Advanced Detailing Techniques for Building Enclosures

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Course Description

- This presentation will provide an in-depth look at a variety of wood-frame building enclosure assemblies and details. Beginning with a review of building enclosure design fundamentals and considerations, it will then focus on best practices with references from technical guidelines and case studies. Finally, the critical detail interfaces between different enclosure assemblies (i.e., walls, roofs, balconies, windows, foundations) will be reviewed with a focus on continuity of critical barriers. A series of details and case studies will be presented for each.

Learning Objectives

- Review building enclosure design best practices for light wood-frame buildings.
- Demonstrate effective methods of controlling heat, air, and moisture movement through wood-frame assemblies.
- Discuss common details used for light wood-frame wall and roof enclosure assemblies.
- Using case studies and details from past projects, demonstrate unique considerations and best practices associated with the interfaces between adjacent enclosure assemblies

Building Enclosure Design Fundamentals

- → **Support**
  - → Structural loads
  - → Structural movements
- → **Control**
  - → Water penetration
  - → Air flow
  - → Vapor diffusion / condensation
  - → Heat flow
  - → Bugs
  - → Light and solar radiation
  - → Noise, fire, and smoke
- → **Finish**

Trends in Building Enclosure Design

→ Trend towards more energy efficiently building enclosures

→ Air barriers now required in IECC

→ Continuous insulation becoming more common

→ **More insulation = less heat flow to dry out moisture**

  → "Marginal" assemblies that worked in the past may no longer work

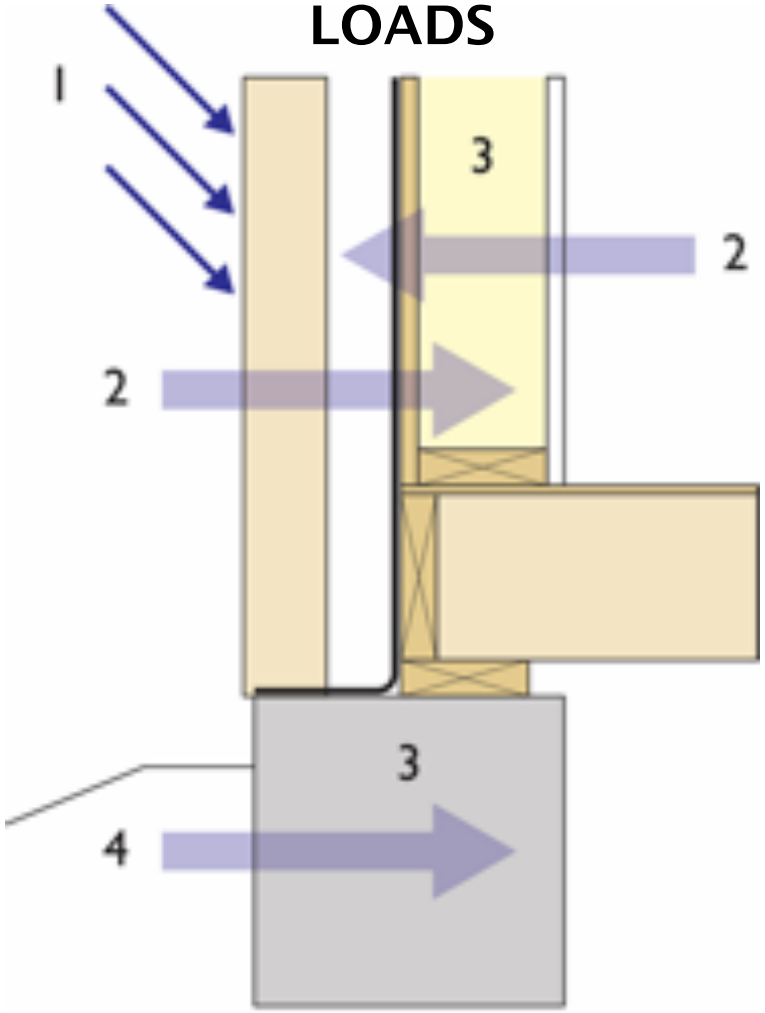
→ **Need to fully understand the science and interaction of design parameters**

The Old Way

The New Way – “Light & Tight”

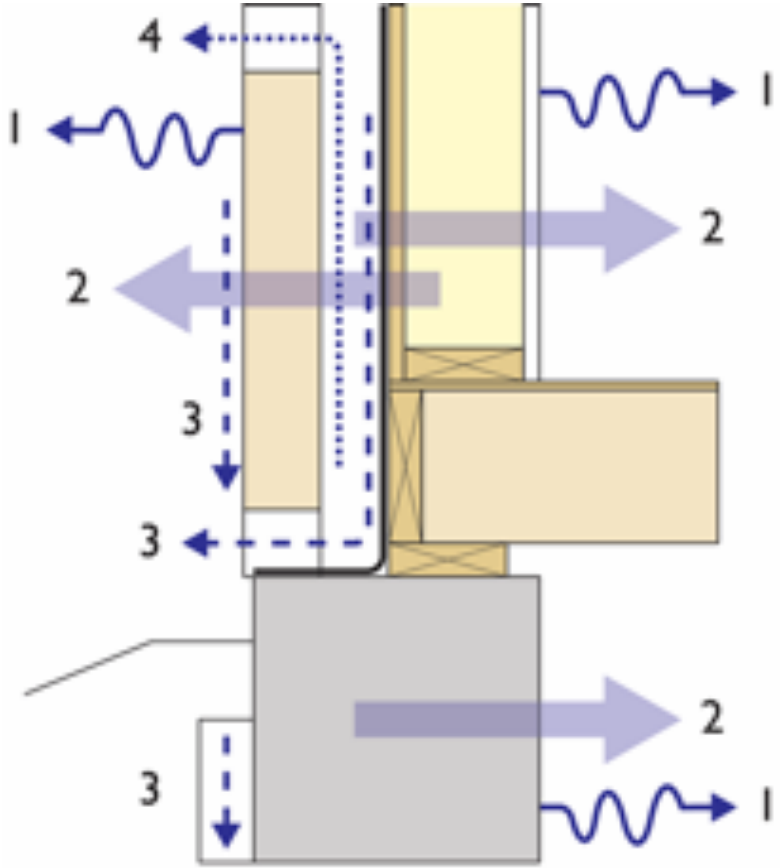
Controlling Water – The Balance

LOADS



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

RESISTANCE

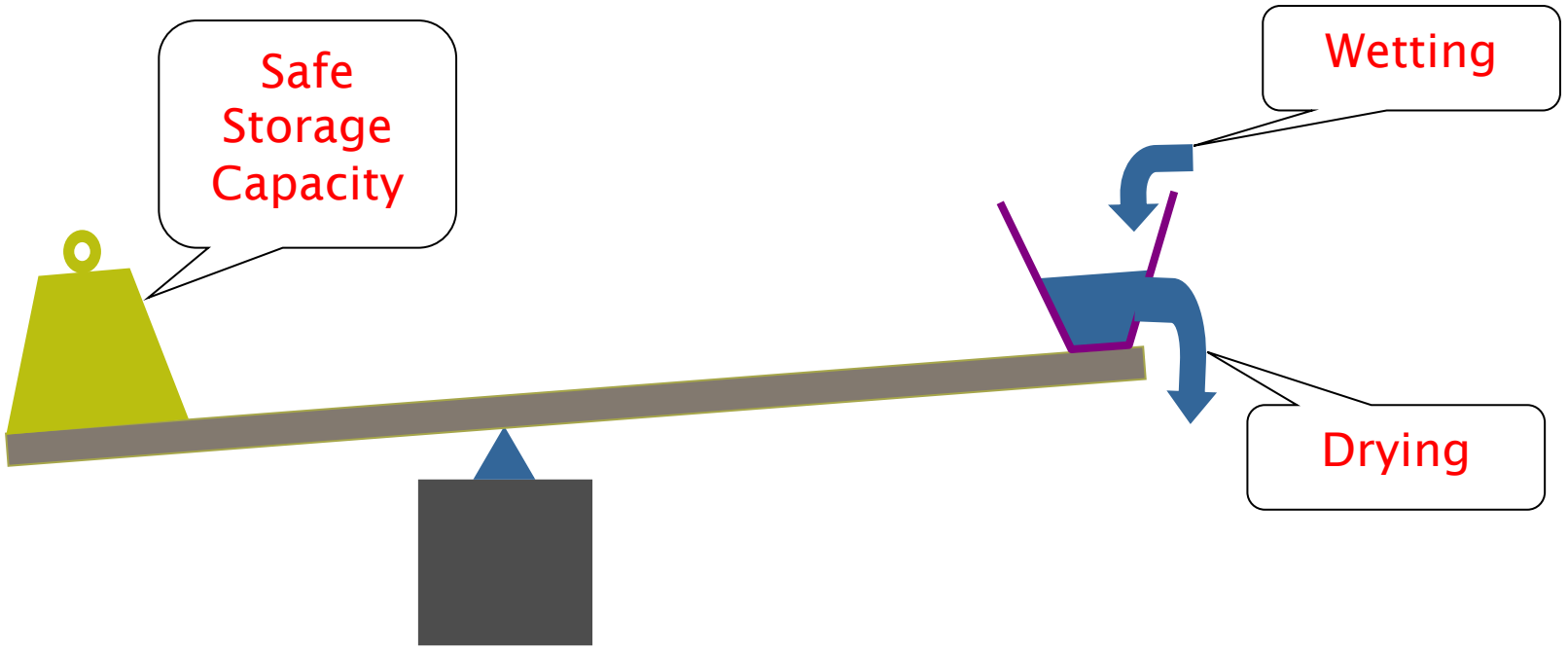


1. Evaporation of water at surfaces
2. Water vapor transport by diffusion and/or air movement (outward or inward)
3. Drainage
4. Ventilation drying by air exchange

Controlling Water – The Balance

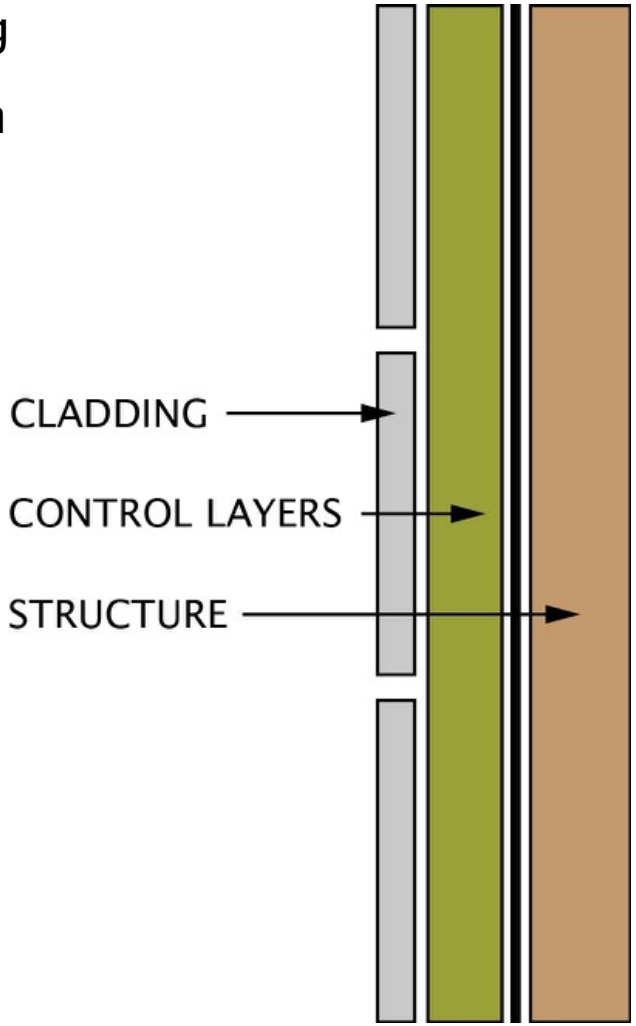
→ Wetting is ok (and inevitable)

