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October 17, 2013

Interior Insulation of Mass Masonry Walls: A Pittsburgh-Area PH Case Study

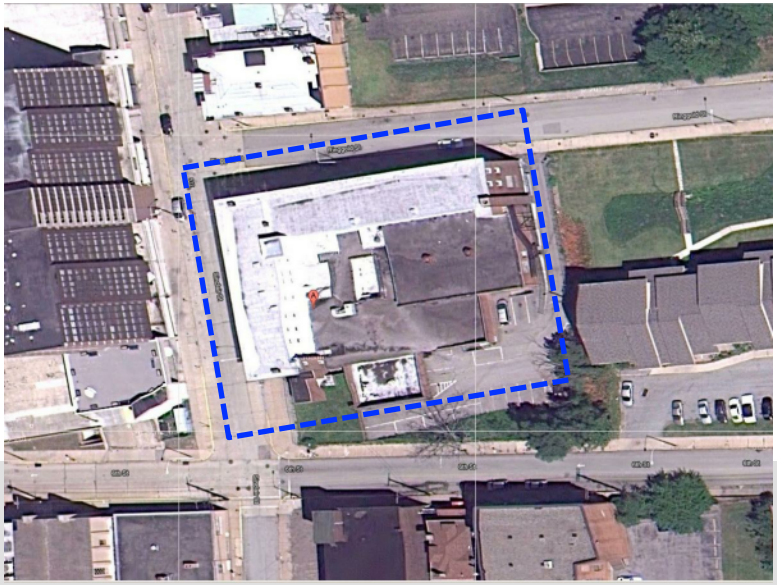
8th Annual North American Passive House Conference

Project Background

McKeesport, PA YMCA Building

- Former YMCA building, circa 1923 construction
- Action Housing Inc. - Downtown Housing facility
- ~65,000 sf; ~75 units (rental, shelter rooms)

McKeesport, PA YMCA Building

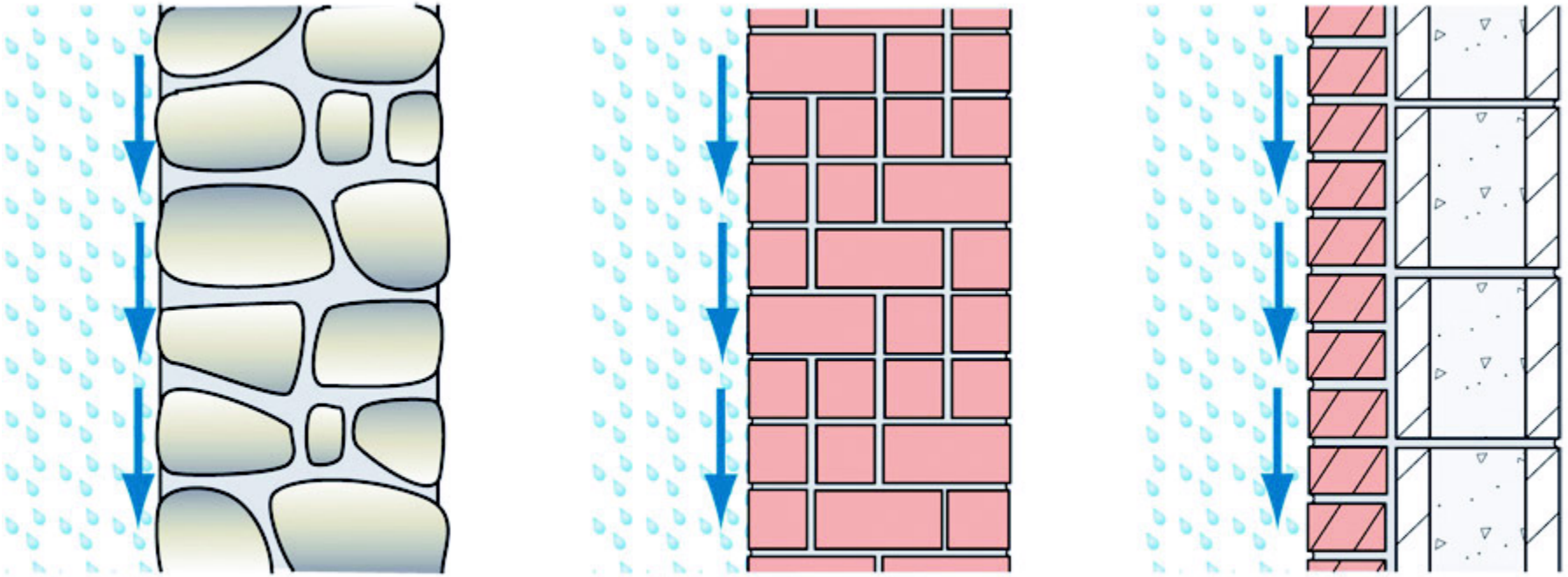


McKeesport, PA YMCA Building

- Former YMCA building, circa 1923 construction
- Action Housing Inc. - Downtown Housing facility
- ~65,000 sf; ~75 units (rental, shelter rooms)
- Major energy efficiency retrofit project underway
  - PH target; occupied rehab project
- Thoughtful Balance Inc. (architecture firm)
  - Laura Nettleton, Michael Whartnaby
- BSC acting as sub-consultant
  - Masonry interior insulation retrofit; other energy issues

Masonry Insulation Background

Mass Walls (Rain Control)



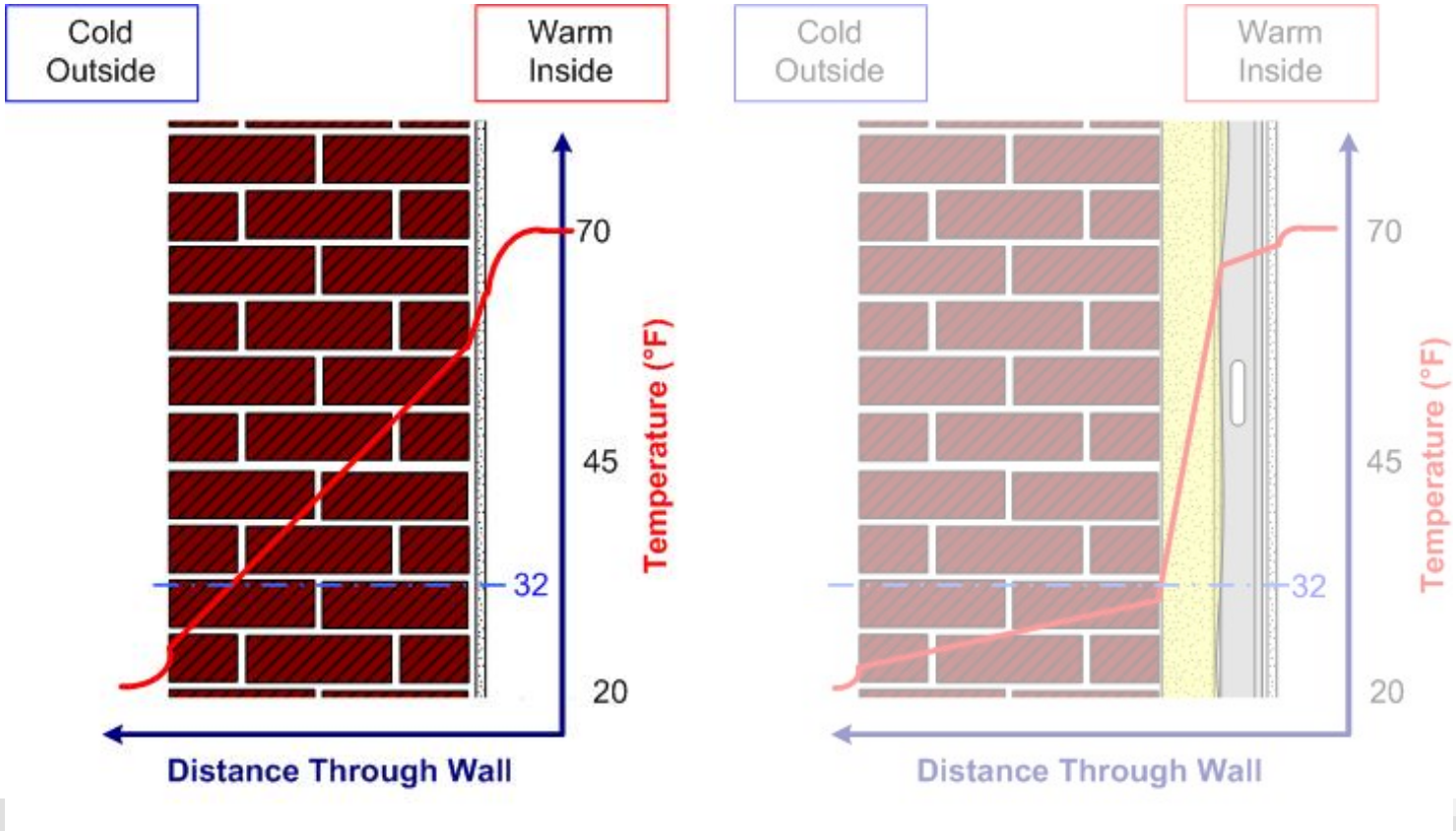
- Moisture is absorbed/safely stored during rain
- Moisture re-evaporates/dries while warmer
- No “drainage plane”

Inside or Outside Insulation?

