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Deep Energy Retrofit:

Historic Masonry Homes

Why Save Old Buildings?

- Preserving the character and history of a neighbourhood
- Save money
- Save time
- Reduce waste
- Reduce carbon foot print (?)
  - Buildings are currently responsible for 39% of global carbon emissions
  - For new construction, embodied carbon accounts for 50% of carbon emissions.
  - Is “The greenest building is the one that is already built”?
    - It depends…..
    - Embodied carbon vs. operating carbon emissions

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Why Not Leave Old Buildings Alone?

- Building Code-Related issues
- Energy use (and cost)
- Operational carbon emissions
- Comfort issues

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Building Science Fundamentals

The Building Enclosure

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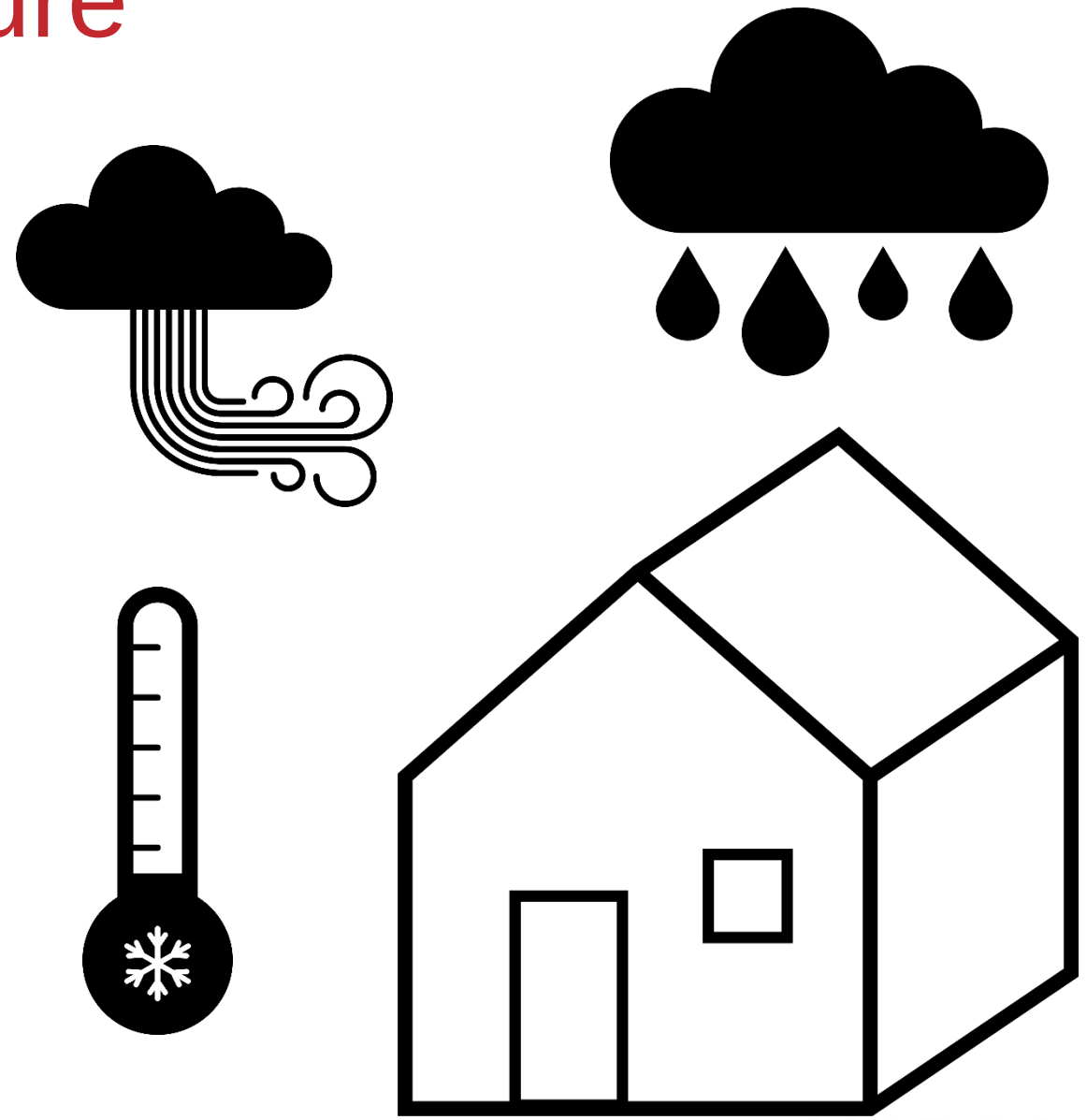
The Building Enclosure

- **Structure**
- **Functional Layers**
  - Water Control
  - Air Control
  - Thermal Control
  - Vapour Control



The Building Enclosure: New School

- **Structure-** wood framed, concrete, steel, CLT
- **Functional Layers**

  - **Water Control-**

  House wrap, SA membrane, liquid applied, ZIP, foam..

  - **Air Control-**

  House wrap, ZIP, polyethylene sheet, spray foam…

  - **Thermal Control-**

  batts, rigid foam, loose fill, dense pack, spray foam...

  - **Vapour Control**

  Poly, smart membranes, VB paint, plywood…

The Building Enclosure: Old School

- **Structure-** Bricks
- **Functional Layers**

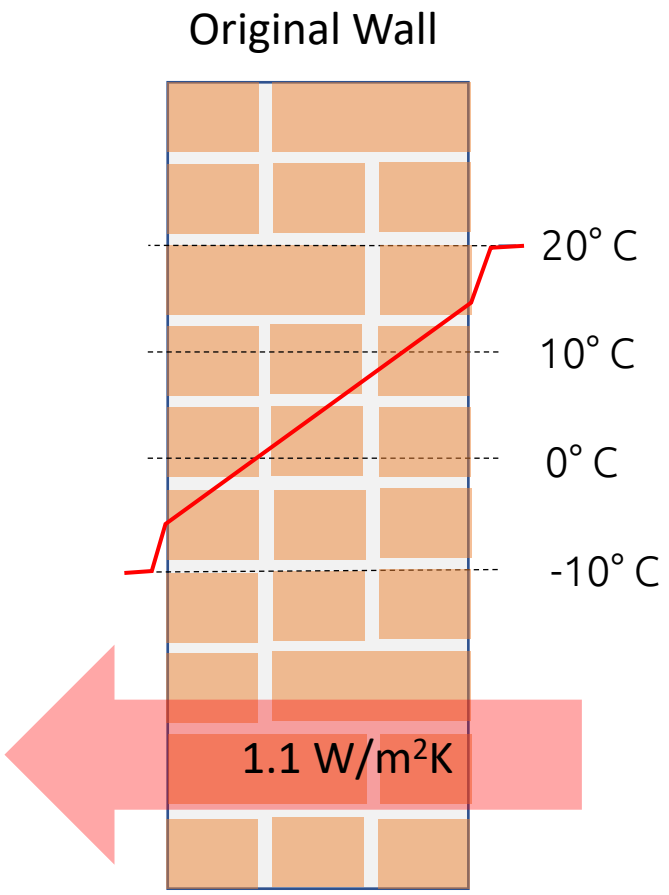
  - **Water Control-** Bricks
  - **Air Control-** Bricks
  - **Thermal Control-** Bricks
  - **Vapour Control-** Bricks

The Building Enclosure

-What is the intended function of each layer?
-What is the required level of performance?
-How do layers interact?
-How do layers transition?
-What about penetrations?

-Continuity is key
-Detailing is critical

Heat Flow Through an Old Brick Wall



Thermal Performance

Old Brick – Thermal Conductivity - 0.4 W/m K

- Thermal Conductance- 1.3 W/m^{2}K
- Thermal Resistance- 0.76 m^{2}K/W
- R-Value = 0.36 per inch
- **R-Value = 4** for a triple wythe wall

Interior Air Film – Thermal Resistance (RSI)– 0.19 m^{2}K/W

-**R-Value = 1.1**

Exterior Air Film – Thermal Resistance (RSI) – 0.15 m^2 K/W

-**R-Value = 0. 9**

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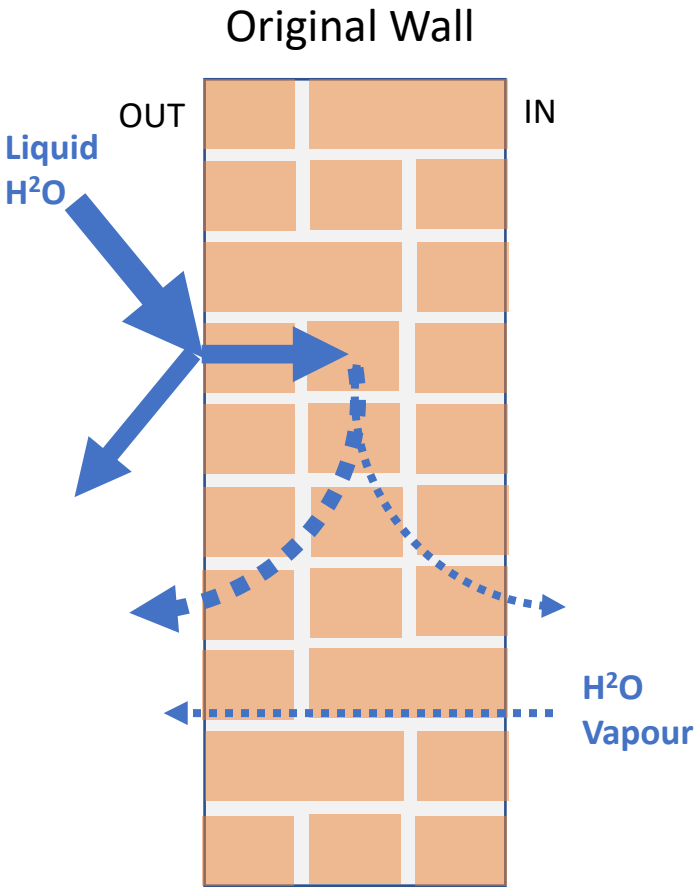
Moisture Flow Through an Old Brick Wall



Moisture Performance

Old Brick wall absorbs a large percentage of driving rain, roof/window run-off, splash back etc.

