



**Assessing Masonry Freeze-Thaw Risk
in a Deep Energy Retrofit of a Large,
Old Chicago Building**

12TH NORTH AMERICAN PASSIVE HOUSE CONFERENCE

SEPTEMBER 29, 2017

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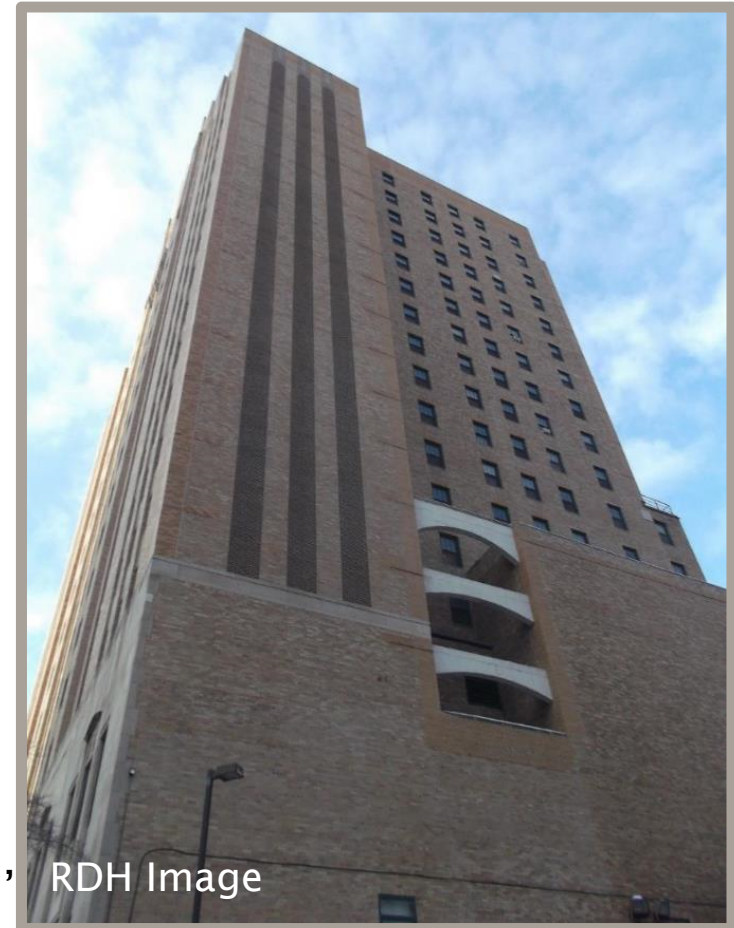
RDIH BUILDING SCIENCE
LABORATORIES

Before: YMCA Lawson House 30 Chicago Ave W., Chicago IL

583 units, 200 sqft, shared bathrooms, \$140/month

reviews.birdeye.com (Aug 14, 2011)

- “plenty to do in the area...”
- “No utilities, low-cost phone and internet available...”
- “programs for getting back on one's feet...awesome caseworkers, and all in all, a million times better than being on the street.”
- “Ohhhh the cons! Curfew for guests!!!...”
- “CRAZY neighbors (like random screaming)”
- “FULL of bedbugs and roaches, community bathrooms, funny smells in the hallways...”



Vision: YMCA Lawson House 30 Chicago Ave W., Chicago IL

- Peter Holsten buys for \$1 in 2013
- At least 50 years low-income housing
- \$100 million renovation
- 400 sqft unit with individual bathrooms and kitchens

FARR ASSOCIATES

- National Register of Historic Places submitted
- Sought LEED Platinum
- Sought PHIUS+2015 - **Walls +30 Effective R-value**



“Effective” R-value

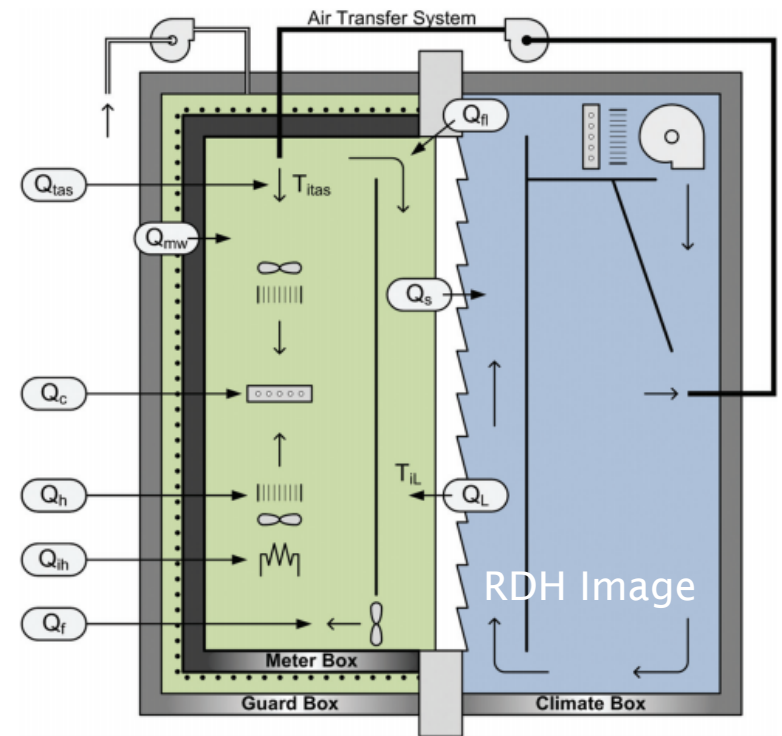
R-value definitions

- Installed or Nominal R-value, R_{Nominal}
- Assembly R-value or Centre-of-Cavity
- Clear Wall R-value, $R_{\text{Clear Wall}}$
- Whole Wall R-Value, $R_{\text{Whole Wall}}$
- Overall (Wall) R-Value

John Straube “Meeting and Exceeding Building Code Thermal Performance Requirements”

