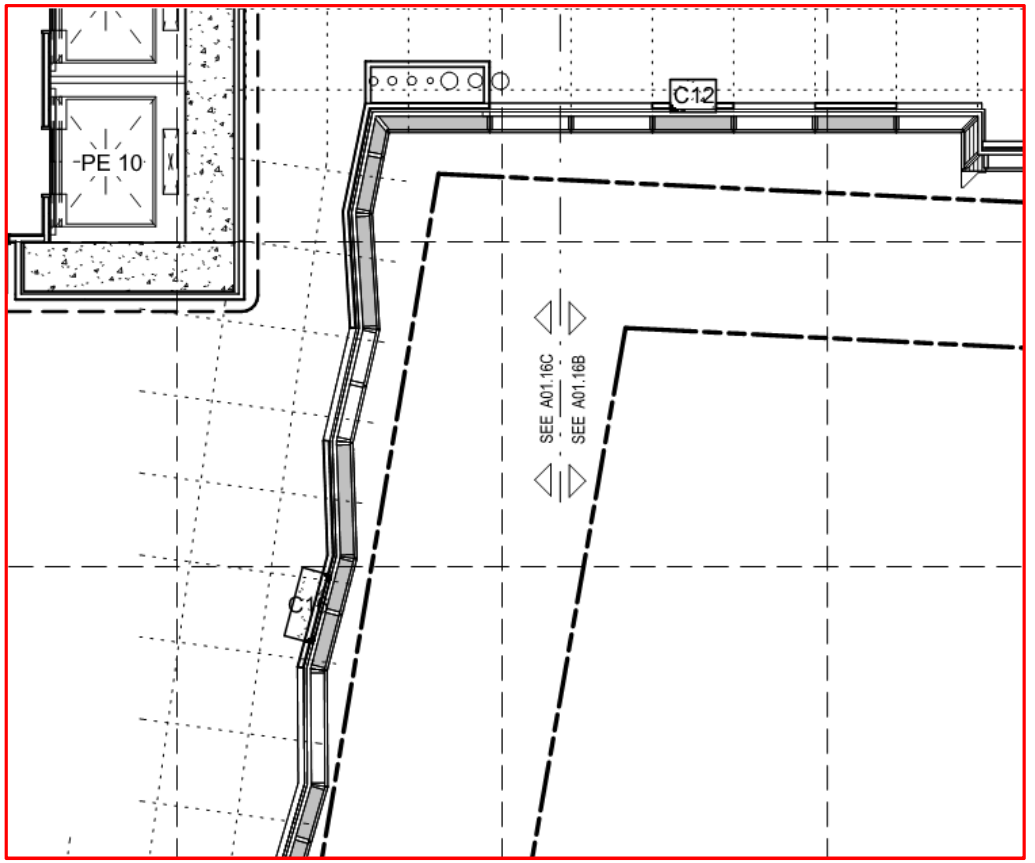
Winthrop Square Design Requirements

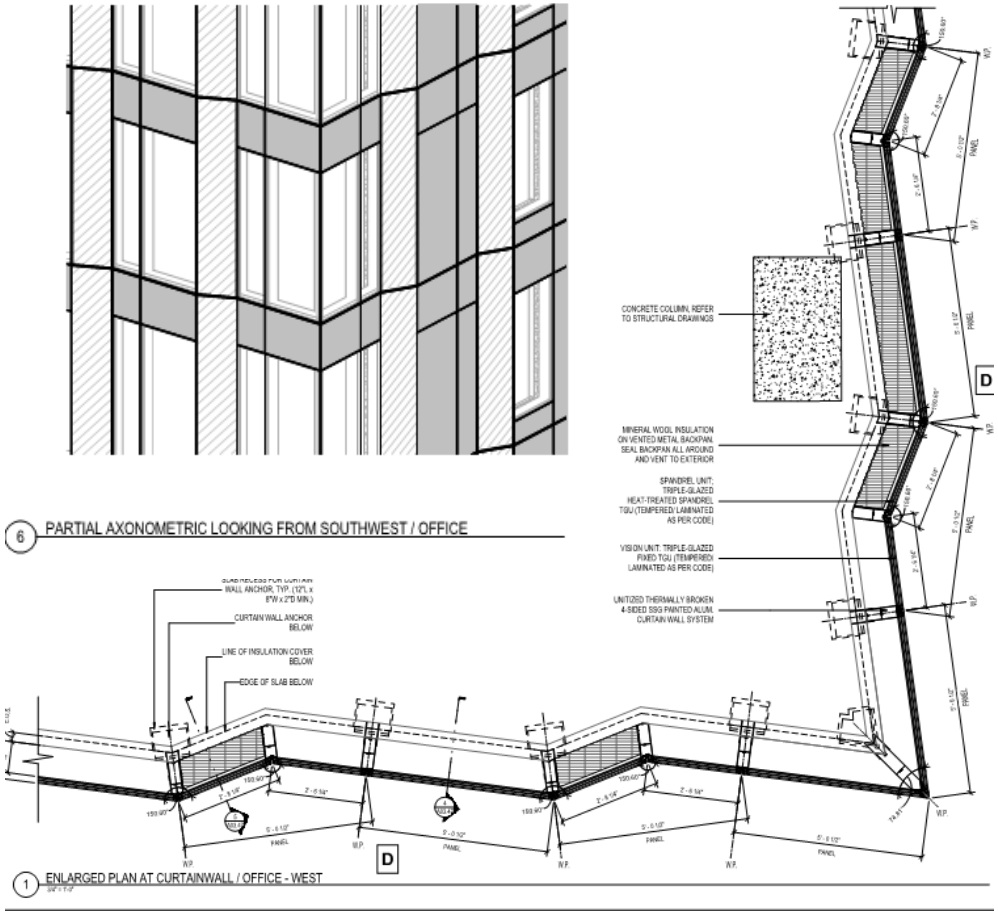
- Completely custom system
- Unitized system in 5 ft modules
- Hung from inside
- High wind loads
- **Stringent thermal requirements for PH** **R-18**
  - Opaque U-value ≤ 0.055 Btu/hr.ft².°F *(0.312 W/m².K)*
  - Vision U-value ≤ 0.220 Btu/hr.ft².°F *(1.249 W/m².K)*