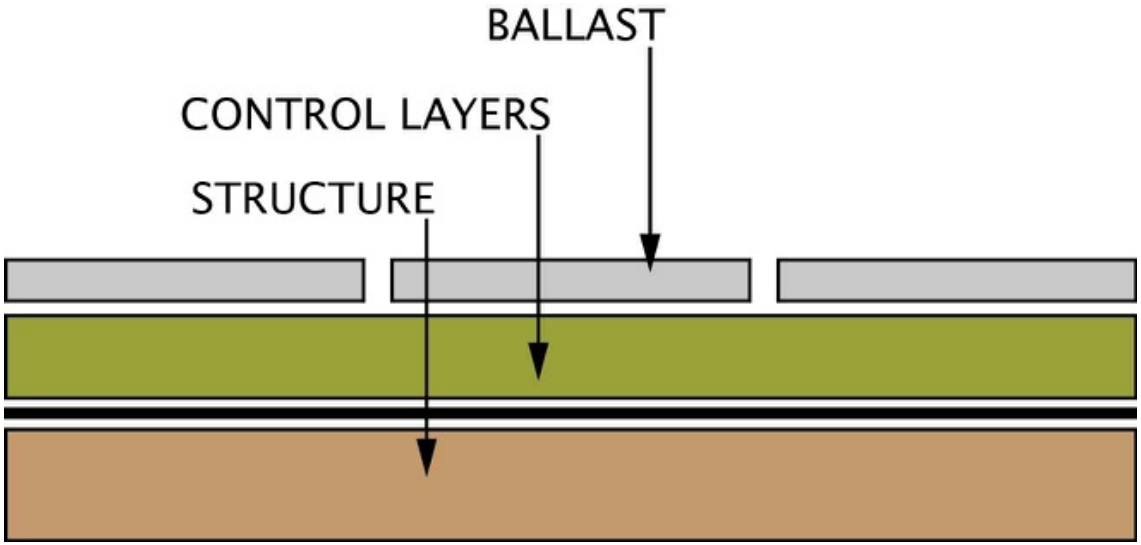
→ But not too much or for too long



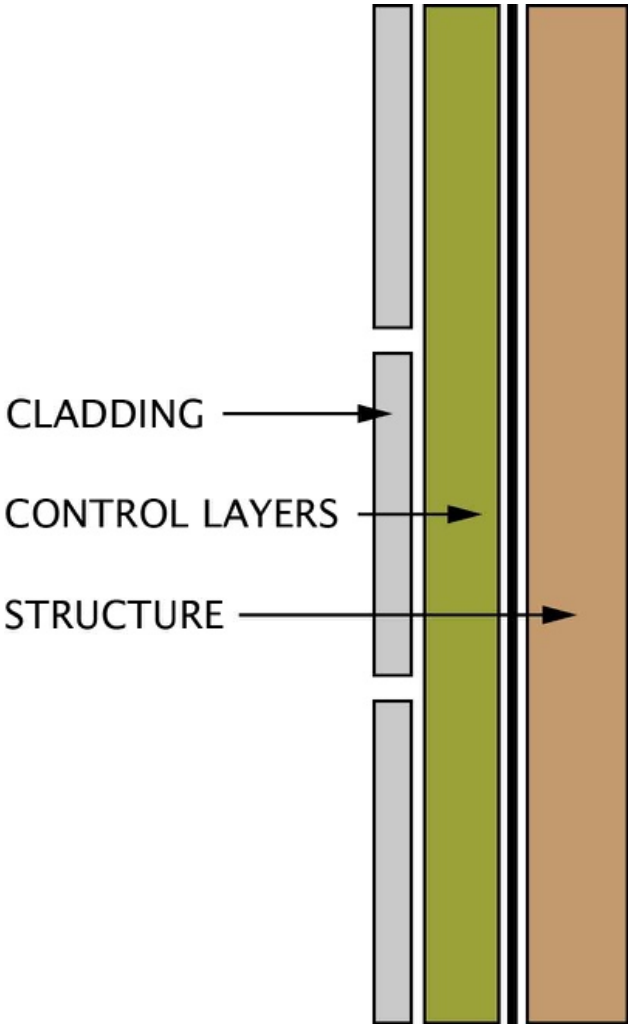
The ‘Perfect’ Assembly

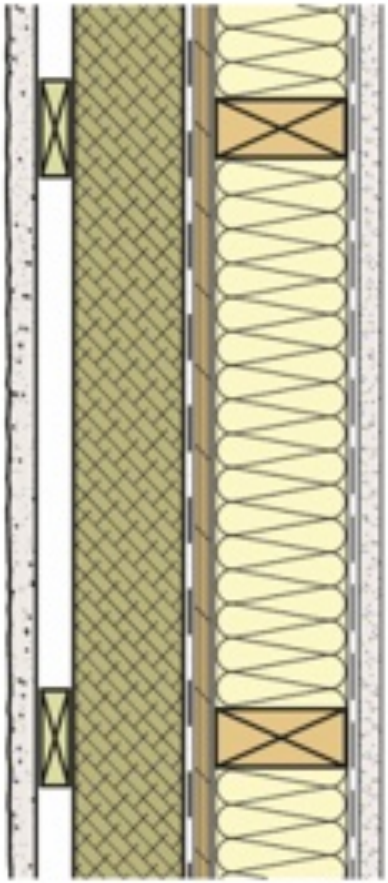
- → Rain penetration control: rainscreen cladding
- → Air leakage control: robust air barrier system
- → Heat control: continuous insulation layer
- → Locate all barriers **exterior** of structure
  - → Keep structure warm and dry
- → 50+ year old concept!





