Advanced Detailing Techniques for Building Enclosures

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.



Course Description

 \rightarrow 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 woodframe 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

\rightarrow Support

- \rightarrow Structural loads
- \rightarrow Structural movements

\rightarrow Control

- \rightarrow Water penetration
- \rightarrow Air flow
- \rightarrow Vapor diffusion / condensation
- \rightarrow Heat flow
- \rightarrow Bugs
- \rightarrow Light and solar radiation
- \rightarrow Noise, fire, and smoke

 \rightarrow Finish





Trends in Building Enclosure Design

- → Trend towards more energy efficiently building enclosures
- \rightarrow 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

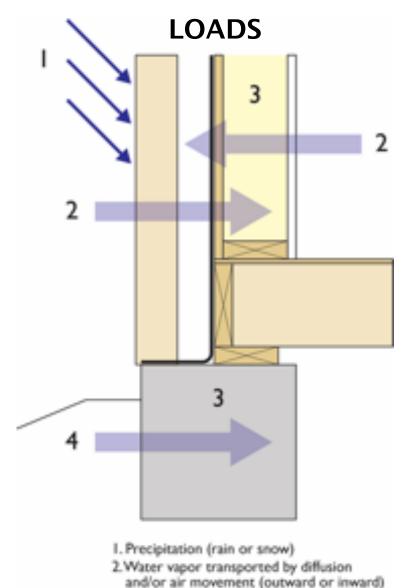


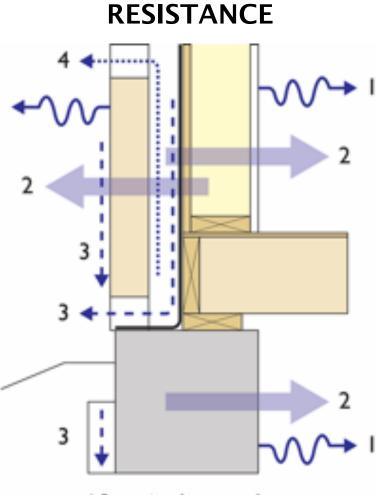
The Old Way

The New Way – "Light & Tight"



Controlling Water – The Balance



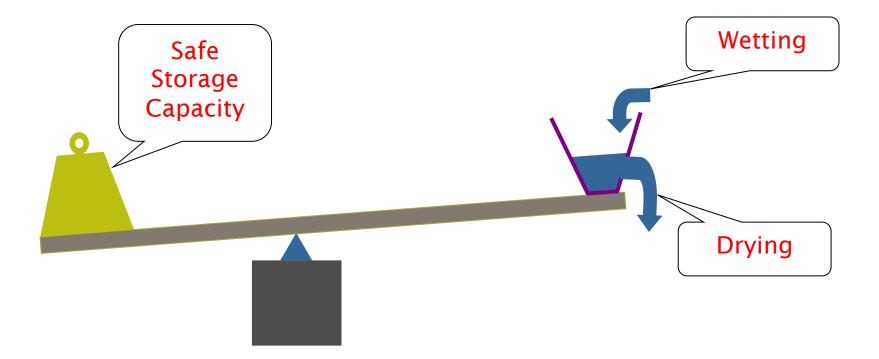


- I. Evaporation of water at surfaces
- Water vapor transport by diffusion and/or air movement (outward or inward)
- 3. Drainage
- 4.Ventilation drying by air exchange

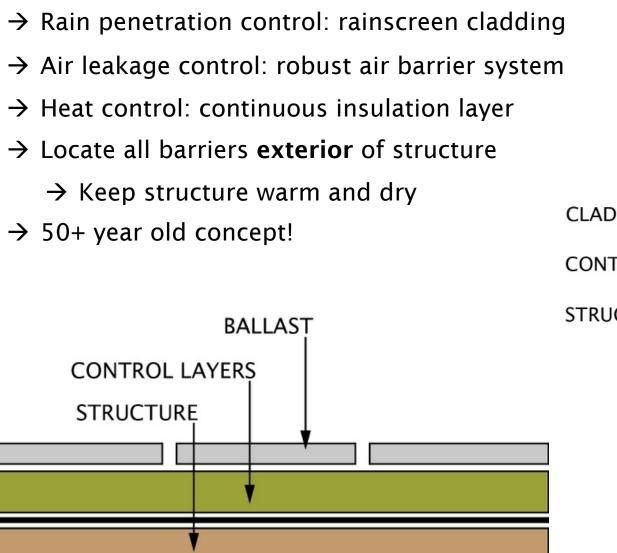
- 3. Built-in construction moisture
- Groundwater

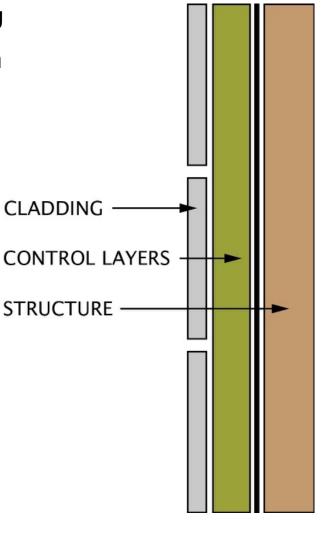
Controlling Water – The Balance

- \rightarrow Wetting is ok (and inevitable)
- \rightarrow But not too much or for too long