Old brick wall allows drying to the exterior and interior as conditions allow

Old brick wall allow slow, steady flow of vapour

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Freeze-Thaw Damage

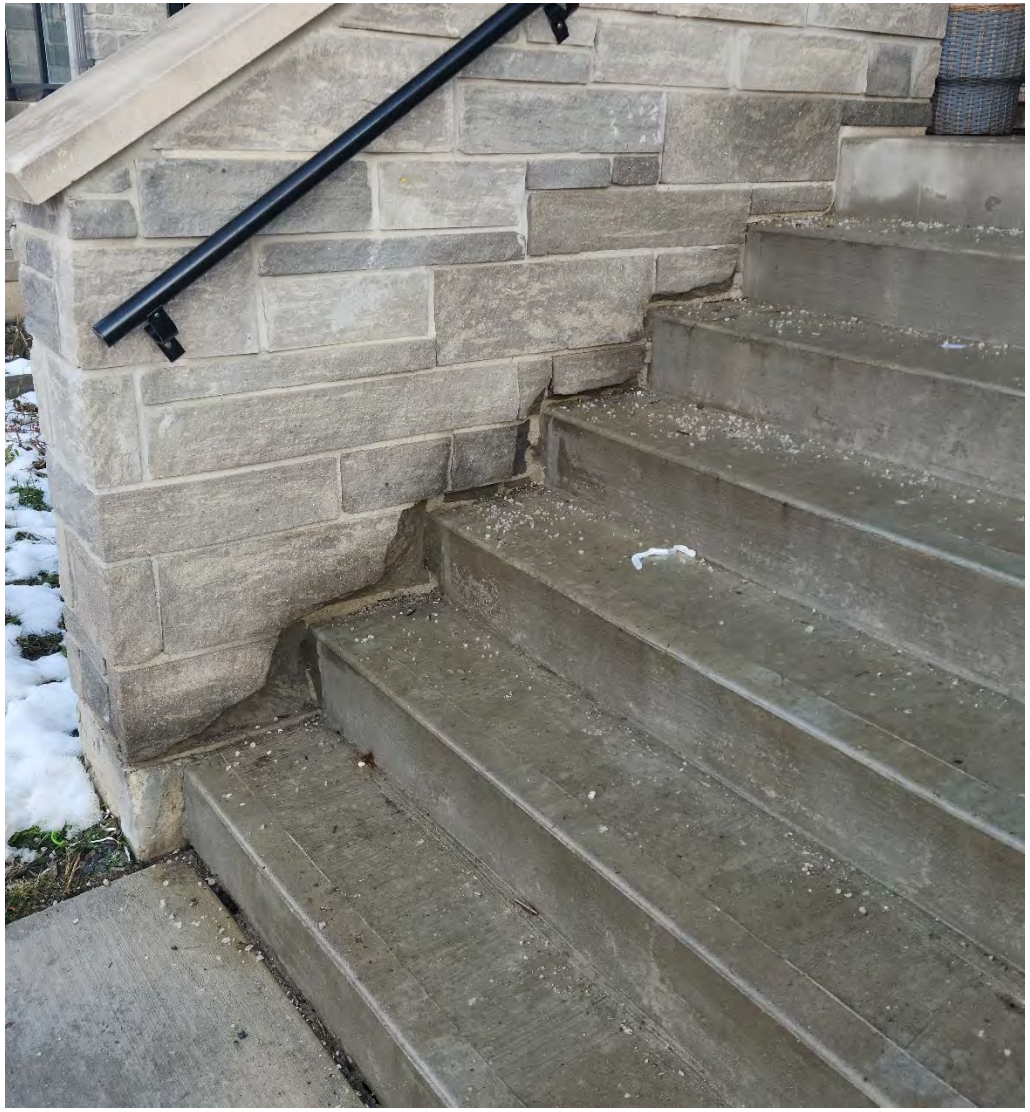
- The formation of frost and the expansion of liquid water within the pores of a masonry material can result in high internal forces

- Freeze-thaw damage is structural deterioration of masonry materials resulting in chipping or crumbling of the material – AKA spalling

- For freeze-thaw damage to occur, two conditions must be met:

1) The material must experience below freezing temperatures
2) The material must be ‘sufficiently’ wet

* Salts can accelerate this process



Freeze-Thaw Damage

How Cold is Cold Enough?

- The moisture inside the pores of a masonry material needs to reach temperature well below 0 deg. C to form frost or to freeze due to increased pressure within the pores.

- The freezing point of water within the pores of a brick is -3 to -5 deg. C

- Taking into account the increased exterior surface temperature of an uninsulated brick wall, the air temperature would need to be -7 to -10 degrees before water will begin to freeze.

- This changes when we insulate these walls

Freeze-Thaw Damage

How Wet is Wet Enough?

- Some masonry materials can safely hold more water than others
  - This is a function of the pore sizes and distribution and the strength and flexibility of the material

- The maximum amount of water that a material can hold without experiencing freeze-thaw damage is called it's 'Critical Saturation' value.
  - For clay bricks, the Critical Saturation value can range between 30% and 90% of the maximum saturation value.

- To approximate the freeze-thaw vulnerability of the brick on a building, visually inspect those areas that are wettest and coldest

Evaluating Freeze-Thaw Susceptibility

Most Vulnerable Areas

- Near downspouts
- Chimneys
- Buttresses
- Bricks near grade
- Parapets
- Garage
- Landscaping

Insulating Old Brick Walls

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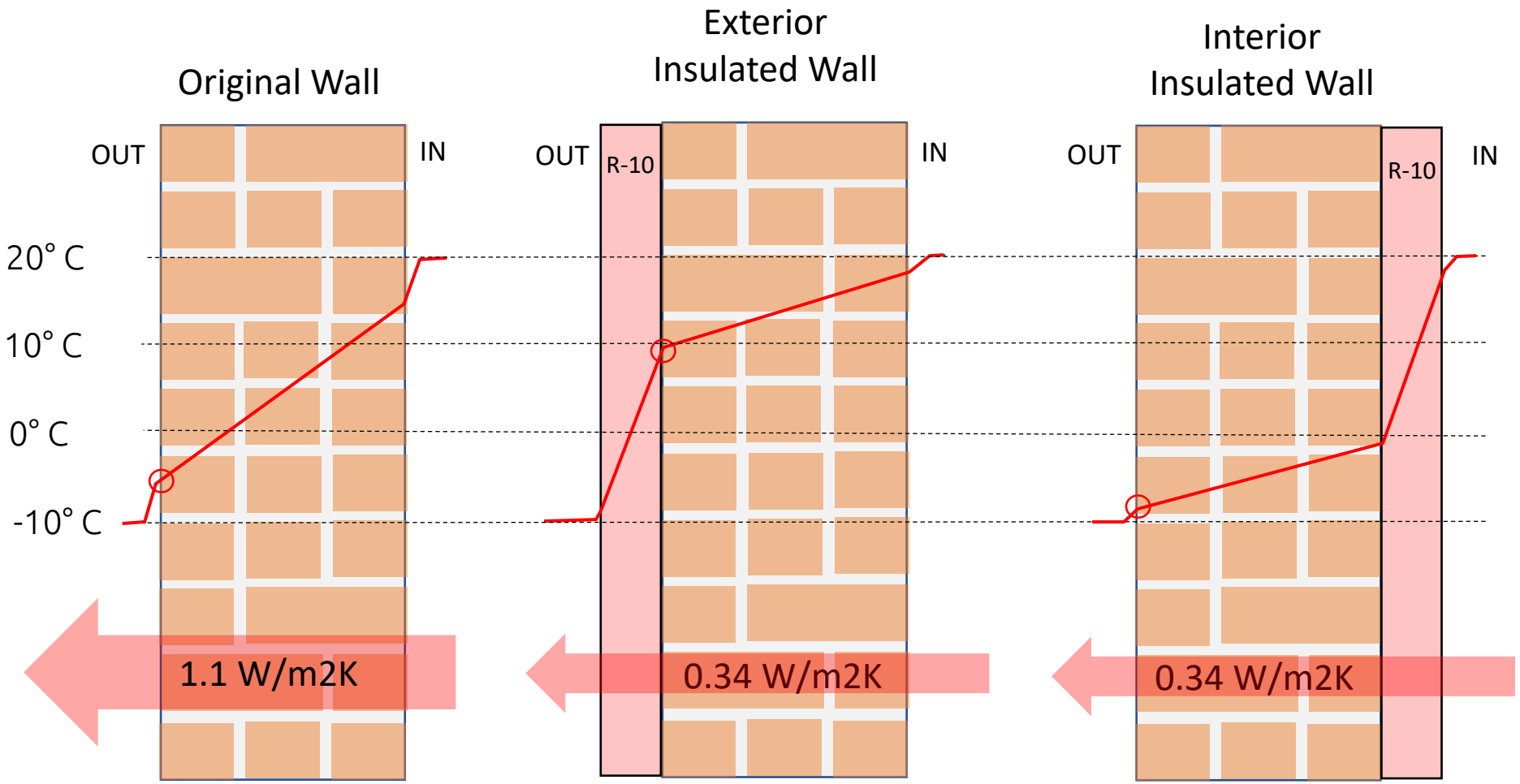
Changing the Temperature/Heat Flow Dynamic