Wood-Frame Assemblies – 'Pretty Good' Wall



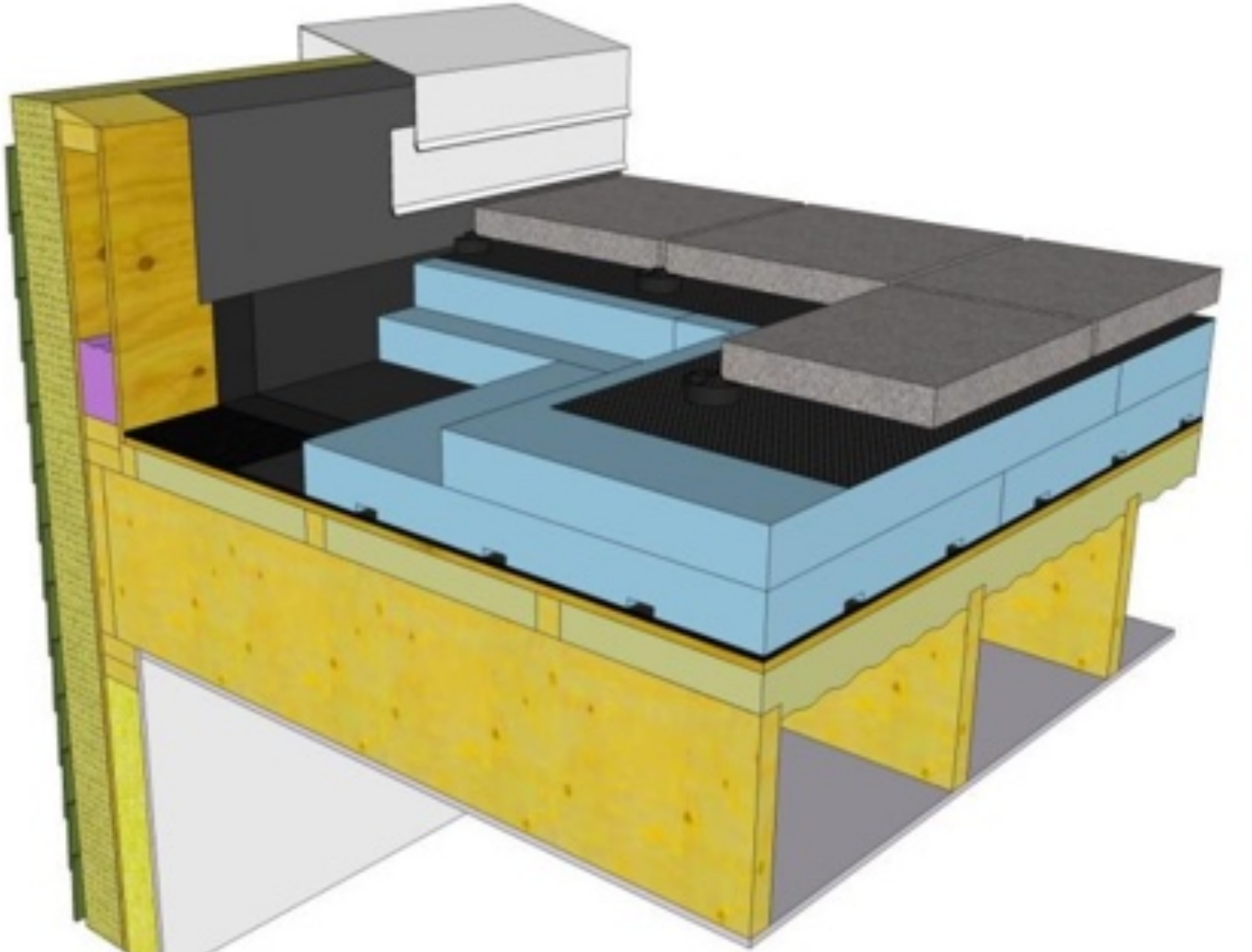


EXTERIOR

- 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

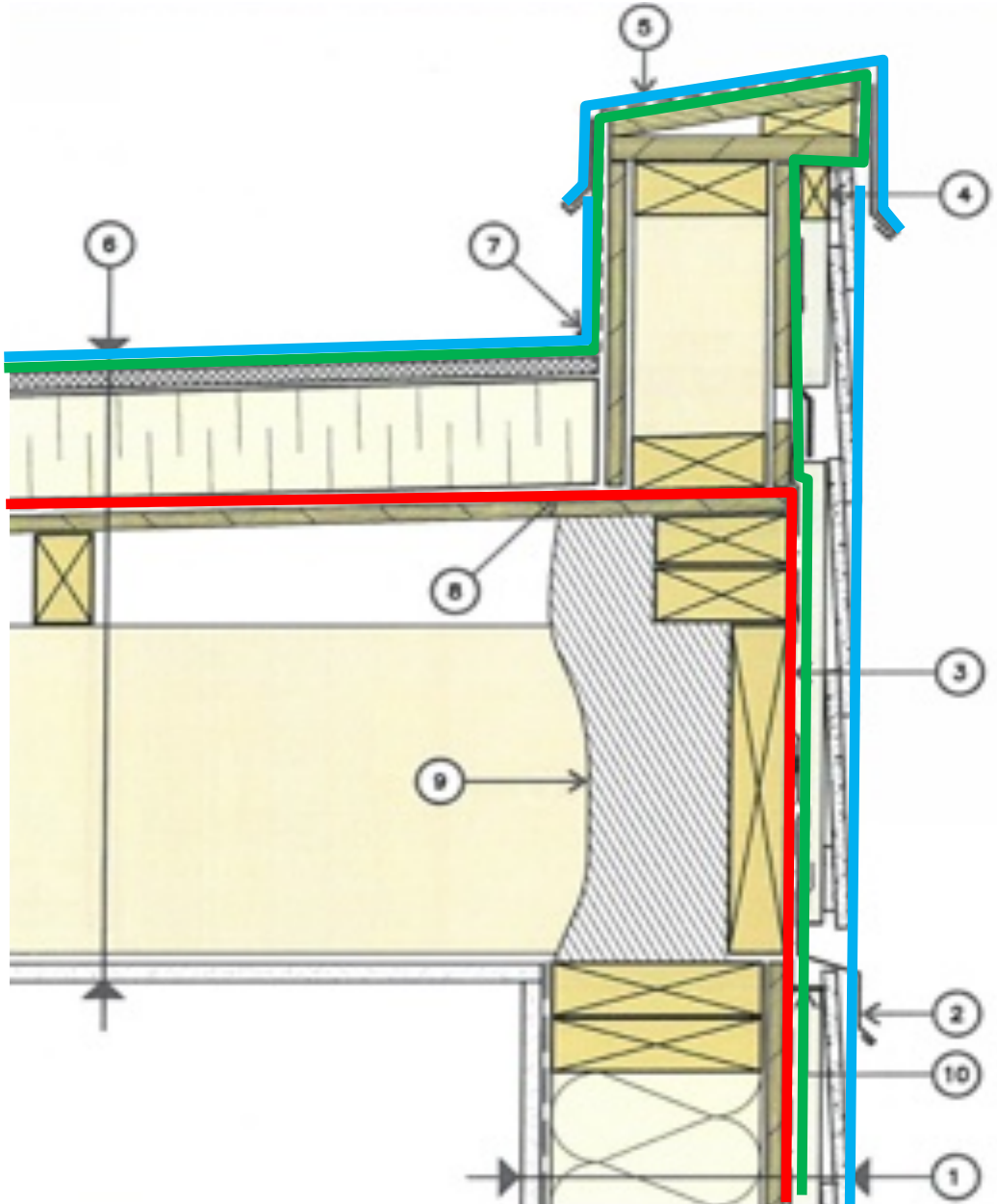
Wall-to-Roof Detail



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



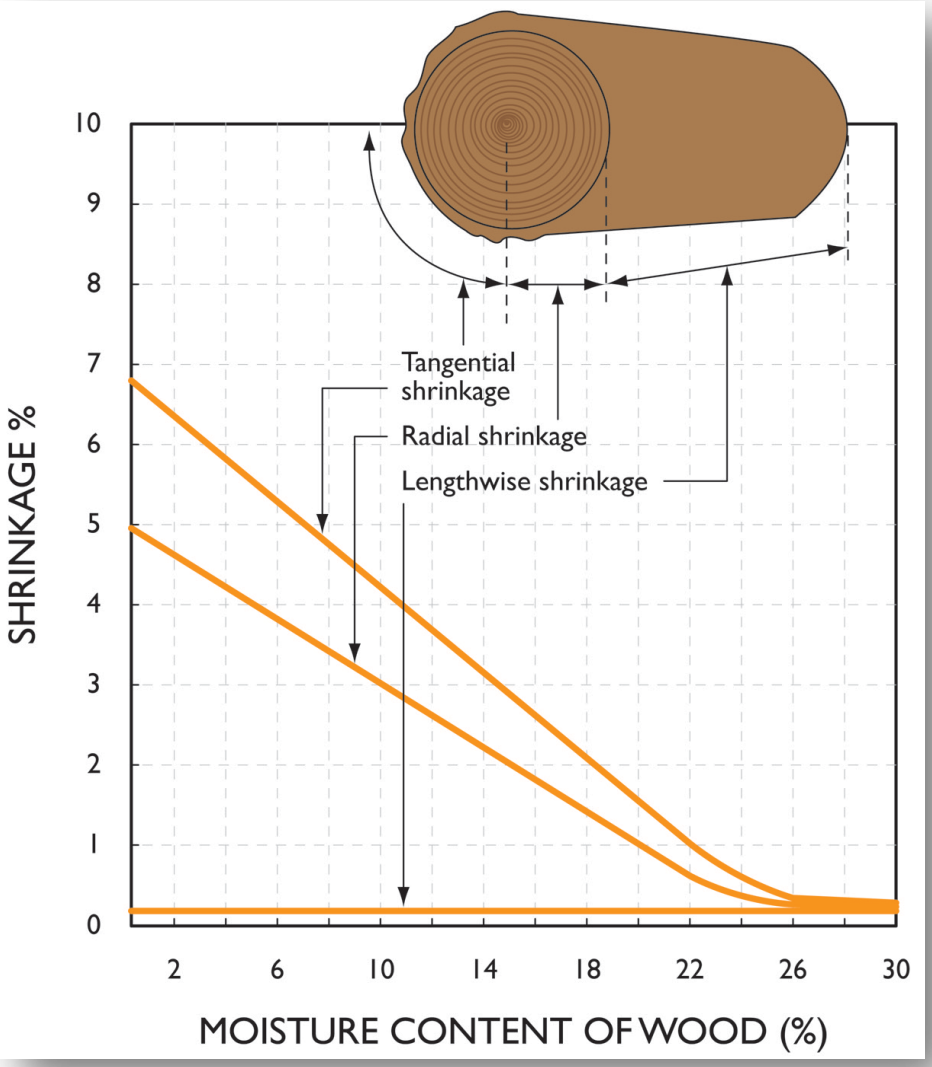

1.Frame shrinkage
2.Air tightness
3.Balcony interfaces
4.And more…

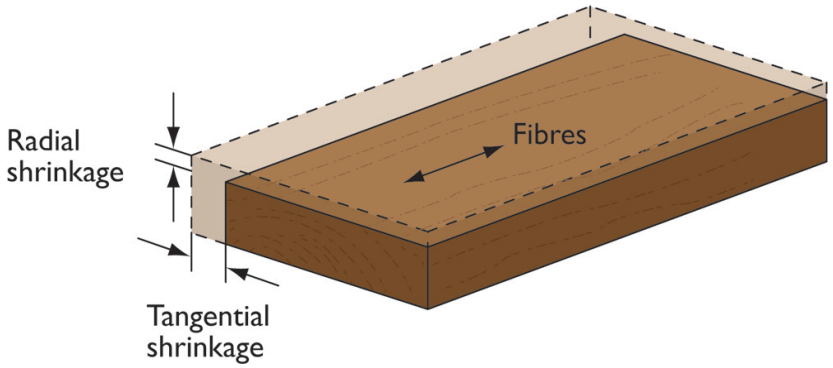
Wood-frame Building Enclosure Design Guides

- → 2019 Building Enclosure Design Guide – Wood-frame Multi-Unit Residential Buildings
  - → Emphasis on best practices, moisture and new energy codes
- → 2013 Guide for Designing Energy-Efficient Building Enclosures
  - → Focus on highly insulated wood-frame assemblies to meet current and upcoming energy codes
- → CLT Handbook

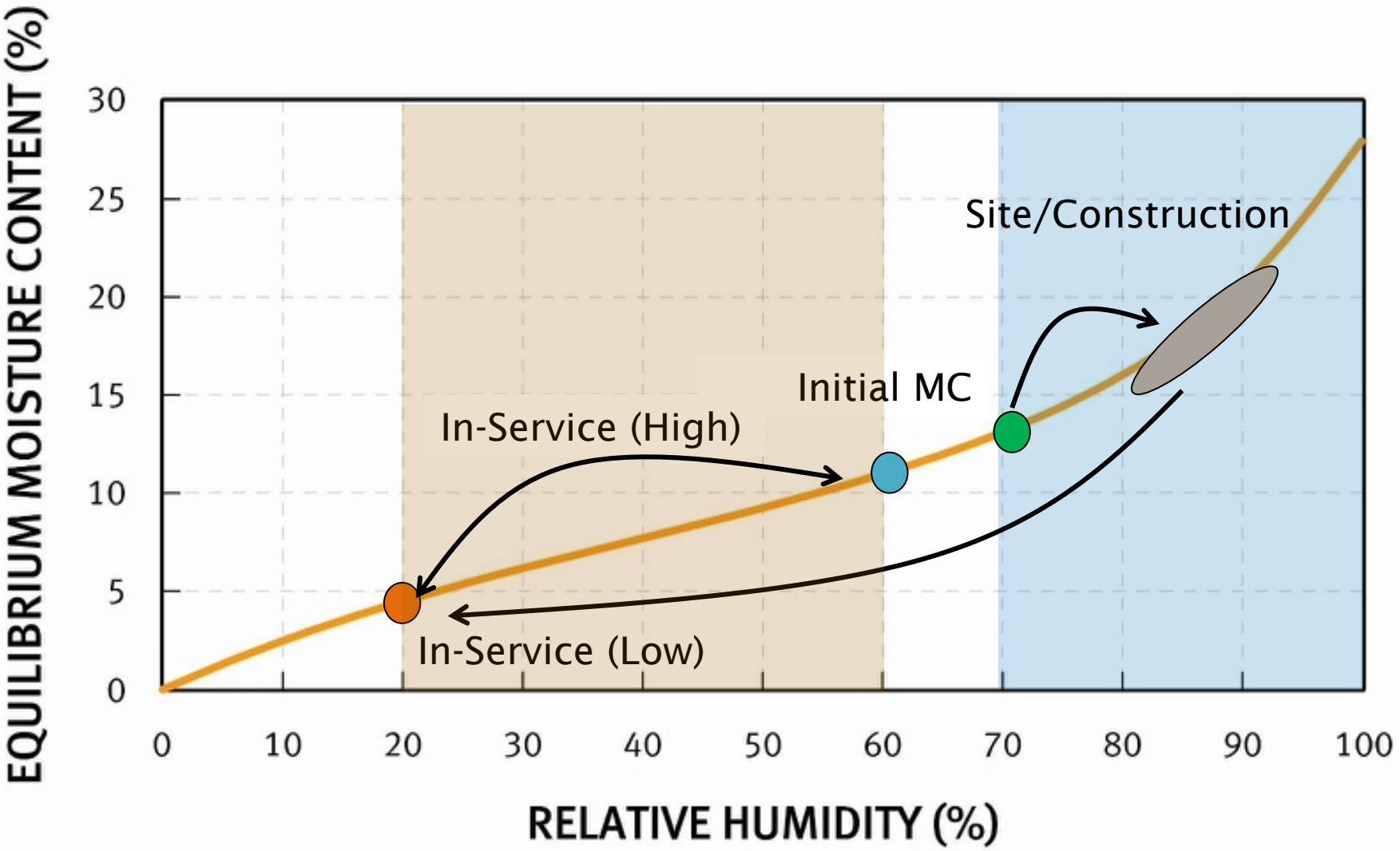
Design for Shrinkage

Behaviour of Wood in Construction





Wood Moisture Content vs Relative Humidity



Wood shrinkage is 0.20% to 0.25% in dimension per 1% change in MC

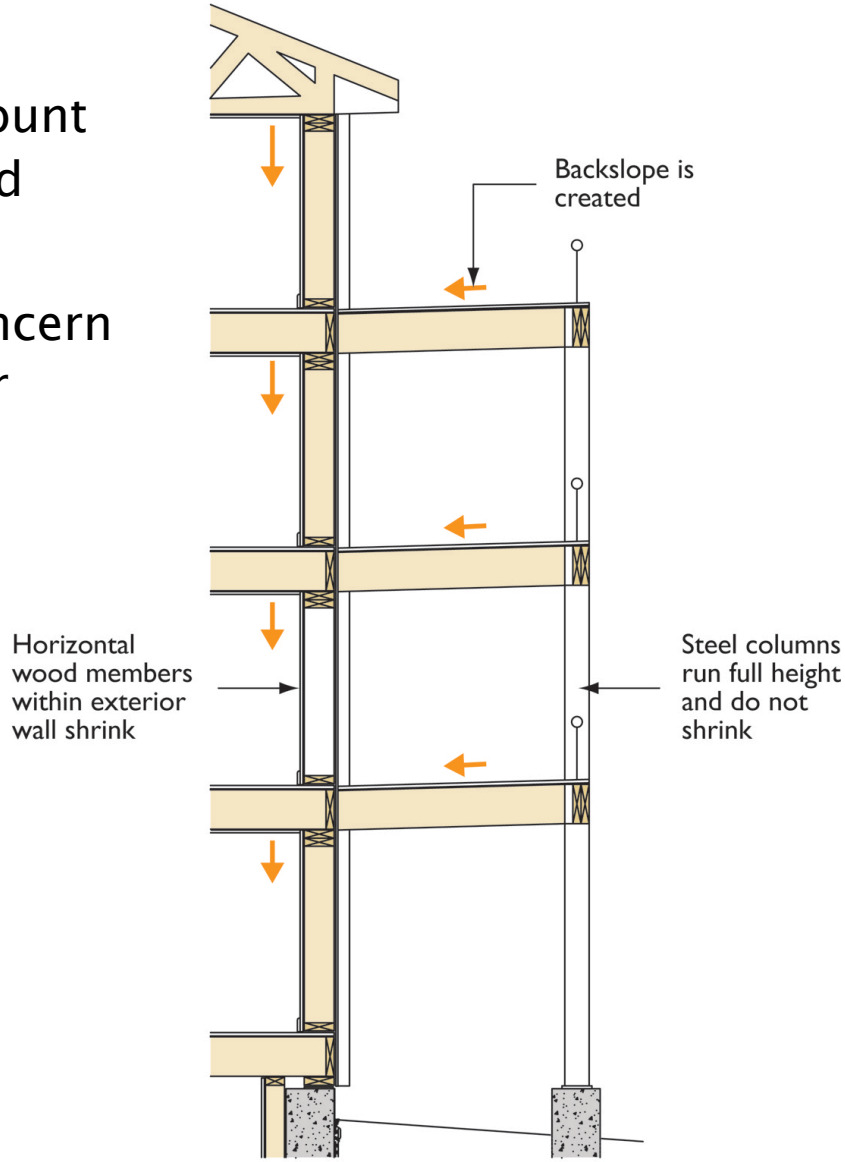
Behaviour of Wood in Construction

→ Wood-frame Shrinkage

- → Total shrinkage dependant on amount of tangential/radial grain wood and initial moisture content
- → Differential movement is a real concern when detailing, especially for taller wood-frame buildings

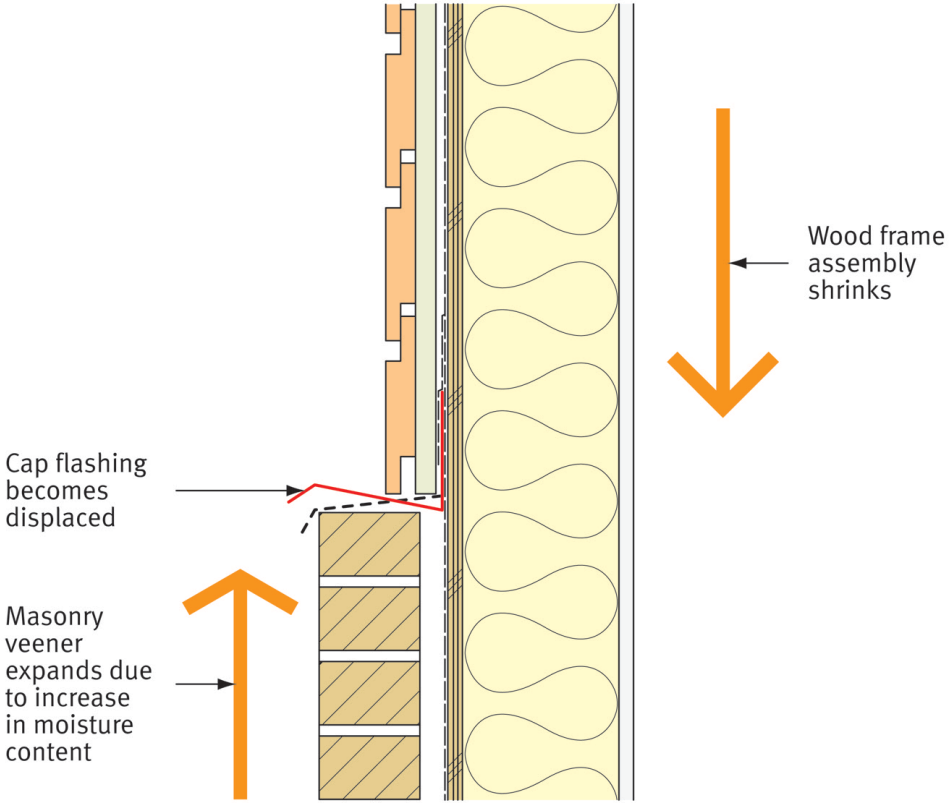
Case	Estimated Shrinkage at Eave	
	(mm)	(inches)
#1 – S-GRN joists and S-GRN plates	146	5¾"
#2 – S-DRY joists and S-DRY plates	74	3"
#3 – Dried S-DRY joists and dried S-DRY plates	46	1¾"
#4 – SCL joists and S-DRY plates	42	1⅔"

