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Building Enclosure Design and Best Practices for Wood-Framed Buildings

Colin Shane M.Eng., P.Eng.
Associate, Senior Project Engineer
RDH Building Sciences Inc.
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Course Description

- Through a combination of building science fundamentals, case studies, and current research, this presentation will explore best practices for designing durable, energy efficient building enclosures for mid-rise buildings constructed using traditional light wood-frame construction. Differences in enclosure design associated with taller wood-framed buildings using mass timber products will also be discussed.

Learning Objectives

- Review building science fundamentals and building enclosure design considerations for light wood-frame buildings.
- Discuss best practices for light wood-frame building enclosure design, detailing, and construction techniques
- Compare the differences in building enclosure design criteria and systematic approaches between light wood-frame structures and tall, mass timber-frame structures.
- Demonstrate examples of building enclosure details and assemblies used in light wood-frame projects and discuss lessons learned through case studies.

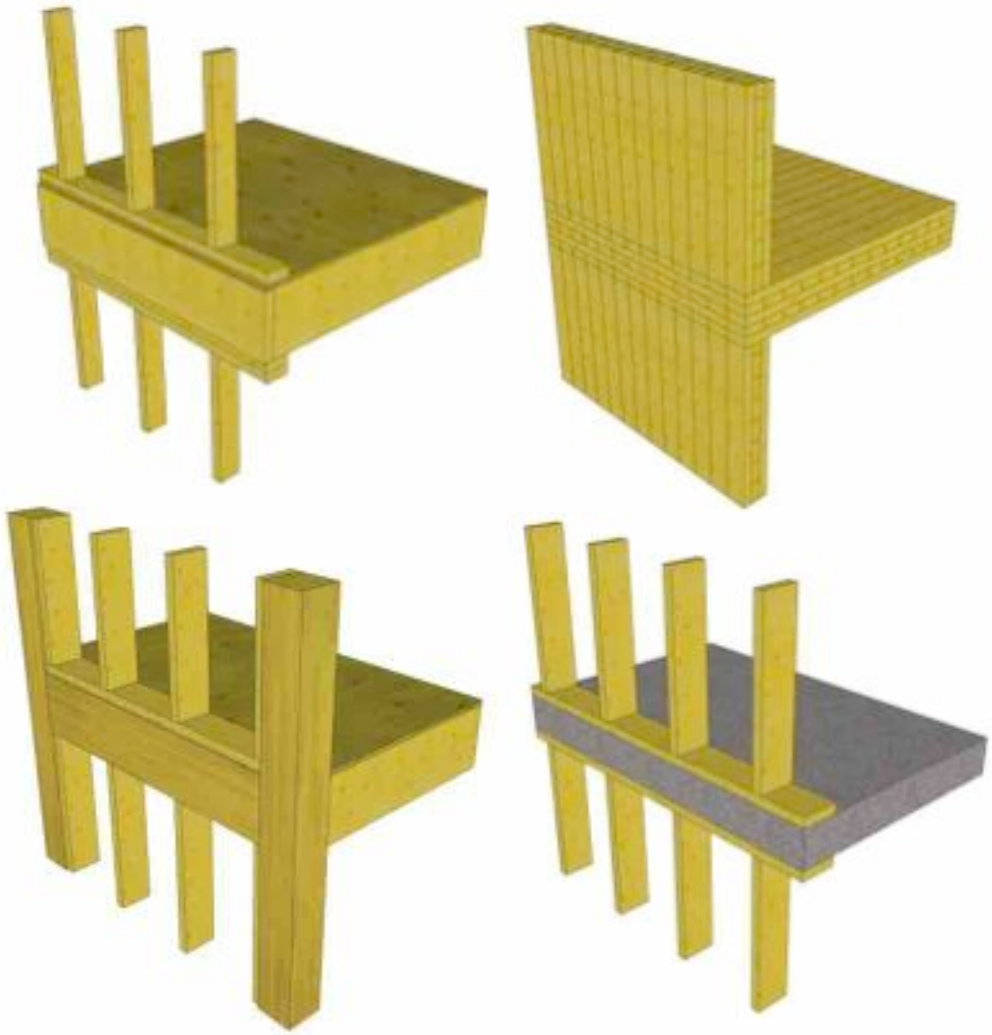
Background

Wood-frame Building Enclosure Design Guides

- Original 1999/2011 Wood Frame Envelopes in the Coastal Climate of British Columbia - Best Practice Guide (CMHC) - Emphasis on moisture control
- 2011 Building Enclosure Design Guide – Wood-frame Multi-Unit Residential Buildings (HPO)
  - Emphasis on best practices, moisture and new energy codes
- 2013 Guide (FP Innovations)
  - Focus on highly insulated wood-frame assemblies to meet current and upcoming energy codes
  - Passive design and green buildings

What Types of Buildings are the Guides For?

- → Multi-Unit Residential Buildings are the focus of the guide (and one of most challenging building types)
- → Relevant for other building types as well utilizing **platform framing**, **cross laminated timber**, **wood frame infill**, & **post and beam**.
- → Also applies to houses



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!

Trends in Building Enclosure Design

- Trend towards more energy efficiently building enclosures
- Air barriers now required in 2012 IECC and 2013 CEC
- Continuous insulation becoming more common
  - Seeing more new building materials, enclosure assemblies and construction techniques

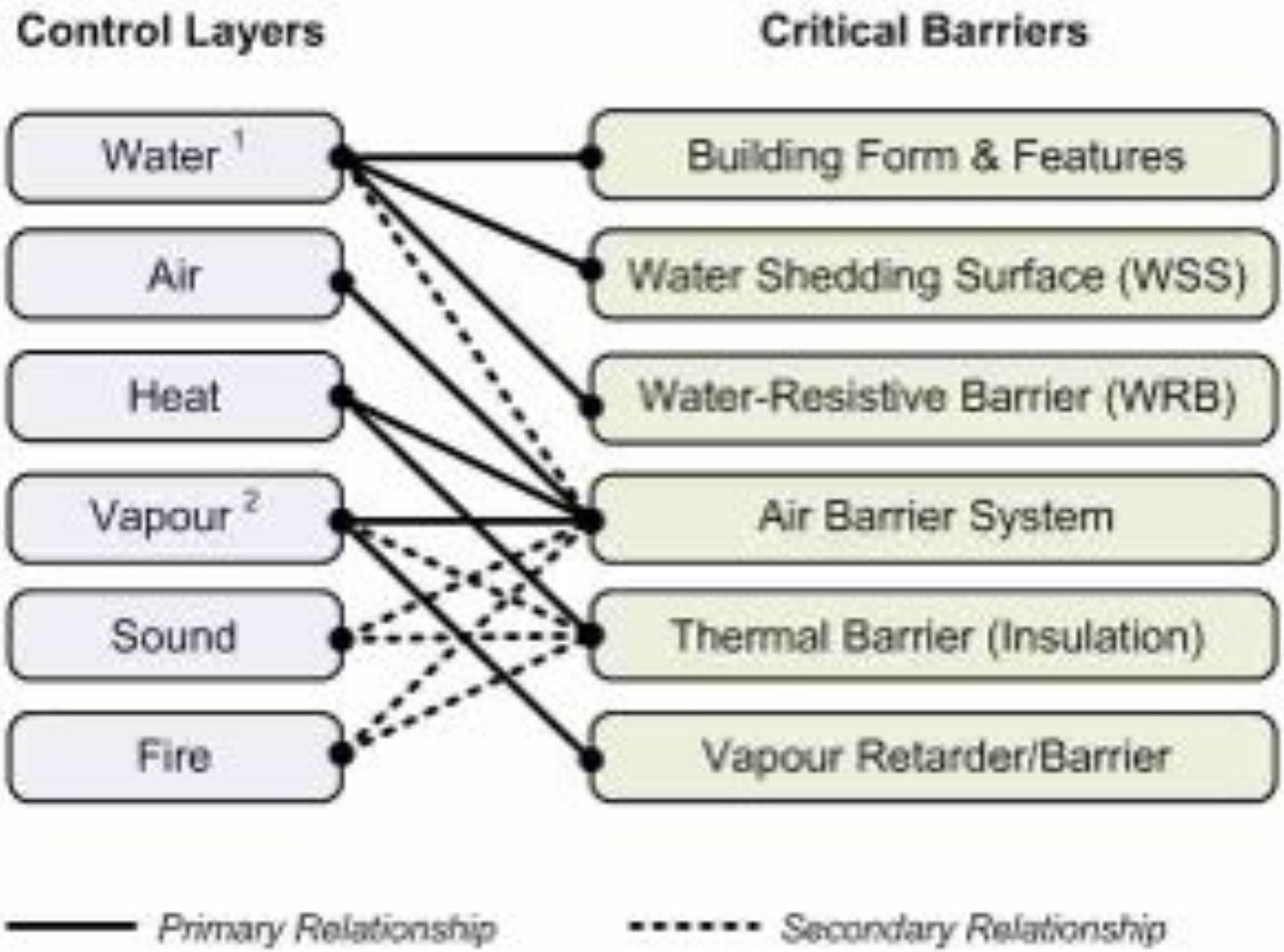
- **More insulation = less heat flow to dry out moisture**
  - "Marginal" systems that worked in the past may no longer work
  - Amount, type and placement of insulations matters, for vapor, air and moisture control

- **Need to fully understand the science of building enclosure design**

What Have We Learned?

- **Control Rain** – Rainwater penetration causes most problems - poor details (e.g. lack of, poorly implemented, bad materials)
- **Control Air** – Air leakage condensation can cause serious problems – especially in pressurized buildings in colder-climates and energy
- **Control Vapor** – Vapor diffusion can cause wetting – but more importantly is critical to drying after construction and in-service
- **Control Heat** – But do so smartly – place insulation on the outside of structural elements, warmer materials are drier materials

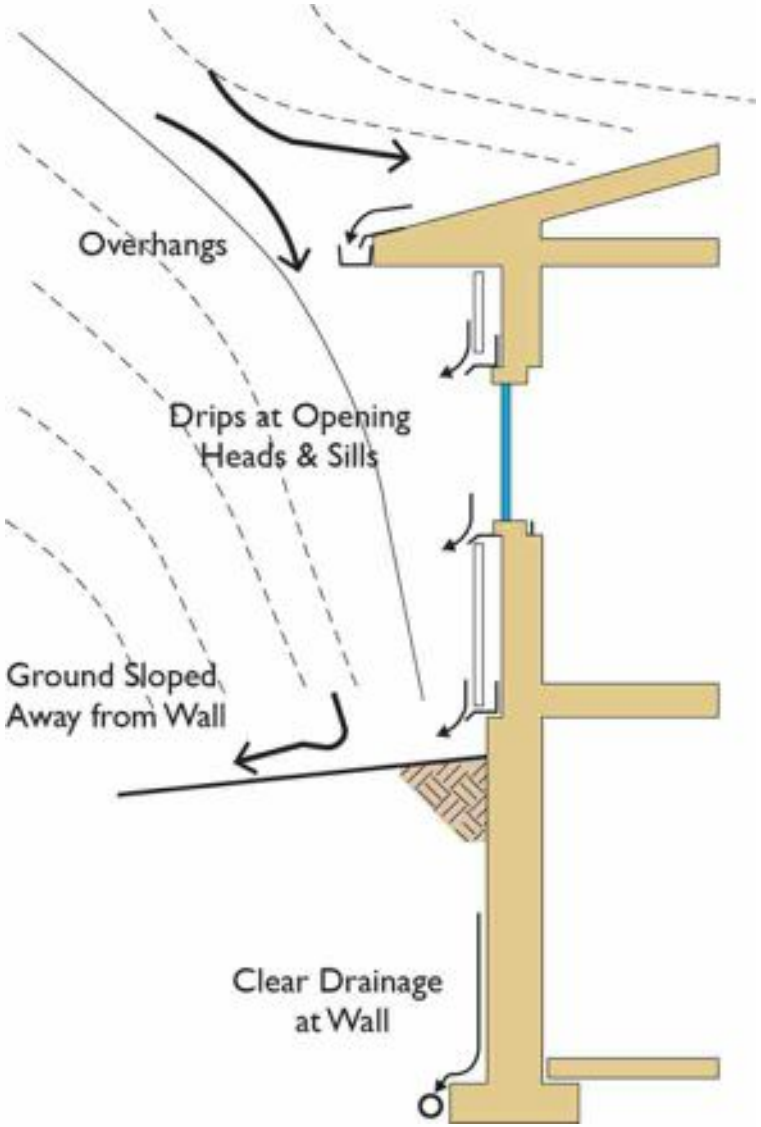
Building Enclosure Control Layers



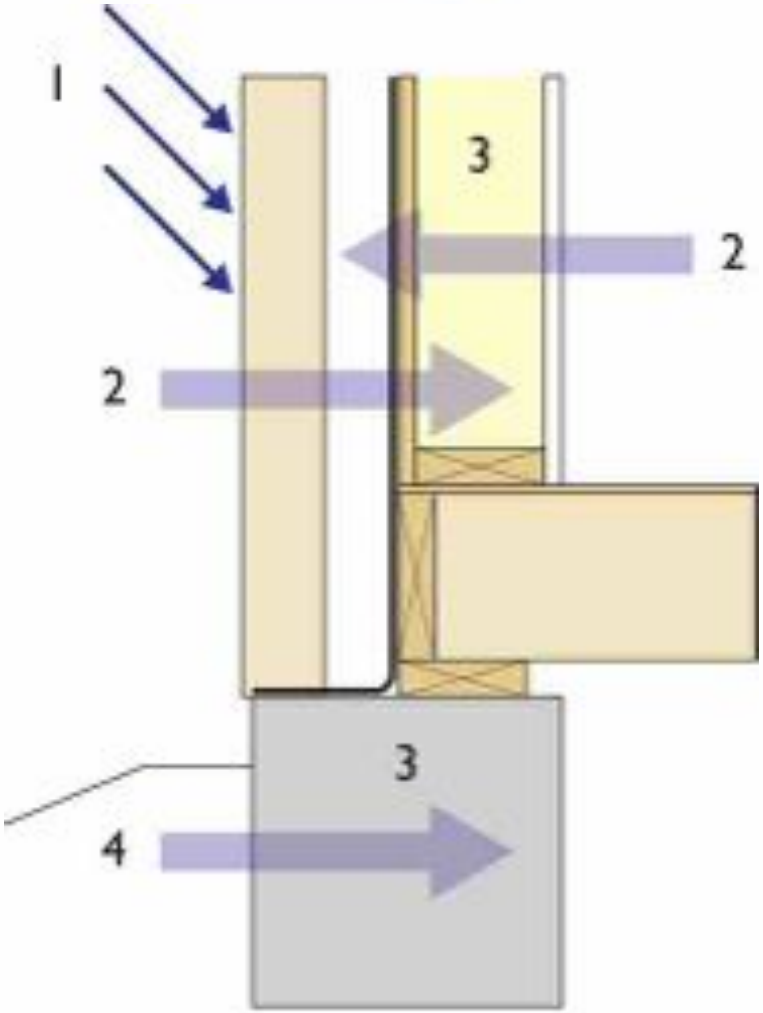
1 – Water is defined here as precipitation (rain, snow, hail, etc.) and ground water
2 – Vapour is separately defined here as the water vapour in air