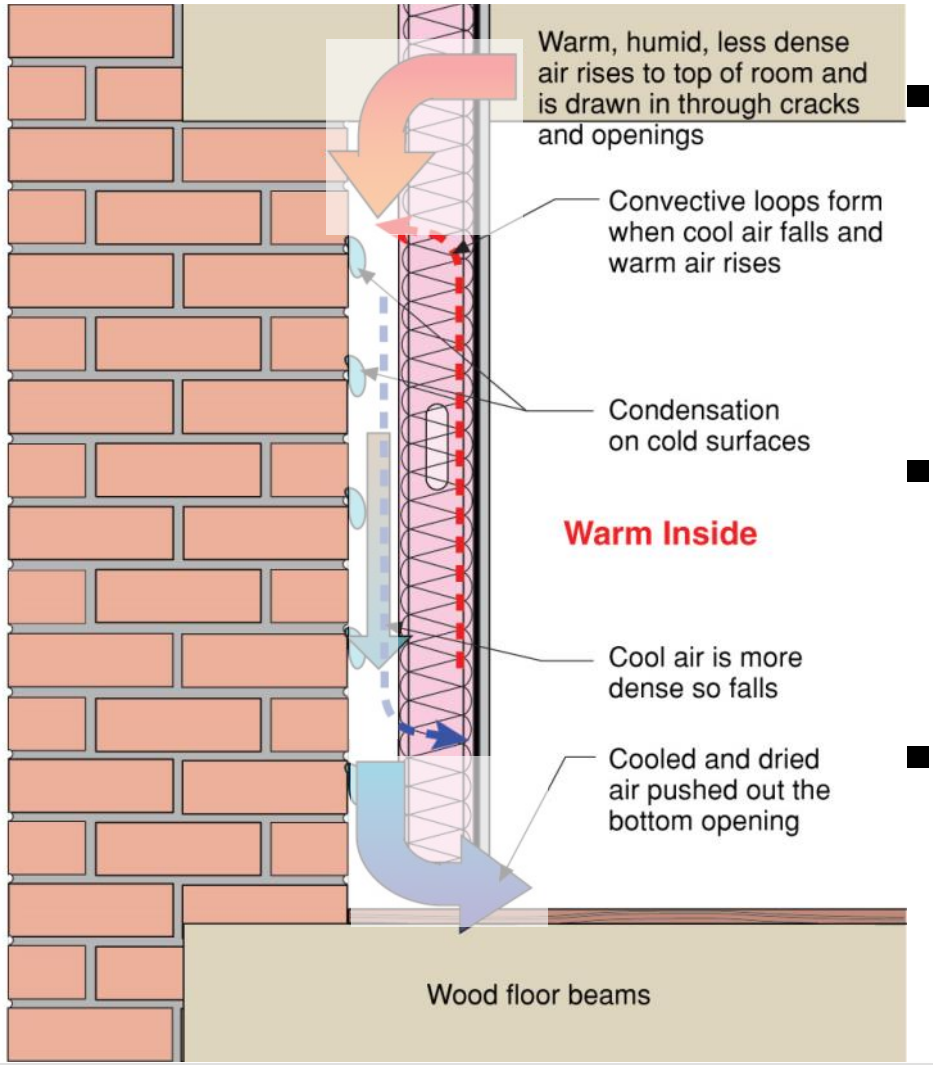
- Insulating on exterior always preferable (masonry durability, condensation risks)
- Interior insulation → historic preservation reasons
- Interior → potential durability risks
- Energy efficiency, preserve exterior, museum-level durability: choose 2 of 3

Cold Climate Risks

1. Freeze-thaw (reduced drying)
2. Air leakage condensation on interior face of masonry
3. Rot / corrosion of embedded elements

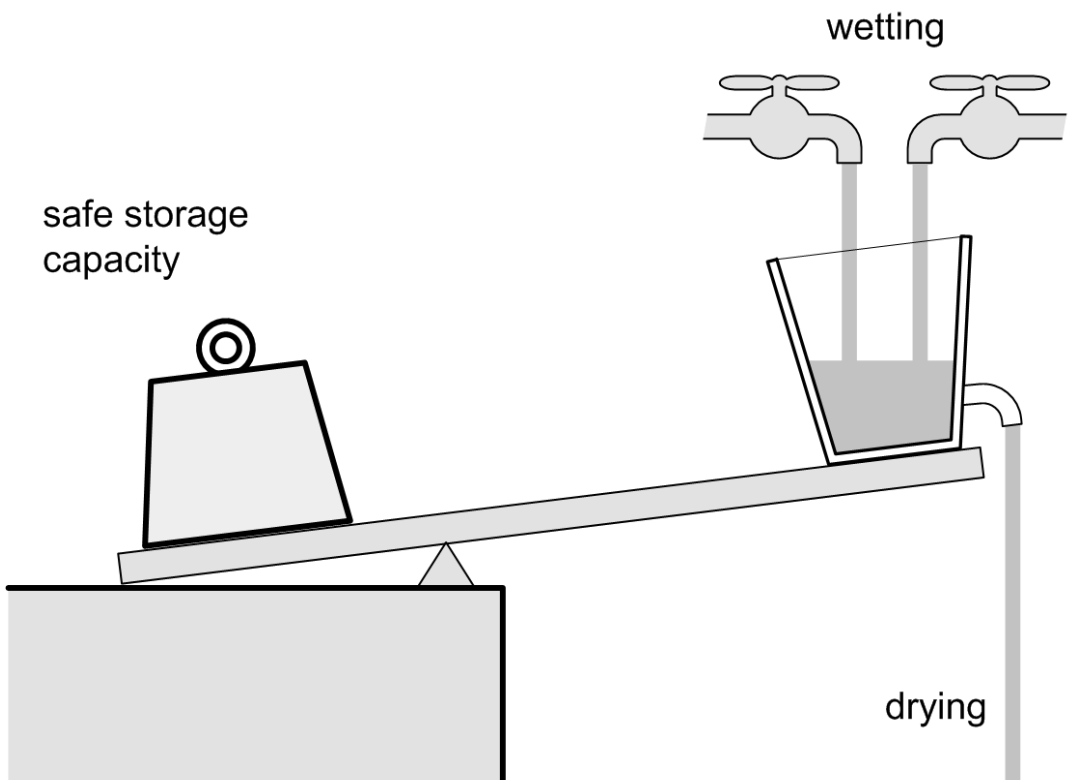


Cold Climate Risks: Condensation



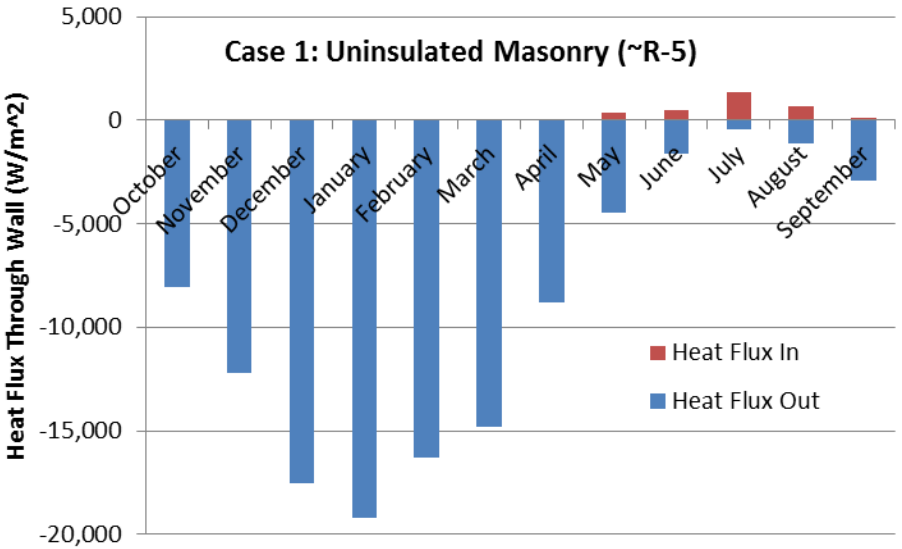
- Requires perfect workmanship at air barrier—around penetrations, etc.
- Made worse by air gap behind insulation
- **NOT RECOMMENDED**

