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BUILDING ENCLOSURE CONFERENCE 2023

At the Roof Edge: Intersection of Design and Performance

Jennifer Keegan and Andrea Wagner

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At the Roof Edge:

Intersection of Design & Performance

The roof to wall intersection is the junction where building aesthetics meets structural performance, air and moisture management, energy efficiency, construction trade sequencing, and operational maintenance. At such a critical interface, proper parapet detailing, installation coordination, and execution are paramount.

How do you achieve performance at the roof to wall interface without compromising the aesthetics over the edge of the roof? How can the design anticipate the construction phase coordination efforts and sequencing between masons, carpenters, and roof and wall subcontractors, and provide a constructible and integrated building solution? This session will provide guidelines to successfully navigate these often competing interests and provide strategies for achievable performance through design and specification without compromising the aesthetics with distracting details over the edge of the roof.

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Learning Objectives

1. Understand requirements to manage condensation risk through air barrier continuity.
2. Understand code requirements and how to achieve compliance.
3. Outline design and specification requirements to set achievable performance.
4. Develop critical details where the roof and wall intersects.

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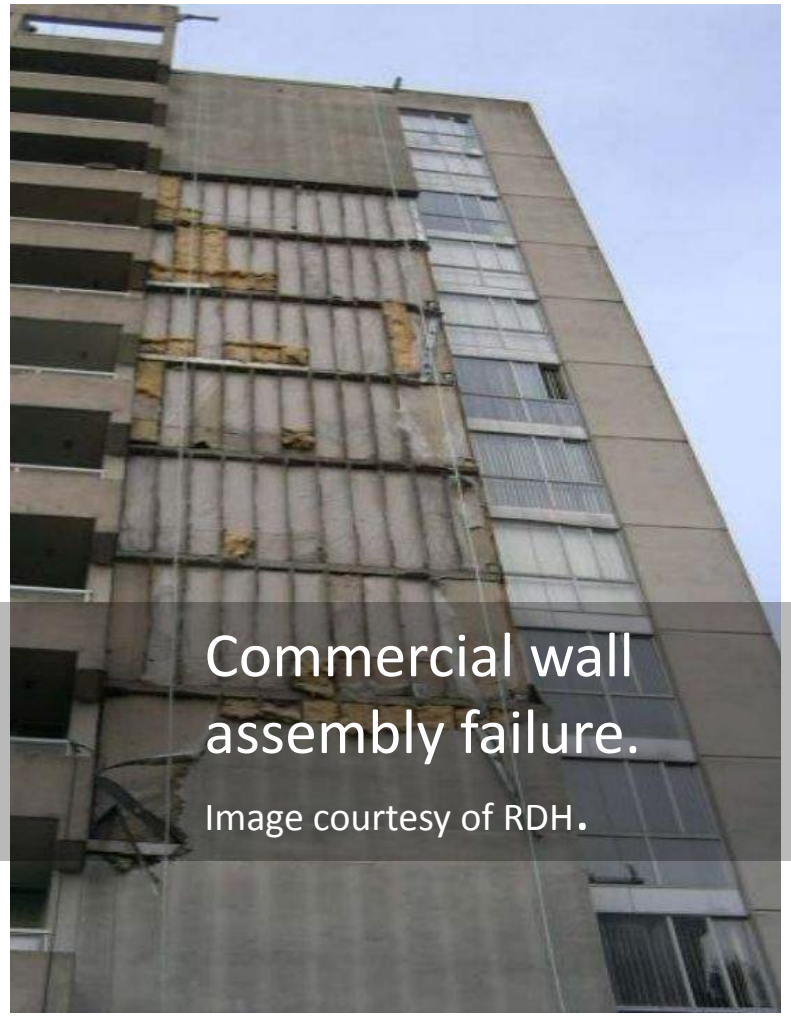
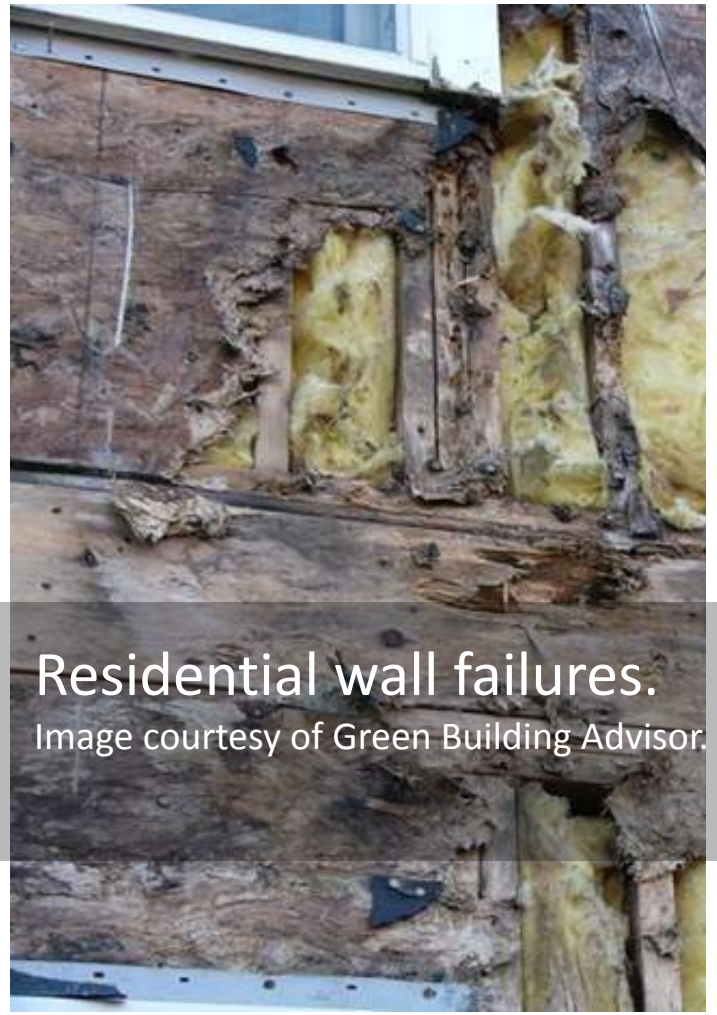
Air Barriers - What Can Go Wrong?



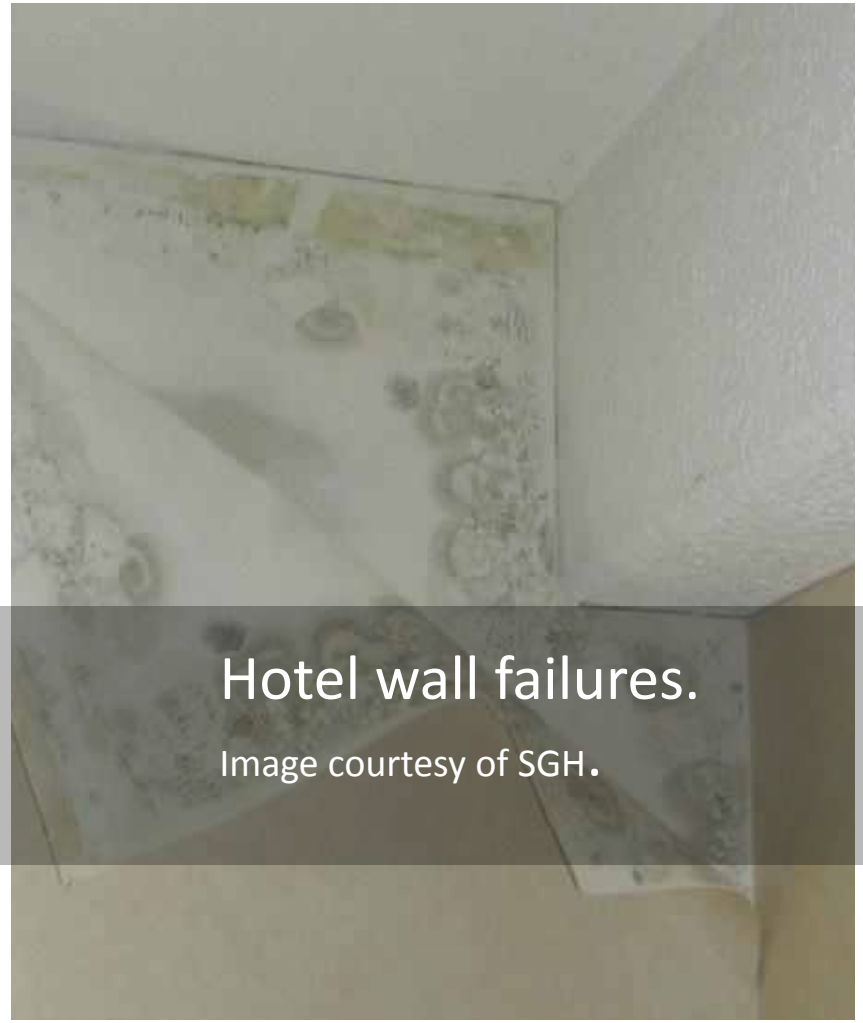
Commercial wall assembly failure.

Image courtesy of RDH.



Residential wall failures.

Image courtesy of Green Building Advisor.



Hotel wall failures.

Image courtesy of SGH.

Air Barriers - What Can Go Wrong?

Wind Uplift failure.
Image courtesy of StEER.

Air Barriers - What Can Go Wrong?

Commercial roof failure.
Image courtesy of Phil Dregger.

Air Barriers - What Can Go Wrong?

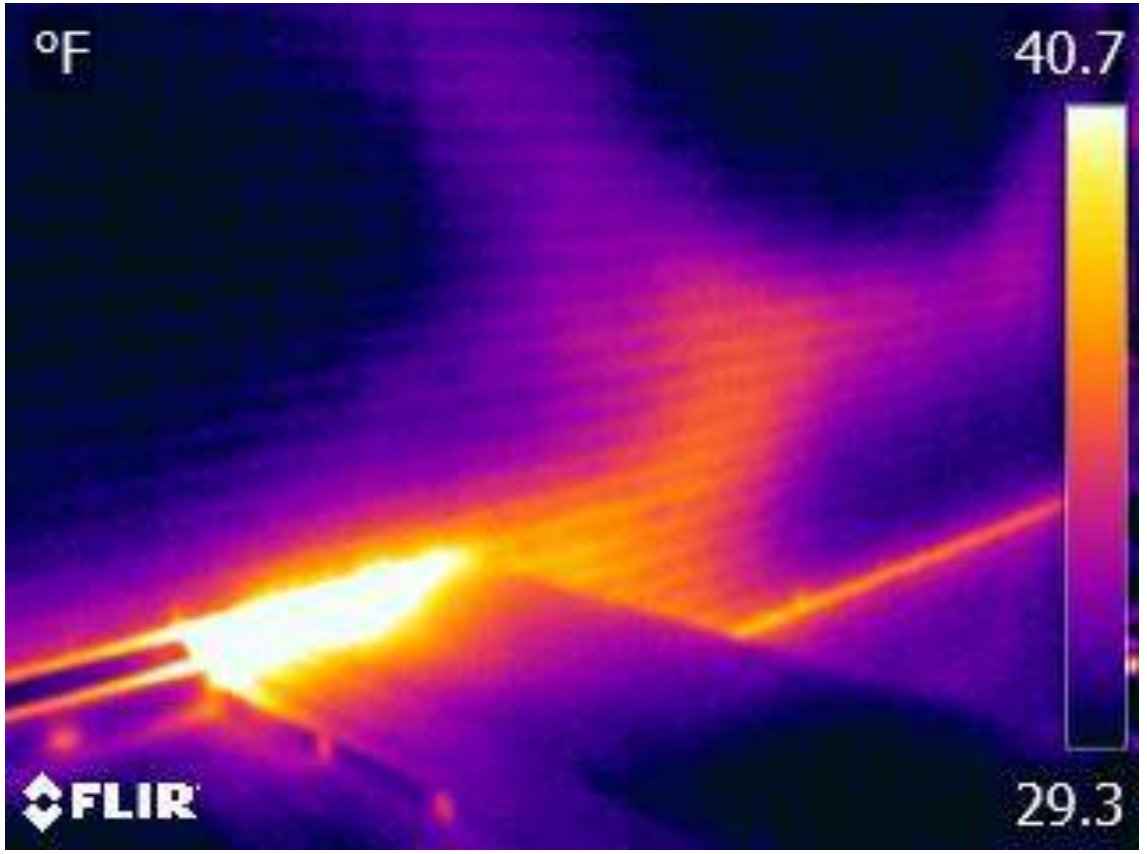
Commercial building failure at parapet.
Image courtesy of Intertek

Managing Condensation Risk

Air Leakage

Video courtesy of QEConsultants

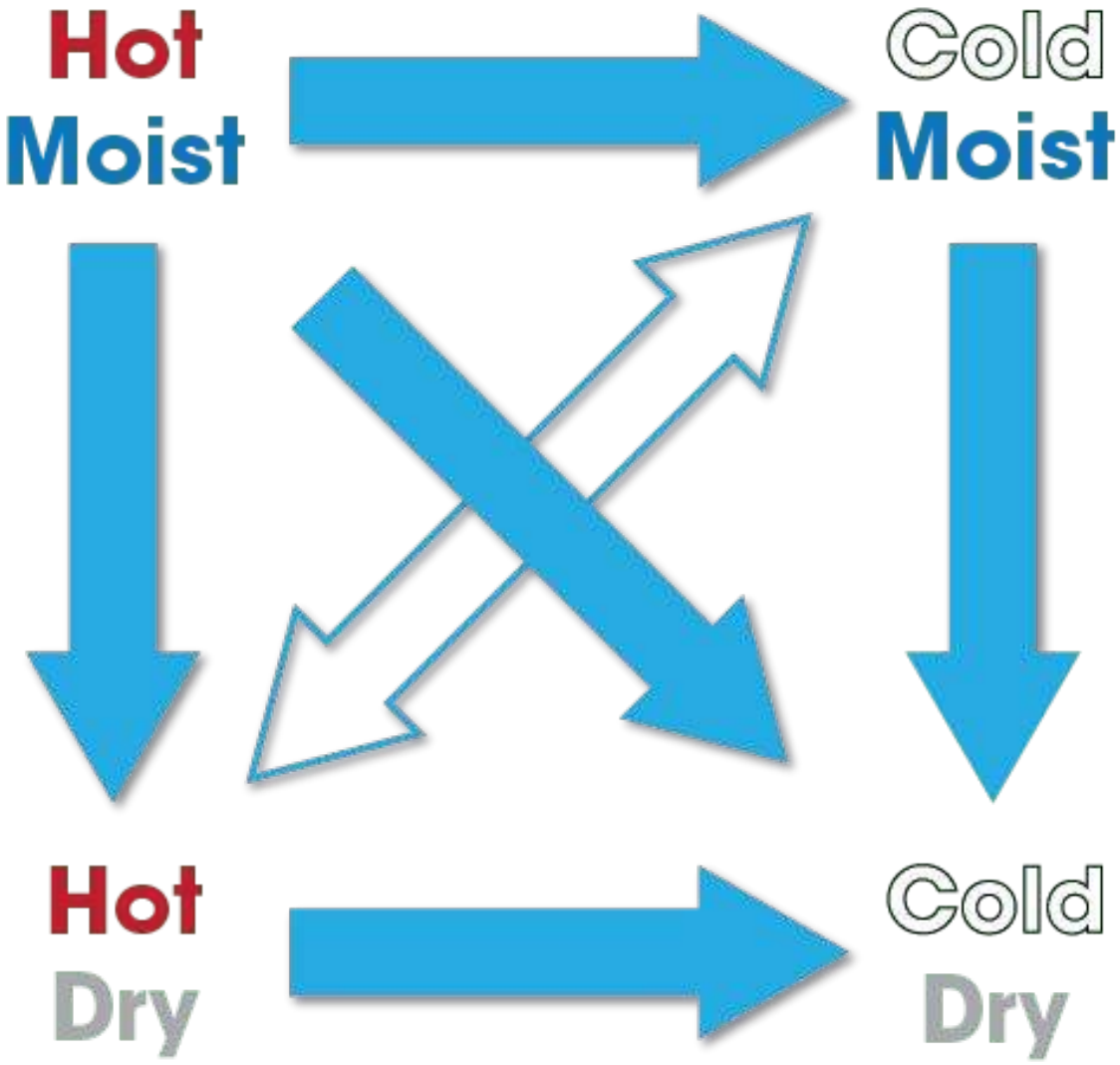
Air Leakage visible using Infrared Thermography



Images courtesy of SmithGroup

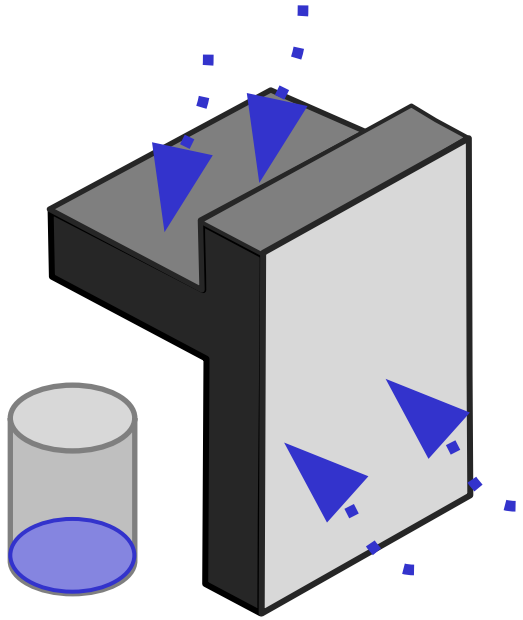
Condensation

Principles of Thermodynamics



Controlling Air/Vapor - Condensation

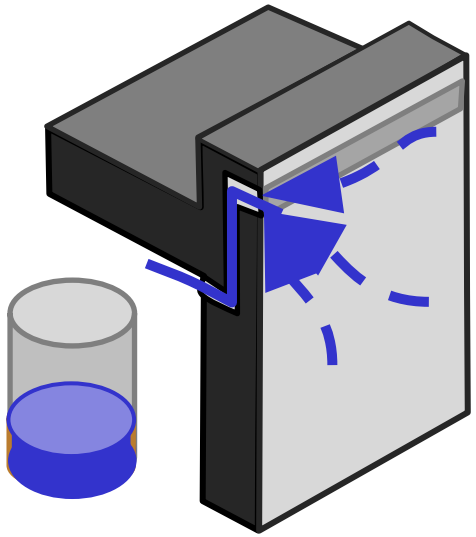
Air Transports up to 100 X's more moisture than diffusion



Diffusion (moisture vapor)

1x

- Limiting vapor diffusion shouldn't be a primary moisture strategy.
- Avoid placement of unintended vapor barriers within assemblies.