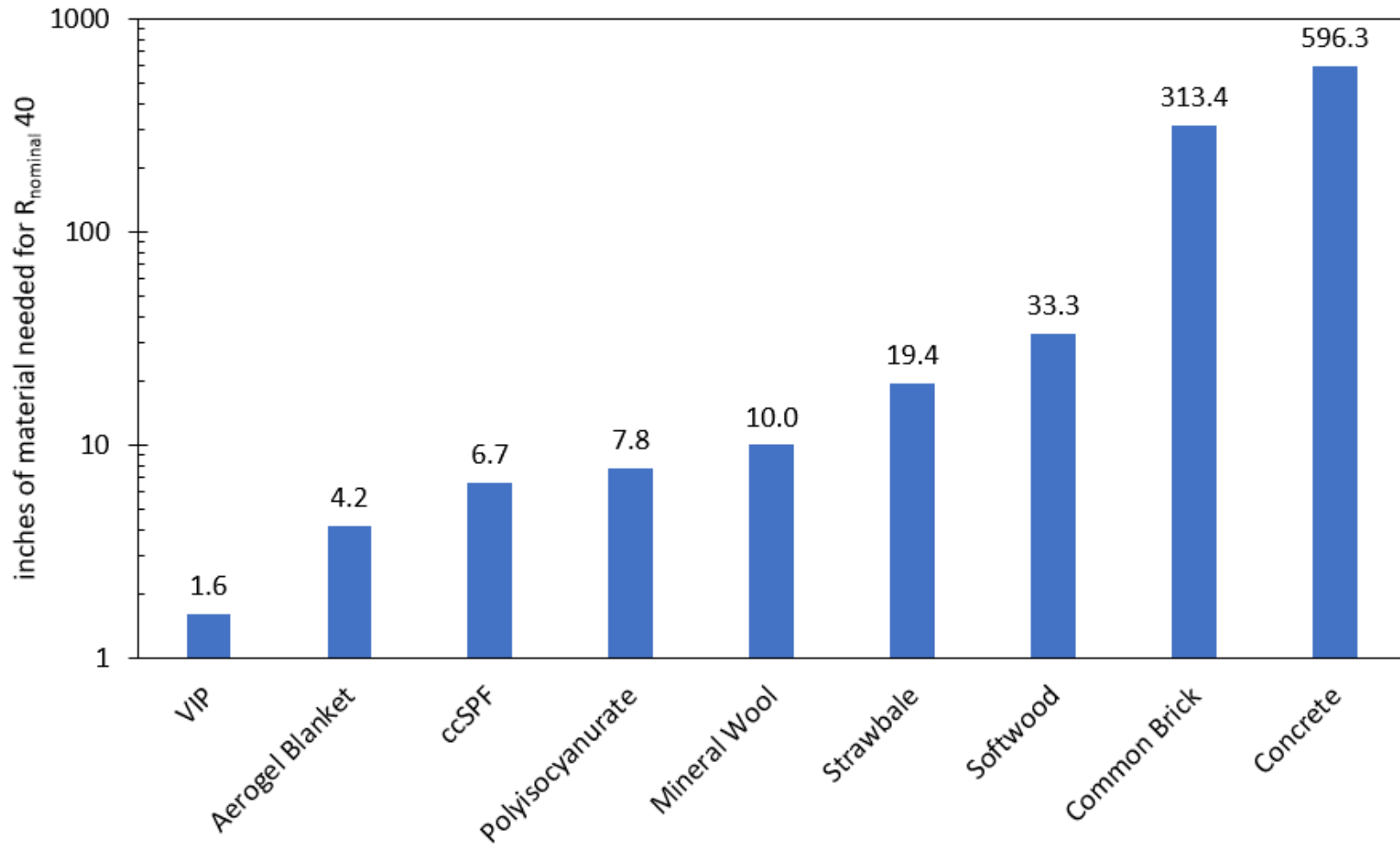
downloads.cpci.ca/491/download.do

www.masonrysystemsguide.com

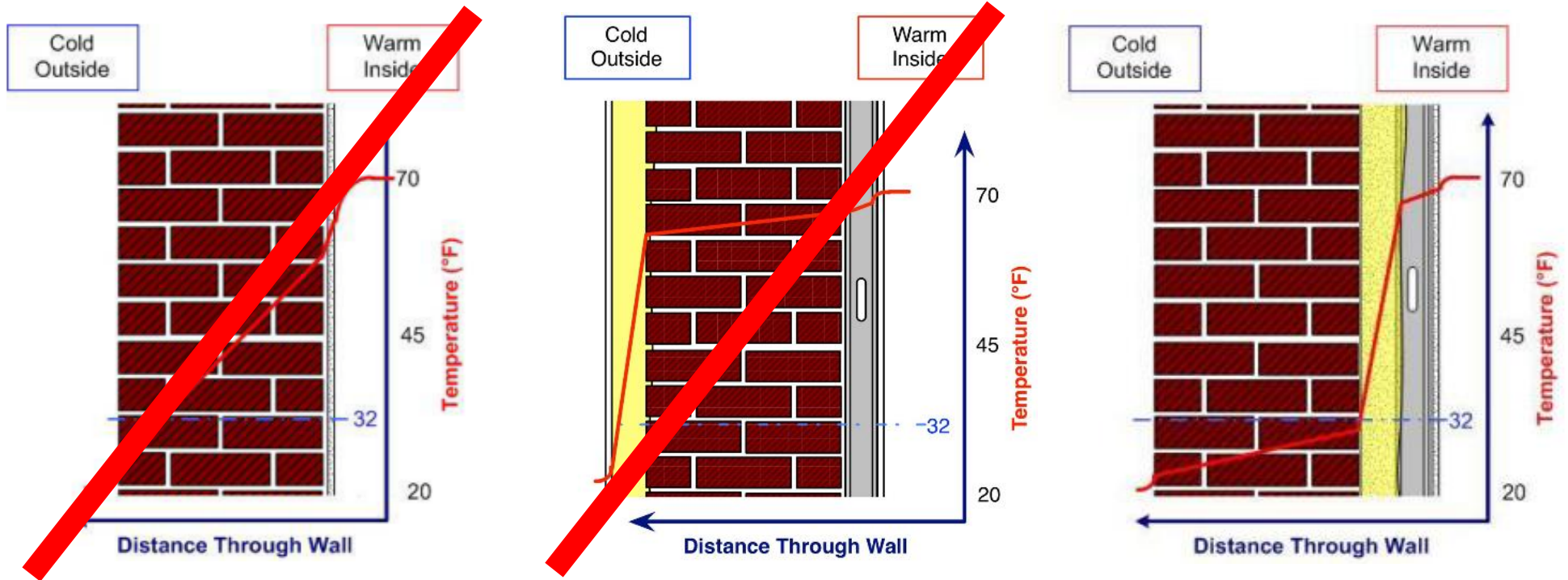


Schematic of ThermoMetric Guard Hot Box

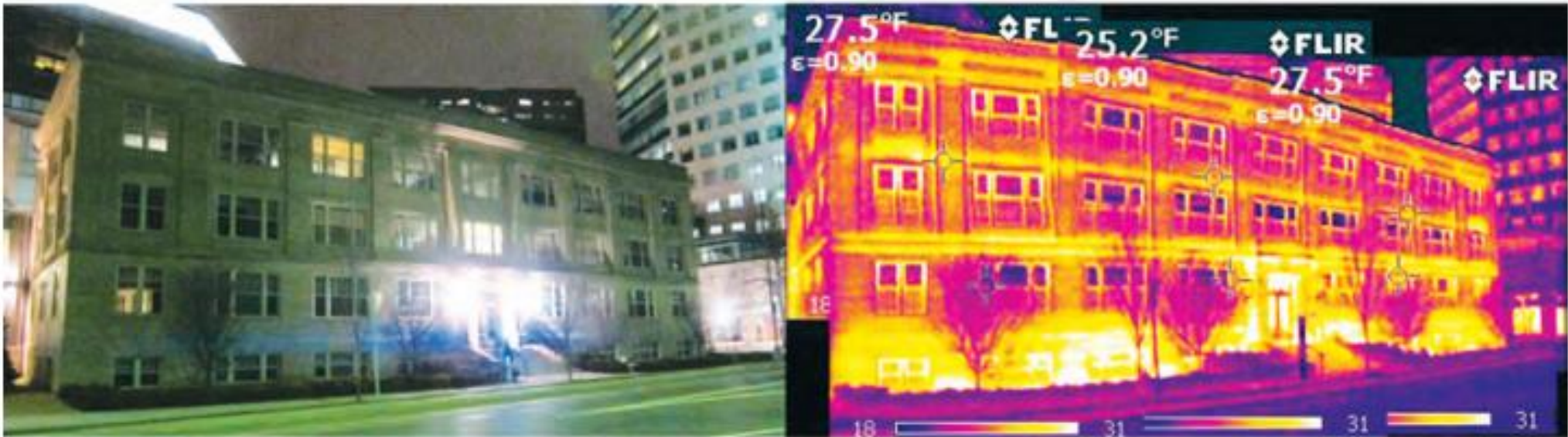
Retrofit Insulation Options - Insulation Materials



Retrofit Insulation Options - Interior vs Exterior Insulation

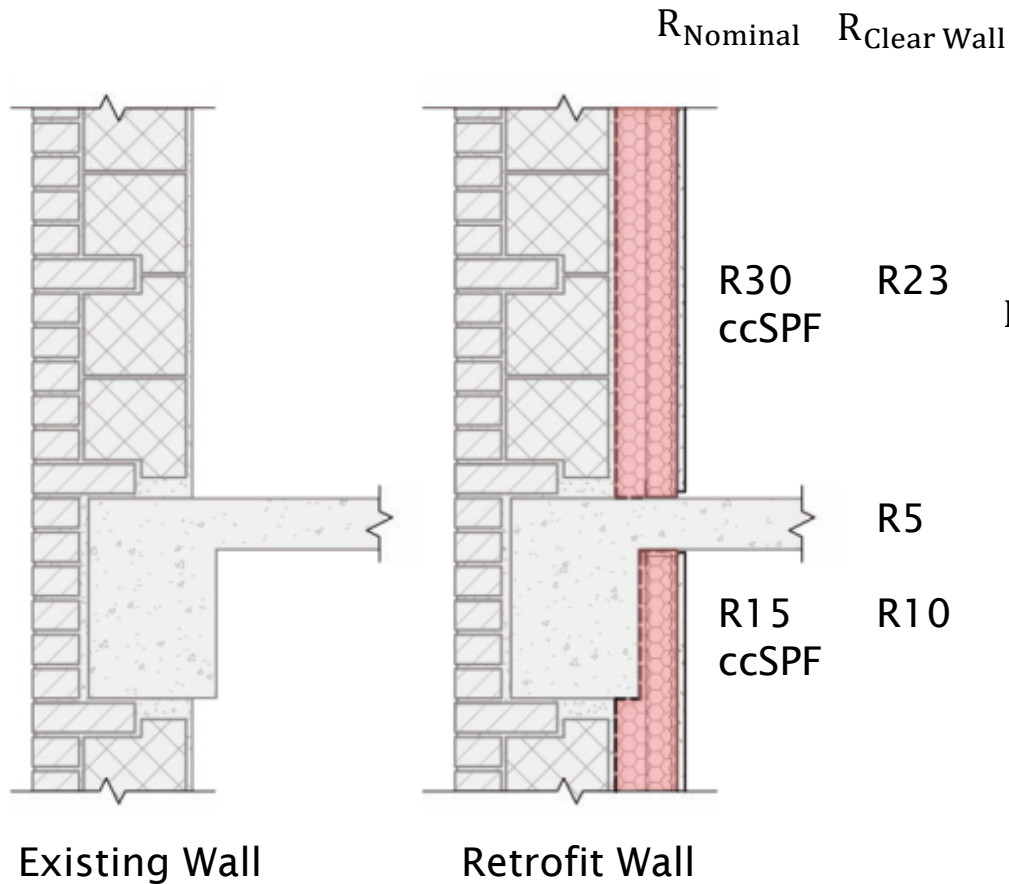


Retrofit Insulation Options – Interior Insulation Performance



Ueno, K, Straube, J., and Van Straaten, R., "Field Monitoring and Simulation of a Historic Mass Masonry Building Retrofitted with Interior Insulation" *Thermal Performance of the Exterior Envelopes of Whole Buildings XII International Conference*, Clearwater, Florida, 2013