Cumulative Shrinkage for 6 storey Wood-frame Building at roof eave



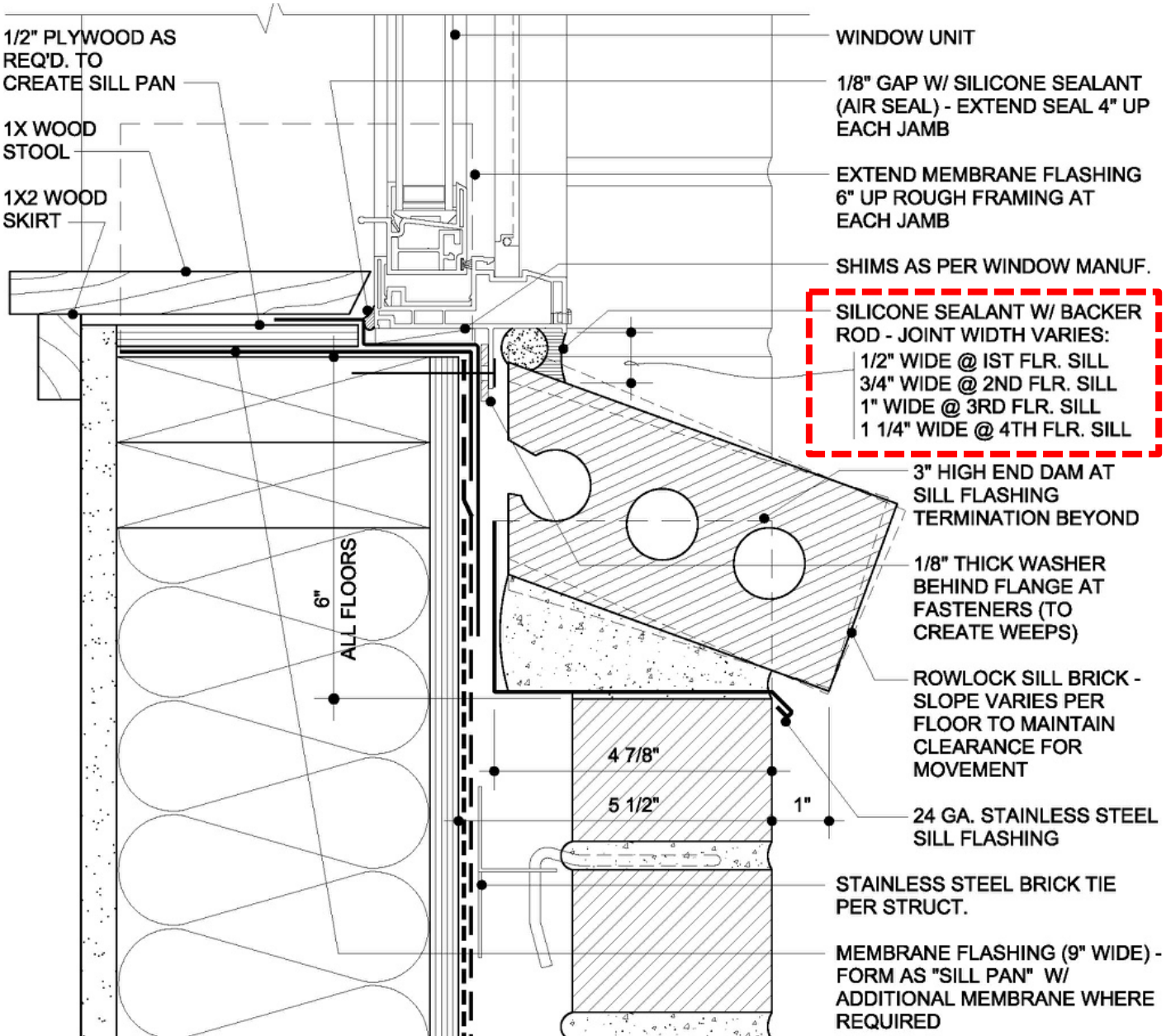
Behaviour of Wood in Construction

→ Detailing for Differential Shrinkage is Important

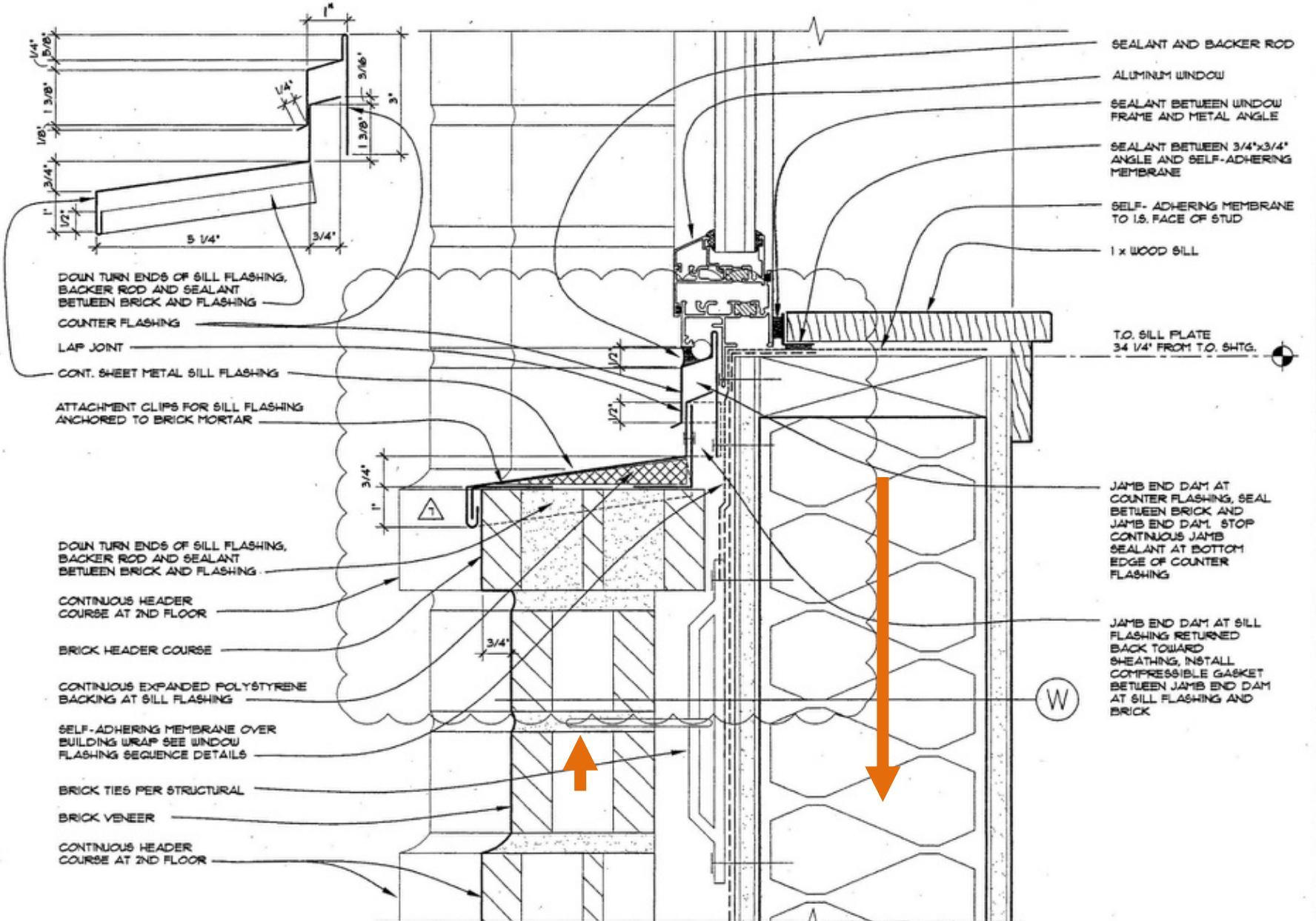


Lessons Learned from Wood-frame Shrinkage

Window Sill Detail – Sealant Joint Method



Window Sill Detail – Sliding Flashing Method



Window Sill Detail – Sliding Flashing Method

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

Air Tightness

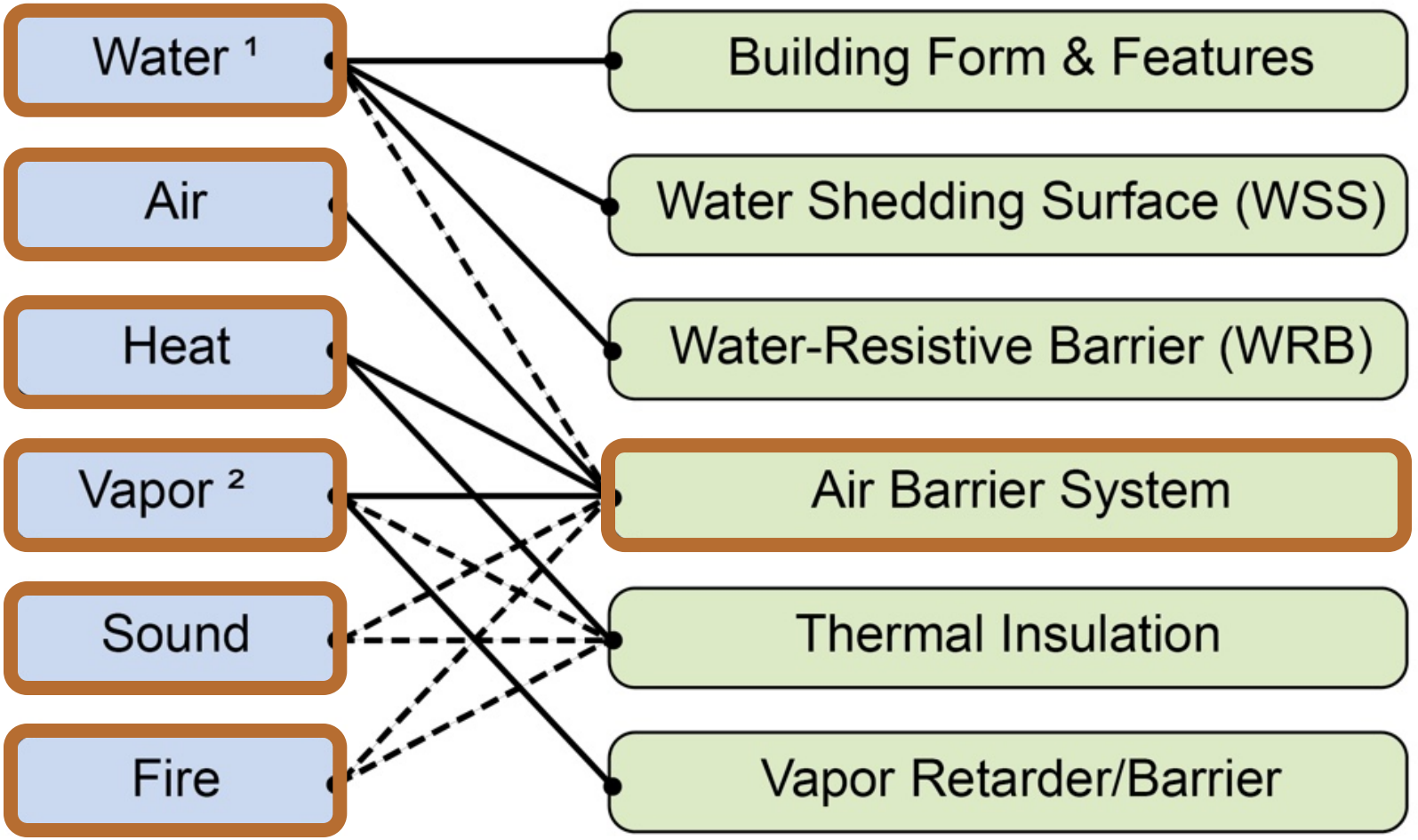
Systems and Details

Why We Care

→ Infiltration and Exfiltration Affect:

- → Code Compliance
- → Building Energy Consumption – Heat Loss and Gains ($)
- → Indoor Air Quality – Pollutants
- → Building Durability – Condensation
- → Occupant Comfort – Thermal & Acoustics

Building Enclosure Control Functions



1 – Water is defined here as precipitation (rain, snow, hail, etc.) and ground water

2 – Vapor is separately defined here as the water vapor in air, as well as condensate moisture