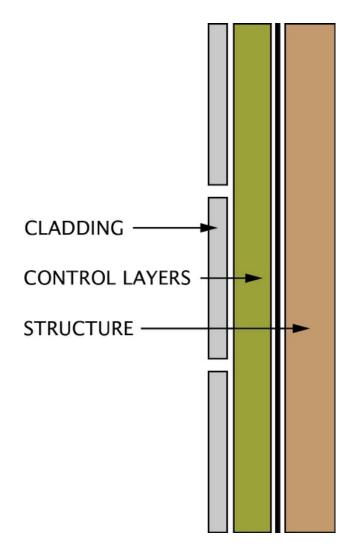


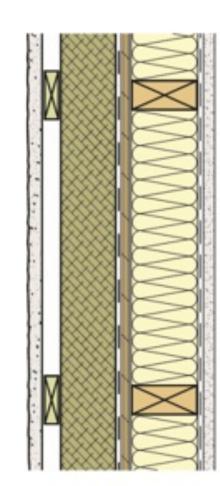
The 'Perfect' Assembly





Wood-Frame Assemblies - 'Pretty Good' Wall

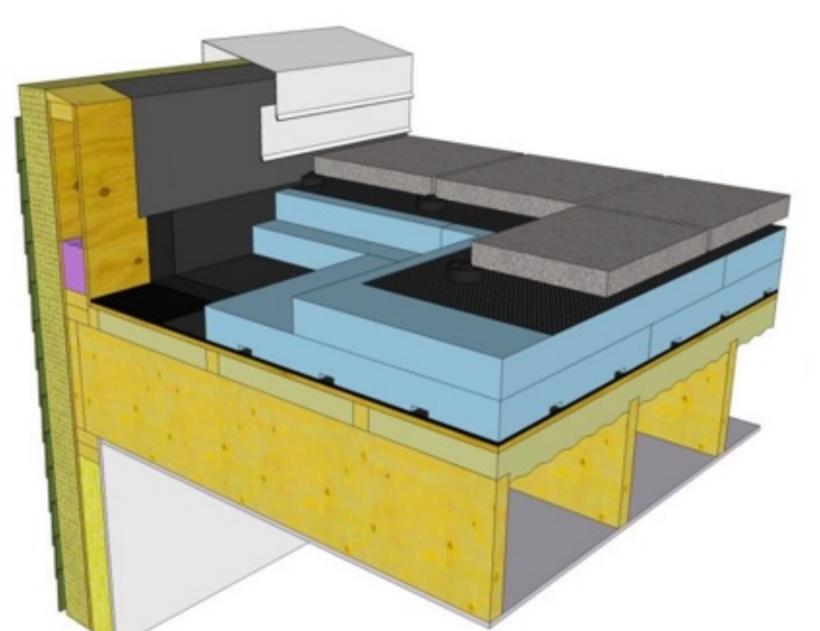




EXTERIOR

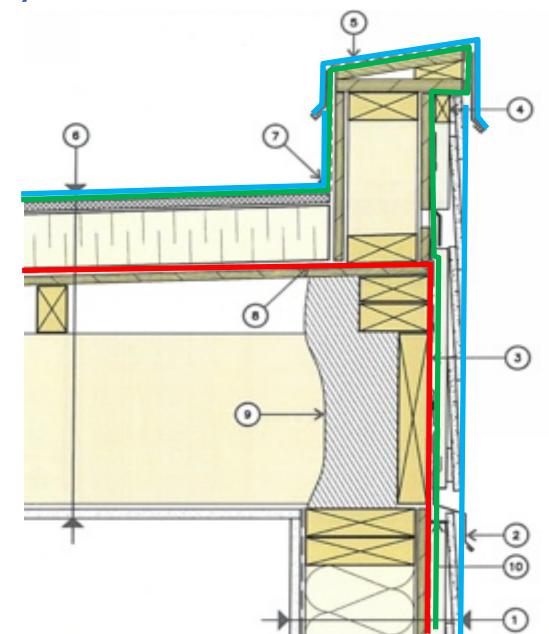
- Cladding
- Airspace (ventilated)
- 1x3 wood strapping, screwed through Insulation
- Rigid, mineral-fibre insulation (thickness to meet R-value requirement)
- Vapour-permeable sheathing membrane
- Sheathing (plywood or OSB)
- 2x4 or 2x6 wood framing with batt insulation
- Polyethylene film (cold climates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

yvek

vek

3.Balcony interfaces

4.And more...