Winthrop Square Typical Office Floor Plan





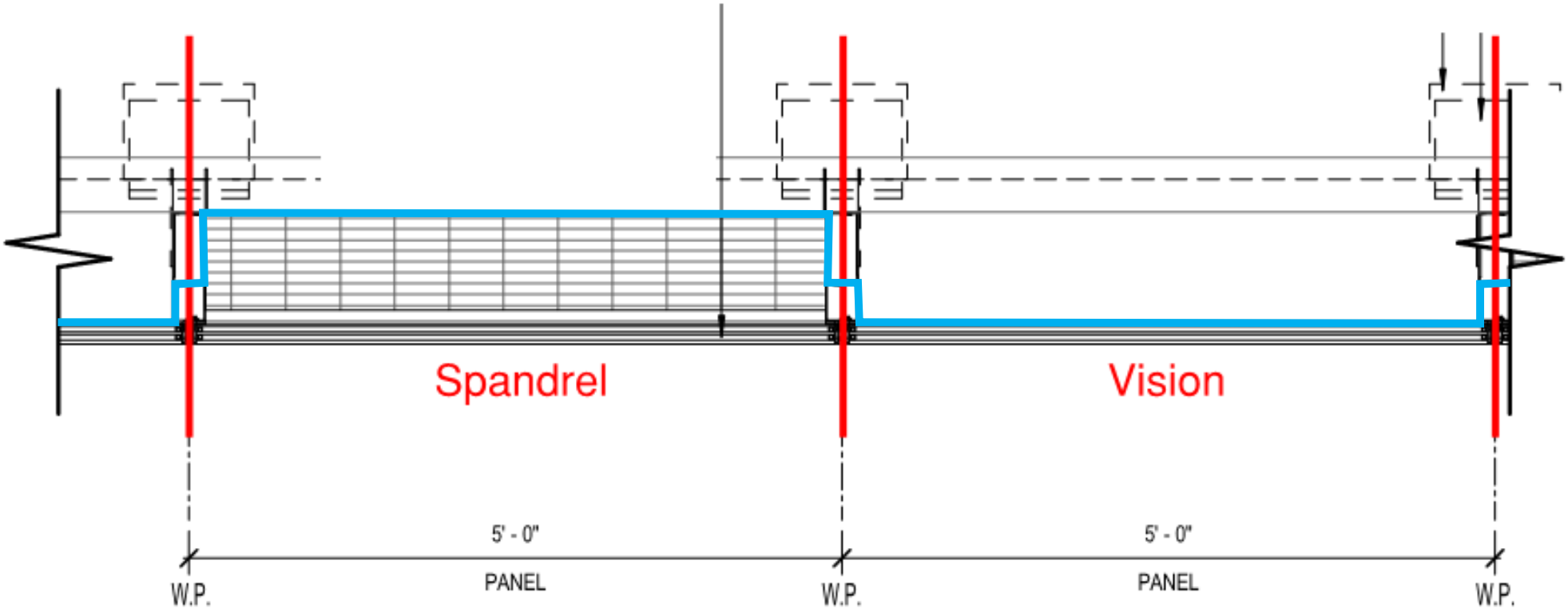


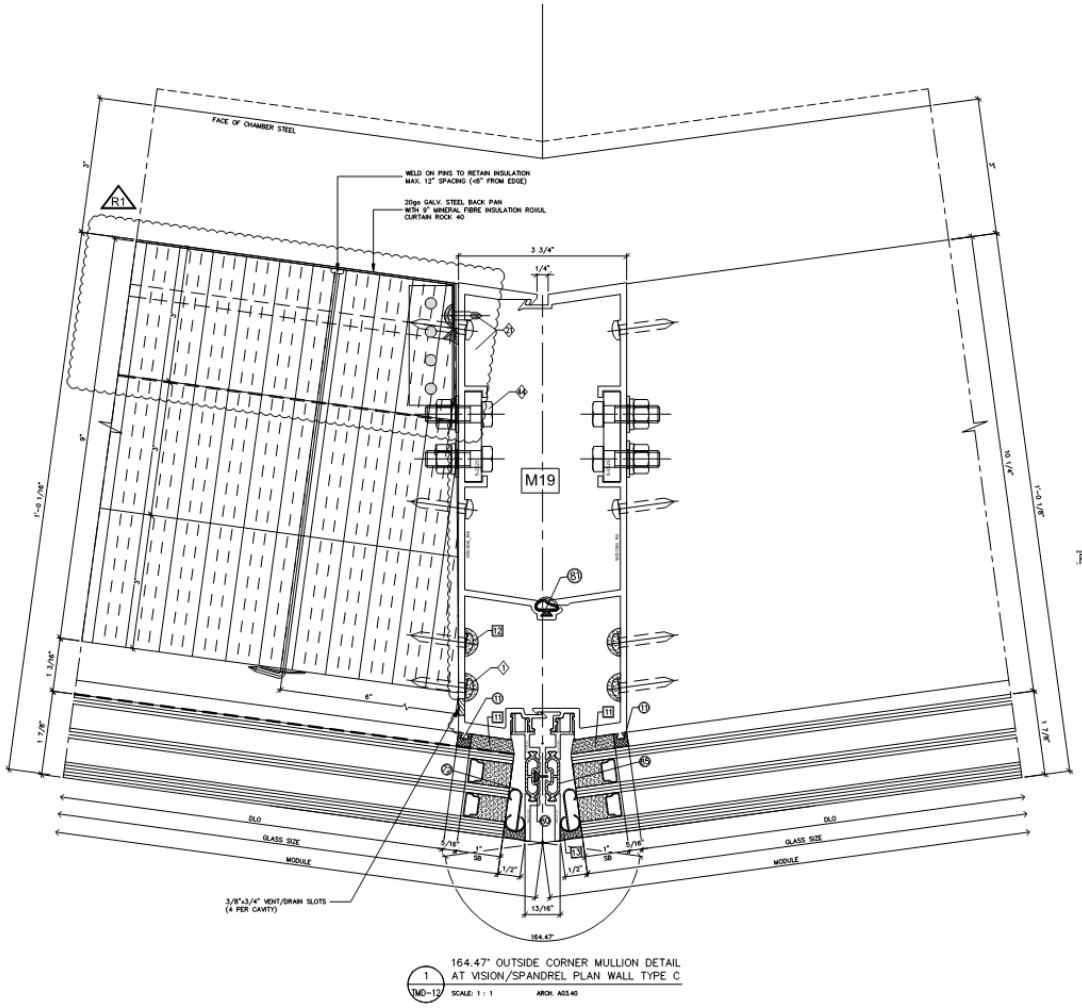
Curtainwall
Solutions

Current Curtainwall Design Values:
Vision Glass: U-0.221 (R-4.52)
Spandrel: R-15.7

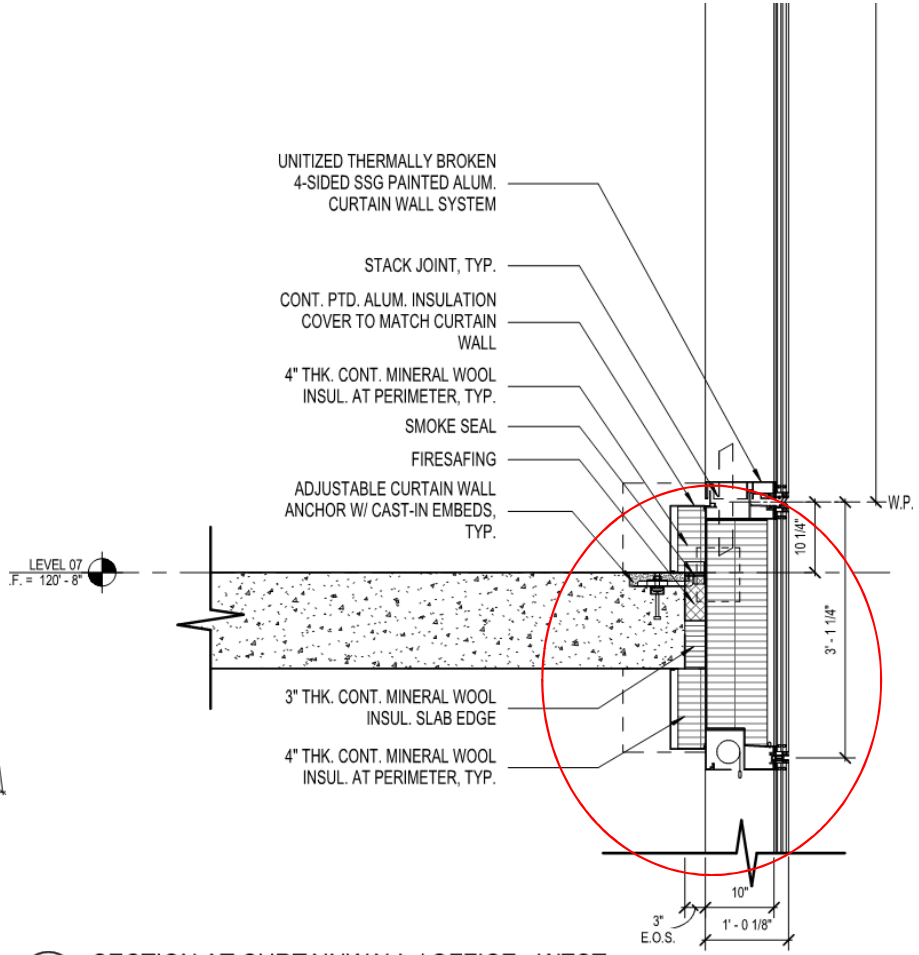
Spandrel Insulation: 9” MW + 4” horizontal MW at head and sill + added vertical mullion insul. at spandrel to spandrel

