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AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY

Who’s the Culprit in WRB-AB Leakage?

A Look at Test Results and Best Practices

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Georgia-Pacific

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Learning Objectives

Upon completion of this course, you should be able to:

- 1. **Explore** how fasteners attached to sheathing become a point of vulnerability during extreme weather events, which can stress wall assemblies and cause water to enter the building envelope.
- 2. **Review** the differences between standard test methods and the extreme conditions that were introduced by RDH Building Sciences in order to test several cladding fastener options.
- 3. **Understand** the differences between thin-mil and thick-mil fluid-applied versus an integrated WRB-AB sheathing solution. Find out which option performed the best when exposed to high wind and heavy rain simulations.
- 4. **Discover** best practices for cladding attachment options, depending on factors like climate, building form and architectural complexity among others.

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Part 1
The Issues

Continuous Barriers

Drying Capability

Construction Techniques

Cladding Attachment Impact on WRB/AB

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The Issue – Continuous Barriers

Continuous Water Resistive and Air Barriers

- Exterior framed walls commonly use fiberglass mat faced gypsum as the exterior sheathing
- To meet code requirements, a water-resistive barrier (WRB) and an air barrier (AB) need to be present on the face of the sheathing
- There are choices:
  - Roll-on/ spray-on
  - Self-adhered membranes
  - Some foam insulation
  - Integrated sheathing

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The Issue – Continuous Barriers

Choice: Rolled or Sprayed on Liquid Membrane

- Liquid membrane applied on the job-site to completely cover the gypsum sheathing
  - Applied by hand requiring skilled applicators
  - Need appropriate equipment
  - Different products require different thicknesses to be effective

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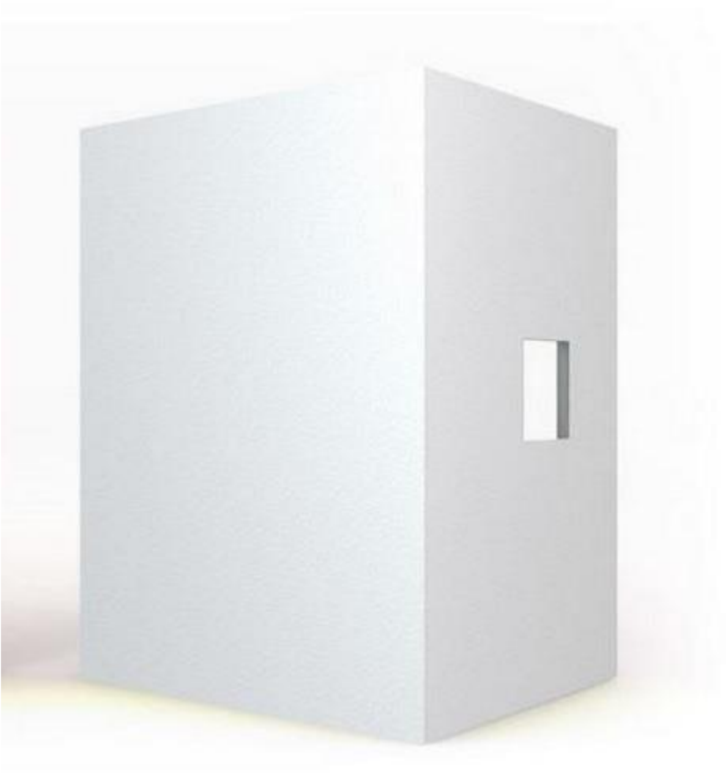
The Issue – Continuous Barriers

The Key is Continuity

- Rolled-on and spray on liquid barriers cover over entire surface including all joints, seams, corners and penetrations
- This creates fairly uniform membrane as a result
- The continuity of the barriers is achieved by the liquid nature of the product
- It is not the easiest to install, however



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The Issue – Continuous Barriers

Choice: Self-Adhered Membranes

- Self-adhered membranes come on rolls and are applied to cover the sheathing
  - Work best on smooth, flat, surfaces
  - Need attention to building corners, edges, openings, etc.
  - Variety of types and material make-ups – not all are AB
  - Lots of seams - makes continuity a challenge

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The Issue – Continuous Barriers

Choice: Certain Foam Plastic Insulation

- Some closed cell foam plastic insulation can act as an AB and a WRB
  - Commonly installed over sheathing as continuous insulation
  - May or may not qualify as WRB or AB but present in wall for thermal properties
  - May still need WRB AB