OASIS

DASIS

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
- \rightarrow CLT Handbook

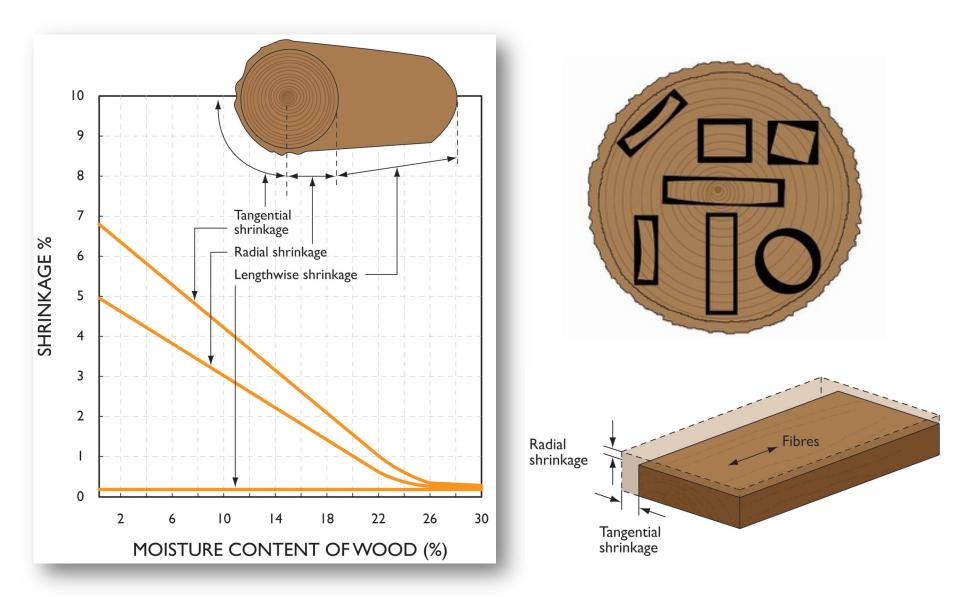
Building Enclosure Design Guide

Wood-Frame Multi-Unit Residential Buildings

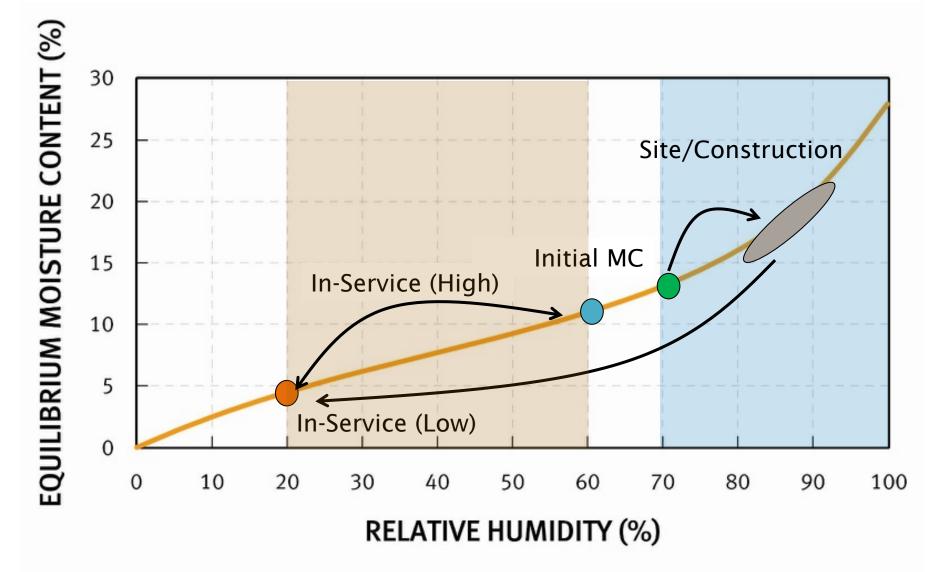


Design for Shrinkage

Behaviour of Wood in Construction



Wood Moisture Content vs Relative Humidity



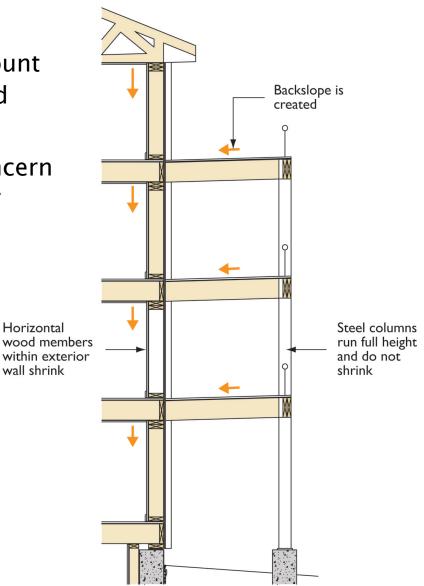
Wood shrinkage is 0.20% to 0.25% in dimension per 1% change in MC

Behaviour of Wood in Construction

- \rightarrow 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

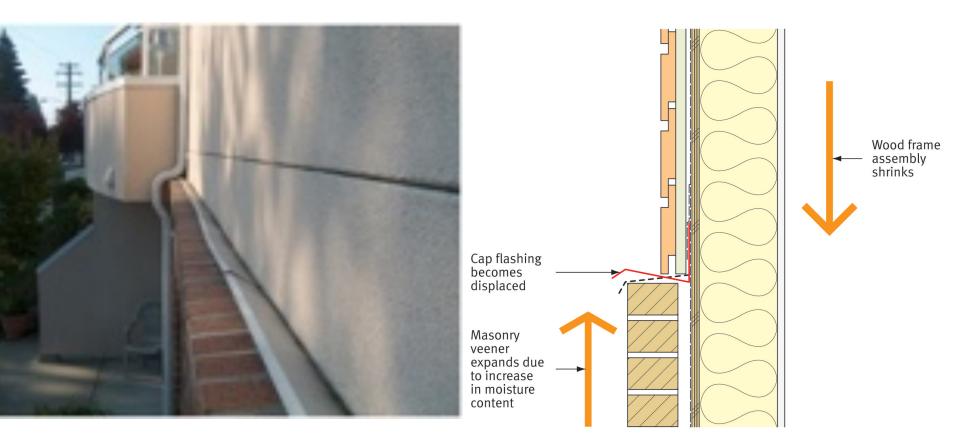
Case	Estimated Shrinkage at Eave	
	(mm)	(inches)
#1 - S-GRN joists and S-GRN plates	146	53/4"
#2 - S-DRY joists and S-DRY plates	74	3"
#3 - Dried S-DRY joists and dried S-DRY plates	46	3/4"
#4 - SCL joists and S-DRY plates	42	2/3