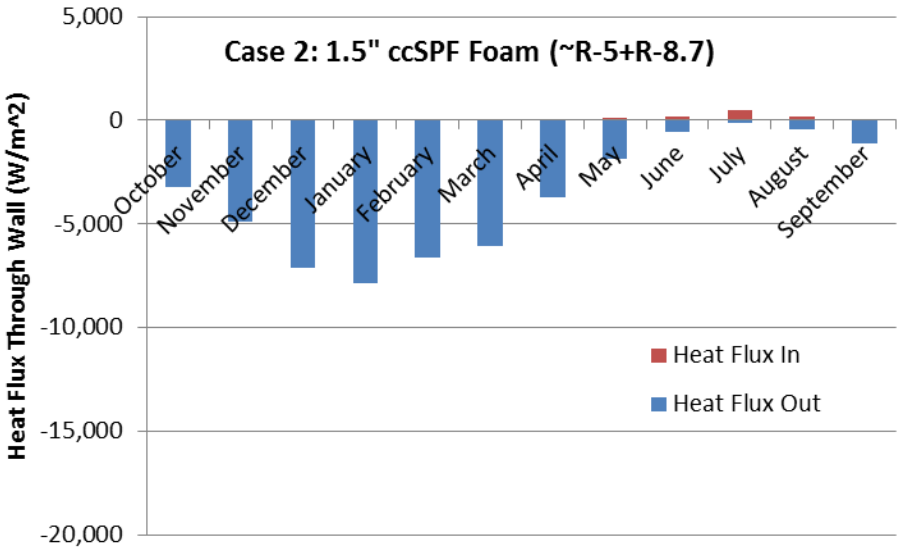
The Moisture Balance



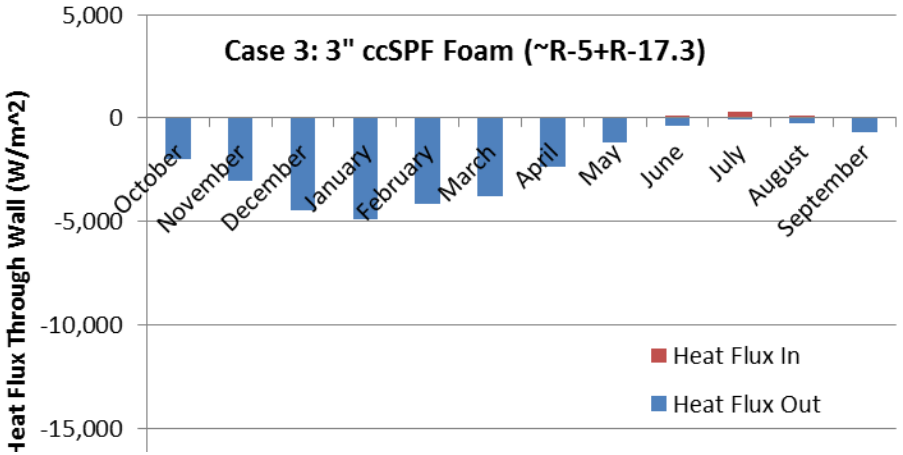
- Large storage capacity (mass wall)
- Drying decreases with insulation
- Design should reduce/control wetting to compensate

Do We Need to Insulate Mass Walls?





Climate: Burlington, VT



Case 2 (add 1.5” ccSPF, R-8.7) ≈ 60% reduction in heat flow through walls vs. uninsulated case

Case 3 (add 3” ccSPF, R-17.3) ≈ 75% reduction in heat flow through walls vs. uninsulated case

Mass vs. no mass → Adds ~R-1

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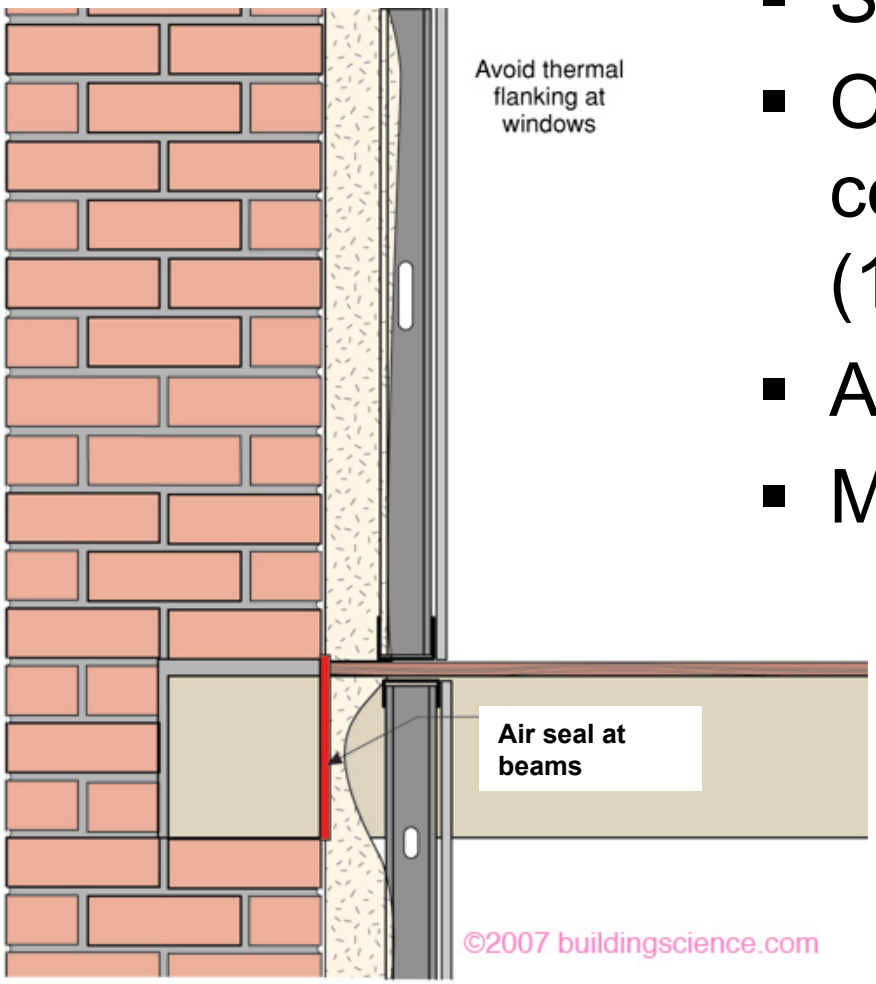
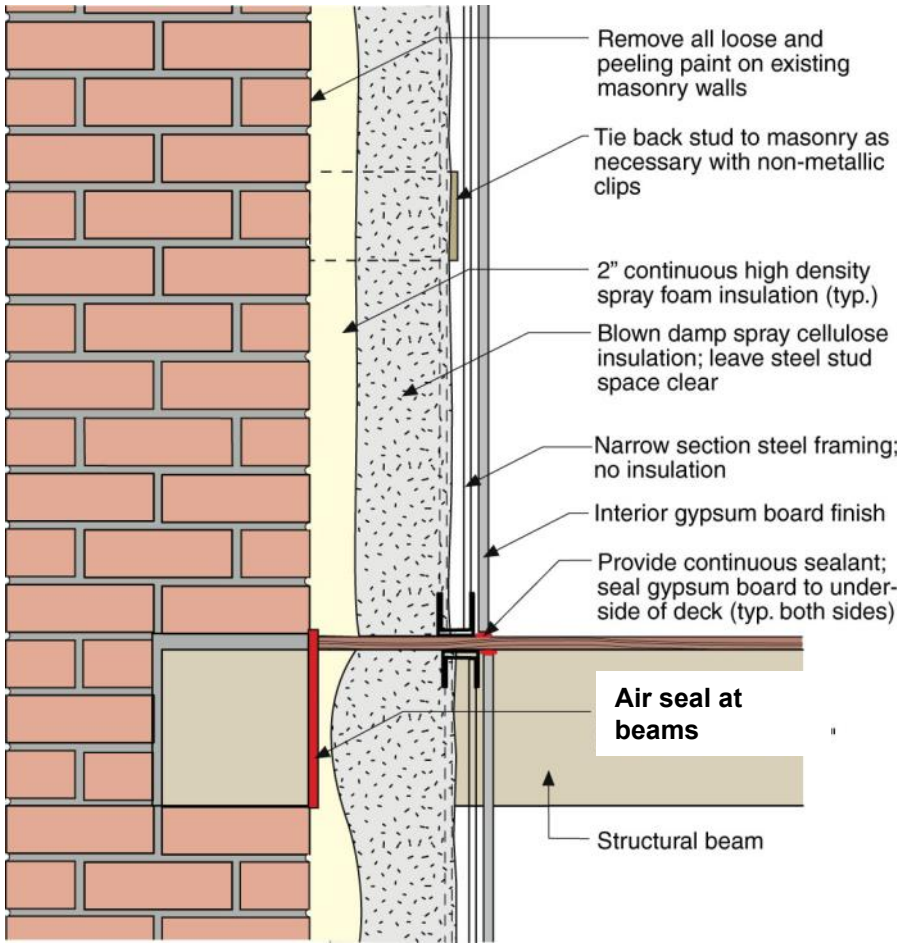
Retrofit Approaches

