Wood Frame Building Enclosures

LESSONS LEARNED FROM THE WET COAST

PRESENTATION FOR BUILDING ENCLOSURE COUNCIL – GREATER DETROIT

OCTOBER 20, 2015

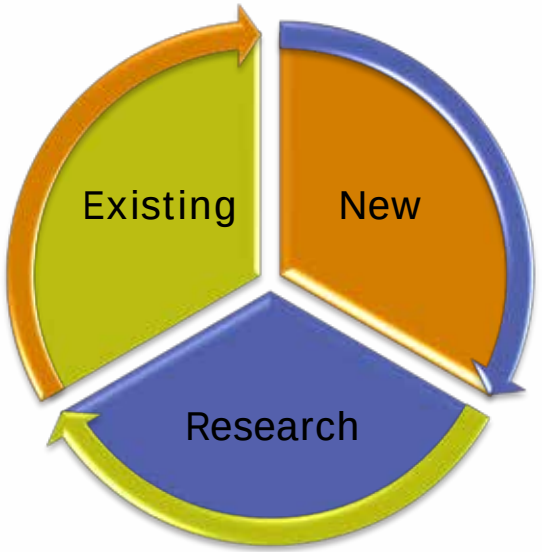
MICHAEL AOKI-KRAMER, LEED™ AP, PRINCIPAL

RDH

RDH – Who We Are

- 170+ staff in 7 offices
  - Canadian offices: Toronto, Vancouver, Victoria, Courtney
  - US offices: Seattle, Portland, SF Bay Area (Oakland)

- All Focused in Building Science
  - Existing Buildings
  - New Building Consulting
  - Research & Forensics



RDH Building Sciences – What we Believe

- **Making Buildings Better**
  - More durable
  - More energy efficient
  - More comfortable and inspiring to occupants
  - Increased building performance can be achieved in a cost effective manner and be still be a **durable, effective, and inspiring building**
- **Buildings Matter**
  - To the people that occupy them
  - To those that design, finance, and own them
  - To the community they exist in

Agenda

- Why not older buildings?
- Performance Expectations and Selecting Wall Assemblies
- Below Grade Waterproofing (below water table and above)
- Details consistently commented on:
  - air barriers,
  - weather resistive barriers,
  - water shedding continuity
- How to build big wood buildings
  - Exterior Wall Design, Exterior Insulation
  - Roof Assembly Design

Why Not Older Buildings?

- What is different about the way things used to be built vs. the way we build today?
- Does it matter?

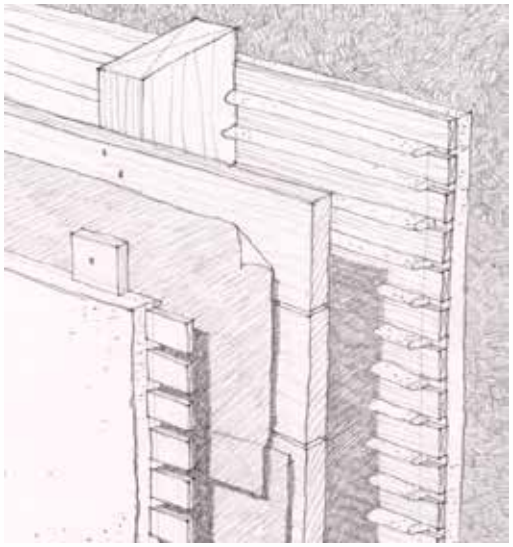
Hot Topics – Why not older buildings?

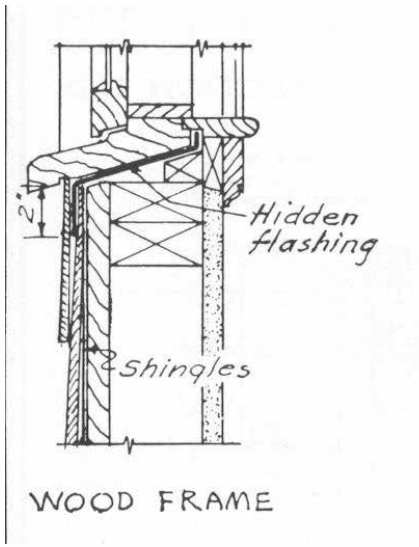
- What is the difference between buildings we build today and those we built 80+ years ago?
  - Building Materials? – More moisture sensitive
  - Insulation levels? – How much? Too much?
  - Air tightness? – How tight? Ventilation?
  - Speed of construction? Time is money.
  - Consumer expectations? Increasing.
  - Lawyers?

Air Barriers? Insulation?

Old vs. New

- Combination of Fundamental Differences
  - *Quality of detailing*
  - *Quantity of insulation*
  - *Exposure conditions (macro and micro)*
  - *Wall assemblies more tolerant of moisture*
  - *Purpose of Buildings*





Old vs New

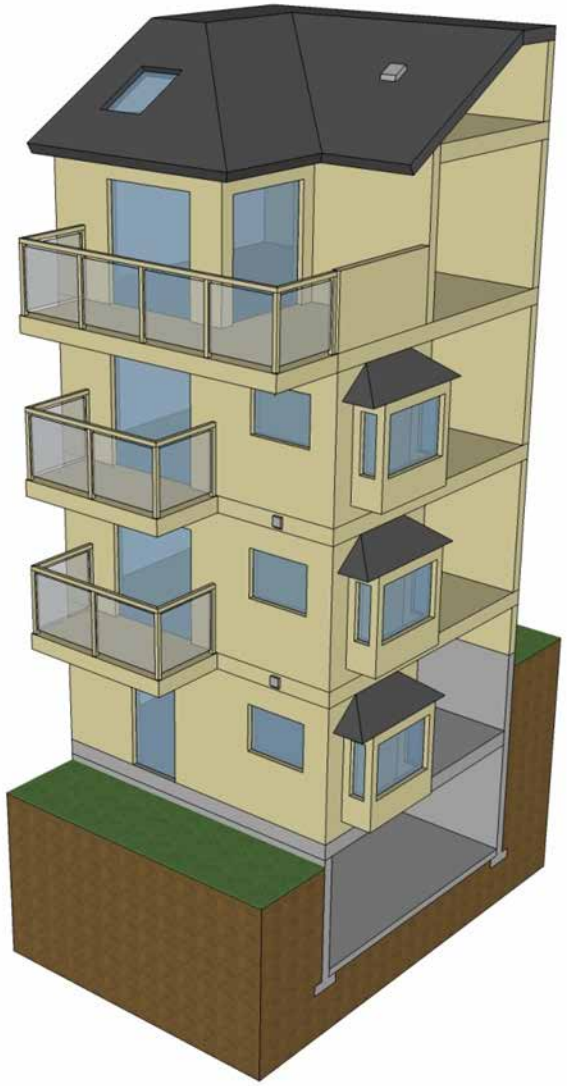
- Fundamental differences between Modern and Historic
  - *Complexity of building form (more details = more opportunities)*

Modern Design Considerations

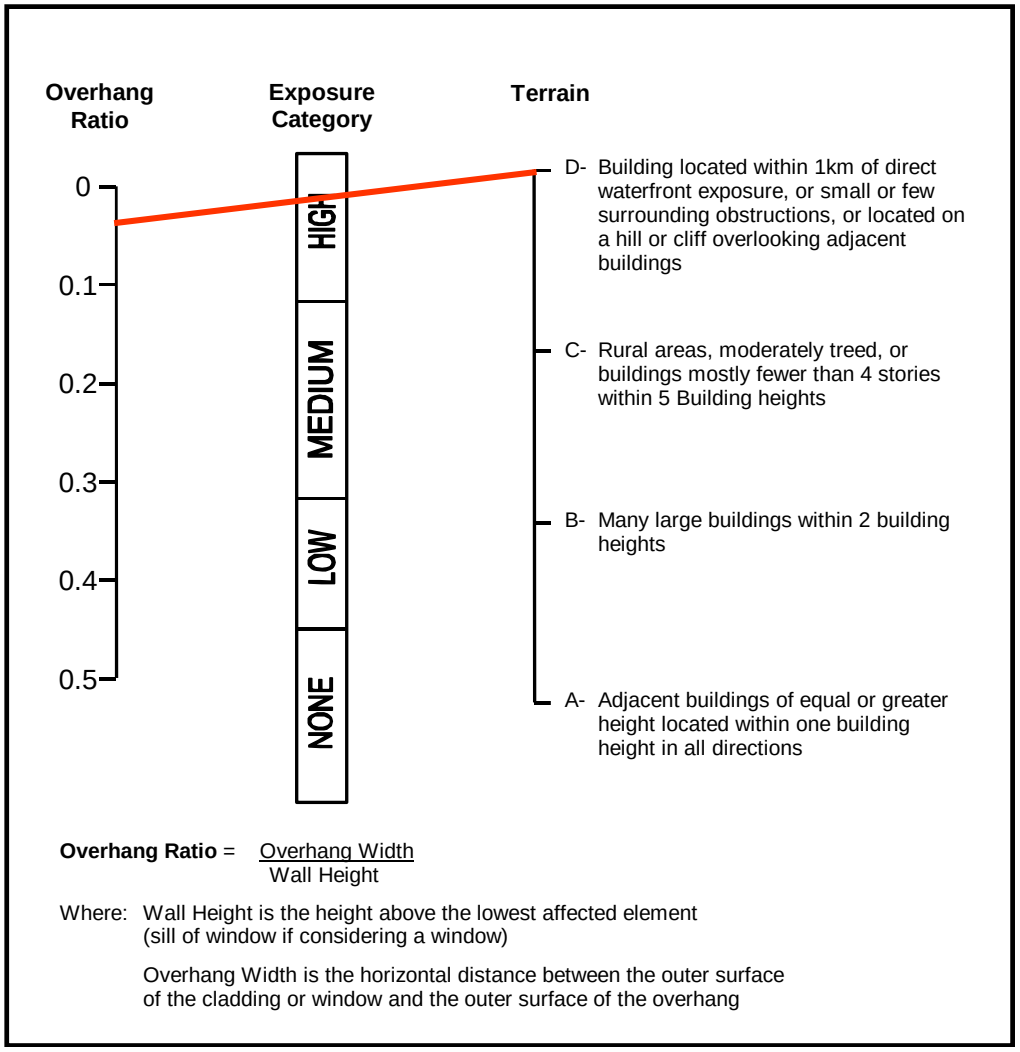
- Primary Consideration: Moisture / Rain Penetration Control
  - Overhangs, simple architecture, simple rules. More complicated = more details and chance for water entry. We can handle if needed.
  - 2 stage control for wall systems
    - cladding (water shedding surface)
    - Weather resistive barrier (WRB) is last line of defense
  - Weather Resistive Barrier – numerous types
  - Air Barrier – numerous types
  - Flashing at penetrations, especially window openings
  - Window and Door Selection – water penetration resistance, thermal performance, etc. Yes, this applies to doors too!

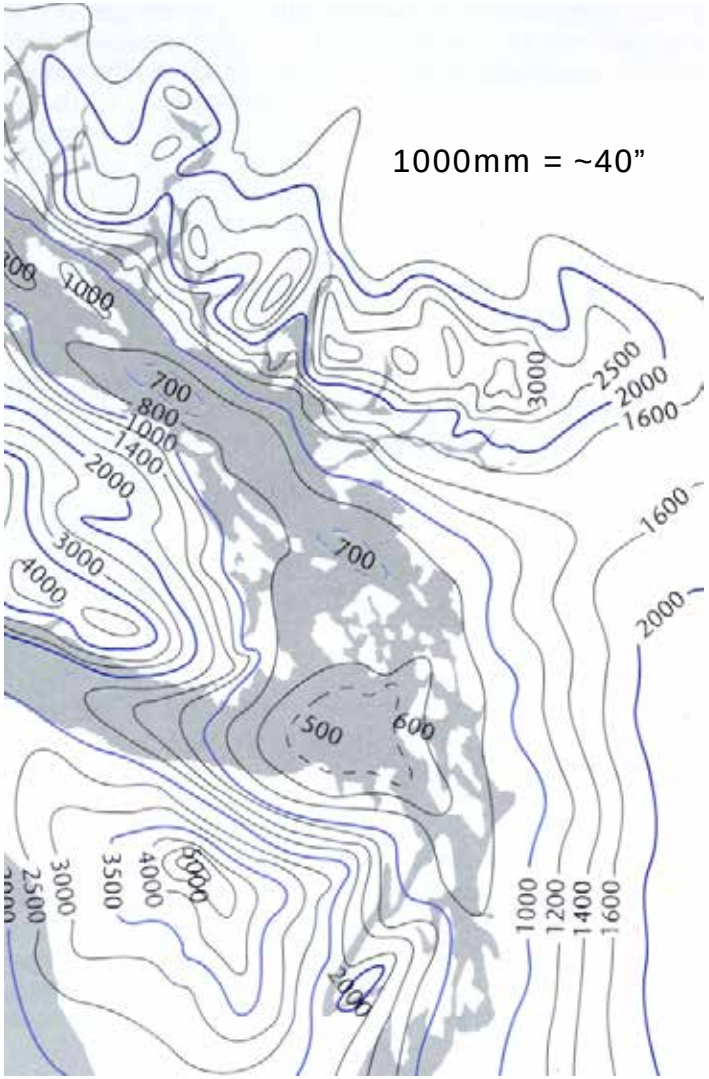
Building Enclosure Design Fundamentals

- Separate indoors from outdoors, by controlling:
  - Heat flow
  - Air flow
  - Vapor diffusion
  - Water penetration
  - Condensation
  - Light and solar radiation
  - Noise, fire, and smoke
- While at the same time:
  - Transferring structural loads
  - Being durable and maintainable
  - Being economical & constructible
  - Looking good!