Rain Penetration Control

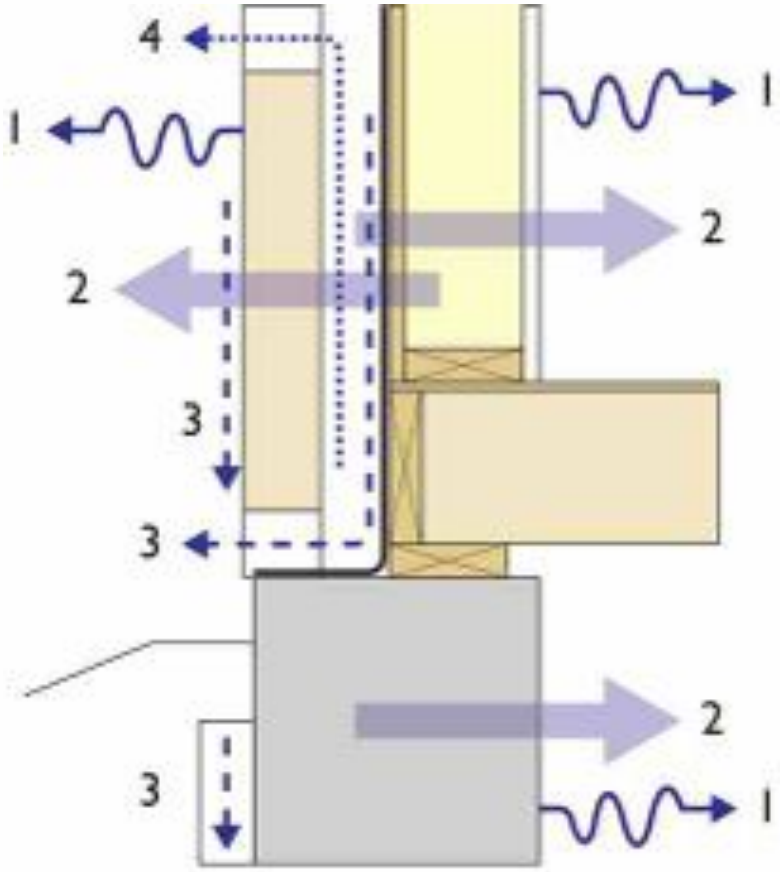
- 3 Conditions for Rain Penetration
  - A **source of water** at the surface of the material (exposure to rain or groundwater)
  - Openings or materials through which water can pass (**water entry paths**)
  - A force to move the water through the openings (**driving force**)
- Deflection, drainage, drying, durability



How do Walls get Wet and Dry?

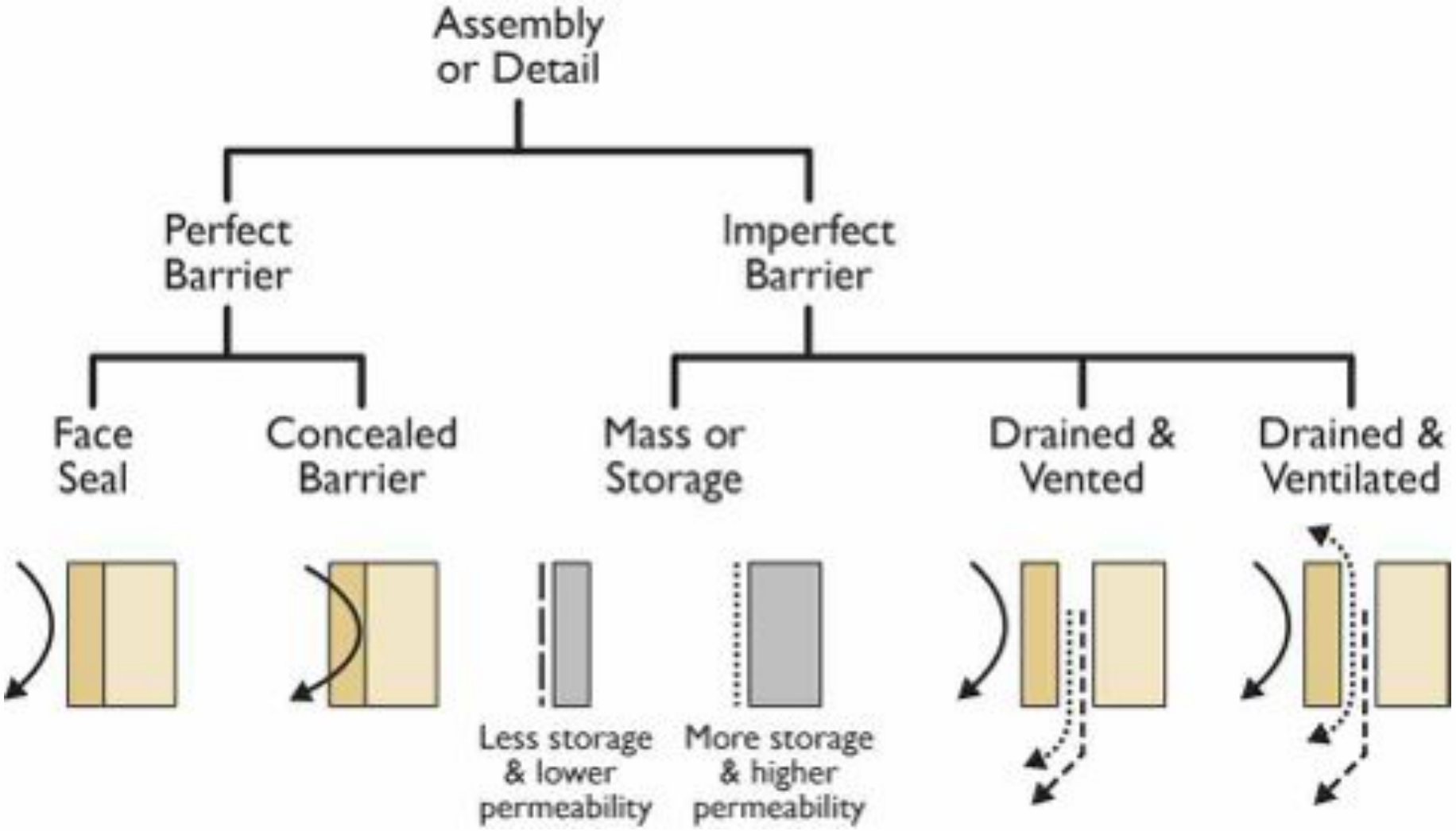


1. Precipitation (rain or snow)
2. Water vapor transported by diffusion and/or air movement (outward or inward)
3. Built-in construction moisture
4. Groundwater

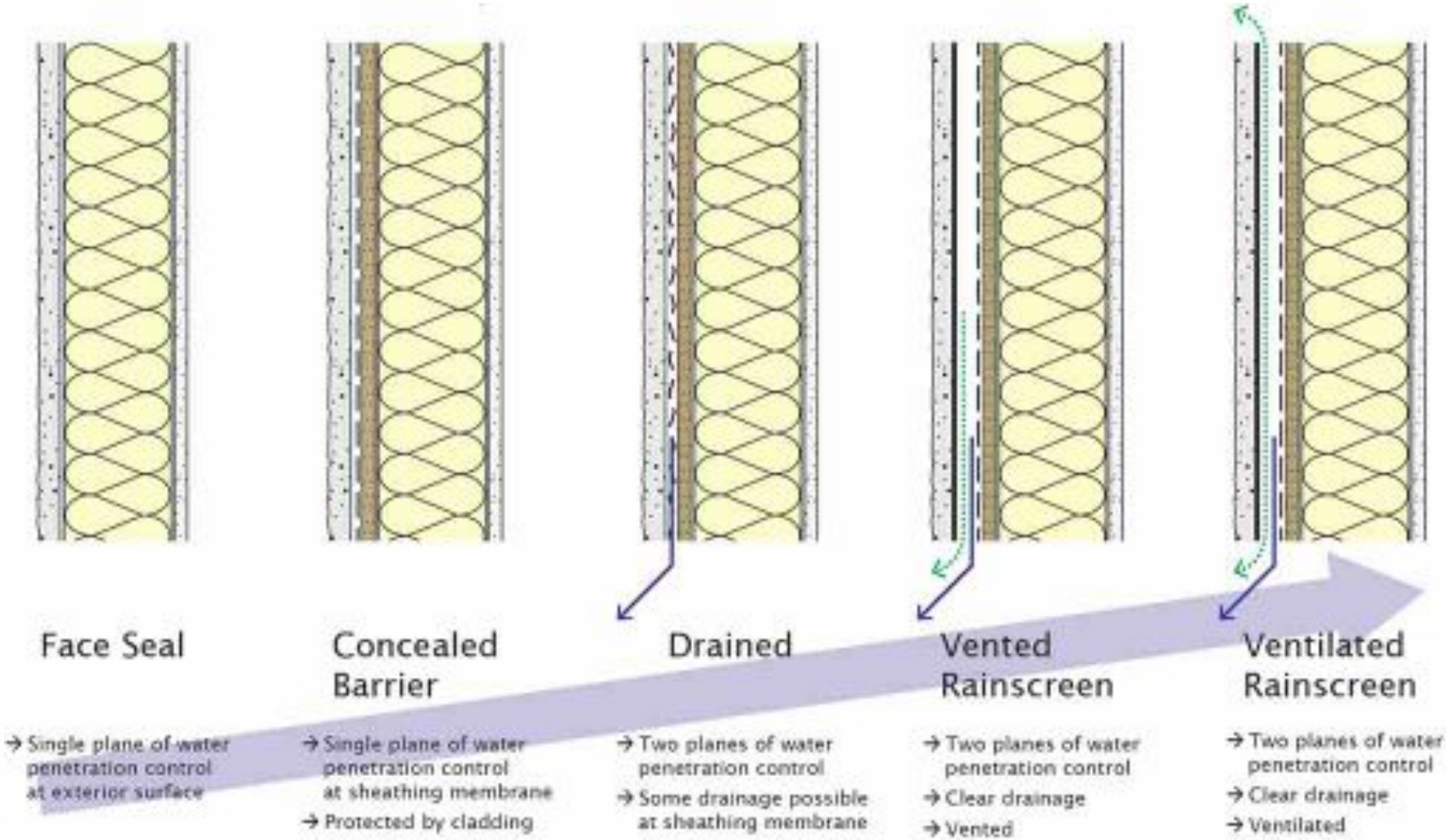


1. Evaporation of water at surfaces
2. Water vapor transport by diffusion and/or air movement (outward or inward)
3. Drainage
4. Ventilation drying by air exchange

Classification of Enclosure Systems



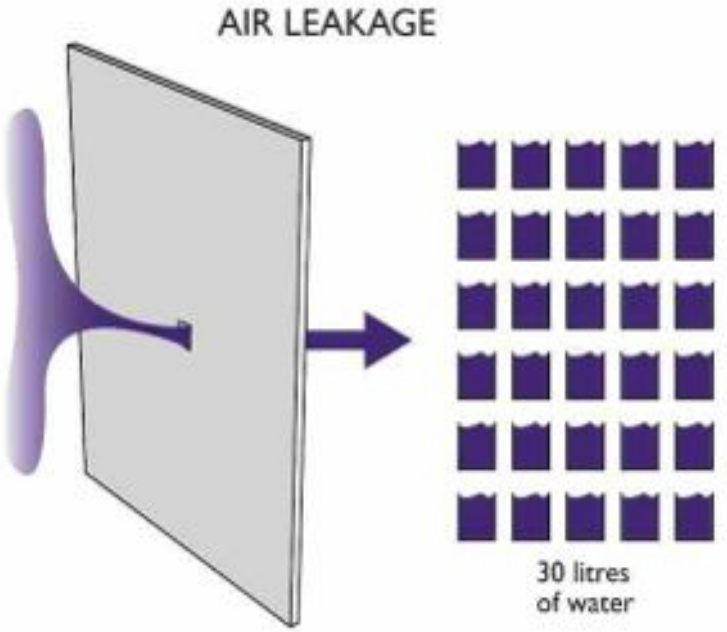
Water Penetration Control Strategies

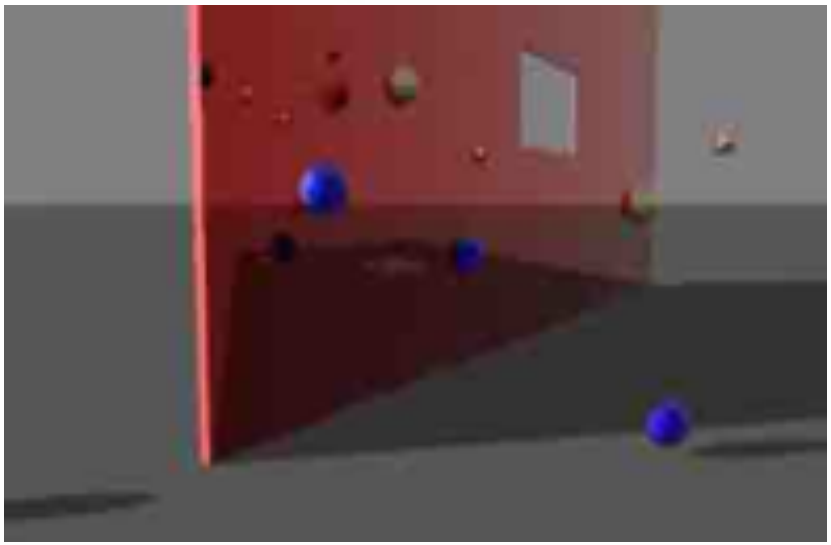


Rainscreen Cladding

Air Penetration Control – Why?