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

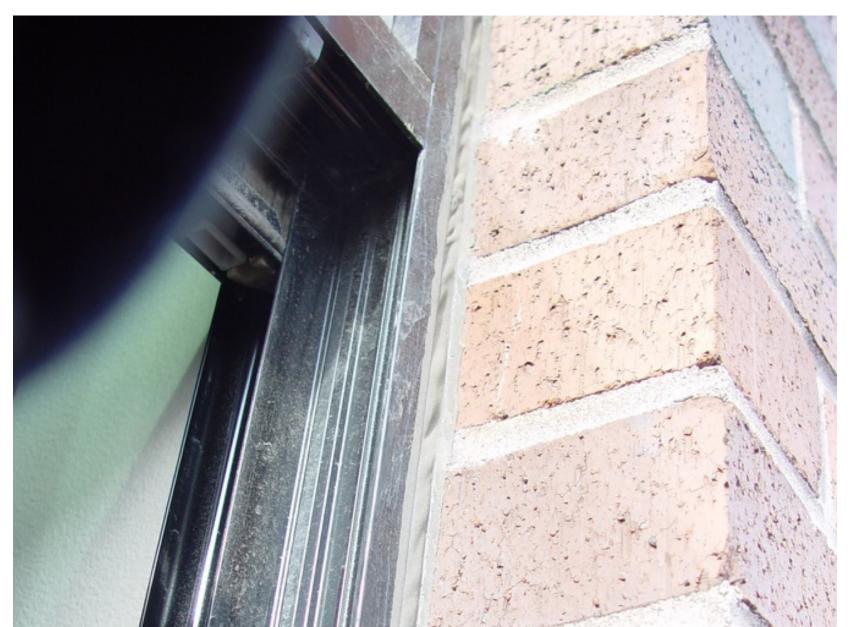


Behaviour of Wood in Construction

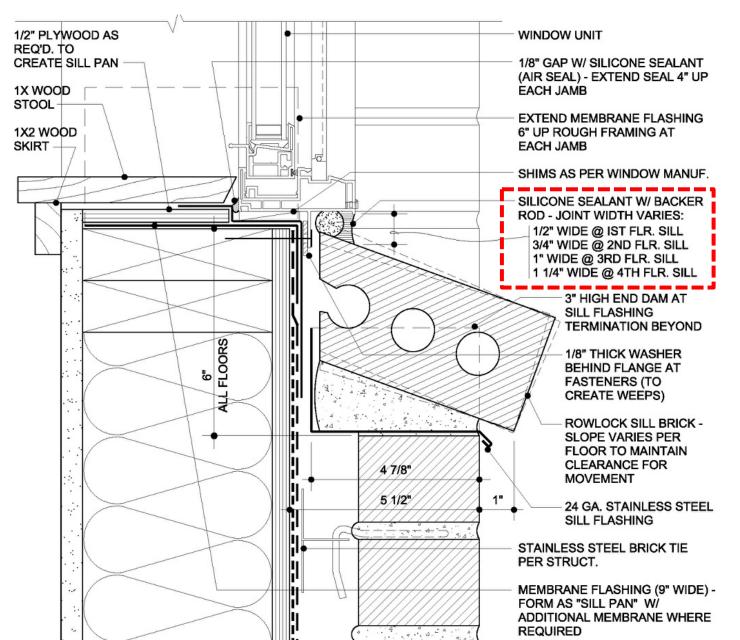
\rightarrow Detailing for Differential Shrinkage is Important



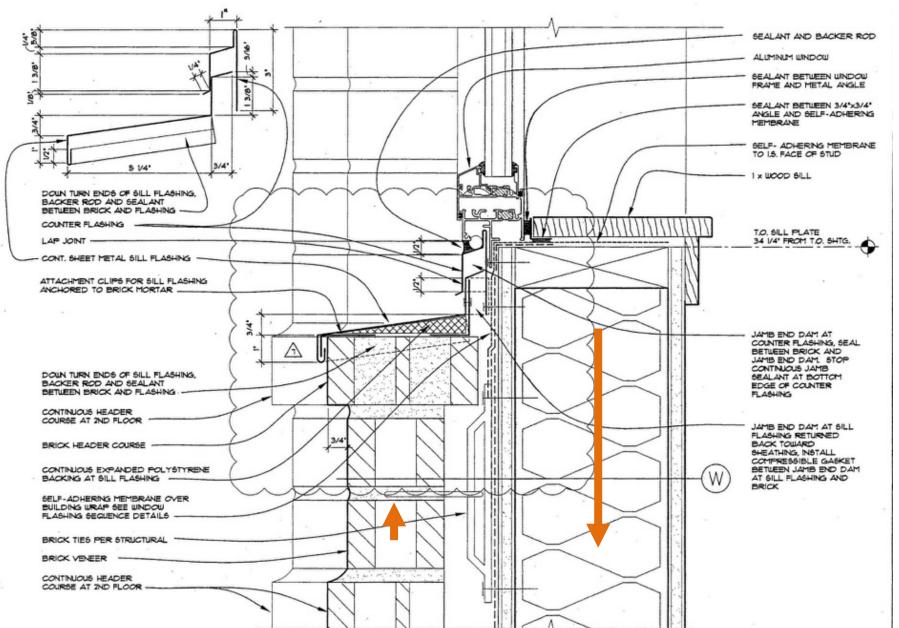
Lessons Learned from Wood-frame Shrinkage



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
- \rightarrow Engineered floor joists
- → Modified platform framing practices
 - → Floor joists hang from top plate of wall, essentially reducing shrinkable wood at floor line
- \rightarrow Balloon framed details