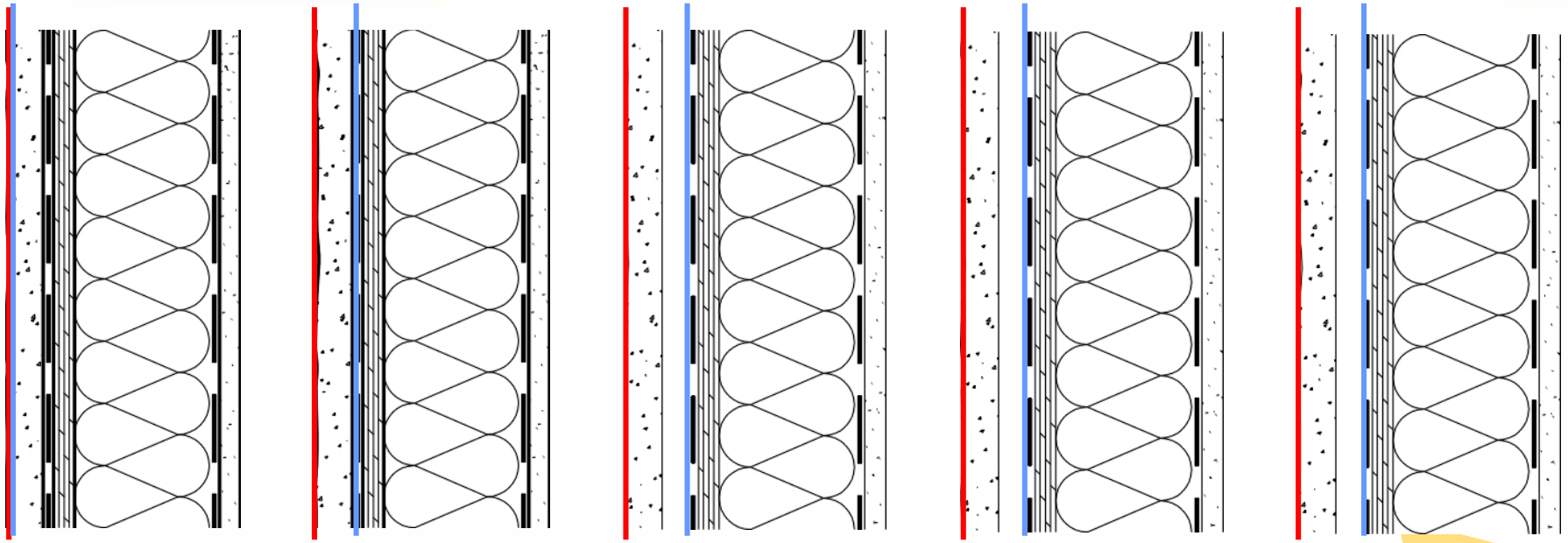


Macro/Micro Exposure





Continuum of MC Strategies for Framed Walls



Barrier or Face Sealed

Concealed Barrier

Drained Cavity

Rainscreen

P. M. Rainscreen

PERFORMANCE

Faith-based Moisture Control

One line of defense

Two lines of defense
Some drainage possibilities

Two lines of defense
Clear drainage

Two lines of defense
Clear drainage
Good air barrier

Two lines of defense
Clear drainage
Good air barrier
Compartmentalization

Opportunity for Drainage and Ventilation Drying

Below Grade Waterproofing

- “Standard Approach” to Below Water Table Waterproofing
- Positive/Negative Side
- Damp proofing

Sheet Applied – PSA (Positive Side, Blind)

Sheet Applied Membrane – Bentonite Geotextile

Thermoplastic

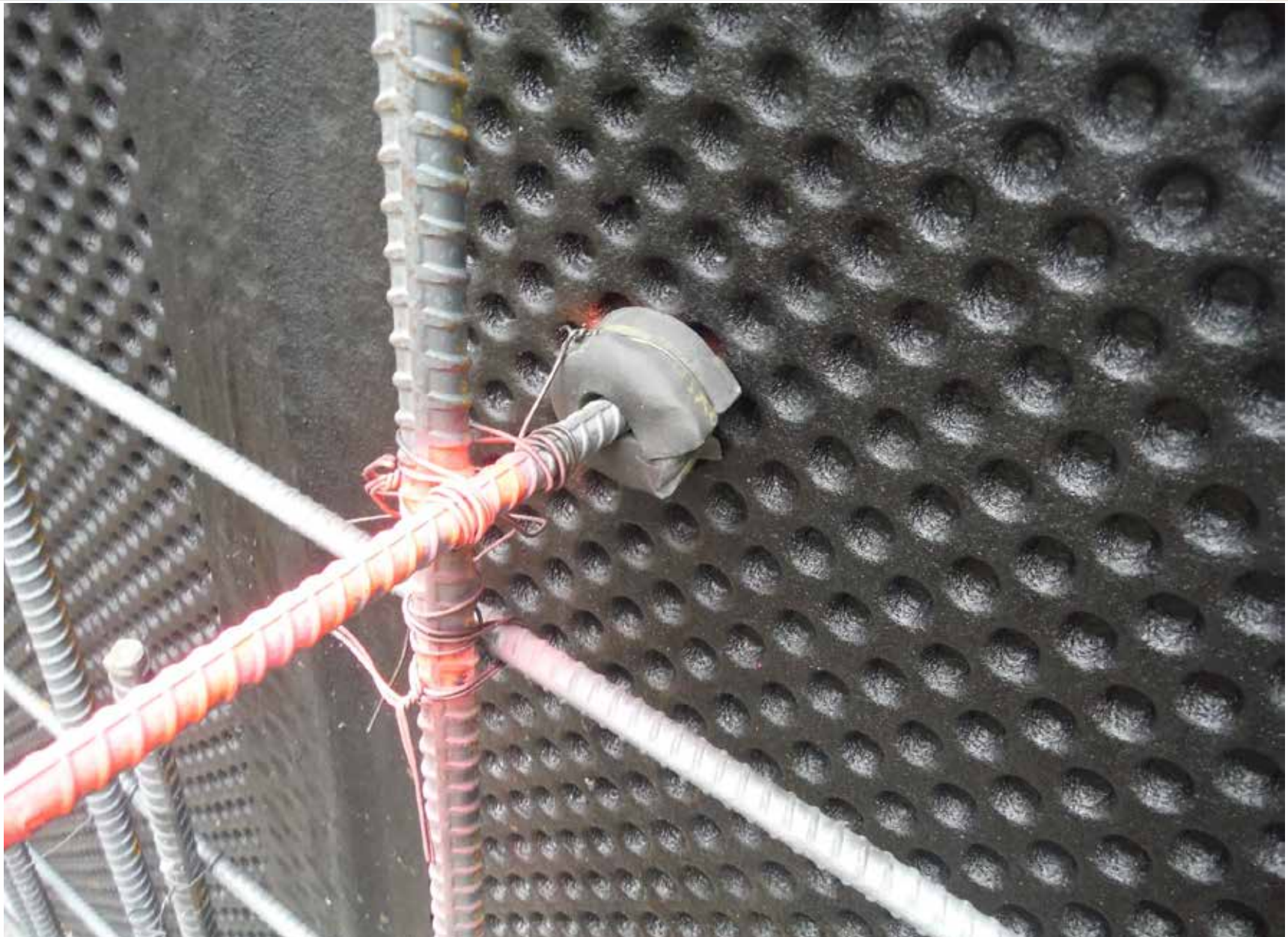
Hybrid Thermoplastic/Bentonite Polymer Alloy

Integral - Hydrophobic

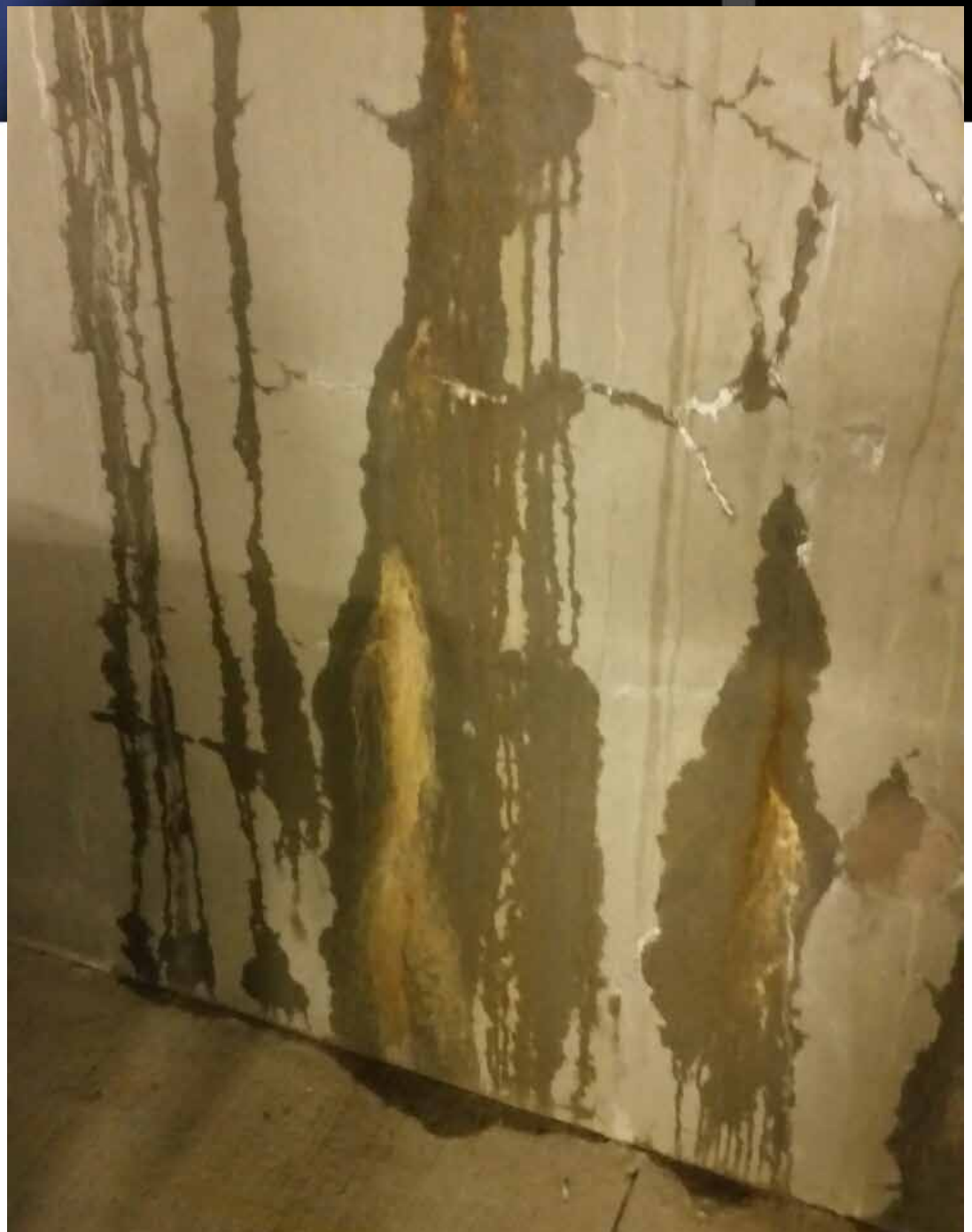
Integral - Crystalline

- Reacts with water and un-hydrated cement particles, forming microscopic, needle-like crystals
- Crystals fill pores and microscopic voids in concrete, blocking pathways for water and contaminants
- Water re-entering through changing pressure or fresh cracks triggers crystal growth, sealing the concrete to re-establish water tightness

Drainage Mat + Cold Spray Applied Membrane



Drainage Mat

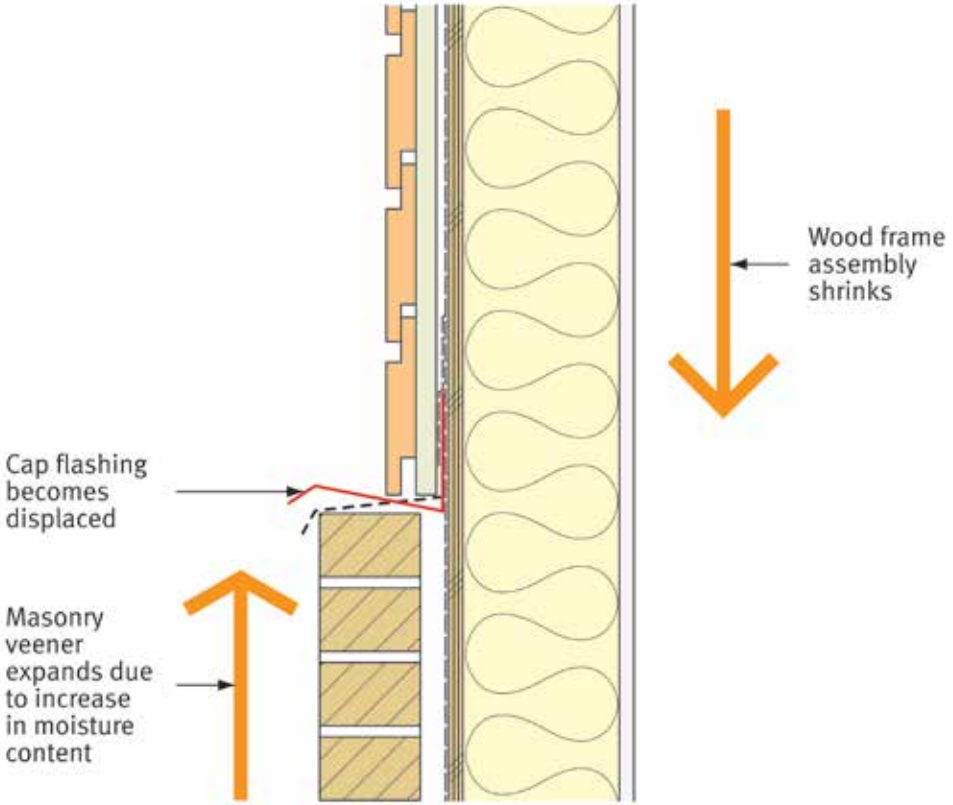


Design for Wood-Movement & Shrinkage

- Wood shrinkage/Brick Growth
- Floor lines
- Windows
- Balconies

Behavior of Wood in Construction

- Detailing for Differential Shrinkage is Important



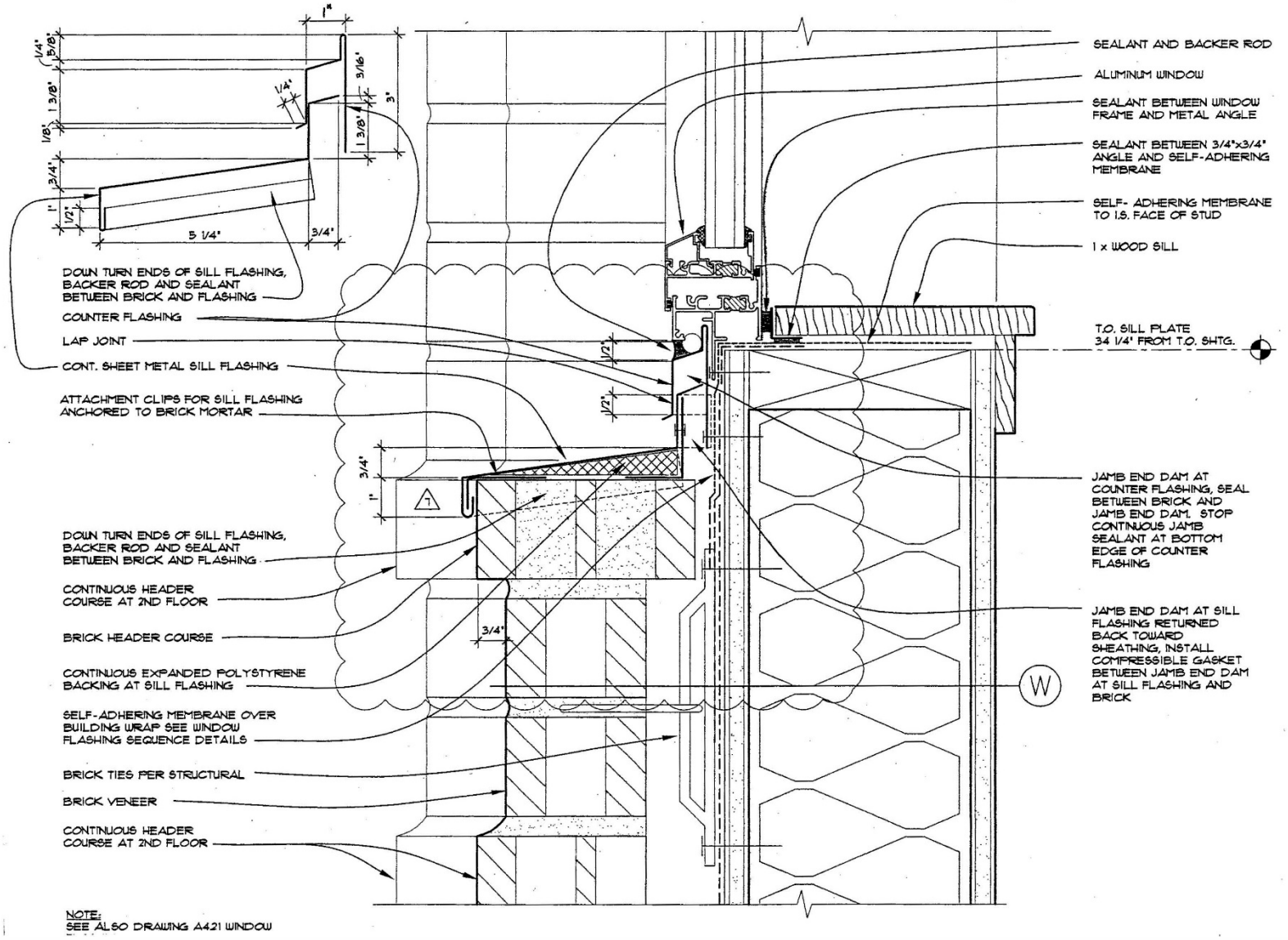
Think of the effect that this also has on plumbing and other services running through walls