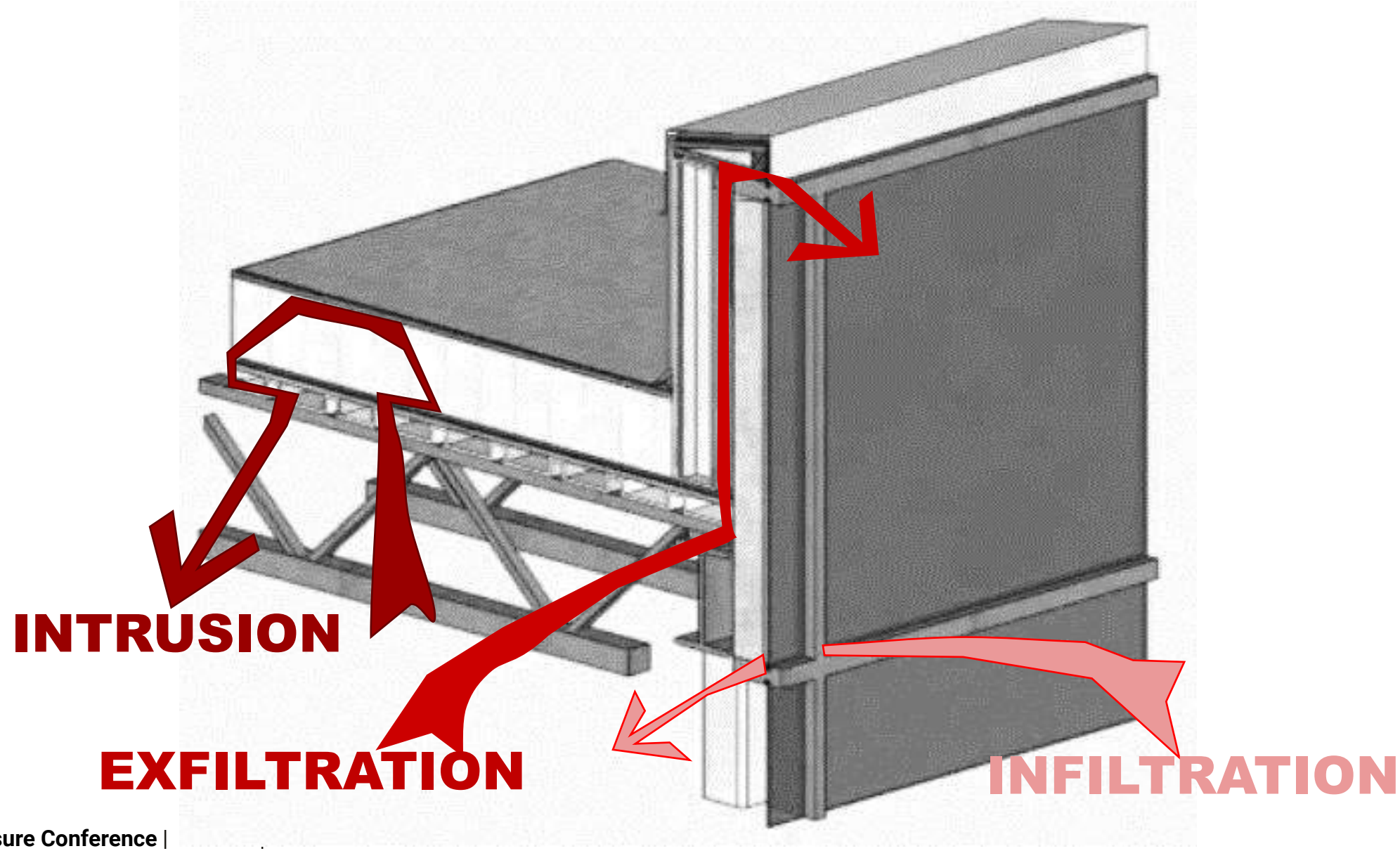


Air Transport (moisture vapor) 100x

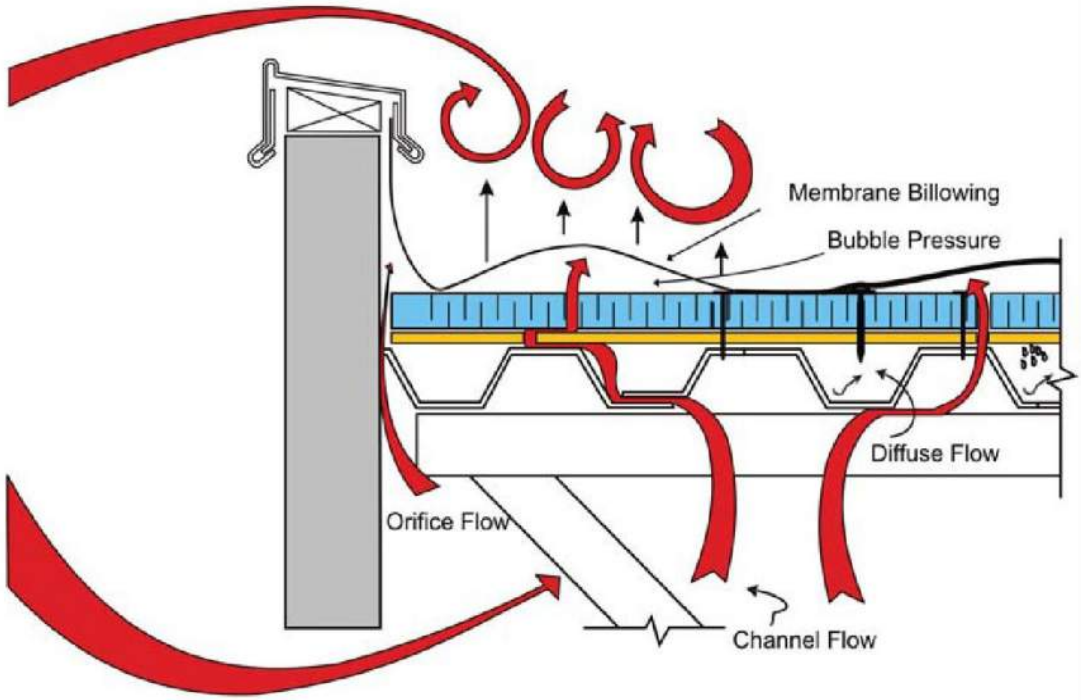
- Ensure design is constructible and continuous across assemblies.
- Perform construction verification and onsite performance testing.

Keep your air barrier warm to avoid most condensation

Air Movement vs Air Leakage



Controlling for Air and Vapor



Graphics courtesy of National Research Council of Canada

Wind Uplift

- Determine Wind Pressures to include in performance spec
- Perimeters, corners, and edge metal are more susceptible to damage

Energy Efficiency

- Air infiltration and exfiltration are key contributors to heat loss and gain
- Detail for continuity of air barrier

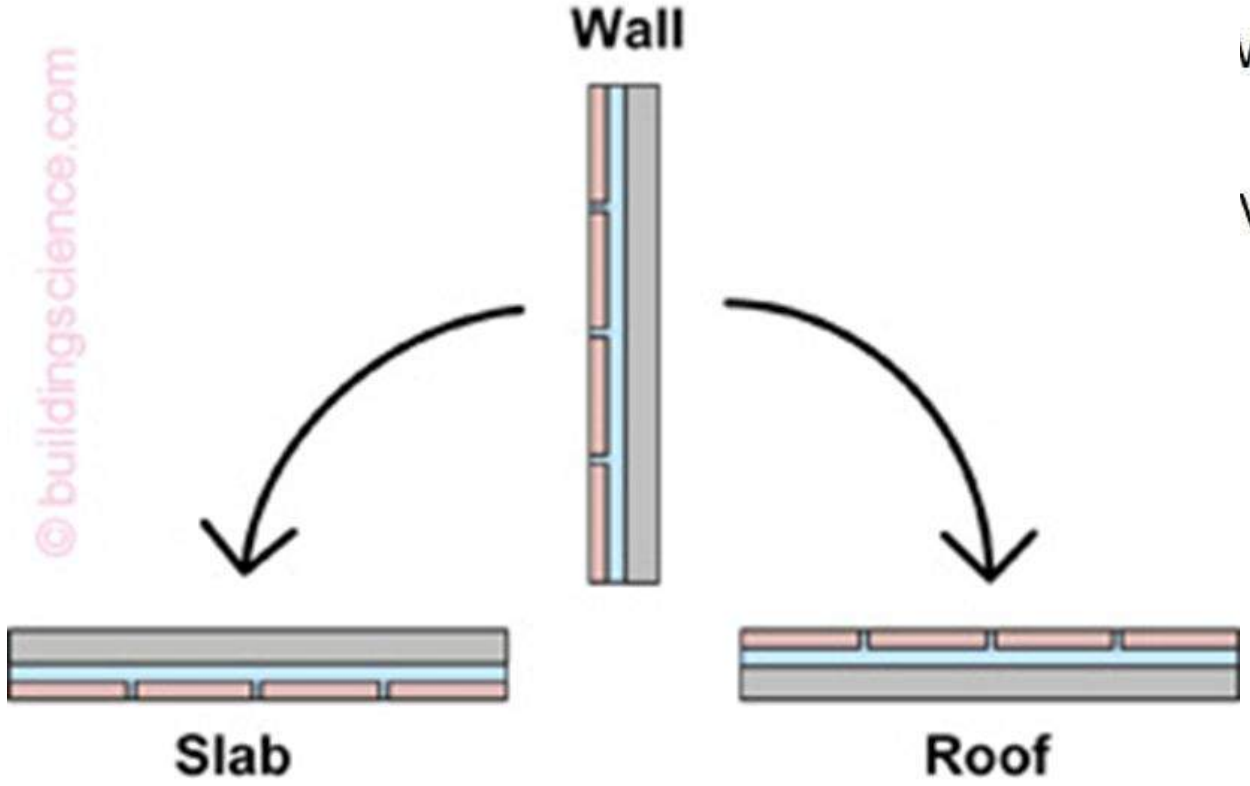
Condensation

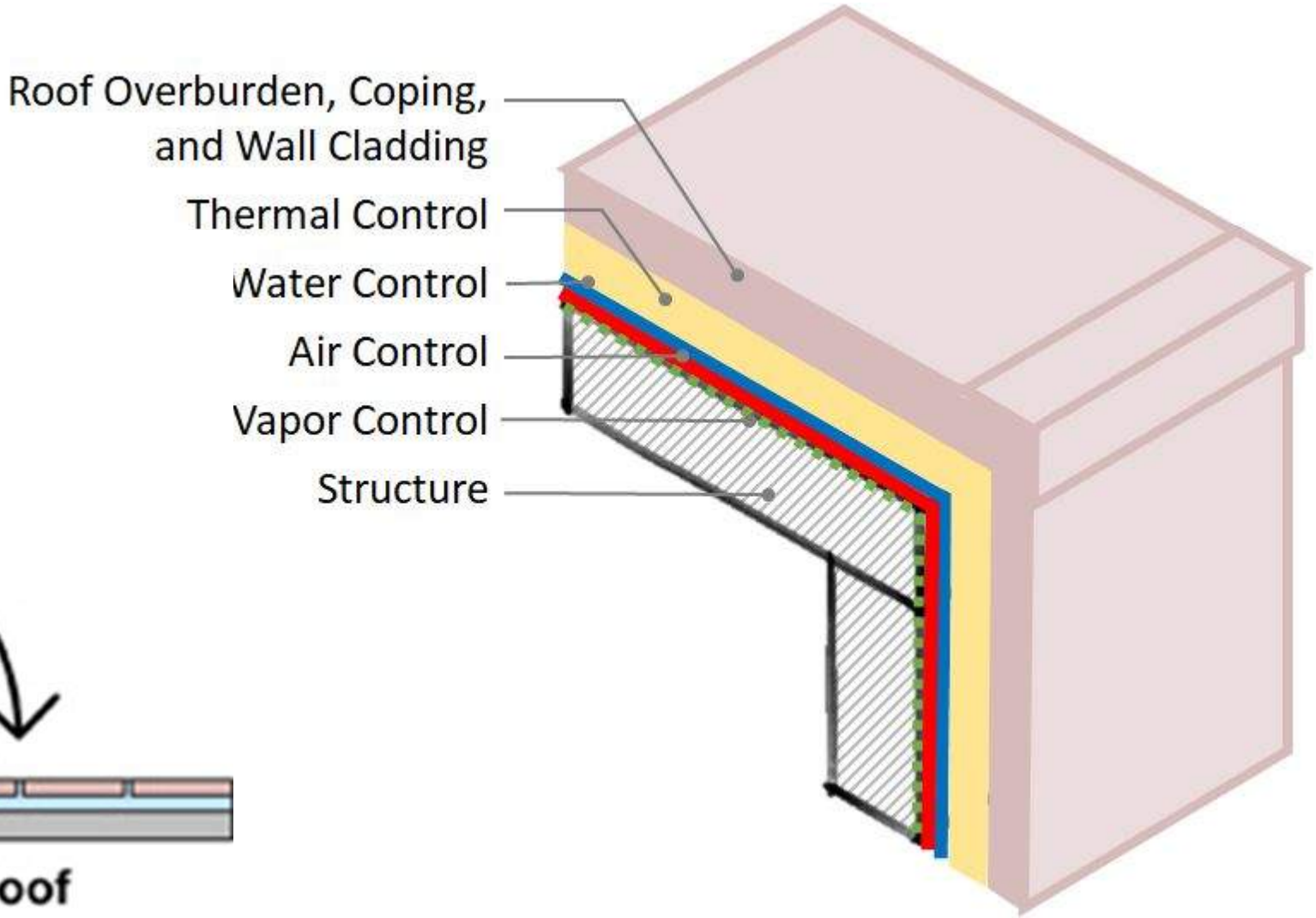
- Provide continuous air barrier on warm side of insulation to limit risk of condensation
- Vapor barriers or retarders may be required depending on climate and building use


United Rentals

Achievable Performance and Compliance

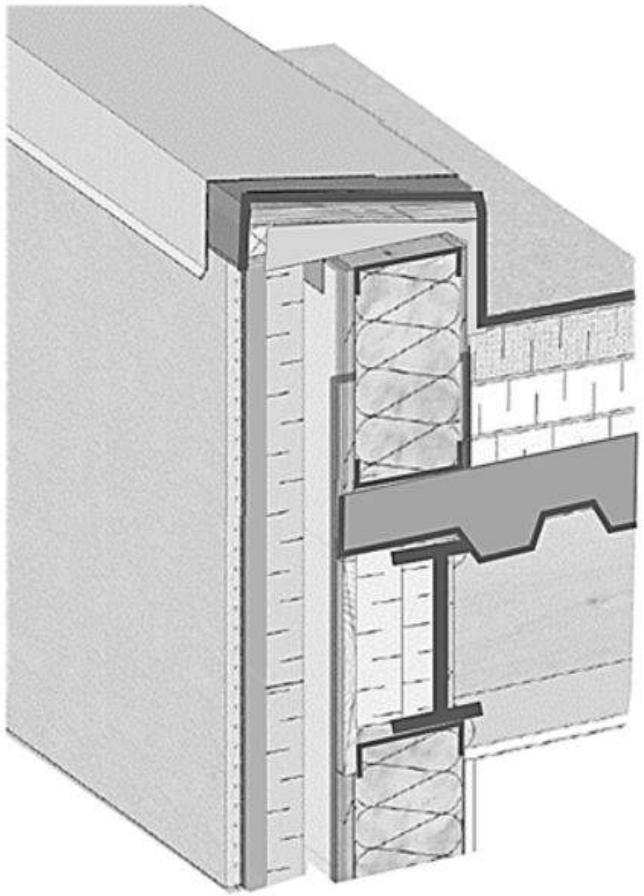
The "Ideal" Roof to Wall Scenario

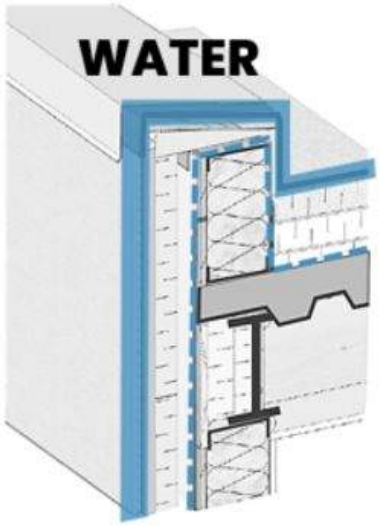


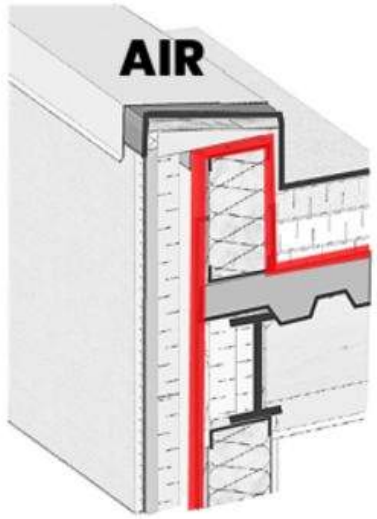


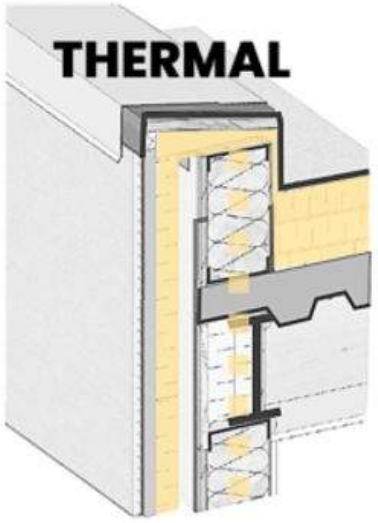
Control Layers

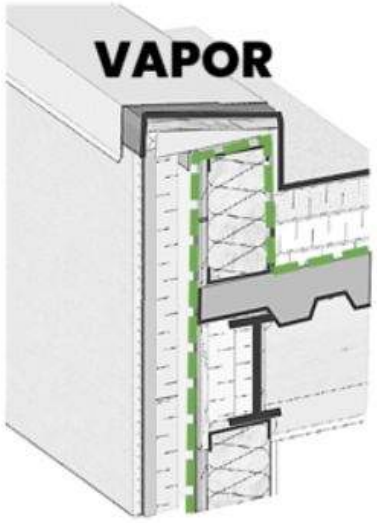
Control layers become more complicated when the roof meets the wall at the parapet condition