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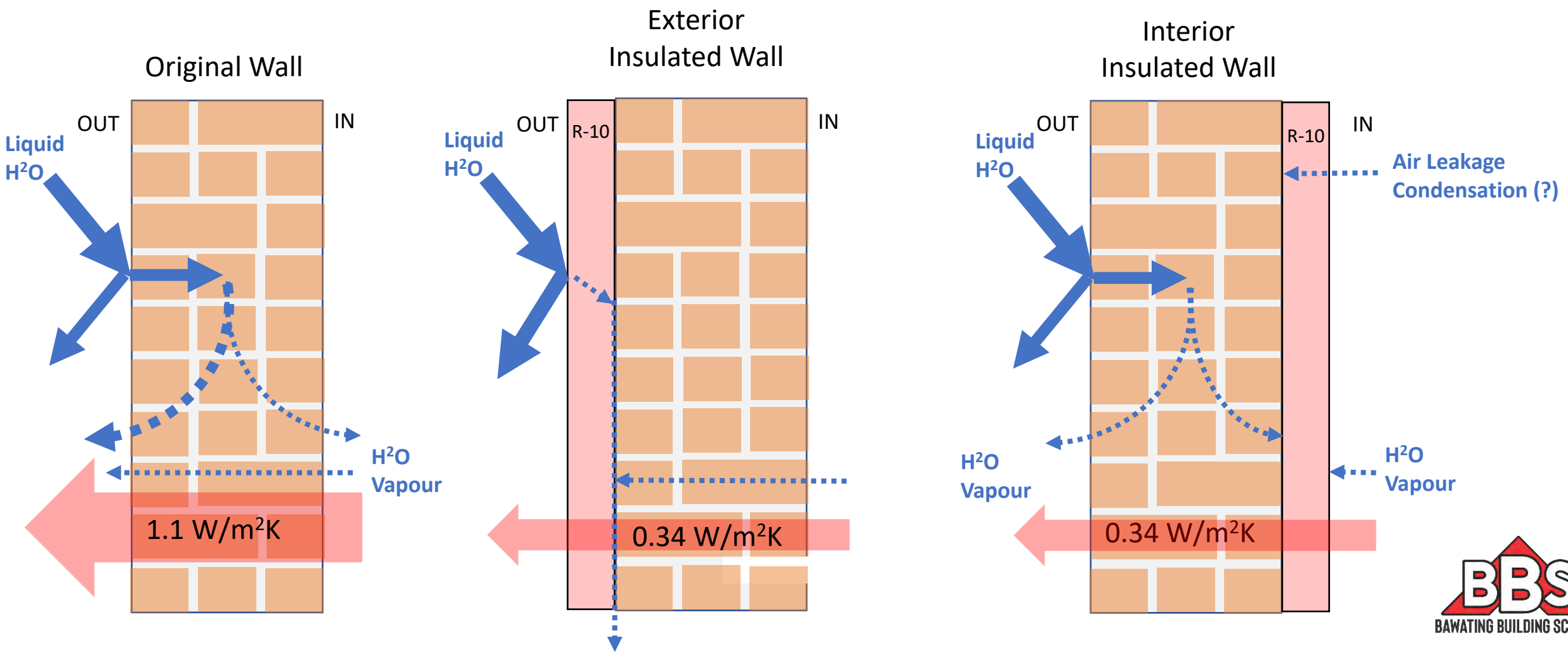
Changing the Moisture Flow Dynamic



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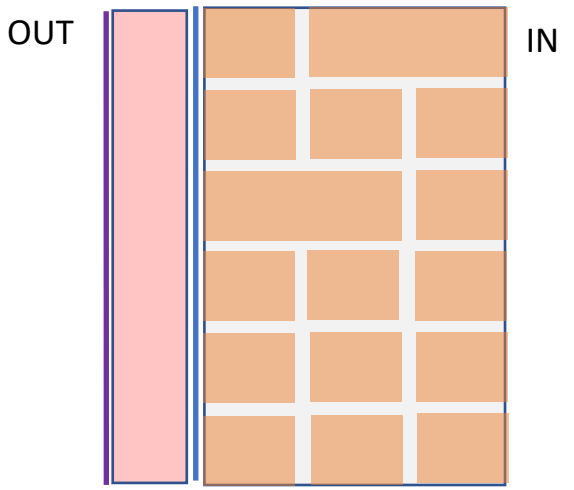
Approaches that Work

1) Exterior Insulation

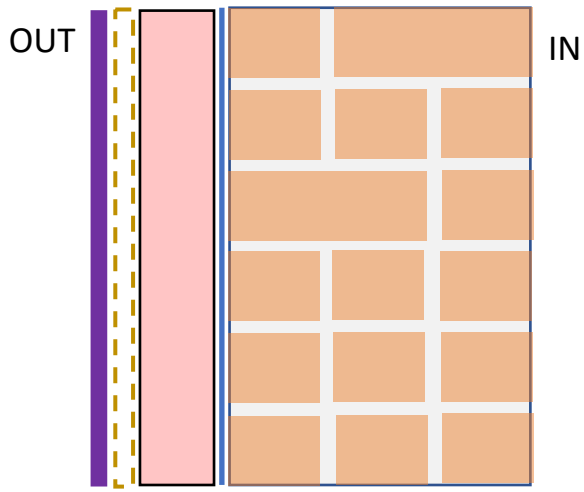
a) EIFS Retrofit



Steps:

1) Repair damaged bricks/mortar
2) Clean exterior surface
3) Install liquid AWB
4) Install drained EIFs system

b) Over cladding Retrofit



Steps:

1) Repair damaged bricks/mortar
2) Clean exterior surface
3) Install liquid AWB
4) Install rigid insulation
5) Install strapping or clip and rail system
6) Install cladding

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Approaches that Work

1) Exterior Insulation

Benefits:

- Bricks stay warm and dry
- Embedded wood stays warm and dry
- All work from the exterior (+/-)

Drawbacks:

- Lose historic façade
- Cost implications
- All work from exterior (+/-)

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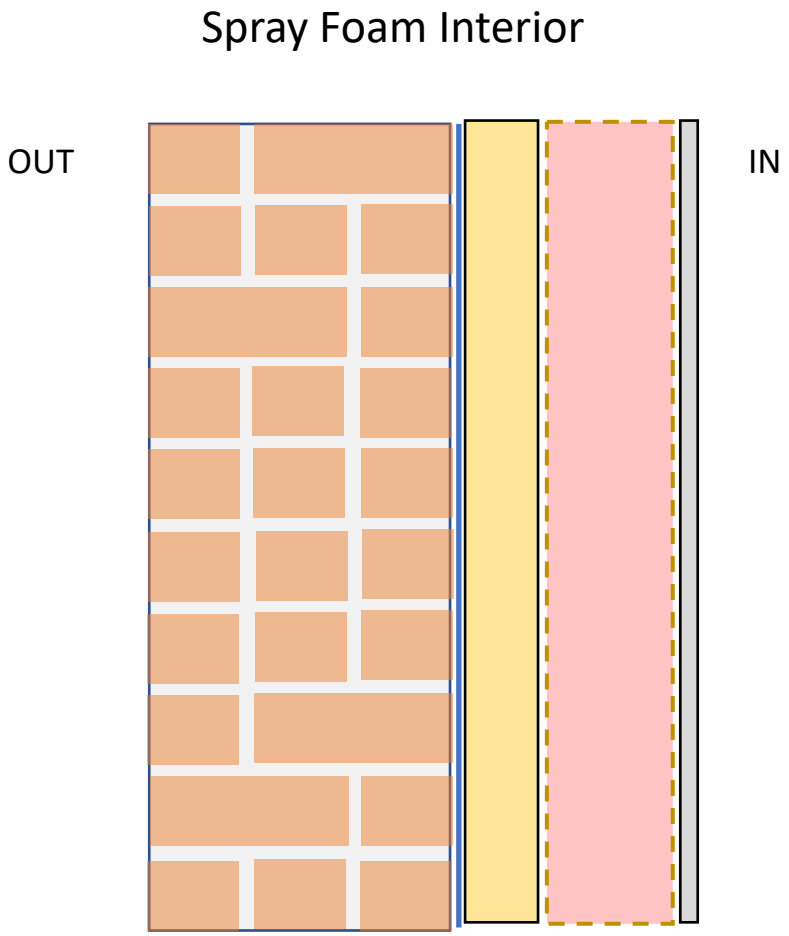
Approaches that Work

2) Interior Insulation: Spray Foam



Steps:

1) OPTIONAL: Install bond break layer
2) Install interior stud wall with 2” gap to masonry
3) Install continuous layer of spray foam to masonry
4) Install batt or spray foam in stud wall
5) Install drywall or other interior finish
6) OPTIONAL: install vapour barrier primer/paint