- Code requirement
- Moisture
  - Air holds moisture that can be transported and deposited within assemblies.
  - Pressure moderation as a part of water penetration control is highly dependent on the existence of an effective air barrier.
- Energy
  - Unintentional airflow through the building enclosure can account for as much as 50% of the space heat loss/gain in buildings.





Air Barrier Systems

- Air Barrier Systems Must:
  - Be continuous, airtight, durable
  - Resist Structural Loads – Stiffness & Strength
  - Flexible detailing across inter-story and drift joints
  - Not negatively affect drying ability
- Traditional loose sheet applied house-wrap products are challenging to make air-tight on larger buildings

Types of Air Barrier Systems

Loose Sheet Applied Membrane – Taped Joints & Strapping

Sealed Gypsum Sheathing – Sealant Filler at Joints

Liquid Applied – Silicone sealants and silicone membrane at Joints

Sealed Plywood Sheathing – Sealant & Membrane at Joints

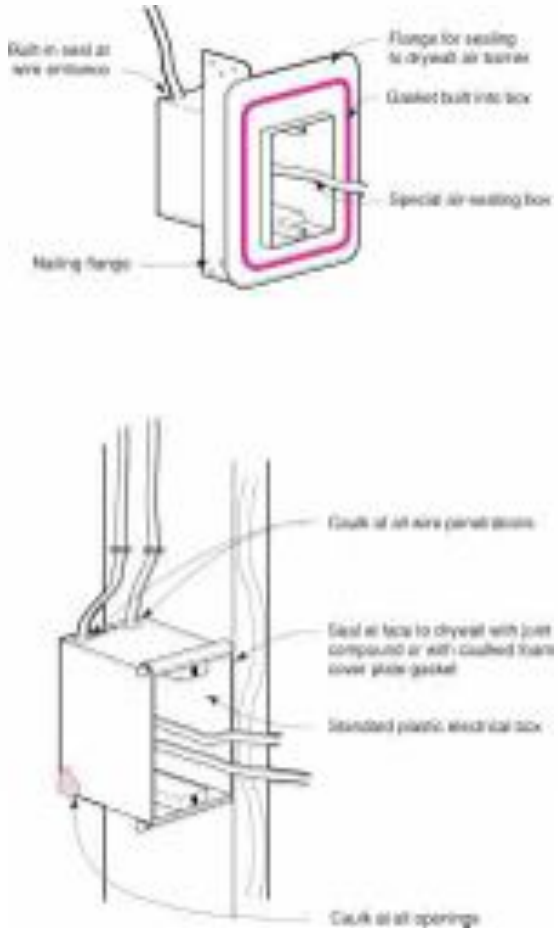
Sealed Sheathing – Membrane at Joints

Self-Adhered vapor permeable membrane

Plywood sheathing with taped joints (good tape)

Airtight Drywall Approach

→ Airtight Drywall Approach



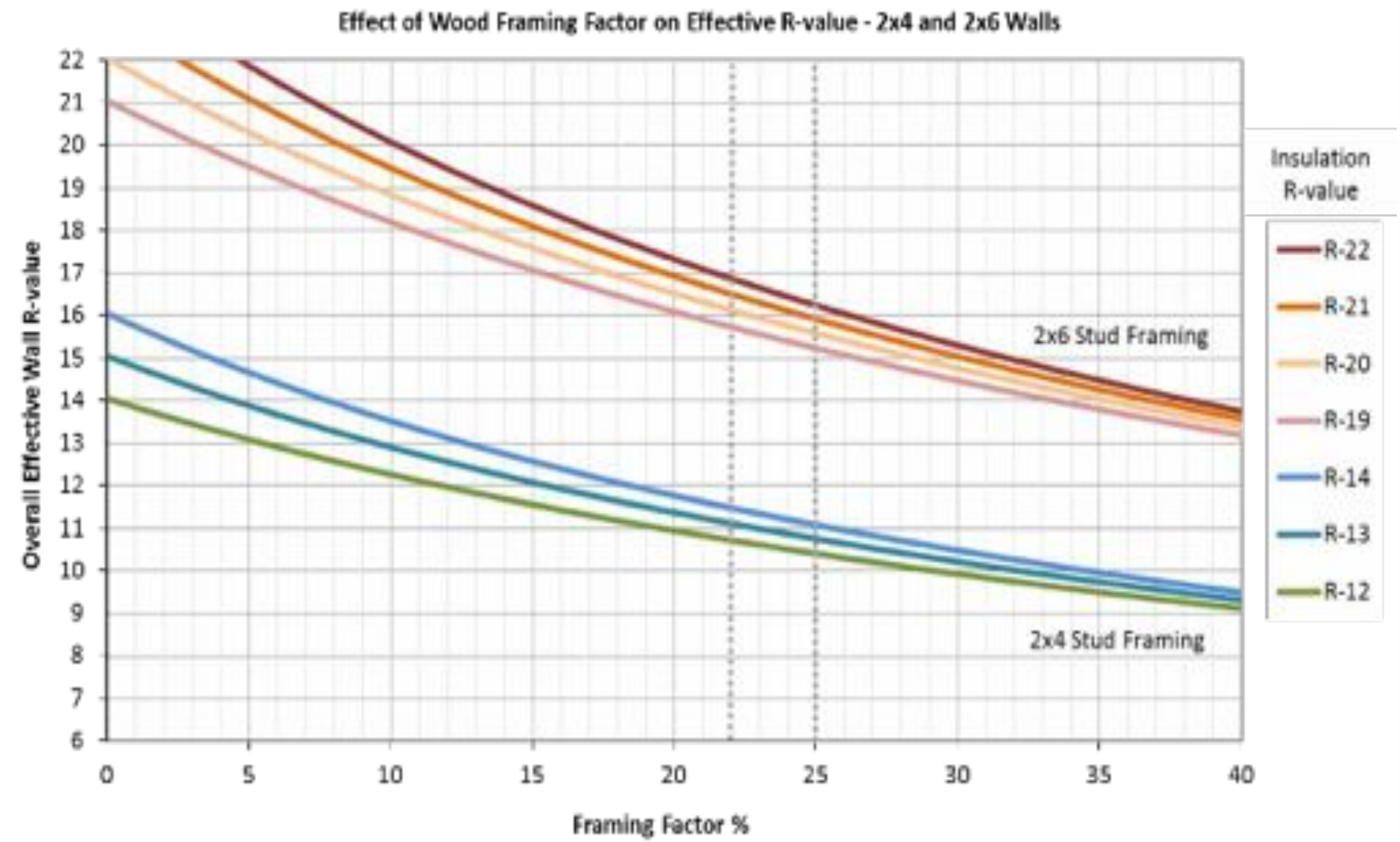
Spray Foam Air Barriers

- → Spray foam excellent for sealing hard to detail areas (like rim joists etc) as part of other air barrier strategies
- → Still requires detailing at transitions, sealants, gaskets etc similar to other approaches
- → Drying?

Conductive Heat Loss Control

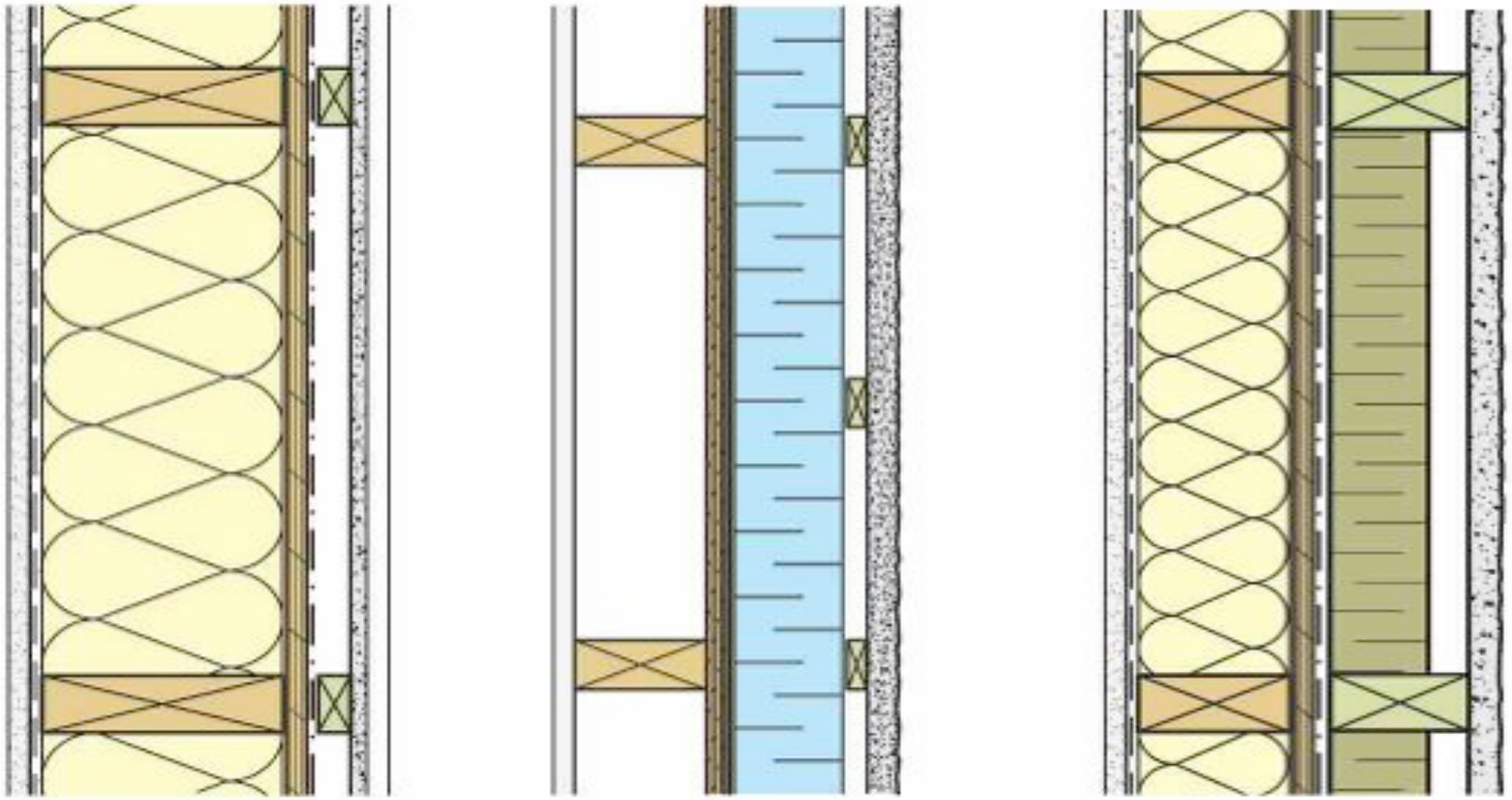
- → Insulation between studs is most common heat control strategy
- → Need to consider effective R-values
- → Continuous insulation on exterior becoming more common