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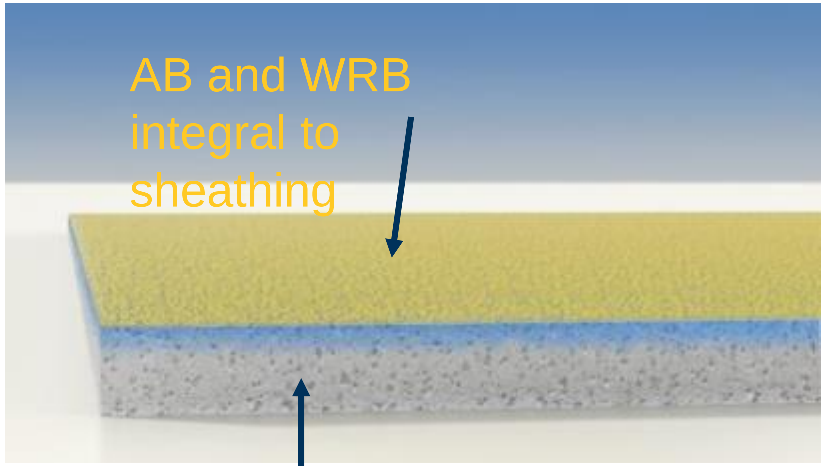
The Issue – Continuous Barriers

Choice: Integrated Sheathing

- Allows one engineered product to provide AB and WRB with a single installation of exterior sheathing
- Eliminates step of applying air and water barriers separately reducing construction time
- Simpler installation means less labor

INTEGRATED SHEATHING



Glass Mat Exterior Gypsum Sheathing

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The Issue – Continuous Barriers

The Key is Continuity

- Integrated sheathing uses liquid sealant to cover all joints, seams, penetrations, etc.
- Proven to create full continuity of barriers

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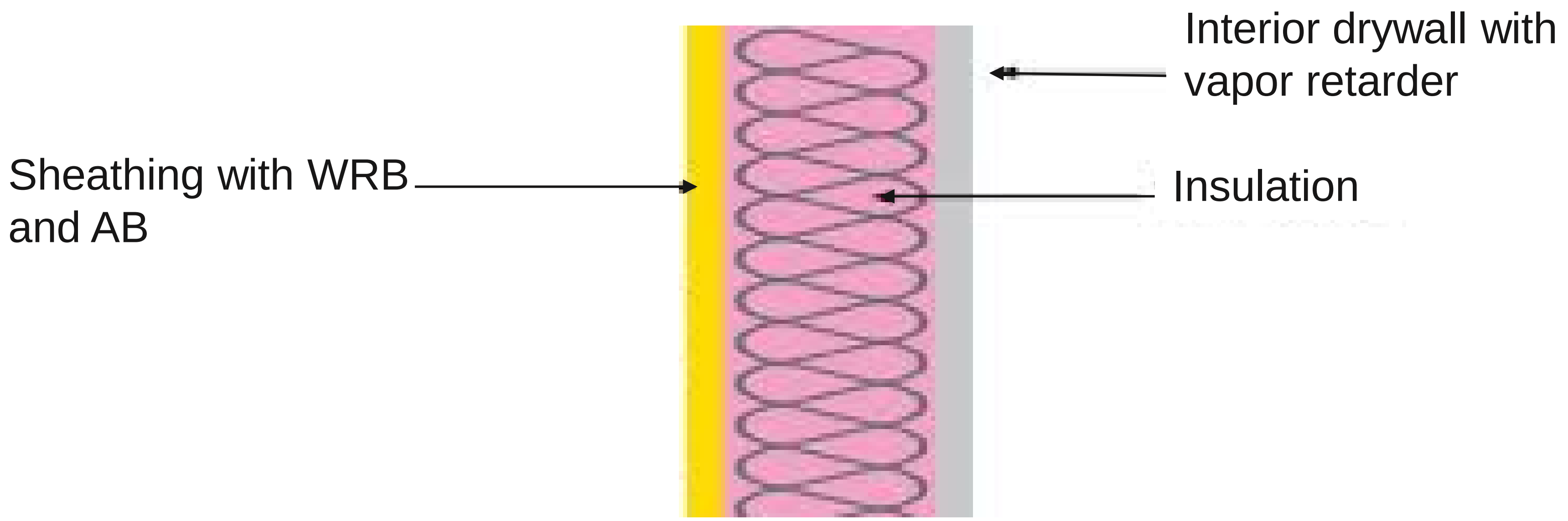
The Issue – Drying Capability – Interior

Vapor Diffusion

- WRB / AB keeps bulk water and air infiltration outside
- Best solutions need also to address vapor permeability to release moisture trapped inside the assembly
- Vapor permeable WRB/AB allow moisture to escape



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The Issue – Drying Capability - Exterior