Air Tightness

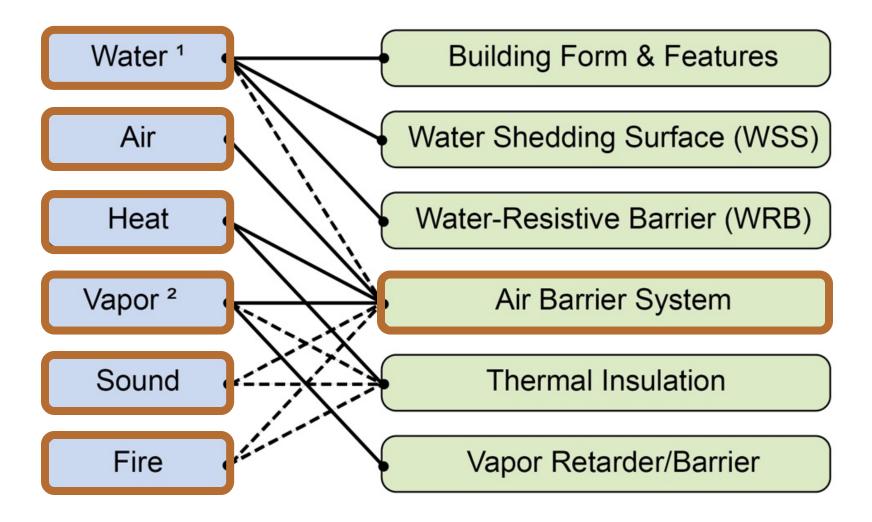
Systems and Details

Why We Care

- \rightarrow Infiltration and Exfiltration Affect:
 - \rightarrow Code Compliance
 - \rightarrow Building Energy Consumption Heat Loss and Gains (\$)
 - → Indoor Air Quality Pollutants
 - \rightarrow Building Durability Condensation
 - \rightarrow Occupant Comfort Thermal & Acoustics



Building Enclosure Control Functions



— Primary Relationship – – – – – Secondary Relationship

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

\rightarrow Continuous

→ Primary need, common failure

\rightarrow Strong

 \rightarrow Designed for full wind load

\rightarrow Durable

→ critical component - repair, replacement

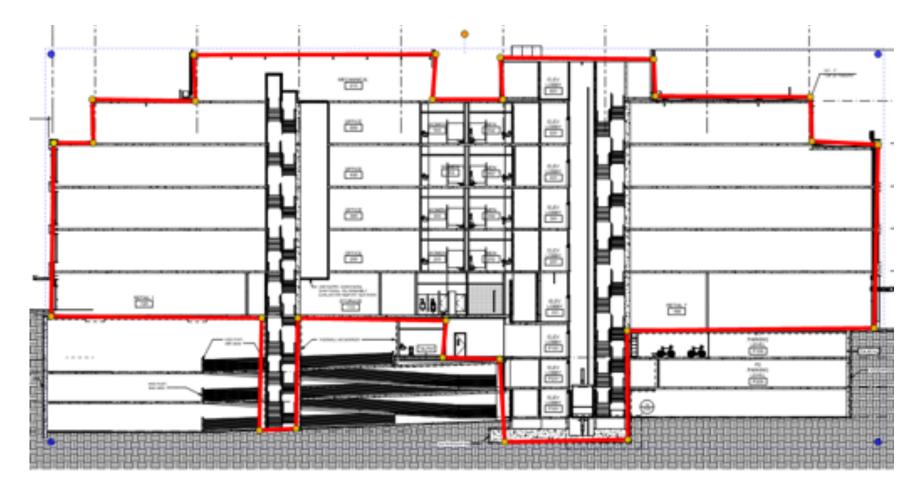
\rightarrow Stiff

- \rightarrow Control billowing, pumping
- \rightarrow Air Impermeable



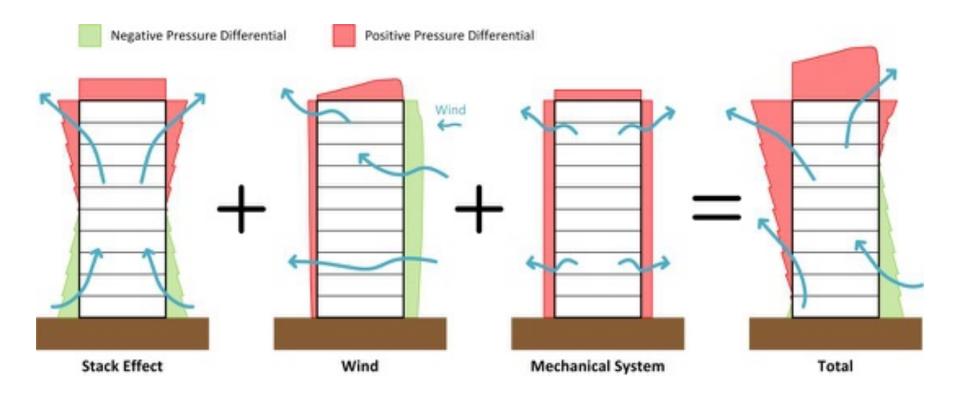


Air Barriers - Continuity



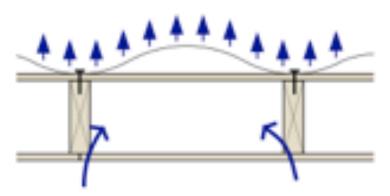
Air Barriers - Strength

- → Stack Effect
- \rightarrow Wind
- \rightarrow Mechanical Systems



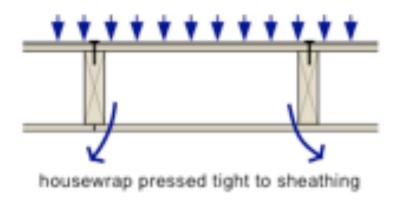
Air Barriers - Stiffness

- →Loose sheets commonly "stiff" under positive exterior pressures
- →Air leakage often exacerbated under negative pressure



negative pressure gust

housewrap balloons outwards air flows from interior into stud space positve pressure gust



air flows out of stud space to interior

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



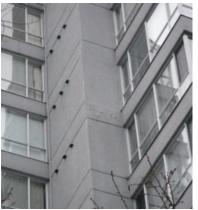
Loose Sheet Applied Membrane – Taped Joints & Strapping