Winthrop Square Air Tight Layer

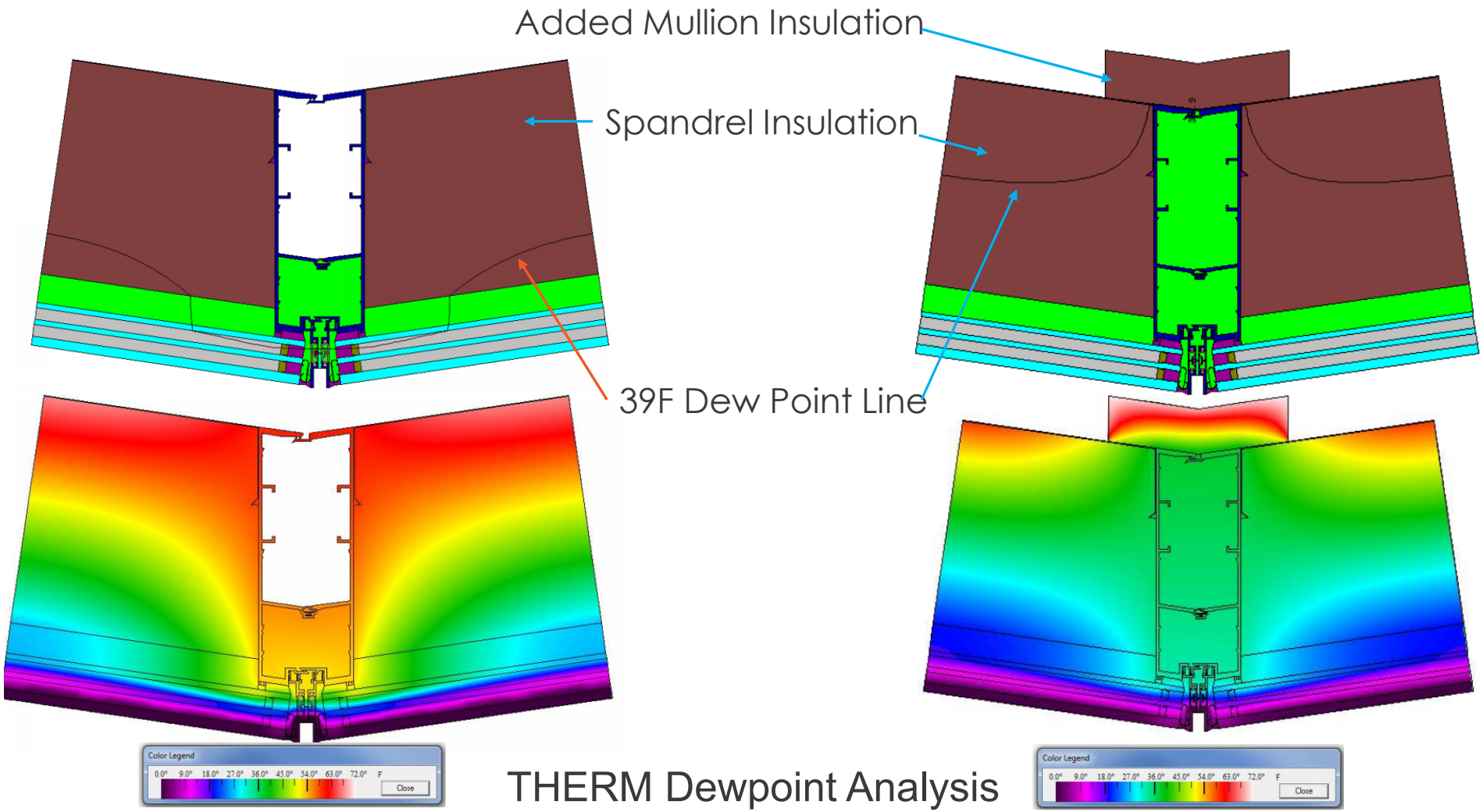




1 TMD-12 164.47" OUTSIDE CORNER MULLION DETAIL AT VISION/SPANDREL PLAN WALL TYPE C
SCALE: 1 : 1 ARCH. A03.40

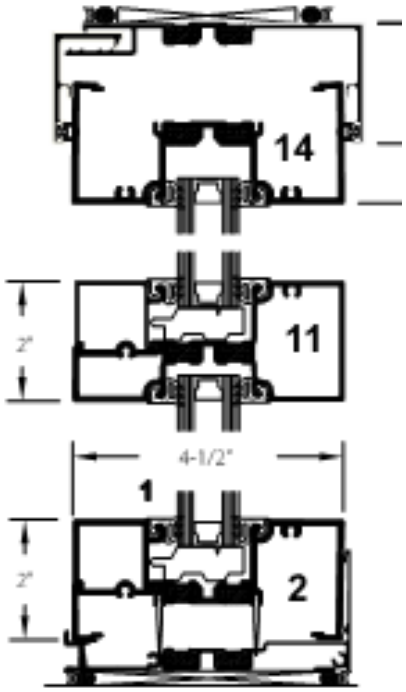


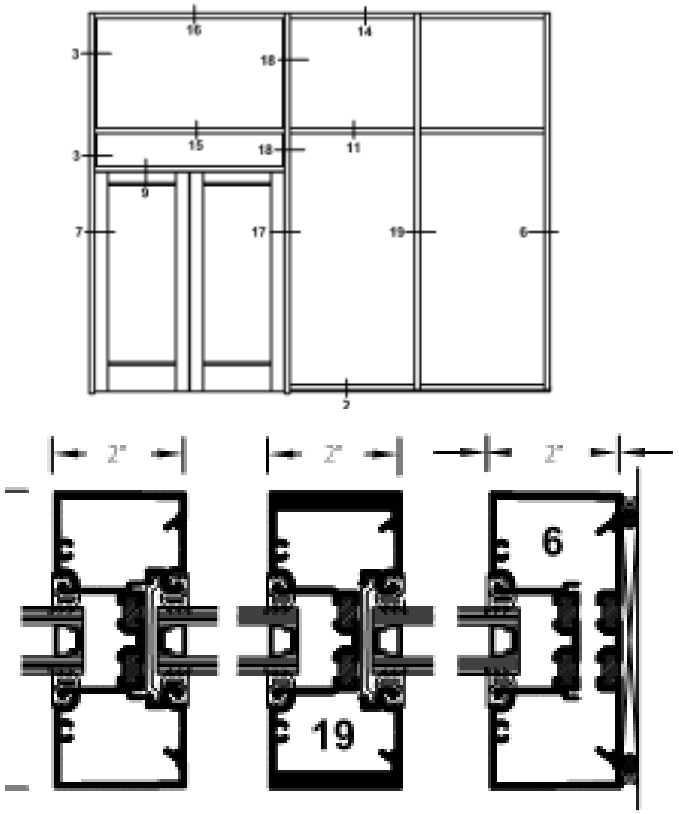
4 SECTION AT CURTAINWALL / OFFICE - WEST
3/4" = 1'-0"