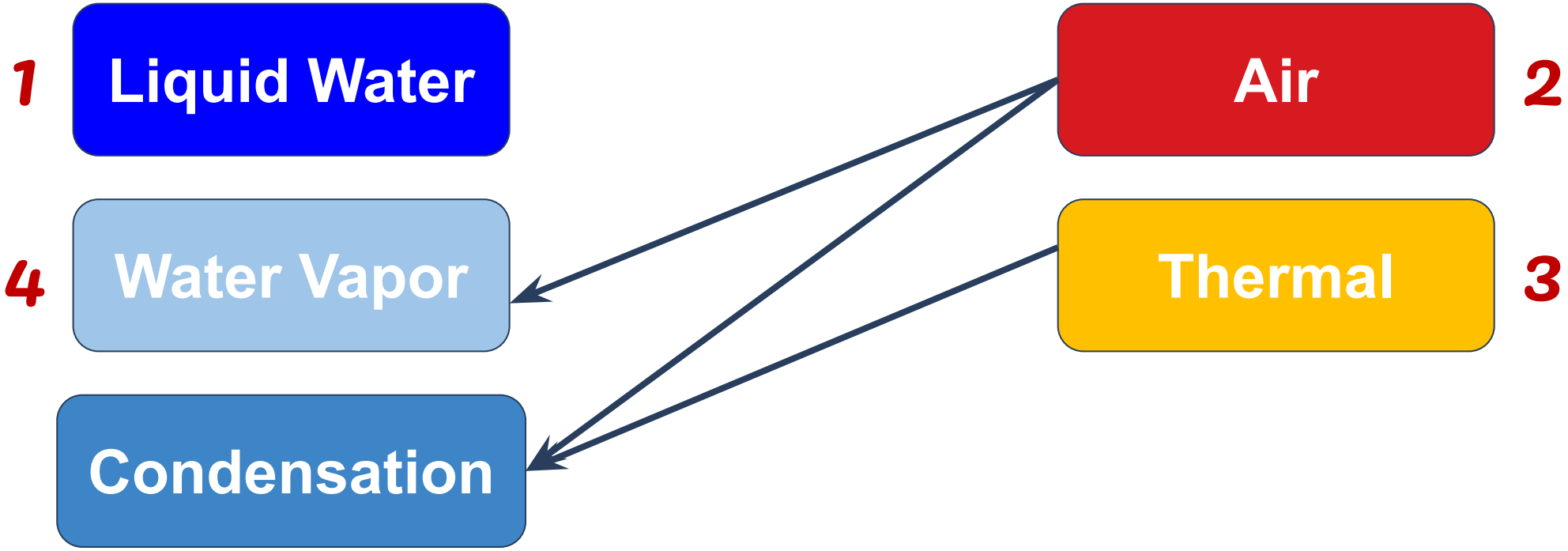




Control Layers

Moisture Management

Energy Efficiency



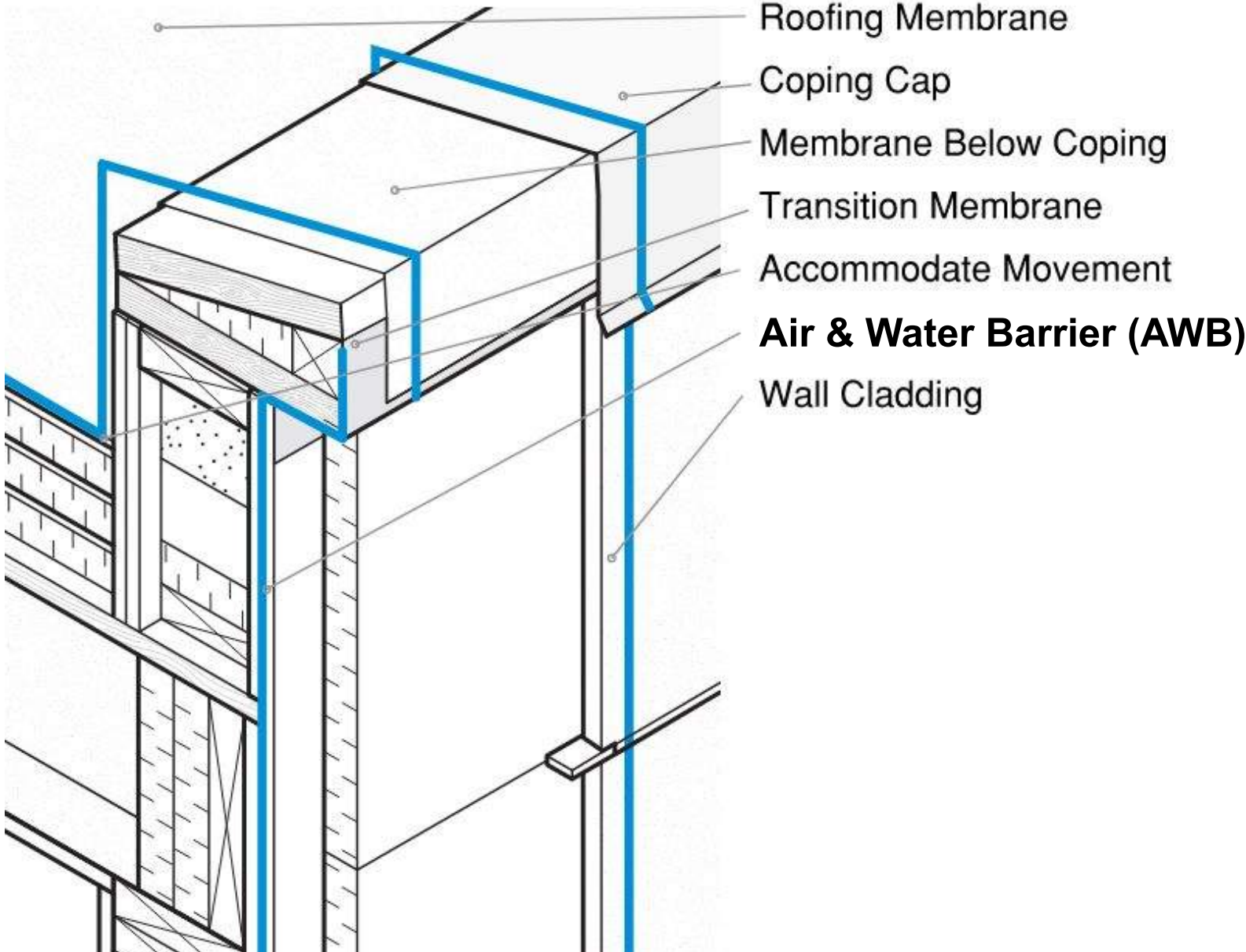
WATERcontrol – Principles

Water Control Continuity Across Roofs & Walls

Membrane Continuous Under Coping

Slope Coping Inward

Drip Edges

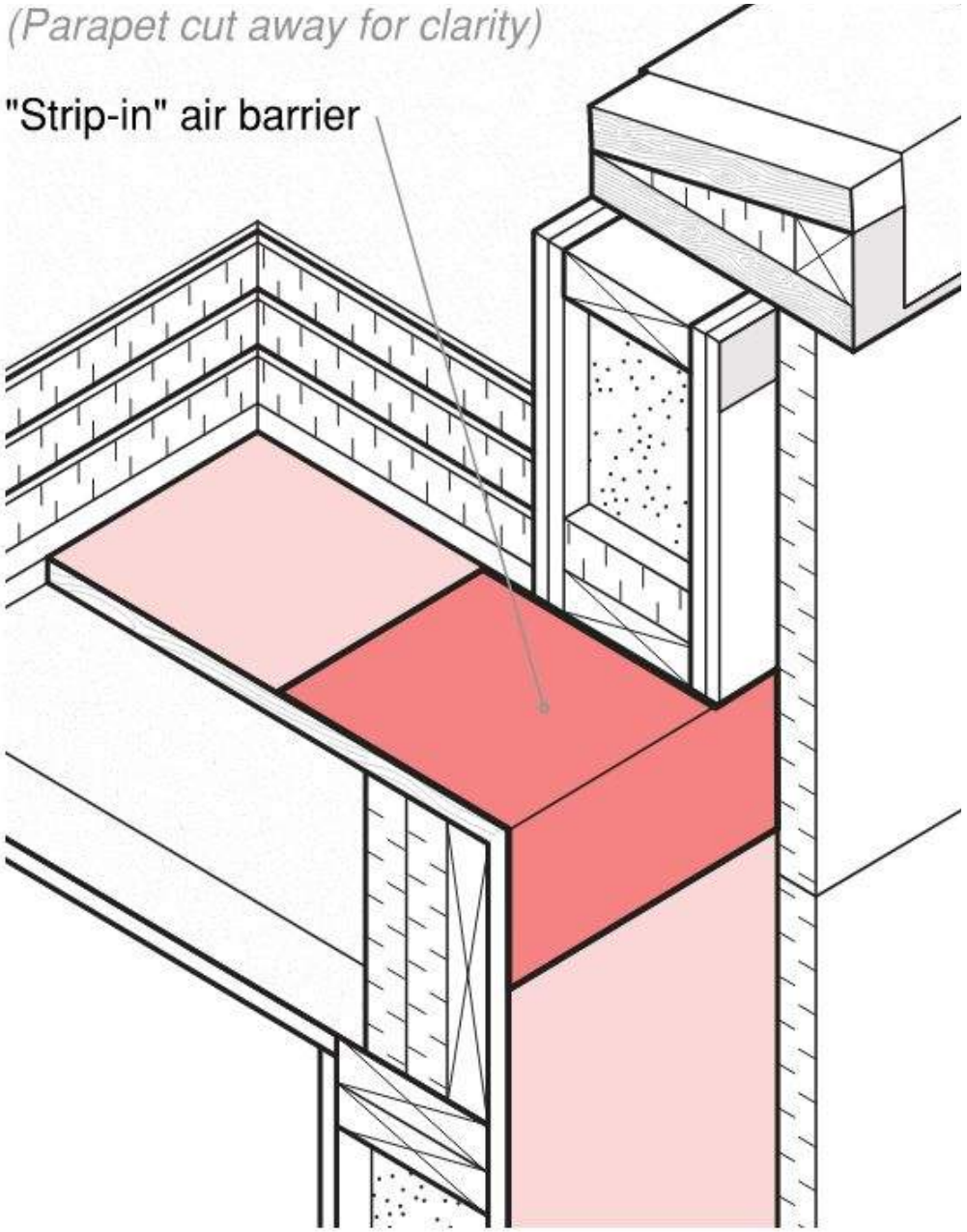


AIRcontrol – Principles

Continuity in Roofs and Walls

Responsibility of Registered Design Professional

IECC Section C103.2.1

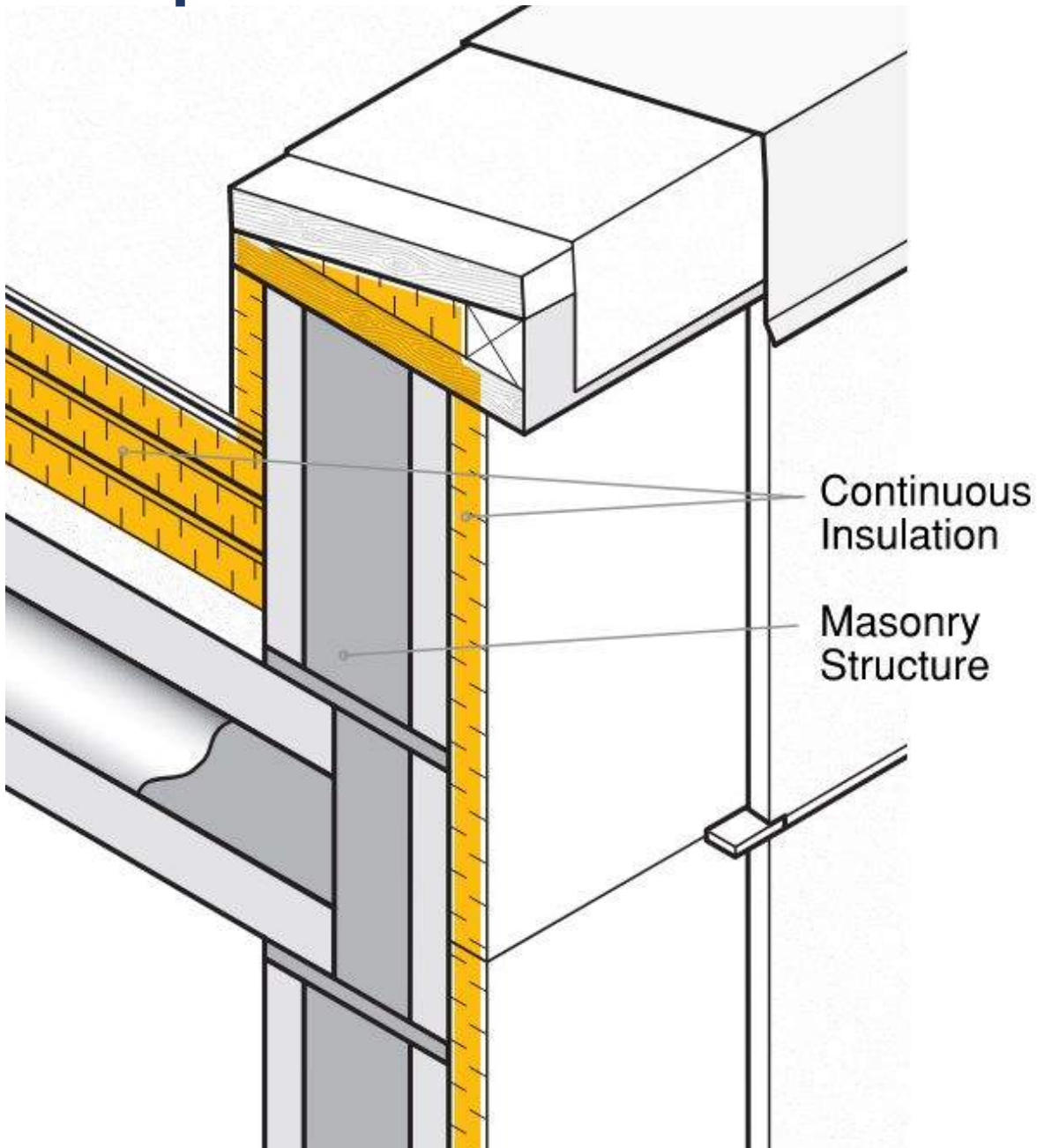


THERMALcontrol – Principles

Continuity of Thermal Control Layers in Roofs and Walls

Transfer of Thermal Movement

Thermal Envelope Depiction – IECC C103.2



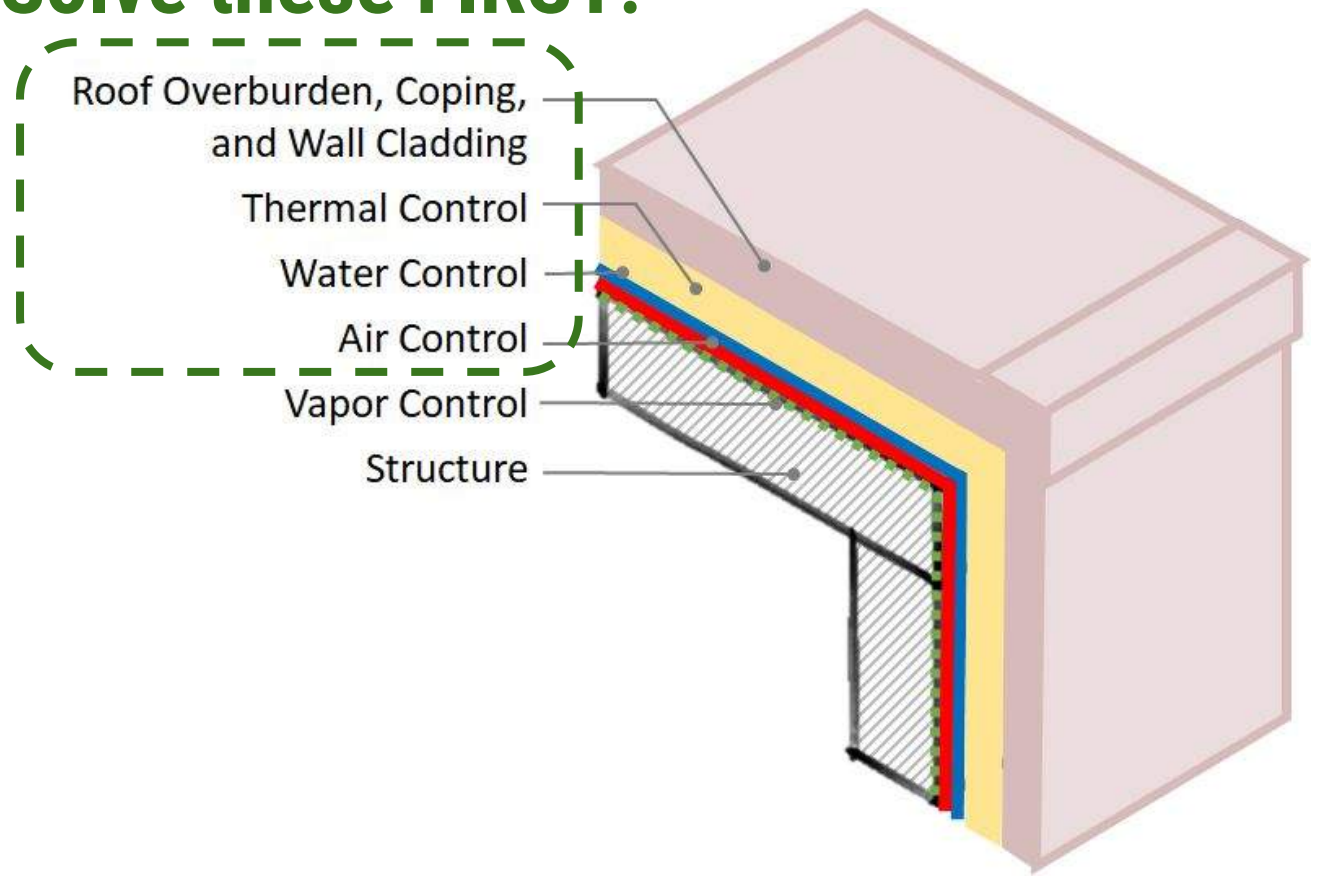
VAPORcontrol – Principles

Continuity of Vapor Control Layers in Roofs and Walls

Permeability & application appropriate for assembly, location and occupancy

Avoid placement of ***unintended*** vapor barriers within assemblies

Solve these FIRST!