Lessons Learned from Wood-frame Shrinkage

Reducing Wood-frame Shrinkage - Floors

- Keep wood dry, watch saturation of floor framing during construction
- Engineered floor joists
- Modified platform framing practices
  - Floor joists hang from top plate of wall, essentially reducing shrinkable wood at floor line
- Balloon framed details

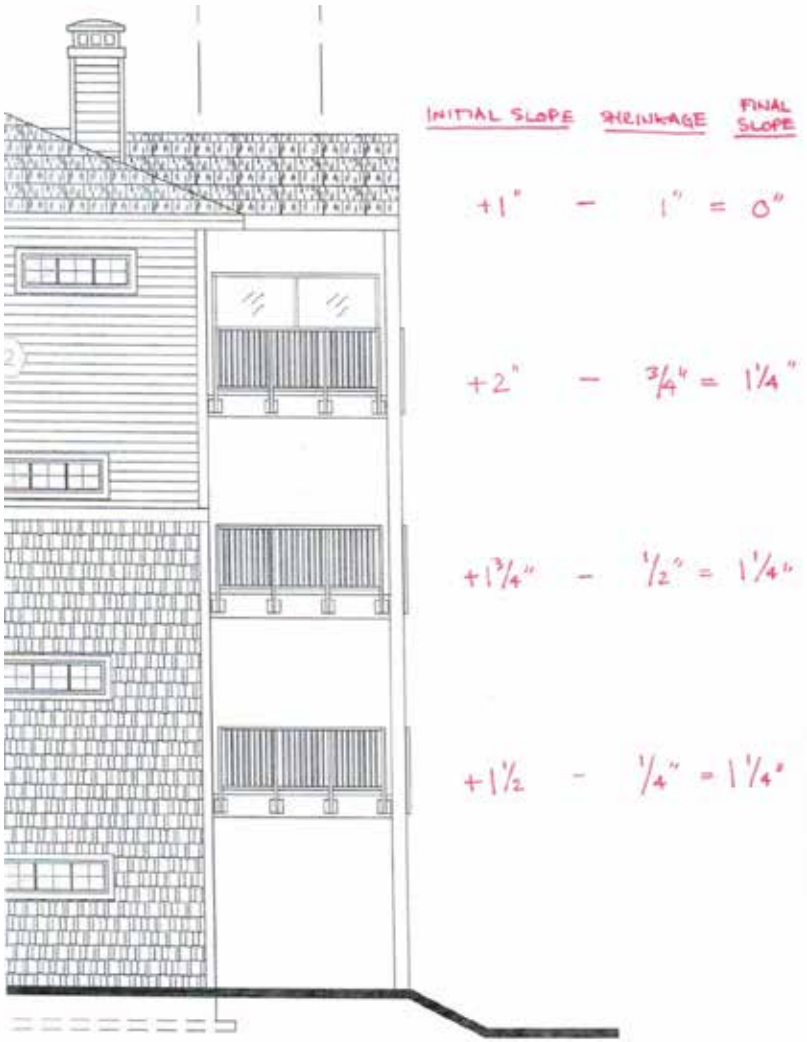
Allow for Movement



Window Sill Detail – Sliding Flashing Method

Wood Shrinkage and Post-Supported Balconies

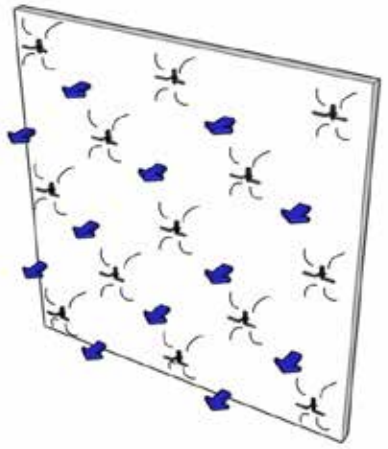
- Design for Movement

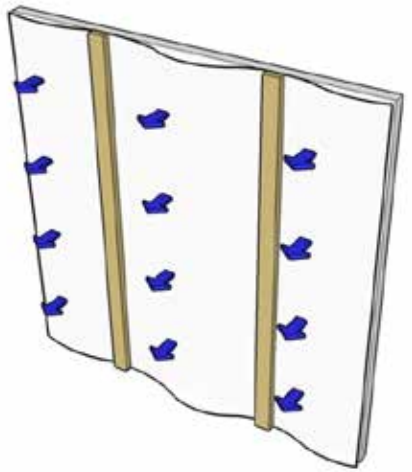


Air and Weather Barrier Detailing for Taller Wood Buildings

Impact – Increase in Wind & Rain Loads

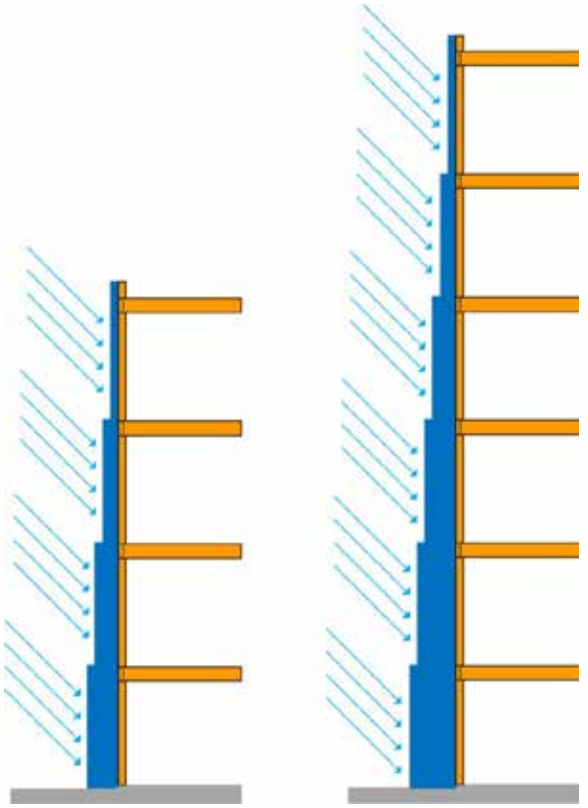
- Increase in height generally means higher wind loads (in the order of 10%), and increased rain deposition
- Other factors just as significant
  - Proximity to open water
  - Sloped site
  - Local terrain
- Air barrier/Weather barrier
  - Exterior sheathing membrane
  - Exterior sheathing





Increase in Wind and Rain Loads

- Specified structural and water penetration performance criteria for windows
  - Some low-rise windows may not work as well in mid-rise buildings
- Cumulative runoff
  - Water shedding features become more critical – continuity, drip edges
  - Water penetration control strategy
  - Selection of materials
- Moisture during construction



Types of Air Barriers (and WRBs in some cases)

Loose Sheet Applied Membrane – Taped Joints & Strapping

Sealed Gypsum Sheathing – Sealant Filler at Joints

Liquid Applied – Silicone or hybrid sealants (STPE) and membrane

Sealed Plywood Sheathing – Sealant & Membrane at Joints

Sealed Sheathing – Membrane at Joints

Self-Adhered vapor permeable membrane

Plywood sheathing with taped joints (good tape)

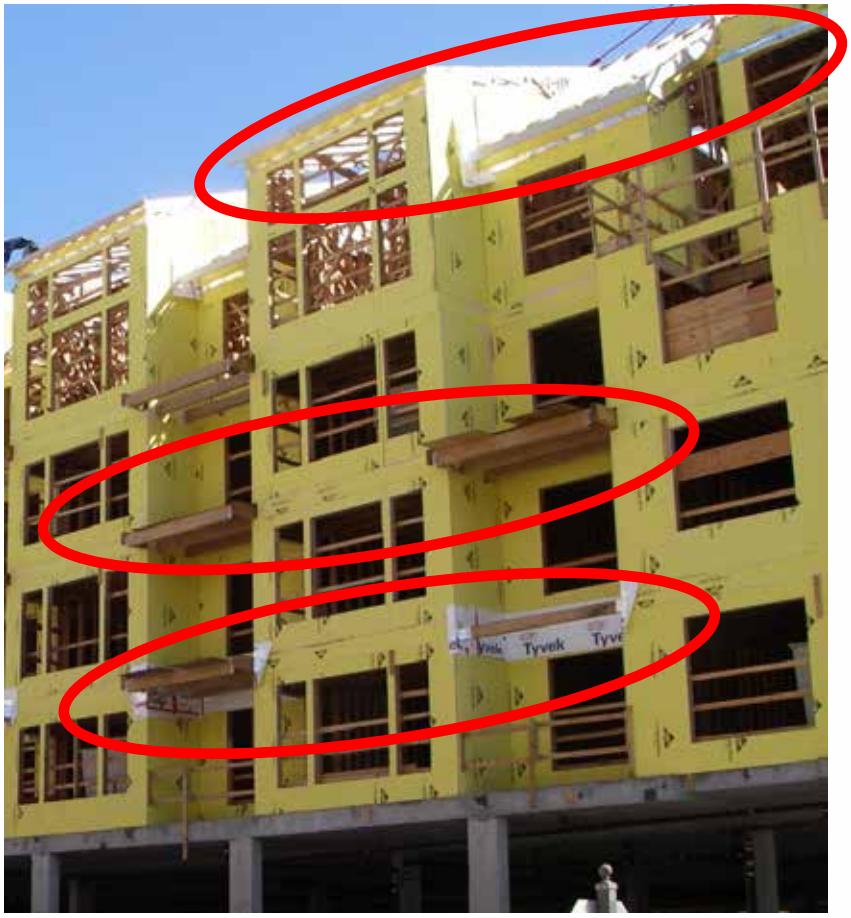
Air Barriers and Water Control Layers

Airtightness Does Not Happen By Accident

RDH

Air Barrier Details

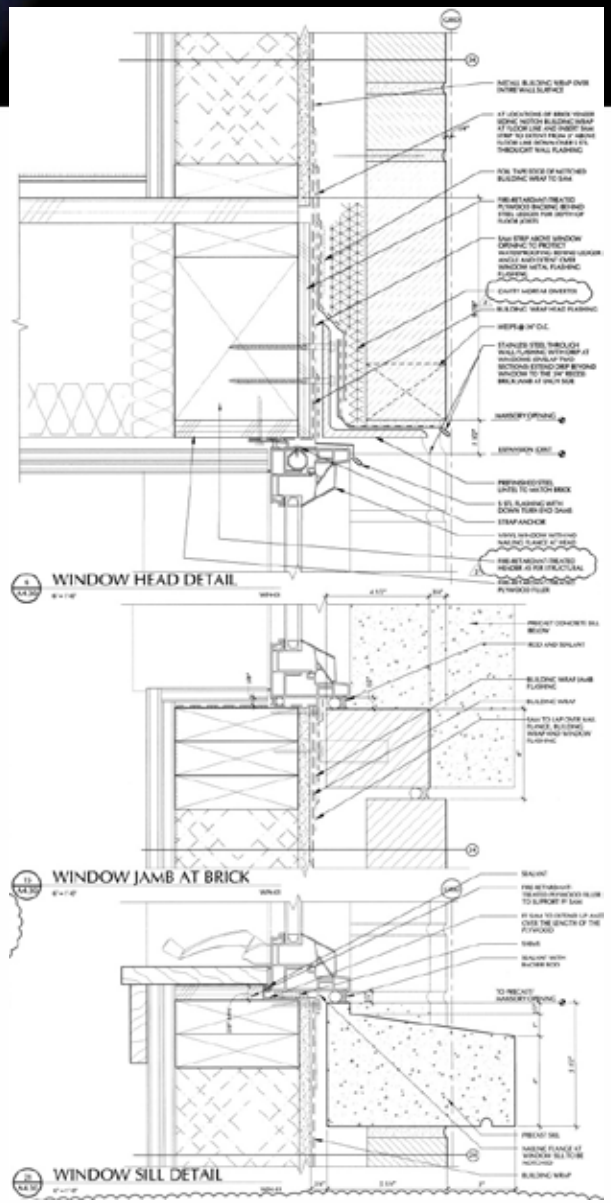
- Pre-stripping AB membrane is often recommended at balconies and roof-wall transitions – but often forgotten!