Wood Framing Factor Impact

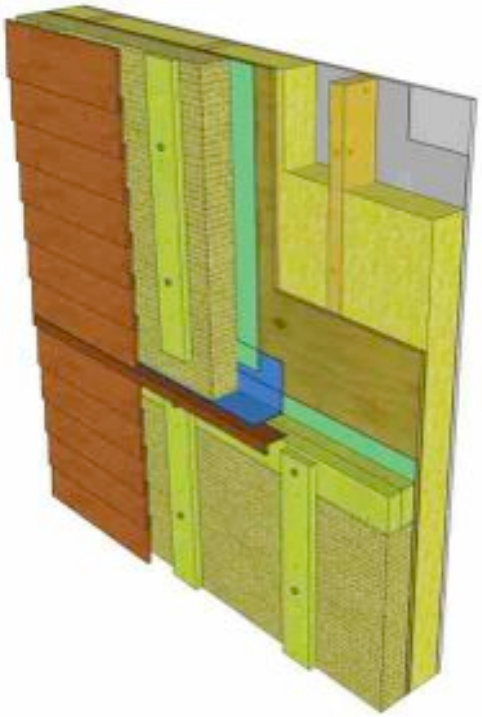


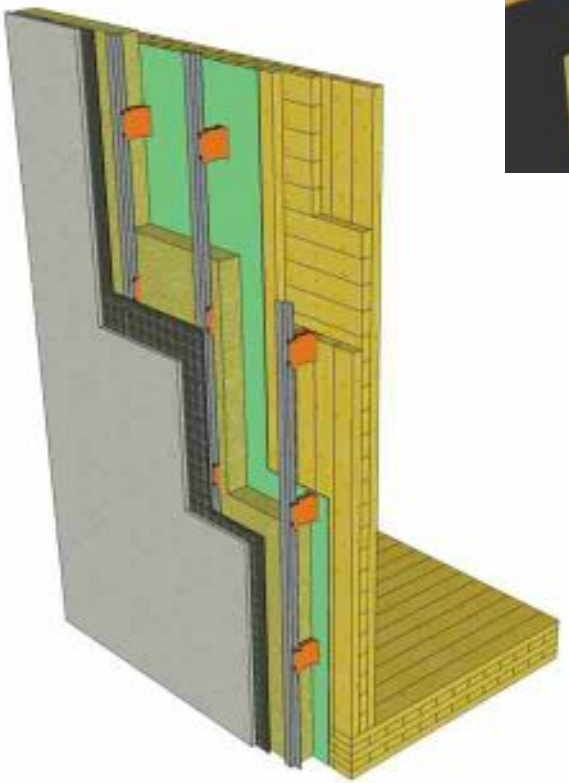
Insulation Placement

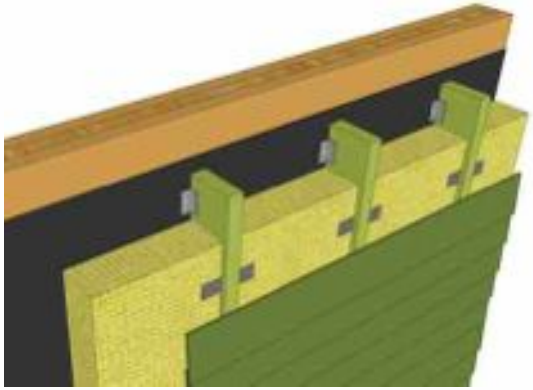
→ Consider effective thermal resistance

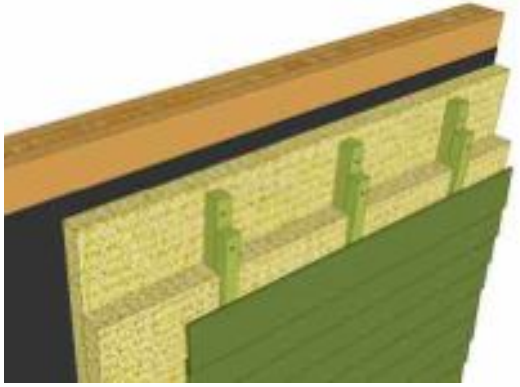


Cladding Attachment through Exterior Insulation

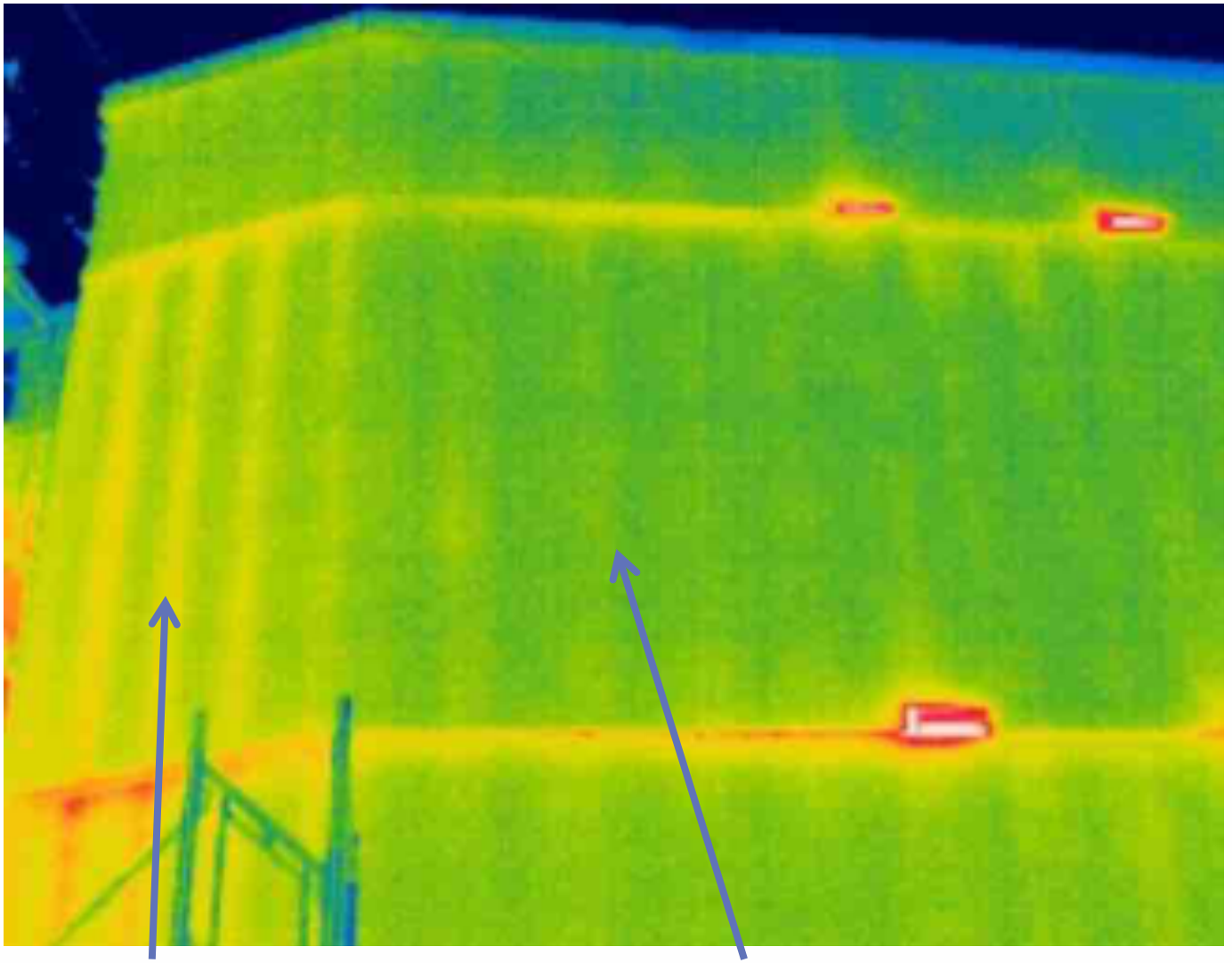








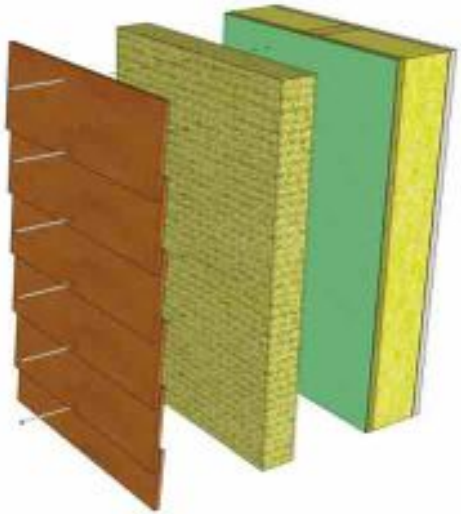
Thermally Improved Performance



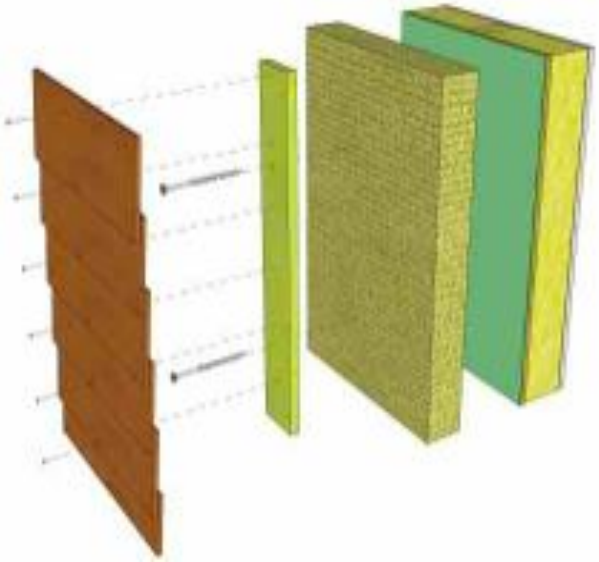
Continuous metal
Z-girts

Fiberglass Clips &
Hat-Tracks

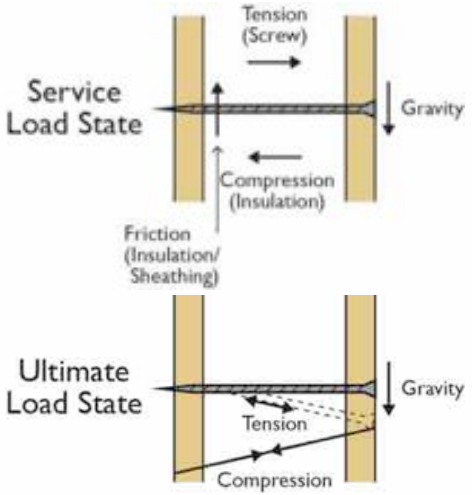
Cladding Attachment through Exterior Insulation

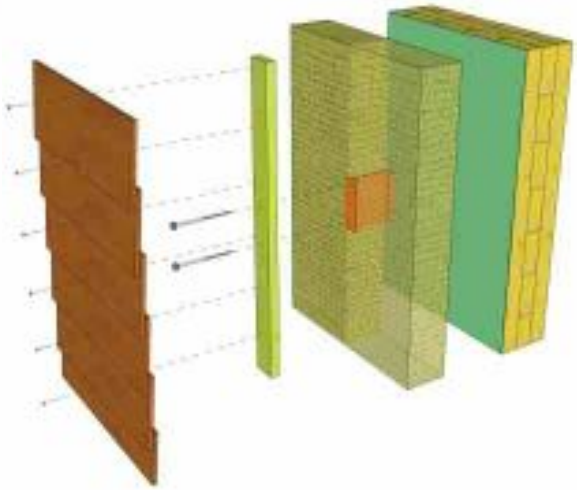


Longer cladding Fasteners directly through rigid insulation (up to 2” for light claddings)



Long screws through vertical strapping and rigid insulation creates truss (8”+) – short cladding fasteners into vertical strapping



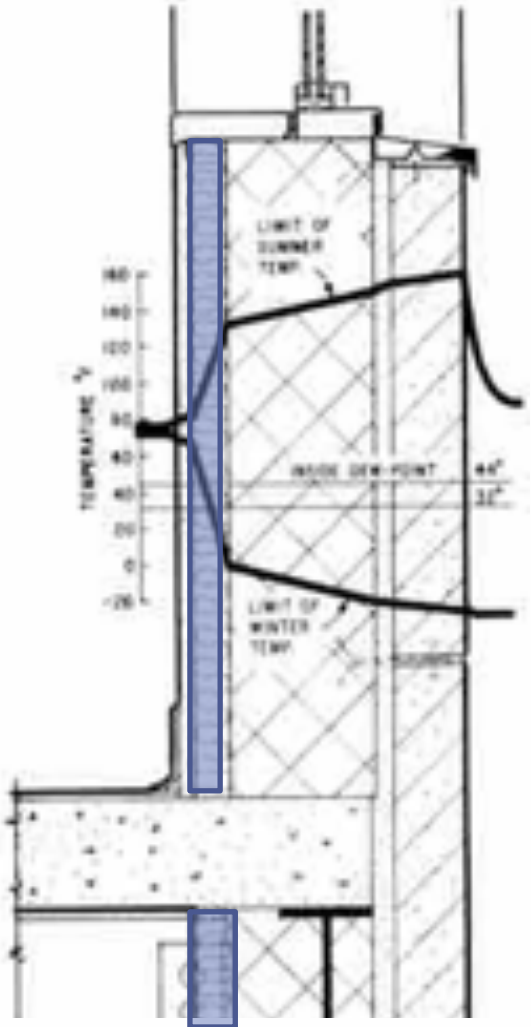


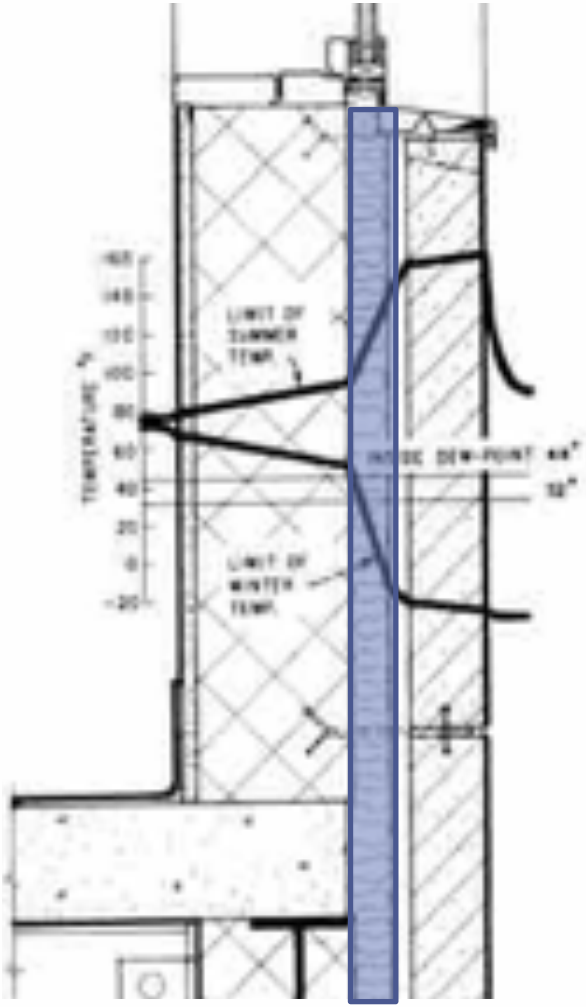
Rigid shear block type connection through insulation, cladding to