Cladding Over WRBs and ABs

- After WRB and AB are in place, then cladding is installed
  - Masonry
  - Metal
  - Wood
  - Fiber cement
  - Other material
- Each have their own characteristics
- Each have own installation approach

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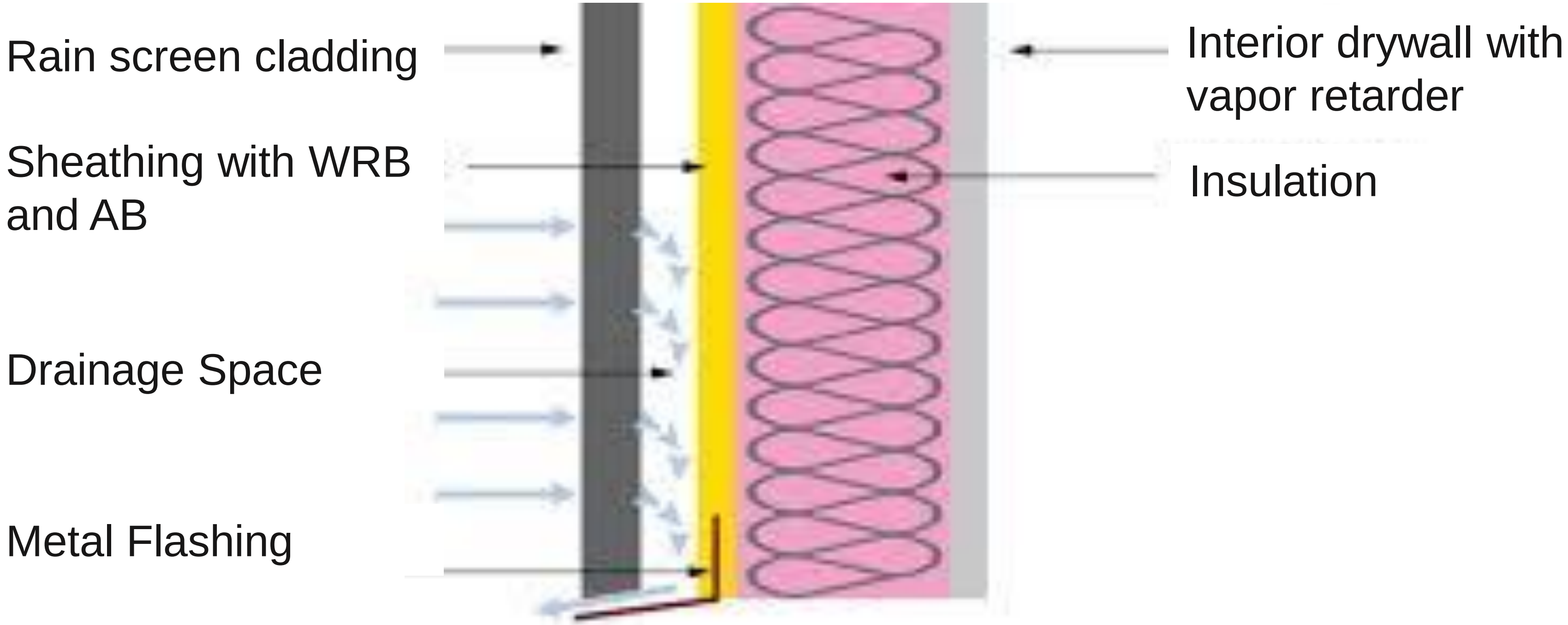
The Issue – Drying Capability - Exterior

Drainability

- Installation needs to provide a gap or air space between cladding and barriers
- This allows for water drainage down face of barriers and out through weep holes, etc.



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The Issue – Construction Technique

Common Masonry Treatment

- In masonry wall assemblies, providing a drainage space between the WRB / AB and masonry is routine
  - Rain or moisture that enters exits so as not to cause damage to the wall
  - Common flashing techniques with weep holes or other means achieve this

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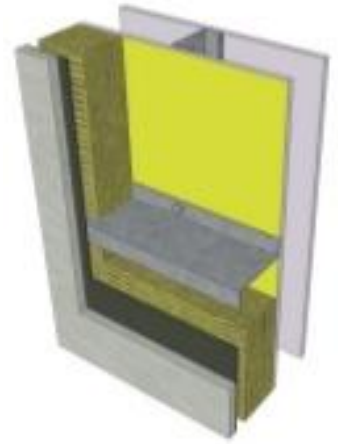
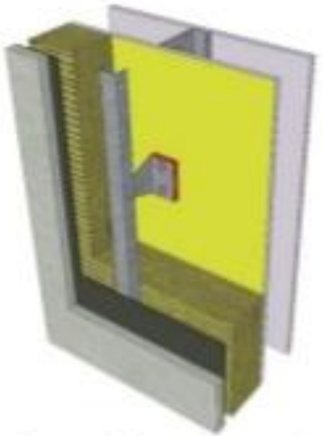
The Issue – Construction Technique