Retrofit Insulation Options - Interior Insulation Performance



ccSPF

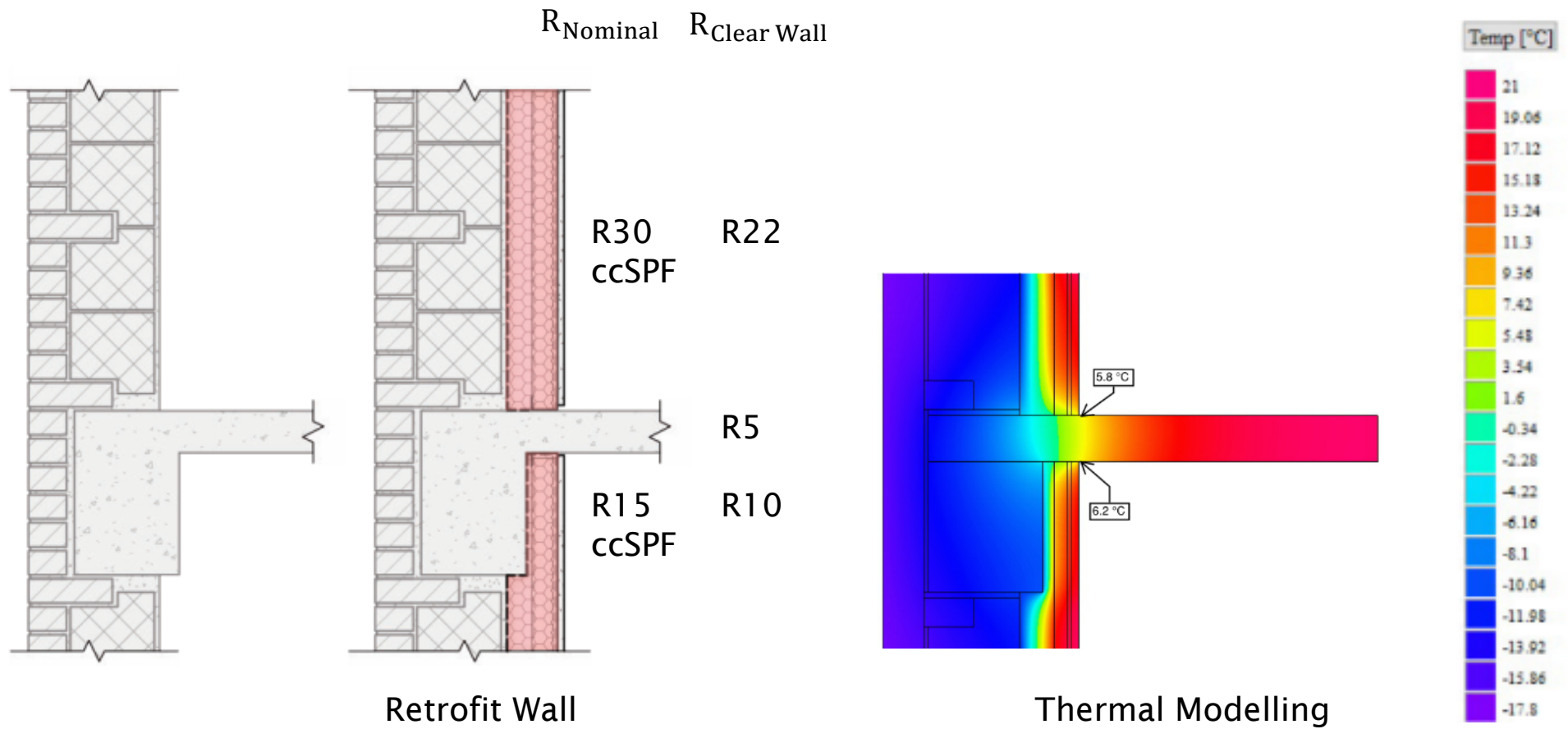
$$R_{\text{Whole Wall}} = \frac{1}{\frac{80\%}{R23.5} + \frac{15\%}{R10.5} + \frac{5\%}{R5}} = \mathbf{R17}$$

ocSPF

$$R_{\text{Whole Wall}} = \frac{1}{\frac{80\%}{R17} + \frac{15\%}{R10} + \frac{5\%}{R5}} = \mathbf{R14}$$

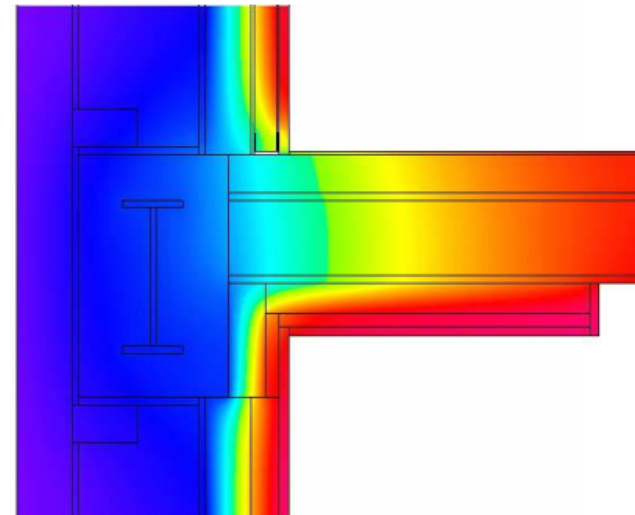
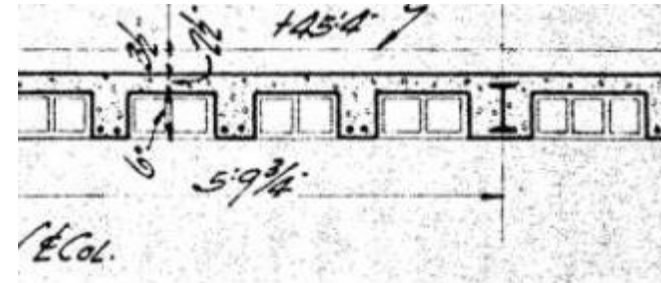
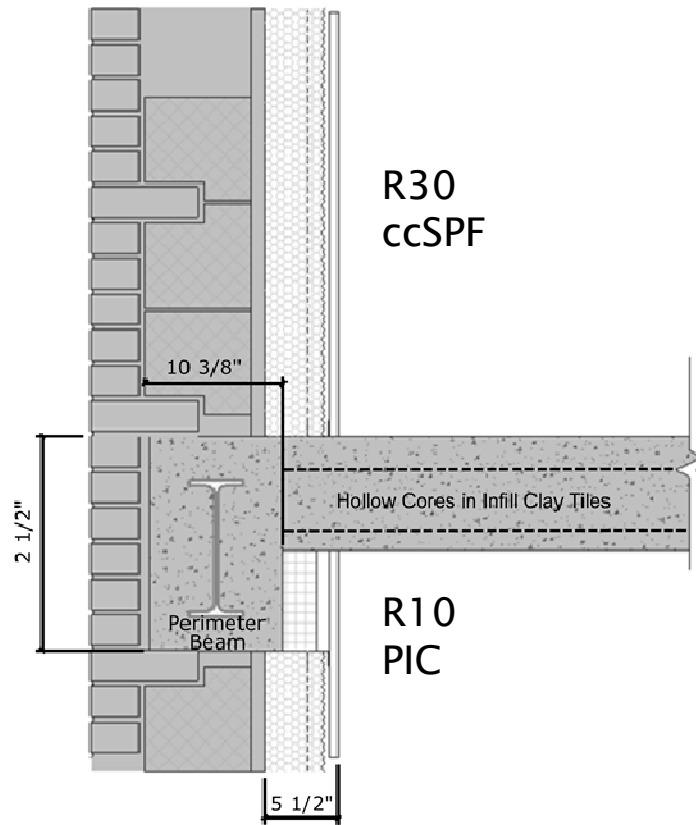
Parallel Path Method

Retrofit Insulation Options – Interior Insulation Performance

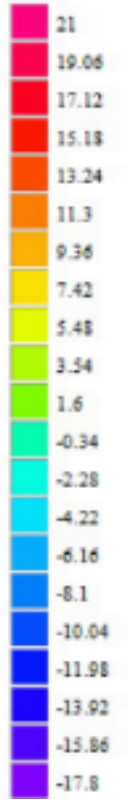


Retrofit Insulation Options – Interior Insulation Performance

$R_{Nominal}$



Temp [°C]

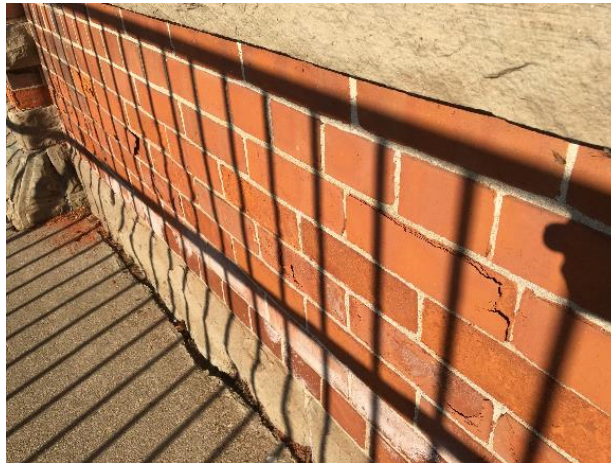


Retrofit Insulation Options – Interior Insulation Performance

Modelling results for ccSPF wall and PIC perimeter insulation

Tile Config	Perimeter Insulation	Insulation under Bottom Track	Floor-to-Flor On-Centre Wall Height			
			10 ft.	12 ft.	14 ft.	16 ft.
Hollow	No	None	R-13.6	R-15.0	R-16.1	R-17.1
	Yes	None	R-15.7	R-17.0	R-18.1	R-19.0
	Yes	R0.75	R-15.7	R-17.1	R-18.2	R-19.1
	Yes	R5	R-15.8	R-17.2	R-18.3	R-19.2
Foam Filled	No	None	R-15.7	R-17.1	R-18.2	R-19.1
	Yes	None	R-17.4	R-18.7	R-19.7	R-20.6
	Yes	R0.75	R-17.4	R-18.7	R-19.8	R-20.6
	Yes	R5	R-17.6	R-18.9	R-19.9	R-20.8

Freeze Thaw Risk of Retrofit Insulation



Is There is an ASTM for That?



