

Kohta Ueno
October 17, 2013

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

8th Annual North American Passive
House Conference



Project Background



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McKeesport, PA YMCA Building

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



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McKeesport, PA YMCA Building



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- 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



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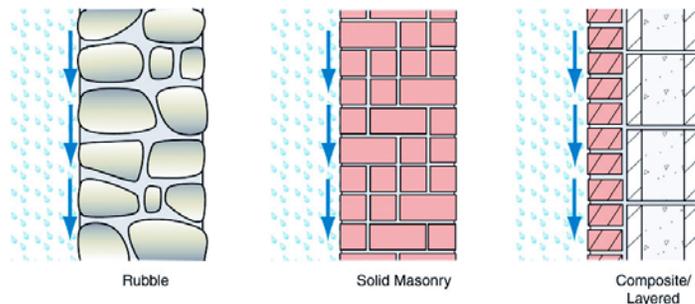
Masonry Insulation Background



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Mass Walls (Rain Control)



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



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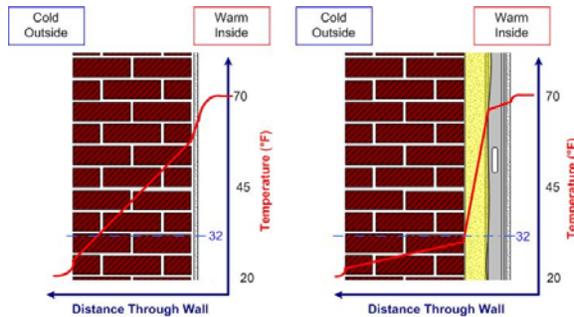
Inside or Outside Insulation?

- 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

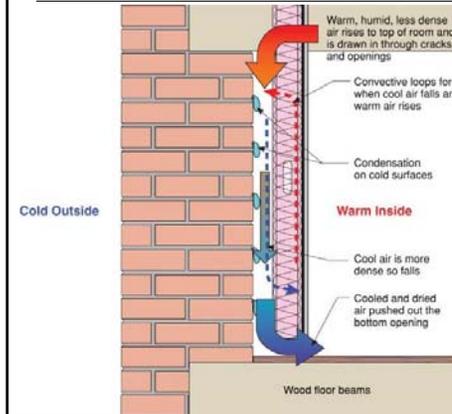


Cold Climate Risks

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

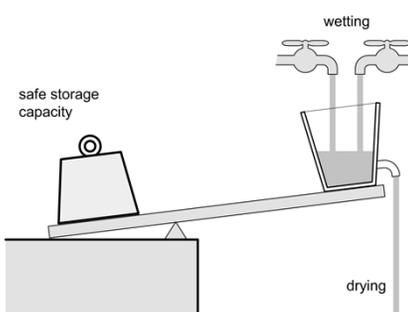


Cold Climate Risks: Condensation



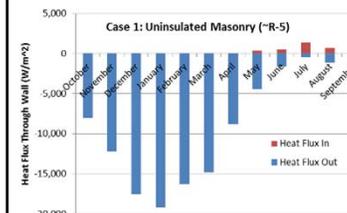
- Requires perfect workmanship at air barrier—around penetrations, etc.
- Made worse by air gap behind insulation
- NOT RECOMMENDED**

The Moisture Balance



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

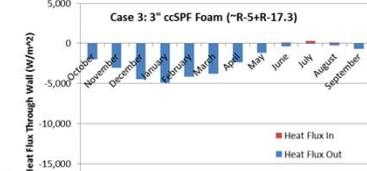
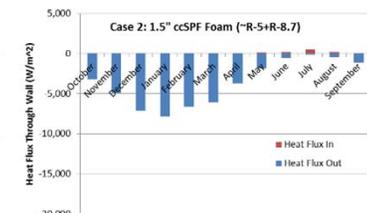
Do We Need to Insulate Mass Walls?



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

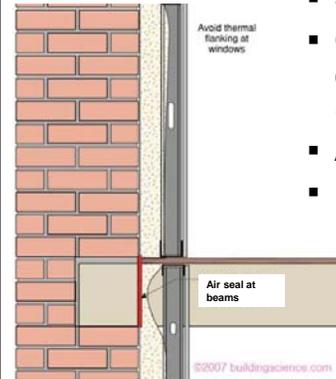
Retrofit Approaches



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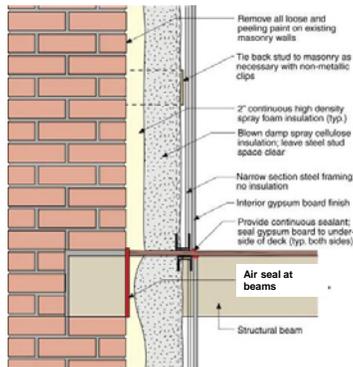
Recommended Approaches