Air Control: Air Barrier Requirements

- → **Continuous**
  - → Primary need, common failure
- → **Strong**
  - → Designed for full wind load
- → **Durable**
  - → critical component - repair, replacement
- → **Stiff**
  - → Control billowing, pumping
- → **Air Impermeable**

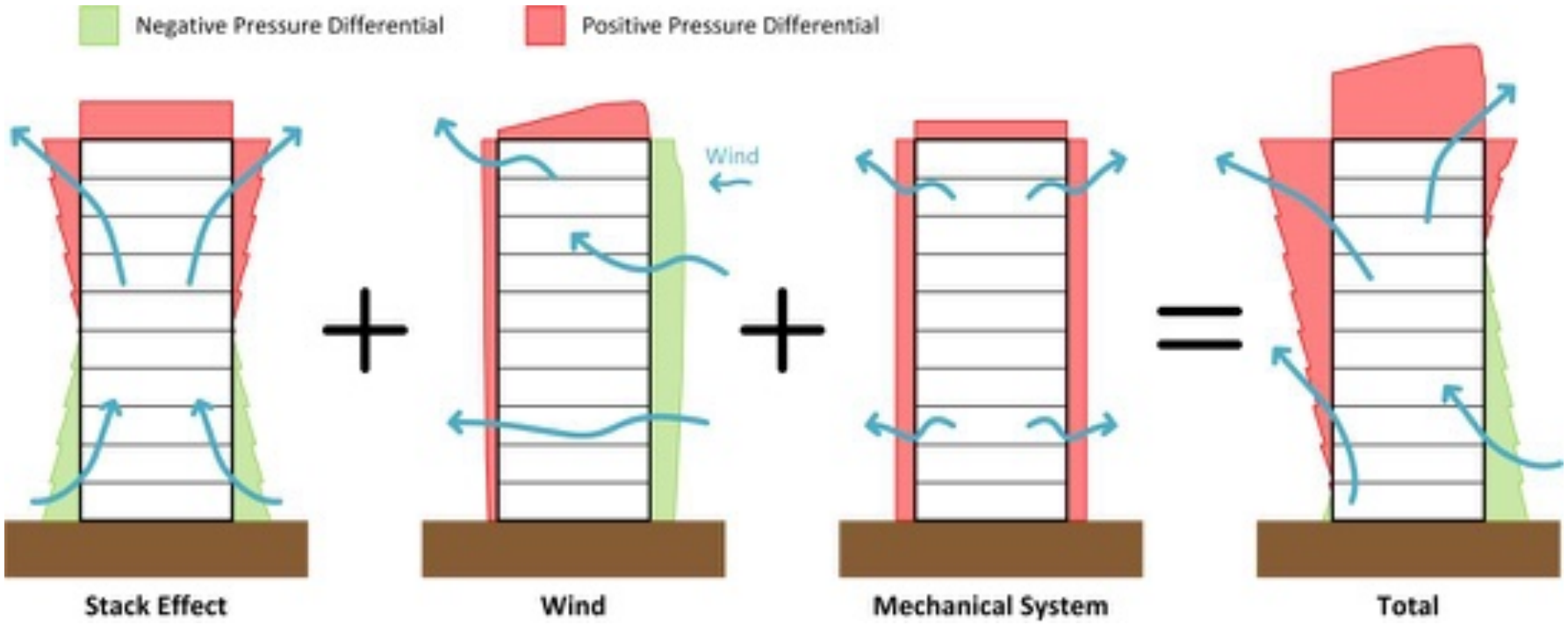
Air Barriers - Continuity

Air Barriers - Strength

→ Stack Effect

→ Wind

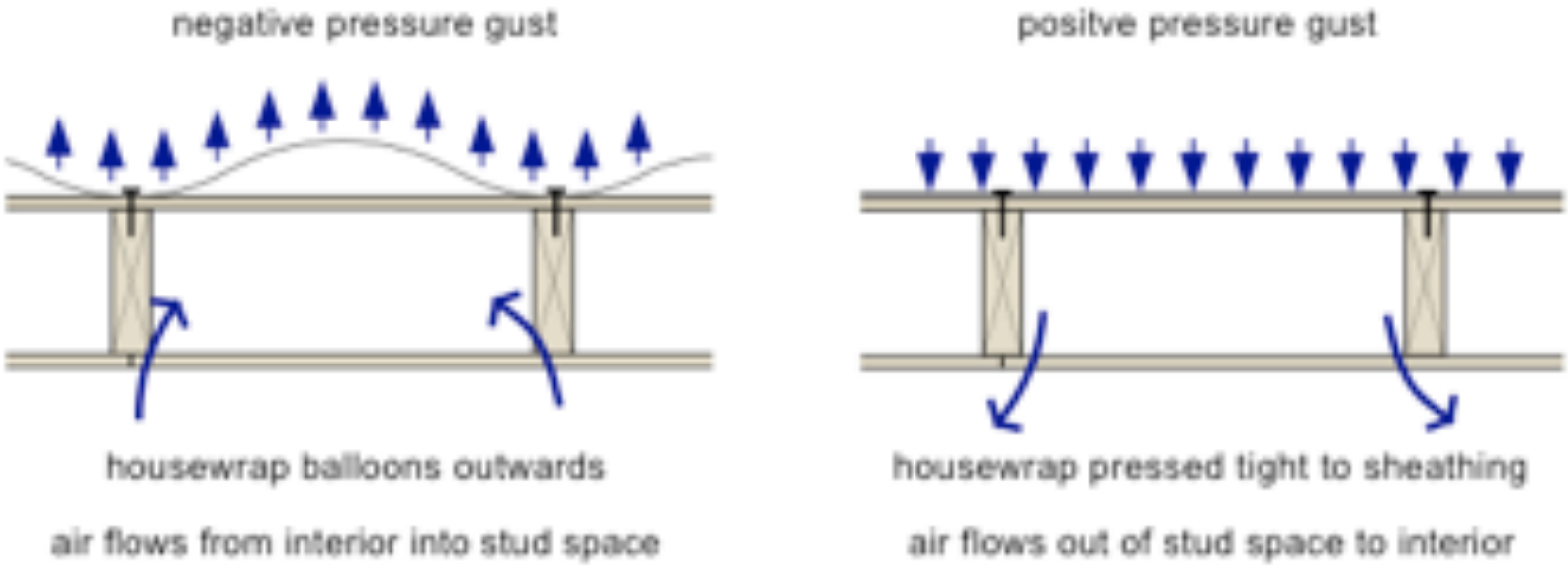
→ Mechanical Systems



Air Barriers - Stiffness

→Loose sheets commonly “stiff” under positive exterior pressures

→Air leakage often exacerbated under negative pressure



Sealed House-Wrap Details & Support Matter

Air Barriers - Impermeable

→Peanut Butter (brand unknown) – 20 mils

→0.0041 cfm/ft² @ 75 Pa – More than twice as tight as Tyvek!

BUT, IT'S THE DETAILS AND DURABILITY THAT MATTER

Many Air Barrier Systems Available

Loose Sheet Applied Membrane – Taped Joints & Strapping

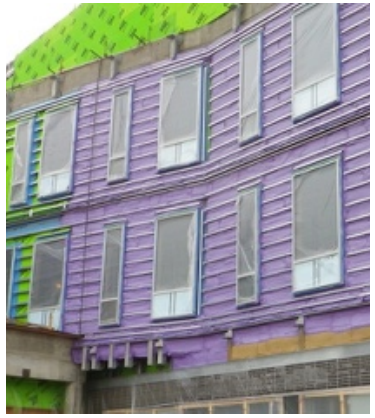
Sealed Gypsum Sheathing – Sealant Filler at Joints

Liquid Applied Sealants/Membranes

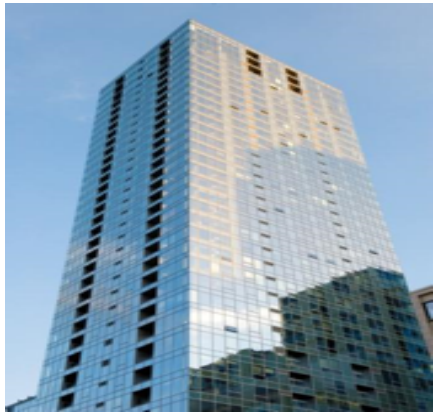
Mass Walls (concrete)