Best Practices

The ‘Perfect’ Assembly

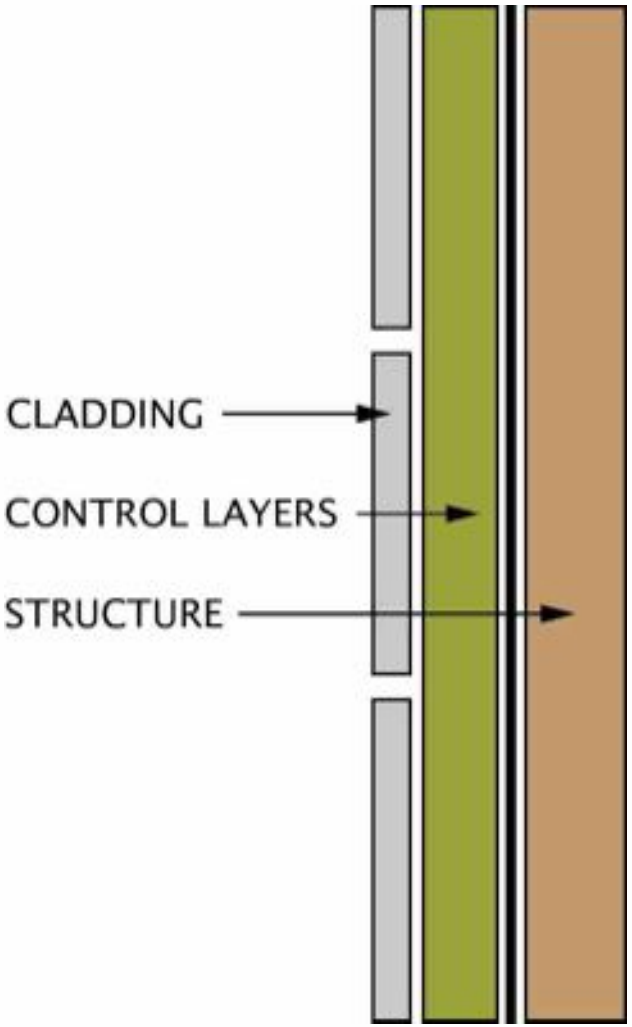
→ Canadian Building Digest #50 (1964):

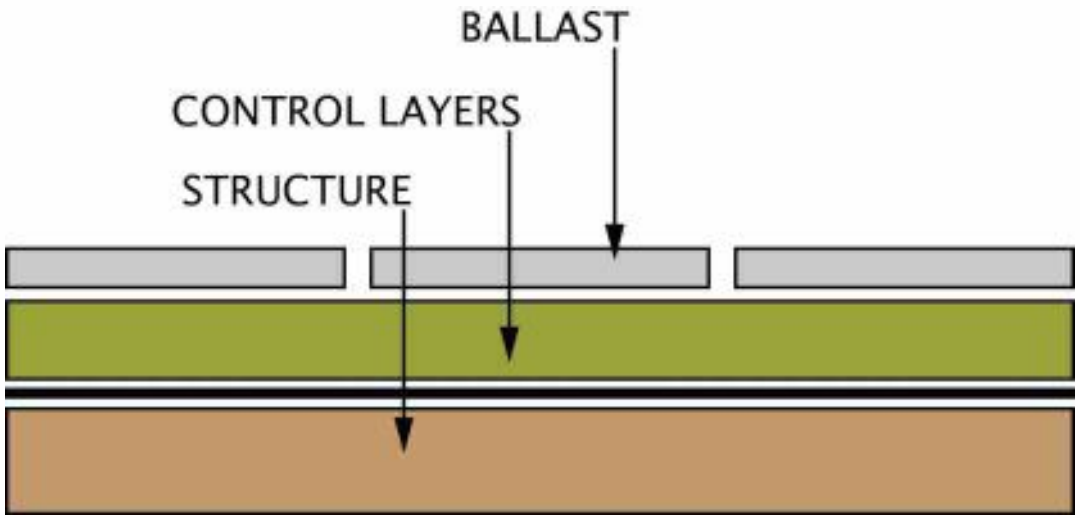




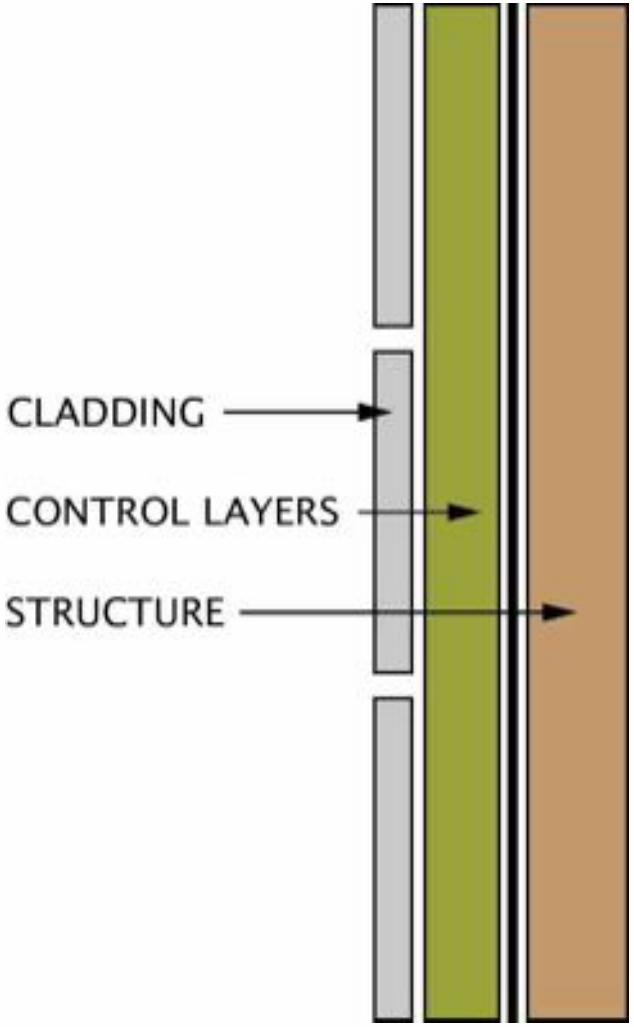
The 'Perfect' Assembly

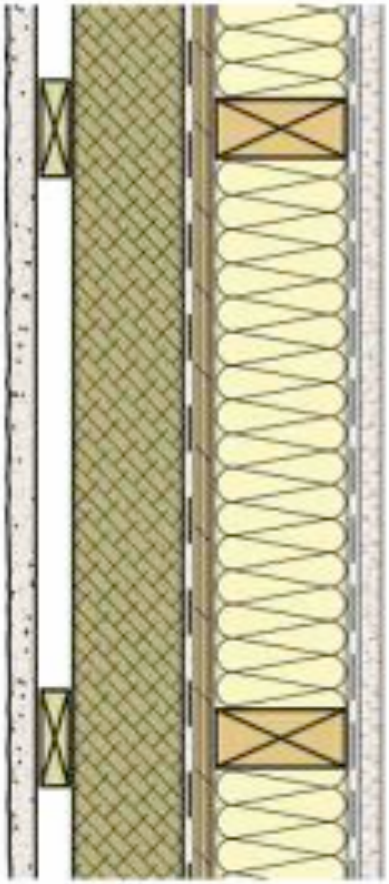
- Rain penetration control: rainscreen cladding over waterproof barrier
- Air leakage control: robust air barrier system
- Heat control: continuous insulation layer
- Locate all barriers **exterior** of structure
  - Keep structure warm and dry
- 50+ year old concept!





Wood-Frame Assemblies – 'Perfect' Wall



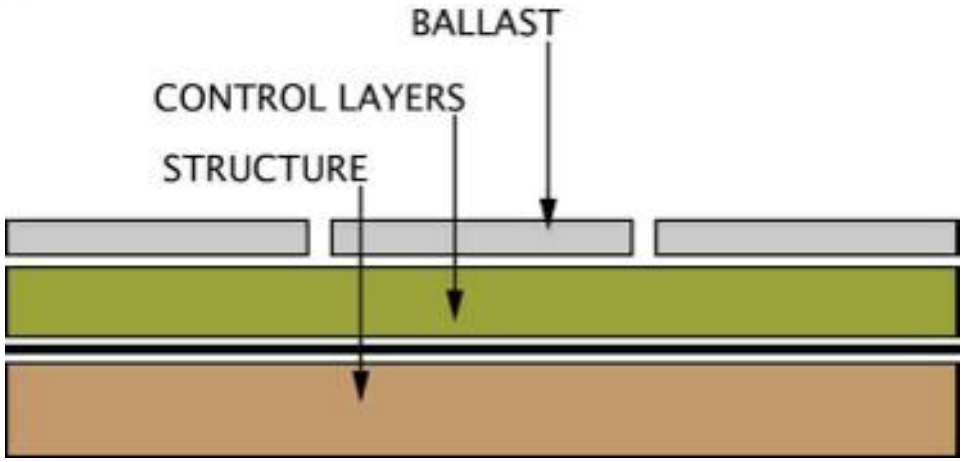


EXTERIOR

- Cladding
- Airspace (ventilated)
- 1x3 wood strapping, screwed through Insulation
- Rigid, mineral-fibre insulation (thickness to meet R-value requirement)
- Vapour-permeable sheathing membrane
- Sheathing (plywood or OSB)
- 2x4 or 2x6 wood framing with batt insulation
- Polyethylene film (cold climates only)
- Gypsum board and paint

INTERIOR

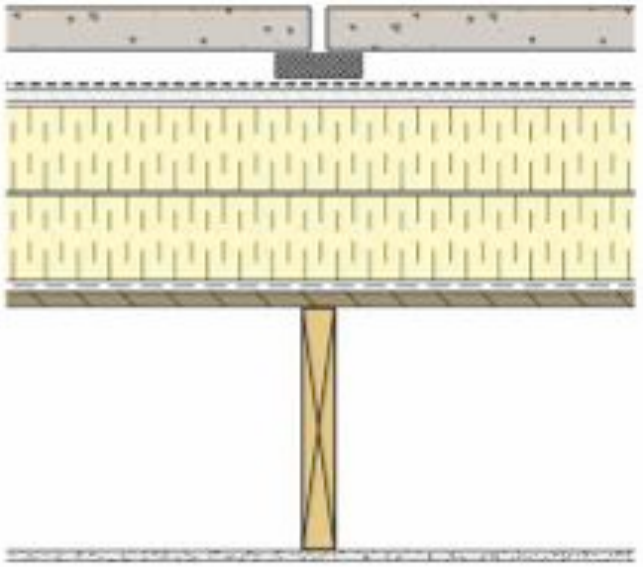
Wood-Frame Assemblies – 'Perfect' Roof



EXTERIOR

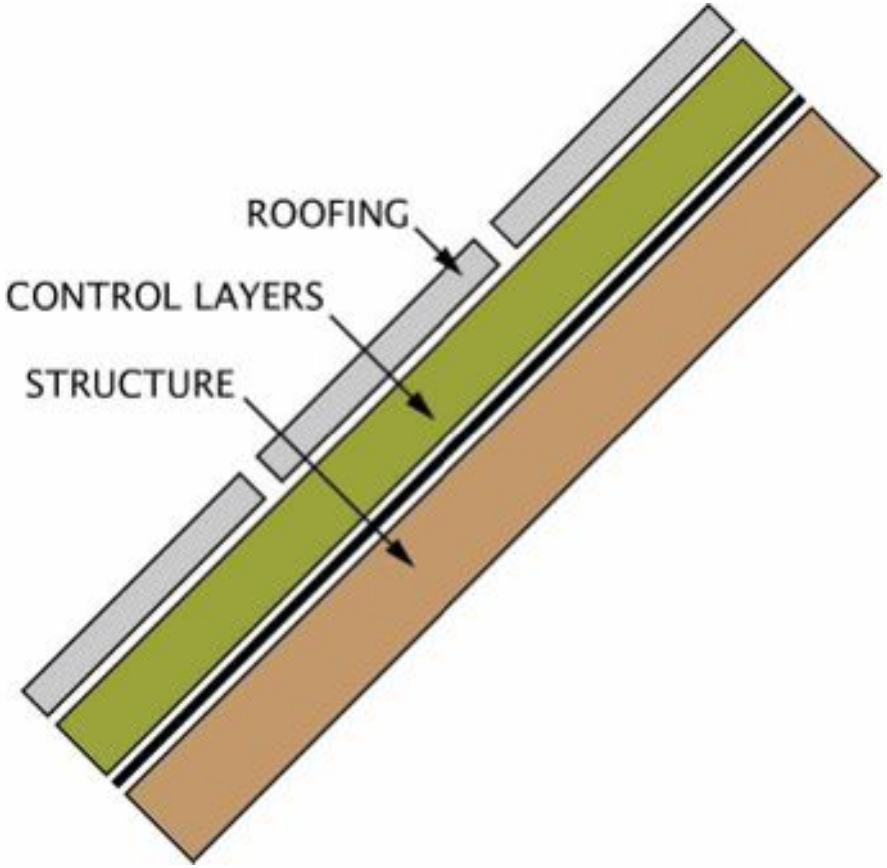
- Pavers and pedestal system (roof deck)
- Waterproof roof membrane system
- Protection board
- Rigid insulation layers
- SAM air/vapour barrier
- Roof sheathing
- Roof joists
- Interior gypsum board