- 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



Site Assessment



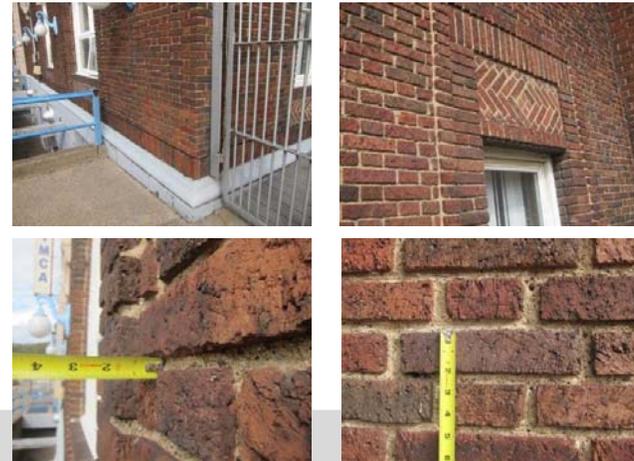
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Site Assessment: Where is it Wet?



Site Assessment: Brick Condition



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Roof-Wall Interface

The diagram shows a cross-section of a roof-wall interface. A blue area indicates water penetration from the roof into the wall. Below the diagram is a bar chart showing the percentage of all walls with problems based on the width of overhang above the wall.

Width of overhang above wall (in/mm)	Percent of all walls which have problems
0 in / 0 mm	~95%
0.1 - 12 in / 1 - 300 mm	~65%
12.1 - 24 in / 301 - 600 mm	~55%
over 24 in / over 600 mm	~25%

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Site Assessment: North Parapet

Four photographs showing different views of a brick parapet wall on a roof. The top-left photo shows a wide view of the parapet on a brick building. The top-right photo is a close-up of the brickwork and a metal cap. The bottom-left photo shows a view from the roof edge looking down at the parapet. The bottom-right photo shows another view of the parapet with some debris on the roof surface.

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Windows (Water Concentration)

Two photographs on the left show brick walls with water stains. The right side features a technical cross-section diagram of a window sill with the following annotations:

- Sealant (air barrier)
- Sill pan flashing: note backdam to prevent inward water movement; overhang and drains onto surface of sill; pan flashing should extend min. 4" up jamb vertically
- Caulk and backer rod joint; to avoid entry of water into masonry wythes
- Regletted flashing/drip edge; can be wedged in place instead of mechanical fastening; if acceptable. Alternate: improves drainage but is more visible—have drip edge fall from outside edge of sill.

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Site Assessment: Windows (Rowlock)

Four photographs showing different views of windows on a brick building. The top-left photo shows a window with a decorative finial. The top-right photo shows a close-up of a window sill and the brickwork above it. The bottom-left photo shows two windows on a brick wall. The bottom-right photo shows a close-up of a window sill and the brickwork below it.

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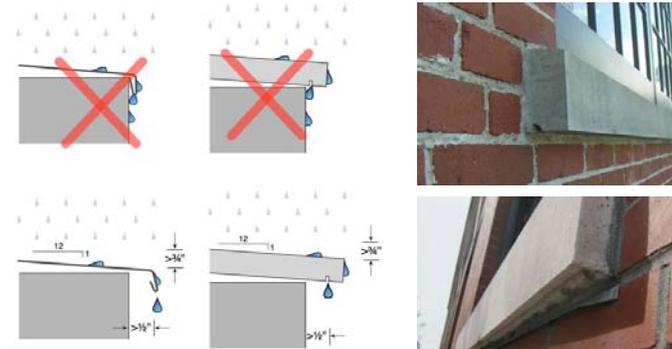
Site Assessment: Windows (Terra Cotta)