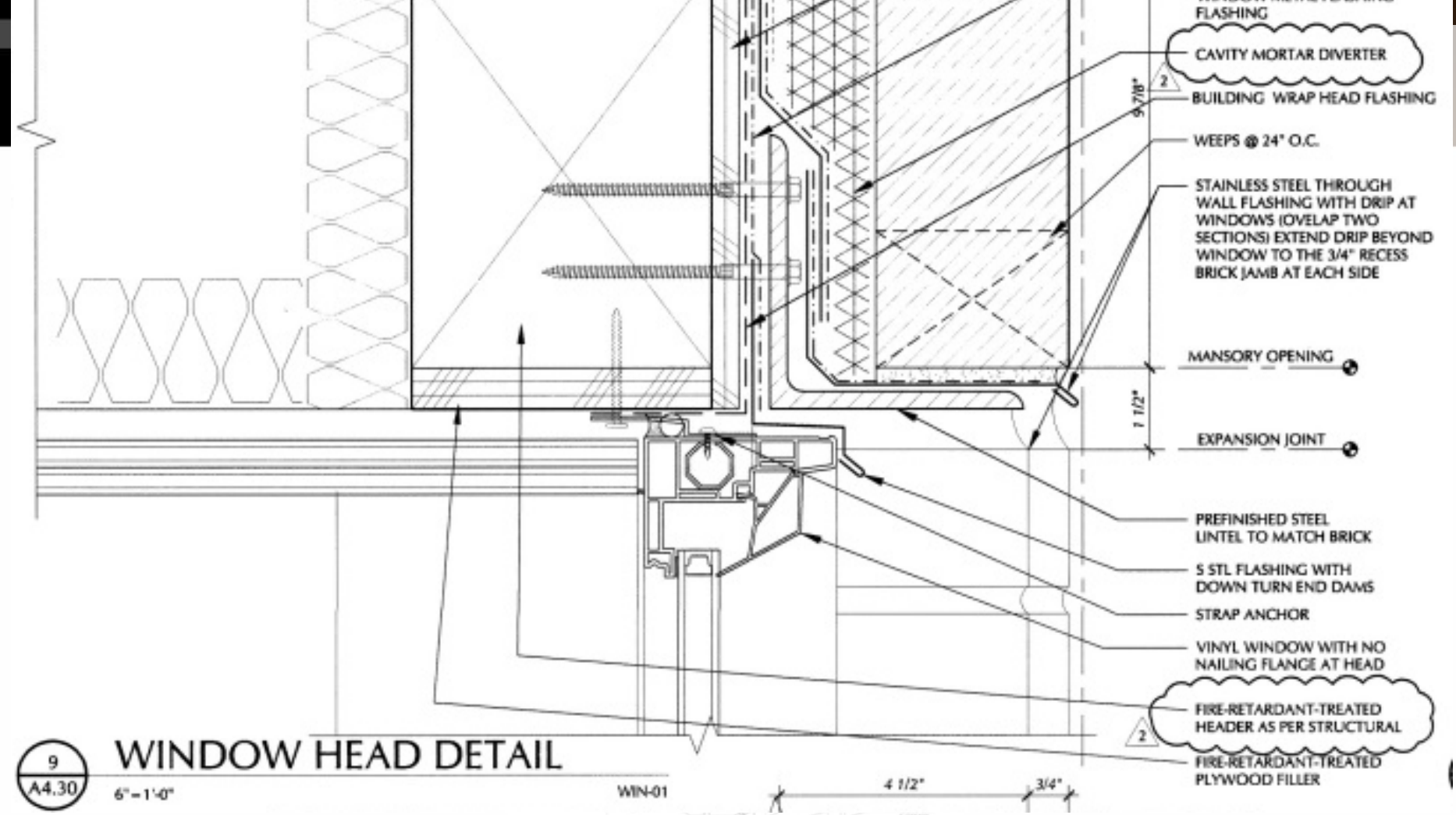


How to Tell the Membrane is Not the Air Barrier

Air/Moisture Barrier Detailing

- Windows


WINDOW HEAD DETAIL
WINDOW JAMB AT BRICK
WINDOW SILL DETAIL

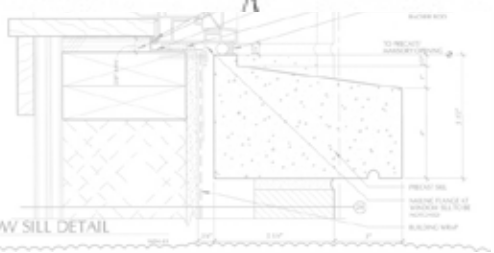


9
A4.30

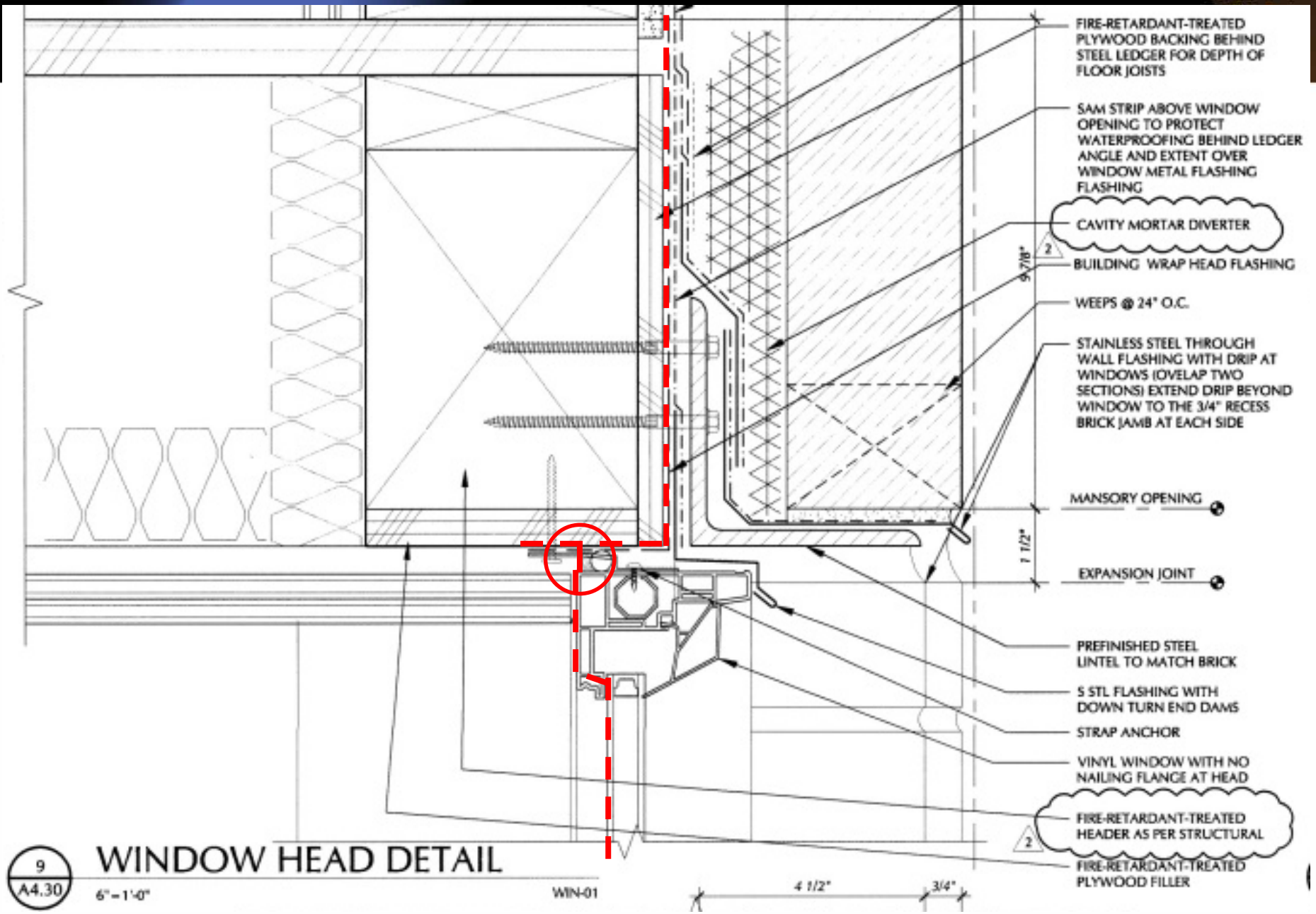
WINDOW HEAD DETAIL

6" = 1'-0"

WIN-01



WINDOW SILL DETAIL

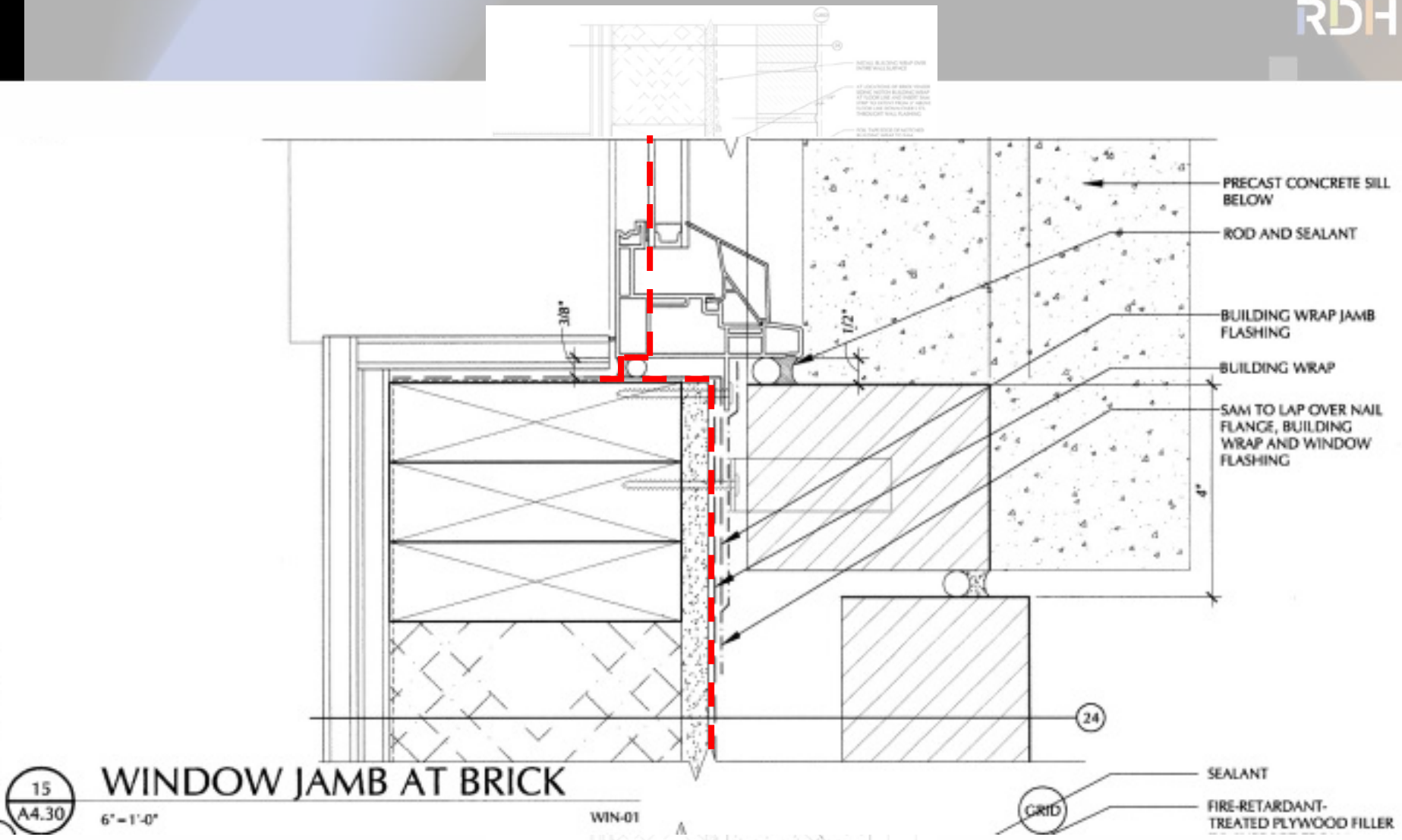


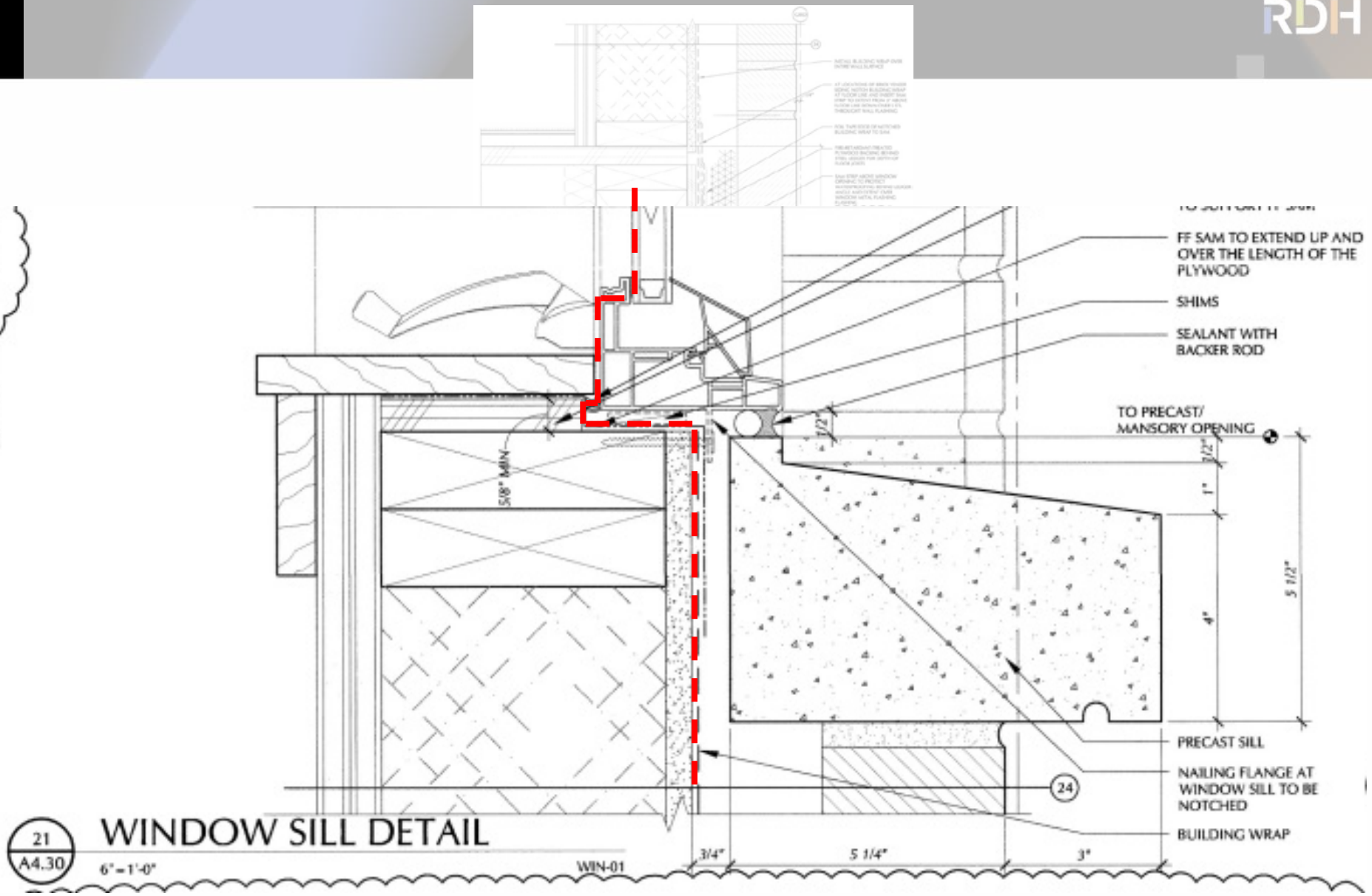
9
A4.30

WINDOW HEAD DETAIL

6" = 1'-0"

WIN-01


PRECAST CONCRETE SILL BELOW
ROD AND SEALANT
BUILDING WRAP JAMB FLASHING
BUILDING WRAP
SAM TO LAP OVER NAIL FLANGE, BUILDING WRAP AND WINDOW FLASHING
SEALANT
FIRE-RETARDANT-TREATED PLYWOOD FILLER
3/8"
1/2"
4"
24
GRID
15
A4.30
WINDOW JAMB AT BRICK
6" = 1'-0"
WIN-01