Sealed Gypsum Sheathing – Sealant Filler at Joints



Liquid Applied Sealants/Membranes



Mass Walls (concrete)



Self-Adhered vapor permeable membrane



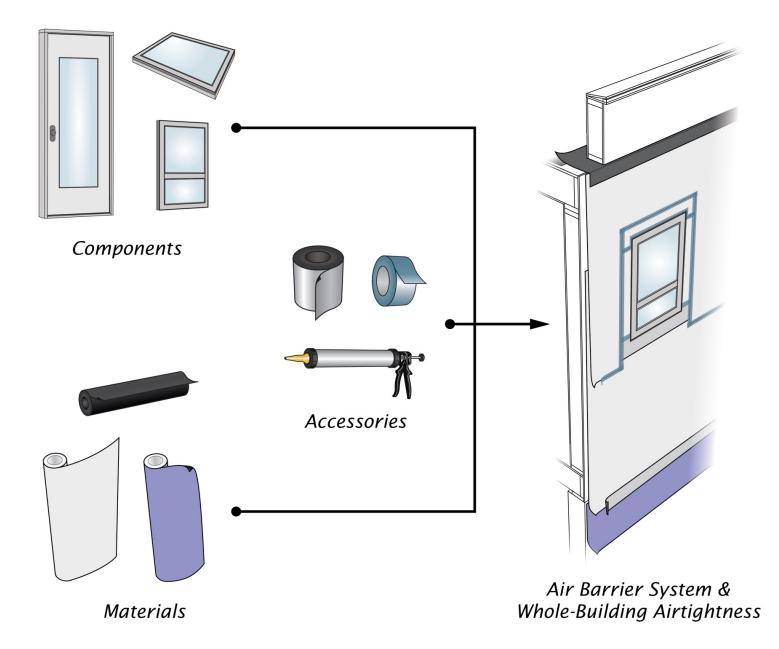
Self-Adhered vapor impermeable membrane



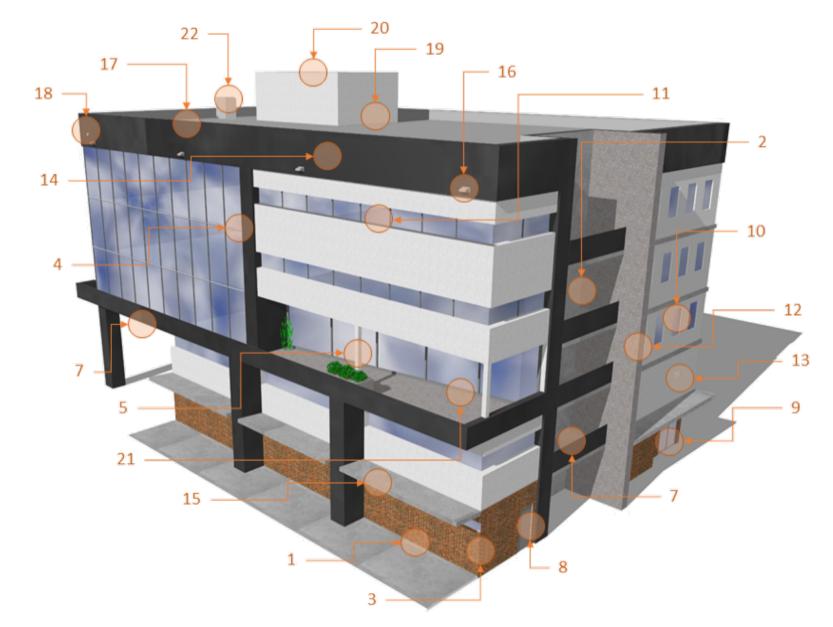
Sprayfoam



Curtainwall, window-wall & glazing systems

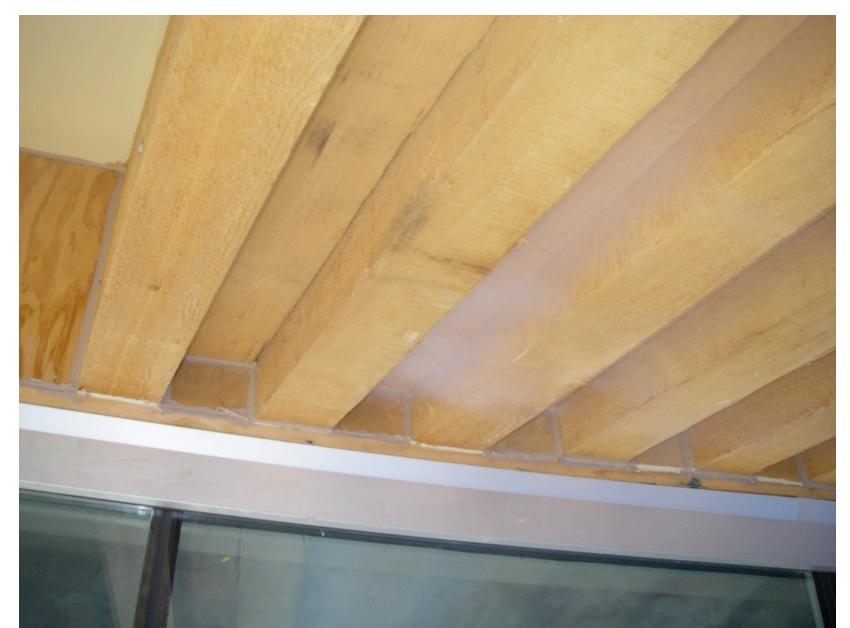


Only As Strong as Weakest Detail











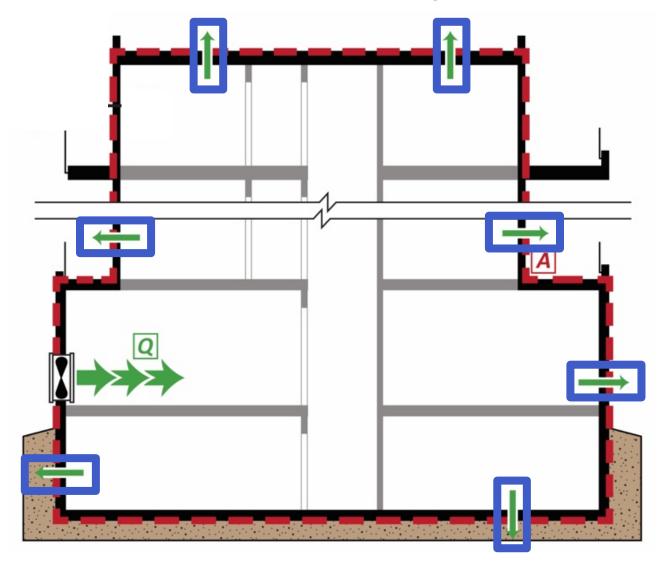


Equivalent Leakage through these cracks added up to two double wide doors being left open year round



Airtightness Testing

Airflow In = Airflow Out \longrightarrow Air Leakage Rate (L/s·m²)



Air Leakage - What are the results?

- \rightarrow Previously very limited published data regarding in situ air leakage test results
- \rightarrow General interest in results
- \rightarrow ASHRAE Annual Conference