Designation: E3069 - 17

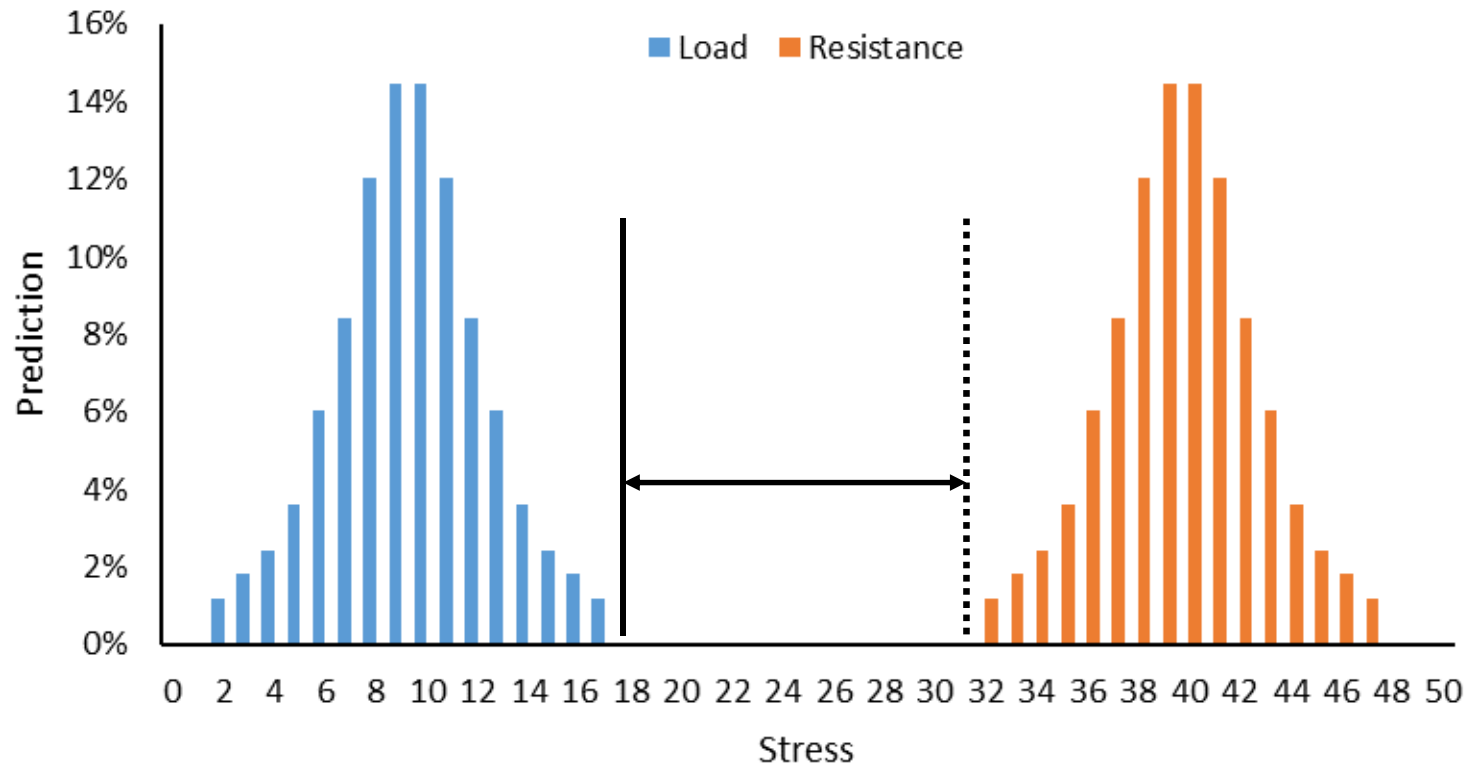
Standard Guide for Evaluation and Rehabilitation of Mass Masonry Walls for Changes to Thermal and Moisture Properties of the Wall¹

11.2.2 The increased potential for freeze-thaw damage within the masonry should be assessed. The critical moisture content and temperature gradient change across the wall assembly should be evaluated to assess the increased potential for freeze-thaw damage, to include the temperatures within the outermost one-half inch ($\frac{1}{2}$ in.) of the masonry under the original wall performance as compared to the proposed assembly. Additionally, the number of expected annual freeze-thaw cycles of the proposed wall assembly as compared to the existing wall assembly should be compared. Any increase in the freeze-thaw cycles should be carefully considered in conjunction with the masonry's saturation coefficient and freeze-thaw durability testing. The coincident moisture content of the materials when the additional freeze-thaw cycles are predicted to occur and the location within the wall assembly should also be considered.