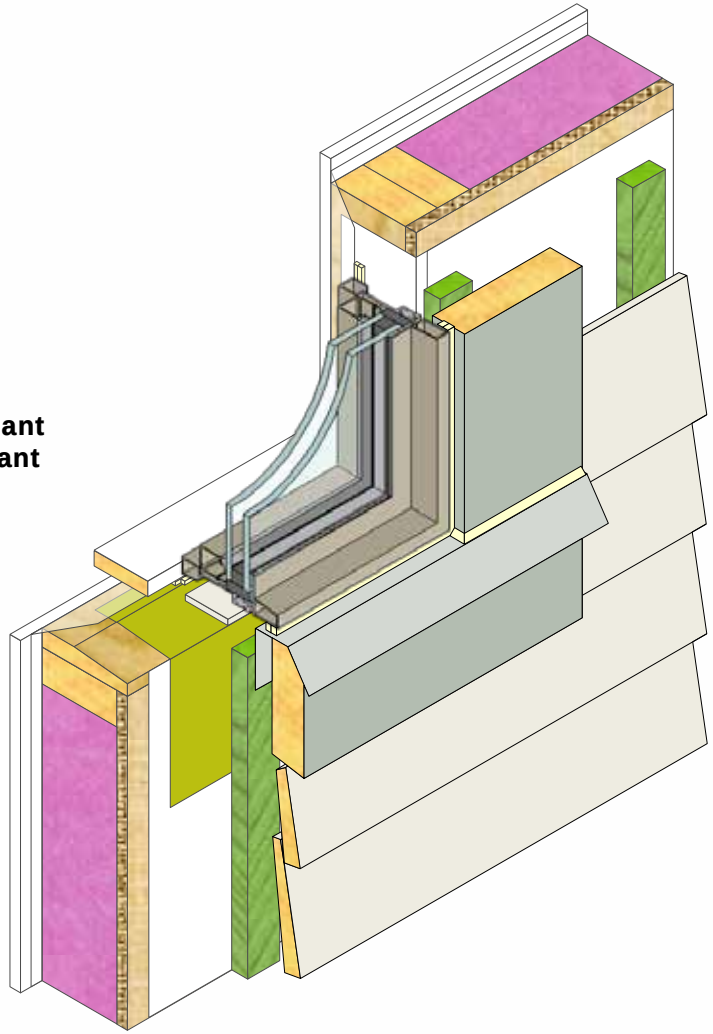
21
A4.30

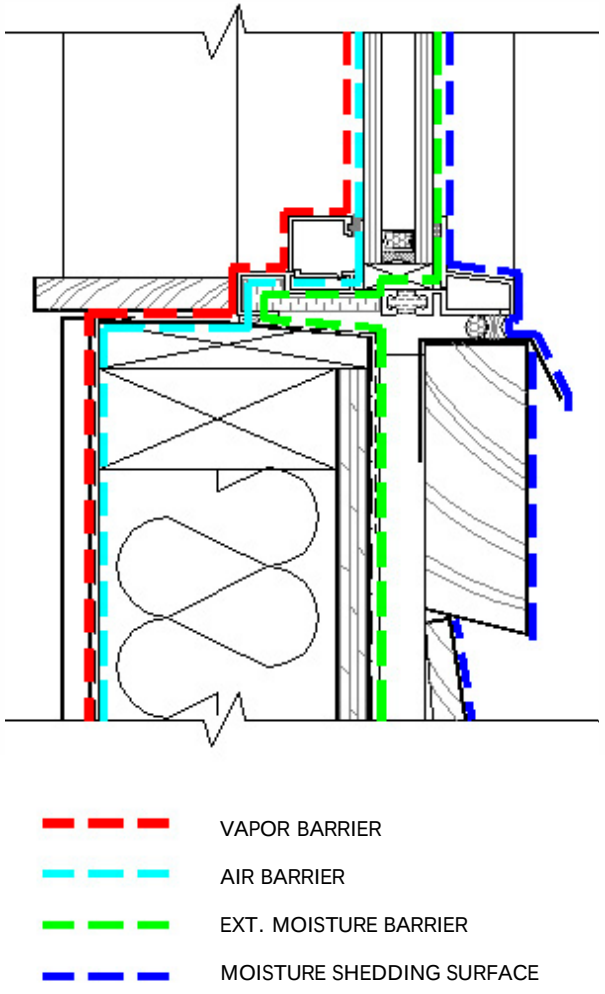
WINDOW SILL DETAIL

6" = 1'-0"

Rainscreen and Window Detailing

Framing
Wall Sheathing
Beveled Wood Sub-Sill
Sheathing Paper
Sill Membrane
Corner Membrane
Jamb Membrane
Sheathing Paper
Shims
Window
Sheathing Paper
Wood Strapping
Metal Drip Edge
Trim Board
Wood Siding
Backer Rod & Exterior Sealant
Backer Rod & Interior Sealant
Insulation
Polyethylene
Wood Stool
Interior Gypsum Board





Flashings are your friends

- Gravity is Free
- Slope to drain
- Clean buildings are full buildings, or at least look like you care

Flashings deflect water off your building

- Flashings are your friends

Flashings Keep Buildings Clean

- Flashings are your friends

Flashings reduce maintenance costs

- Flashings are your friends

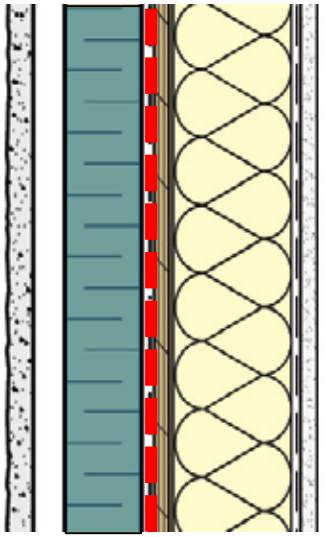
The Future of Insulation: Hybrid Insulation/Split Insulated Assemblies

Increase In Structural Mass

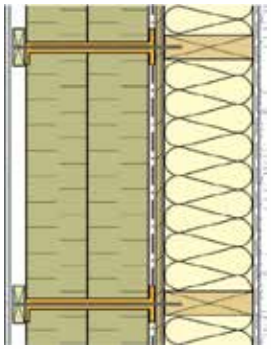
- Where to put the insulation
  - Exterior insulation approach?
- Service penetrations
  - Space to run pipes and ducts more limited
  - More careful planning and coordination required during design

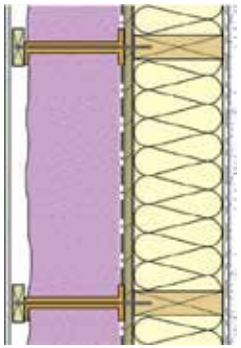
Split Insulated – Exterior Insulation Selection

- Rigid exterior foam insulations (XPS, EPS, Polyiso, closed cell SPF) are vapor impermeable (in thicknesses of 2”+)
  - Is the vapor barrier on the wrong side?
  - Does the wall have two vapor barriers, can it dry?
  - Can I remove the interior vapor barrier?
- How much foam insulation should be put outside of the sheathing?
- As semi-rigid/rigid mineral fiber insulation is vapor permeable, it simplifies many design concerns & and improves redundancy
- Vapor permeance properties of WRB/air barrier membrane is also very important

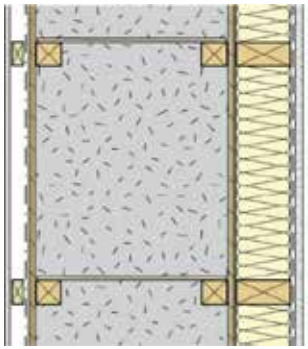


Split Insulated Wall Considerations

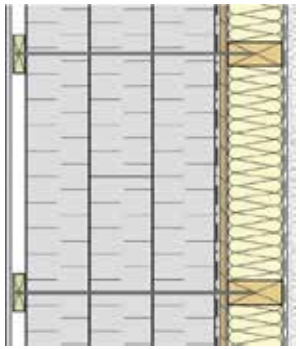




Semi-rigid or sprayfoam insulation with intermittent thermally improved cladding attachments

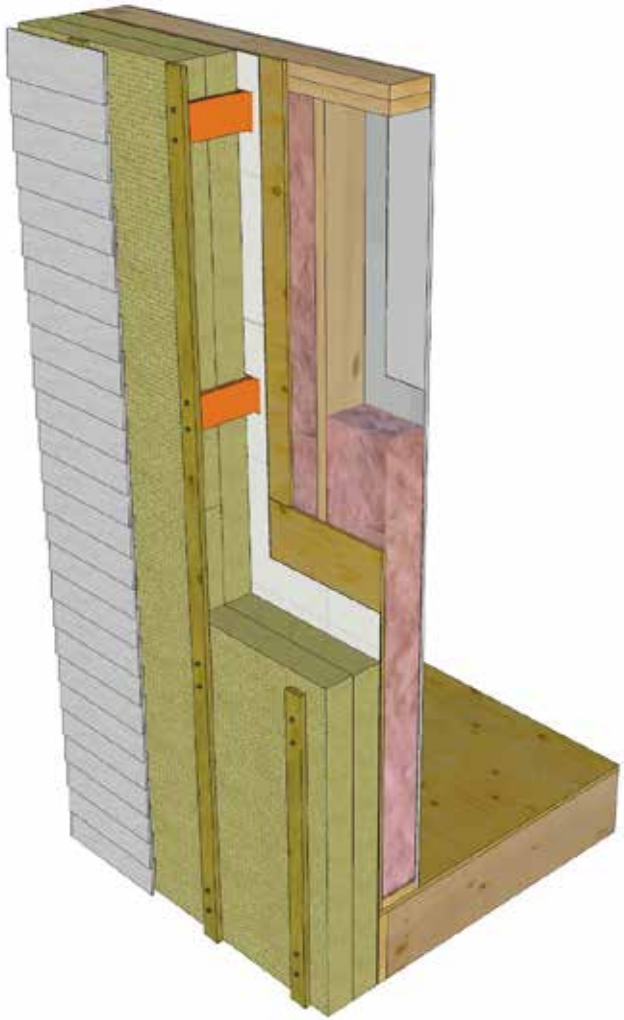


Larsen truss over 2x4 wall



12" EPS over 2x4 wall

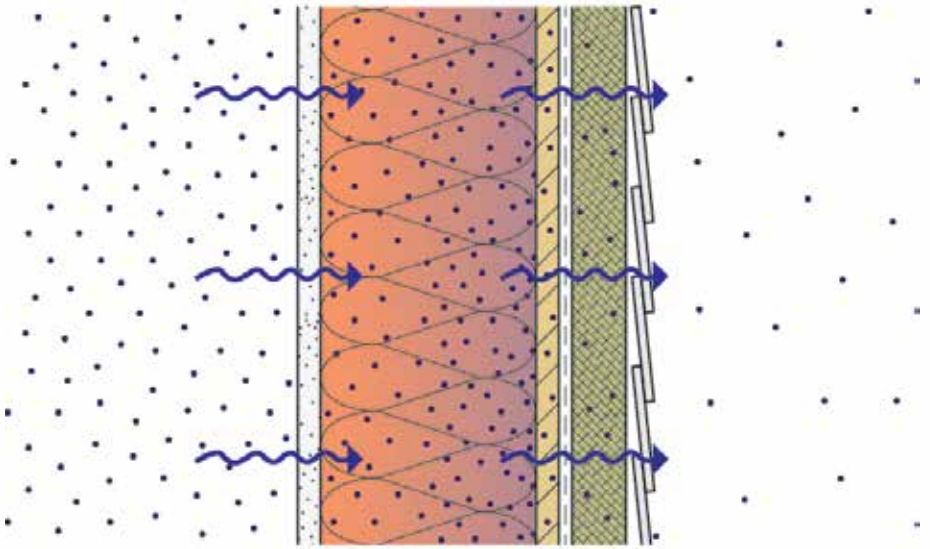
Key design considerations:
type of exterior insulation,
cladding attachment through exterior insulation,
air/vapor barrier placement



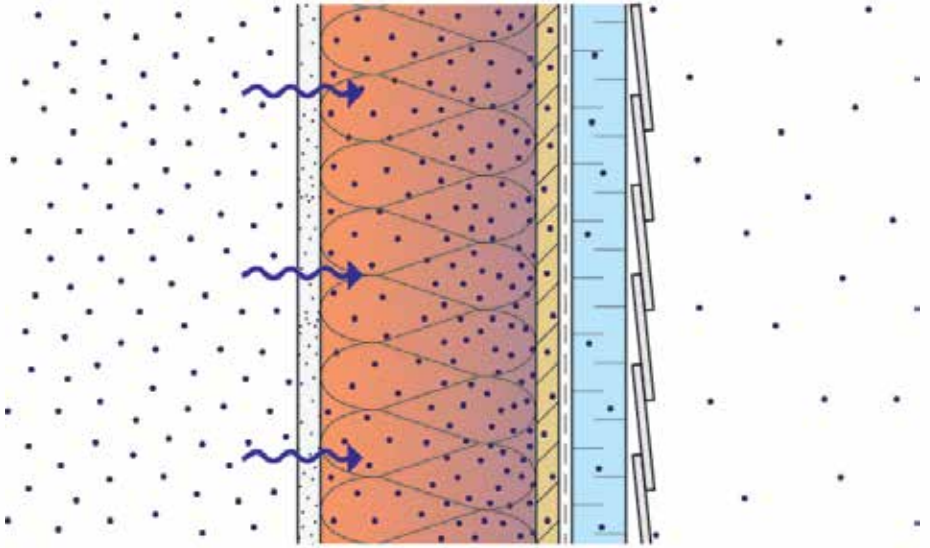
Split insulated 2x4 wall with rigid or semi-rigid insulation

Why is Vapor Permeable Insulation Safer?