Lightweight Cladding Supports

- Many panelized cladding systems need to be supported away from the sheathing WRB/ AB
- Commonly, girts or spacers, or similar components and systems are used



Horizontal Z-girts



Thermally Improved Clip & Rail

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The Issue – Construction Technique

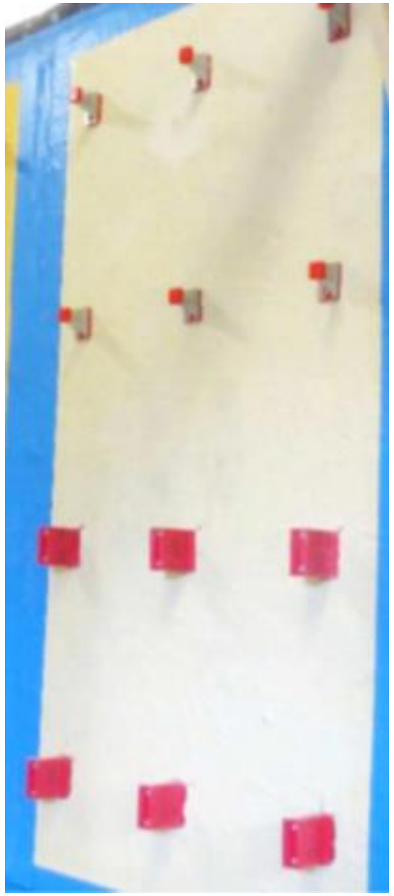
Z-Girts

- Horizontal metal z-girts are commonly used
  - Provide continuous cladding support
  - Provide space and support for rigid insulation
  - May interfere with drainage capabilities across sheathing surface

The Issue – Construction Technique

Spacer Clips

- Spaced clips fastened through face of sheathing and into framing
  - Provide spot support for cladding
  - Provide space for rigid insulation
  - Leaves space for drainage down sheathing surface



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The Issue – Construction Technique

Fasteners

- Fasteners, such as screws or bolts, are needed to secure girts, spacers, or insulation directly to exterior sheathing
  - Fasteners thus penetrate through the WRB/AB
  - In so doing, they breach the WRB-AB and can cause leakage

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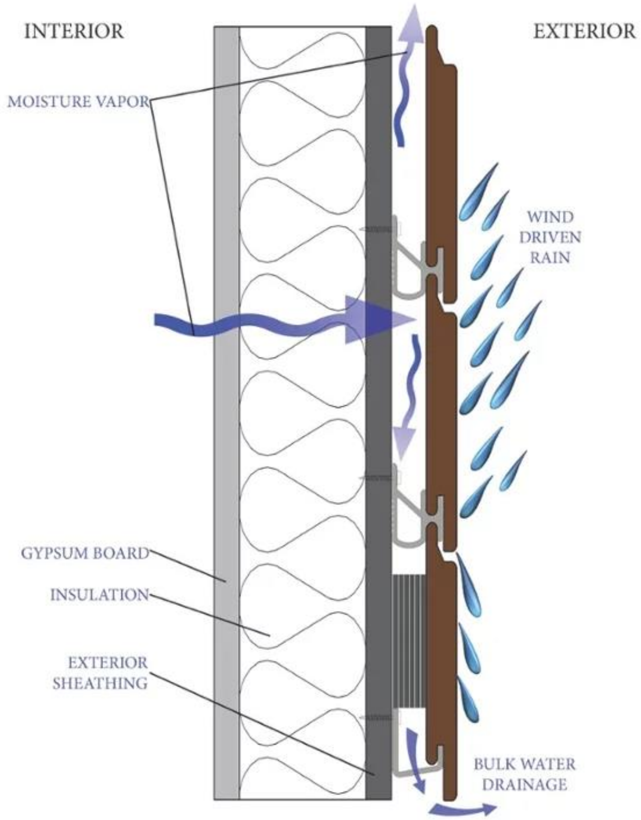
The Issue – Cladding Impact on WRB / AB

What is the Impact of Cladding Attachment?