Design Limit States 101

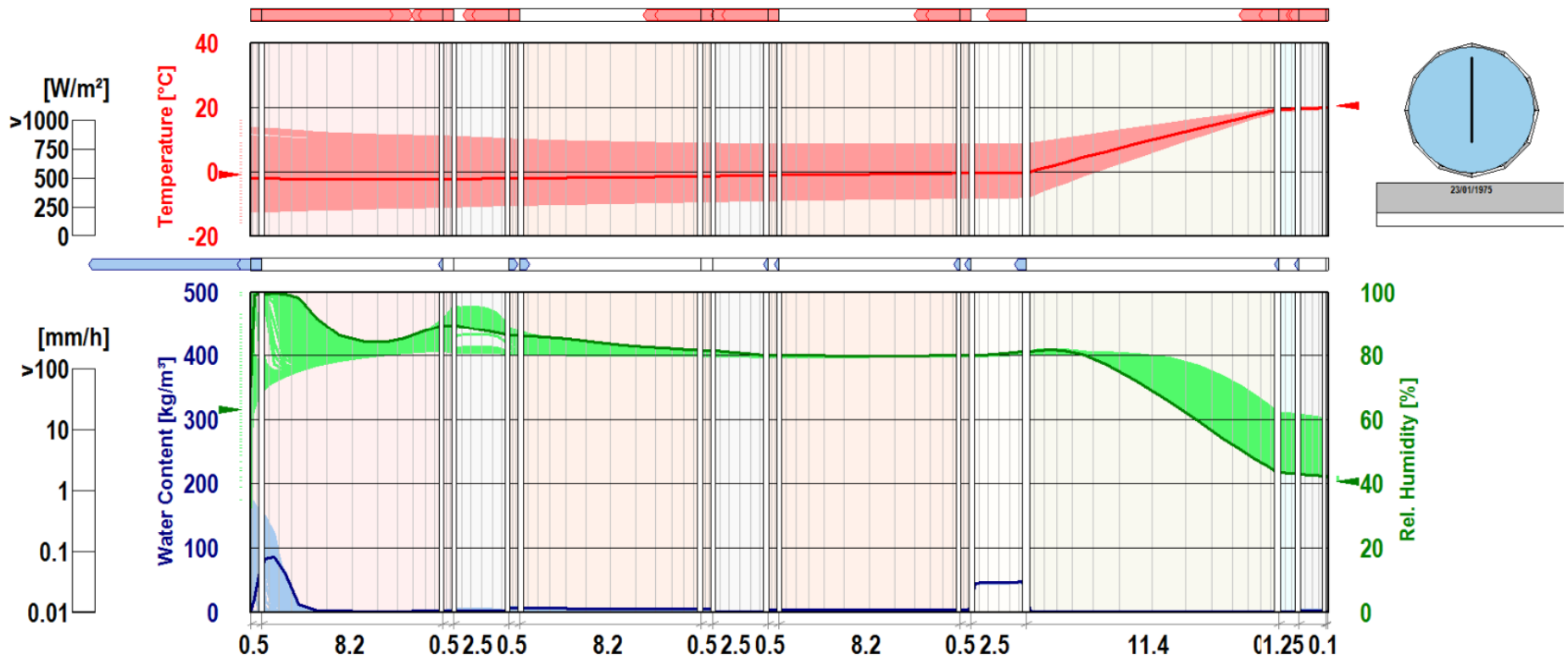


Design Limit States 101 – Load vs Resistance



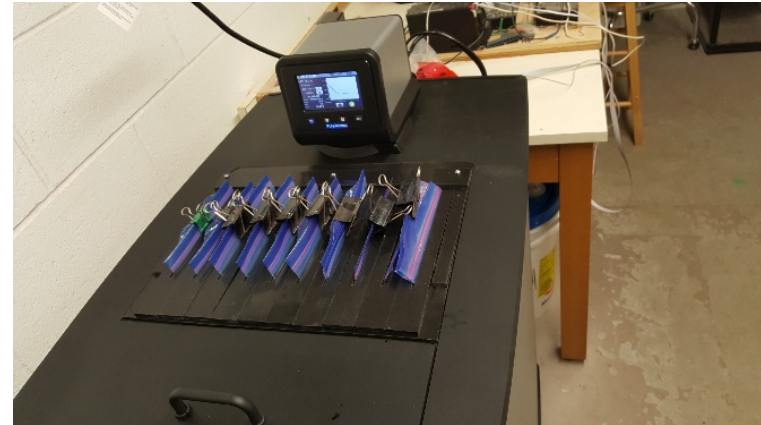
Design Limit States - Load

Predict moisture contents during freezing for insulation retrofits options



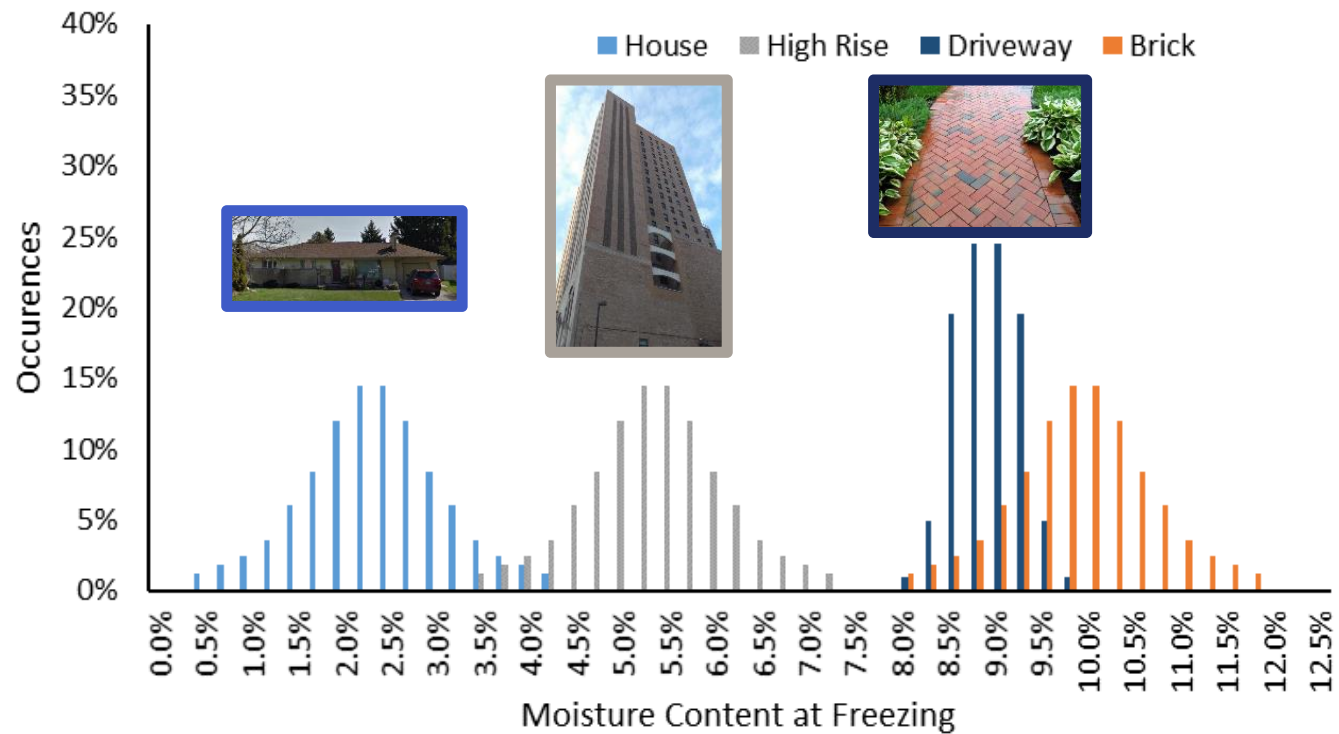
Design Limit States 101 - Resistance

Critical Freeze-Thaw Saturation (Scrit)



Van Straaten, R., Trainor, T., and Schumacher, C., "Critical Freeze-Thaw Saturation Measurement of In-Service Masonry" *Thermal Performance of the Exterior Envelopes of Whole Buildings XIII International Conference*, Clearwater, Florida, 2016

Design Limit States 101 - Load vs Resistance



Exploratory Openings/ Sampling



Exploratory Openings - Brick Over Speed Tile Wall Assembly



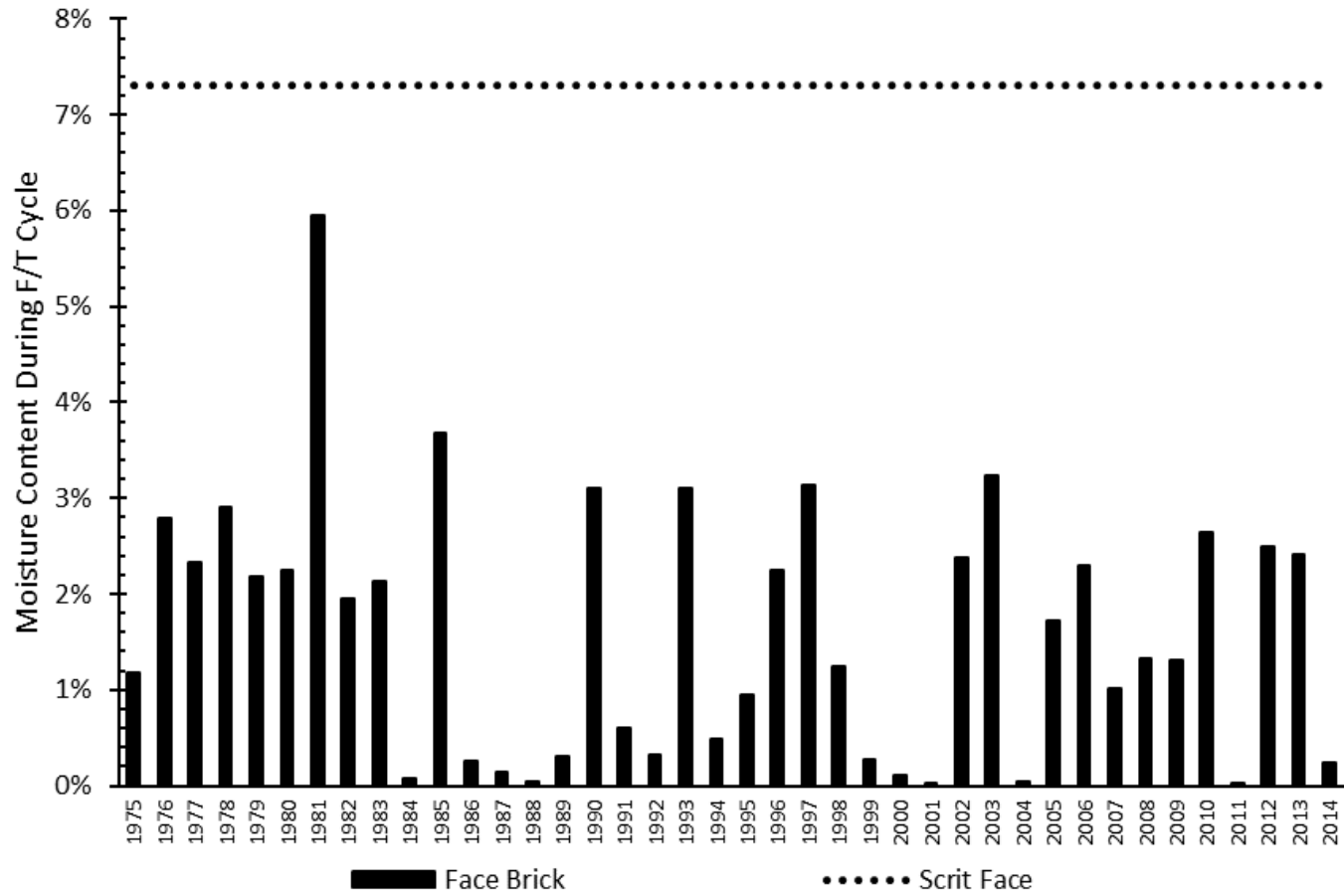
Exploratory Openings - Multi-Wye Brick Wall Assembly