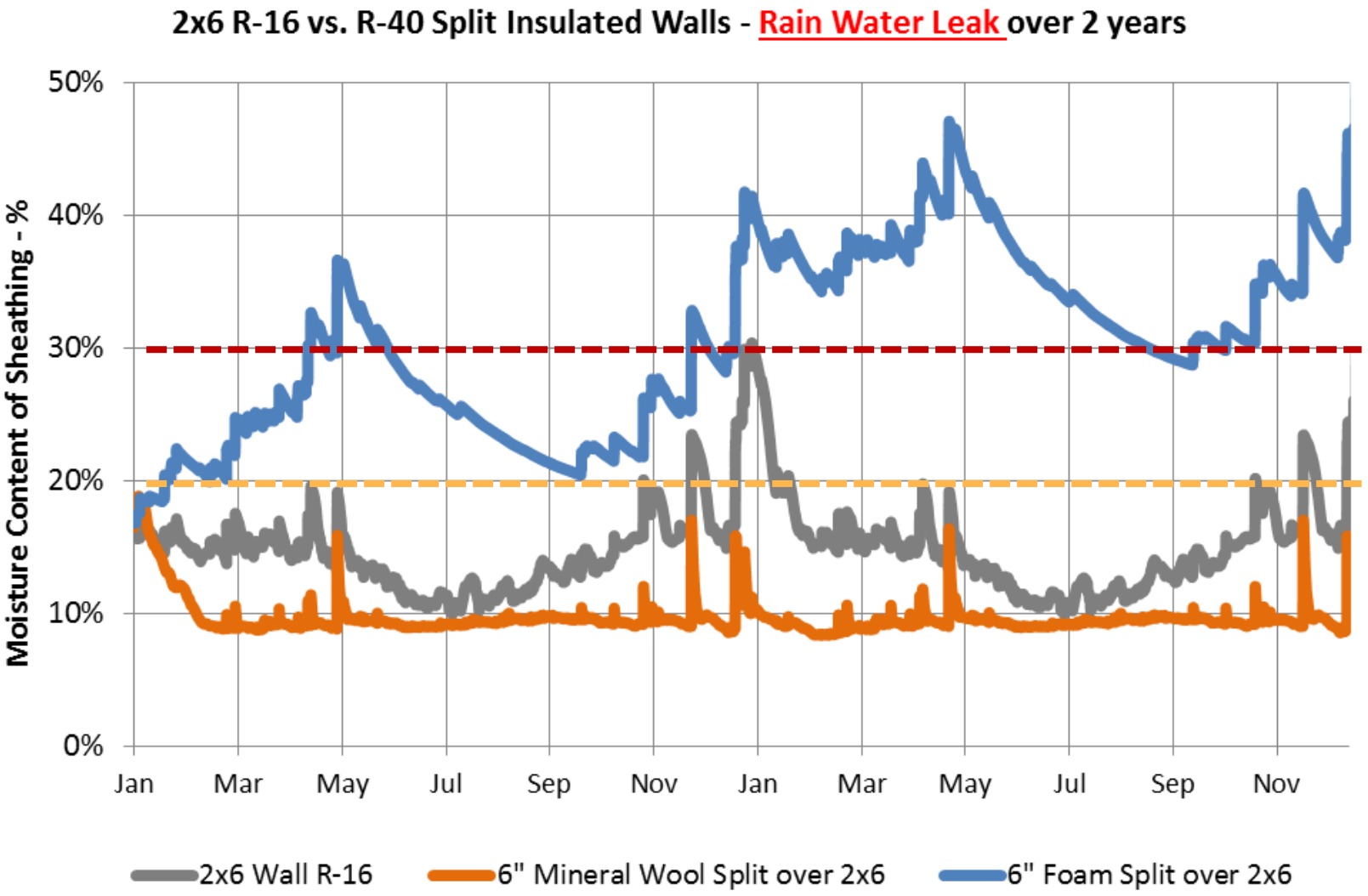
*Outward vapor diffusion **drying** allowed through vapor open mineral wool, fiberglass or cellulose insulation on exterior*



*Outward vapor diffusion **drying** restricted by foam plastic insulation on exterior – even if enough insulation is installed to prevent condensation*



Split Insulation and Moisture Risk Assessment

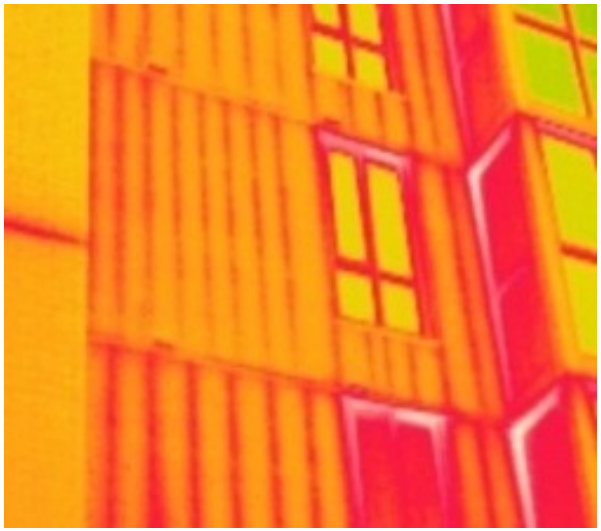


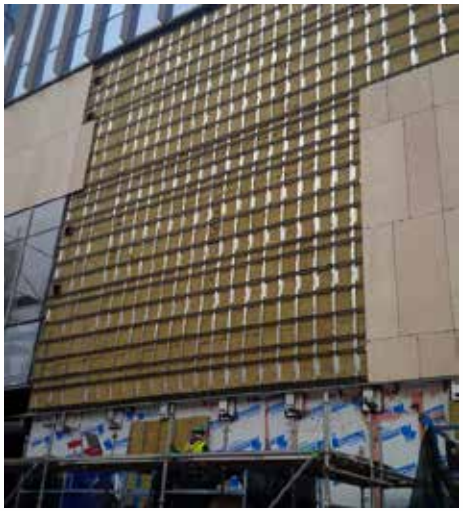
Exterior Insulation & Cladding Attachment Considerations

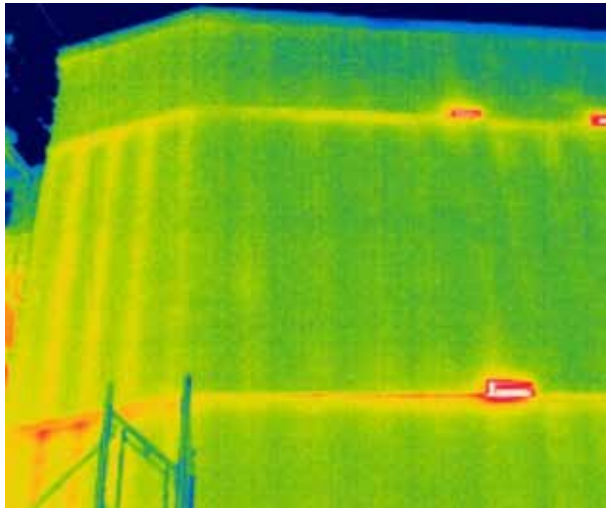
- Cladding weight & gravity loads
- Wind loads
- Seismic loads
- Back-up wall construction (wood, concrete, steel)
  - Attachment from clip/girt back into structure (studs, sheathing, or slab edge)
- Exterior insulation thickness
- Rigid vs semi-rigid insulation
- R-value target, tolerable thermal loss?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

Cladding Attachment & Exterior Insulation

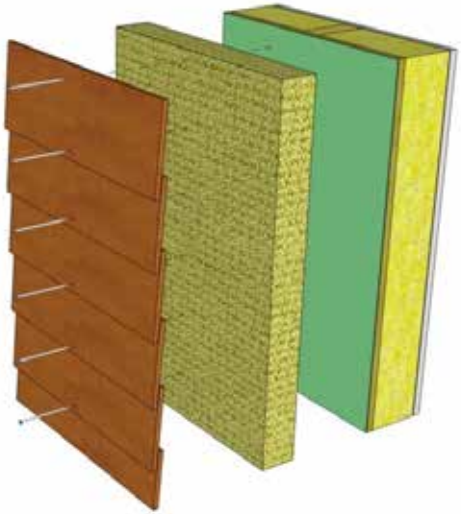
- Exterior insulation is only as good as the cladding attachment strategy
- What attachment systems work best?
- What is and how to achieve true continuous insulation (ci) performance?
- What type of insulation?



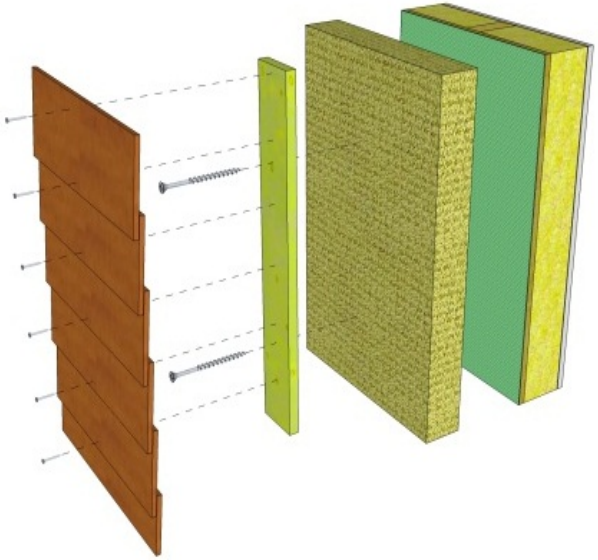




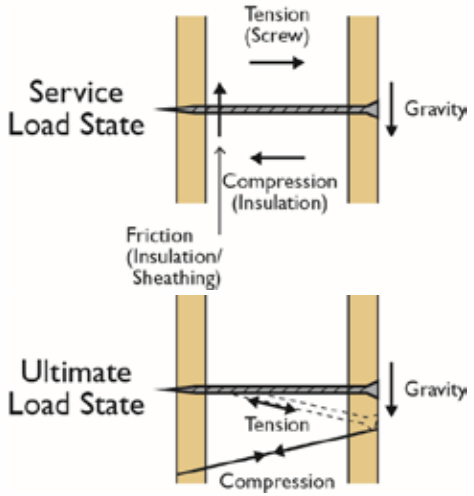
Cladding Attachment: Screws through Insulation

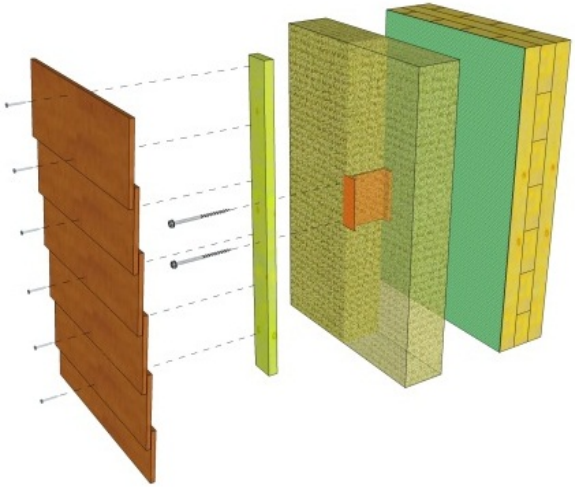


Longer cladding Fasteners directly through rigid insulation (up to 2” for light claddings)



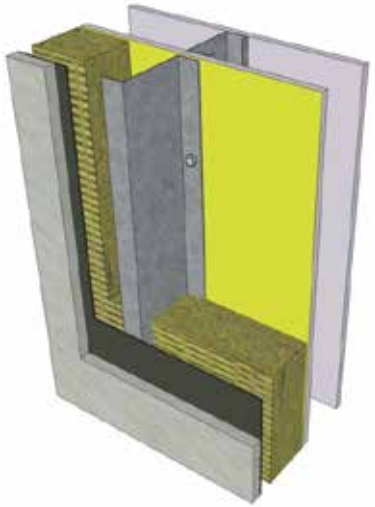
Long screws through vertical strapping and rigid insulation creates truss – short cladding fasteners into vertical strapping



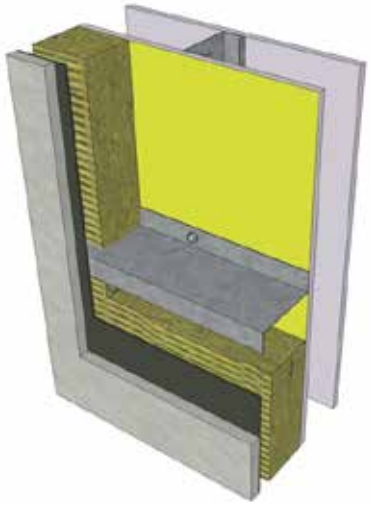


Rigid shear block type connection through insulation, short cladding fasteners into vertical strapping

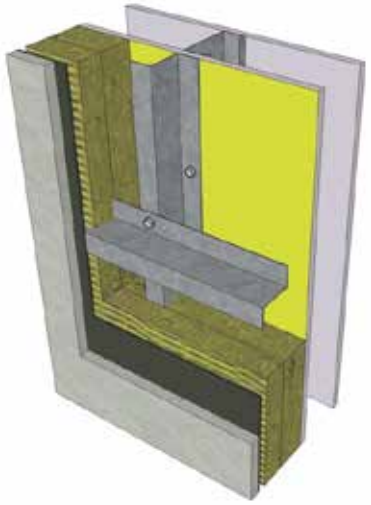
Many Cladding Attachment Options & Counting