Recommended Approaches



- Spray foam against masonry
- Open cell (0.5 PCF)? Closed cell (2.0 PCF)? Intermediate (1.0 PCF)?
- Air seal at joist pockets
- Montreal experience

Hybrid Wall Insulation Assembly



Non Spray Foams Options

- Rigid board foams, adhered to wall—air barrier
- Expanded polystyrene/EPS (non-GWP foam)

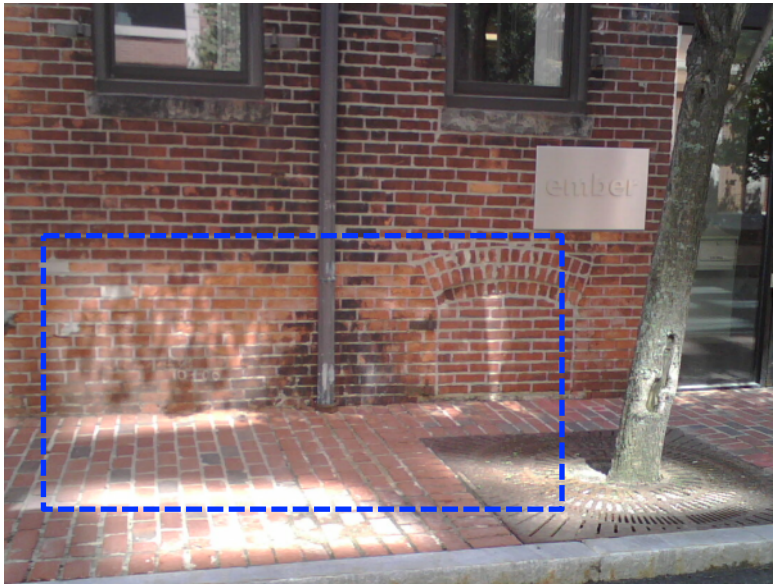
Non-Foam Options?

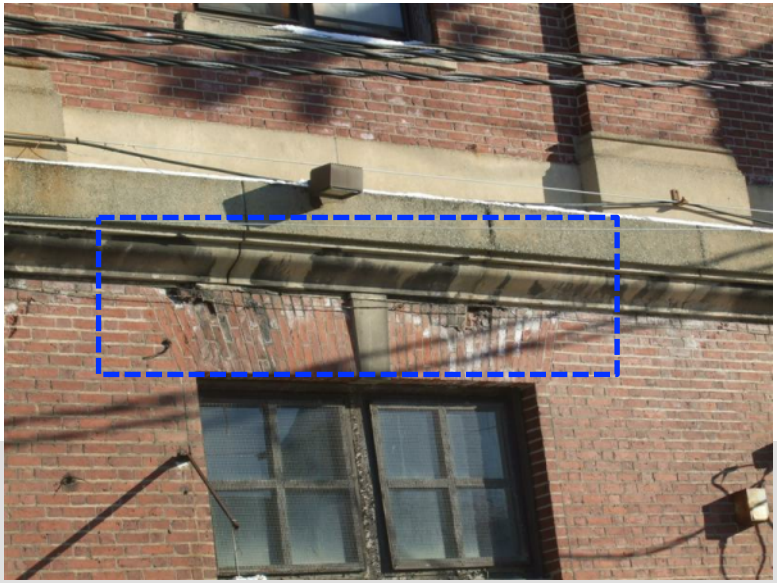
- Dense pack cellulose against brick
- High-density mineral fiber/glass fiber & variable permeability vapor retarder
- Requires meticulous workmanship/air barrier—air barrier outboard of framing & services

Photo: Chris Benedict

Site Assessment

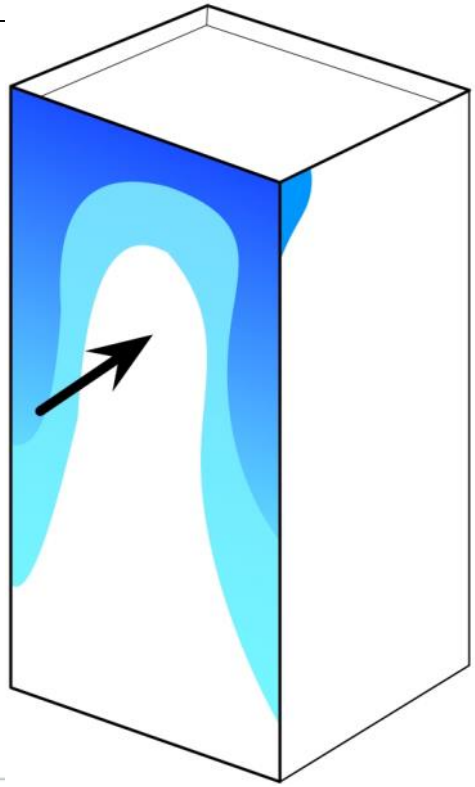
Site Assessment: Where is it Wet?