- To determine who the "culprit" is in WRB-AB leakage need to ask:
  - How significant are the fasteners?
  - How significant are the z-girts?
  - Does the type of WRB-AB make a difference?
  - What conditions are a concern?
- Demonstration testing is needed to answer



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Part 2
The Test

Test Setup

Test Methods

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The Test

Independent Laboratory Testing

- Specific test carried out by RDH Building Sciences in Waterloo, Ontario in 2017
- RDH/ BSC founded by Joseph Lstiburek, Ph.D., P.Eng., ASHRAE Fellow
- Based on ASTM E331-00(2016), "Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference"
  - *ASTM International, West Conshohocken, PA, 2016, www.astm.org*

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The Test - Setup

Test Wall Panels

- Six test wall panels were constructed for testing
    - All of the test panels were representative of commonly used systems that are code-compliant
    - Five of the 4'x8' panels focused on fasteners for cladding support

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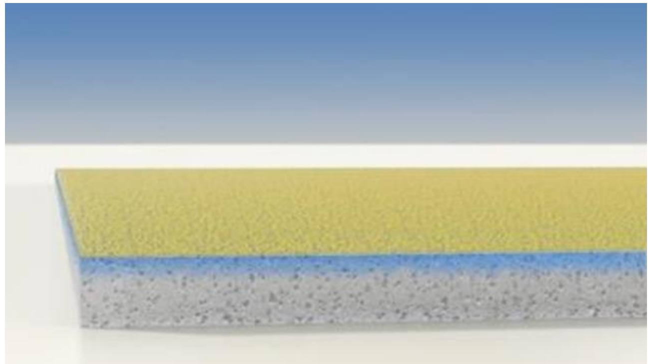
The Test - Setup

Test Wall Panels

- Three WRB systems employed:
  - Thin mil fluid-applied WRB
  - Thick mil fluid-applied WRB
  - Integrated sheathing



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The Test - Setup

Test Wall Panels

- Two different cladding attachment clips
  - Fiberglass thermal spacers
  - Thermally broken metal

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The Test - Setup

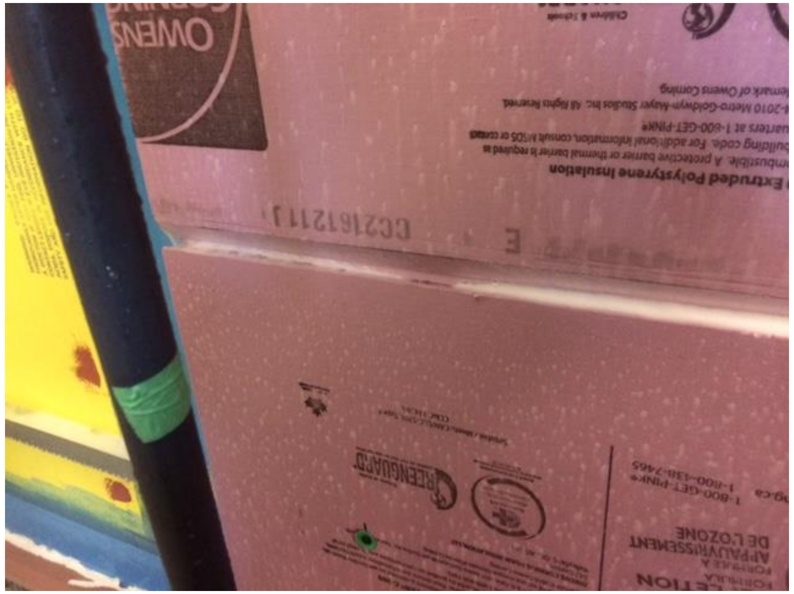
Test Wall Panels

- Two different metal z-girt arrangements
  - Flange down
  - Flange up (as commonly seen in the field)

The Test - Setup

Test Wall Panels

- One of the 4’x8’ test panels used two inch thick XPS insulation board directly over sheathing
  - Attached using 4 inch long, self-drilling, self-tapping screws with large (1 inch diameter) plastic cap washers
  - Top edge of insulation was cut to bevel backwards toward wall, forcing some water behind insulation