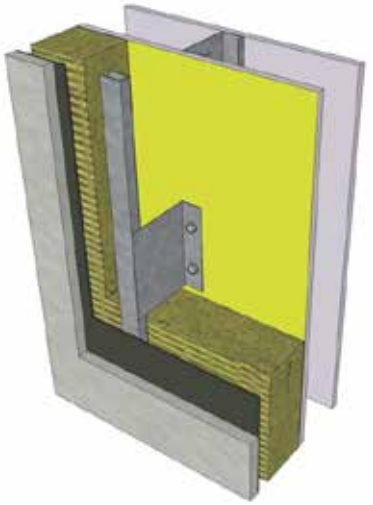
Vertical Z-girts



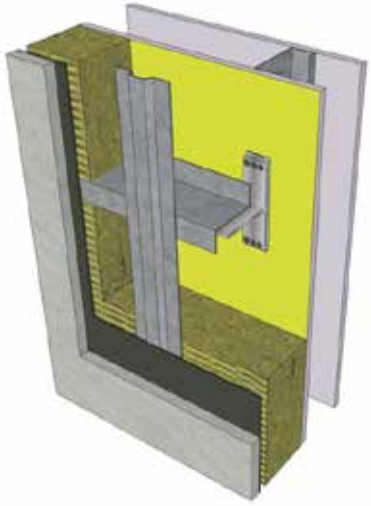
Horizontal Z-girts



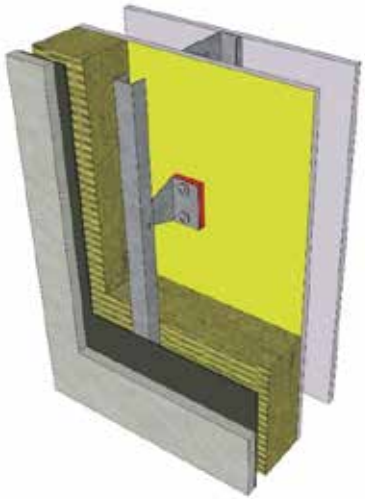
Crossing Z-girts



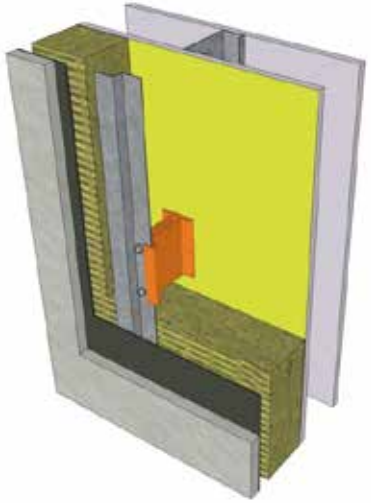
Galvanized/Stainless Clip & Rail



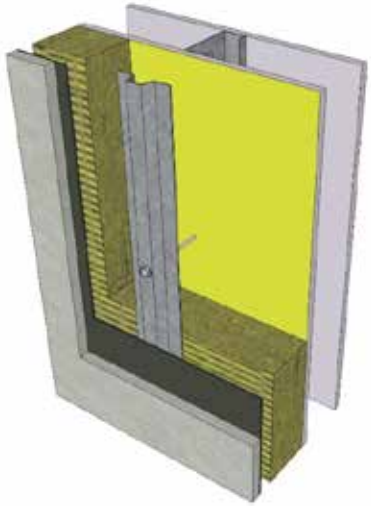
Aluminum Clip & Rail



Thermally Improved Clip & Rail

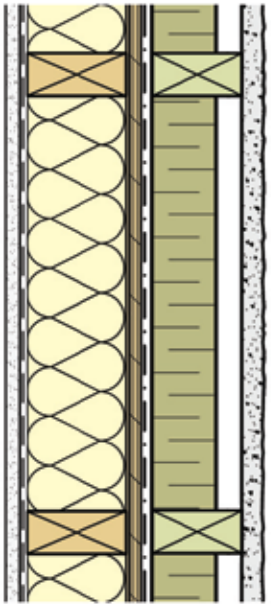


Non-Conductive Clip & Rail



Long Screws through Insulation

Cladding Attachment: Continuous Wood Framing



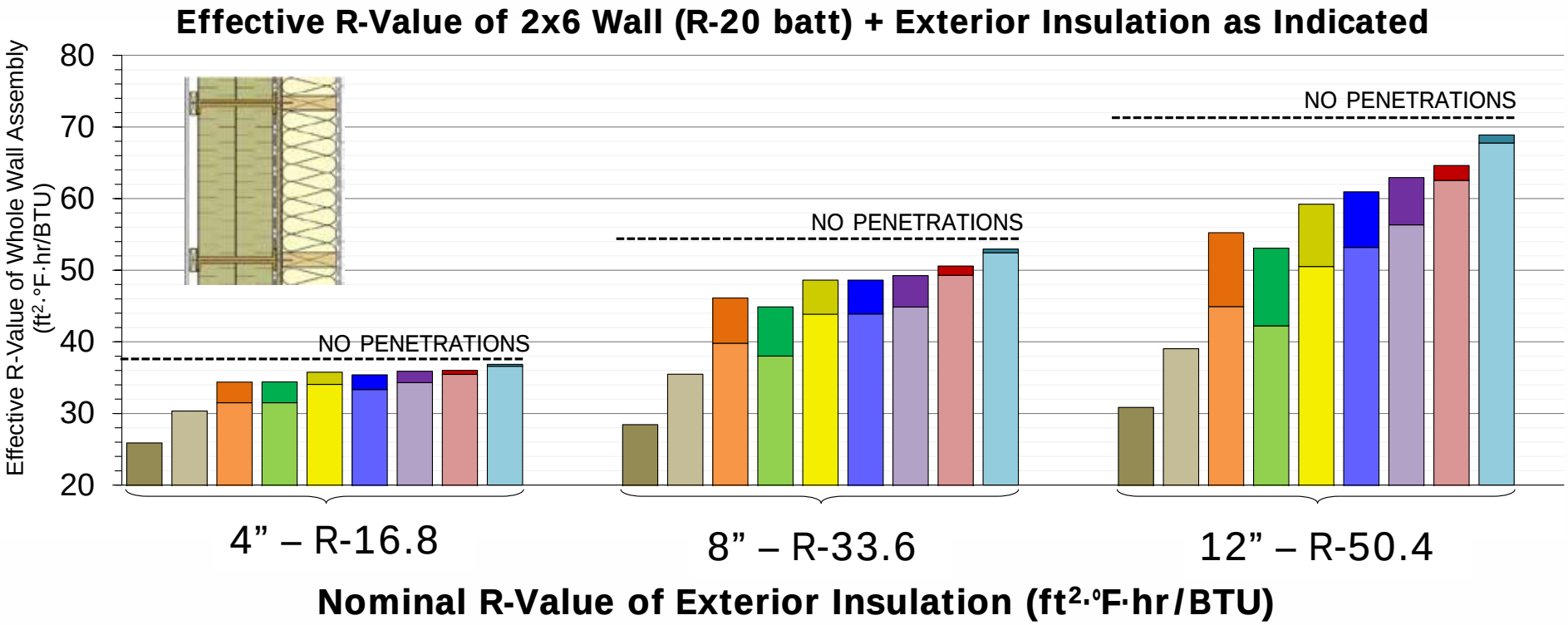
~15-30% loss in R-value

Cladding Attachment: Screws Through Insulation

Cladding Attachment: Screws through Insulation

Really Thick Insulation = Really Long Screws

Cladding Attachment Matters – Effective R-values



- Continuous Vertical Z-Girt - 16" OC
- Continuous Horizontal Z-Girt - 24" OC
- Aluminium T-Clip - 16" x 48"
- Aluminium T-Clip - 16" x 24"
- Intermittent Galvanized Z-Girt - 16" x 48"
- Intermittent Galvanized Z-Girt - 16"x 24"
- Isolated Galvanized Clip - 16" x 48"
- Isolated Galvanized Clip - 16" x 24"
- Intermittent SS Z-Girt - 16" 48"
- Intermittent SS Z-Girt - 16" x 24"
- Fiberglass Clip - 16" x 48"
- Fiberglass Clip - 16" x 24"
- Galvanized Screws - 16" x 16"
- Galvanized Screws - 16" x 12"
- SS Screws - 16" x 16"
- SS Screws - 16" x 12"

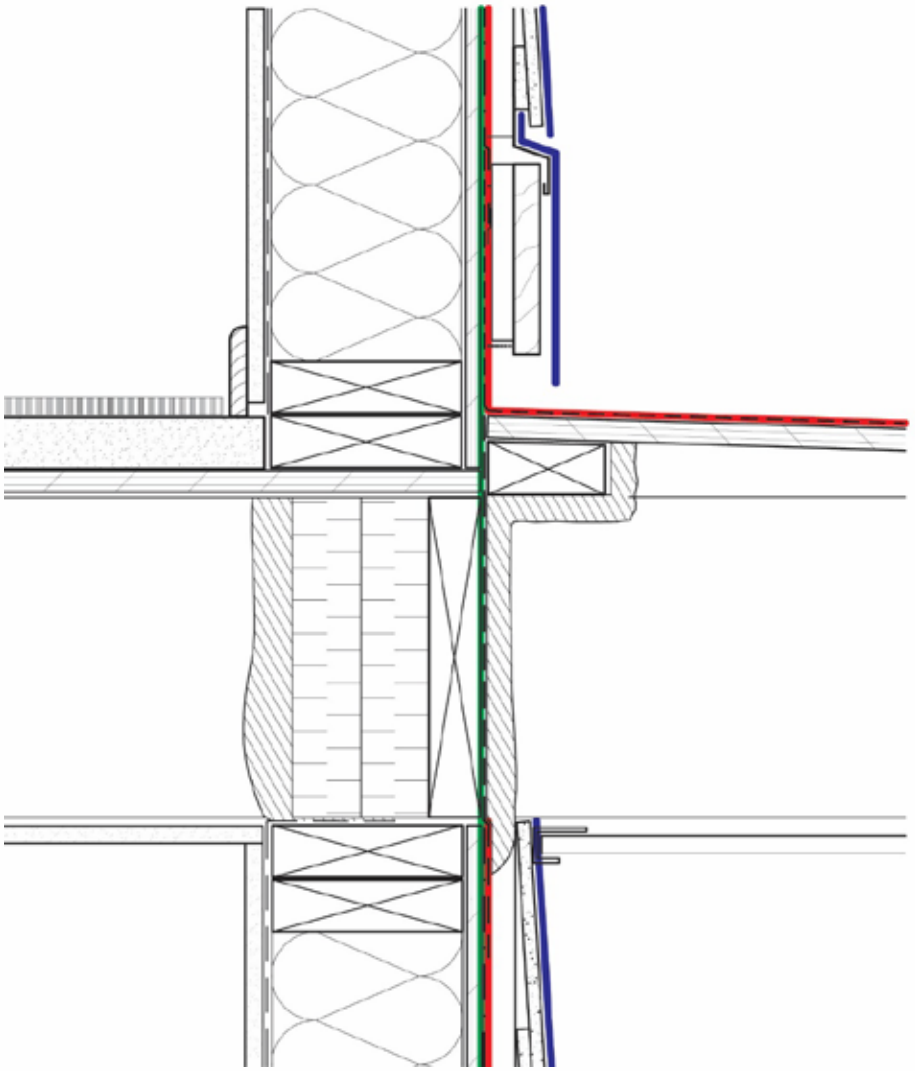
Balcony Designs

Wood-Framed Balcony

- Likely the most common framing method
- Questions:
  - Where is the air barrier?
  - Thermal barrier?
  - Water barrier?
  - ‘Saddles’?
  - Do we vent?
  - Guardrail attachment?

Cantilevered Balcony – Control Layers

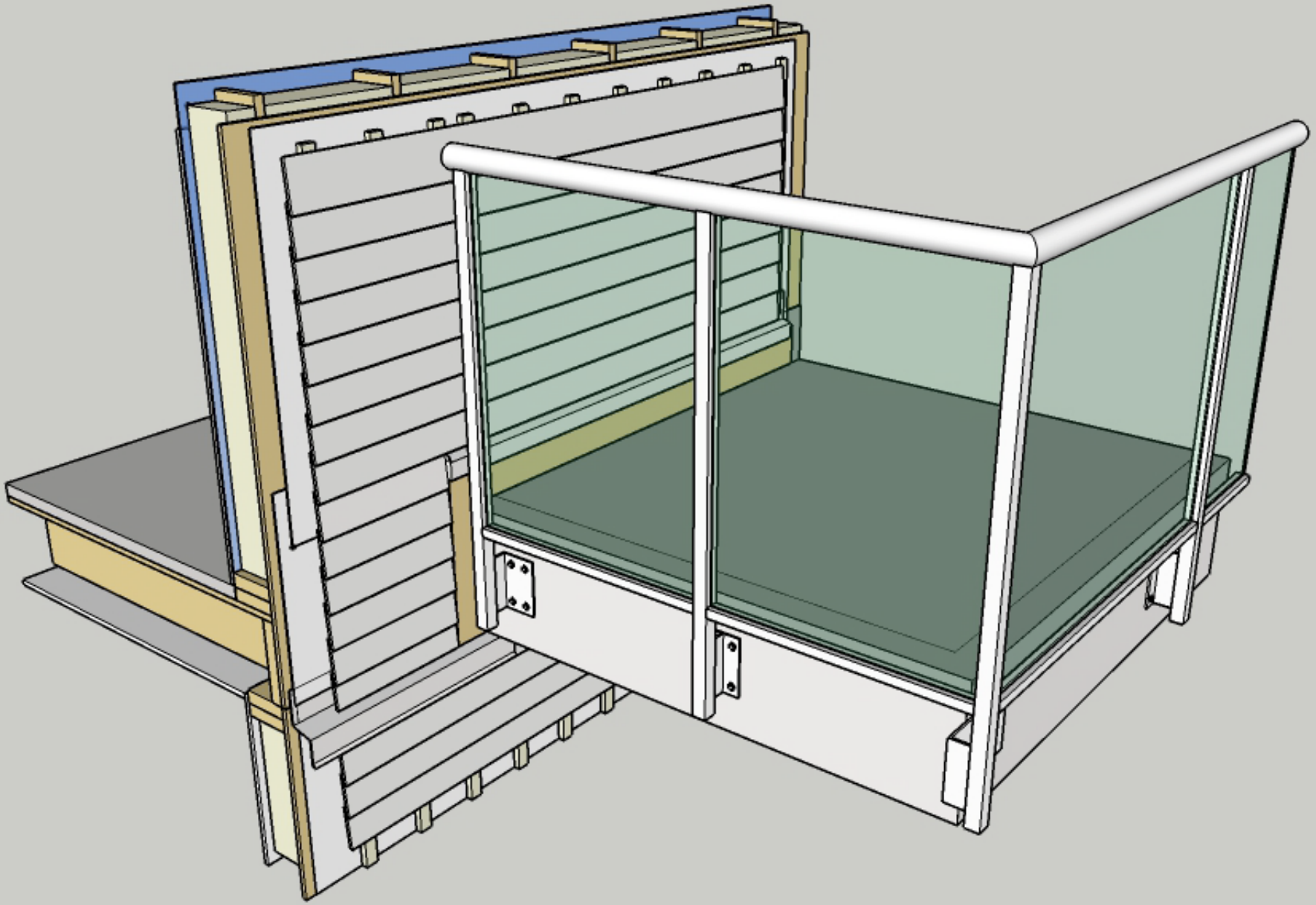
- Air barrier:
  - Use the shortest path possible
  - Prevent interior air from entering balcony soffit
  - Vent soffit
- Thermal barrier:
- Water barrier:
  - Over a sloped and drained balcony surface



Cantilevered Balcony - Saddles

- à 3-dimensional integration of assemblies
- à Include a 3-dimensional detail

Cantilevered Balcony Construction



Pre-Finished Steel Balcony over Wood

- ‘Bolt-on’ architectural component, but not part of building enclosure
- Air, water, and thermal control layers continuous behind pre-finished balcony
- Simplifies detailing – no saddles
- Use durable materials

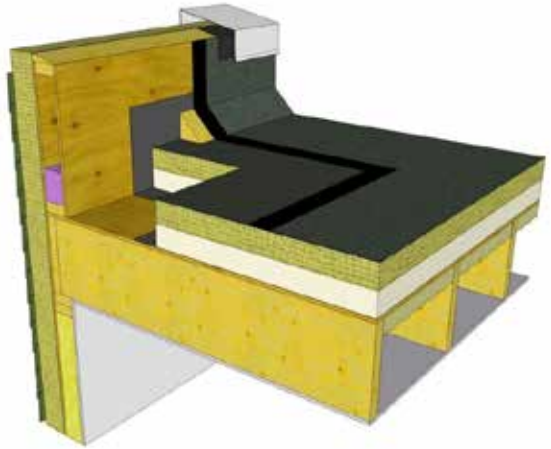
Pre-Finished Steel Balconies

Roof Designs

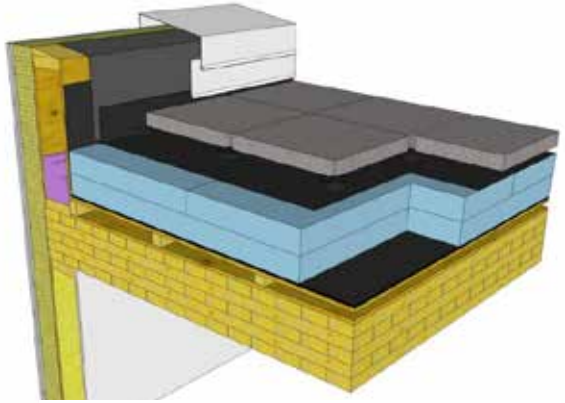
- Ventilated roofs aren’t what they used to be.