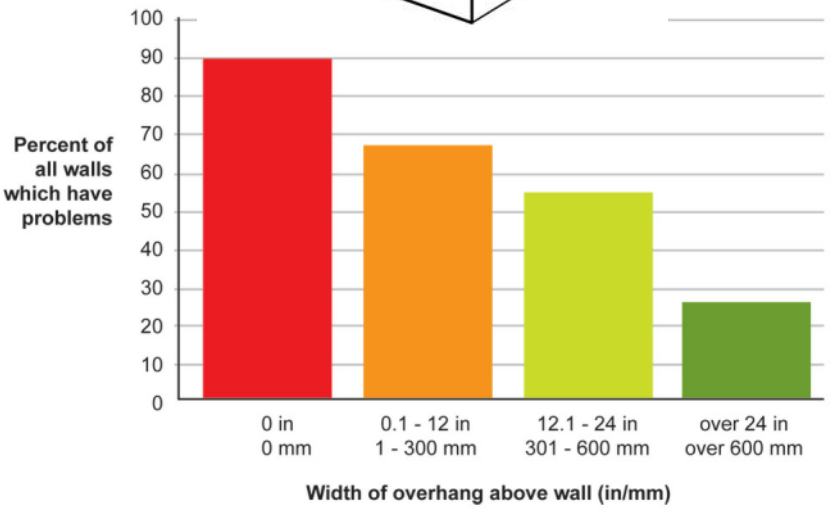




Site Assessment: Brick Condition

Roof-Wall Interface



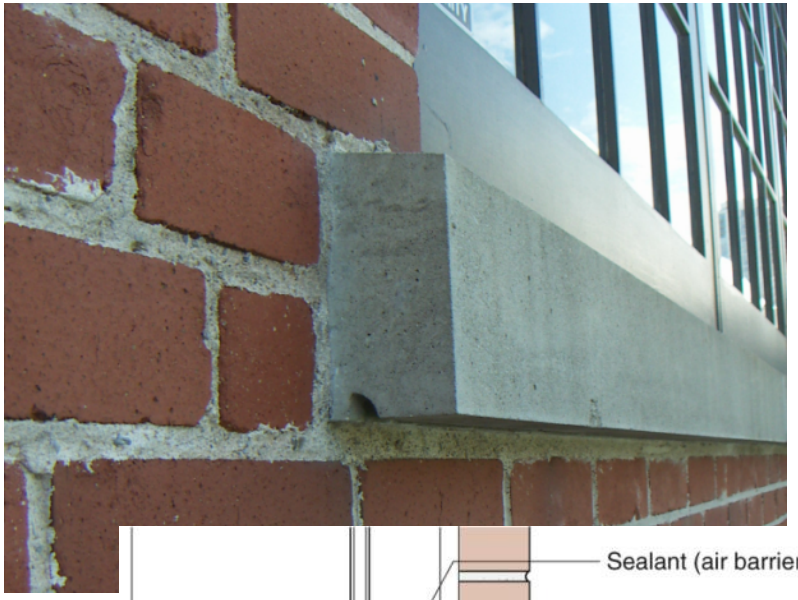


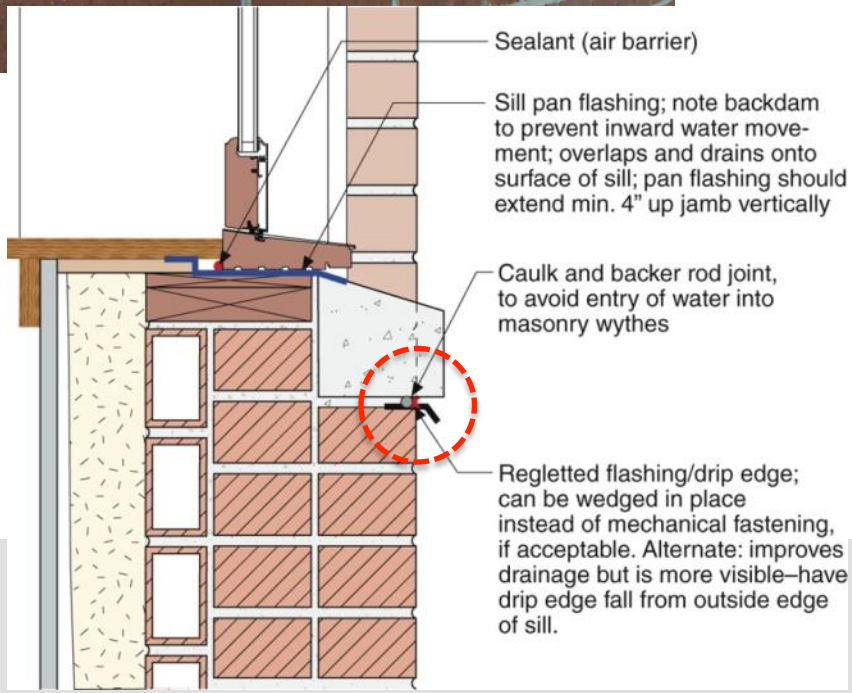
Site Assessment: North Parapet

Site Assessment: Windows (Rowlock)

Site Assessment: Windows (Terra Cotta)

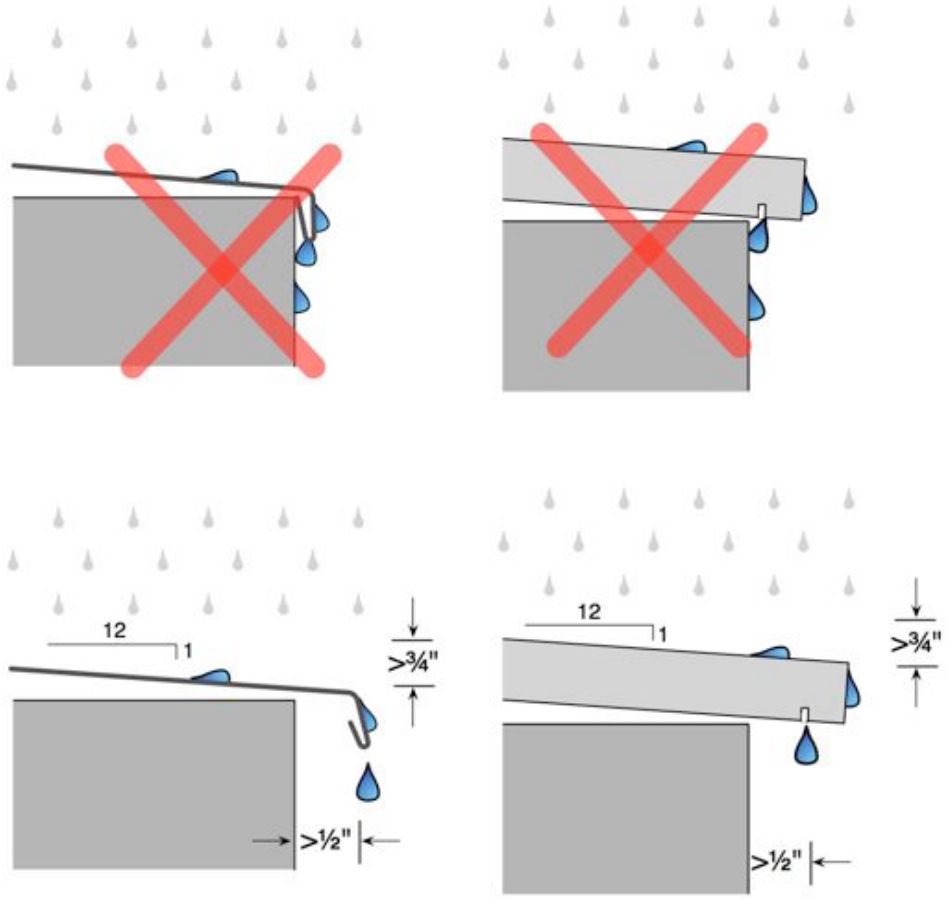
Windows (Water Concentration)



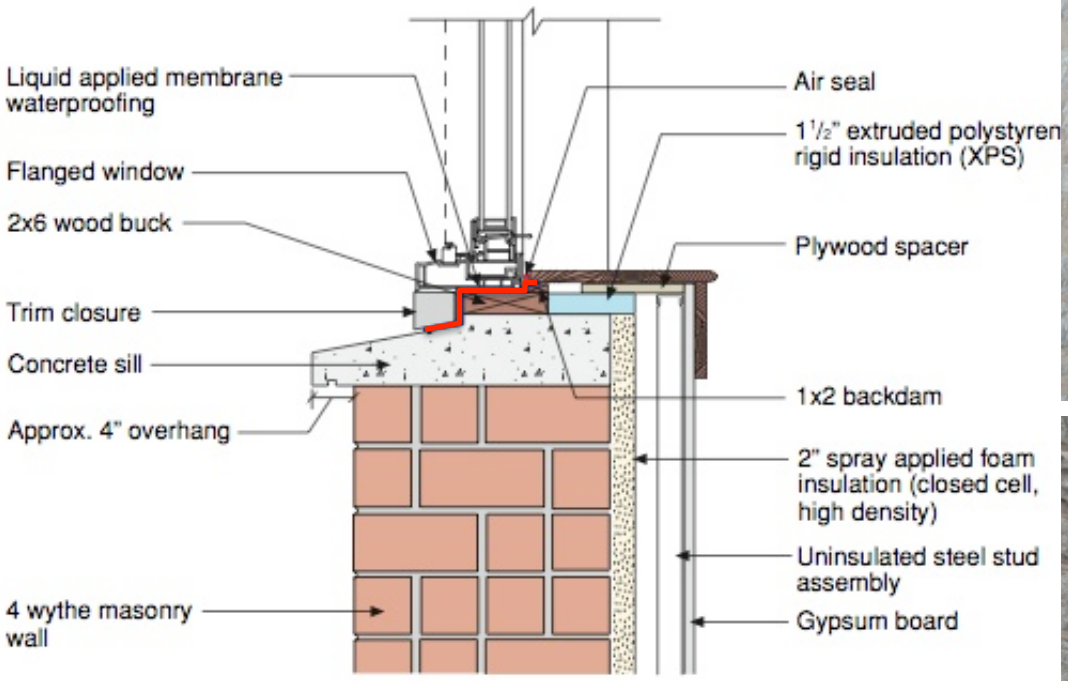


Drip Edges

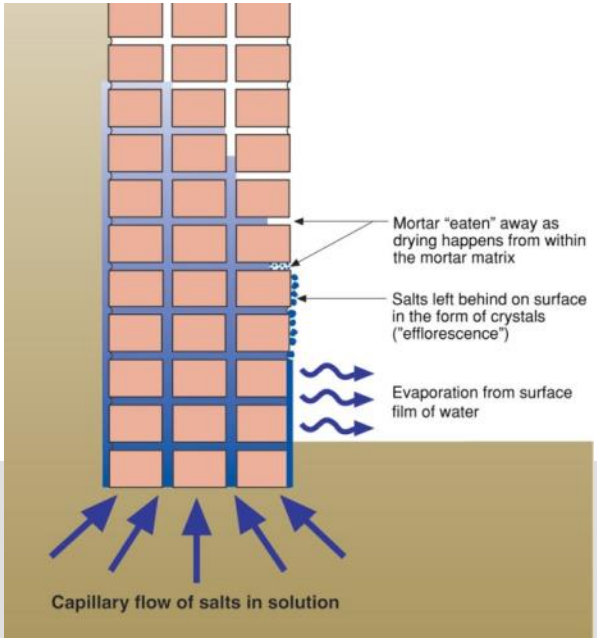
- Minimum projection of drip edge



Windows (Potential Rain Entry Point)



Site Assessment: Ground Capillarity?