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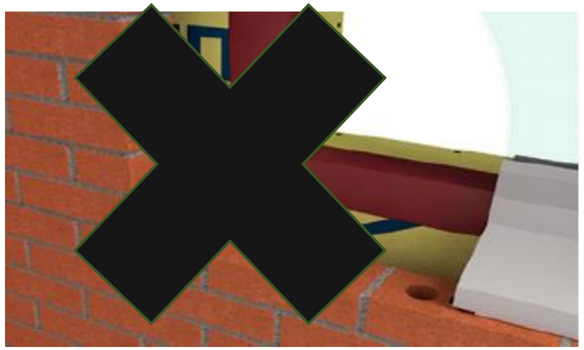
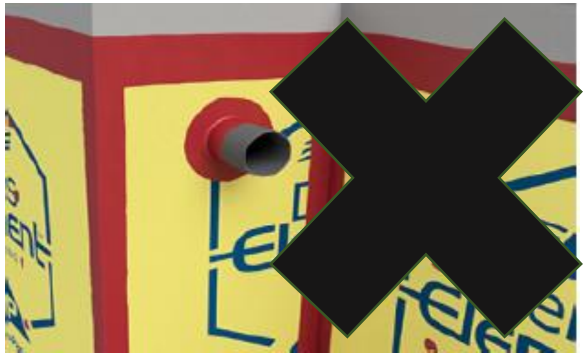
The Test - Setup

Test Wall Panels

- 4’x8’ panels did not contain any other locations for water to penetrate other than cladding support connections
  - There were no windows, pipe penetrations, joints, material transitions, or other designed water entry locations.





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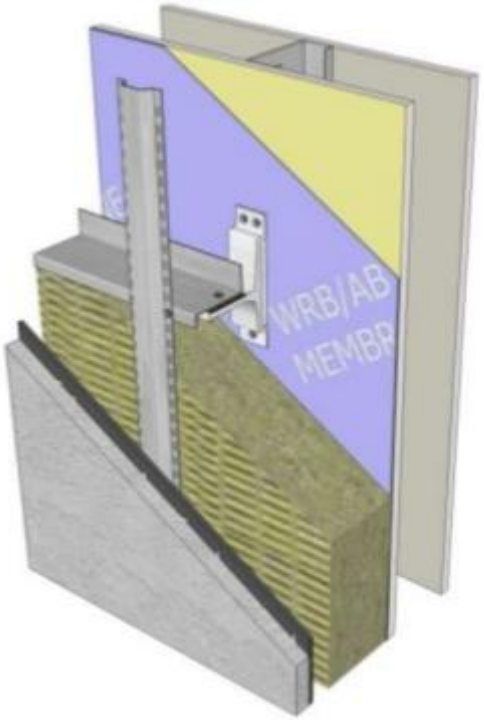
The Test – Methods Employed

Test Methods

- In order to test differing installation techniques, two cladding attachment methods were used to secure clips and z girts:
  - Tightly against the sheathing or WRB surface
  - Spaced away from the sheathing or surface with different spacer thicknesses to allow water to flow behind the attachment



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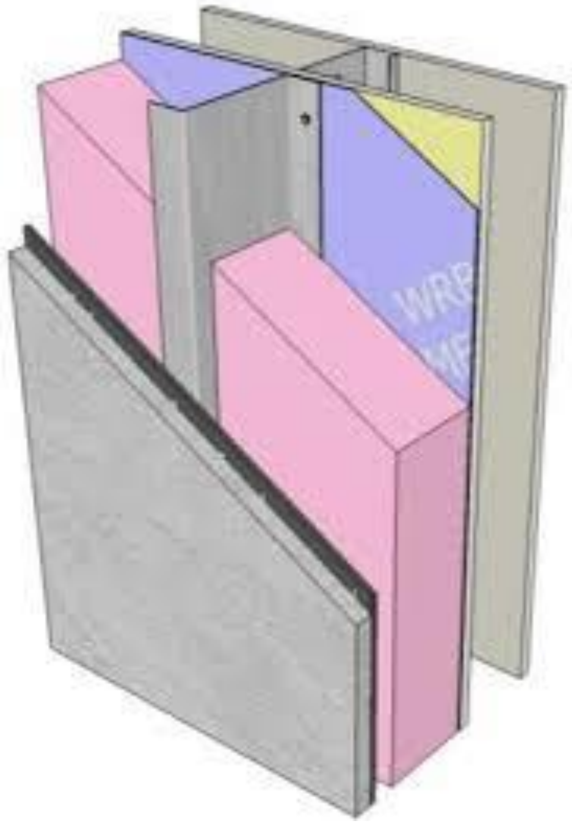
The Test – Methods Employed

Test Methods

- Rigid insulation board installed in a similar manner:
  - one section tight to the sheathing
  - two other sections spaced away from the sheathing at different spacing thicknesses to create a gap between the back of the insulation and exterior face of the sheathing



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The Test – Methods Employed

Test Methods

- Water spray nozzles were set up facing the test wall sections (simulating rain conditions) all according to ASTM E331
- Negative pressure conditions were also created between the two sides of the wall (simulating wind conditions) also per ASTM E331 protocols
- Intent of testing was to take assemblies to the point of failure

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The Test – Methods Employed

Test Methods

- Code compliant water resistance testing levels require a continuous spray of 5.0 gallons per hour per square foot for a period of 15 minutes
  - Actual water application rate was higher at 7.5 gallons per hour per square foot and longer at a full 60 minutes
  - Same water spray application was repeated for an additional 60 minutes for each of 5 different air pressure conditions – i.e. five hours of total testing instead of 15 minutes.