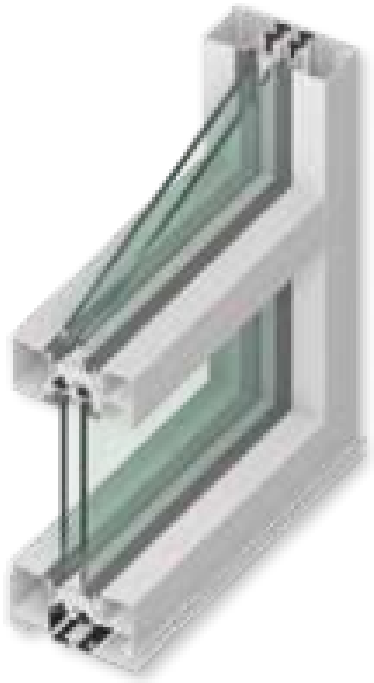


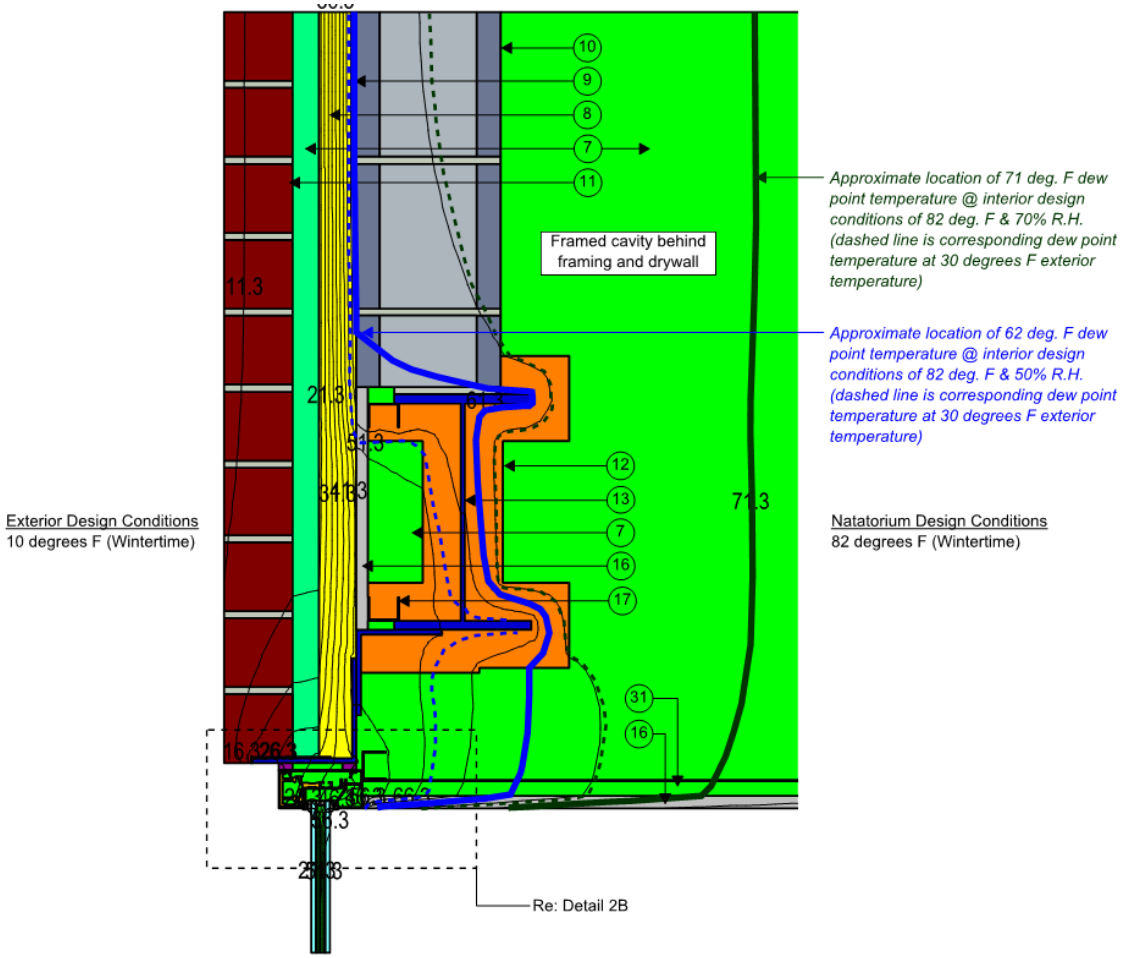
THERM Dewpoint Analysis

High-Performance Storefront Systems

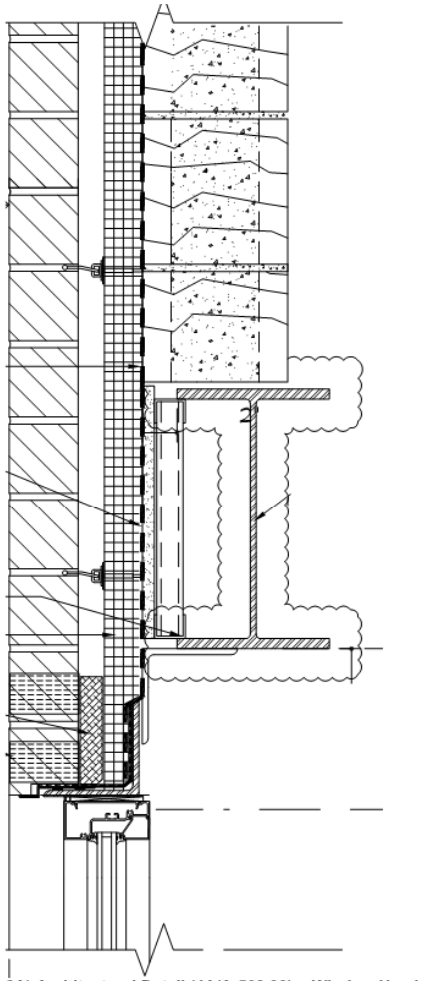






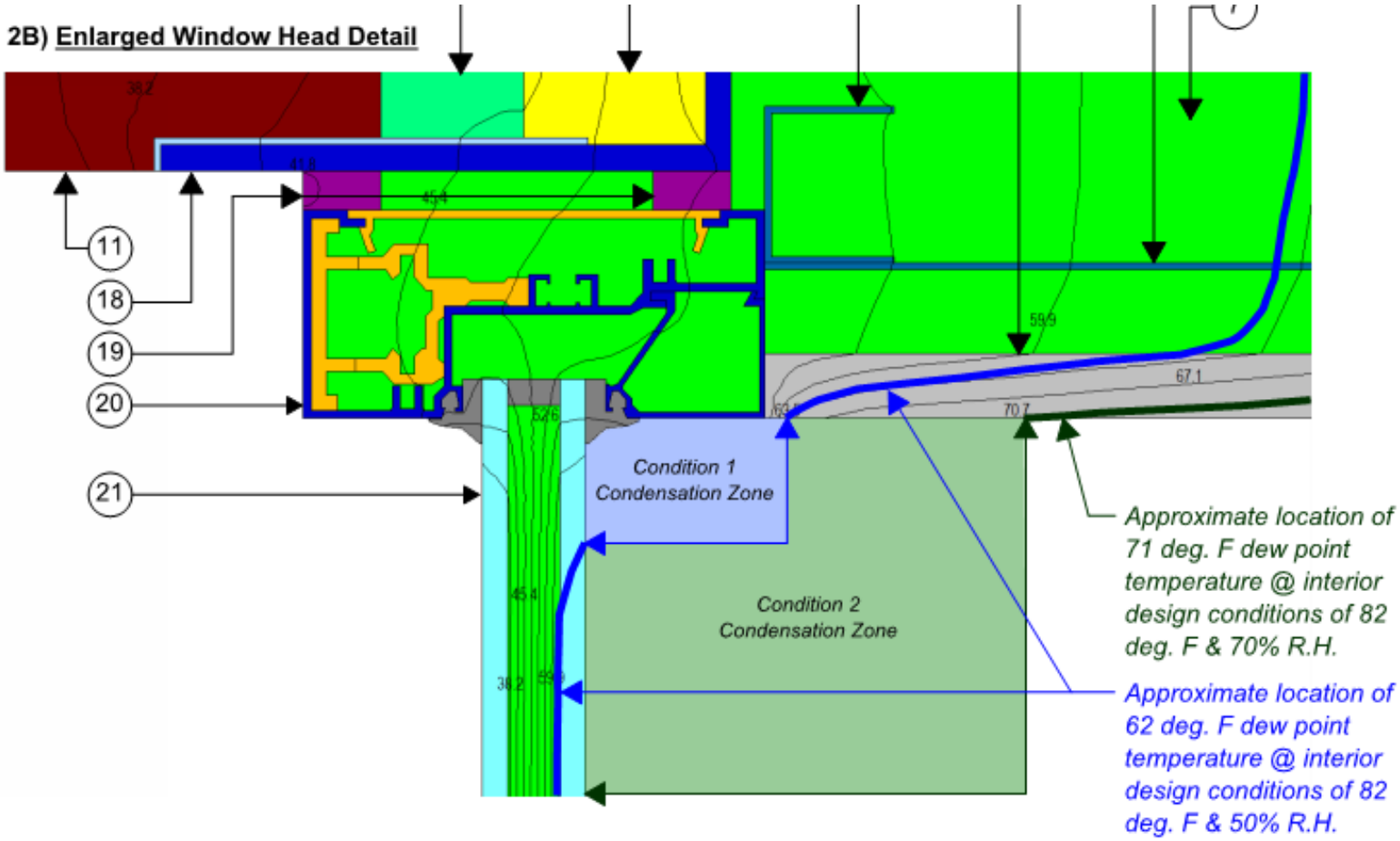


2) THERM Model - Window Head

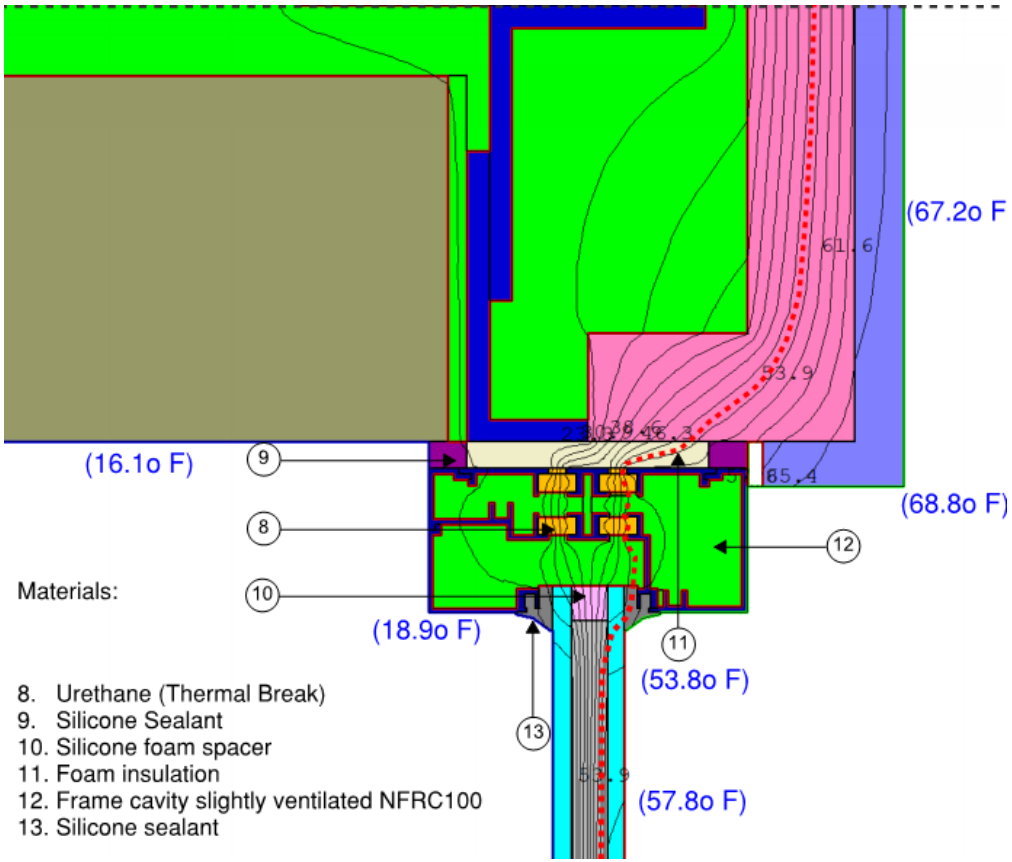


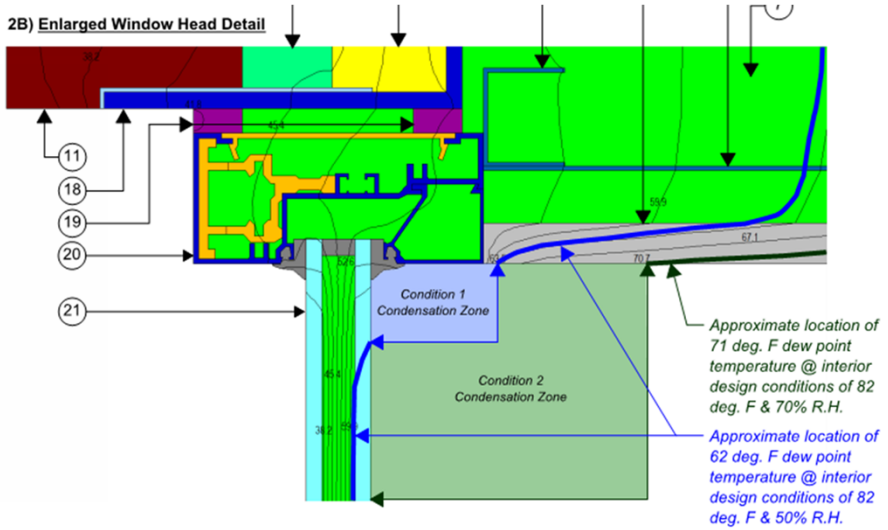
2A) Architectural Detail (4A/A-563.00) - Window Head

2B) Enlarged Window Head Detail



Thermally Broken vs. Non-Thermally Broken





Questions?



15 Minute Break

Construction Phase QA/QC

Airtightness

- Planning during design and the integrated design approach
- Training for contractors and subs
- Inspections and testing

Contractor Buy-In

- General contractor and subcontractor buy-in is critical to project success
- All trades have an impact on project results and may require a mind shift on performance testing
- Passive House Tradesperson training mandatory for key personnel
- GC needs at least two people who will be dedicated to PH scope and coordination



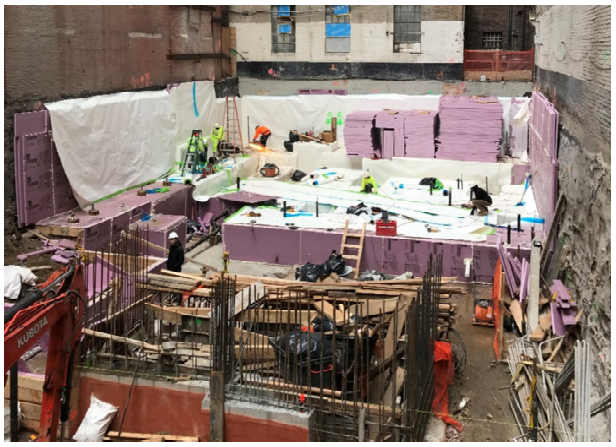


Contractor Buy-In

- Ensure GC & trades fully understand what is included in respective work scopes
- Discuss expectations with whole project team during bidding
- Ask questions, dispel myths

Verification for Large Projects

- Foundations
  - Abutting neighbor(s)
  - Staging of foundation
  - Under slab / stem walls
- Above Grade Walls
  - Wall construction type: CMU, wood framed, etc.
  - Sequencing for hoistways, upper vs. lower floors
- Roof
  - Thermal breaks and roof membrane penetrations
  - Bulkheads, louvers & dampers