- \rightarrow 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**

Bonat Jones, Bade Baley Brown, M.S. DT Tony Thompson

Graham Finch, P.Eng. second standard

ABSTRACT

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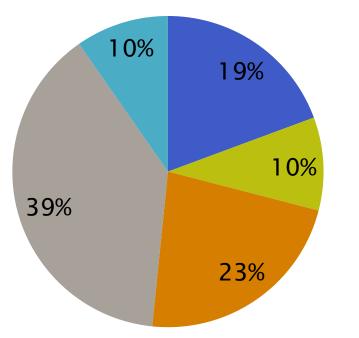
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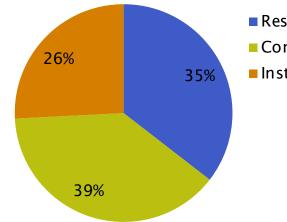
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What are the results?

- → ASTM E779
- \rightarrow >100 Buildings
- \rightarrow Excludes roofs and below-grade



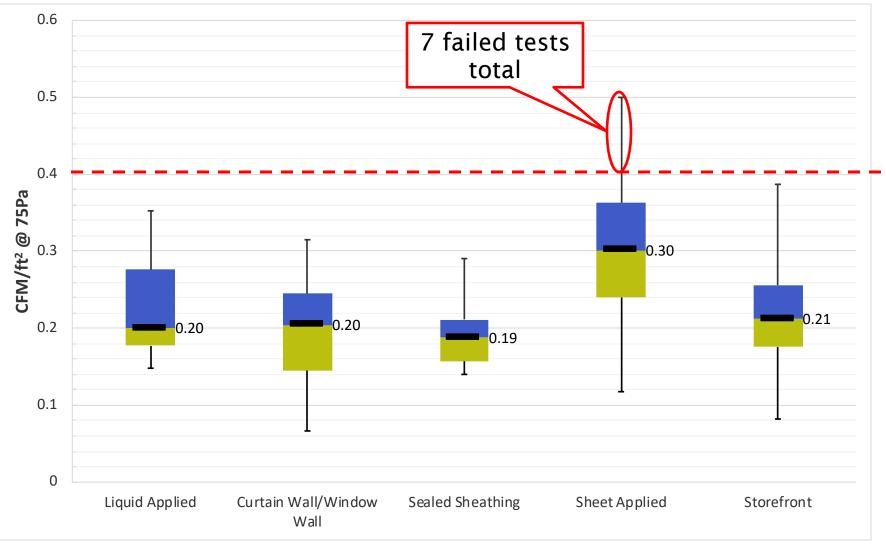


Residential
 Commercial
 Institutional

Liquid Applied

- Curtain Wall/Window Wall
- Sealed Sheathing
- Sheet Applied
- Storefront

RDH Test Results - Over 100 Buildings



Effects of M+V



Upstream Effects

Changes in Air Barrier System Selection

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



Lessons Learned So Far...