INTERIOR



ROOF DECK

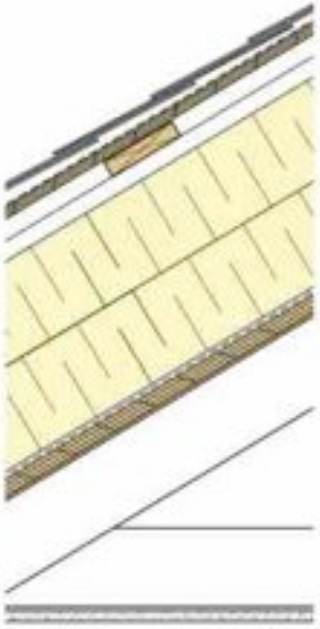
Wood-Frame Assemblies – 'Perfect' Roof



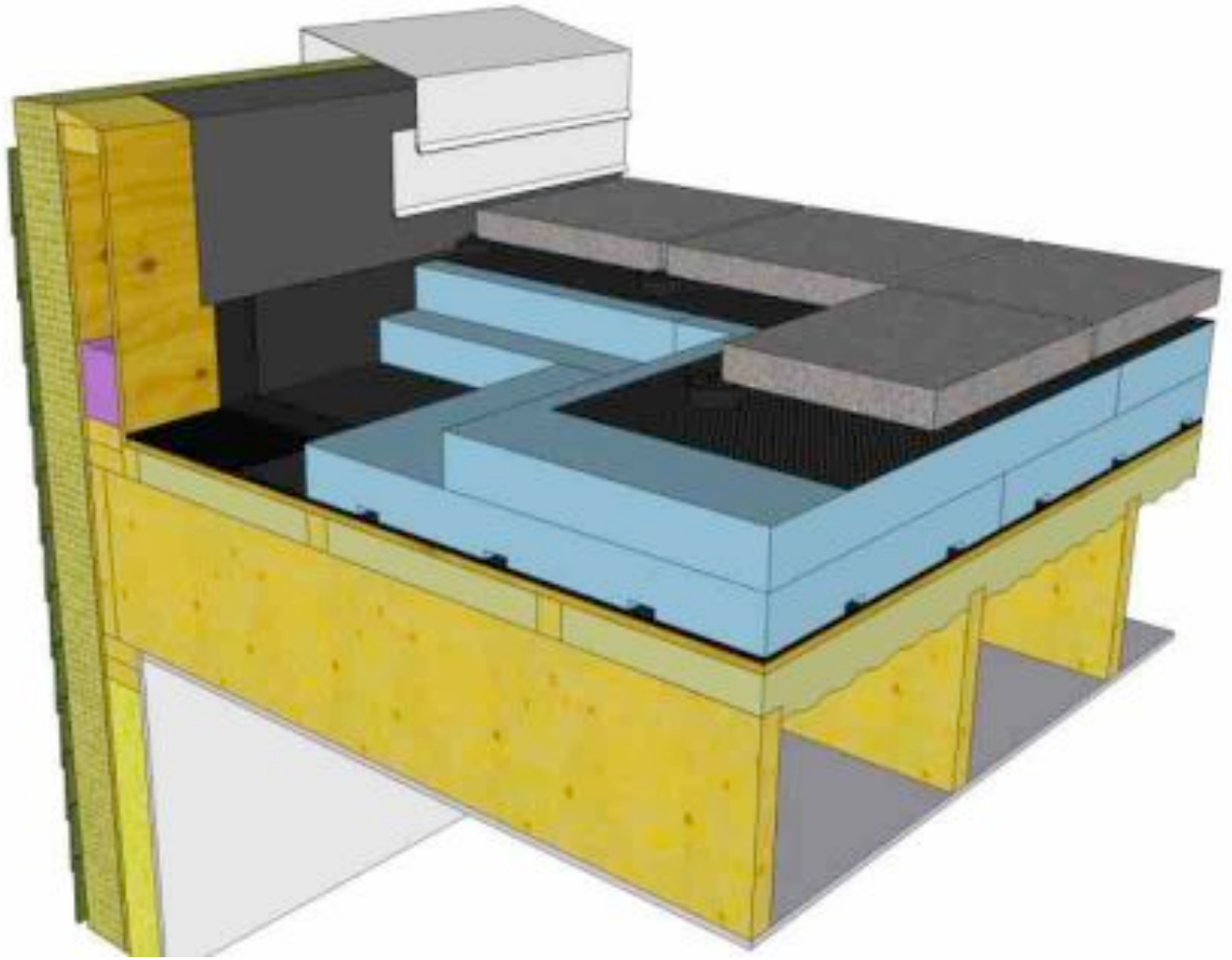
EXTERIOR

- Shingles (asphalt, concrete, clay tile, cedar, etc.)
- Underlayment
- Roof sheathing (plywood or OSB) if required for roofing support
- Horizontal and vertical wood strapping (vented airspace)
- Overhang joists at eaves
- Rigid insulation (polyiso, XPS, mineral wool)
- Self adhered membrane
- Roof sheathing
- Roof framing
- Attic (interior conditioned space)
- Interior gypsum board

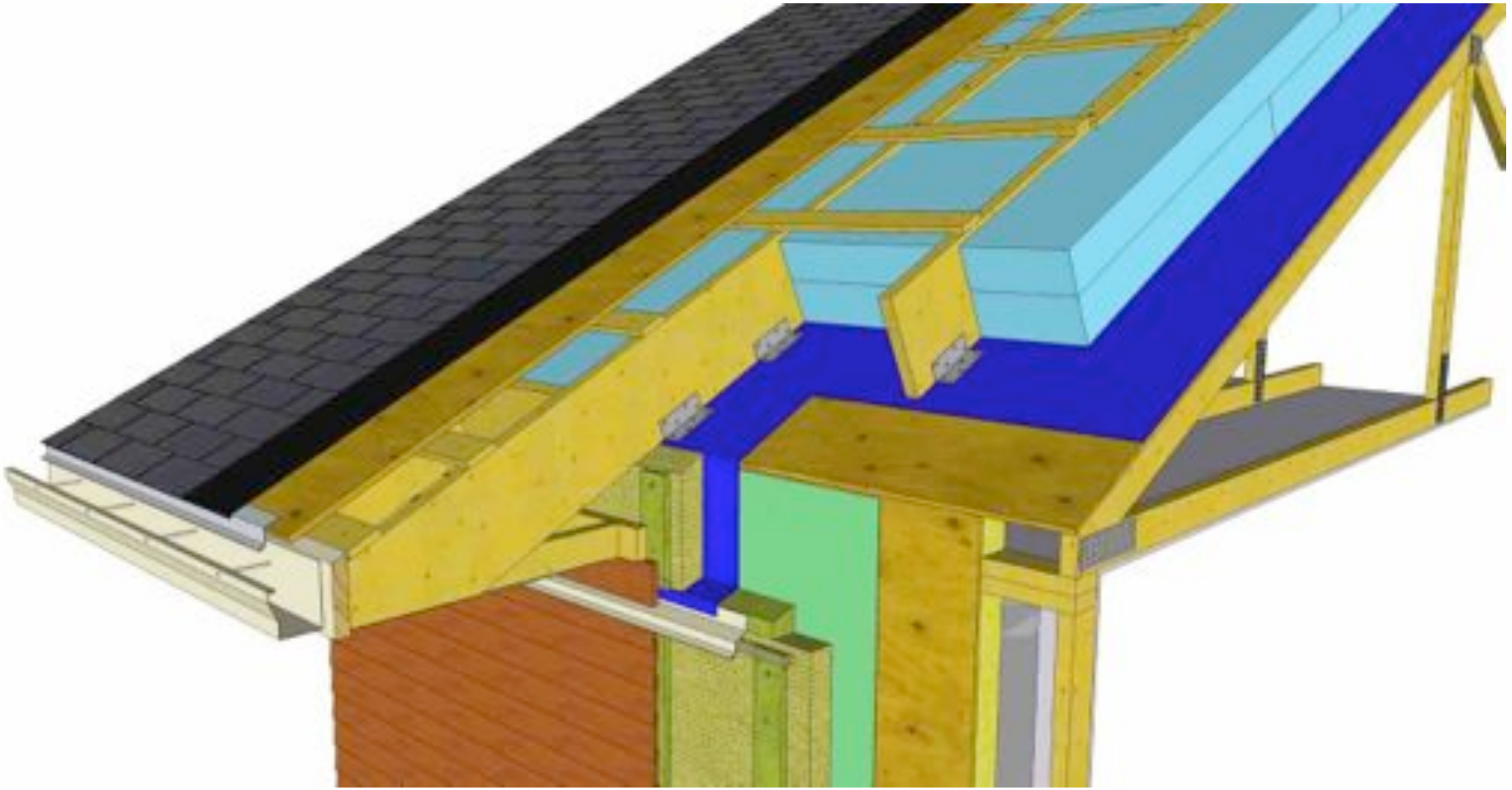
INTERIOR



Wall-to-Roof Detail



Wall-to-Roof Detail

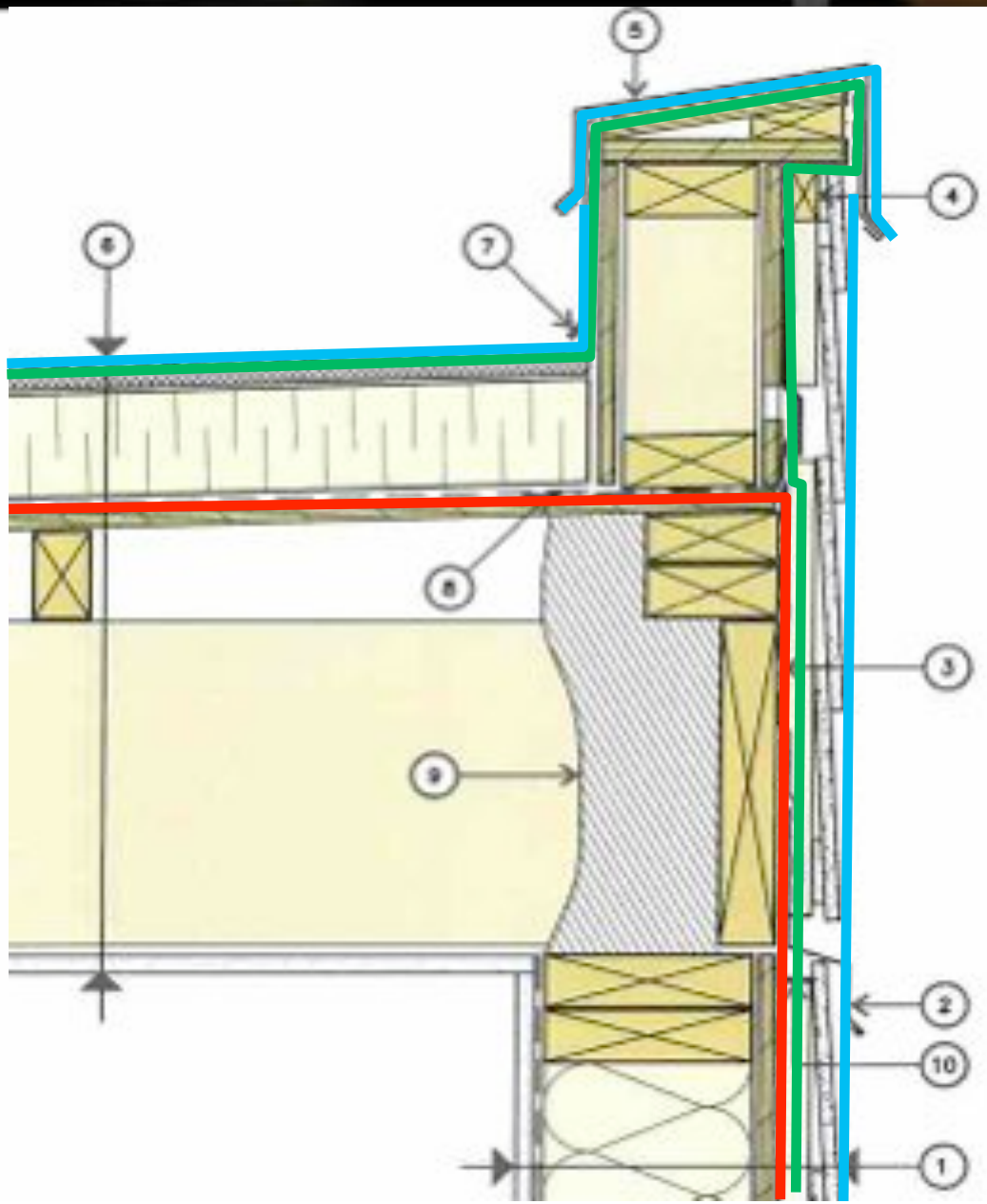


Details – Continuity of Control Layers

→ In practice, need to evaluate and design assemblies and details that are not ‘perfect’

→ Continuity of control layers within and between assemblies is critical

→ Hygrothermal analysis



Details – Continuity of Control Layers

A

B

C

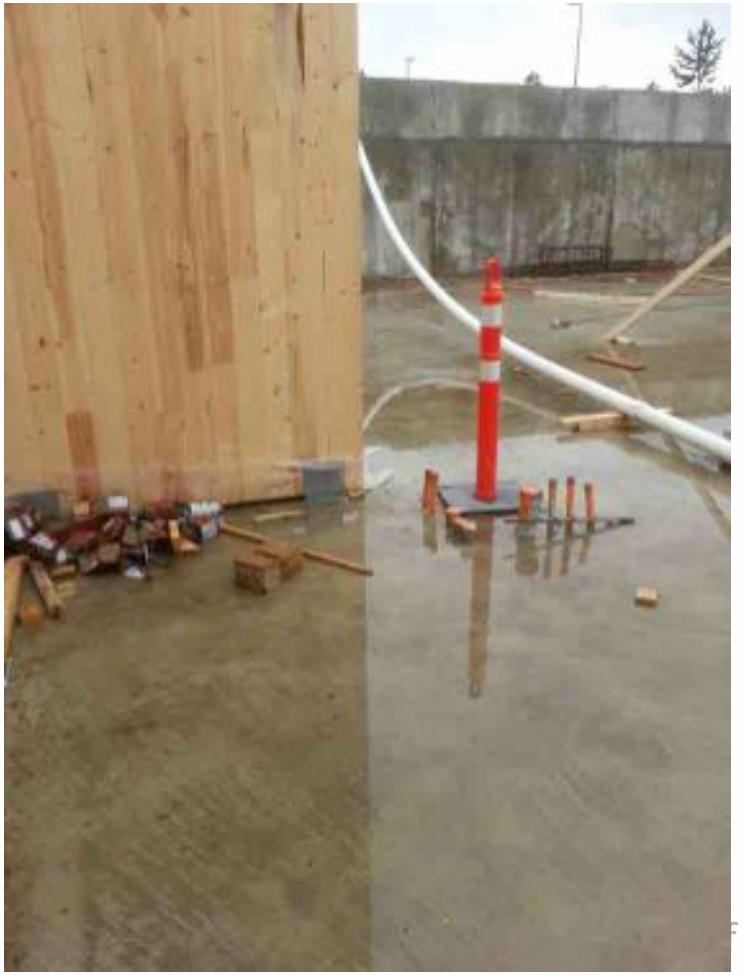
1. Window
2. Window sill flashing
3. Wood trim
4. Cementitious siding
5. Self-adhesive membrane at window sill
6. Sealant
7. Flashing end dam