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Approaches that Work

2) Interior Insulation: Spray Foam

Benefits:

- Readily available materials and trades
- Easier to transition at foundation and roof
- Cost effective
- All work from the interior (+ /-)

Drawbacks:

- Bricks will be colder and wetter than before
  (Risk of future freeze-thaw degradation)
- Embedded wood wetter than before
- Risks associated with spray foam

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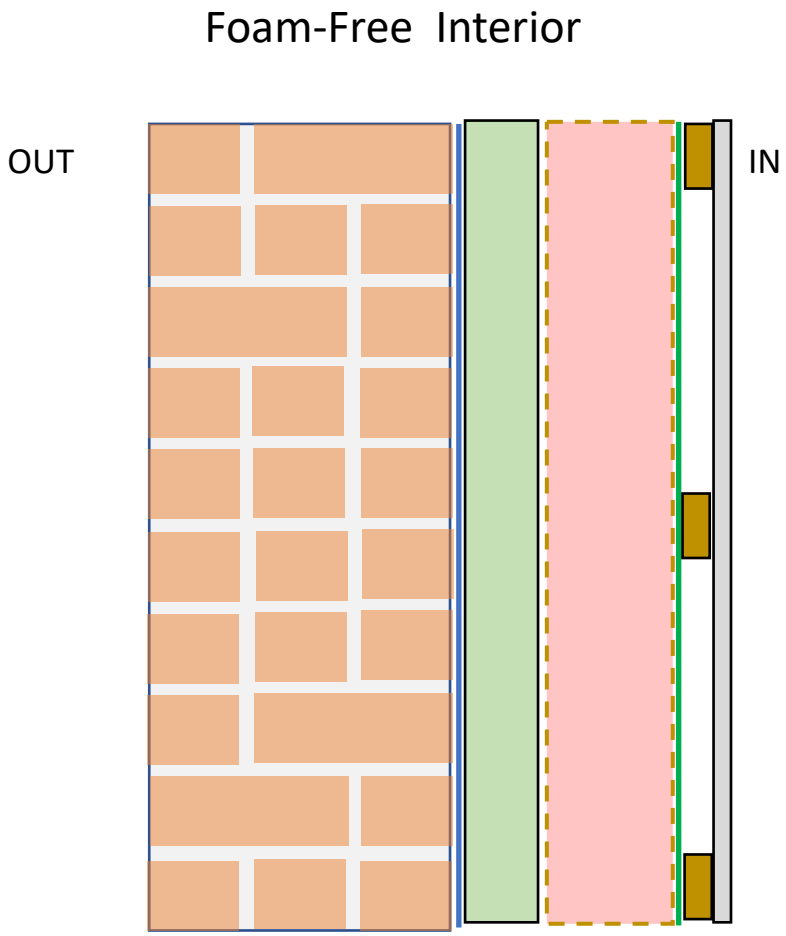
Approaches that Work

3) Interior Insulation: Foam Free



Steps:

1) Install water control layer
2) Install continuous layer of semi-rigid mineral wool
3) Install interior stud wall
4) Install batt insulation in stud wall
5) Install smart vapour retarder/**air barrier**
6) Install strapping to create service chase
7) Install drywall or other interior finish

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Approaches that Work

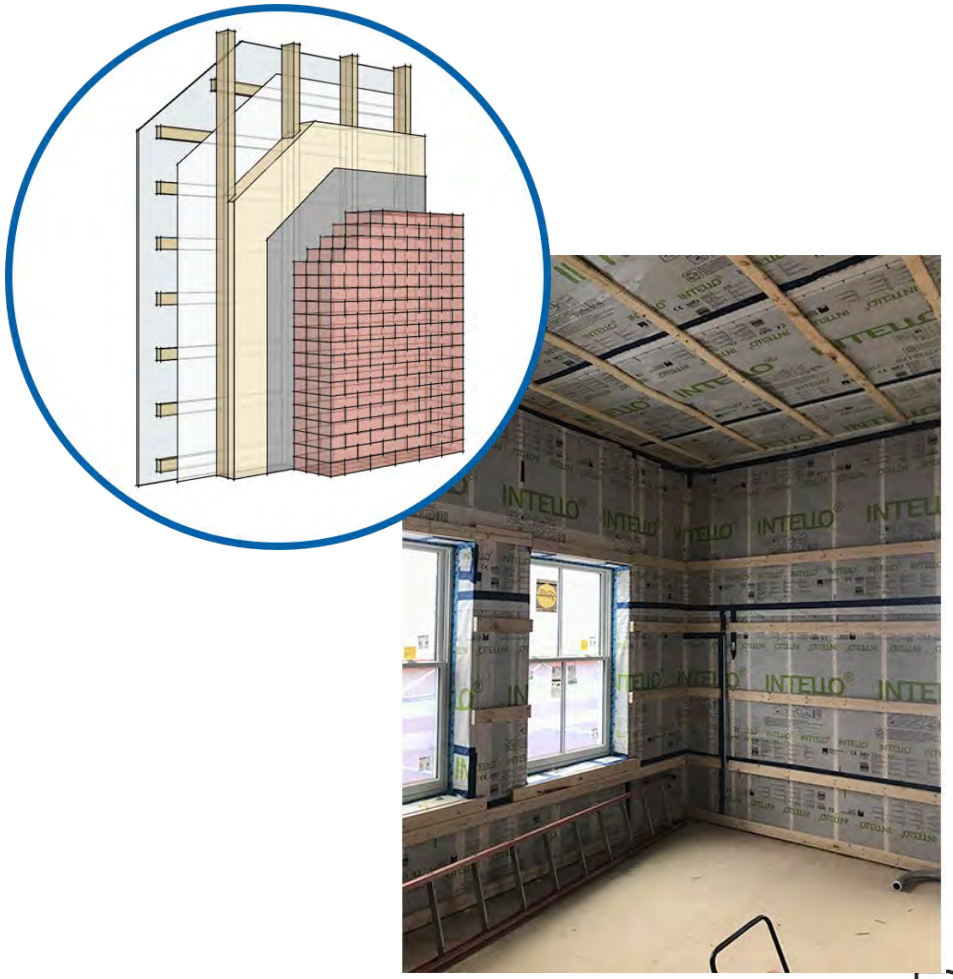
3) Interior Insulation: Foam Free

Benefits:

- No spray foam/petrochemicals
- Easier to transition at ceiling
- All work from the interior (+ /-)

Drawbacks:

- Bricks will be colder and wetter than before (Risk of future freeze-thaw degradation)
- Embedded wood wetter than before
- More difficult to transition at foundation
- Risk of air leakage condensation
- Less available materials and trades



Images from: foursevenfive.ca

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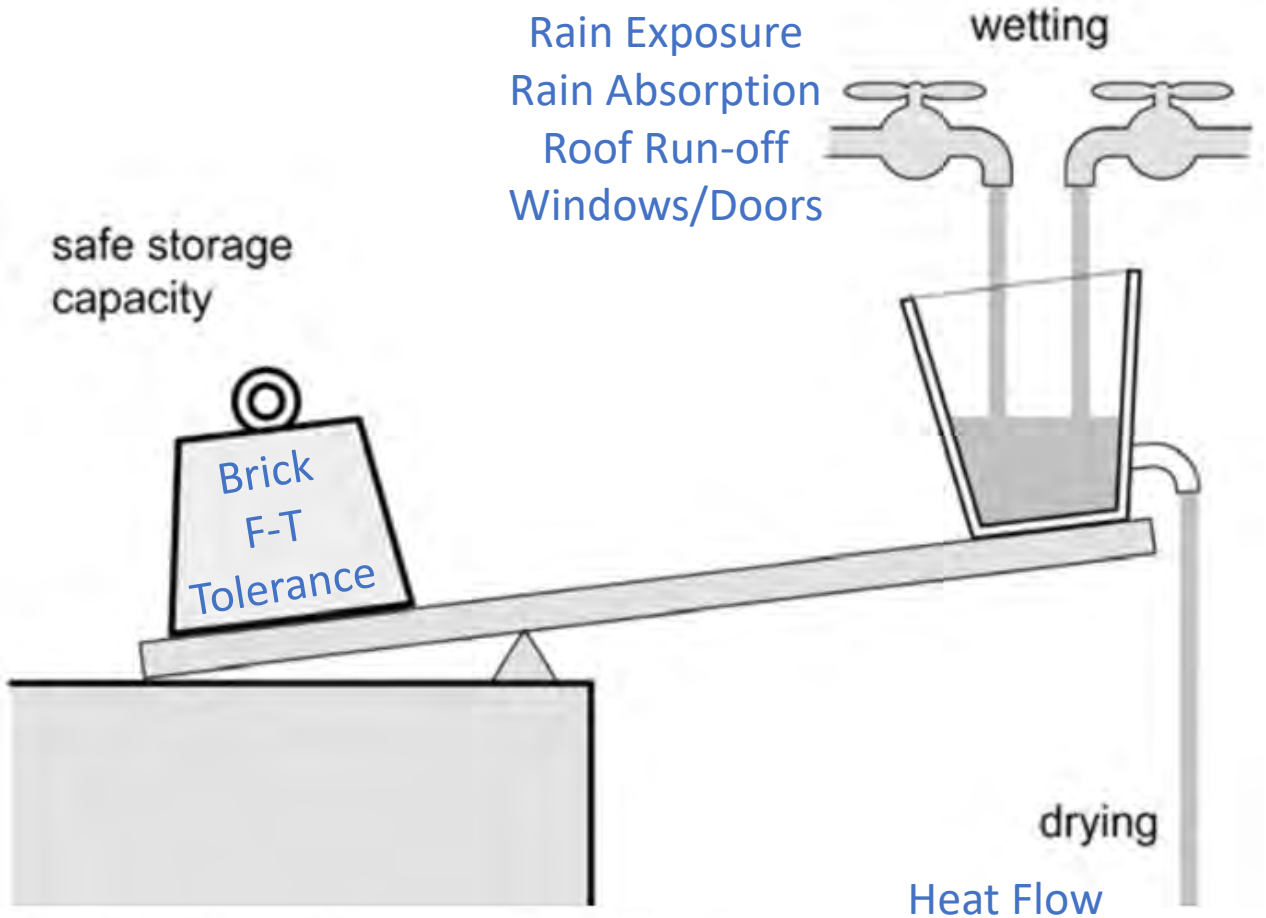
The Moisture Balance