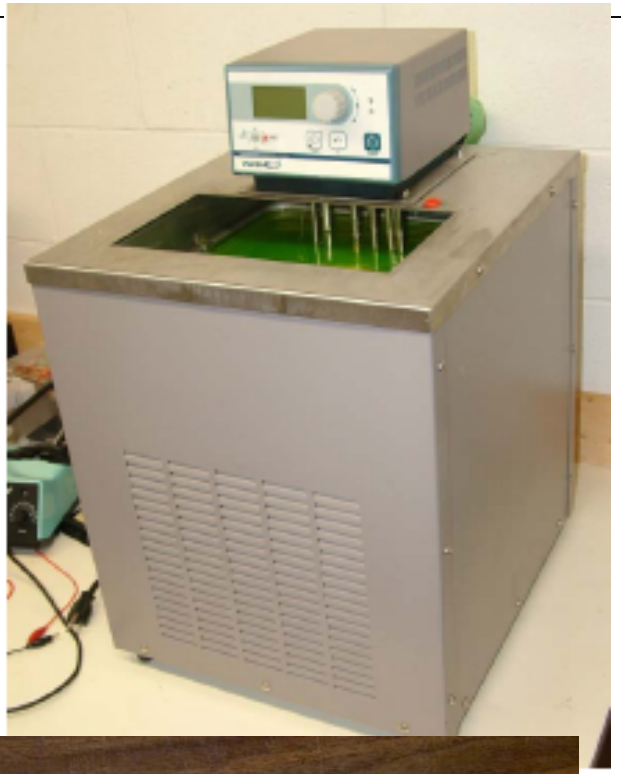


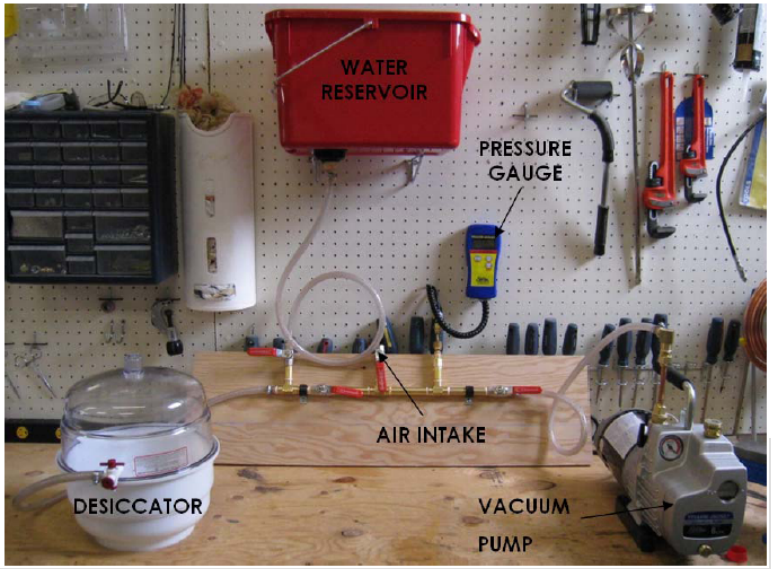
Brick Testing & F/T Simulations

Measurement of S_{crit}

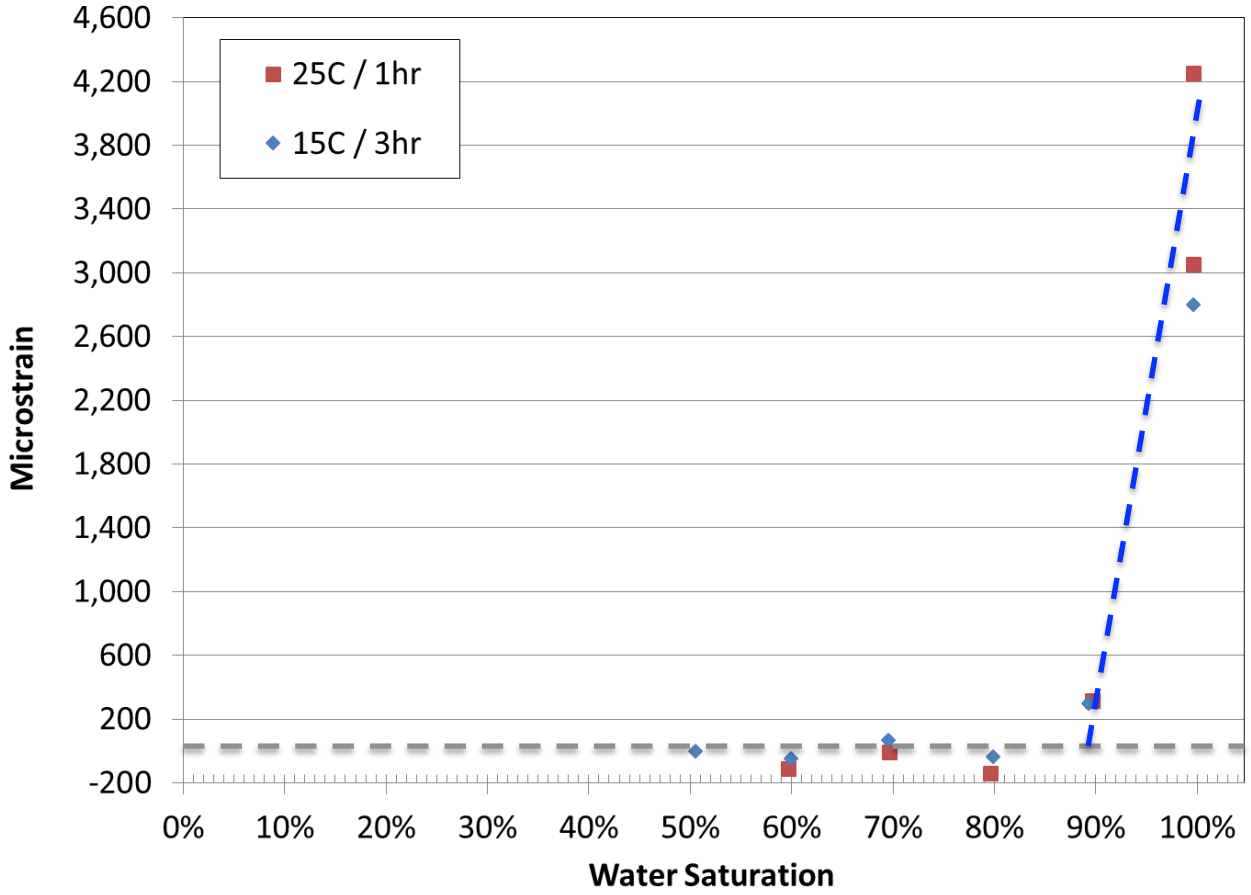
- Critical Degree of Saturation (S_{crit})
  - European research on stone and masonry
  - Below this moisture content: no damage w. F/T
  - Above this moisture content: damage occurs quickly
- Cut brick samples; measurements
- Vacuum saturate to range of moisture contents
- Subject to freeze-thaw cycles
- Measure dilation (growth) of samples (very small!)
- “Hook” in graph signifies S_{crit}