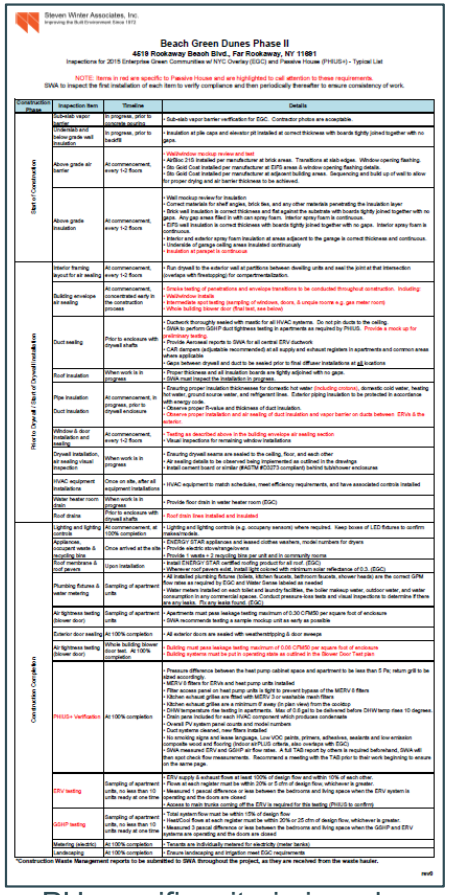
Verification for Large Projects

- MEP
  - In unit heat/cool duct testing
  - Ventilation
  - TAB process
  - Pipe insulation
  - Lighting wattages & controls

Start of Construction

Prior to Drywall / Start of Drywall Installation

Construction Completion



Steven Winter Associates, Inc.
Improving the Built Environment Since 1972

Beach Green Dunes Phase II
4618 Rockaway Beach Blvd., Far Rockaway, NY 11691
Inspections for 2015 Enterprise Green Communities w/ NYC Overlay (EGC) and Passive House (PHIUS+) - Typical List

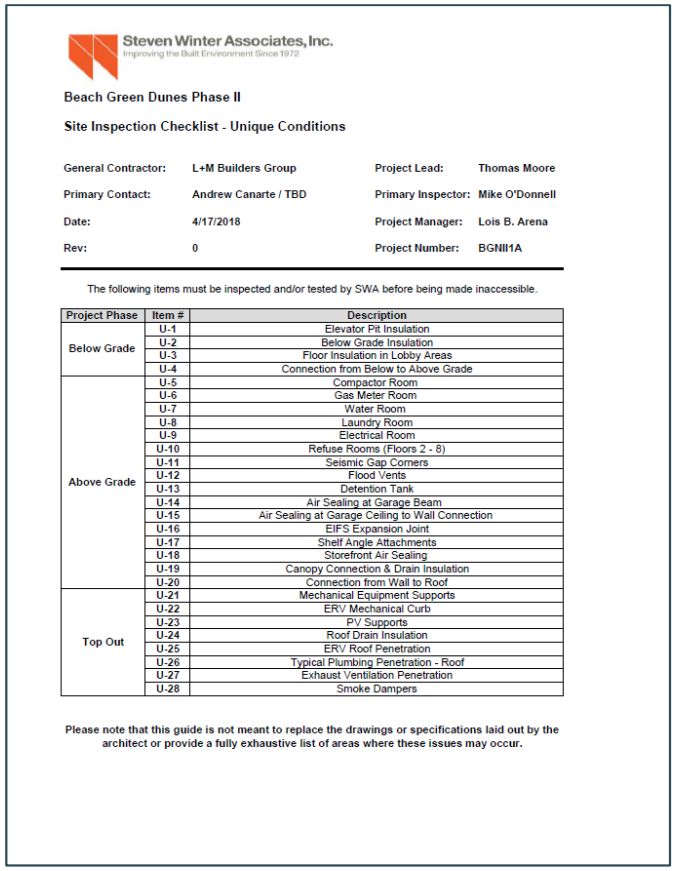
NOTE: Items in red are specific to Passive House and are highlighted to call attention to these requirements.
SWA to inspect the first installation of each item to verify compliance and then periodically thereafter to ensure consistency of work.

Construction Phase	Inspection Item	Timeline	Details
Start of Construction	Sub-slab vapor barrier	In progress, prior to concrete pouring	- Sub-slab vapor barrier verification for EGC. Contractor photos are acceptable.
	Underslab and below grade wall insulation	In progress, prior to backfill	- Insulation at pile caps and elevator pit installed at correct thickness with boards tightly joined together with no gaps.
	Above grade air barrier	At commencement, every 1-2 floors	- Washwindow mockup review and test - AirBloc 21G installed per manufacturer at brick areas. Transitions at slab edges. Window opening flashing. - Sto Gold Coat installed per manufacturer at EIFS areas & window opening flashing details. - Sto Gold Coat installed per manufacturer at adjacent building areas. Sequencing and build up of wall to allow for proper drying and air barrier thickness to be achieved.
	Above grade insulation	At commencement, every 1-2 floors	- Wall mockup review for insulation - Correct materials for shelf angles, brick ties, and any other materials penetrating the insulation layer - Thick-wall insulation is correct thickness and flat against the substrate with boards tightly joined together with no gaps. Any gap areas filled in with can spray foam. Interior spray foam is continuous. - EIFS wall insulation is correct thickness with boards tightly joined together with no gaps. Interior spray foam is continuous. - Interior and exterior spray foam insulation at areas adjacent to the garage is correct thickness and continuous. - Underside of garage ceiling areas insulated continuously - Insulation at parapet is continuous
Prior to Drywall / Start of Drywall Installation	Interior framing layout for air sealing	At commencement, every 1-2 floors	- Run drywall to the exterior wall at partitions between dwelling units and seal the joint at that intersection (overlape with firestopping) for compartmentalization.
	Building envelope air sealing	At commencement, concentrated early in the construction process	- Smoke testing of penetrations and envelope transitions to be conducted throughout construction. Including: - Washwindow installs - Intermediate spot testing (sampling of windows, doors, & unique rooms e.g. gas meter room) - Whole building blower door (final test, see below)
	Duct sealing	Prior to enclosure with drywall shafts	- Ductwork thoroughly sealed with mastic for all HVAC systems. Do not pin ducts to the ceiling. - SWA to perform SIWP duct tightness testing in apartments as required by PHIUS. Provide a mock up for preliminary testing. - Provide Aeroseal reports to SWA for all central ERV ductwork - CAR dampers (adjustable recommended) at all supply and exhaust registers in apartments and common areas where applicable - Gaps between drywall and duct to be sealed prior to final diffuser installations at all locations
	Roof insulation	When work is in progress	- Proper thickness and all insulation boards are tightly adjoined with no gaps. - SWA must inspect the installation in progress.
	Pipe insulation Duct insulation	At commencement, in progress, prior to drywall enclosure	- Ensuring proper insulation thicknesses for domestic hot water (including crotons), domestic cold water, heating hot water, ground source water, and refrigerant lines. Exterior piping insulation to be protected in accordance with energy code. - Observe proper R-value and thickness of duct insulation. - Observe proper installation and air sealing of duct insulation and vapor barrier on ducts between ERVs & the exterior.
	Window & door installation and sealing	At commencement, every 1-2 floors	- Testing as described above in the building envelope air sealing section - Visual inspections for remaining window installations
	Drywall installation, air sealing visual inspection	When work is in progress	- Ensuring drywall seams are sealed to the ceiling, floor, and each other - Air sealing details to be observed being implemented as outlined in the drawings - Install cement board or similar (#427M #33273 compliant) behind tub/shower enclosures
	HVAC equipment installations	Once on site, after all equipment installations	- HVAC equipment to match schedules, meet efficiency requirements, and have associated controls installed
	Water heater room drain	When work is in progress	- Provide floor drain in water heater room (EGC)
	Roof drains	Prior to enclosure with drywall shafts	- Roof drain lines installed and insulated
Construction Completion	Lighting and lighting controls	At commencement, at 100% completion	- Lighting and lighting controls (e.g. occupancy sensors) where required. Keep boxes of LED fixtures to confirm makes/models.
	Appliances, occupant vaults & recycling bins	Once arrived at the site	- ENERGY STAR appliances and leased clothes washers, model numbers for dryers - Provide electric stoves/range/ovens - Provide 1 waste + 2 recycling bins per unit and in community rooms
	Roof membrane & roof pavers	Upon installation	- Install ENERGY STAR certified roofing product for all roof. (EGC) - Wherever roof pavers exist, install light colored with minimum solar reflectance of 0.3. (EGC)
	Plumbing fixtures & water metering	Sampling of apartment units	- All installed plumbing fixtures (toilets, kitchen faucets, bathroom faucets, shower heads) are the correct GPM flow rates as required by EGC and Water Sense labeled as needed - Water meters installed on each toilet and laundry facilities, the boiler makeup water, outdoor water, and water consumption in any commercial spaces. Conduct pressure-loss tests and visual inspections to determine if there are any leaks. Fix any leaks found. (EGC)
	Air tightness testing (blower door)	Sampling of apartment units	- Apartments must pass leakage testing maximum of 0.30 CFM50 per square foot of enclosure - SWA recommends testing a sample mockup unit as early as possible
	Exterior door sealing	At 100% completion	- All exterior doors are sealed with weatherstripping & door sweeps
	Air tightness testing (blower door)	Whole building blower door test. At 100% completion	- Building must pass leakage testing maximum of 0.06 CFM50 per square foot of enclosure - Building systems must be put in operating state as outlined in the Blower Door Test plan
	PHIUS+ Verification	At 100% completion	- Pressure difference between the heat pump cabinet space and apartment to be less than 5 Pa; return grill to be sized accordingly. - MERV 8 filters for ERVs and heat pump units installed. - Filter access panel on heat pump units is tight to prevent bypass of the MERV 8 filters - Kitchen exhaust grilles are fitted with MERV 3 or washable mesh filters - Kitchen exhaust grilles are a minimum 8" away (in plan view) from the cooktop - DHW temperature rise testing in apartments. Max of 0.8 gal to be delivered before DHW temp rises 10 degrees. - Drain pans included for each HVAC component which produces condensate - Overall PV system panel counts and model numbers - Duct systems cleaned, new filters installed - No smoking signs and lease language, Low VOC paints, primers, adhesives, sealants and low emission composite wood and flooring (indoor airPLUS criteria, also overlaps with EGC) - SWA measured ERV and GSHP air flow rates. A full TAB report by others is required beforehand, SWA will then spot check flow measurements. Recommend a meeting with the TAB prior to their work beginning to ensure on the same page.
	ERV testing	Sampling of apartment units, no less than 10 units ready at one time	- ERV supply & exhaust flows at least 100% of design flow and within 10% of each other. - Flows at each register must be within 20% or 5 cfm of design flow, whichever is greater. - Measured 1 pascal difference or less between the bedrooms and living space when the ERV system is operating and the doors are closed. - Access to main trunks coming off the ERV is required for this testing (PHIUS to confirm)
	GSHP testing	Sampling of apartment units, no less than 10 units ready at one time	- Total system flow must be within 15% of design flow - Heat/Cool flows at each register must be within 20% or 25 cfm of design flow, whichever is greater. - Measured 3 pascal difference or less between the bedrooms and living space when the GSHP and ERV systems are operating and the doors are closed.
	Metering (electric)	At 100% completion	- Tenants are individually metered for electricity (meter banks)
	Landscaping	At 100% completion	- Ensure landscaping and irrigation meet EGC requirements