The moisture balance analogy (Straube and Burnett 2005)

Rain Exposure
Rain Absorption
Roof Run-off
Windows/Doors

Rising damp
Air leakage
Condensation

Heat Flow
Vapour Permeability
Redistribution
Evaporation

- Safe storage is a function of the material
- Interior insulation reduces drying
- We can help the balance by reducing wetting through design details

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Reducing Wetting

Re-Pointing

- Replacing the outer layer of mortar
- Mortar should act as a sacrificial layer and break down before the bricks
- As more mortar breaks down, more water can enter the wall system
- Mortar must be softer and more vapour permeable than the brick it surrounds
- Less portland cement results in softer and more vapour permeable mortar

Mortar Types

M----------S----------**N**----------**O**----------**K**----------L

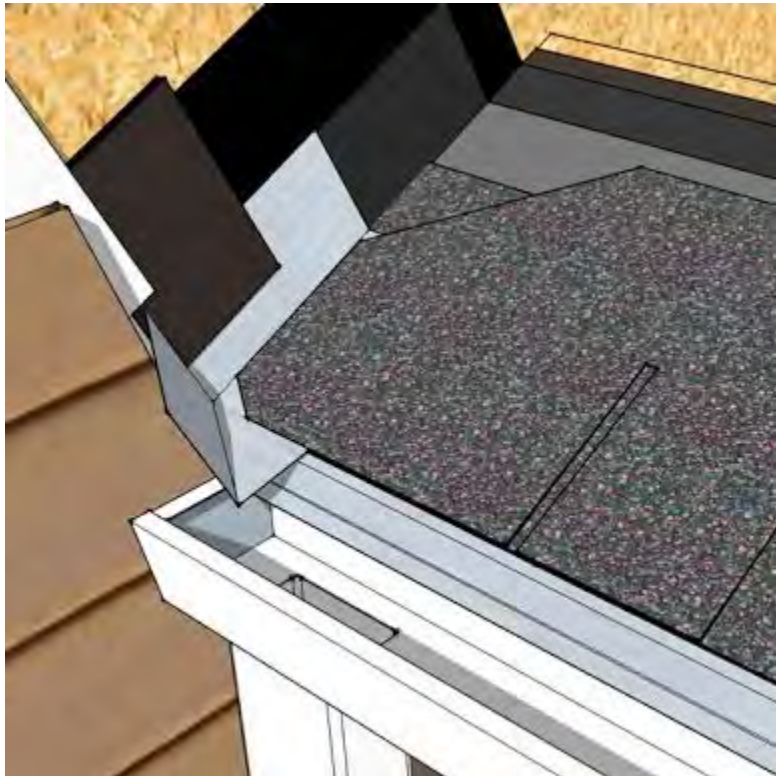
More Portland ---------- No Portland
No Lime ----------More Lime
Harder ---------- Softer
Less Vapour Perm.----------More Vapour Perm.

N, O and K are recommended for historic masonry

Reducing Wetting

Roof Details

- Kick-out flashings and diverters
- Eavestrough size and placement
- Downspout size and placement



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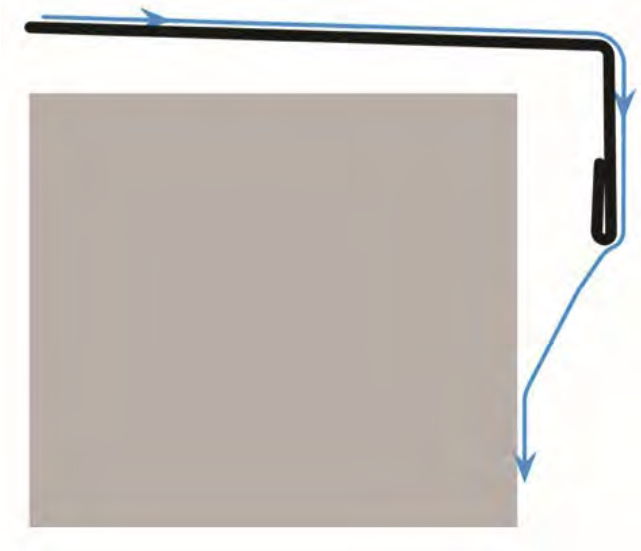
Reducing Wetting

Window Details

- Proper drip edges to divert water away from wall



The Effectiveness of Different Drip Edge Designs
https://www.constructioncanada.net/the-effectiveness-of-different-drip-edge-designs/

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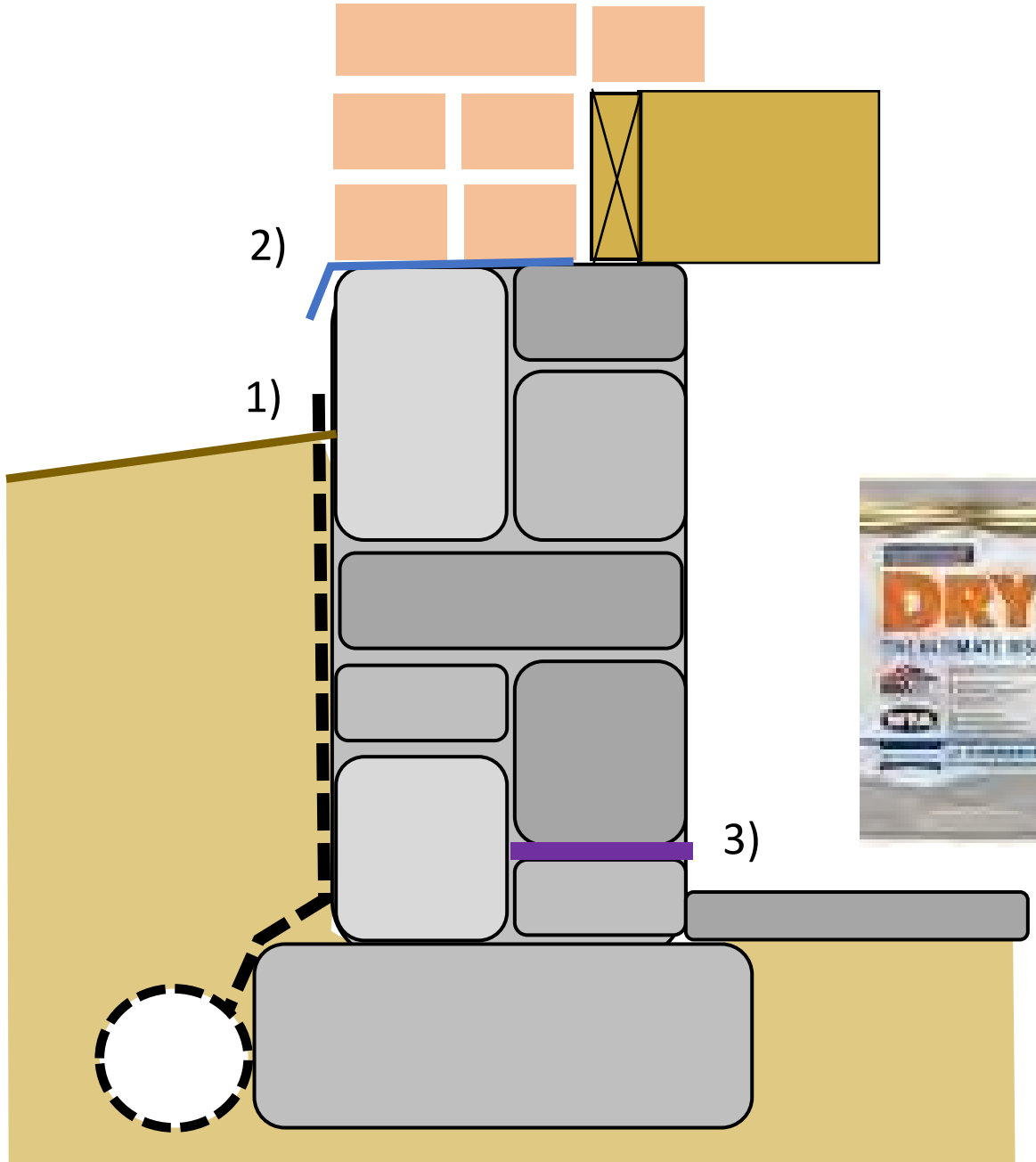
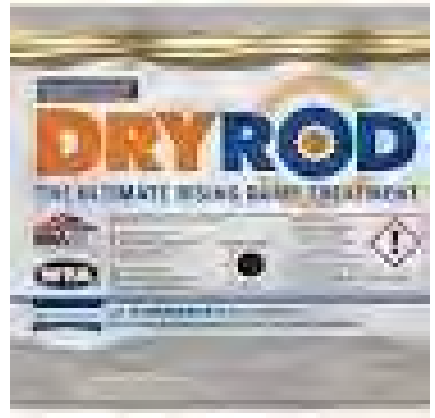
Reducing Wetting