Self-Adhered vapor permeable membrane

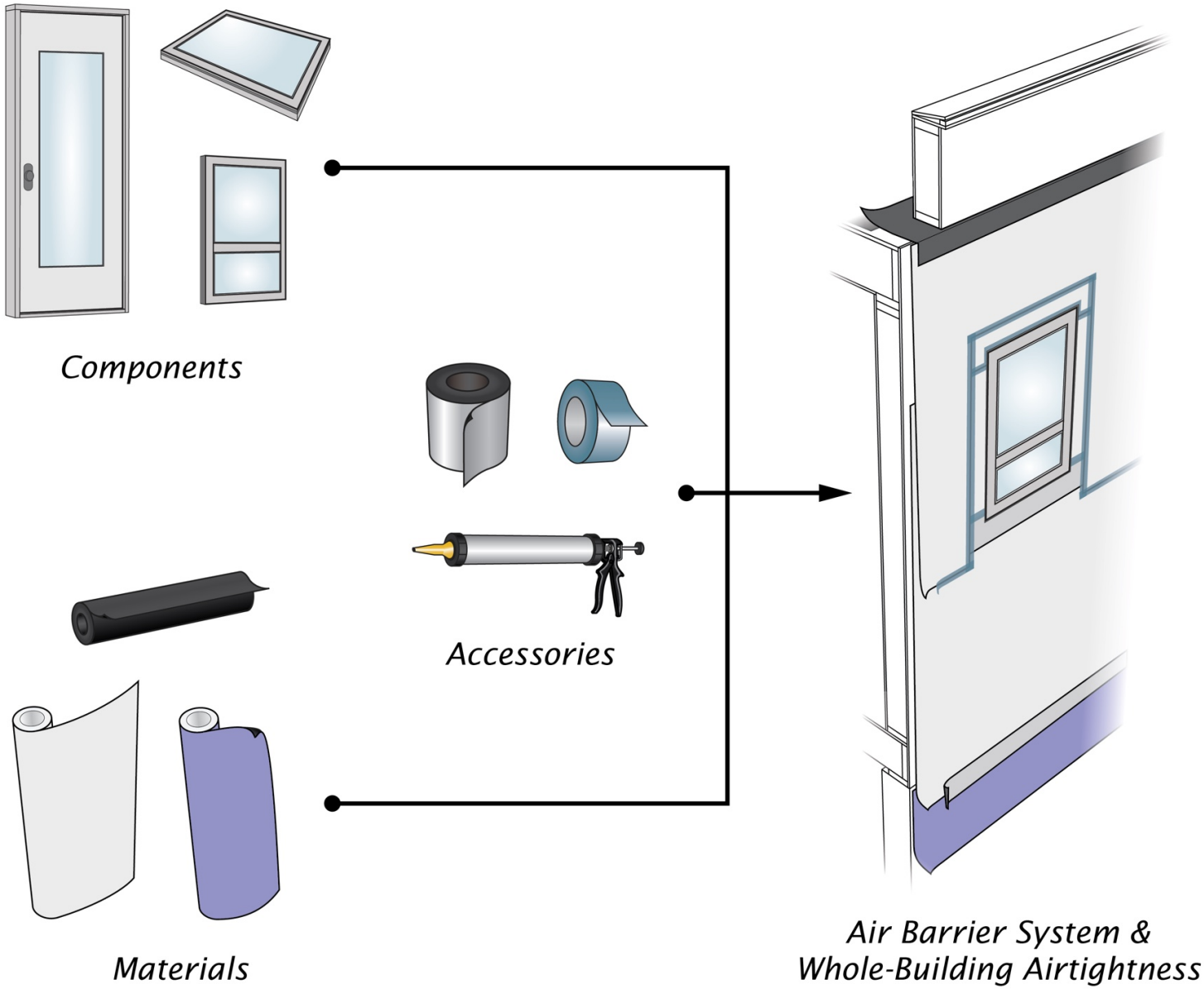
Self-Adhered vapor impermeable membrane



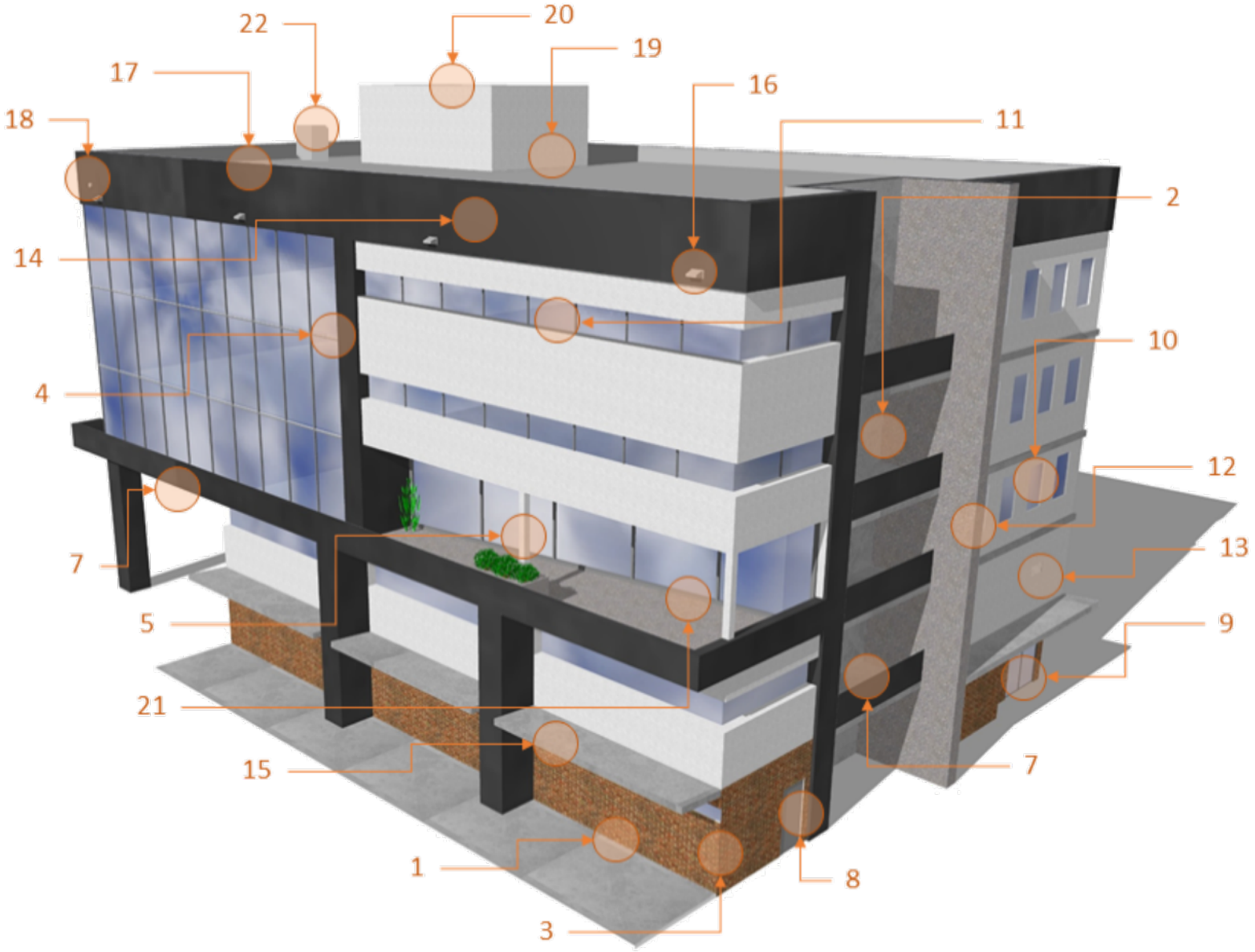
Sprayfoam



Curtainwall, window-wall & glazing systems


Components
Accessories
Materials
Air Barrier System &
Whole-Building Airtightness

Only As Strong as Weakest Detail



Air Leakage – Wasted Energy

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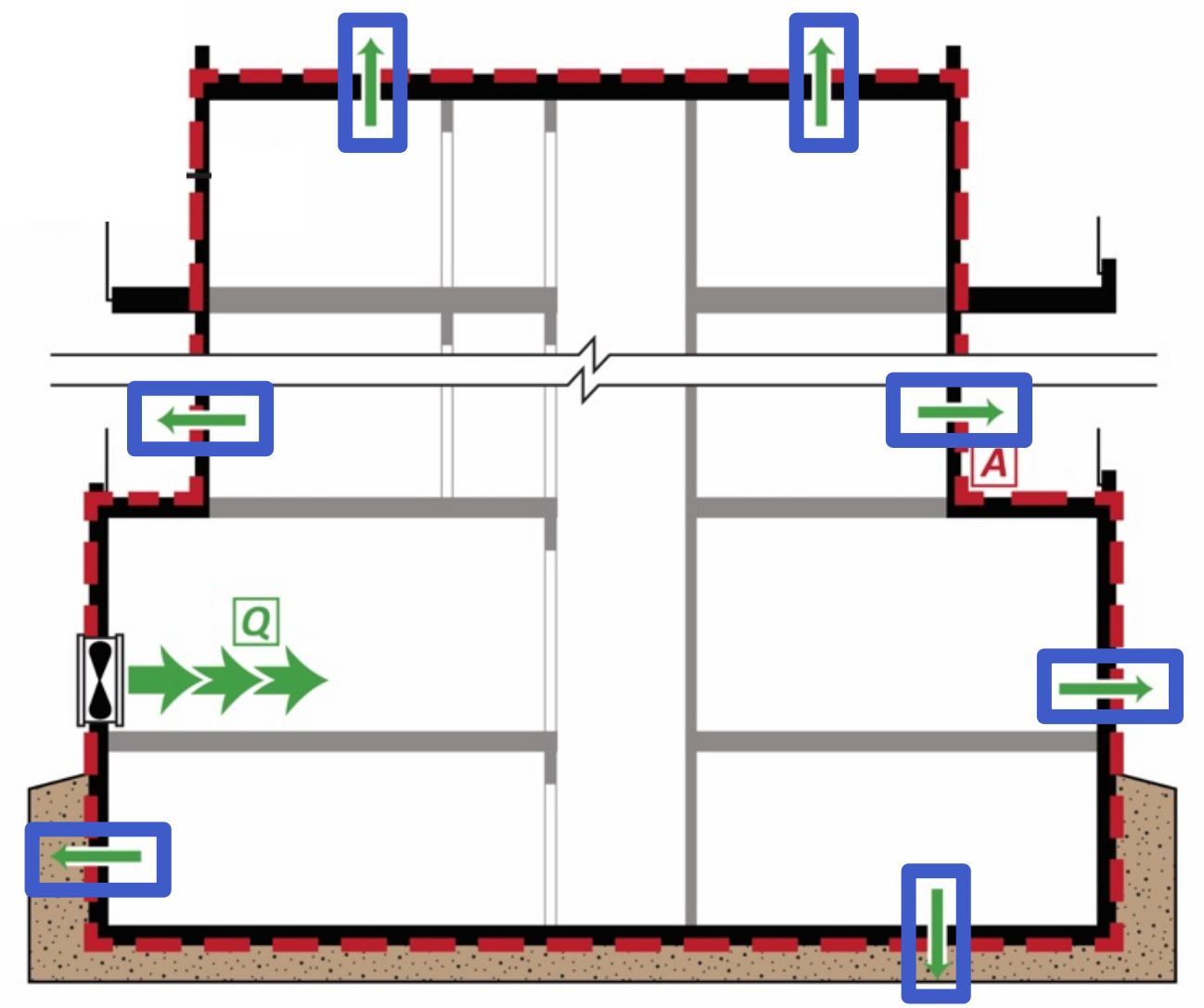
Air Leakage – Wasted Energy

Equivalent Leakage through these cracks added up to two double wide doors being left open year round

Airtightness Testing

Airflow In = Airflow Out ⟶ **Air Leakage Rate (L/s·m²)**



Air Leakage - What are the results?

→ Previously very limited published data regarding in situ air leakage test results

→ General interest in results

→ ASHRAE Annual Conference

→ CEC and IECC include requirement for 0.4 cfm/sf

Building Enclosure Airtightness Testing in Washington State – Lessons Learned about Air Barrier Systems and Large Building Testing Procedures

Donald Jones, BASc Bailey Brown, M.S., EIT Tony Thompson Graham Finch, P.Eng
Member

ABSTRACT

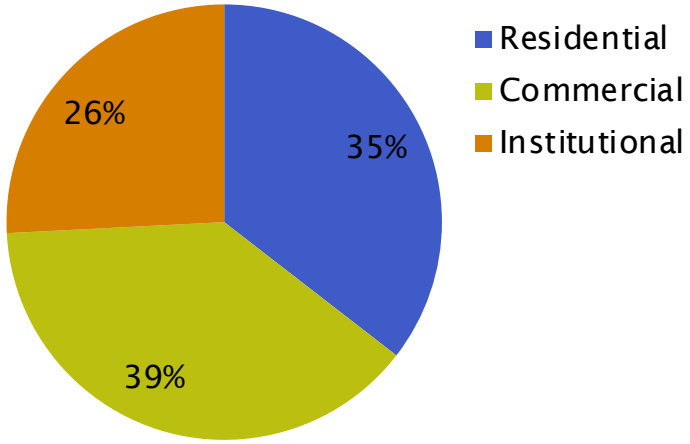
INTRODUCTION

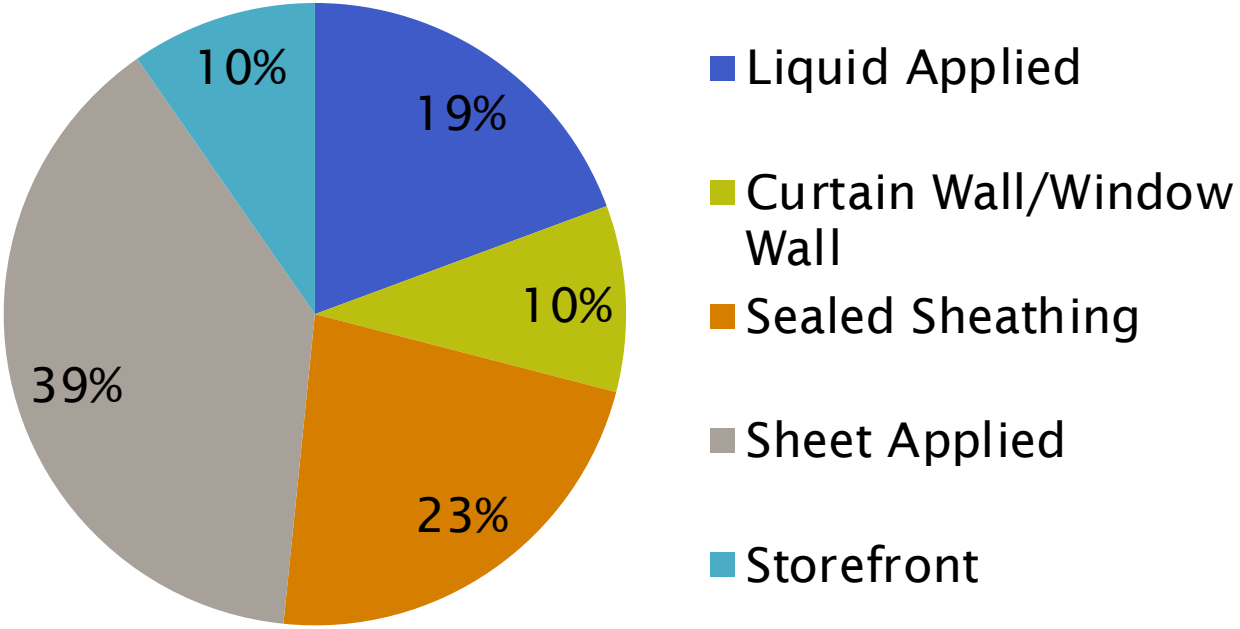
What are the results?