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The Test – Methods Employed

Test Methods

- Air pressure requirements for code compliance:
  - 140 paschals (Pa) (equivalent to wind of approximately 25 miles per hour)
- Test actually included five different conditions:
  - 0 Pa -calm wind conditions
  - 300 Pa- winds of 55 miles per hour
  - 600 Pa- winds of 71 miles per hour
  - 900 Pa- winds of 85 miles per hour
  - 1250 Pa -winds of 100 miles per hour

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Part 3
The Test Results

Performance under stress

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The Test – Results Observed

Test Results

- Under **normal weather conditions** (i.e. the code required level of water spray and wind air pressure/ wind) water did not penetrate into the wall cavity through the cladding attachment fasteners in any of the assemblies

The Test – Results Observed

Test Results

- All of the test panels ultimately leaked (i.e. reached failure) as intended due to the intense water and air pressure conditions created

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The Test – Results Observed

Test Results

- Observations when leaks occurred at higher water and air pressure levels determined that:
  - The **means of attachment** had the most bearing on why the assemblies leaked when subjected to the test conditions
  - The **type of WRB used did not appear to affect the results** in this case – water that found a penetration followed that penetration into the assembly

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The Test – Results Observed

Test Results

- In general, if **the cladding fasteners were installed tight to the sheathing** or fluid-applied WRB surface, water did not penetrate around the fasteners and the assemblies didn't leak.
- Likewise, if **the cladding fastener was installed so it was adequately spaced away from the wall surface,** allowing the water to drain behind the cladding attachment, the assemblies didn't leak.

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The Test – Results Observed

Test Results

- Overall, testing showed that **leakage can occur in extreme weather conditions** when cladding attachment systems use fasteners that penetrate the WRB-AB **regardless of the WRB-AB solution.**
- This reinforces the need for good drainage, vapor diffusion, and drying potential in exterior wall design.

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Part 4
Best Practices

Lessons Learned

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Climate and Construction Factors Identified

FACTORS
Climates
Building exposure
Building form
Architectural complexity
Cladding
Cladding attachment design

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Best Practices

Low Risk Climate and Construction Factors

FACTORS	LOW RISK CLIMATE ZONES AND CONSTRUCTION FACTORS
Climates	Dry
Building exposure	Low-rise urban
Building form	Small, simple box design
Architectural complexity	Extensive protective overhangs, no balconies
Cladding	Closed joint cladding
Cladding attachment design	Non-load bearing, tie back to sheathing with drain/vented space

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Medium Risk Climate and Construction Factors

FACTORS	MEDIUM RISK CLIMATE ZONES AND CONSTRUCTION FACTORS
Climates	Mixed
Building exposure	Mid-rise urban, low-rise rural, hilltop, coastal
Building form	Medium size, mix of simple and complex assemblies
Architectural complexity	Small to no overhangs. Few bumpouts and balconies
Cladding	Direct applied cladding
Cladding attachment design	Knife edge, or bayonet, load bearing clips, with drain space

Best Practices

High Risk Climate and Construction Factors

FACTORS	HIGH RISK CLIMATE AND CONSTRUCTION FACTORS
Climates	Coastal
Building exposure	High-rise urban, mid-rise rural, hilltop, coastal
Building form	Large, complex assembly of boxes
Architectural complexity	Frequent bumpouts, balconies, articulated façade
Cladding	Open joint cladding
Cladding attachment design	Continuous, full depth, horizontal/ vertical girts no drain gap behind girt

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Best Practices

Climate Risk and Construction Factors

Factors	**Low Risk** Climate Zones and Construction Factors	**Medium Risk** Climate Zones and Construction Factors	**High Risk** Climate Zones and Construction Factors
Cladding Attachment Fastener Penetrations	Follow Manufacturer Instructions	Follow Manufacturer Instructions PLUS wet-set cladding attachment fasteners	Follow Manufacturer Instructions PLUS wet-set cladding attachment fasteners PLUS seal the top edge to shed water and add bottom drainage holes

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Best Practices

Climate Risk and Construction Factors

Factors	**Low Risk** Climate Zones and Construction Factors	**Medium Risk** Climate Zones and Construction Factors	**High Risk** Climate Zones and Construction Factors
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Note that best practices relate to a variety of factors, so these all need to be taken into account when deciding when to implement an additional step - i.e. what makes sense in Seattle may not make sense in Phoenix.