Roof Design for Larger Wood Buildings

- **Key Considerations:** Keep dry, allow to dry, robustness of assemblies, sloping strategy
- **Strategies:**
  - Protect wood roof from getting wet during construction
  - Insulation on top of air and vapor control layers - conventional or protected membrane assemblies
  - Connect control layers at walls
- Be cautious of interior insulated approaches, with or without venting
  - Membrane color matters, but maybe not in the way that you think



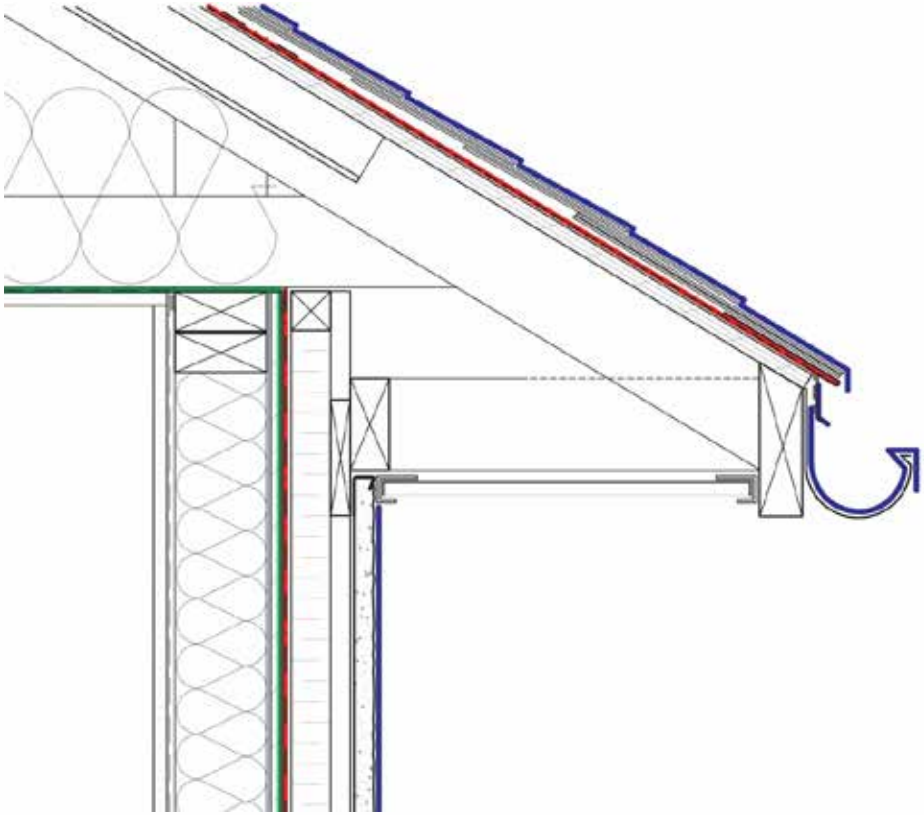
Conventional roof with tapered insulation over wood joists



Protected membrane roof over vented & tapered structure over CLT

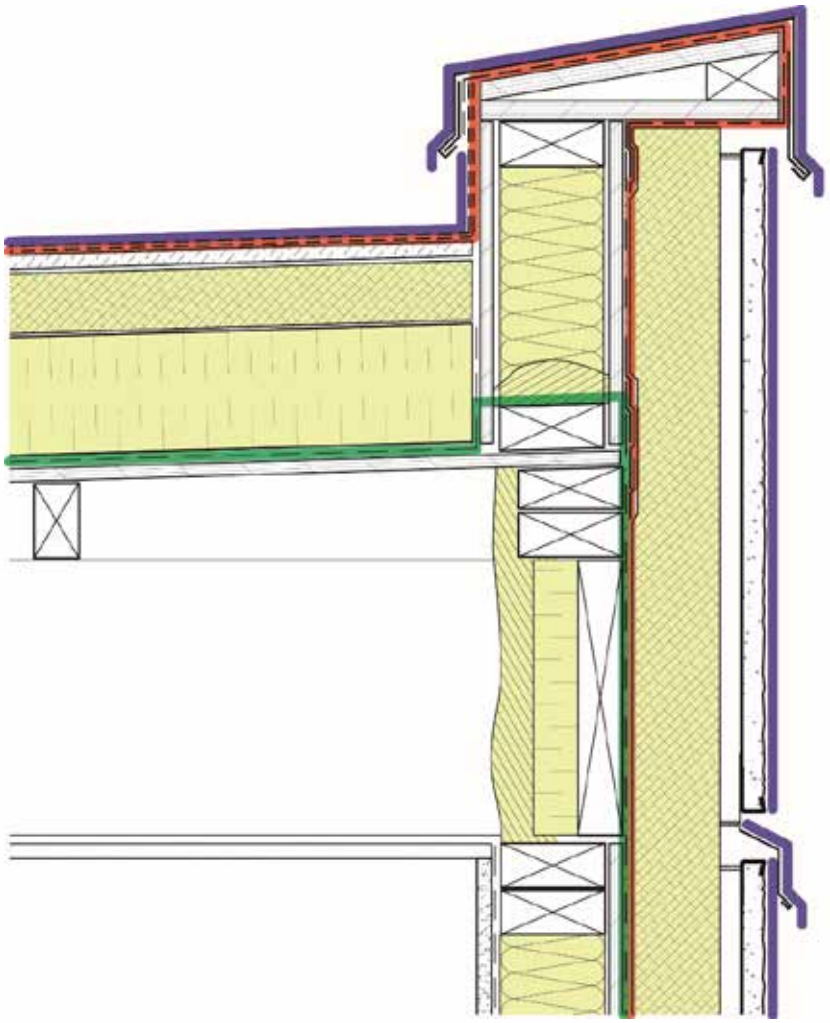
Attics & Vented Roofs – Control Layers

- Likely the most common assembly in USA for sloped roofs – good track record in most climates
- Be cautious if used on low-slope roofs, particularly if venting path is complicated
- Air barrier continuity at ceiling and roof-to-wall is critical



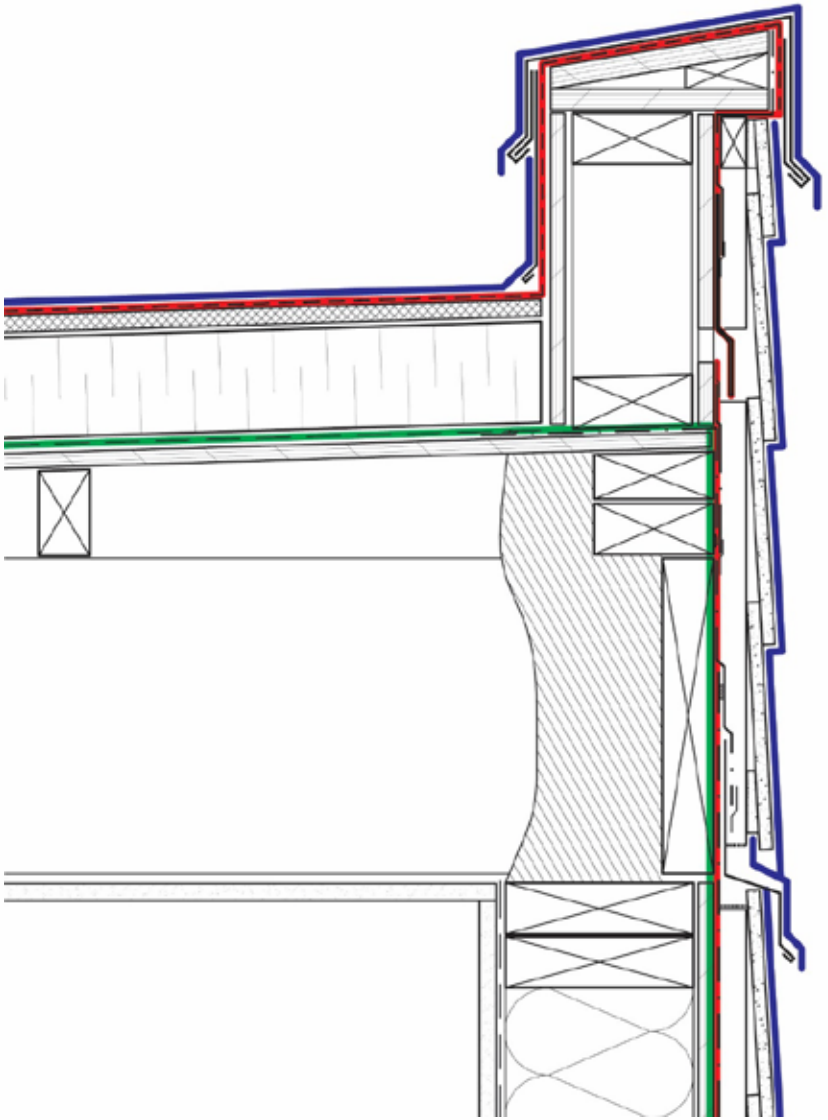
Roof to Wall – Control Layers (EI)

- Air barrier:
  - Use the shortest path possible
  - Ideally below parapet framing
- Thermal barrier:
  - Ideally to exterior of control layers
- Water barrier:
  - Roof membrane to sheathing membrane



Roof to Wall – Control Layers

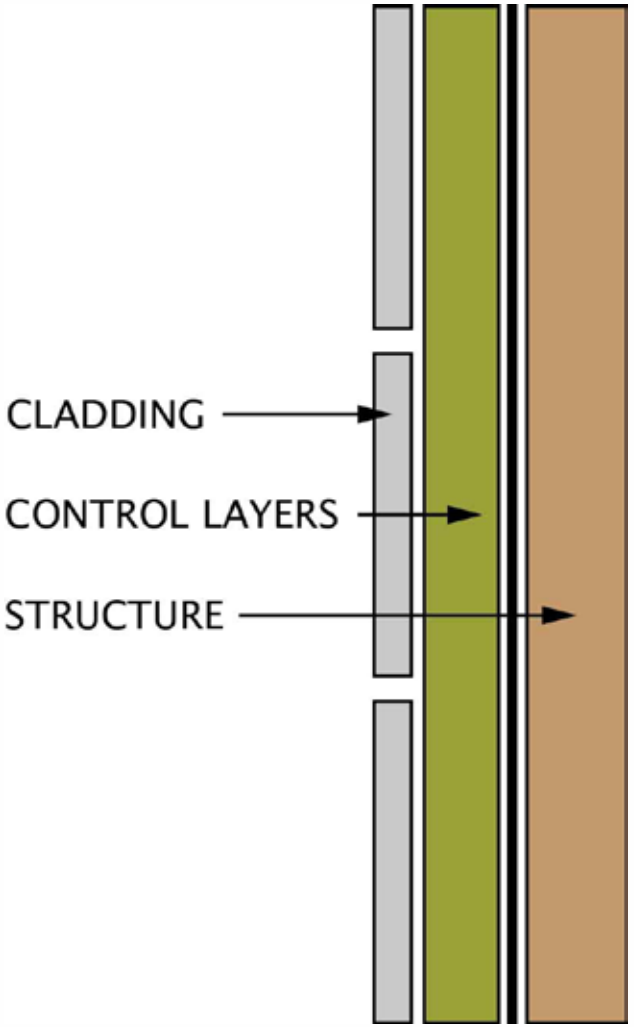
- Air barrier:
  - Use the shortest path possible
  - Ideally below parapet framing
- Thermal barrier:
  - Ideally to exterior of control layers
- Water barrier:
  - Roof membrane to sheathing membrane



Interfaces & Challenges - Parapets

Summary

- Control moisture, air, and heat
- Best practices:
  - Rainscreen cladding
  - Keep structure warm and dry and allow it to dry: control layers on exterior
- Think about the details!
  - Provide continuity of control layers within and between assemblies and details
  - Easier said than done: modern large buildings often architecturally complicated
  - Use simple, common themes for details; everything is a variation on those themes

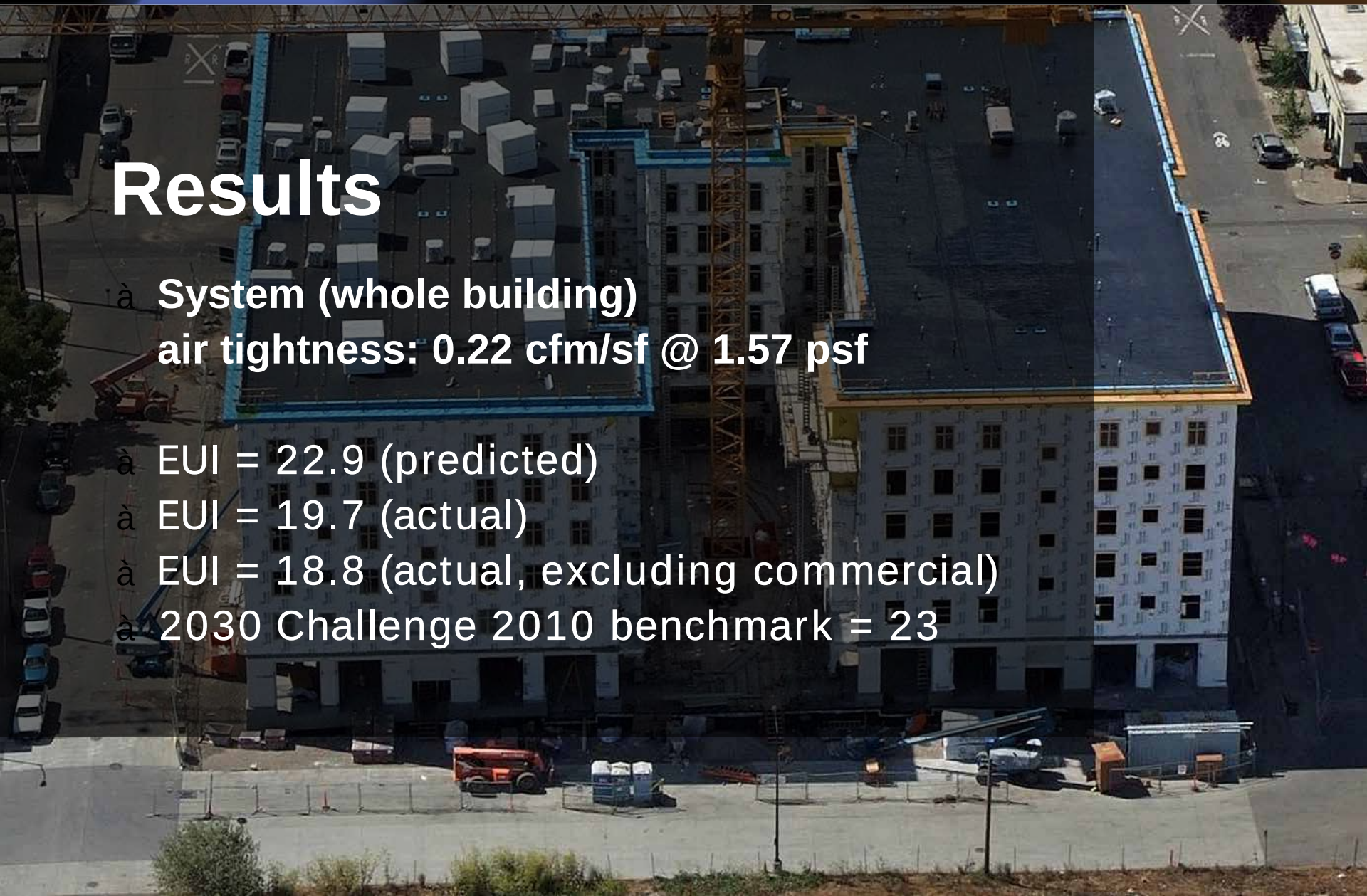


The Ramona Apartments – Portland, OR

- Architecture 2030 Challenge for reducing energy use.
- In 2012 the building consumed 62% less energy than the average for residential buildings in the western region.

The Ramona – Air Barrier Construction

The Ramona – Air Leakage Testing



Results

- **System (whole building)**
  air tightness: 0.22 cfm/sf @ 1.57 psf

- EUI = 22.9 (predicted)
- EUI = 19.7 (actual)
- EUI = 18.8 (actual, excluding commercial)
- 2030 Challenge 2010 benchmark = 23

Discussion + Questions

FOR FURTHER INFORMATION PLEASE VISIT

- rdh.com

RDH