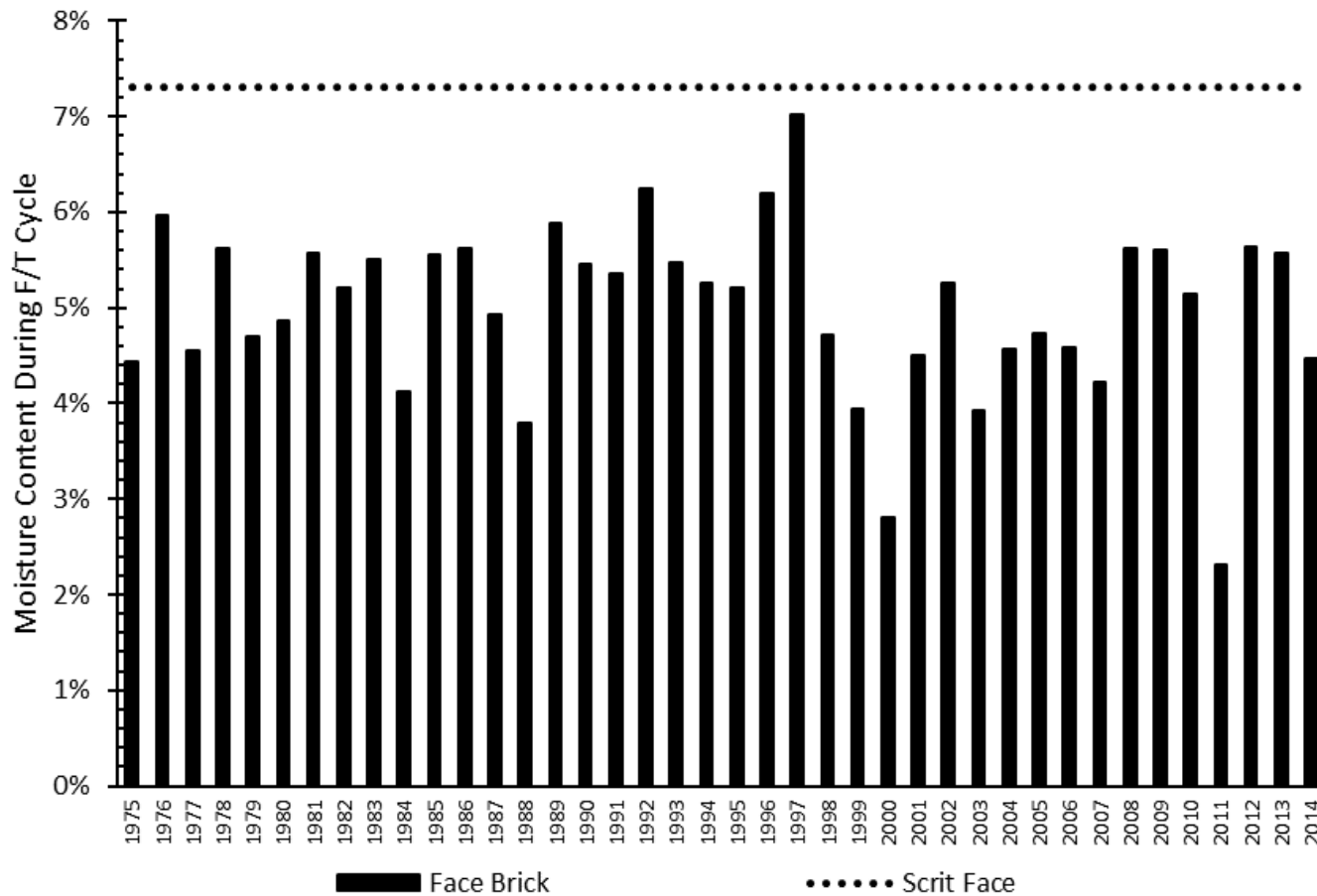
Exploratory Openings - Multi-Wye Brick Wall Assembly



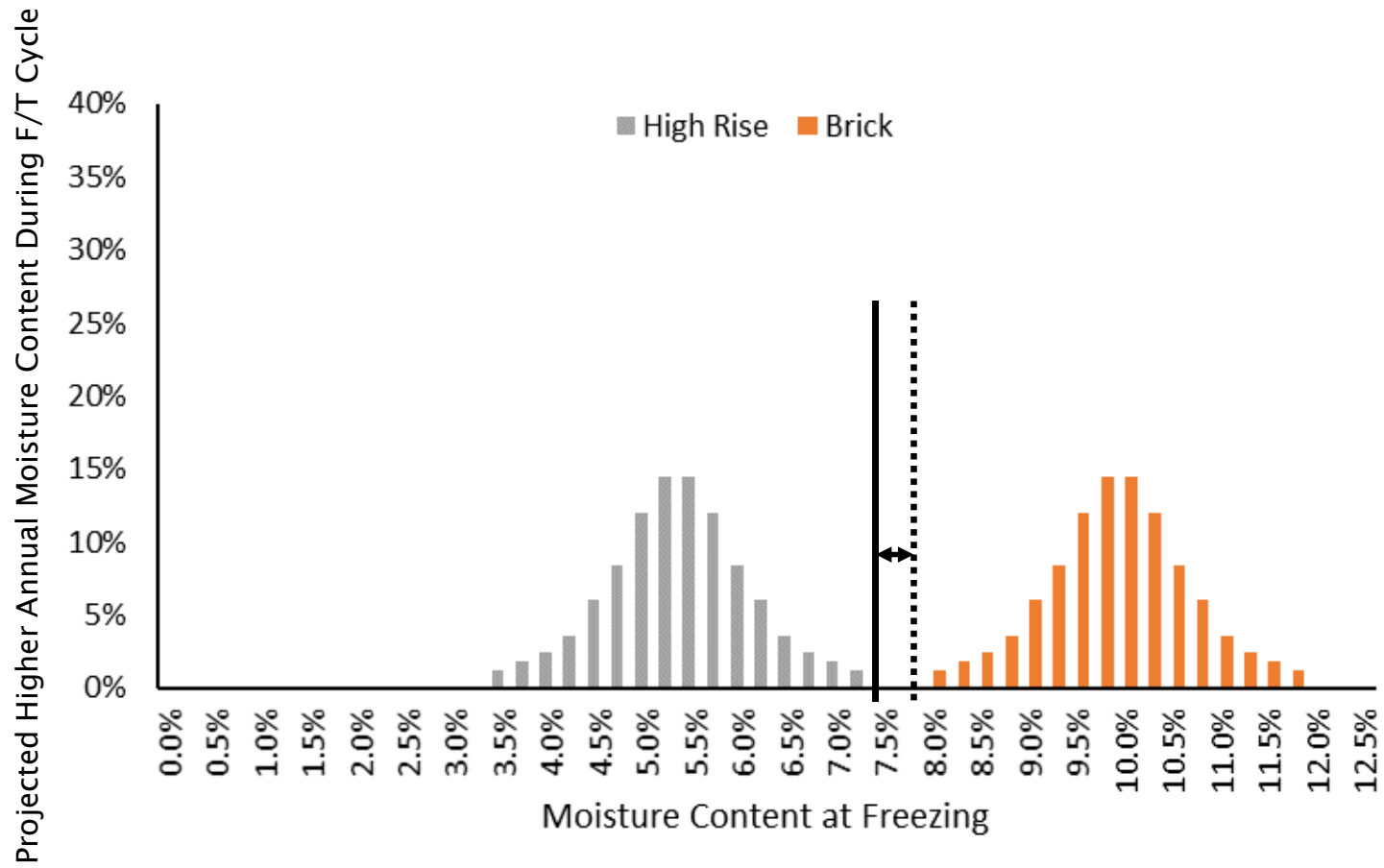
Existing Wall - Conditions Predicted using WUFI Model



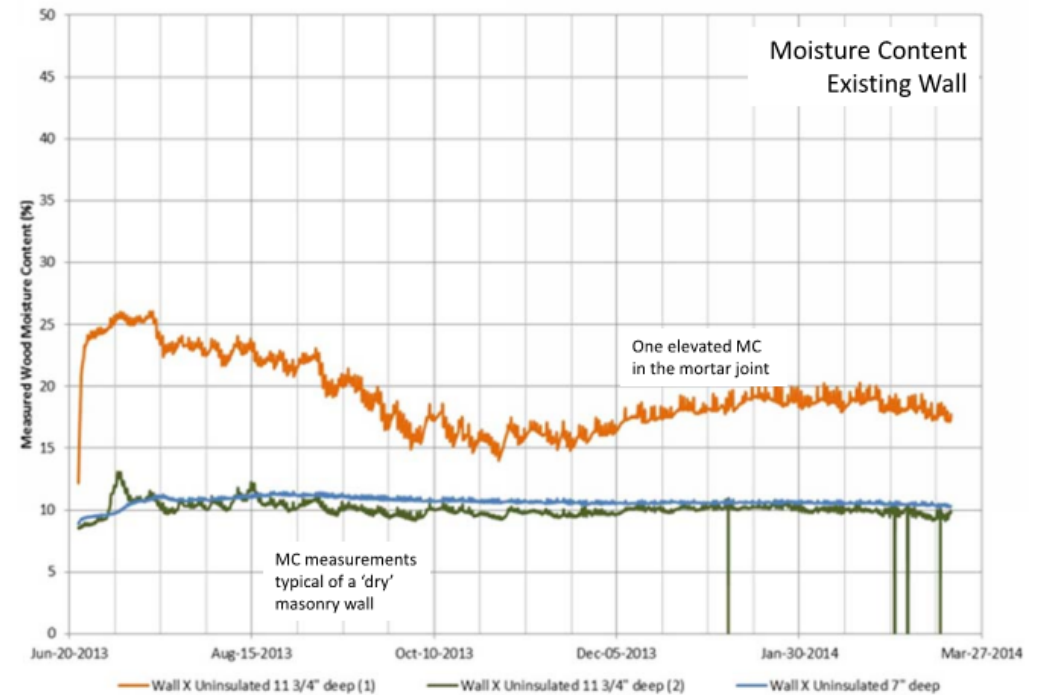
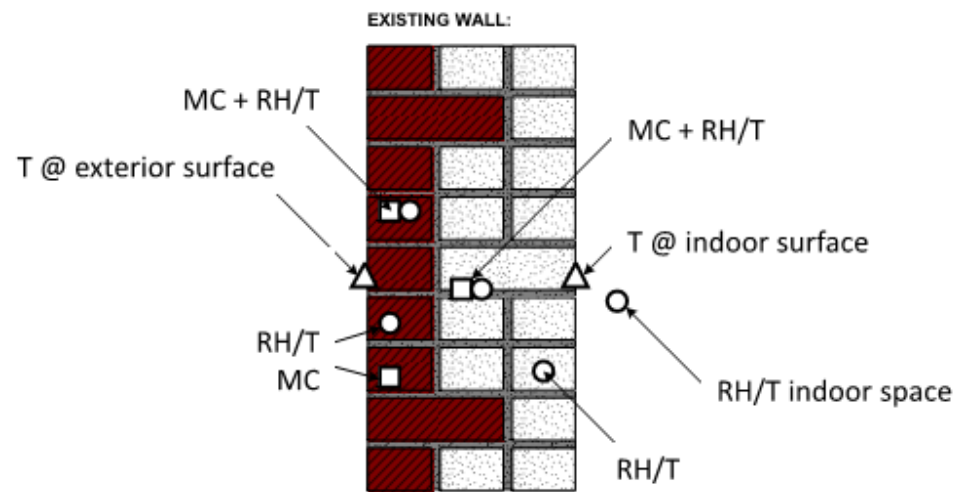
Retrofit Insulation Options - 4.5" of interior ccSPF