*Construction Waste Management reports to be submitted to SWA throughout the project, as they are received from the waste hauler.

rev6

PH specific criteria in red



Steven Winter Associates, Inc.
Improving the Built Environment Since 1972

Beach Green Dunes Phase II

Site Inspection Checklist - Unique Conditions

General Contractor:	L+M Builders Group	Project Lead:	Thomas Moore
Primary Contact:	Andrew Canarte / TBD	Primary Inspector:	Mike O'Donnell
Date:	4/17/2018	Project Manager:	Lois B. Arena
Rev:	0	Project Number:	BGNII1A

The following items must be inspected and/or tested by SWA before being made inaccessible.

Project Phase	Item #	Description
Below Grade	U-1	Elevator Pit Insulation
	U-2	Below Grade Insulation
	U-3	Floor Insulation in Lobby Areas
	U-4	Connection from Below to Above Grade
Above Grade	U-5	Compactor Room
	U-6	Gas Meter Room
	U-7	Water Room
	U-8	Laundry Room
	U-9	Electrical Room
	U-10	Refuse Rooms (Floors 2 - 8)
	U-11	Seismic Gap Corners
	U-12	Flood Vents
	U-13	Detention Tank
	U-14	Air Sealing at Garage Beam
	U-15	Air Sealing at Garage Ceiling to Wall Connection
	U-16	EIFS Expansion Joint
	U-17	Shelf Angle Attachments
	U-18	Storefront Air Sealing
	U-19	Canopy Connection & Drain Insulation
	U-20	Connection from Wall to Roof
Top Out	U-21	Mechanical Equipment Supports
	U-22	ERV Mechanical Curb
	U-23	PV Supports
	U-24	Roof Drain Insulation
	U-25	ERV Roof Penetration
	U-26	Typical Plumbing Penetration - Roof
	U-27	Exhaust Ventilation Penetration
	U-28	Smoke Dampers

Please note that this guide is not meant to replace the drawings or specifications laid out by the architect or provide a fully exhaustive list of areas where these issues may occur.

Typical & Unique Checklists

Testing Tools and Protocols

- Window mockup testing
- Interim guarded blower door testing
- Interim whole building test if schedule and sequencing allows
- Envelope compartmentalization and window testing
- Unique component testing
- Whole building blower door test

Mock Ups

Mock ups







Separate Assembly, First Install, or Off-site





Complete Assembly including Windows



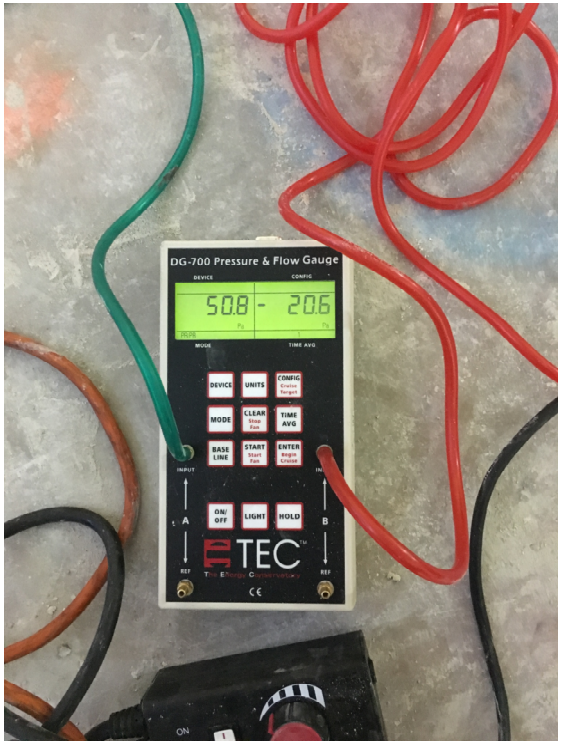


Interim Testing

- Window mockup testing
- Envelope and window testing
- Unique component testing
- Guarded blower door testing
- Whole building blower door test



Testing Interior-Side Air-barrier






11/02/2018


11/02/2018


11/02/2018


11/02/2018


11/02/2018


04/02/2019

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WHOLE BUILDING INFILTRATION TESTING PLAN

TO DETERMINE COMPLIANCE WITH PHIUS+ AIRTIGHTNESS REQUIREMENTS
AT BEACH GREEN DUNES PHASE II
45-19 ROCKAWAY BEACH BLVD., QUEENS, NY 11691
REV 1

APRIL 17, 2018
UPDATED 10/16/2019



Blower Door Test Plan

Blower Door Testing – Whole Building









Questions?