Rising Damp
1) Exterior drainage and landscaping
2) Stainless steel shims
3) Dryrod ‘Damp-proofing’
(capillary blockers)





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Reducing Wetting

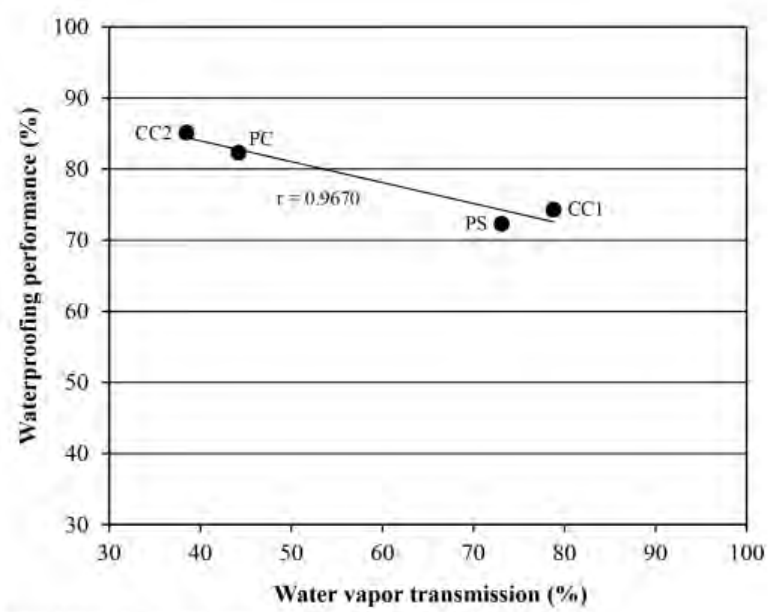
Surface Coatings

Painting Brick

- Will dramatically reduce vapour flow drying
- Outward vapour flow will delaminate paint

Penetrating Sealers

- Will reduce absorption through face of brick
- Does not seal larger cracks between brick and mortar
- Will slow outward vapour flow (ie. drying rate)
- Lab testing of brick/stone and sealer combination recommended to understand the effects on the moisture balance
- Environmental and health hazards of some ingredients



elation between water vapor transmission and waterproofing performance

Safuddin and Soudki, 2015

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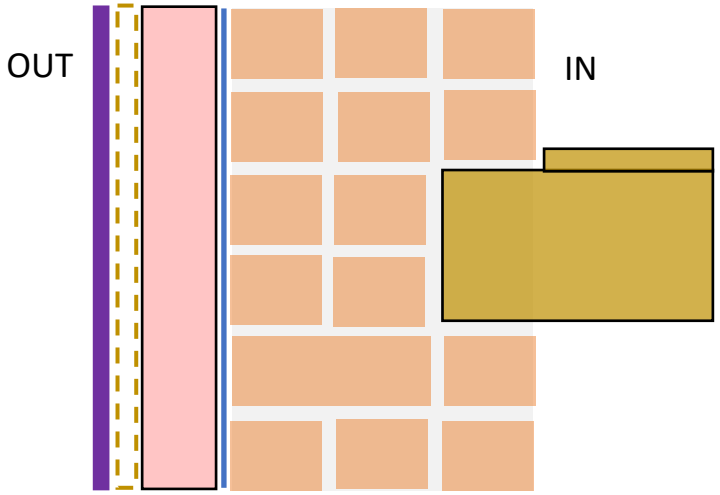
Critical Details:

Embedded Wood Details

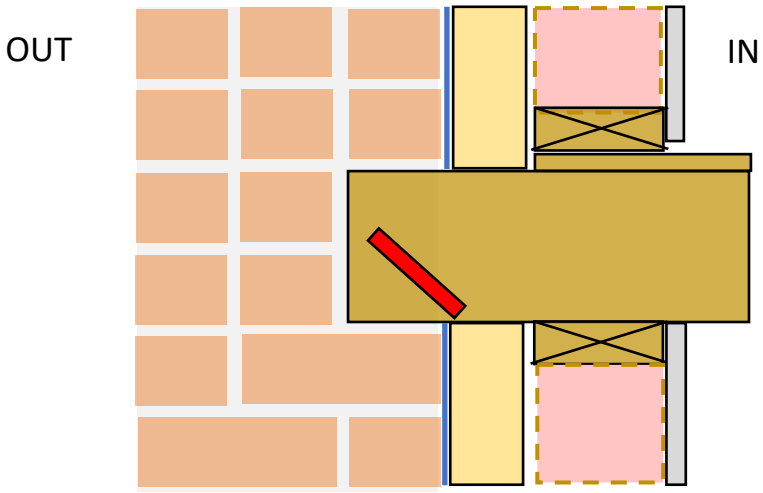
Exterior Insulated



Embedded Wood Members

- Stay warm and dry
- No special details necessary

Interior Insulated



Embedded Wood Members

- Will be wetter than before
- Borate rods can reduce the risk of future rot

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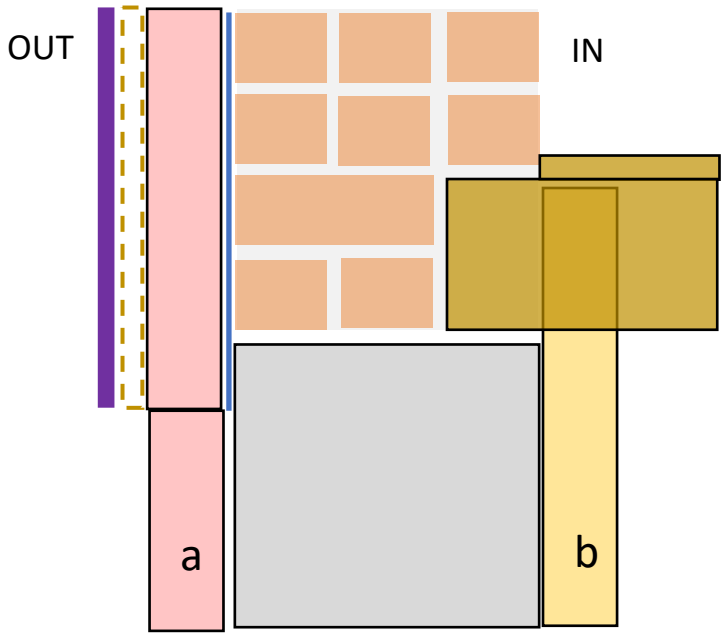
Critical Details:

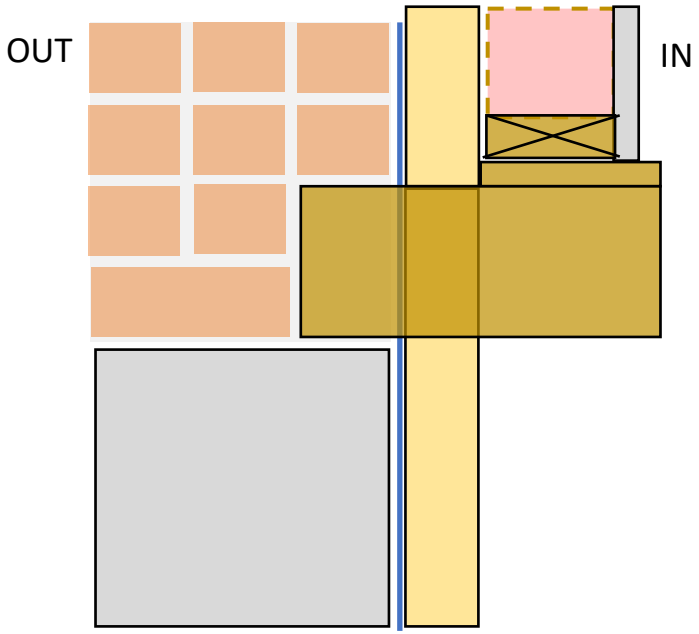
Wall to Foundation Details

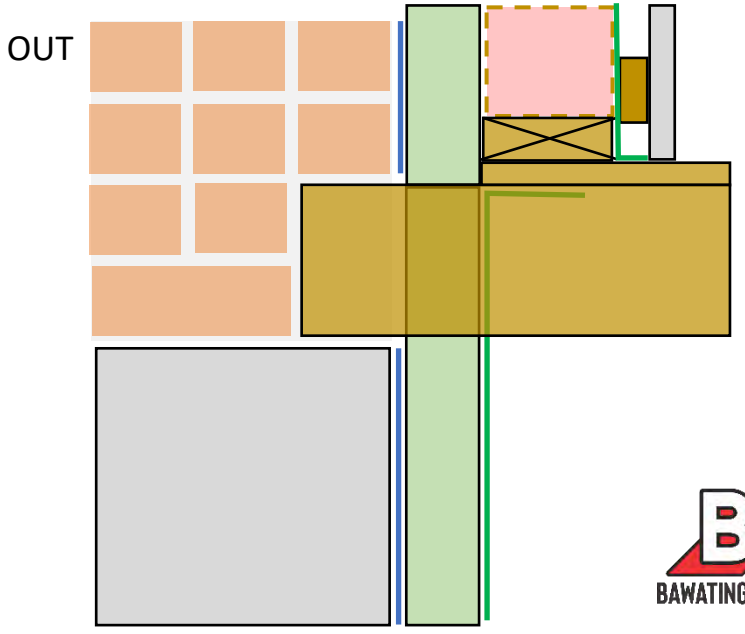
Exterior Insulated
- Air barrier transitions to foundation
- Foundation insulation can be exterior or interior