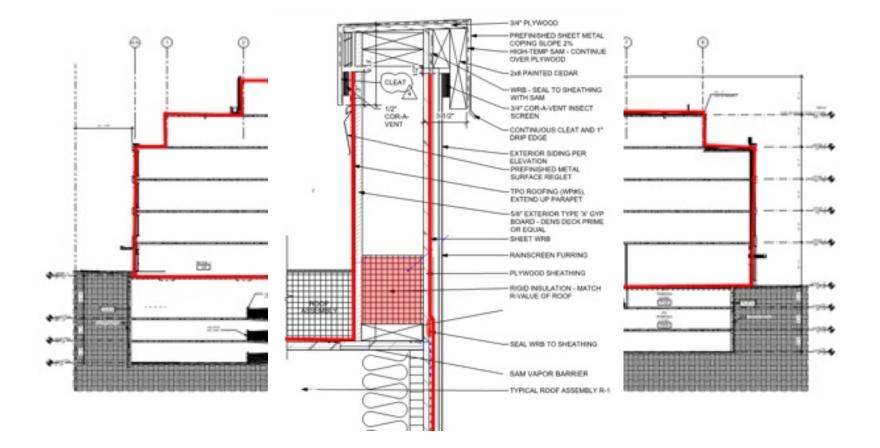






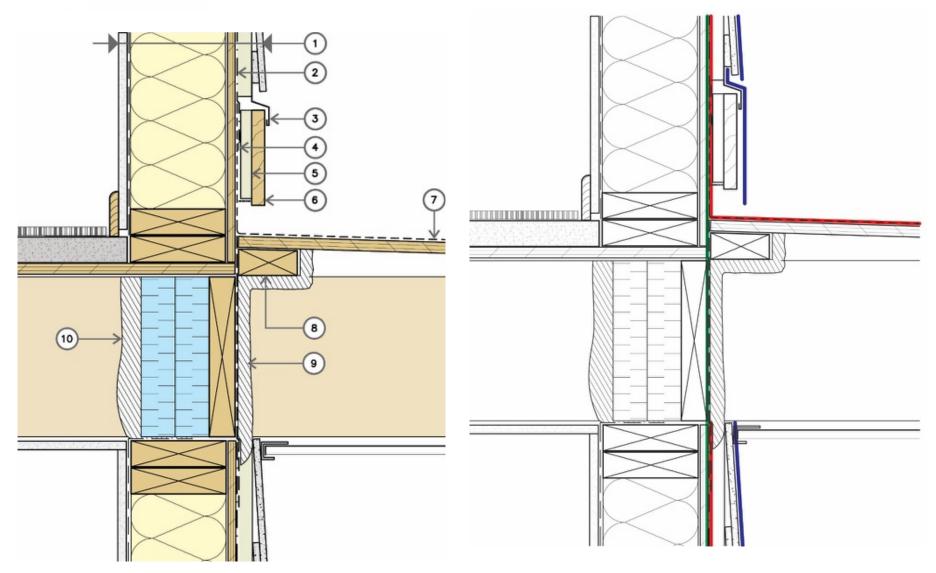
Changes in Design

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



Balcony Interfaces

Cantilevered Balcony – Control Layers

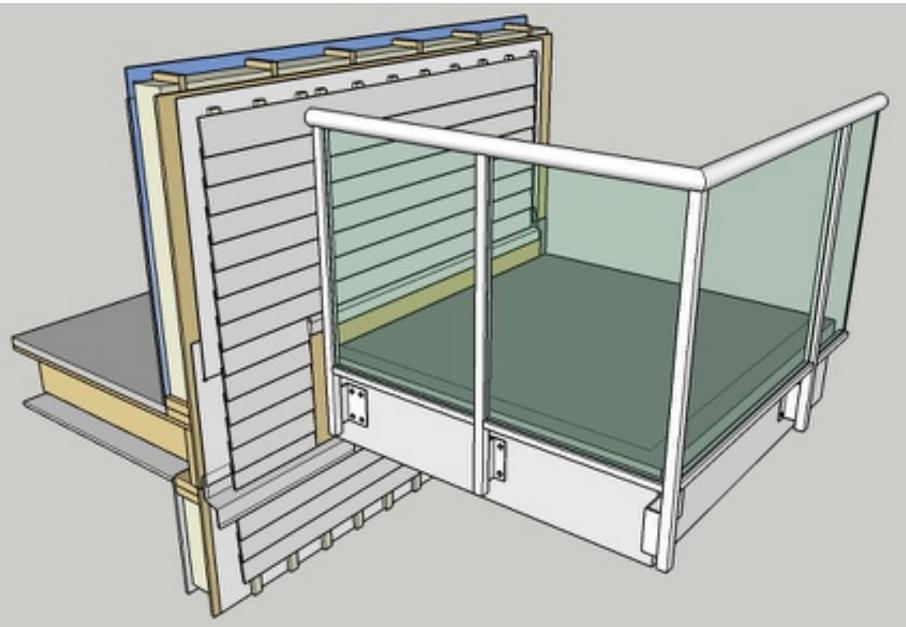


Cantilevered Balcony - Saddles



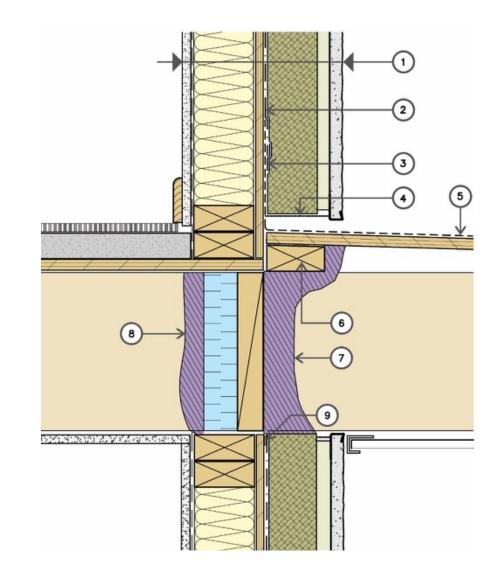
- \rightarrow 3-dimensional integration of assemblies
- \rightarrow Include a 3-dimensional detail

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



Building Enclosure Design Guide

Wood-Frame Multi-Unit Residential Buildings





This concludes the American Institute of Architects Continuing Education System Course

Discussion + Questions

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