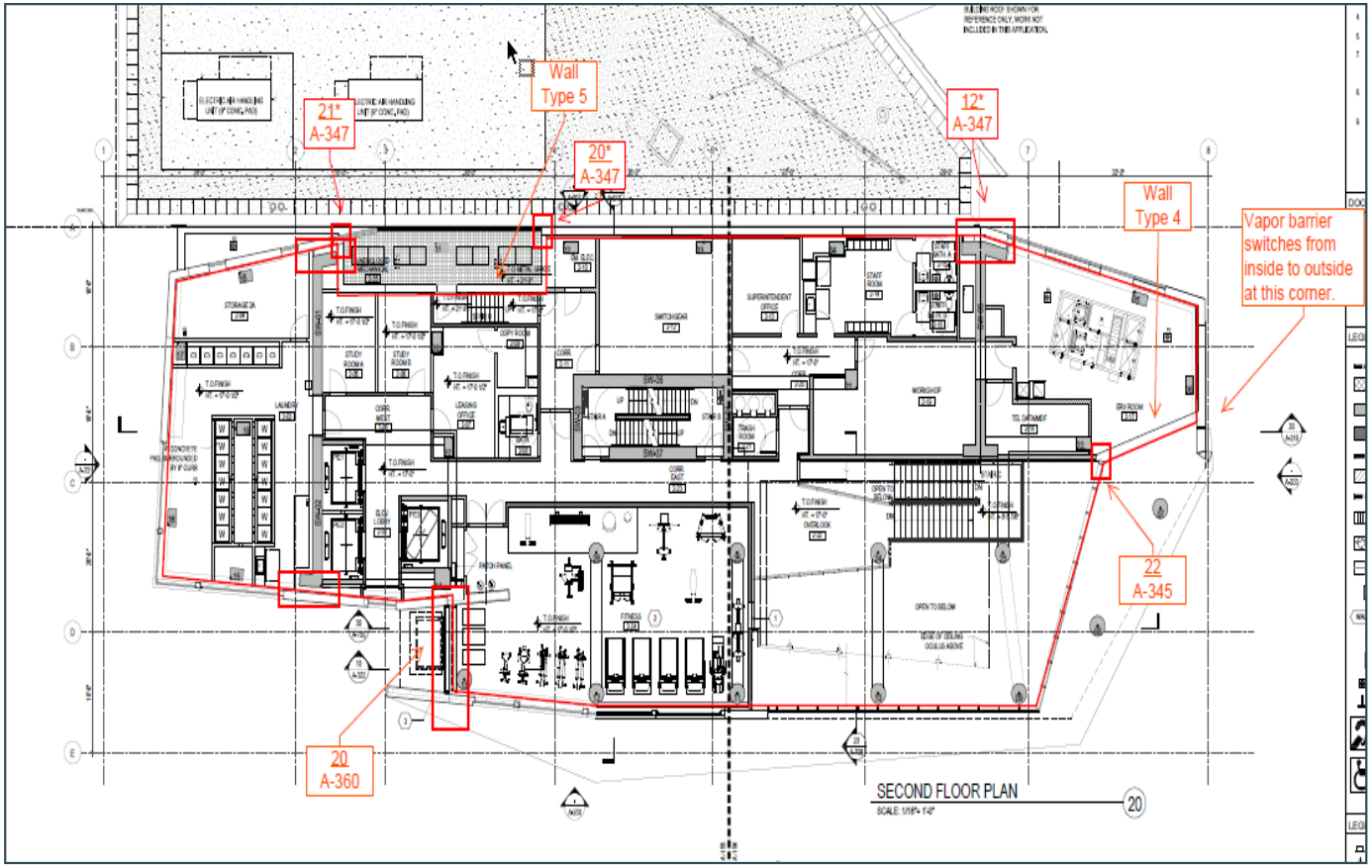


Case Studies

The House at Cornell Tech

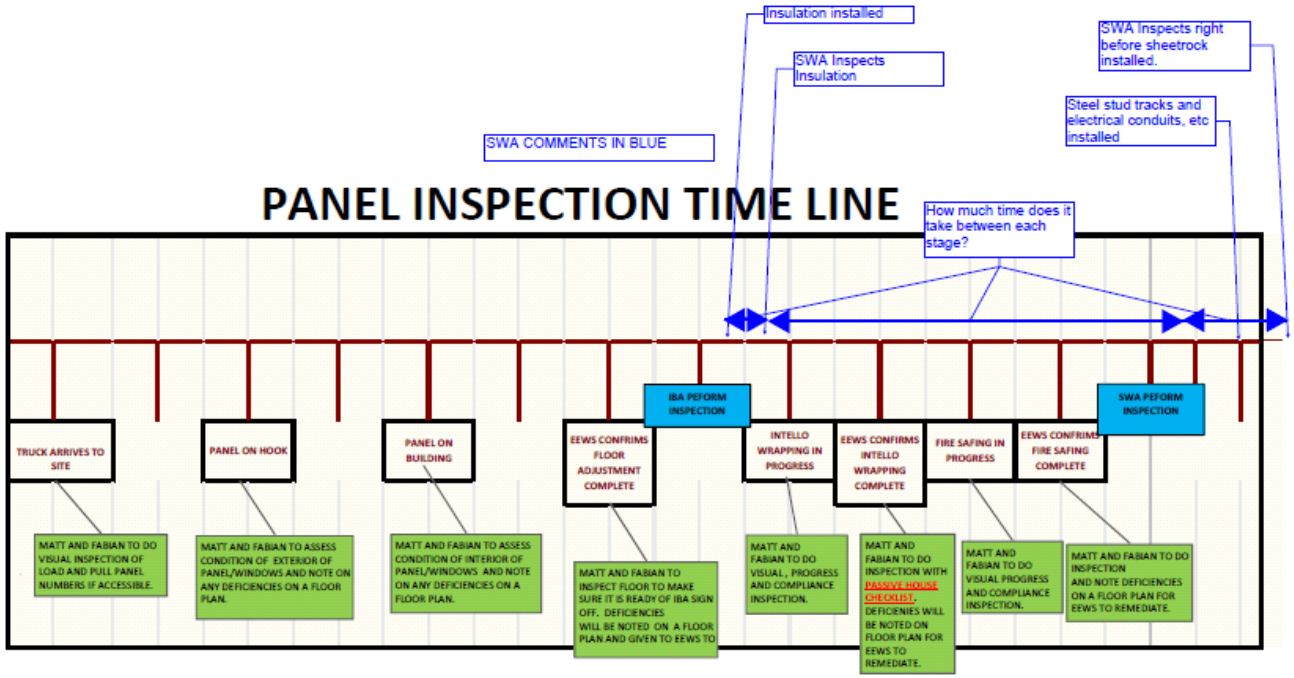
- 352 units, student housing
- Roosevelt Island, NY
- Panelized wall system





Redline Plan & Section – Air Barrier Review

Identify Sequencing & Timing of Inspections

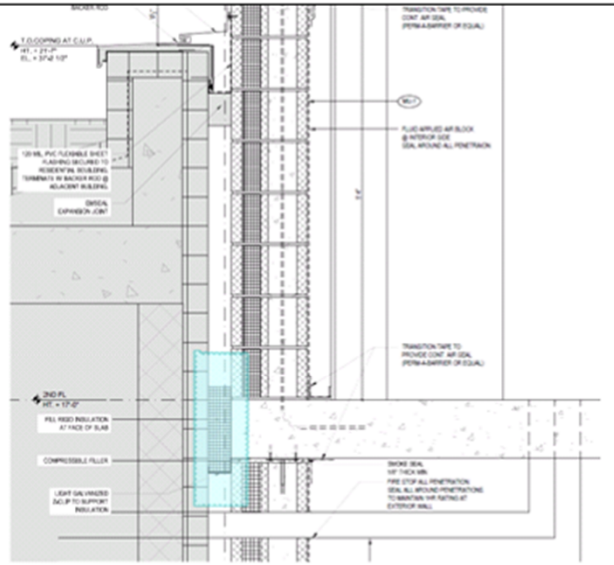
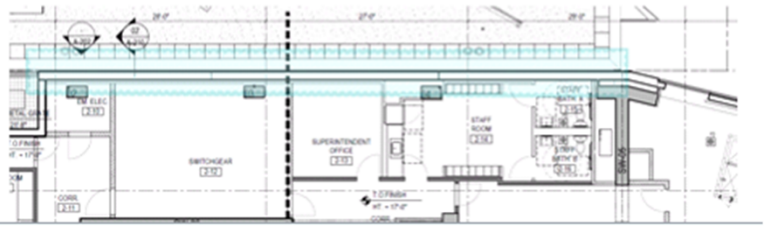



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Velocity
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Wall Panels

Site Visit Reports

Item #	Description	Image
	2nd Floor Slab Edge Insulation: Refer to architectural details 20 A-356. Detail 20 shows 4" thick nsulation at the slab edge between the CUP and the Residential Tower extending 2" above and below the slab (highlighted area in detail at right). This conditions exits at the area highlighted on the plan to the right.	 

Issues Log

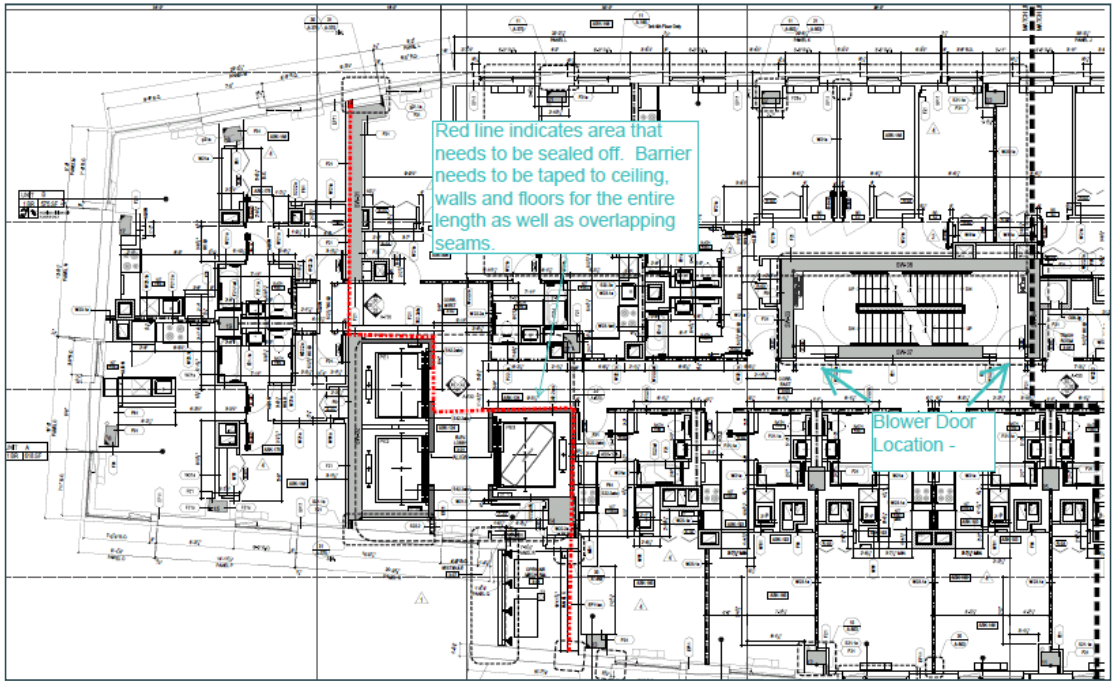
Issues Log - 1/25/2017

SVR #	SVR Item #	Issue Type	Location	Issue	Found by	Date Found	Action Required	Responsible Party	Reinspection Required?	Actions Taken/Updates	Date Verified/ updated	Open/ Closed
7	1	ENV	7th Floor	**Panel Insulation at Joints:** Insulation at the panel joints was found to be around 6 inches deep. Shop drawings indicate 9". (EEWS Shop Drawings Sheet 501, Detail 1, second image right). SWA notified Monadnock of the issue. Monadnock followed up with a photo on 5/11/16 and informed SWA that EEWS will continue to install insulation at 9 inch depth. All panels below the six floor will need to be inspected for insufficient insulation and corrected if needed via exterior scaffolding when exterior caulk is applied.	SWA	5/10/16	Photo documentation using a measuring device will be required to verify PH compliance. SWA & EEWS to agree on frequency of photos and method of depth verification.	Eastern	Y	On 9/22/16, Eastern issued photos of joint insulation being installed along two swing stage areas (Rig 3 Drop 2 and Rig 3 Drop 4). SWA will continue keeping track of Eastern's progress.		Ongoing
24	2	ENV	2nd Floor	Gap at the corner of storage room and condenser porch located behind the column is not air sealed at this time. Neither is the connection of Intesana to block. SWA to inspect when complete.	SWA	8/9/16	Monadnock to send photos of the area to SWA	Monadnock	N			Open
42	3	HVAC	All Floors	**Damaged Ductwork Covers:** SWA observed numerous instances of damaged ductwork opening covers damaged or loose throughout the first and second floors. SWA believes a significant amount of dust has likely accumulated in the ductwork. The project is now at risk of losing a LEED point needed for LEED Platinum certification.	SWA	11/21/16	Monadnock to make sure that all ductwork openings have been covered on floors 1, 2, 15-25. Monadnock to issue written confirmation to SWA once this work has been complete. SWA to spot check these areas in its next visit.	SWA	Y	On 11/30/16, SWA observed that much of previously noted loose and damaged ductwork opening covers were repaired. Issues still persist on the various floors. SWA performed spot checks on floors 1, 2, 15-25 and found issues in all floors. On 12/1/16, Monadnock emailed SWA notifying that floors 1,2, and 15-25 had been reinspected and damaged ductwork covers had been repaired. On 12/12/16, SWA observed issues on floors 1, 2, and 17.		Open
n/a	n/a	ENV	2nd Floor	**Insulation under 2nd floor condensor porch ballast** was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.	SWA	5/24/16	Monadnock possesses photo documentation that shows depth and coverage. Provide images to SWA.	Monadnock	N	On 7/28/2016, Monadnock sent photos showing depth of insulation at condensor porch ballast.	7/28/2016	Closed
n/a	n/a	ENV	26th & 27th Floor	**Roof deck insulation inside AHU curb** was covered before SWA could inspect. Images showing insulation depth and coverage must be provided.	SWA	5/1/16	Monadnock possesses photo documentation that shows depth and coverage. Provide images to	Monadnock	N	On 10/1/2016, SWA received photos from Monadnock showing blurry tape measurements of insulation at the AHU curbs. On 10/24/2016, SWA	10/24/2016	Closed