→ ASTM E779

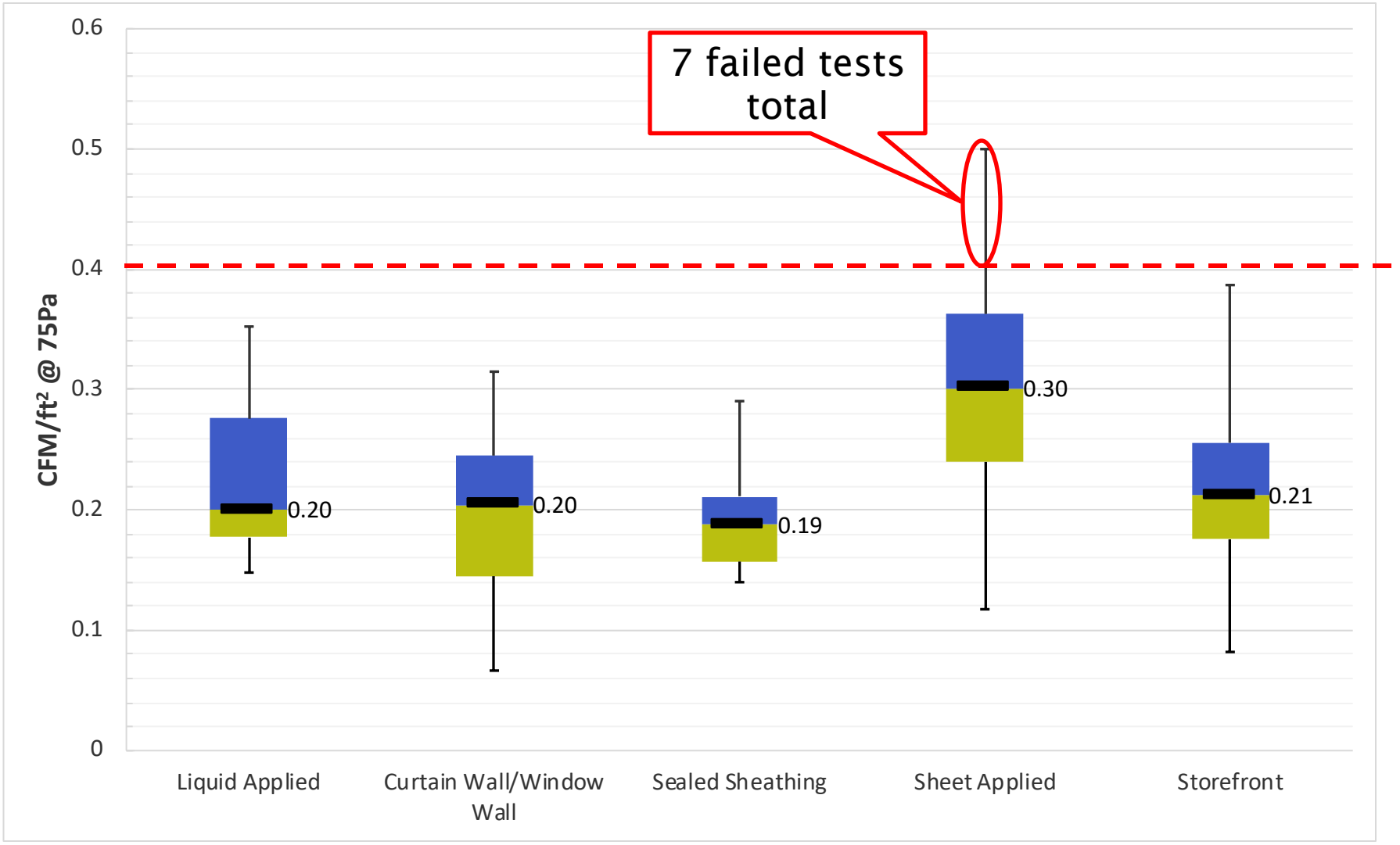
→ >100 Buildings

→ Excludes roofs and below-grade

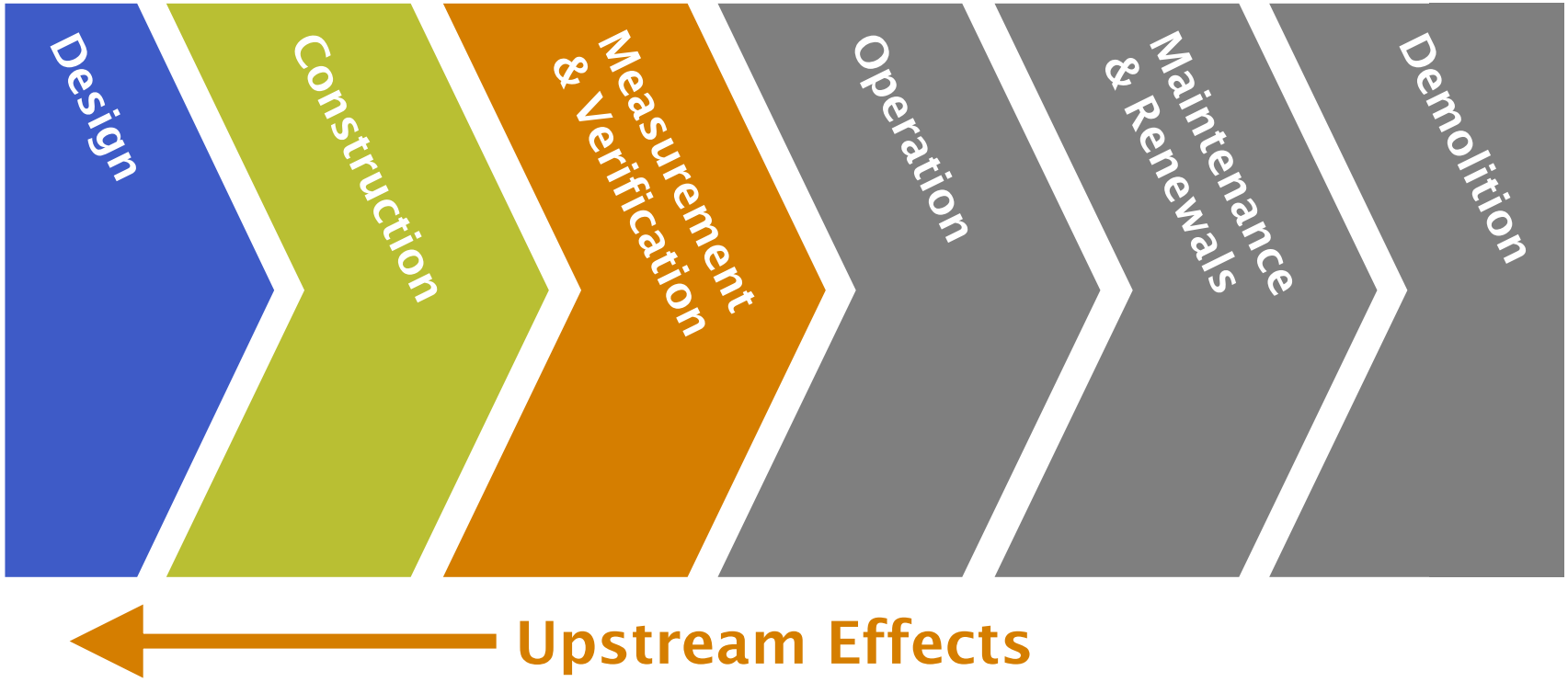




RDH Test Results – Over 100 Buildings



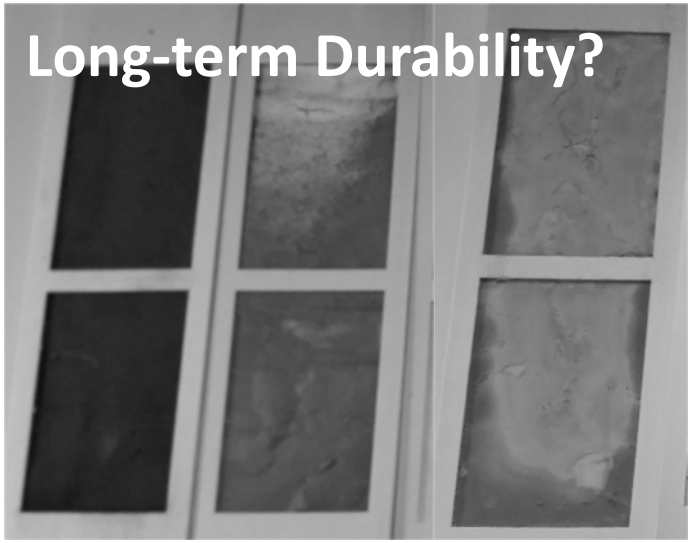
Effects of M+V

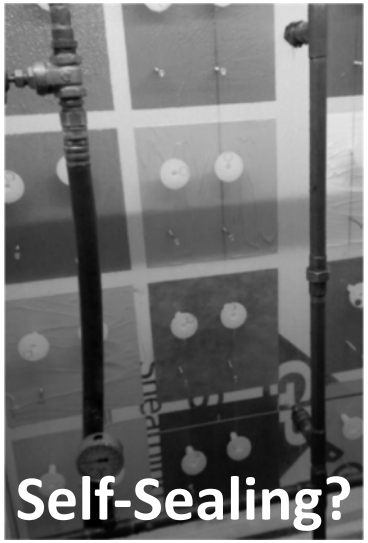


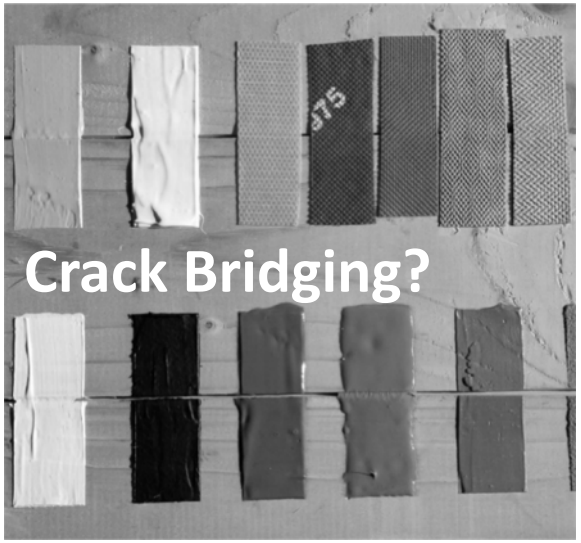
Changes in Air Barrier System Selection

→ Seeing shifts from **Mechanically Attached** to **Self-Adhesive** & **Liquid Applied** membranes