Laboratory Measurement of S_{crit}



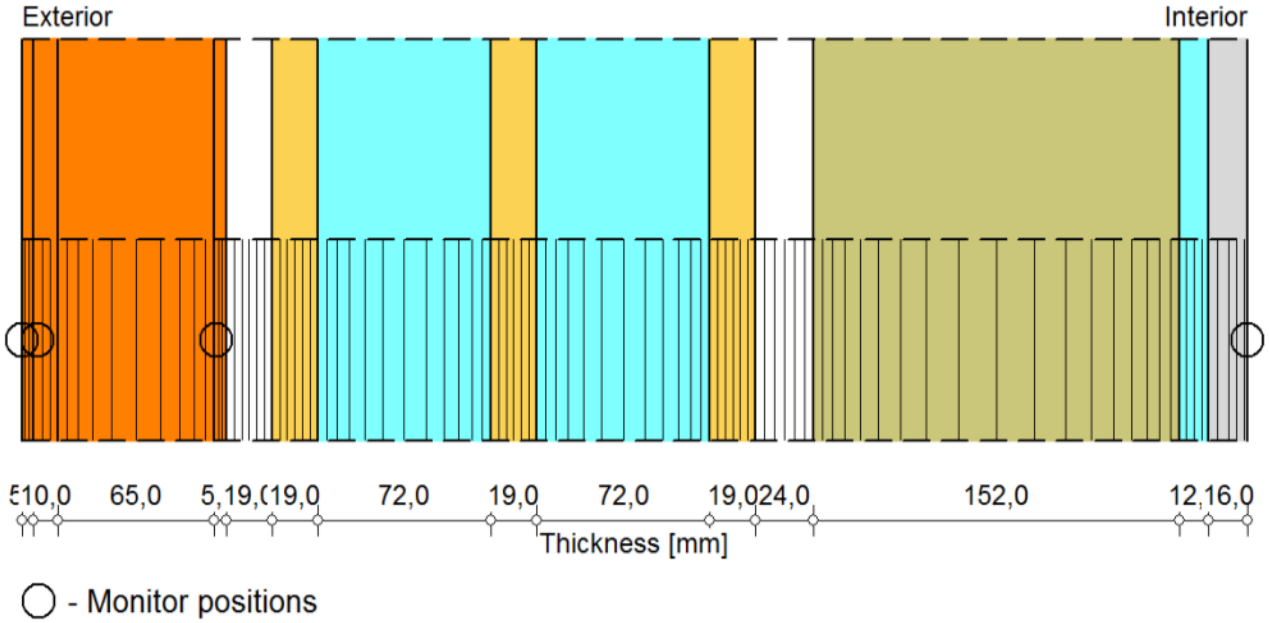


Dilation (Growth) of Samples



- "Hook" in graph signifies S_{crit}

Hygrothermal Simulations



- Simulate existing (uninsulated) wall
- Simulate retrofitted (insulated) wall
- Vary rain loading—sensitivity analysis

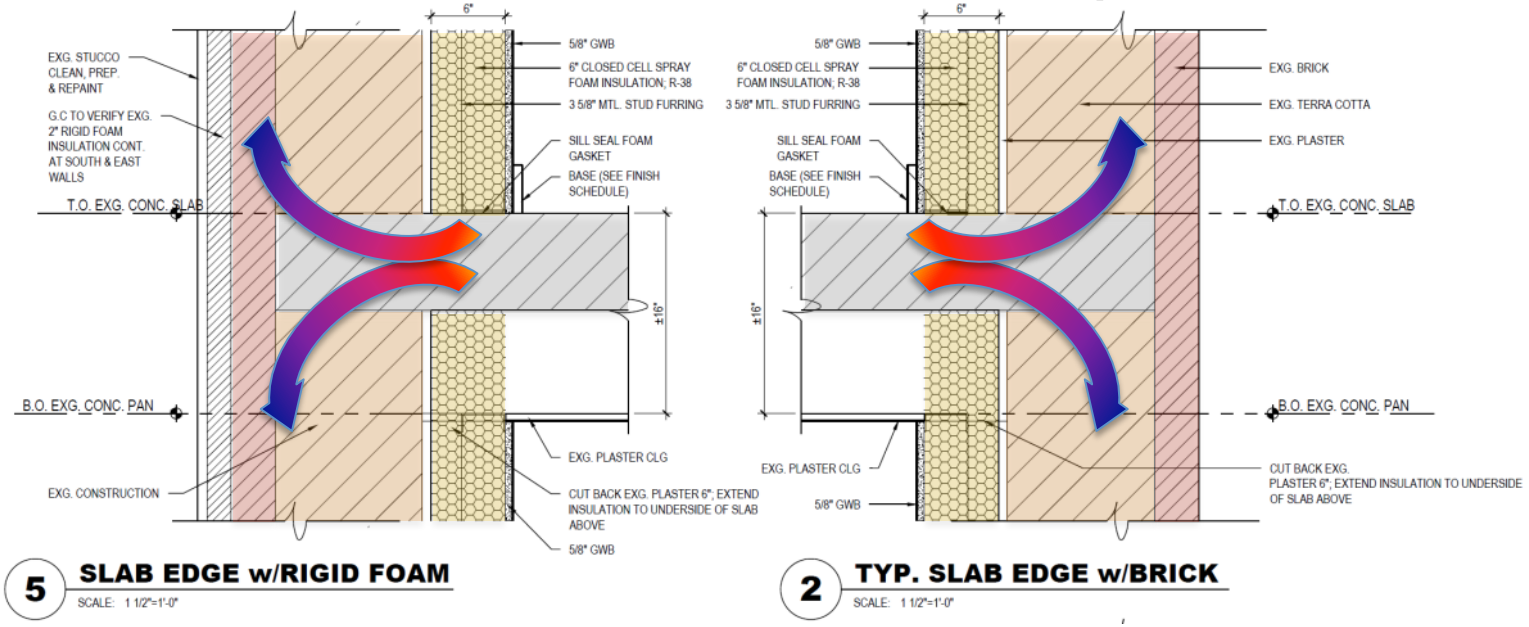
Hygrothermal Simulation Results

- Low risks at low rain exposures—both existing and insulated (below S_{crit})
- Extreme rain loads:
  - Existing wall medium-to-high risks
  - Insulated wall medium-to-high risks
  - Insulated vs. uninsulated—less effect than rain load
  - Even at high insulation levels (8” ccSPF)
- Danger of putting wood-based materials on “cold and wet” side of wall
  - Showed rising moisture contents

Thermal Bridging (Slabs)