VAPORcontrol - Materials

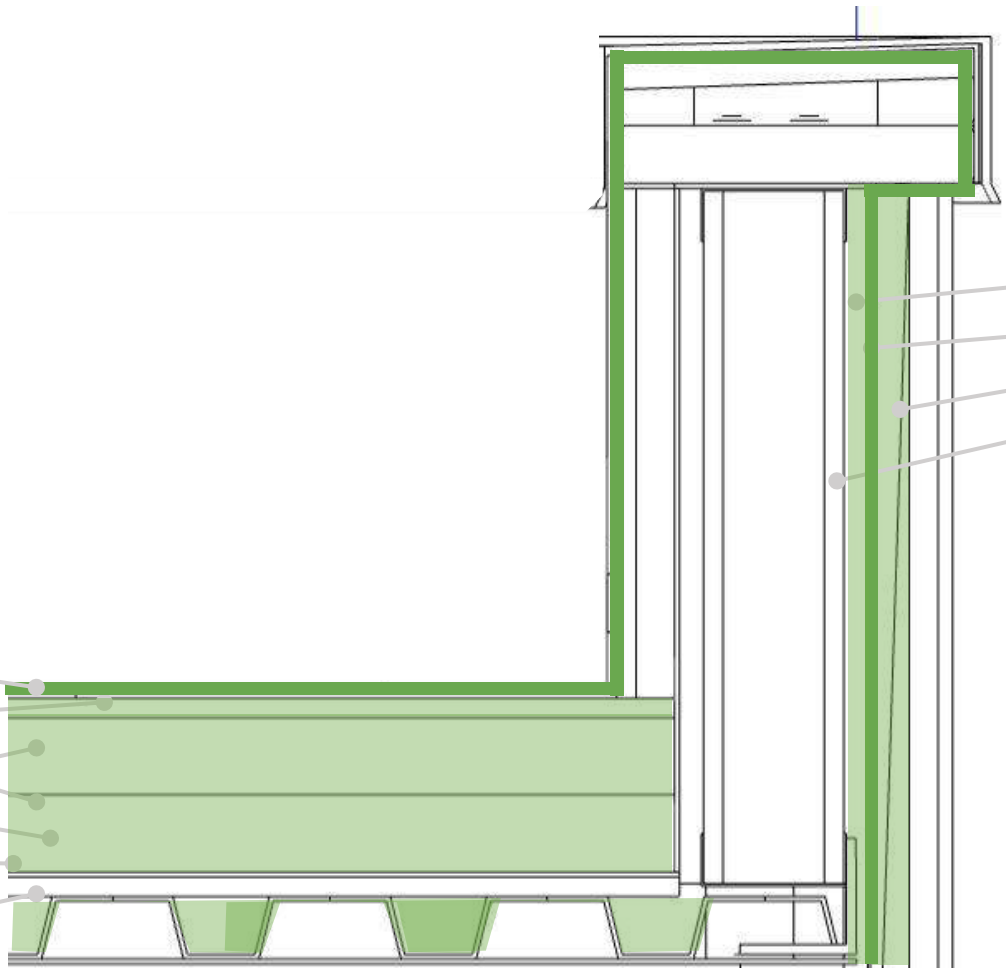
Material	Perm Rating	Classification
Built-Up Roofing Membrane	0.00 – 0.02	Impermeable (Vapor Proof) ≤ 0.1 Perm
Single-Ply Membrane	0.03 – 0.06	
Polyethylene Film	0.06 – 0.08	
Asphalt Felt	0.3 – 0.8	Semi-Impermeable > 0.1 ≤ 1.0 Perm
Polyiso Roof Insulation	1.0	
Extruded Polystyrene	1.0	
Expanded Polystyrene	1.2	Semi-Permeable > 1.0 ≤ 10.0 Perm
Wood Fiber	3.0 – 5.0	
Gypsum Board	30.0 – 50.0	Permeable > 10.0 Perm

Graphics courtesy of Griffin & Fricklas (2006)

Vapor Diffusion occurs when water molecules (vapor) in the air pass through a solid material due to a pressure differential (high to low) on either side of the material.

MOST of the materials in assembly "**Limit Vapor Diffusion**" (less than 10 US Perms), But which one **STOPS condensation**?

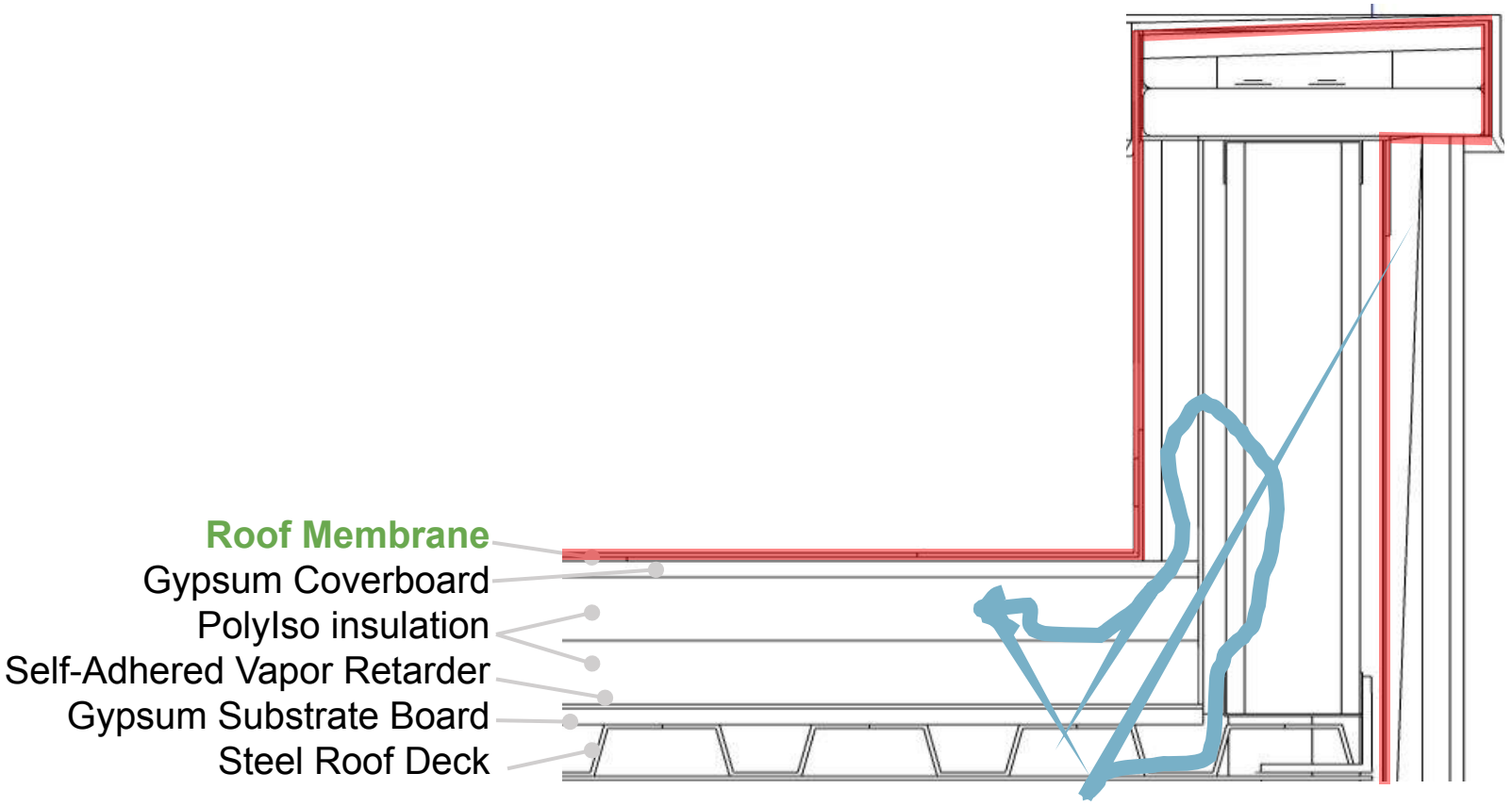
Vapor Control



Exterior Gypsum Sheathing
Low Permeance Air Barrier
Continuous insulation
Steel stud

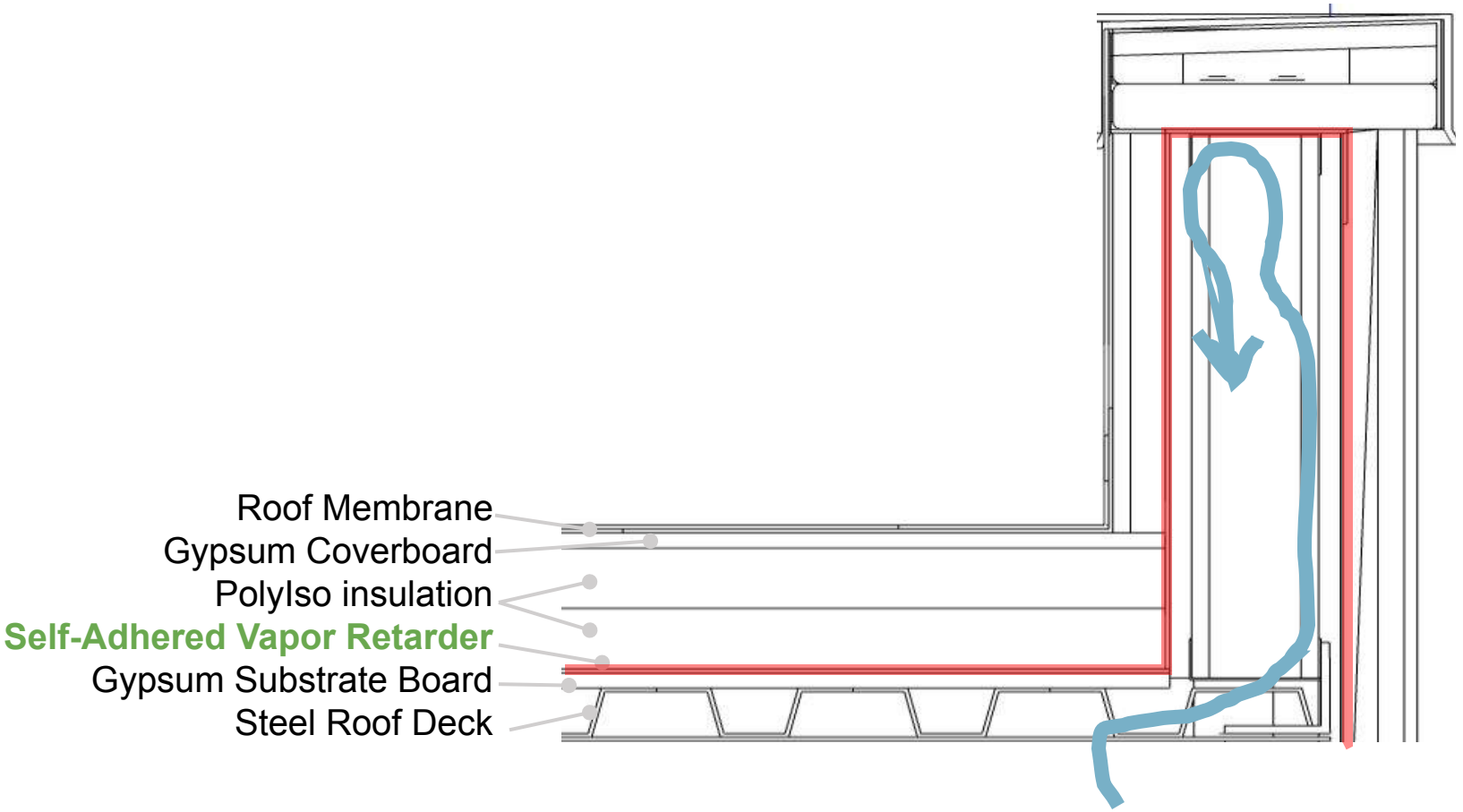
Roof Membrane
Gypsum Coverboard
Polyiso insulation
Self-Adhered Vapor Retarder
Gypsum Substrate Board
Steel Roof Deck

CONDENSATIONcontrol



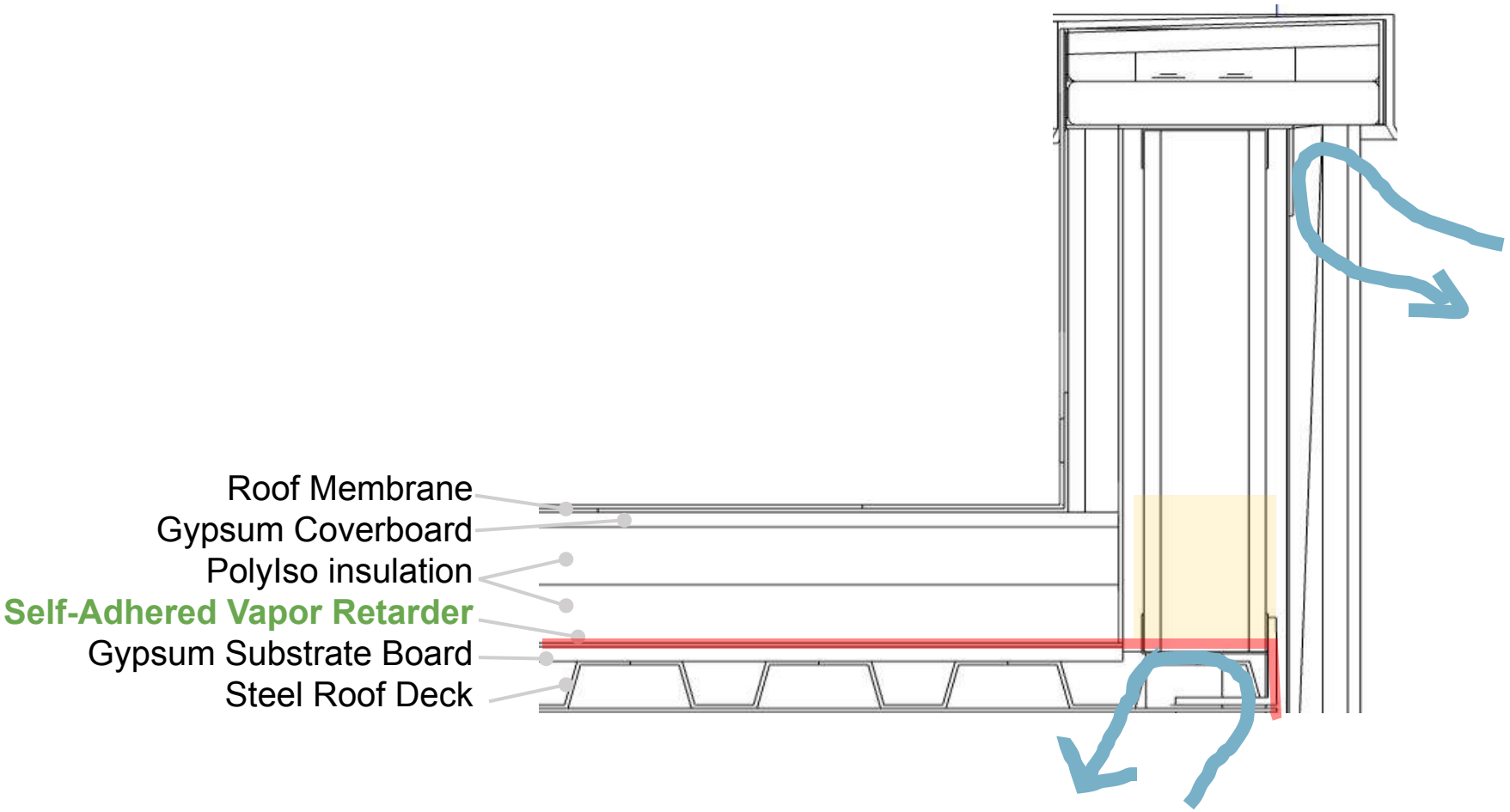
If the **roof membrane** is designed as the **continuous air barrier**, then **AIR INTRUSION** can cause condensation on cold surfaces in the roof assembly

CONDENSATIONcontrol



If the **Self-Adhered VR** is designed as the **continuous air barrier**, then **AIR INTRUSION** is limited, but may condensation on cold surfaces elsewhere

CONDENSATIONcontrol

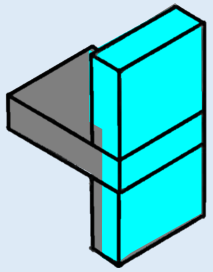


AFTER dynamic **Air Leakage** and **Air Intrusion** is managed, **THEN** a steady-state Hygrothermal analysis can be helpful to determine if there is risk of **condensation**

Code Requirements Overview

"Flashing shall be installed … to prevent moisture from entering the wall or to redirect that moisture to the exterior."