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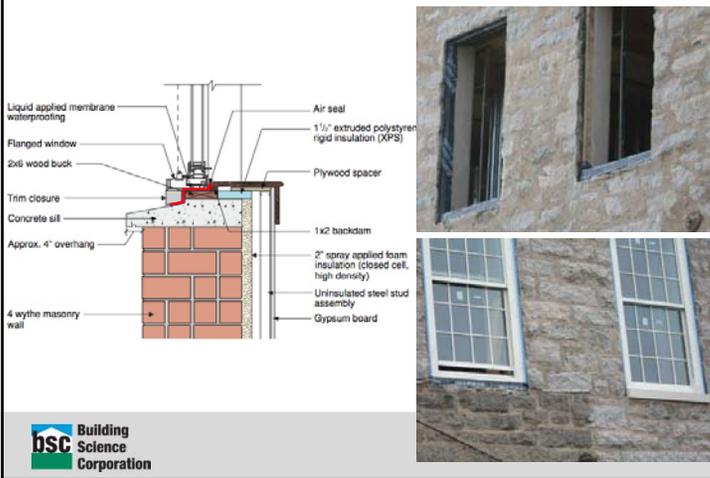
Drip Edges

- Minimum projection of drip edge

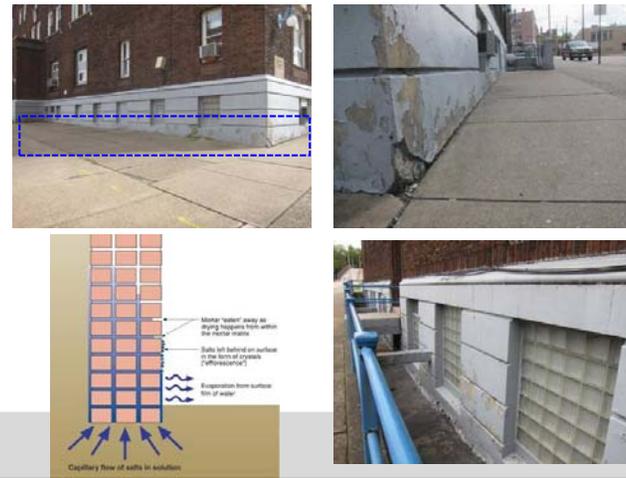


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Windows (Potential Rain Entry Point)



Site Assessment: Ground Capillarity?



Brick Testing & F/T Simulations



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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}



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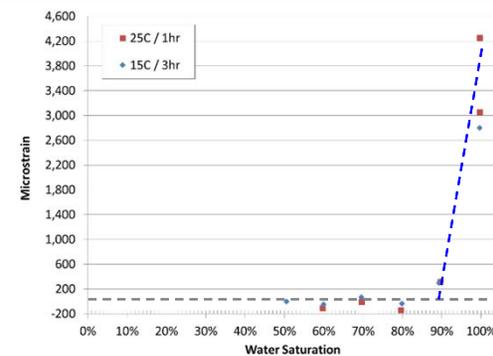
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Laboratory Measurement of S_{crit}



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Dilation (Growth) of Samples



- “Hook” in graph signifies S_{crit}



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Hygrothermal Simulations

- Brick
- Mortar
- Terra cotta
- Air Space
- Plaster
- ccSPF
- Air Space
- Gypsum Board

○ - Monitor positions

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

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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

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Thermal Bridging (Slabs)

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Thermal Bridging at Slab Floors

- Embedded slabs, hollow metal pans

5 SLAB EDGE w/RIGID FOAM SCALE: 1/2"=1'-0"

2 TYP. SLAB EDGE w/BRICK SCALE: 1/2"=1'-0"

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Thermal Bridging at Slab Floors

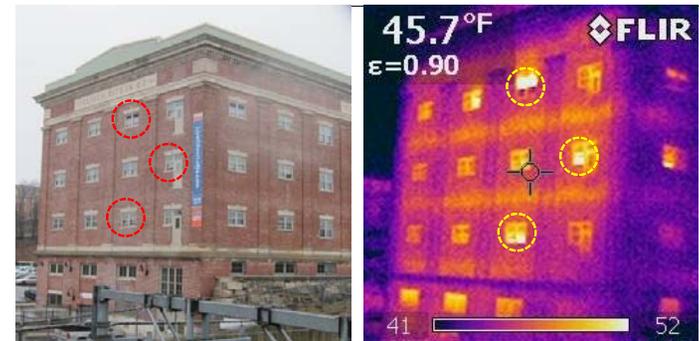
- Typical Insulation Levels
 - R-14 for 8 foot wall
 - R-3 for 8 inch floor slab
 - R-10.9 overall opaque R value
 - **22% loss from nominal value**
- High Insulation Levels
 - R-38 for 8 foot wall (6" ccSPF)
 - R-3 for 8 inch floor slab
 - R-19.9 overall opaque R value
 - **47% loss from nominal value**



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Thermal Bridging at Slab Floors



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Questions?

Kohta Ueno
kohta@building science.com

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<http://www.buildingscienceconsulting.com/presentations/recent.aspx>



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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/lbp/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>



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