Conclusions

Main Take-Aways

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Conclusions

1. Fasteners in Cladding Support Can Leak in Heavy Weather Events

- Testing has identified the real culprits in leakage through fasteners that support cladding systems.

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Conclusions

2. Follow Best Practices Based on Building and Climate Conditions

- Incorporating the best practices learned from this testing will help assure better performance of the WRB-AB in exterior walls.

Factors	**Low Risk** Climate Zones and Construction Factors	**Medium Risk** Climate Zones and Construction Factors	**High Risk** Climate Zones and Construction Factors
Cladding Attachment Fastener Penetrations	Follow Manufacturer Instructions	Follow Manufacturer Instructions PLUS wet-set cladding attachment fasteners	Follow Manufacturer Instructions PLUS wet-set cladding attachment fasteners PLUS seal the top edge to shed water and add bottom drainage holes

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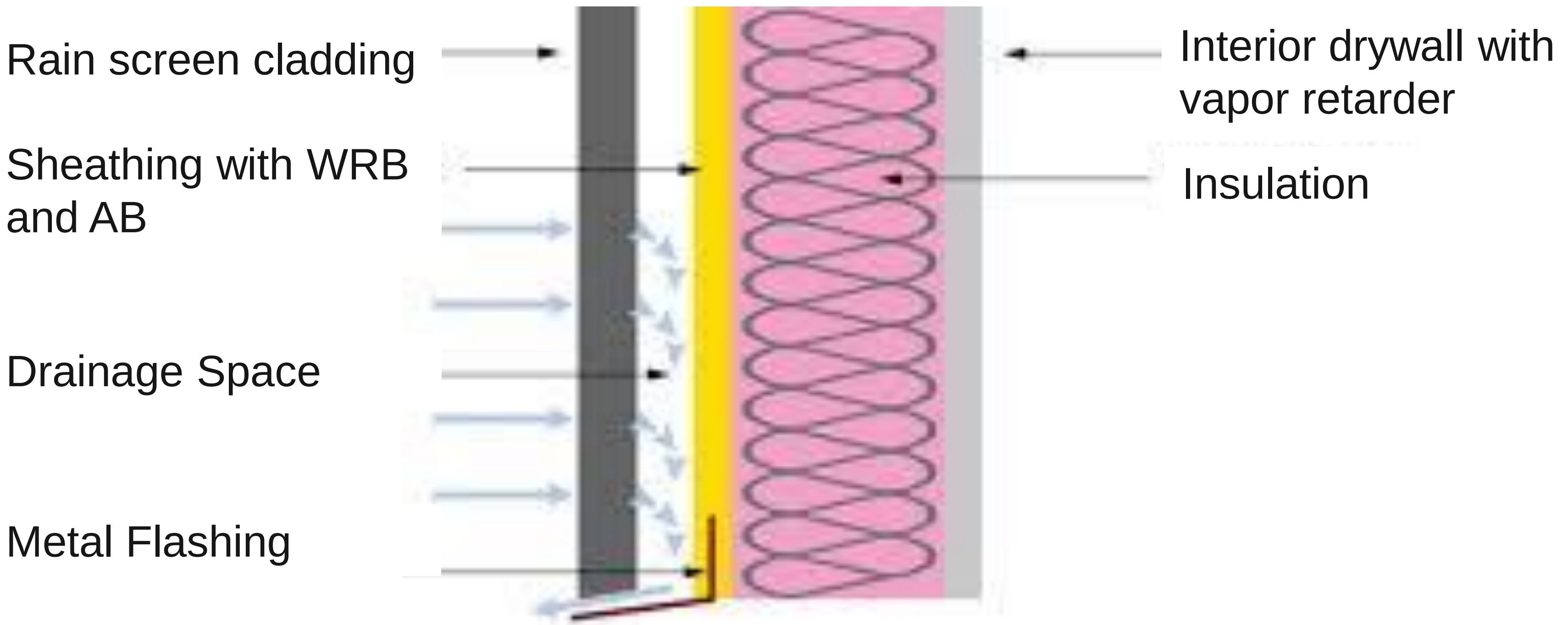
Conclusions

3. Employ WRB and AB Strategies that Provide Drainable and Dry-able Wall Assemblies

- In addition to pure WRB and AB membranes, provide construction techniques that address drying potential and vapor diffusion/permeability



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Who’s the Culprit in WRB-AB Leakage?

Thank you for attending.

QUESTIONS AND ANSWERS

This completes the AIA Continuing Education Presentation.

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