Exterior Walls (Ch.14 IBC)



Weather Protection (IBC 1402.2)

Vapor Retarders (IBC 1404.3)

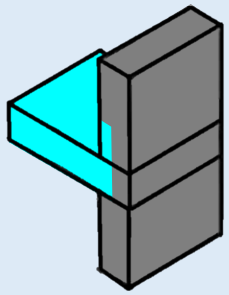
Flashing (IBC 1404.4)

Energy Efficiency (IECC & ASHRAE 90.1)

Thermal (C402 & 90.1 Ch.5)

Air Barrier - (IECC C402.5 & 90.1 - 5.4.3.1)

Roof Assemblies (Ch.15 IBC)



Weather Protection (IBC 1503)

Rqmts for Roof Coverings (IBC 1507)

Flashing (IBC 1503.2)

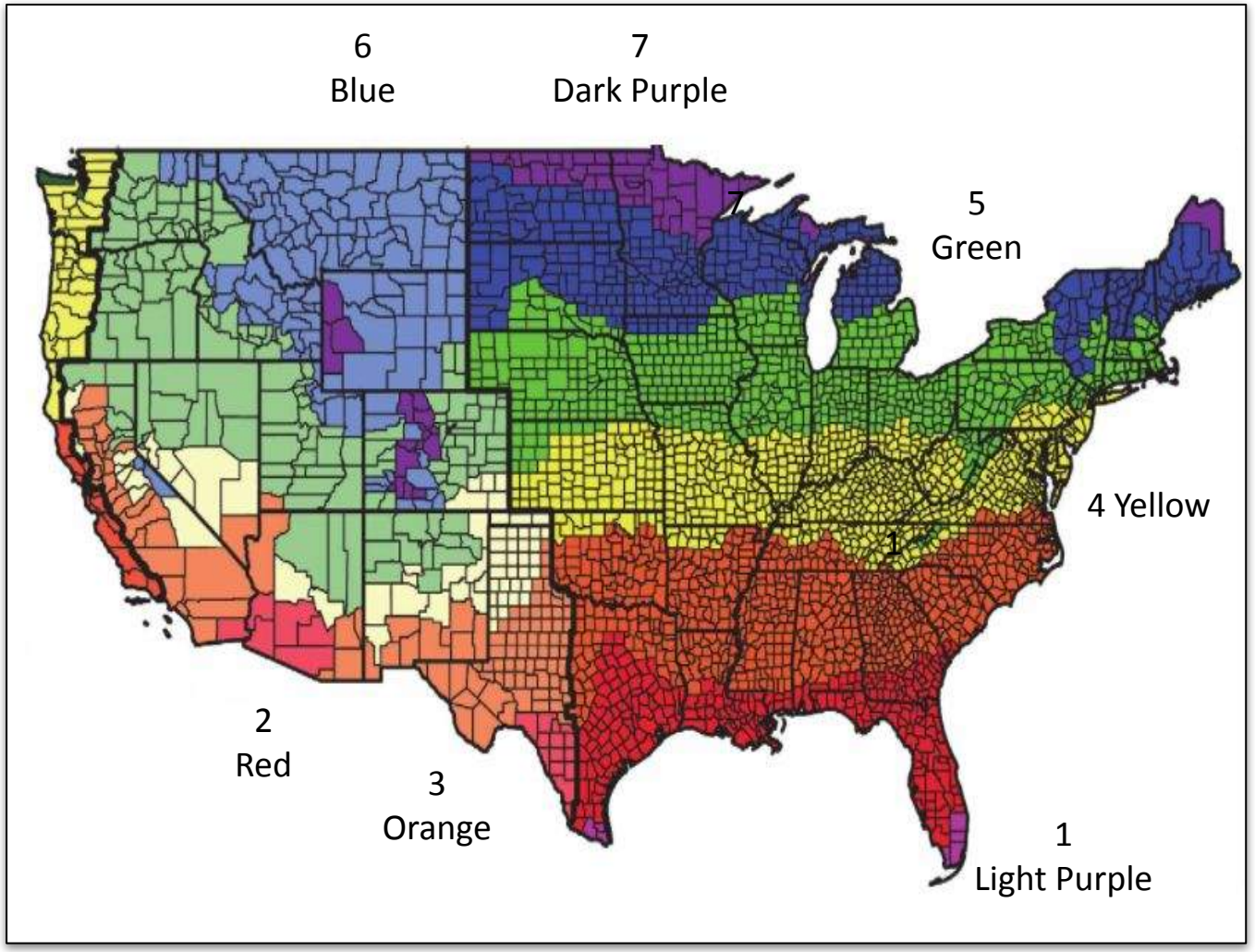
Coping (IBC 1503.3)

Wind Resistance (IBC 1504.1 & ASCE 7)

Edge Securement (IBC 1504.5 SPRI ES-1)

ASHRAE Climate Zone Map

Climate Zone Map



Roofing-specific adaptation of IECC 2012, Table C402.2 and IECC 20125/IECC 2018, Table C402.1.3 *Minimum R-value requirements for "Insulation entirely above deck"*			
Climate Zone	**IECC 2012**	**IECC 2015**	**IECC 2018**
1 - Light Purple	R-20 ci	R-20 ci	R-20 ci
2 -Red		R-25 ci	R-25 ci
3 - Orange			
4 - Yellow	R-25 ci	R-30 ci	R-30 ci
5 - Green			
6 - Blue	R-30 ci		
7 - Dark Purple	R-35 ci	R-35 ci	R-55 ci
8			
ci = continuous insulation			

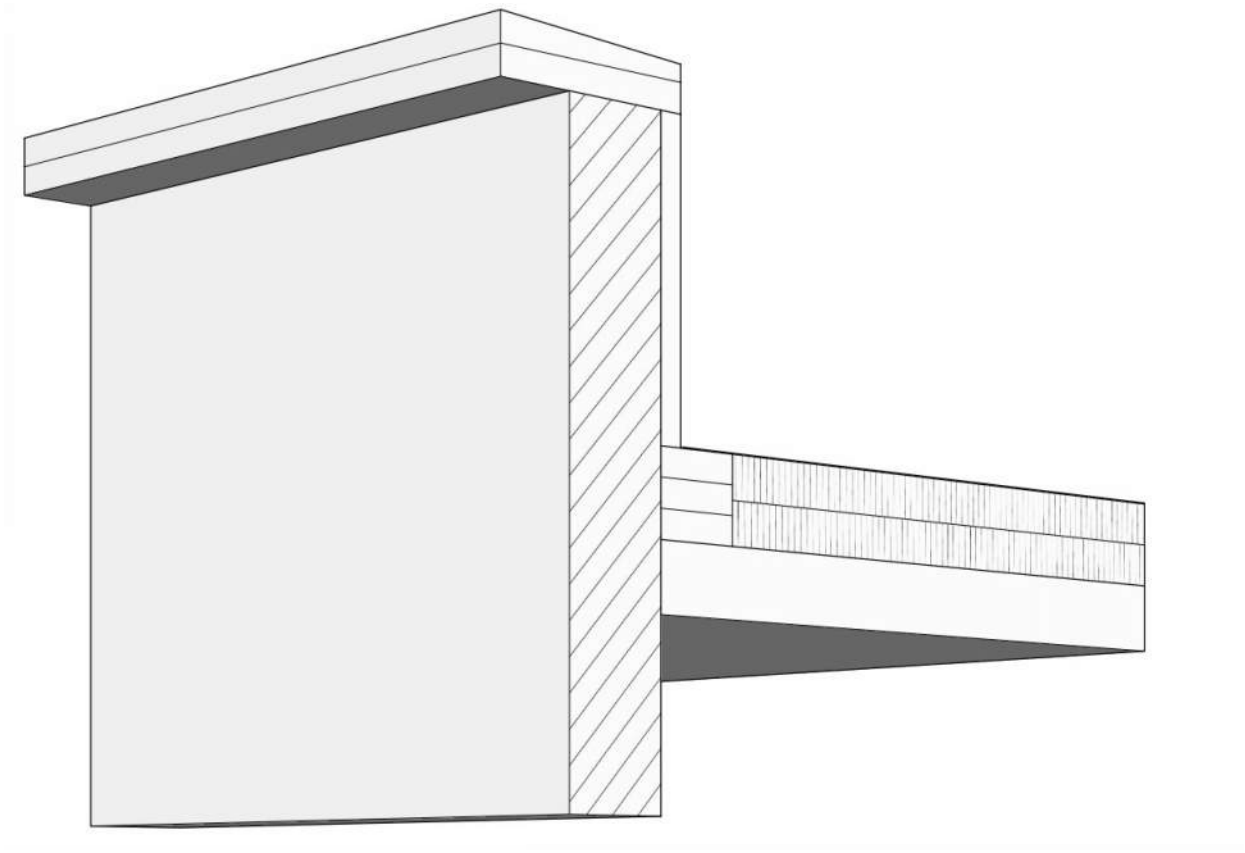
- Additional base layers of insulation may be required in order to meet applicable energy code requirements.
- The use of the average R-value method to show compliance may not be acceptable with the authority having jurisdiction (AHJ).
- This method is intended to be used for tapered insulation systems where the insulation thickness does not vary more than 1 inch.
- When the variation exceeds 1 inch, it is acceptable to use an R-value based on the thickness of the insulation where the insulation is 1 inch thicker than the tapered system's low point.
- Consult with the AHJ for further guidance.

The Tests to Get There

			Wall Membrane(s)	Flashing	Roof
Air Control	**Materials and Assemblies**	Below code maximums per ASTM E2178 and ASTM E2357. Meets CAN/ULC S741 and S742.	X	X	X
	Whole Building	ASTM E779, ASTM E3158	X	X	X
Water Control	**Materials and Assemblies**	Water-resistive Barriers ICC ES Acceptance Criteria AC38 or AC212, ASTM E331	X		X
	Flashings and Penetrations	AAMA 711 or AAMA 714 application performance		X	
Vapor Control	**Vapor Permeance**	ASTM E96, method A and method B	X	X	X
Roof System	**Edge Metal**	ES-1		X	X
	Wind Uplift	ASCE-7	X	X	X

Critical Details

Parapet Transitions

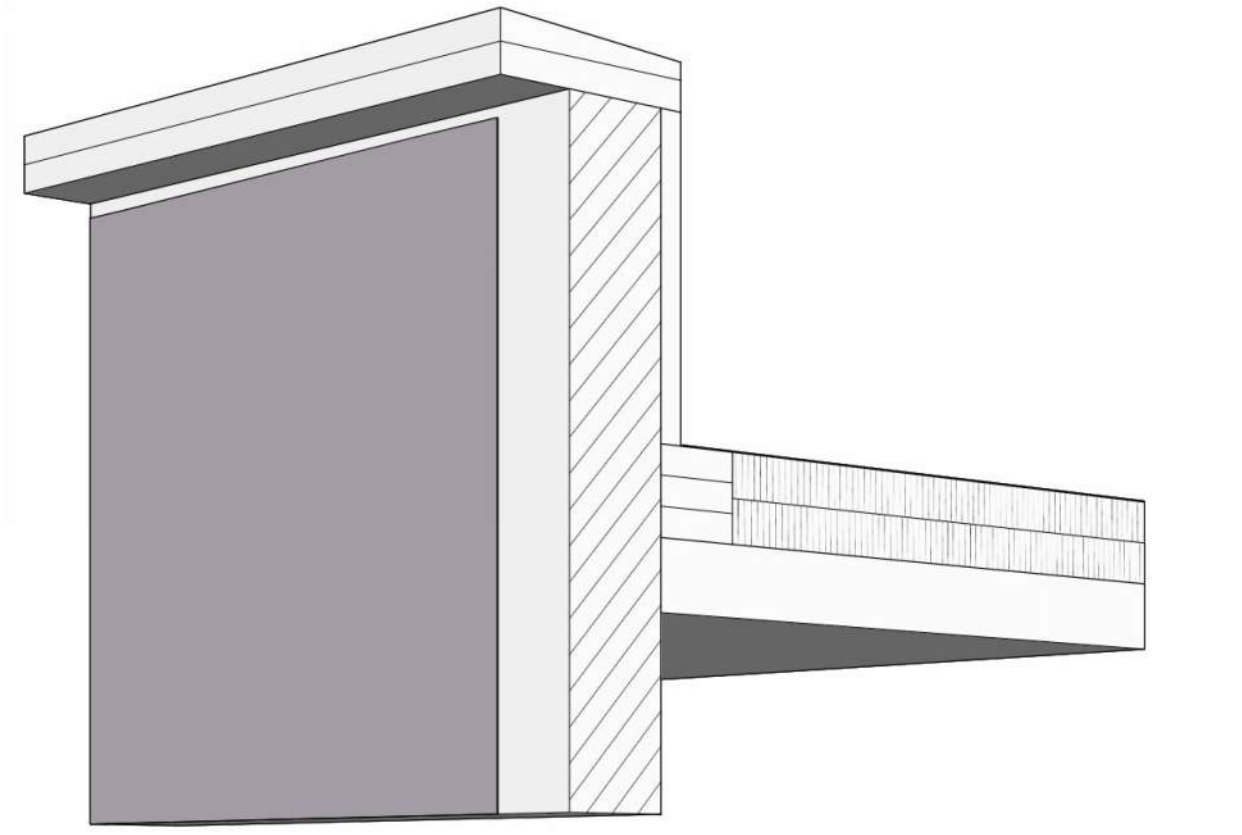


1. **Stainless Steel Butyl Adhered Flashing**
2. **Reinforced Aluminum Butyl Adhered AWB**
3. **Reinforced Aluminum Butyl Adhered Flashing**
4. **Modified Silicone (STPE) VP Liquid AWB**
5. **Modified Silicone (STPE) VP Liquid Flashing**
6. **Elastomeric Sealant**
8. **Primer**

20. Roof Structure
21. Wall Structure
22. Foundation
23. Insulation
24. Relief Angle
25. Termination Bar
26. Drip Edge
27. Adhered Reinforcing Mesh Tape
29. Electrical Conduit
30. Electrical Box
31. Pipe
32. Weep Screed
33. Window
34. Lintel
35 End Dams
36. Compressible Joint Filler
37. Below-Grade Waterproofing
40. Wall Cladding Fasteners
41. Wall Cladding
42. Attached Cladding Anchor
43. Embedded Cladding Anchor
44. Not Used
45. Metal Door Frame
46. Structural Penetration
60. Roof Or Waterproofing System

Excerpt from Detail 04.1

Parapet Transitions



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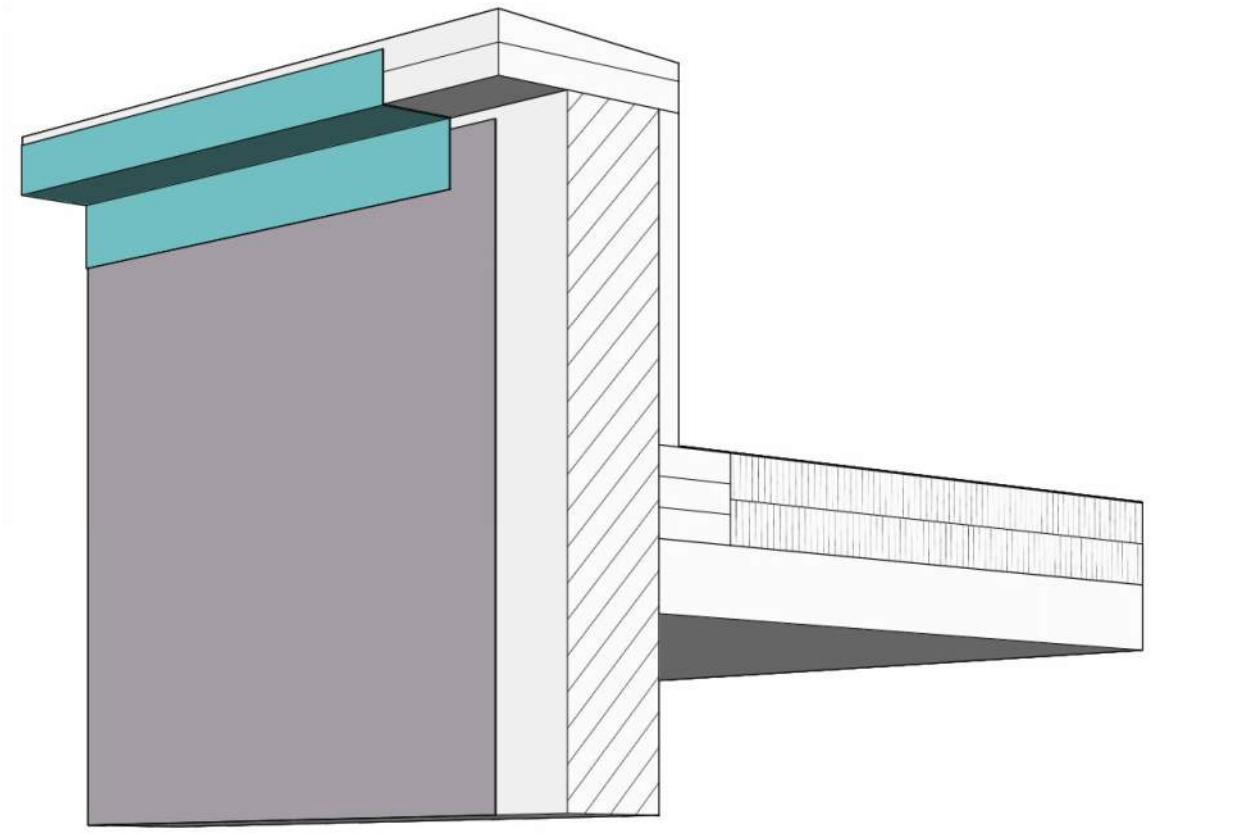