Interior Spray Foam
- Spray foam air barrier seals around floor joists

Interior Foam Free
- Smart air/vapour barrier challenging to transition at floor







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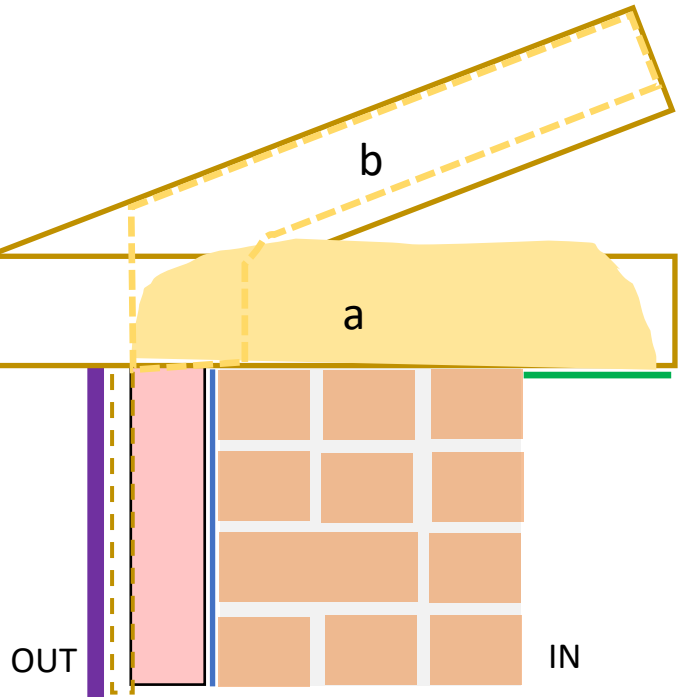
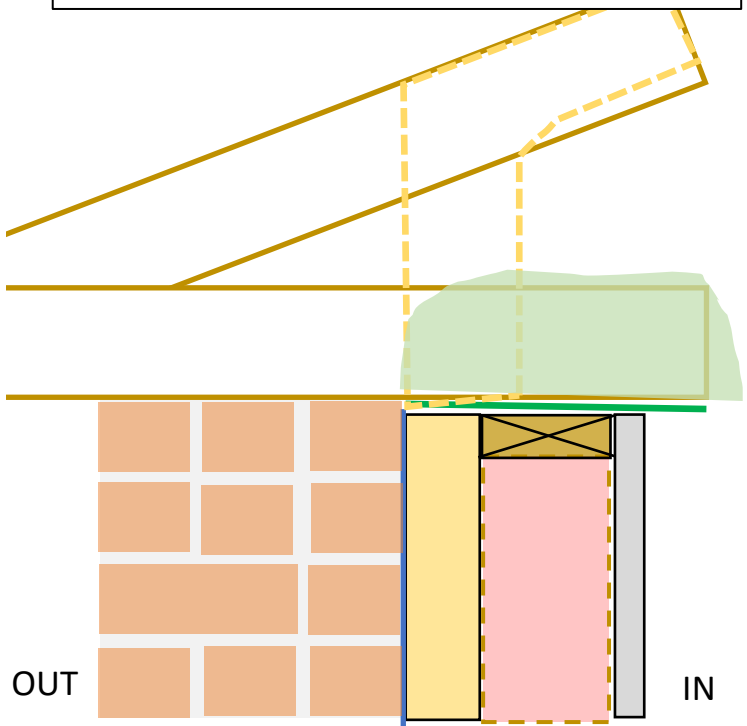
Critical Details:

Wall to Roof Details

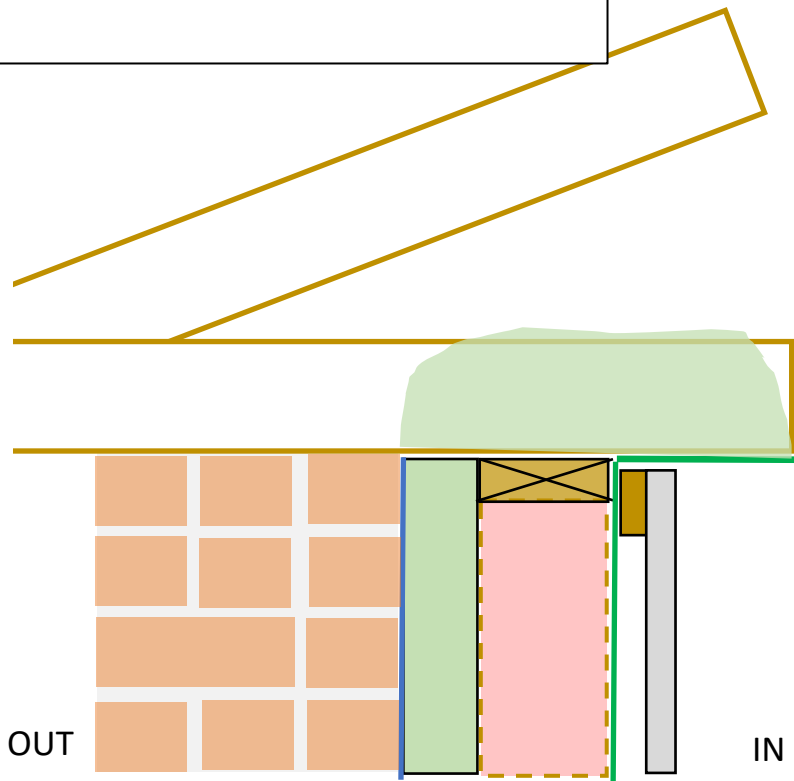
Exterior Insulated
- Air barrier transition to ceiling/roof can be challenging
- Compatible with hot roof approach (b)



Interior Spray Foam
- Spray foam air barrier seals to ceiling air barrier
- Compatible with hot roof approach

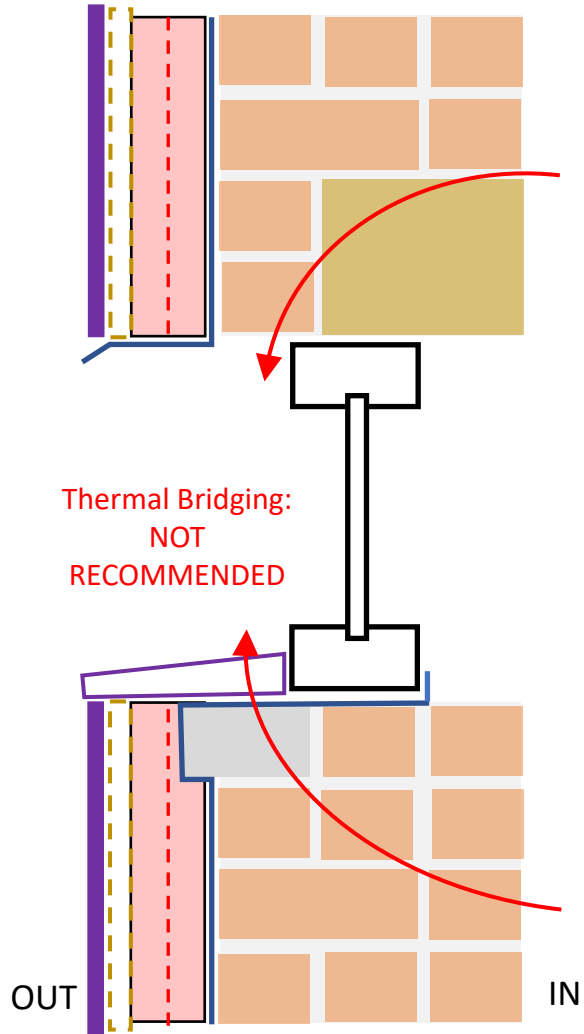


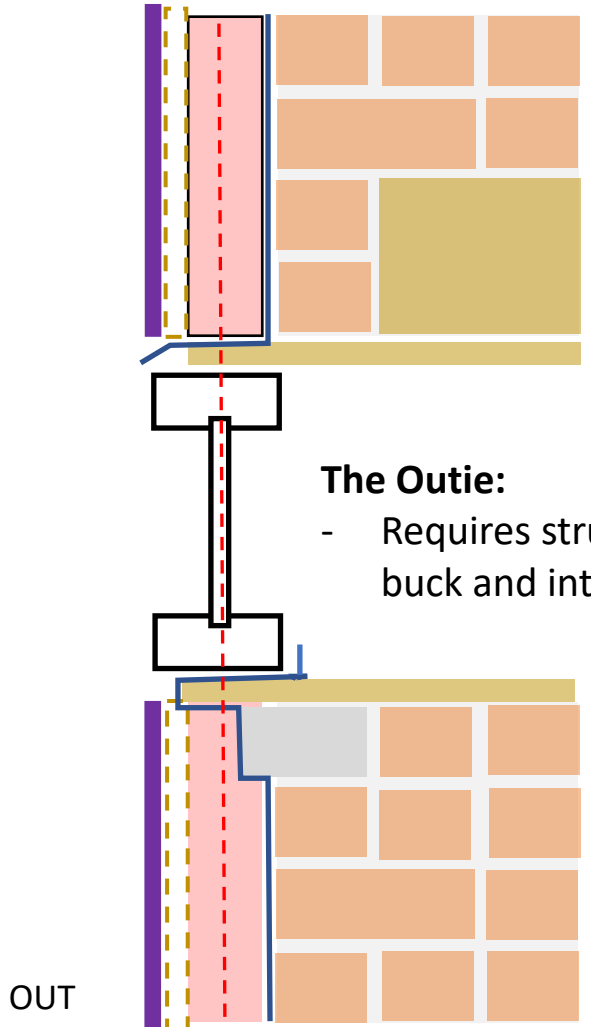
Interior Foam Free
- Smart air/vapour barrier easy to transition at ceiling/roof