Lessons Learned So Far…

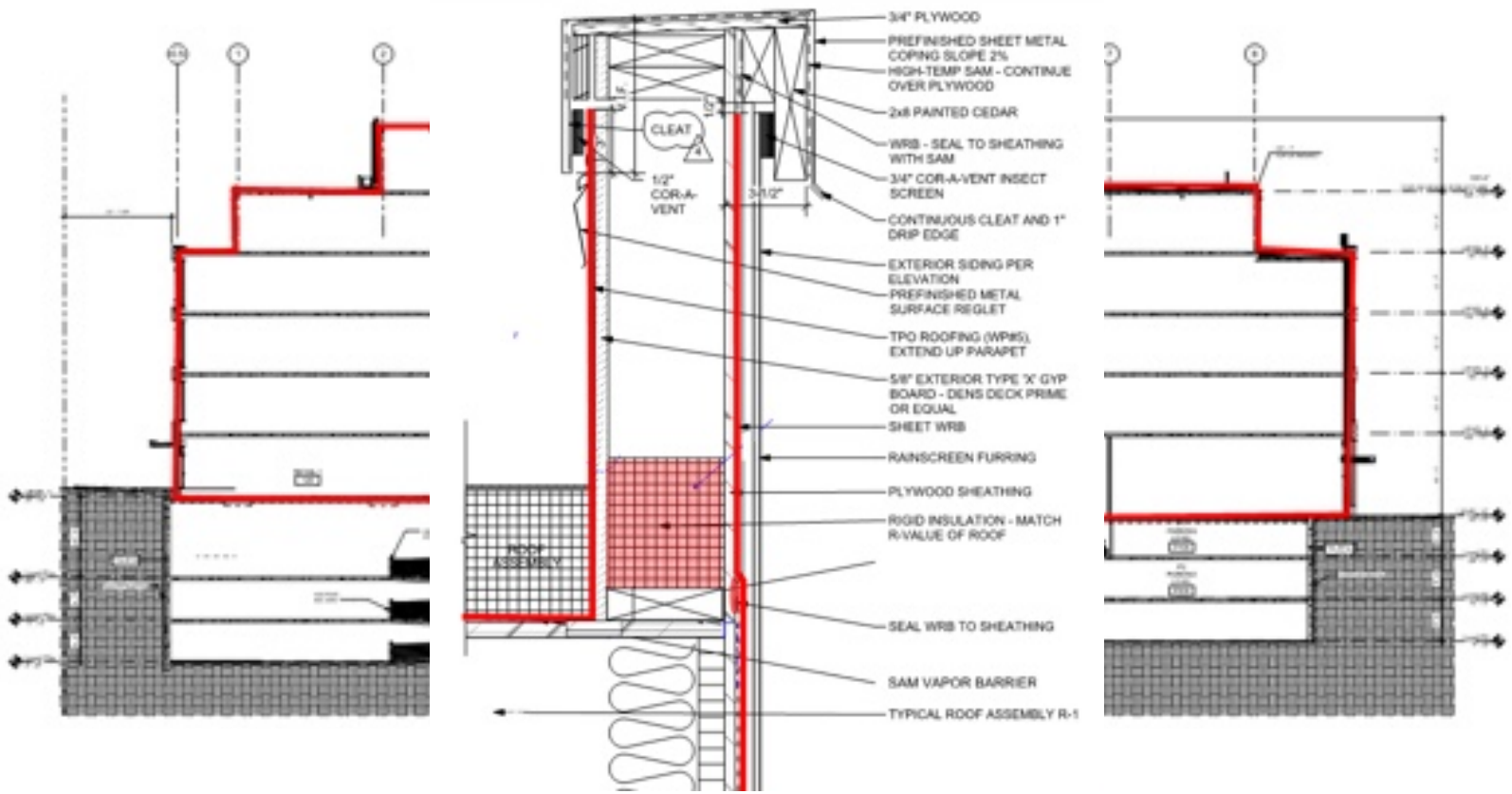






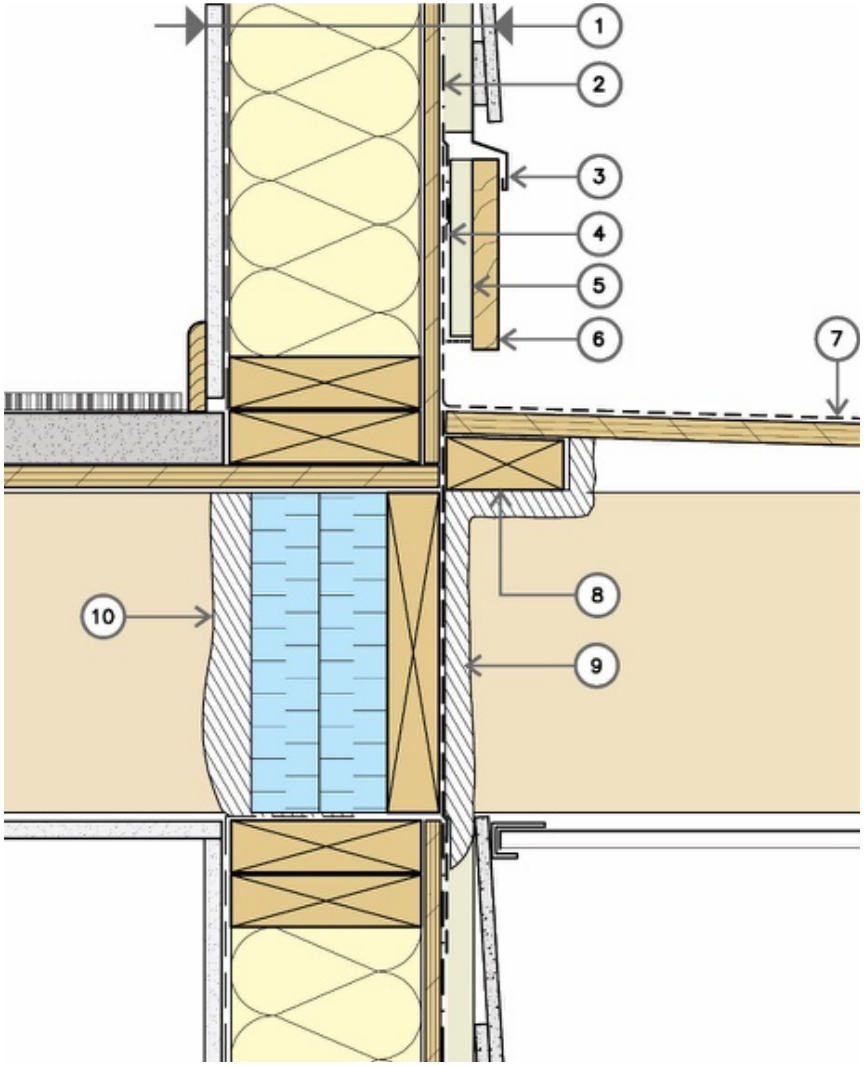
Changes in Design

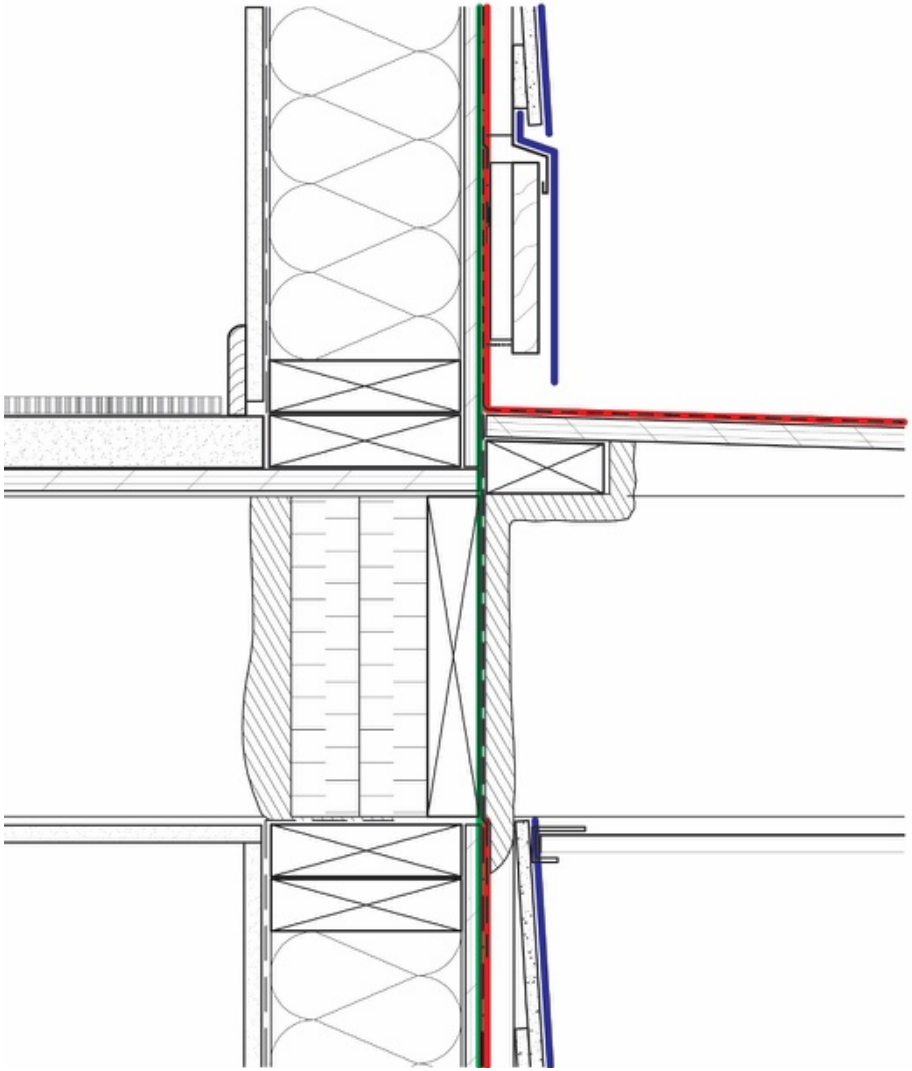
→ Clear identification of air barrier on all drawings both at whole building and detail level



Balcony Interfaces

Cantilevered Balcony – Control Layers



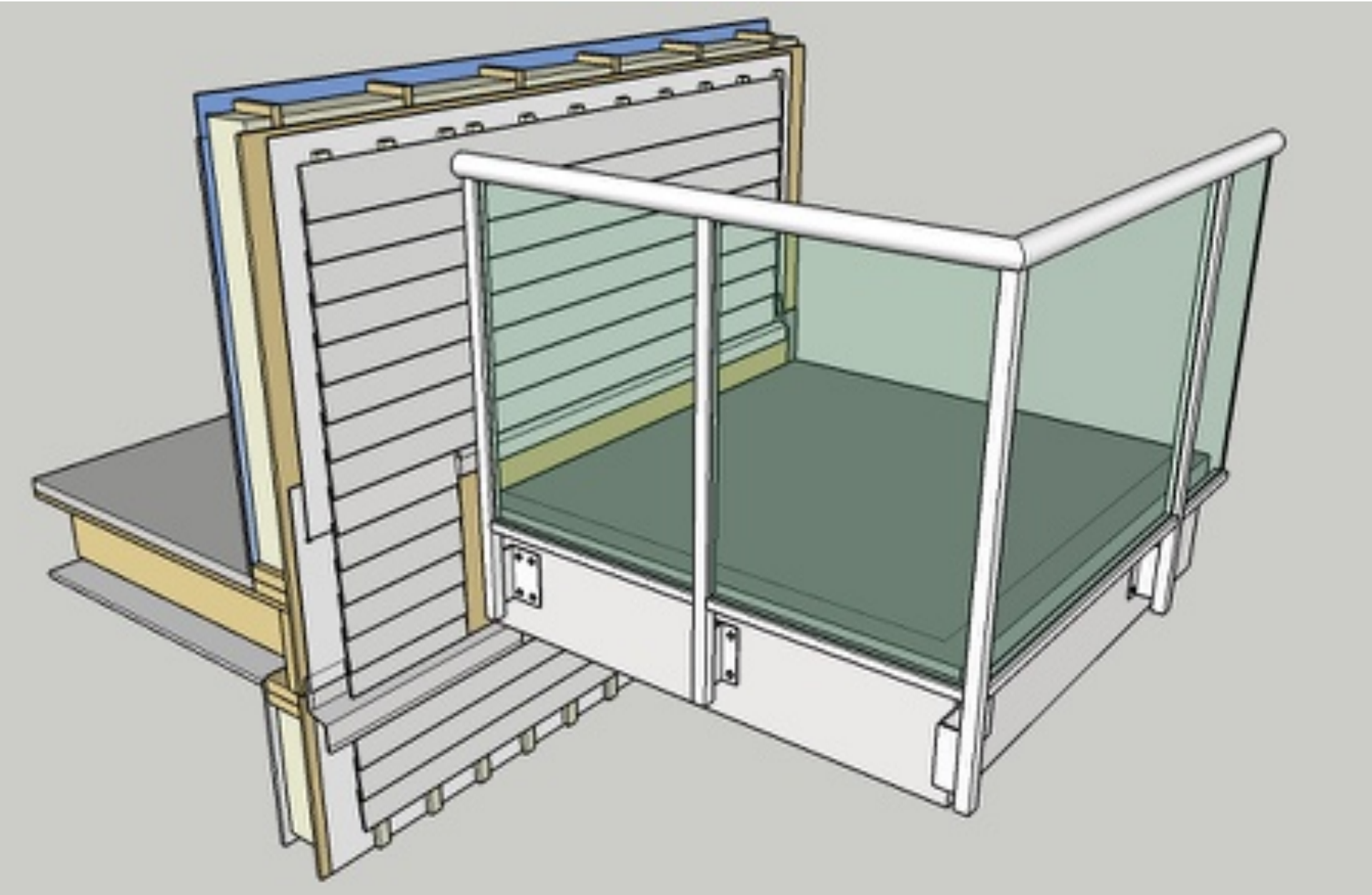


Cantilevered Balcony - Saddles

→ 3-dimensional integration of assemblies

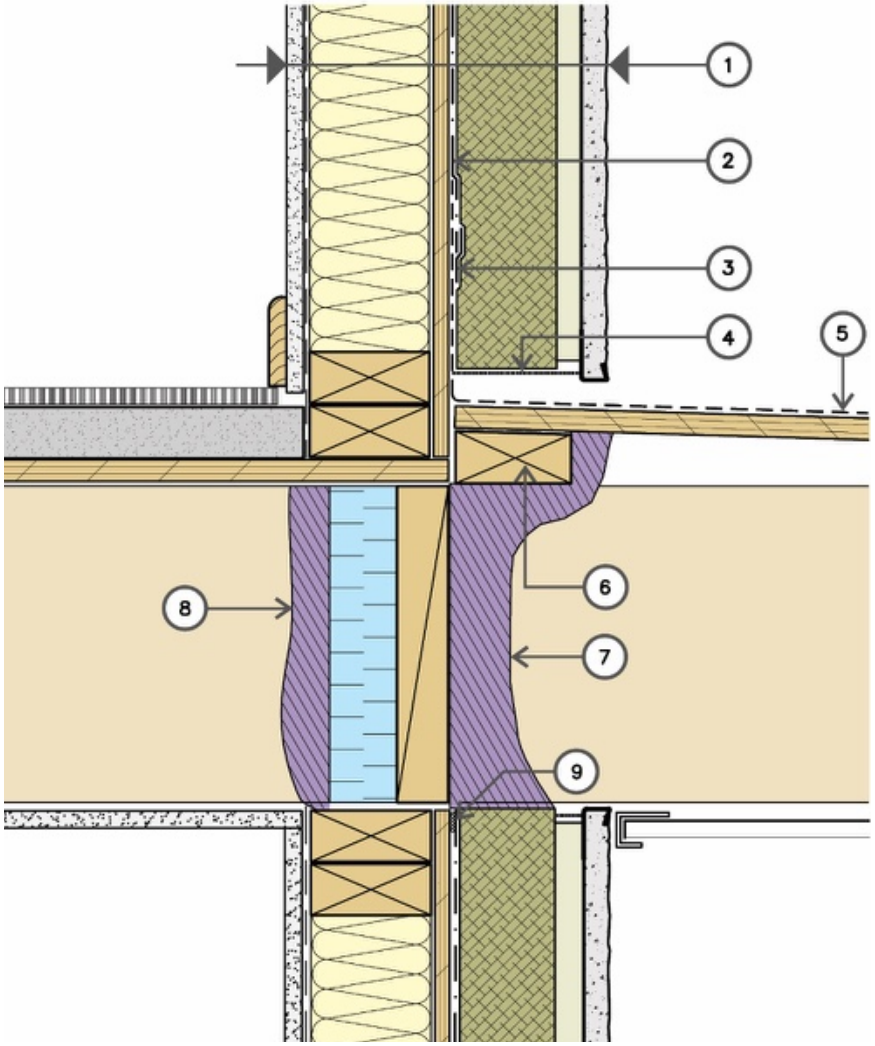
→ Include a 3-dimensional detail

Cantilevered of Water Control Layer



Continuity of Air / Thermal Control Layers

- → Air barrier and thermal barrier continuity often overlooked
- → Difficult to reliably detail sheet membrane around penetrating joists
- → Spray foam often used for air and thermal control



Continuity of Air / Thermal Control Layers

Pre-Finished Steel Balcony over Wood

- → Balcony is a ‘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
- → Continuous water, air, thermal layers

Bolt-on Balconies

More Details

This concludes the American Institute of Architects Continuing Education System Course

Discussion + Questions

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