Heavy Timber & Case Studies

Cross Laminated Timber – Ronald McDonald House

CLT – Construction Moisture

→ Keep it dry during construction – as best as possible



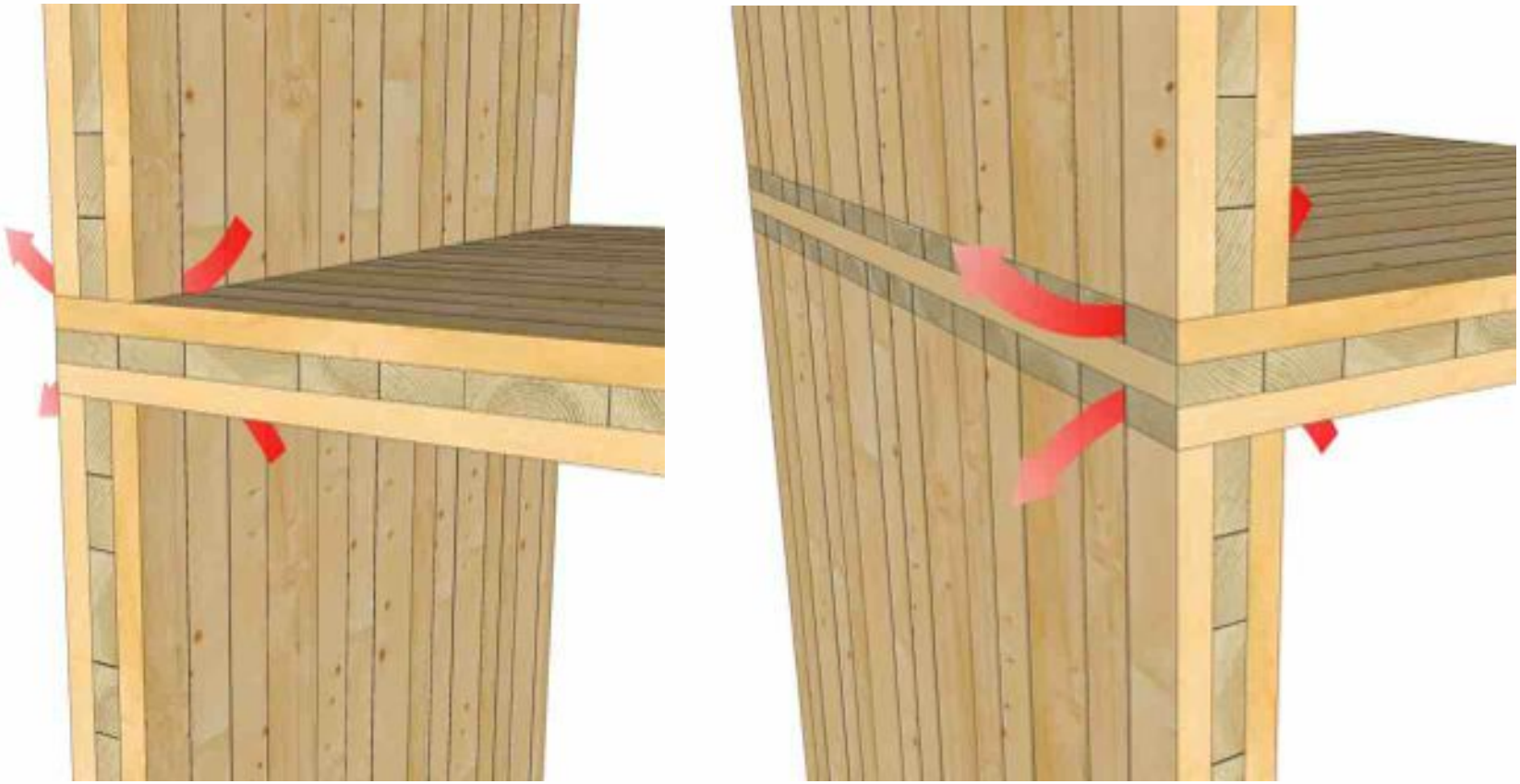
CLT – Air Barrier Considerations

→ Structural connections can interfere with air-barrier membrane installation/sequencing and sharp parts can damage materials (applied before or after)

CLT – Wall Assemblies

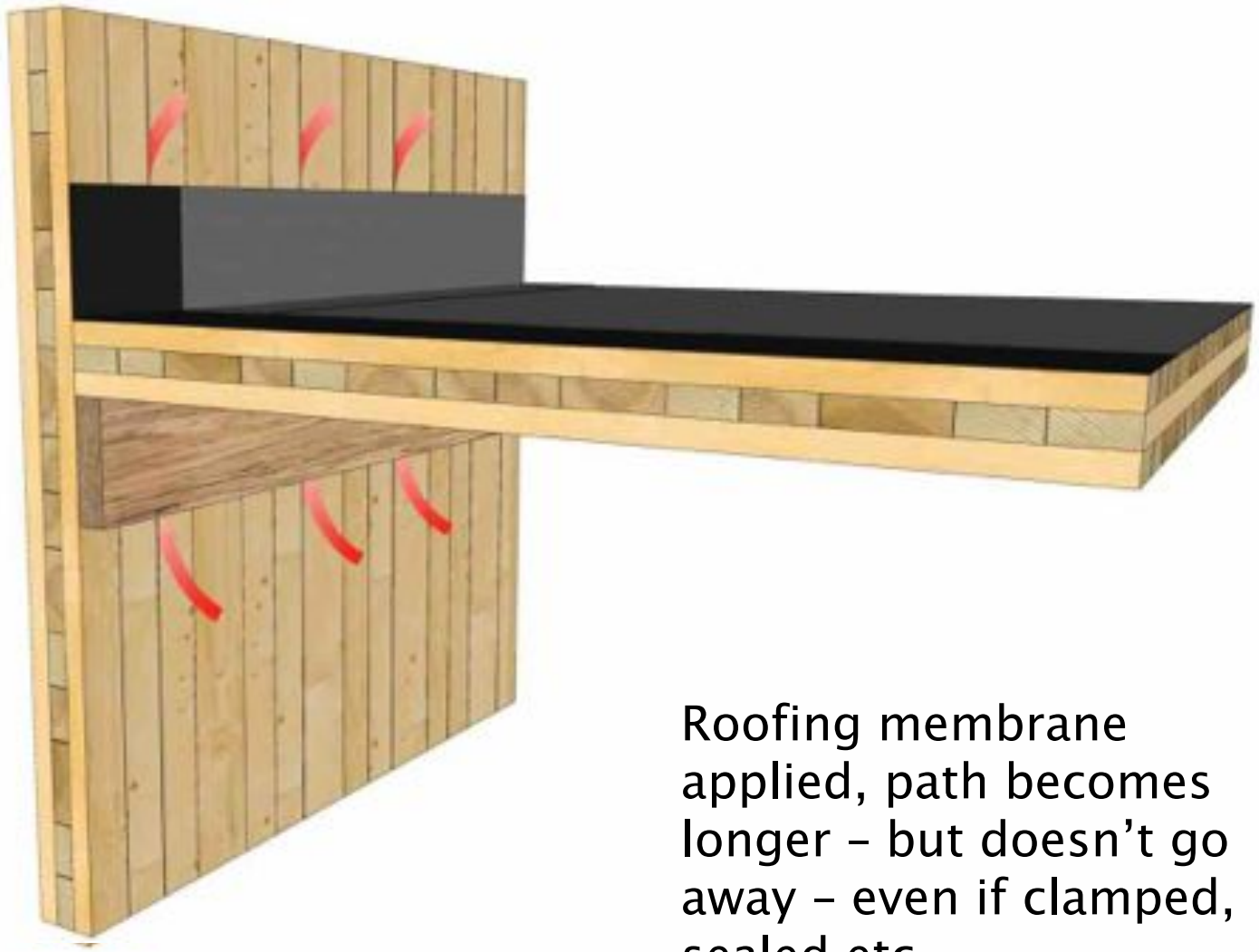
CLT – Unique Details for Consideration

CLT Panel Details Requiring Attention



Sealants, tapes, & membranes applied on either side can't address this type of airflow path through the CLT lumber gaps

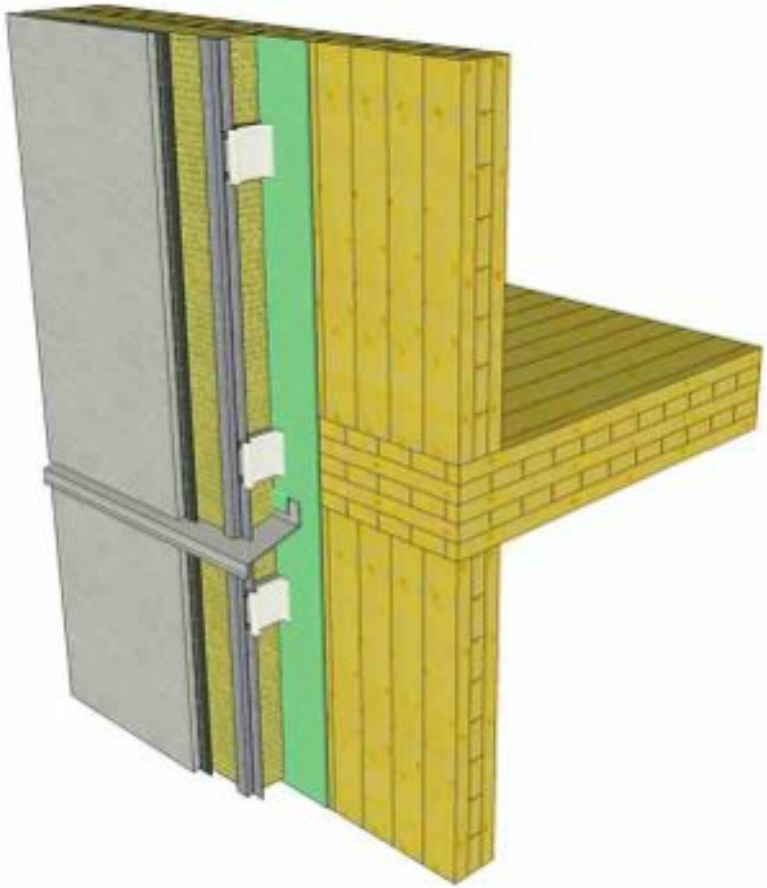
CLT Panel Details Requiring Attention - Parapets



Roofing membrane applied, path becomes longer – but doesn't go away – even if clamped, sealed etc.

Guidance for CLT Assembly Air Barriers

- → CLT panels air-tight as a material, but not as a system
- → Recommend use of **self-adhered** sheet product air barrier membranes or thick liquid applied membrane on exterior of panels *(exterior air-barrier approach)*
- → Use of loose-applied sheets (House-wraps) not generally recommended – more difficult to make airtight, perforating attachment, billowing, flanking airflow behind membrane



CLT Assembly Air Barriers

CLT Considerations

→ Get the architect to take the final photos

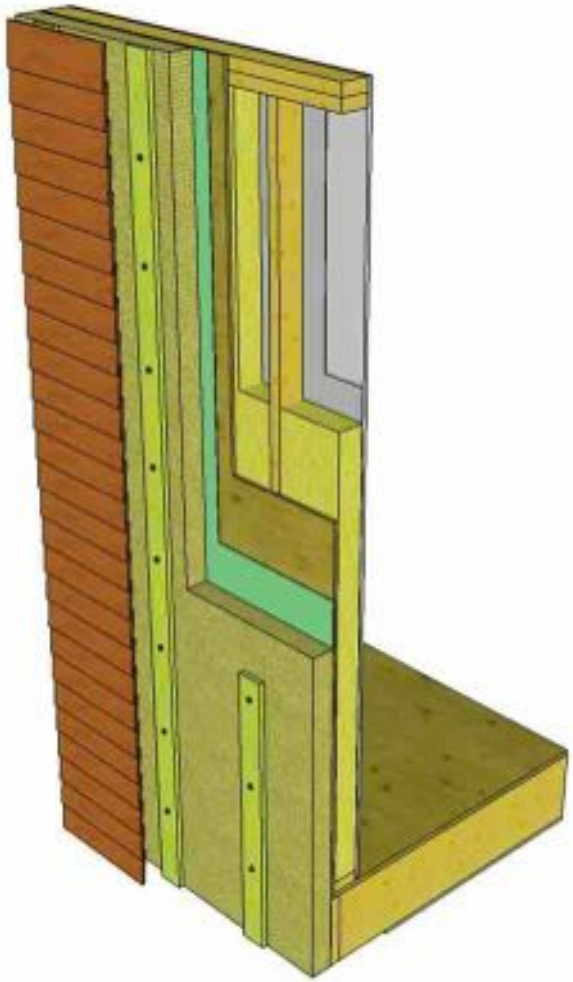
Deep Energy Retrofit

- → Single family home in Vancouver, BC
- → Moisture damage at walls and windows
- → Concealed barrier stucco cladding
- → Vented low-slope roof assembly