Critical Details:

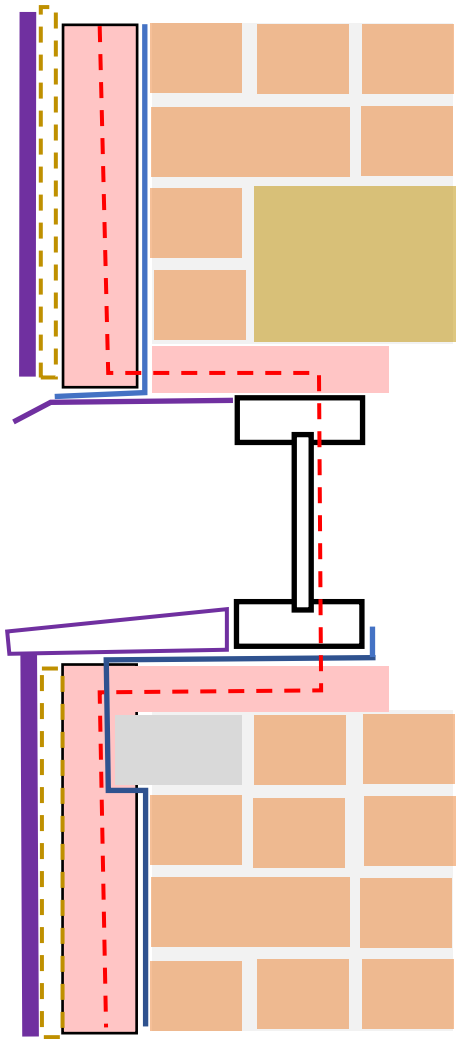
Window Installation Details – Exterior Insulated Wall





The Outie:

- Requires structural buck and interior trim

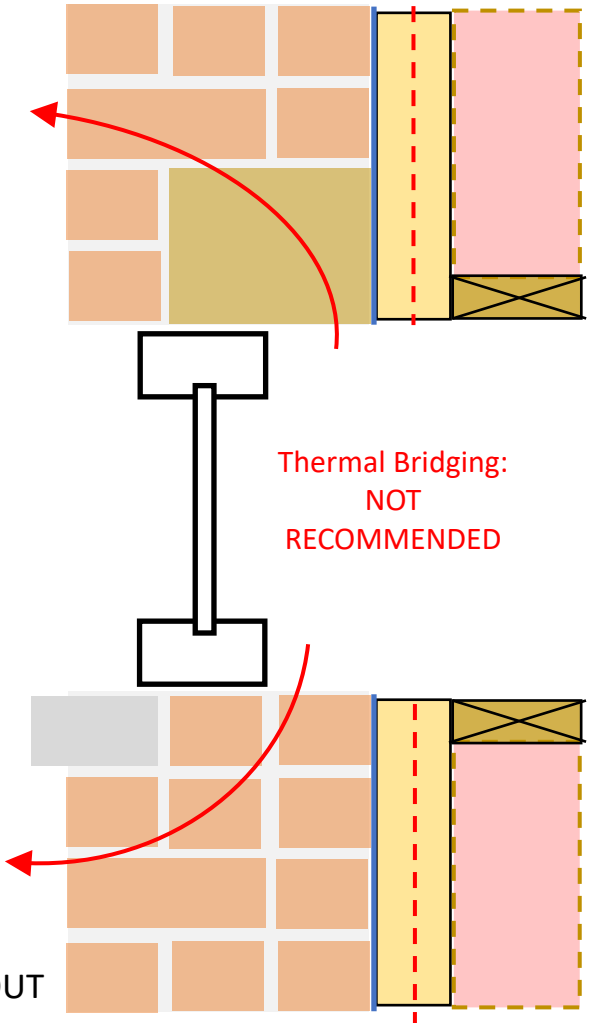


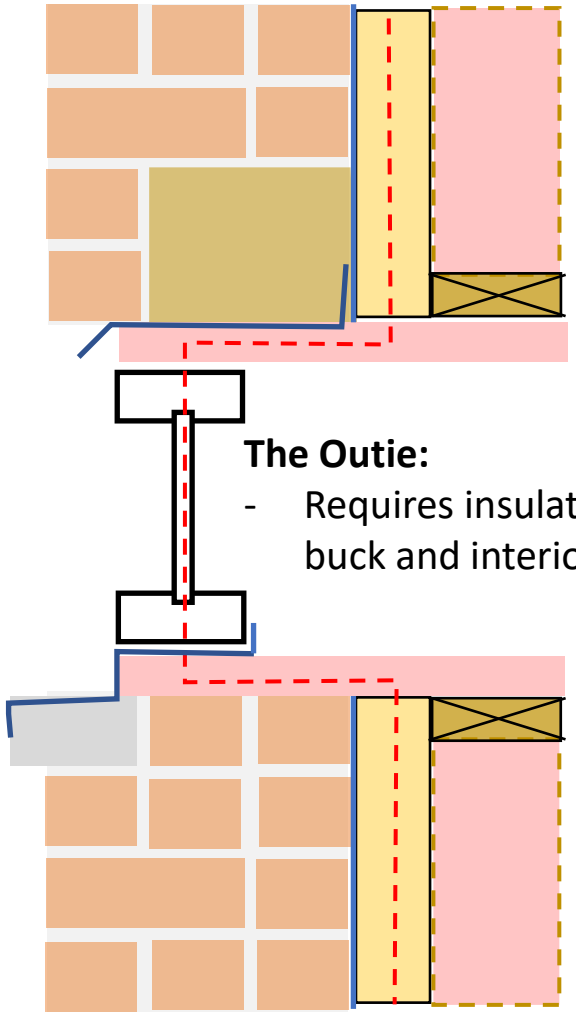
The Innie:

- Requires insulated buck and exterior trim

Critical Details:

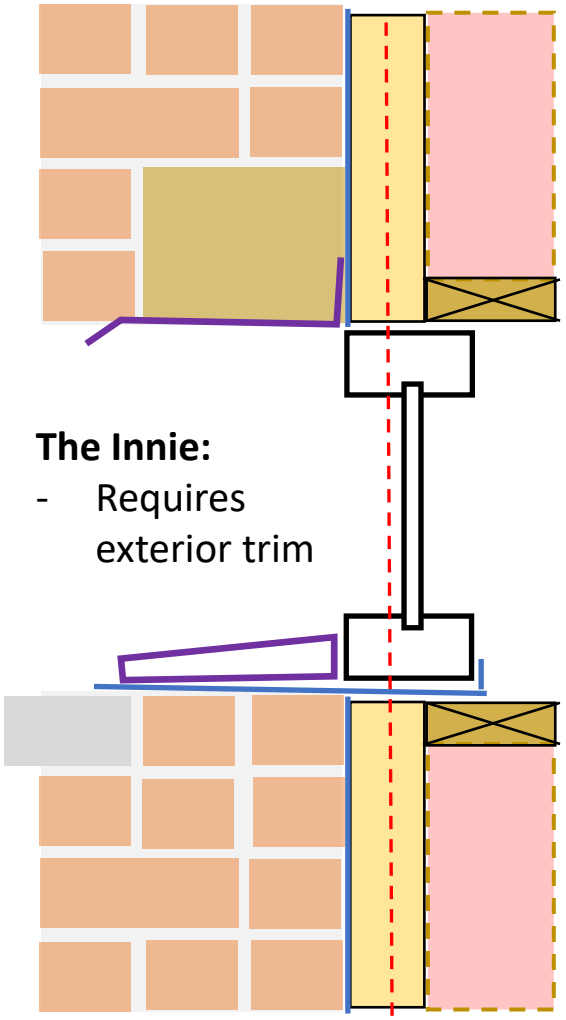
Window Installation Details – Interior Insulated Wall





The Outie:

- Requires insulated buck and interior trim



The Innie:

- Requires exterior trim

Summary

- Exterior insulation retrofit will keep bricks and embeded wood warm and dry

- Interior insulation retrofit will make bricks colder and wetter
  - increasing the risk of future freeze-thaw damage

- Determine the freeze-thaw vulnerability of the brick

- Reduce wetting (without preventing drying)

- Get the details right
  - Water control
  - Air Control
  - Thermal Control
  - Vapour Control

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Questions.....

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