Interim Testing

- Original plan – no whole floor testing
- Revised plan – guarded testing on 4th, 5th and 6th floors
- Window & Door Leakage
- Façade Leakage
- Compartmentalization

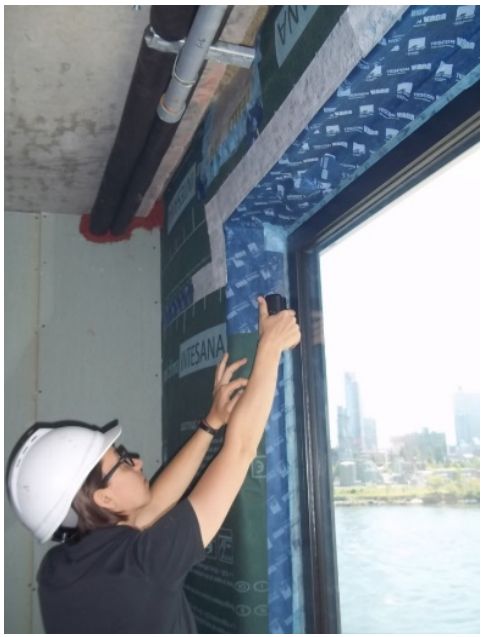
Guarded Test & Temporary Barriers





Guarded Test = Blower Doors on 3 Floors









Other Tests

- Condenser porch doors
- Trash chute rooms / doors





Results

- 6/3/2017 - blower door test completed
  - 0.13 ACH50 (more than 4x less than 0.6)
- ERVs commissioning completed
- 8/1/2017 - students moved in
- *10/17/2017 - PH Certification received!!!*

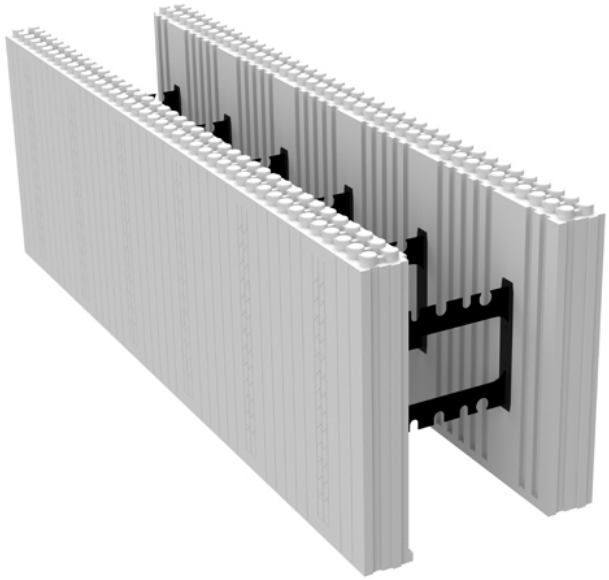
Beach Green North

- 101 units, affordable housing
- Far Rockaway, NY
- Insulated concrete forms (ICF)



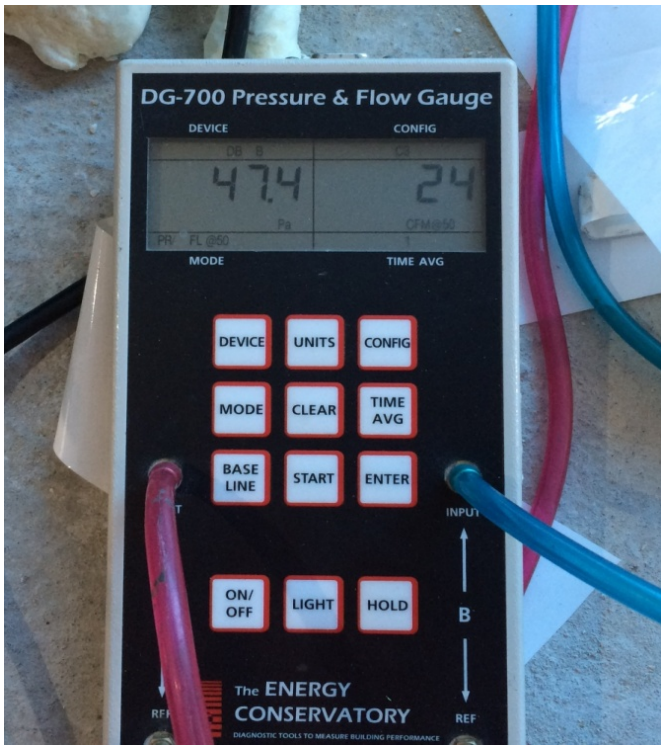
Wall Inspections

- ICF doesn't require as many inspections for insulation and air barrier





1st Window Mock-up Test





2nd Window Mock-up Test





ICF Potential Issues (similar project)





ICF Potential Issues (similar project)







Results

- AeroBarrier by Aeroseal was utilized
- 6/24/2017 - envelope leakage test performed but couldn't finish, Building Department shut down site for working on Saturday
- 7/6/2017 - infiltration test for energy model passed!!
- ERV testing & commissioning completed
- *4/4/2018 - PHIUS Certification received!!!*

Questions?



Final Blower Door Test Planning

Blower Door Test Conditions



Key: HVAC Contractor; Plumber; GC / Builder

Intentional Opening	Test Setting	Notes
Windows, doors, skylights in the building enclosure	Closed and latched	
Doors and operable windows inside the test enclosure	Open	Use stairways to connect all zones of the building
Fire dampers	Remain as found	
Dryer doors	Closed and latched	
Gas meter room	Door to gas meter room closed and weather stripped	
Waste handling system	Trash chute termination at roof taped off. Door to trash rooms closed.	
ERVs (apartments)	Fan off, any dampers closed. Ducts to the outside sealed inside the ERV cabinet in each apartment.	Ventilation is continuous, so can remain taped off
Motorized dampers: ERV-4 (cellar)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized dampers: ERV-5 (1st floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized dampers: ERV-2A (1st floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed off
Motorized damper: Laundry Room (2nd floor)	Fan off, dampers closed. Taped off from the exterior	Untaped for Method A test
Motorized damper: ERV-2 (2nd floor)	Fan off, dampers closed. Taped off from the exterior	Ventilation is continuous, so dampers closed and sealed
Motorized dampers: EMR (1st floor), Stair A, Star B, Elevator, Boiler Room (roof)	Taped off from the exterior	Untaped for Method A test

Whole Building Test Logistics

- Enough fans, cruise manometers, frames, shrouds, tubing, CAT5 cabling, people?
- Is building access limited to avoid people opening and closing doors, windows, etc.?
- Thorough walkthrough the day prior to test date to confirm prep has taken place?
- GC and appropriate subs on site to help with building prep and issues that come up on the test day?
- Saturday work permits active?

Central ERVs and Blower Door

- Need to seal off ERVs for the test
- Wrap rooftop ERVs and/or seal exterior intake and exhaust louver ports





Individual ERVs and Blower Door

- Typically can't reach all vents to seal from outside
- Tape off both outdoor connection ports inside every ERV
- Some ERV's can't be sealed inside the cabinets









Recommendations for Success

Do This ✓

- Insist on
  - Training for construction staff
  - Mockups & don’t stop until the window mockup passes
  - Interim blower door testing
- Advanced Planning
  - Typical and Unique checklists
  - Blower door testing plan
- Quality Control
  - Typical details readily available on site for all subs
  - Communication between GC and PH verifier
  - Panelized construction, if applicable

Do NOT Do This ✗

- Be wary
  - Assume if the GC has done a PH / Net-Zero project that the second will automatically pass
  - Keep going without passing the window mockup
  - Depend on subs understanding contract docs without communication
  - Allow the GC to exclude meeting PH requirements from the contract
- Ignore your PH Consultant!!!!!

Construction Process and Quality Assurances

- Training – site super and subs
- Mock-ups
- Third party inspections and testing

Summary

- Thermal insulation slows heat flows and drying
- Moisture management is **critical!** Understand it.
- Understand dew-points and condensation control
- Understand vapor retarders and their placements
- Air barriers must be complete and continuous
- Insulation is ineffective without air barriers

Summary Continued

- The air barrier must be planned and delineated
- Reduce thermal bridges
- Specify grade I Insulation
- The code will not save you
- Multiple viable insulation options for all circumstances. Consider the issues make informed selections

Contact Us

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203.857.0200 x 2030

www.swinter.com



Take our survey:

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Join Us for More Trainings!

- Module 3: Deep Dive into Air Barrier Development & Implementation
- Module 4: Net Zero HVAC Strategies and Controls + DHW
- Module 5: Contracting for Passive House: Construction Documents and Bidding
- Module 6: Deep Energy Retrofits: Strategies for Gut Rehab or Full Occupancy Retrofits
- Module 7: Beyond Hydrofluorocarbons (HFCs): Refrigerant Management in Design, Construction, and Operations
- Module 8: Construction Manager/Subcontractor/Tradesperson Training: Classroom and Field Training

Register here: https://www.newpaltz.edu/sustainability/view-programs-and-progress/zero-net-carbon-training/workshop-schedule-registration--details/

Resources

- High Performance Walls Guide - http://www.swinter.com/wp-content/uploads/High-Performance-Walls-2019-reformatted.pdf
- THERM Software - https://windows.lbl.gov/software/therm