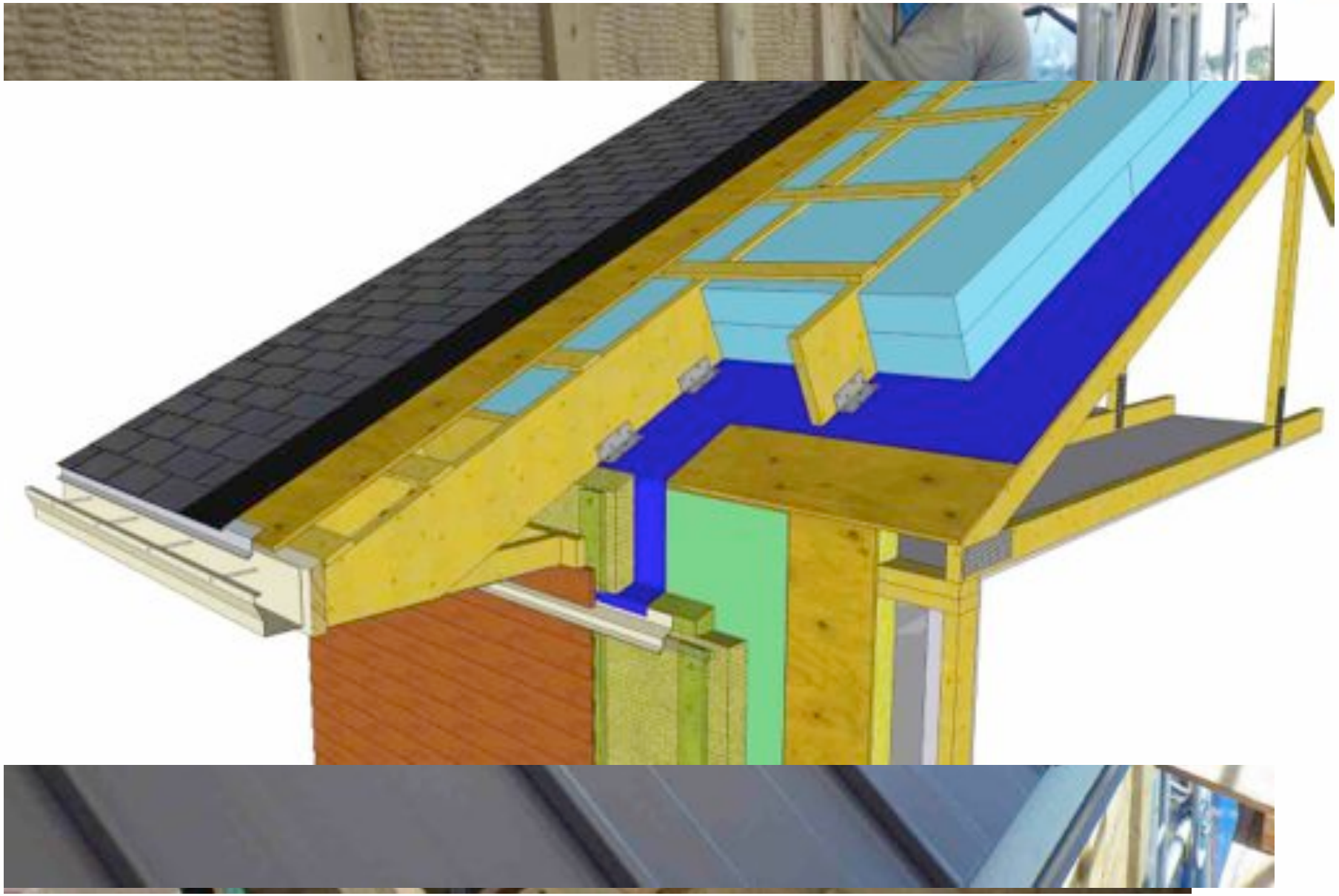
- → Energy efficient rehabilitation of wall, window, and roof assemblies

Wall Rehabilitation

New Exterior Wall Assembly



New Sloped Roof / Overhang Assembly



New Low-Slope Roof Assembly

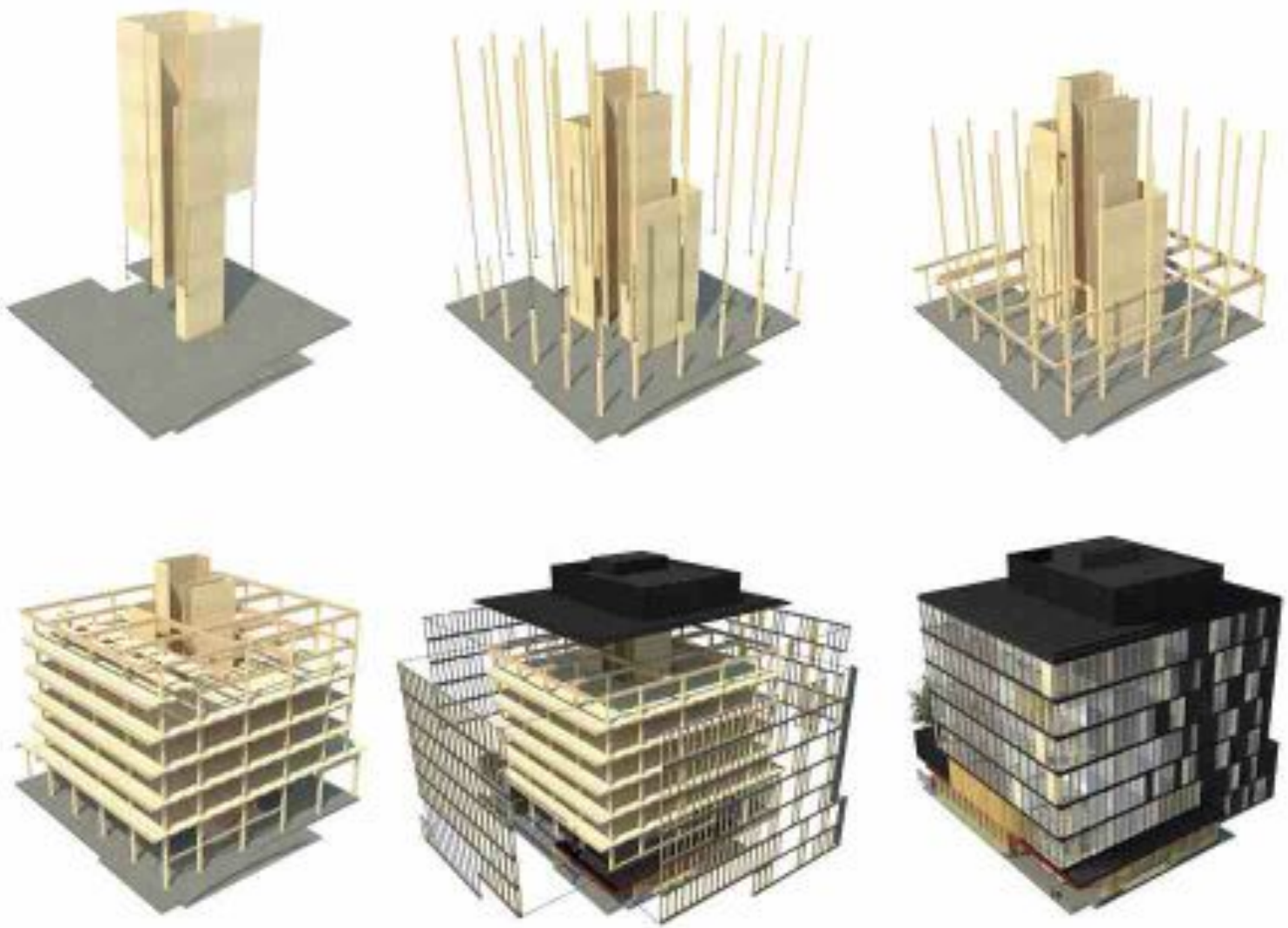
Completed Building Enclosure

Completed Building Enclosure

Wood Innovation Design Center

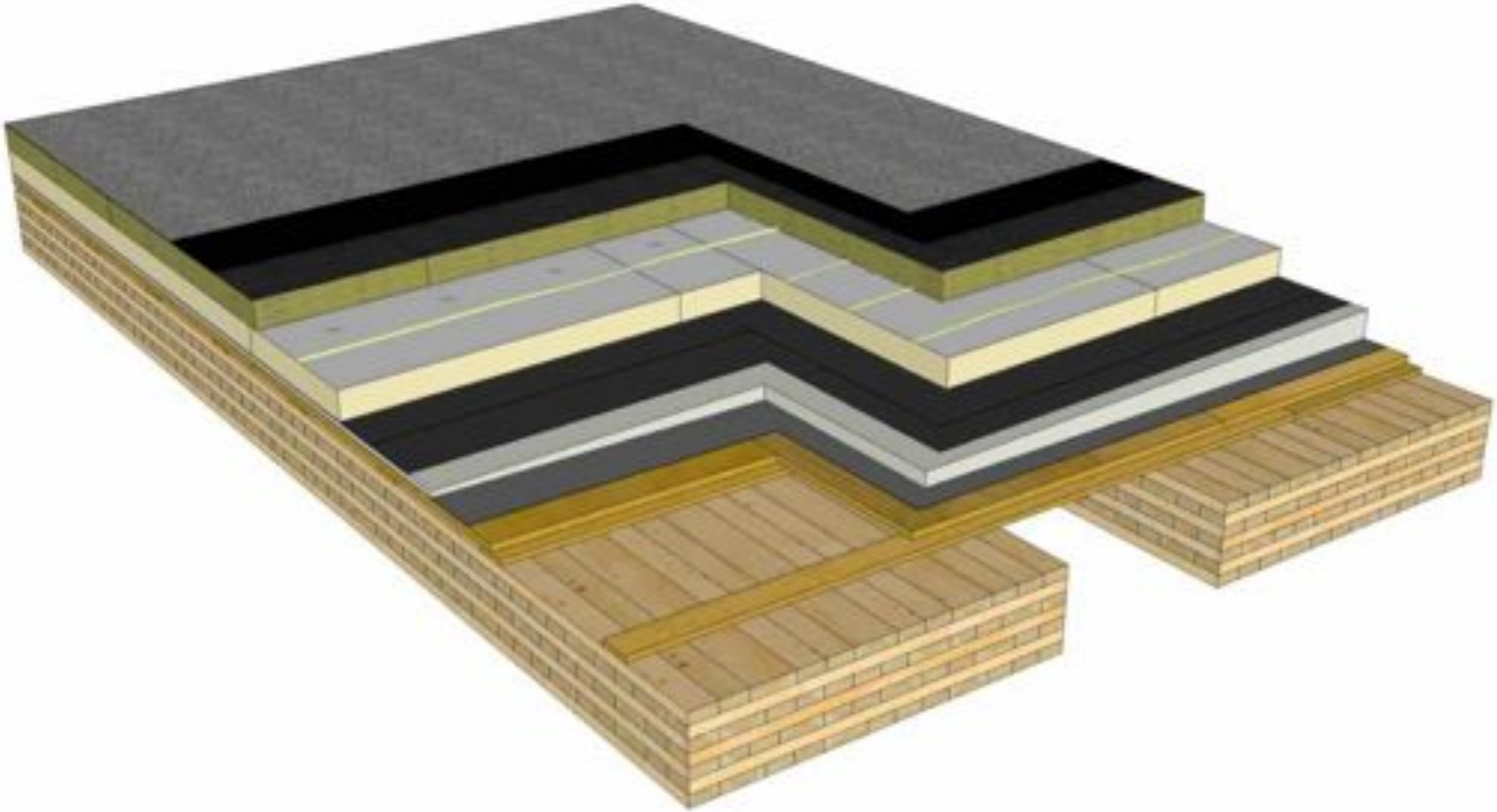
- → Tallest wood structure in North America
- → Cross Laminated Timber panel construction
- → Next project will be 18 storeys

Wood Innovation Design Center



Design & Architectural Renders: Michael Green Architecture (MGA)

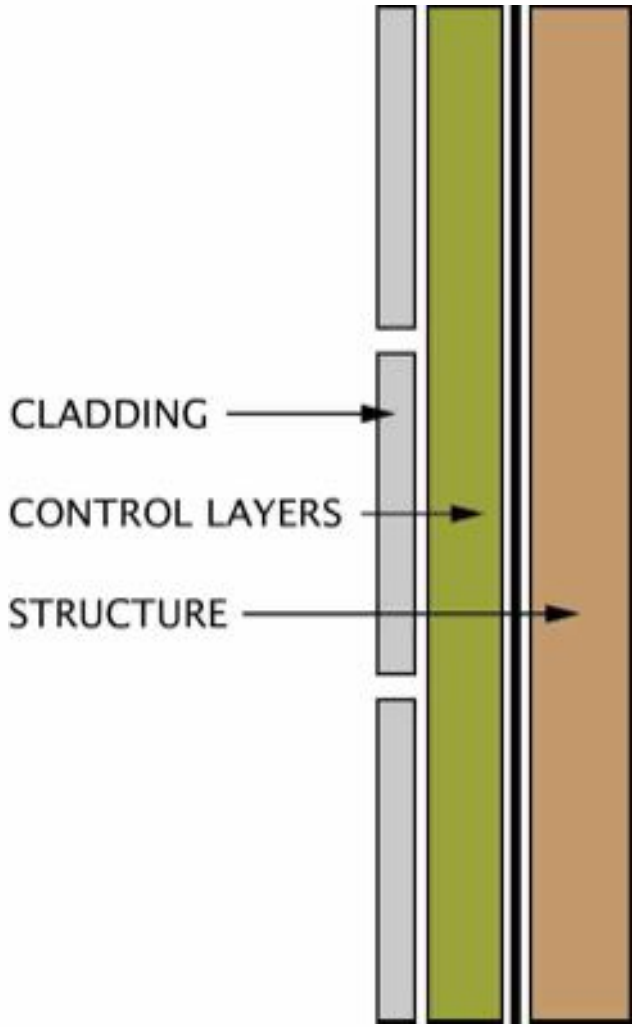
Roof Assembly



R-40+ Conventional Roof Assembly – 2 ply SBS, 4” Stonewool, 4” Polyiso, Protection board, Tapered EPS (0-8”), Torch applied Air/Vapor Barrier(Temporary Roof), ¾” Plywood, Ventilated Space (To Indoors), CLT Roof Panel Structure (Intermittent)

Summary

- → Control moisture, air, and heat
- → 'Perfect' practices:
  - → Rainscreen cladding
  - → Keep structure warm and dry
- → 'Less than perfect' practices:
  - → Analyze and understand hygothermal behaviour
- → Provide continuity of control layers within and between assemblies and details



This concludes The American Institute of Architects
Continuing Education Systems Course

Joe Piñon – jpinon@rdh.com
Colin Shane – cshane@rdh.com
Brian Hubbs – bhubbs@rdh.com
www.rdh.com

Discussion + Questions

Colin Shane – cshane@rdh.com
→ rdh.com