Thermal Bridging at Slab Floors

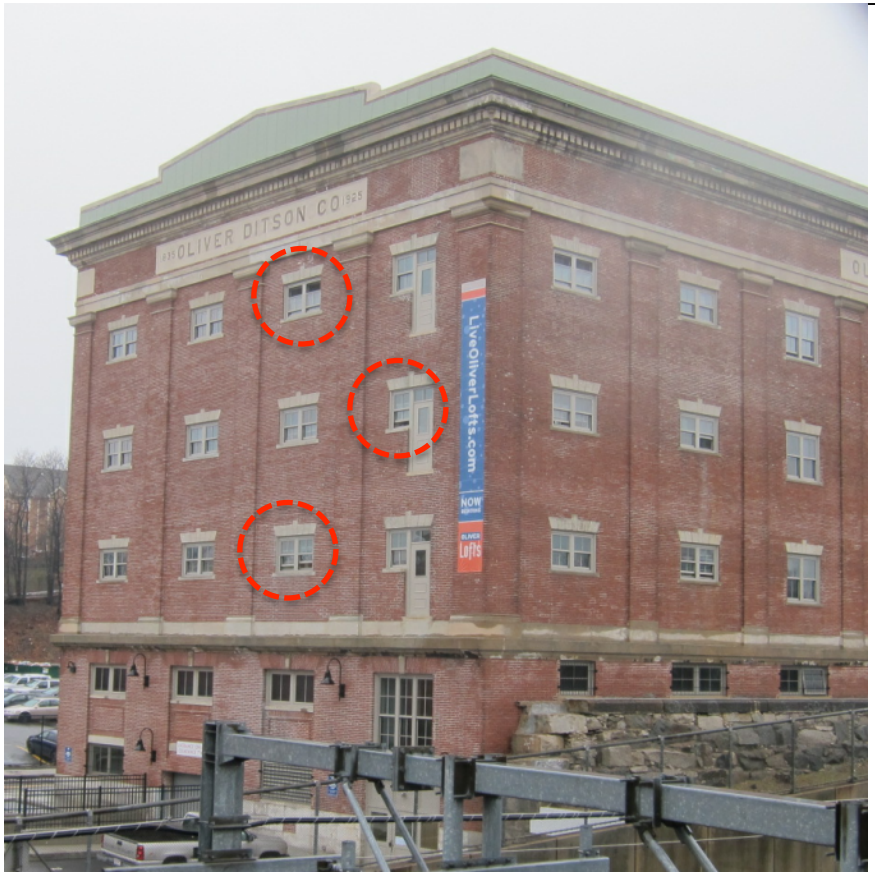
- Embedded slabs, hollow metal pans

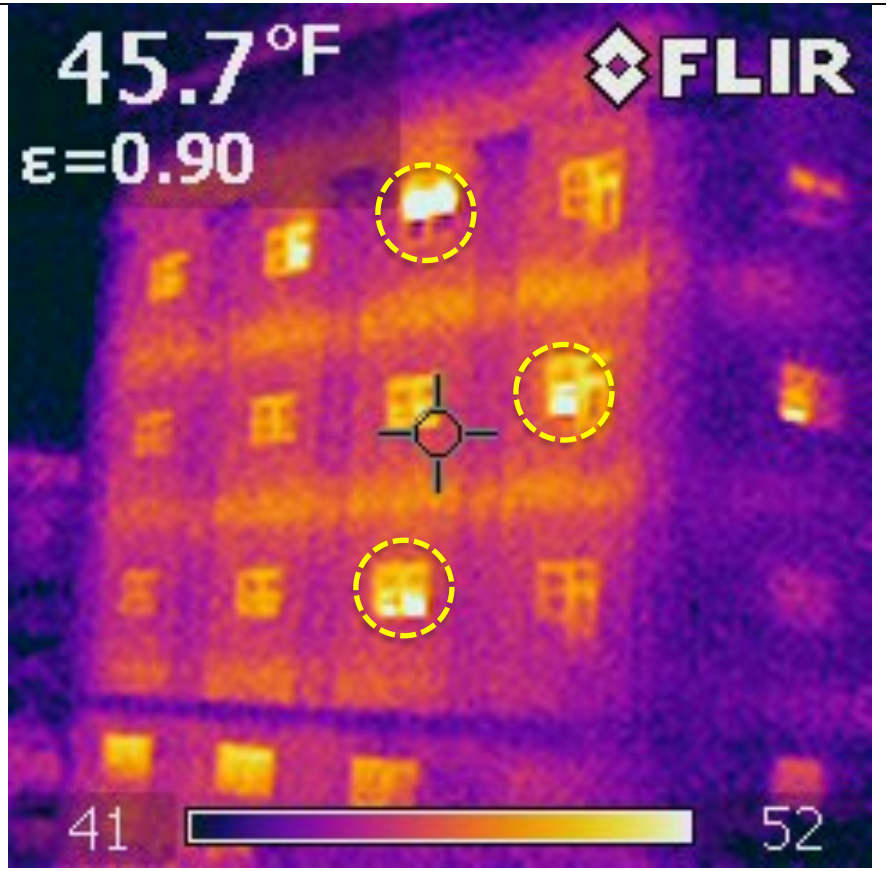


Thermal Bridging at Slab Floors

- Typical Insulation Levels
  - R-14 for 8 foot wall
  - R-3 for 8 inch floor slab
  - R-10.9 overall opaque R value
  - 22% loss from nominal value
- High Insulation Levels
  - R-38 for 8 foot wall (6” ccSPF)
  - R-3 for 8 inch floor slab
  - R-19.9 overall opaque R value
  - 47% loss from nominal value

Thermal Bridging at Slab Floors





Questions?

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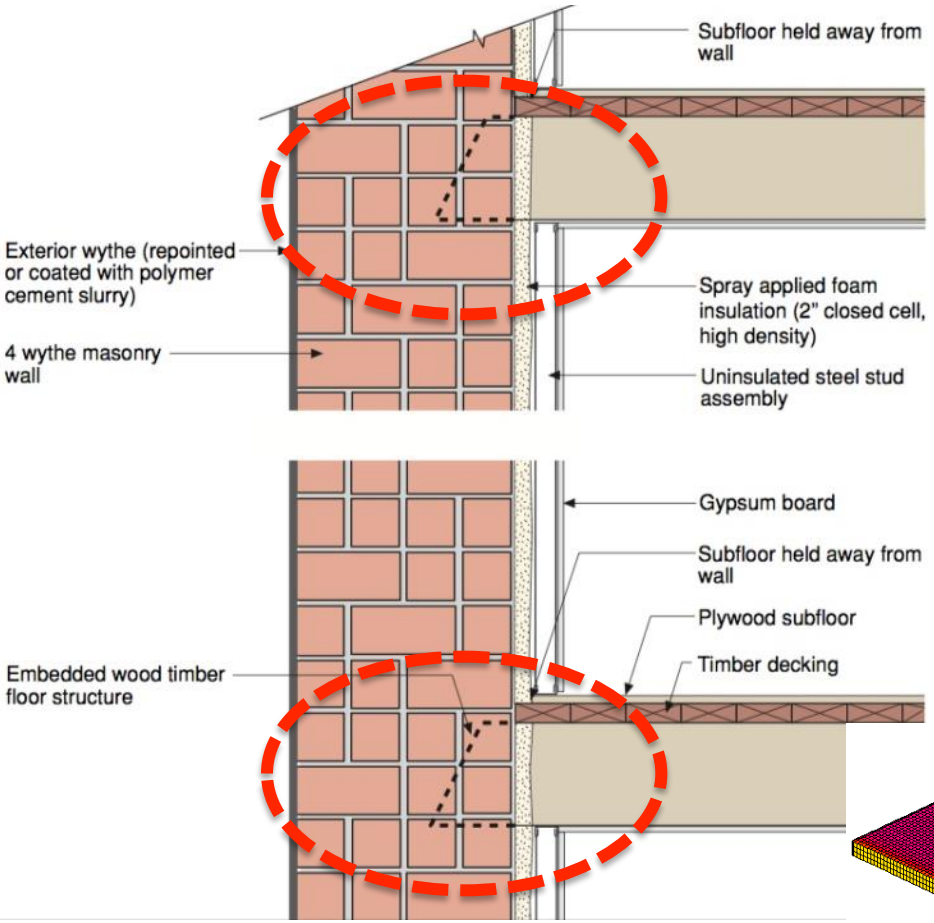
This presentation will be available at:
http://www.buildingscienceconsulting.com/presentations/recent.aspx

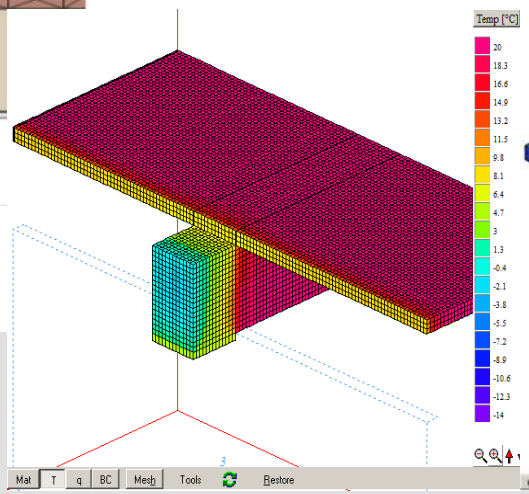
Document Resources

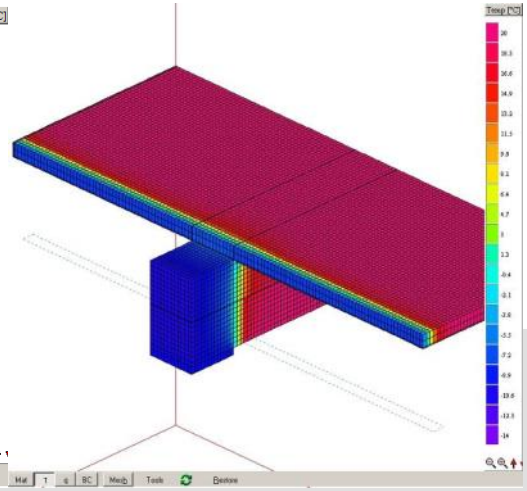
- Building Science Digest 114: Interior Insulation Retrofits of Load-Bearing Masonry Walls In Cold Climates http://www.buildingscience.com/documents/digests/bsd-114-interior-insulation-retrofits-of-load-bearing-masonry-walls-in-cold-climates
- Building Science Insight 047: Thick as a Brick http://www.buildingscience.com/documents/insights/bsi-047-thick-as-brick/
- RR 1013: Assessing the Freeze-Thaw Resistance of Clay Brick for Interior Insulation Retrofit Projects http://www.buildingscience.com/documents/reports/rr-1013-freeze-thaw-resistance-clay-brick-interior-insulation-retrofits/
- RR 1105: Internal Insulation of Masonry Walls: Final Measure Guideline http://www.buildingscience.com/documents/reports/rr-1105-internal-insulation-masonry-walls-final-measure-guideline/
- RR-1307: Interior Insulation of Mass Masonry Walls: Joist Monitoring, Material Test Optimization, Salt Effects http://www.buildingscience.com/documents/reports/rr-1307-interior-insulation-mass-masonry-walls/view
- Interior Insulation Retrofit of Mass Masonry Wall Assemblies Workshop http://www.buildingscienceconsulting.com/services/documents/file/BSC%20TO2%201_3%20Final%20Expert%20Meeting%20Report.pdf
- Canadian Building Digest 2. Efflorescence http://www.nrc-cnrc.gc.ca/eng/ibp/irc/cbd/building-digest-2.html
- Green Building Advisor: Insulation Retrofits on Old Masonry Buildings: Building Science Podcast http://www.greenbuildingadvisor.com/blogs/dept/building-science/insulation-retrofits-old-masonry-buildings-building-science-podcast

Site Assessment: Terra Cotta Details

Embedded Wood Member Risks







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