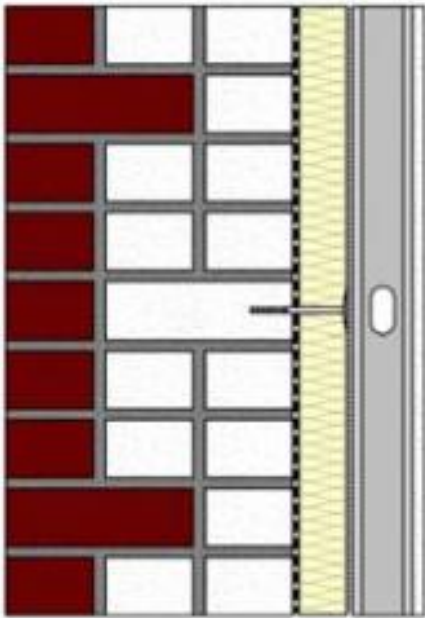
Retrofit Insulation Options - 4.5” of interior ccSPF - Illustration



Masonry Wall Moisture Measurements (NY project)

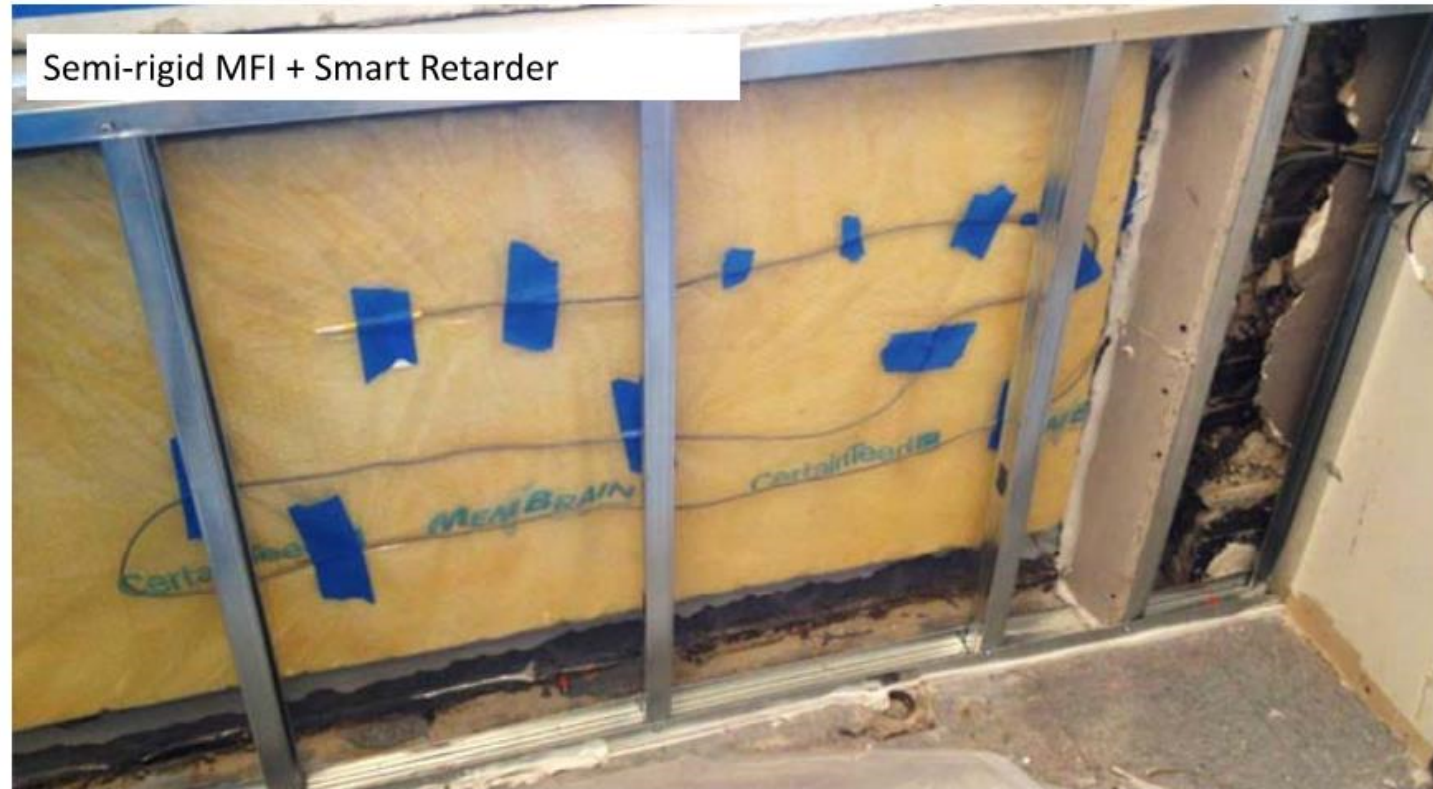


Masonry Wall Moisture Measurements (NY project)

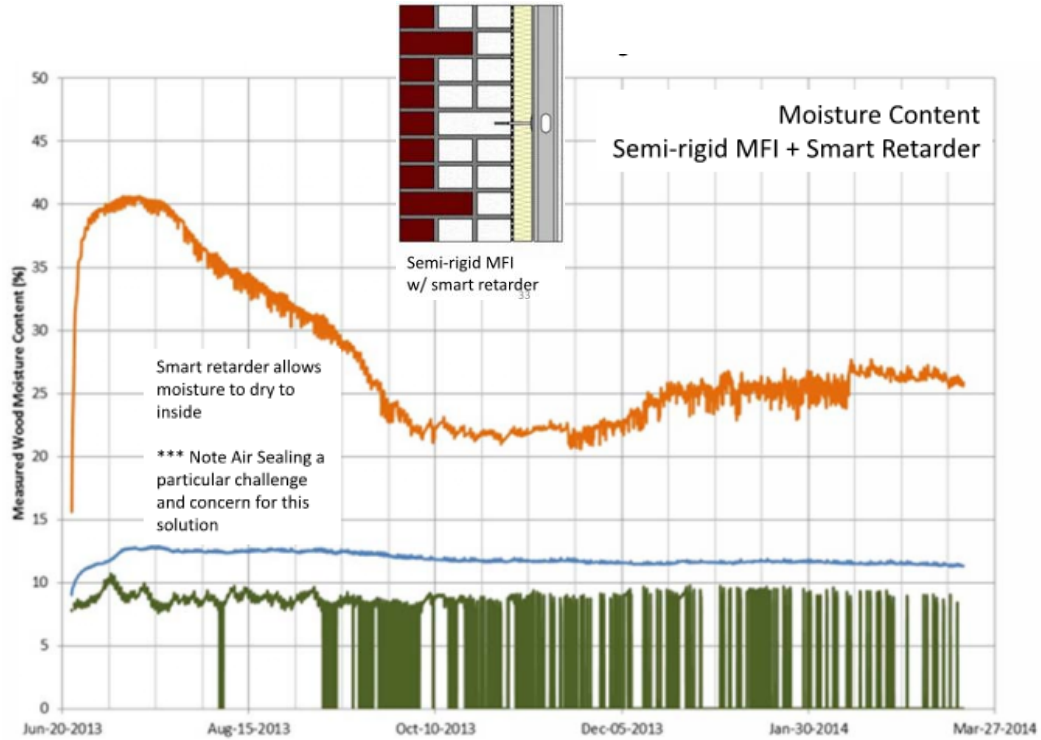
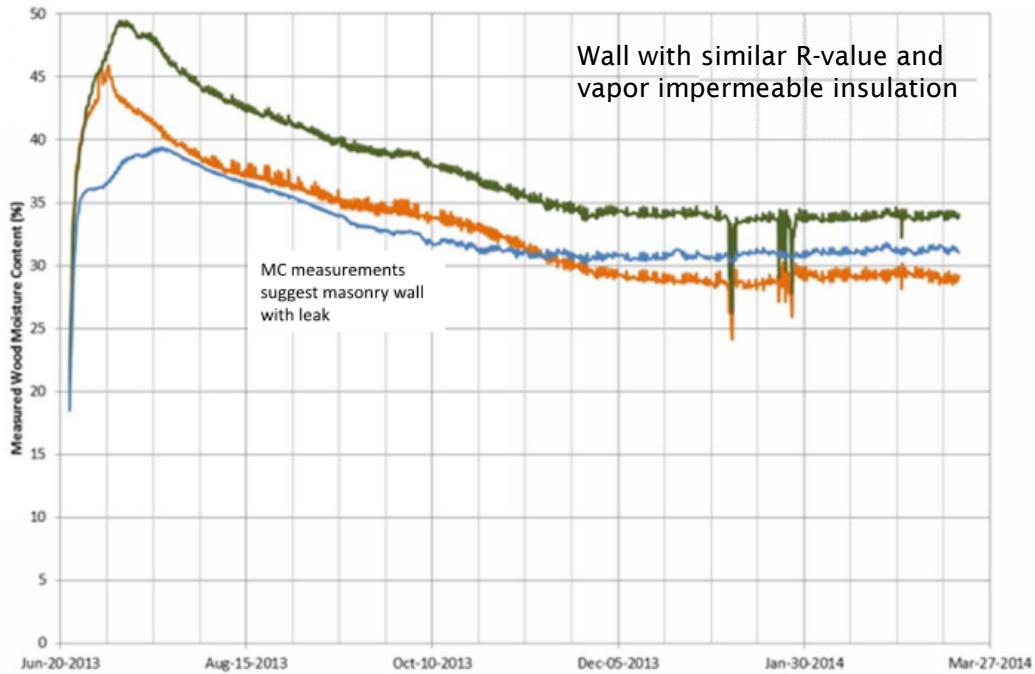