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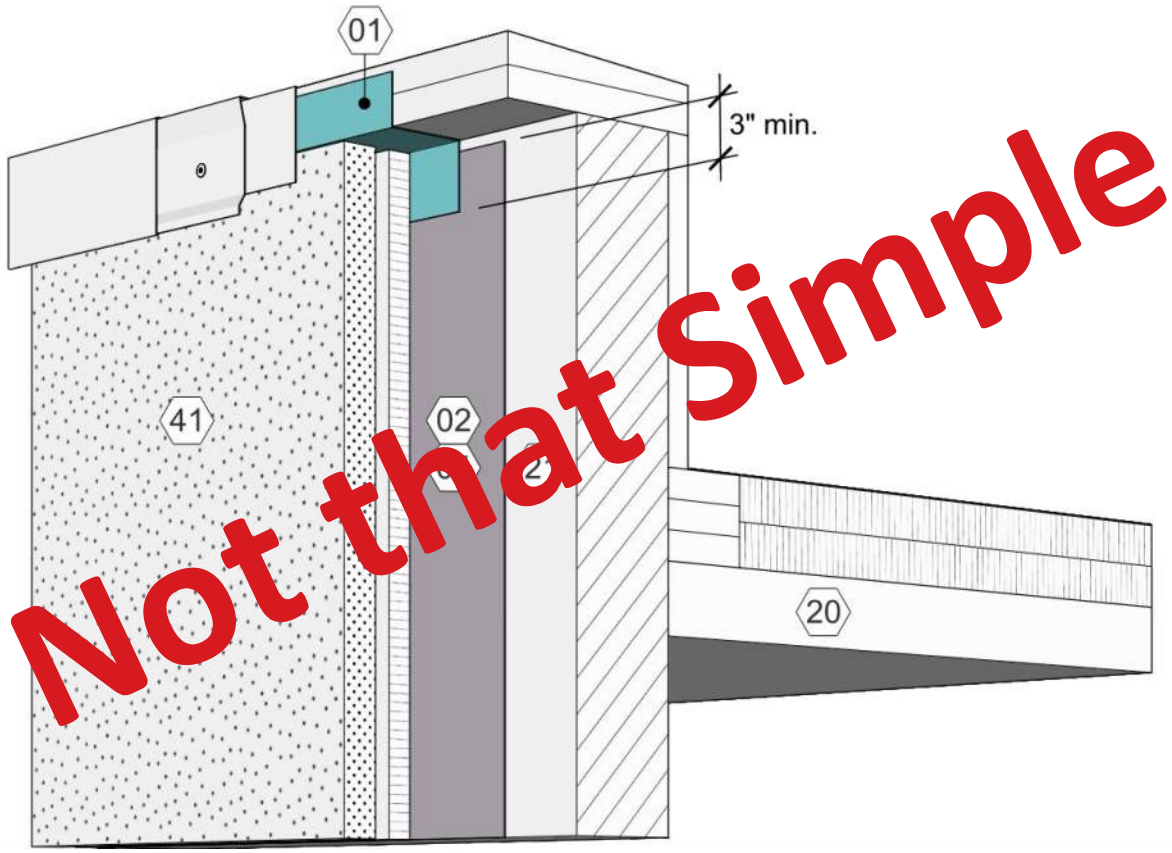

Not that Simple

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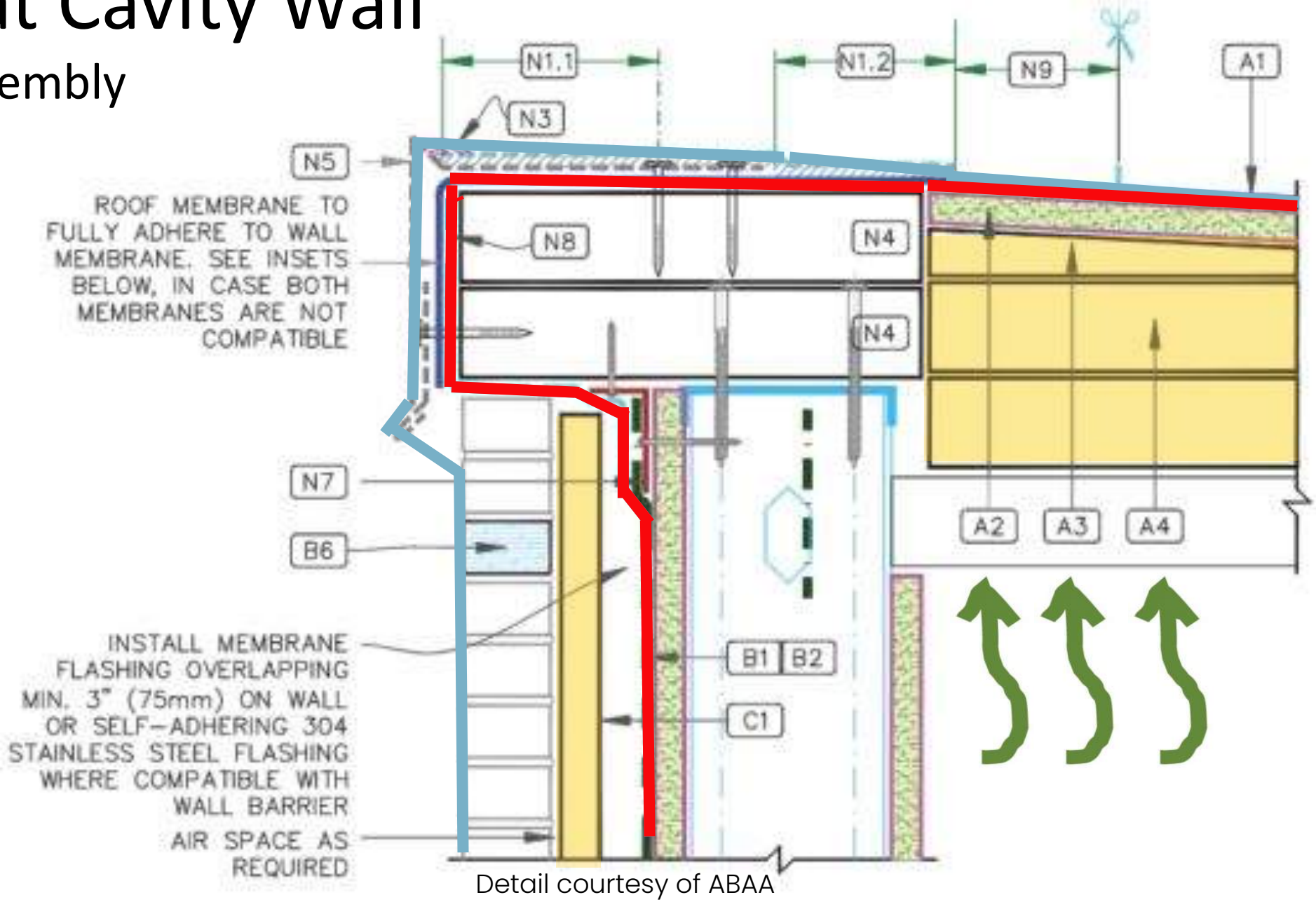
Excerpt from Detail 04.1

Roof Edge at Cavity Wall

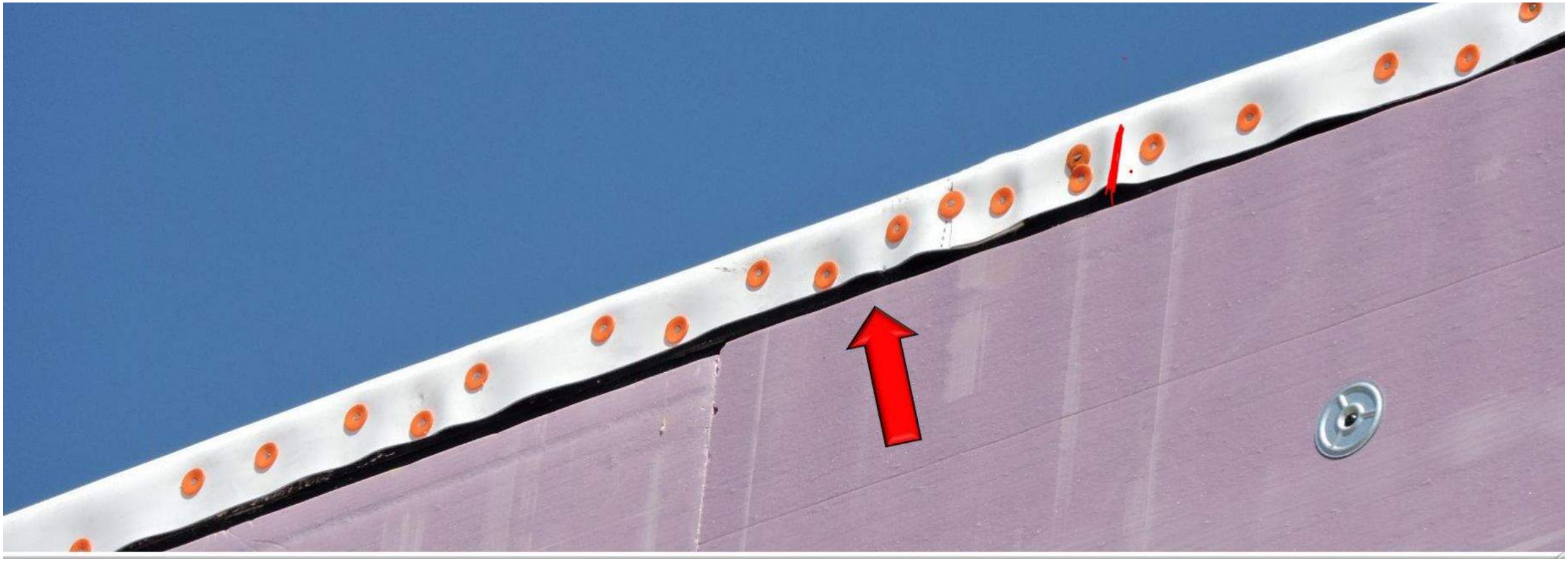
No VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal



Detail courtesy of ABAA



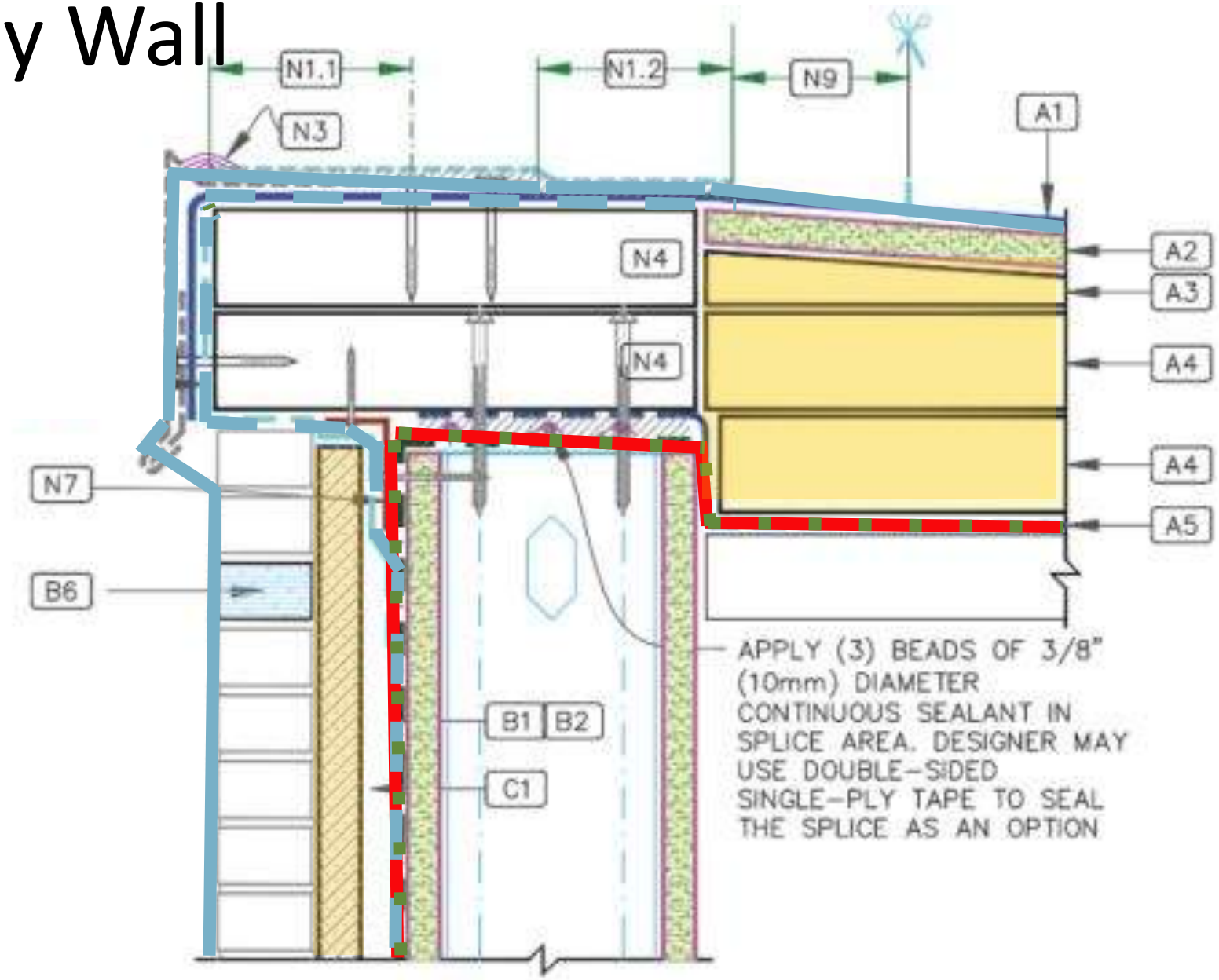
Detail courtesy of Corey Zussman, Pepper Construction

Roof Edge at Cavity Wall

With VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal



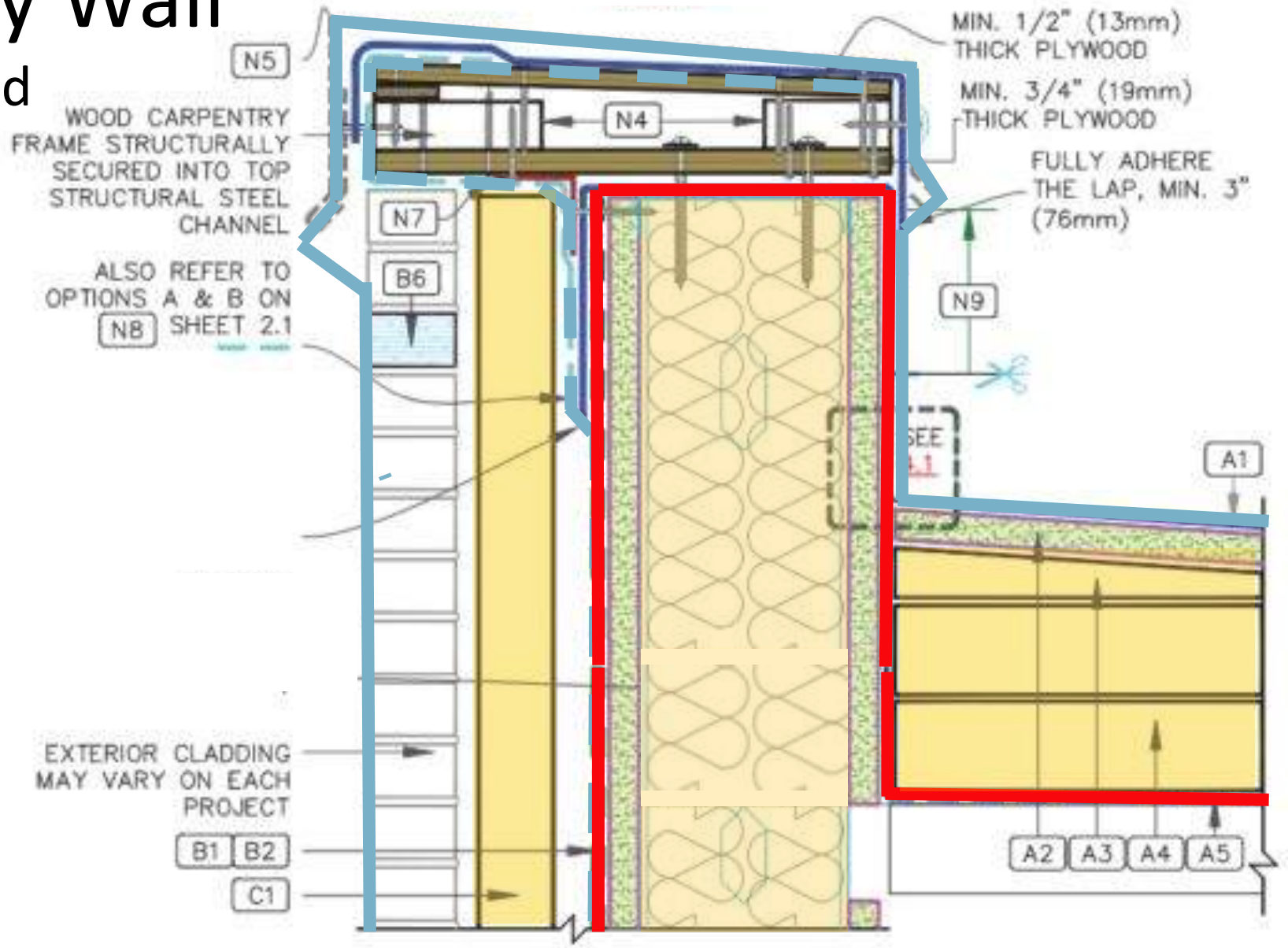
Detail courtesy of ABAA

Parapet at Cavity Wall

With Cavity Insulation and VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal



Detail courtesy of ABAA

roof VR

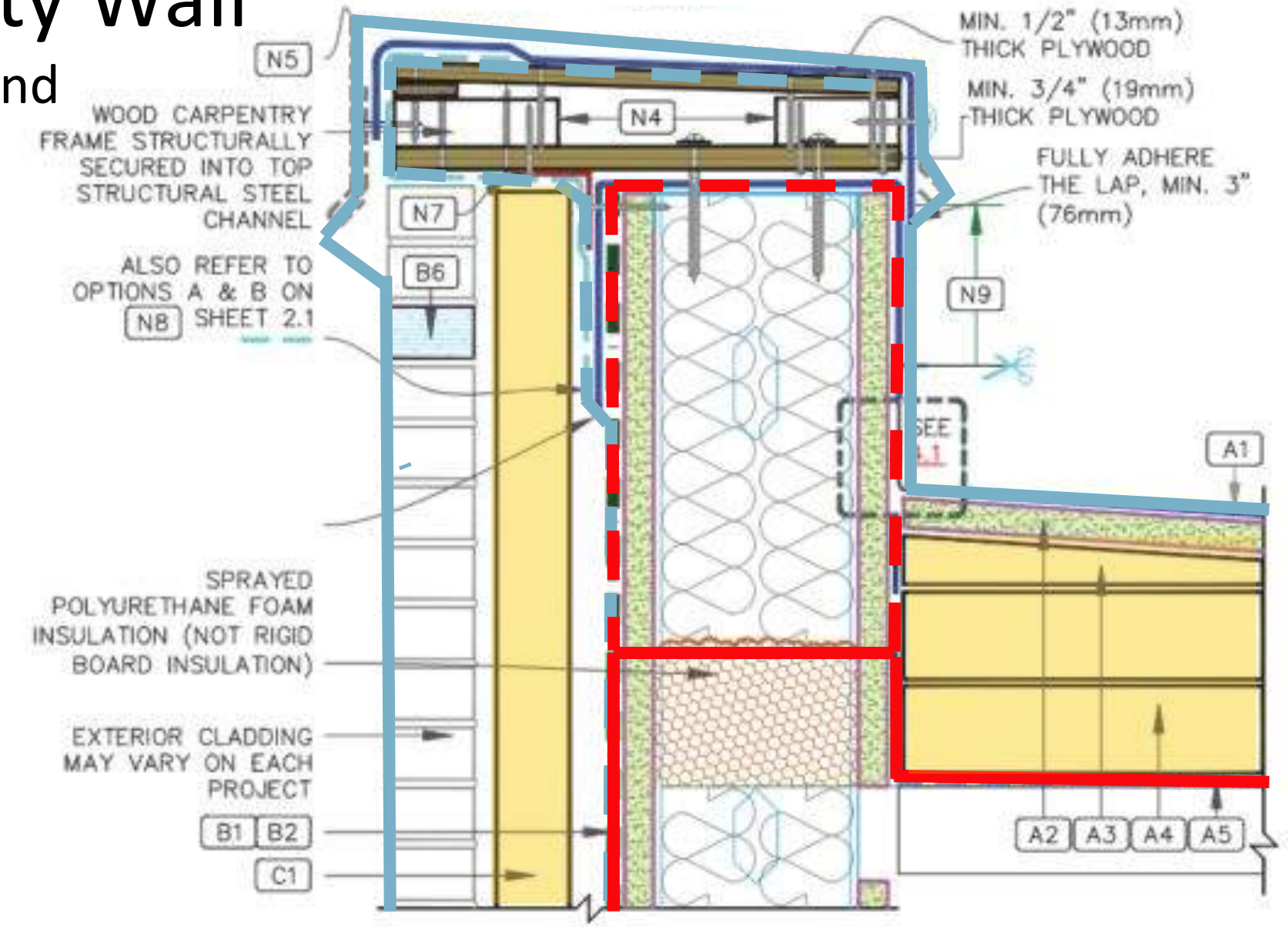
Image courtesy of Intertek

Parapet at Cavity Wall

With Cavity Insulation and VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal



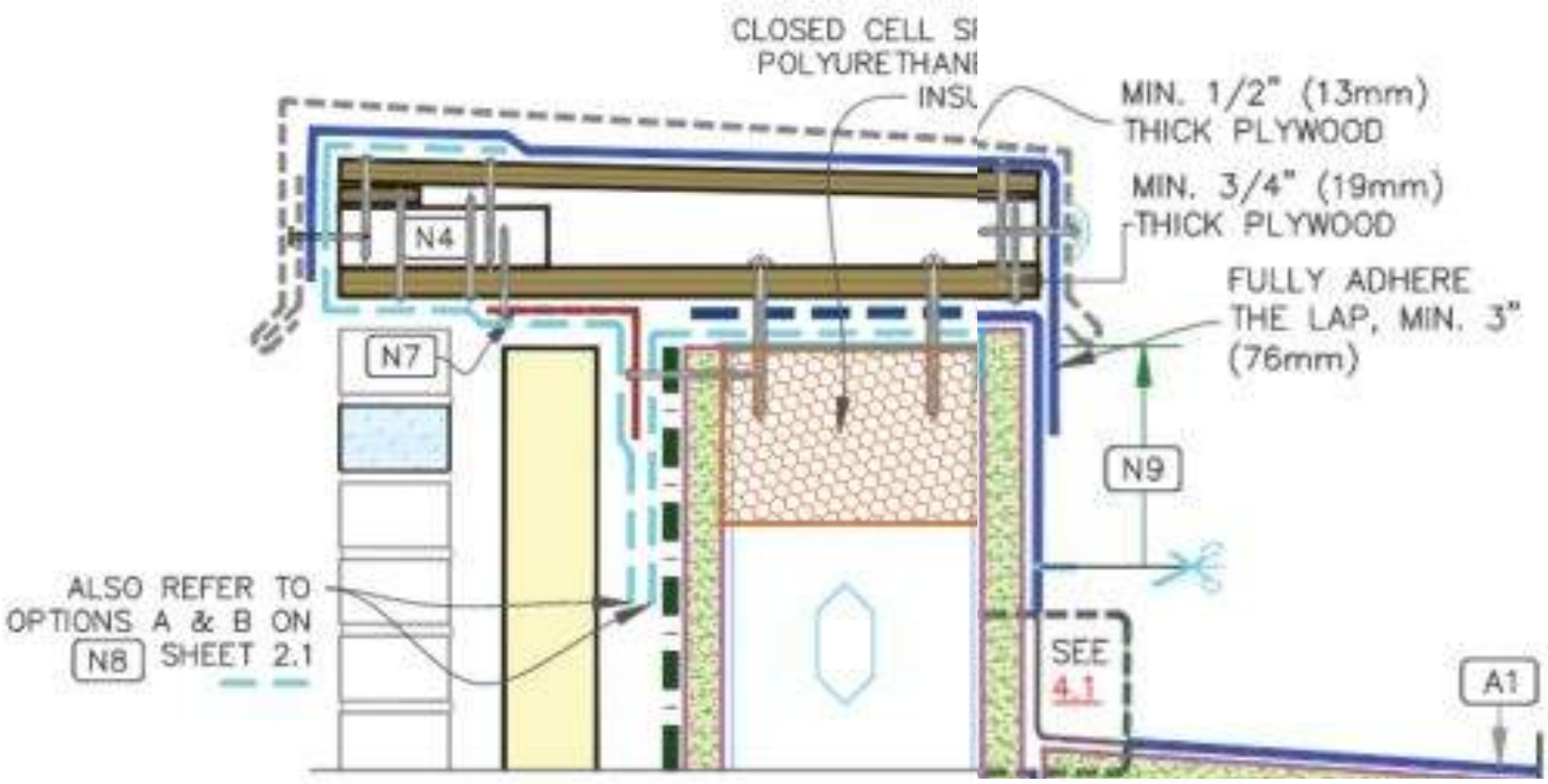
Detail courtesy of ABAA

Parapet at Cavity Wall

Continuous Insulation at Coping

control layers

- Water
- Air
- Vapor
- Thermal



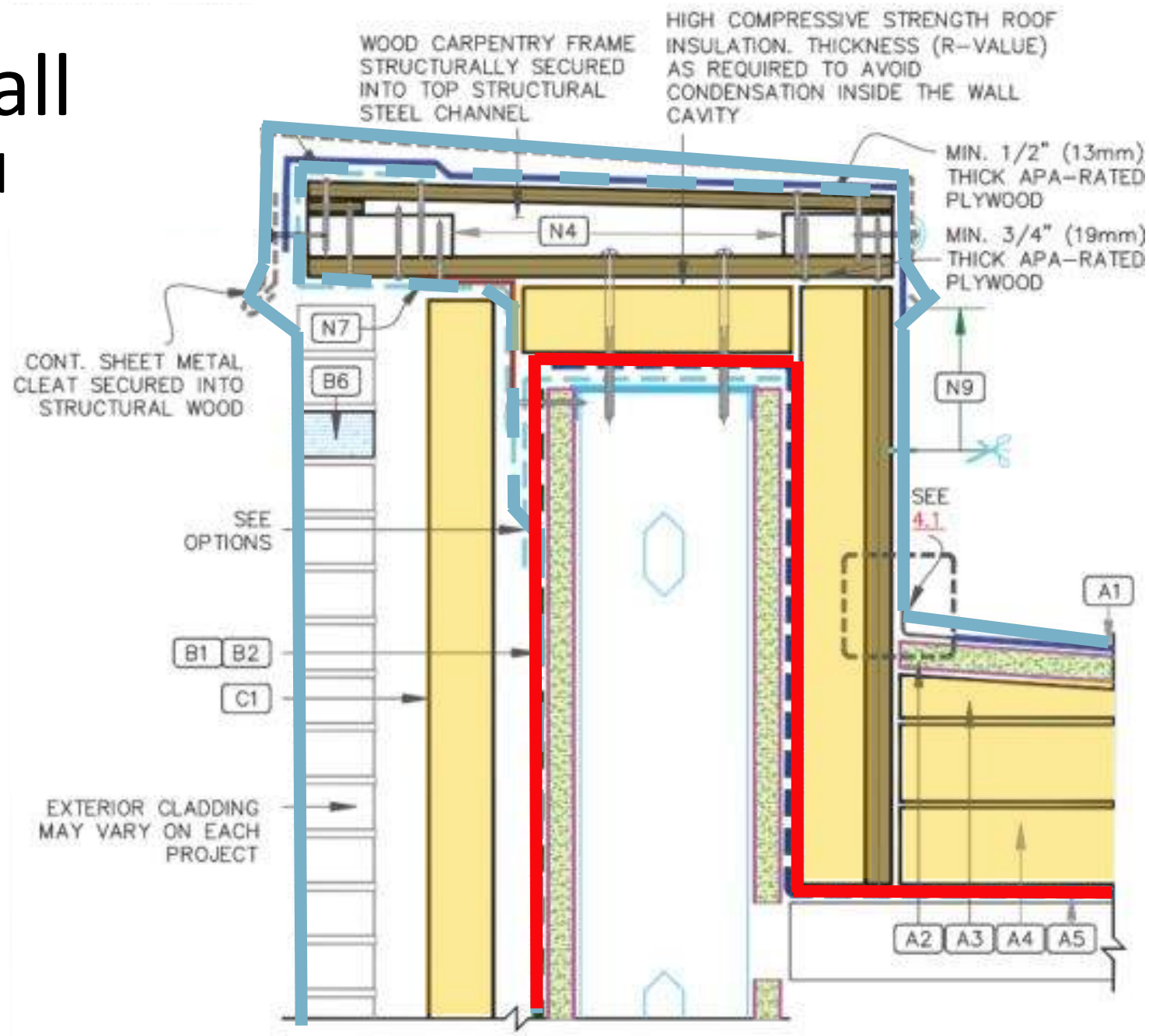
Detail inspired by ABAA

Parapet at Cavity Wall

With Continuous Insulation and VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal



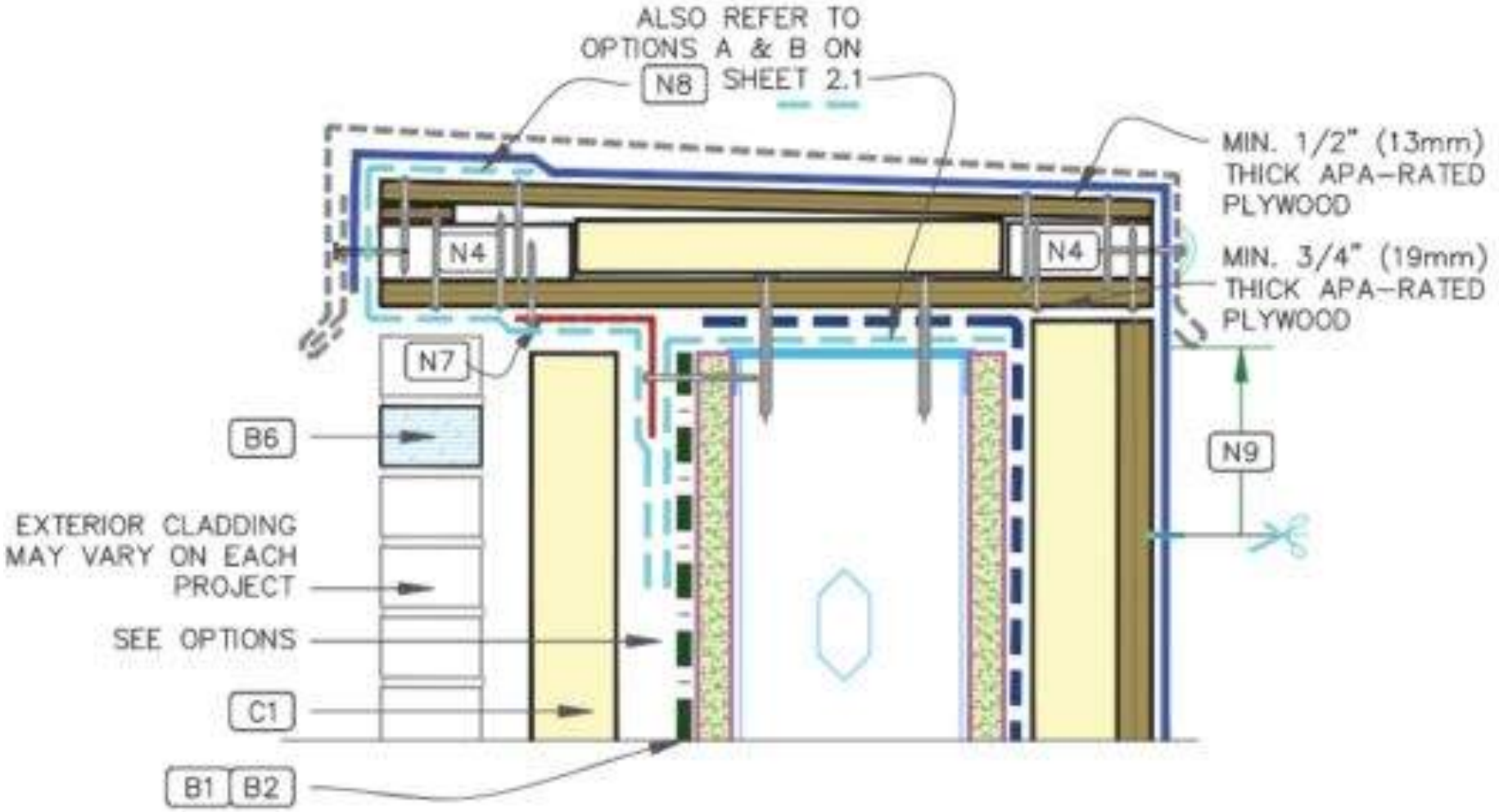
Detail courtesy of ABAA

Parapet at Cavity Wall

Continuous Insulation at Coping

control layers

- Water
- Air
- Vapor
- Thermal



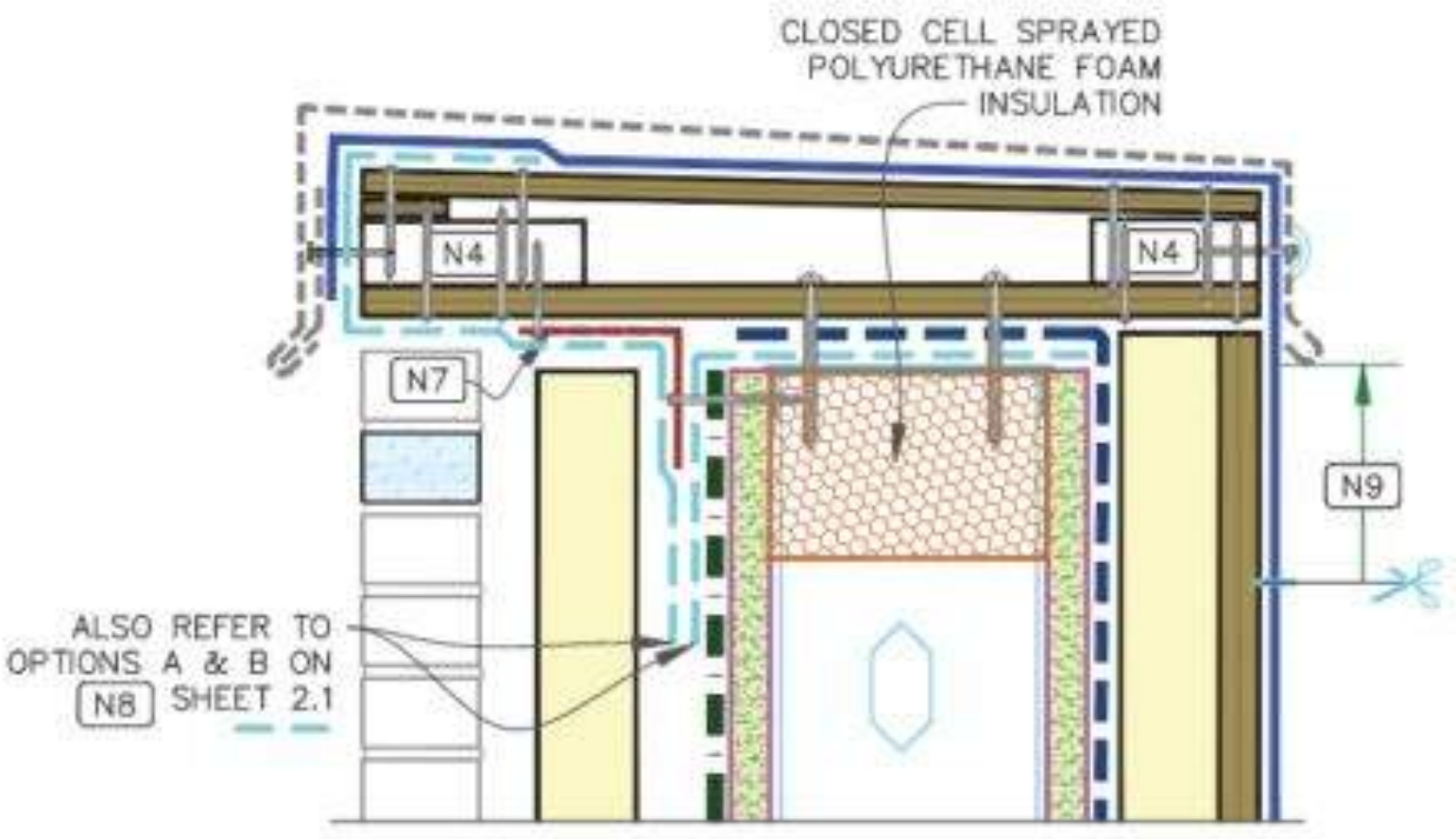
Detail courtesy of ABAA

Parapet at Cavity Wall

Continuous Insulation at Coping

control layers

- Water
- Air
- Vapor
- Thermal



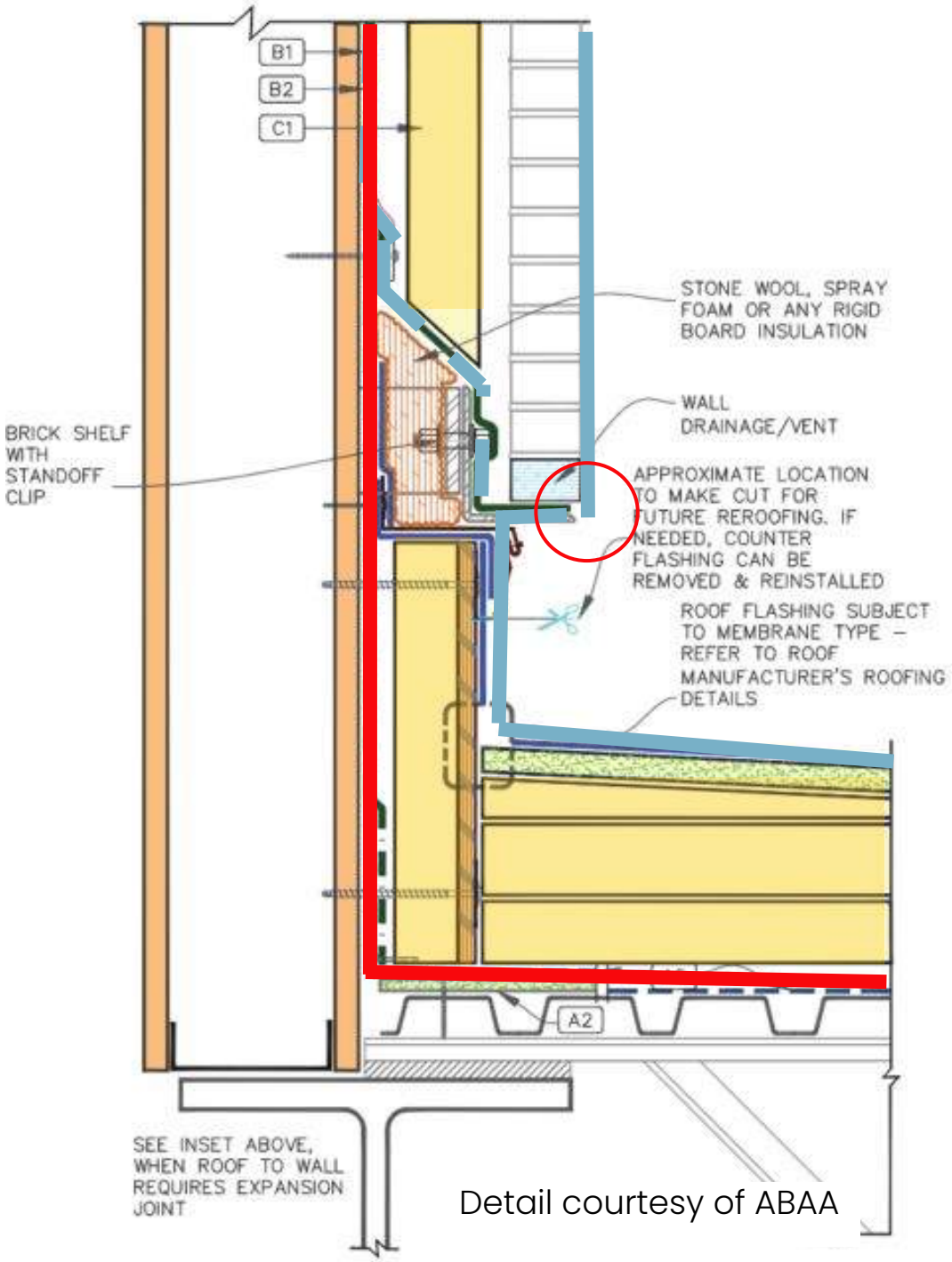
Detail inspired by ABAA

Roof to Rising Wall

With VR in Roof Assembly

control layers

- Water
- Air
- Vapor
- Thermal

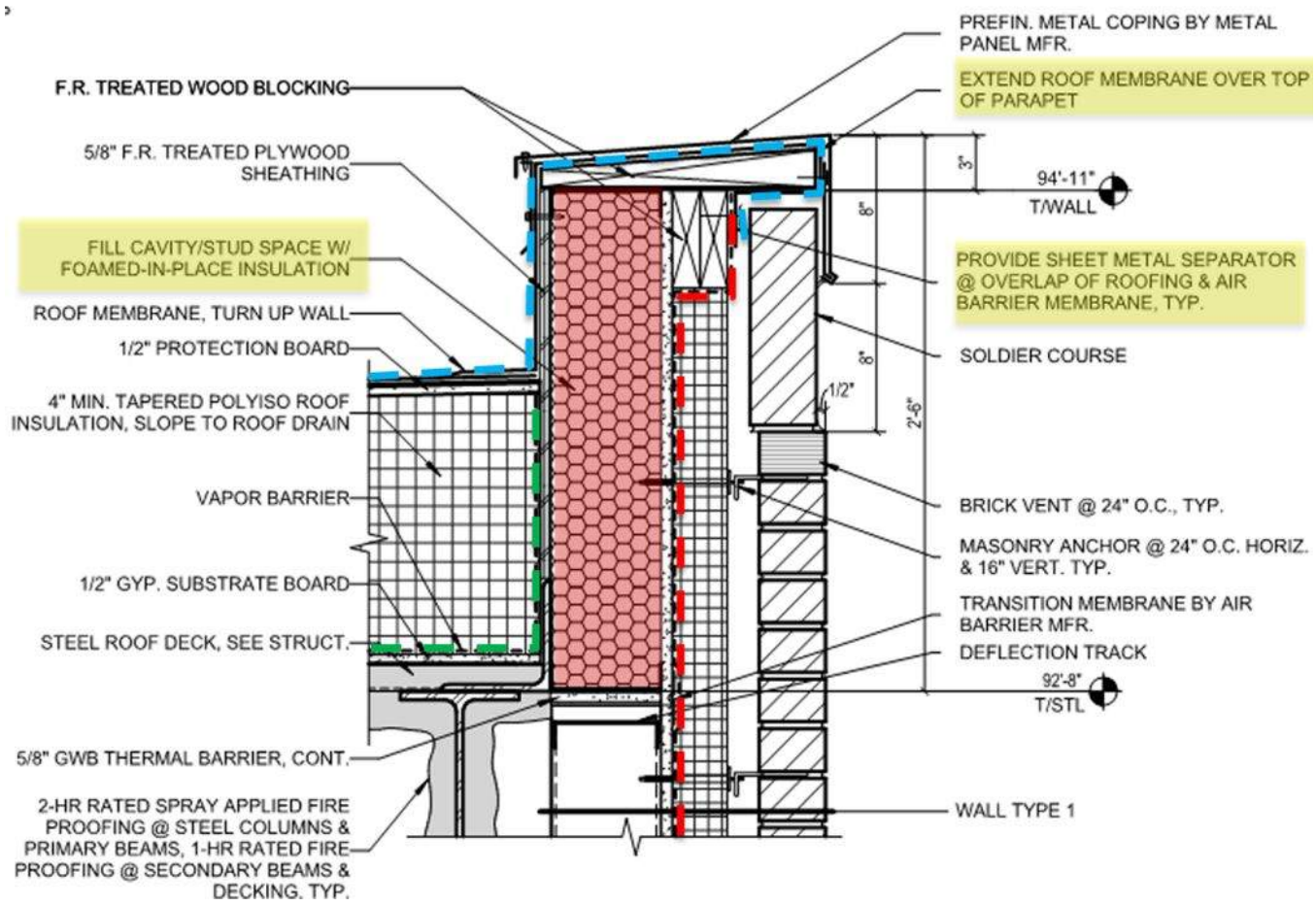


Detail courtesy of ABAA

Sequence of Install

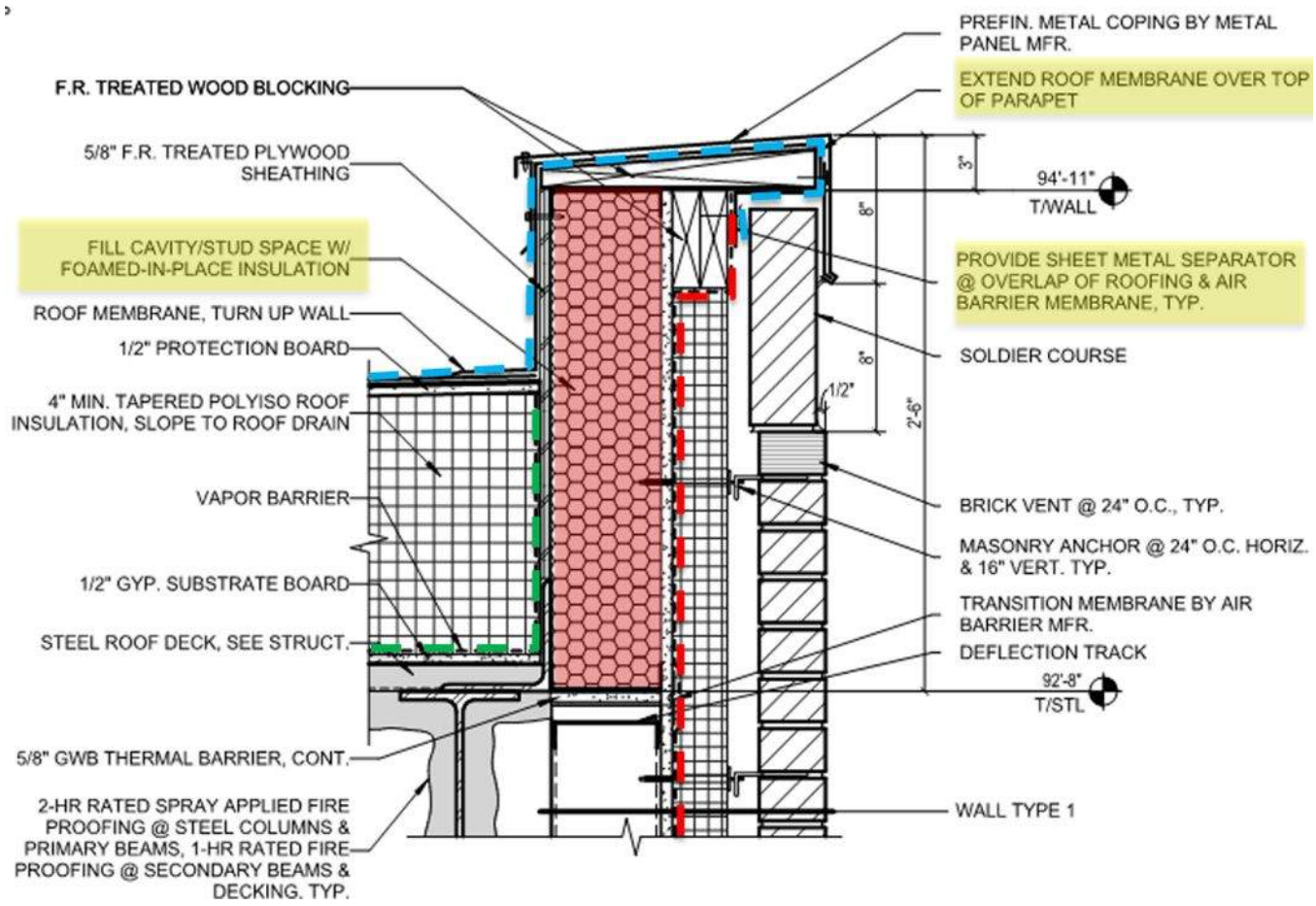
Color Key
Water Control
Air Control
Thermal Control
Vapor Control

Design for Success



- Detail continuous control layers
- Identify material and system transitions
- Sequenced details for complex conditions
- Account for maintenance & replacement

Design vs Reality



Devils in the Details

images courtesy of Intertek

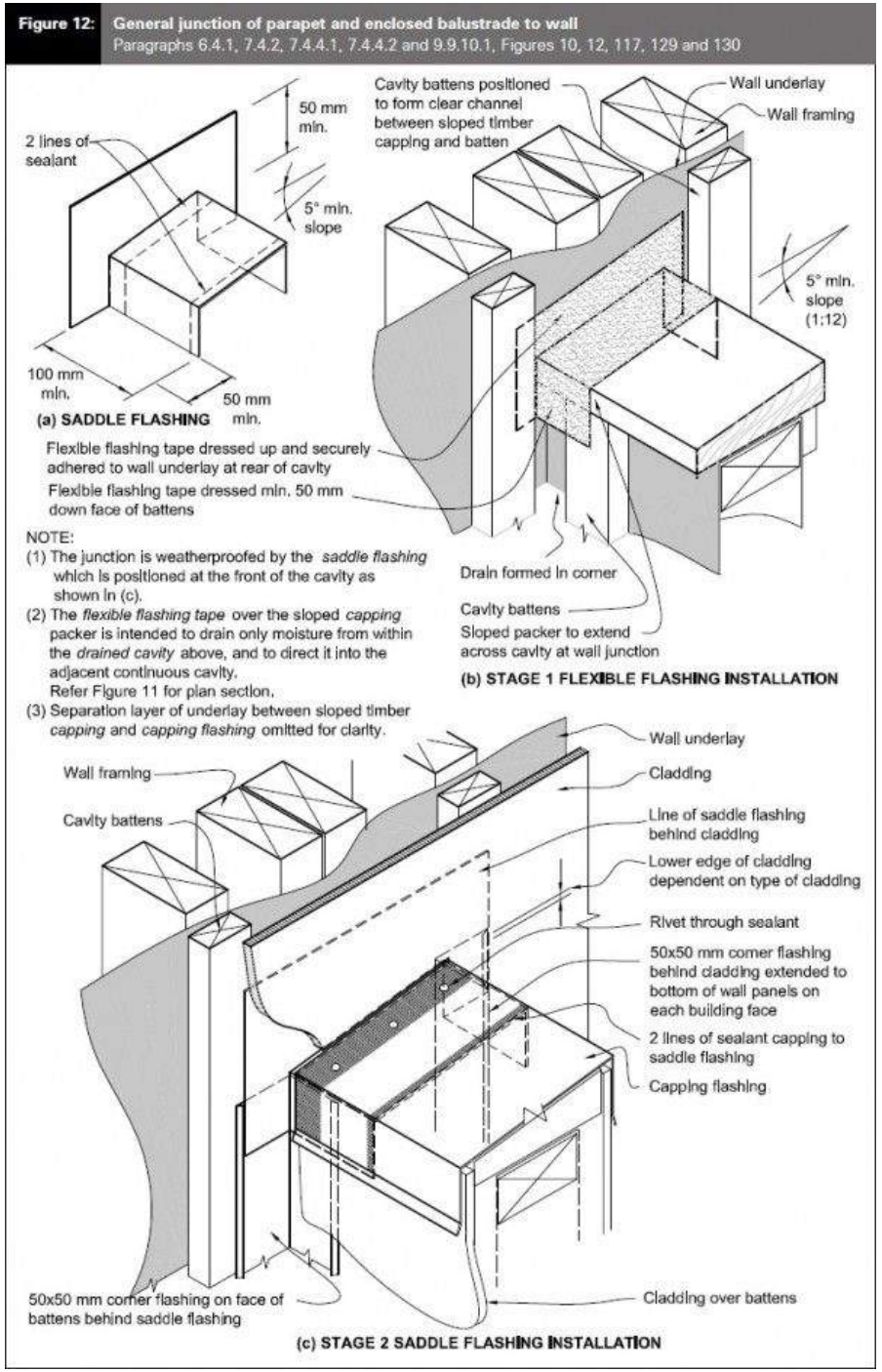
Devils in the Details

image courtesy of Intertek

Conclusions

Drawings

- Detail continuous control layers
- Identify material and system transitions
- Sequenced details for transitions and complex conditions
- Design with sequencing, constructability, maintenance, & replacement in mind



Got Questions?

Book thirty-minutes with the Building & Roofing Science team!

https://us.gaf.com/officehours

Every Friday
12:00 - 1:00pm

Visit us during Office Hours to discuss your project-specific questions, code conundrums, head scratchers, impossible details, or building & roofing science ponderings. Share your screen and we'll work through it together!

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