Semi-rigid MFI
w/ smart retarder

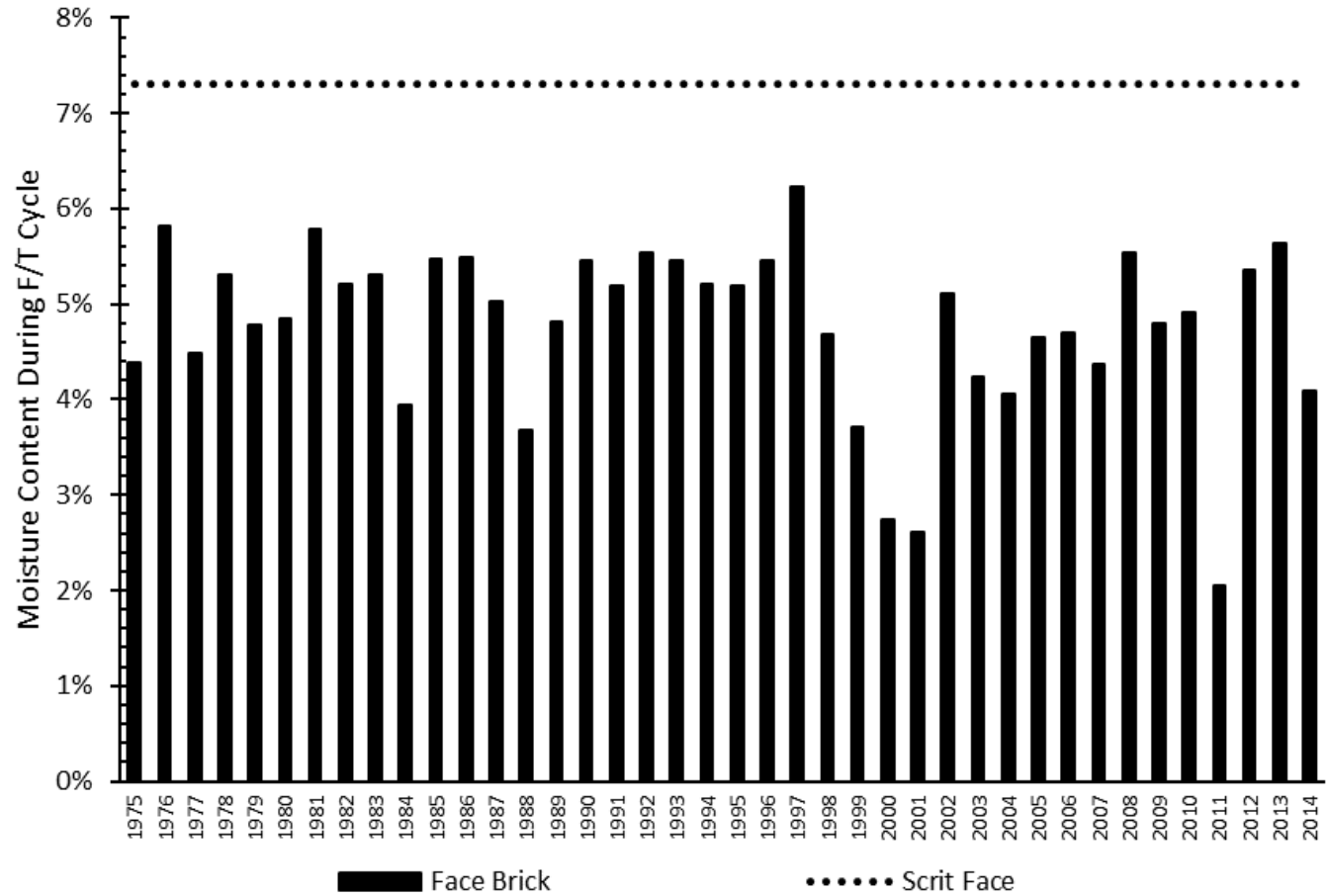
33



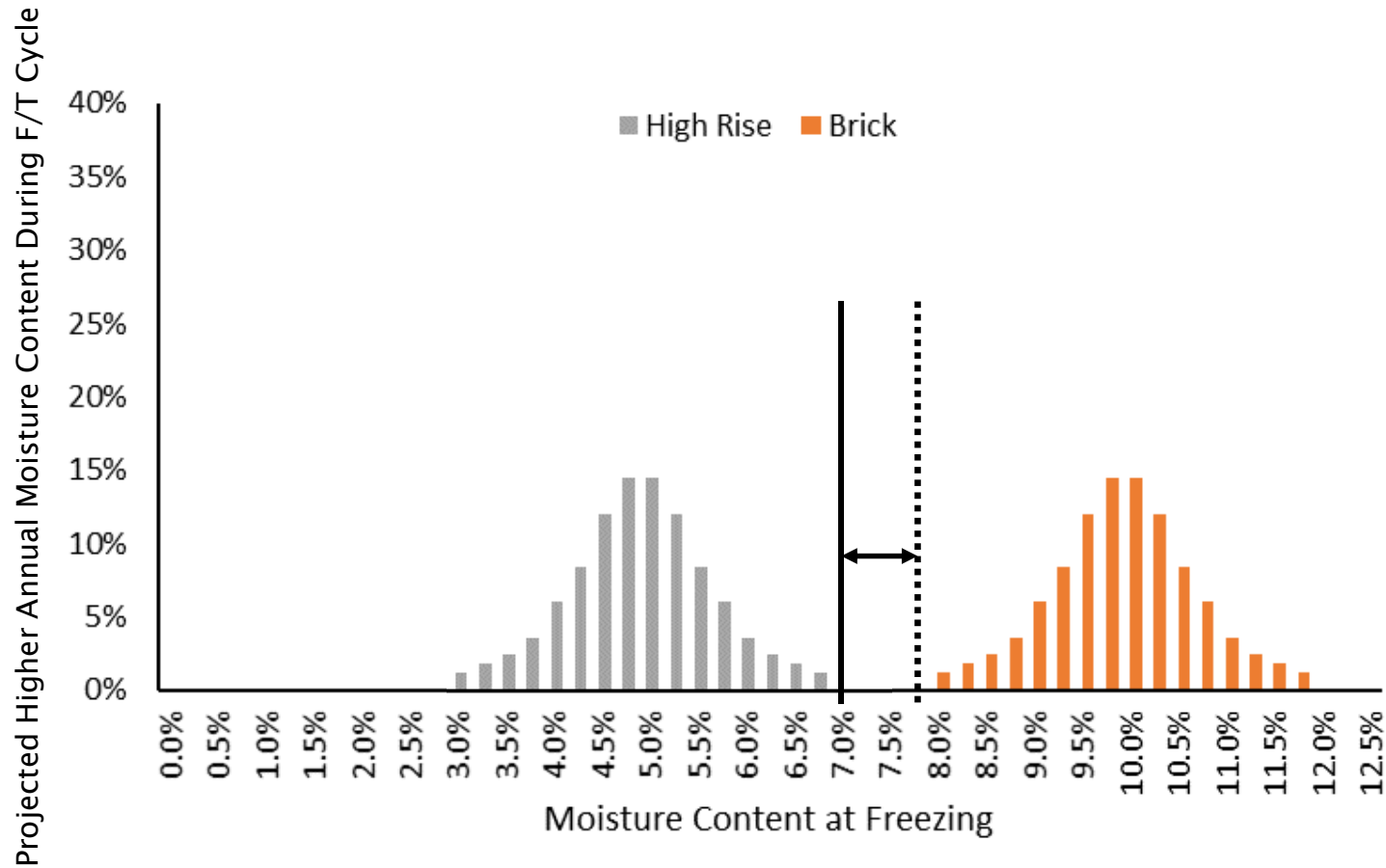
Masonry Wall Moisture Measurements (NY project)



Retrofit Insulation Options - 4.5" of interior ocSPF & smart VB



Retrofit Insulation Options - 4.5" of interior ocSPF & smart VB - illustration



Insights

- It will be hard to reach $R_{\text{Whole_Wall}}$ of 30 (achieve passive house) due floor slab interfaces (10 to 18 $R_{\text{Whole_Wall}}$ is achievable)
- 1 ¼" steel studs and hat channels to mount drywall (+1 to 4 $R_{\text{Whole_Wall}}$)
- 2' of perimeter insulation along ceiling (+2 $R_{\text{Whole_Wall}}$)
- Filling hollow tile slab fill blocks with spray foam adds (+2 $R_{\text{Whole_Wall}}$)

- ccSPF vs ocSPF (or mineral wool) w/smart vapour
 - Both options appear low risk of freeze thaw degradation but ocSPF is least risky
 - ccSPF $R_{\text{Whole_Wall}}$ (+3 to 5 $R_{\text{Whole_Wall}}$)

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