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Masonry Wall Interior Insulation Retrofit Embedded Beam Simulations

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Building Science Corporation

BEST 3 2012 Atlanta CONFERENCE
Building Enclosure Science & Technology

Introduction

- Retrofit interior insulation of masonry buildings
- Exterior insulation ideal solution
- Interstitial condensation, freeze-thaw issues

- Moisture-sensitive (wood) beams and joists embedded in masonry structure
  - Reduced heat flow
  - Higher localized relative humidity
  - Reduced drying (with low-permeance insulations)

Literature Review (DuMont et al. 2005)

- In SK (Zone 7B), joists stayed dry (10-15% MC)
- In ON (Zone 6A), at times 20%+ MC
  - Capillarity from foundation?
  - Rainwater absorption through face of masonry?

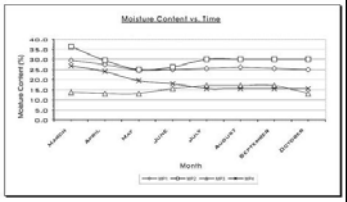


Figure 1

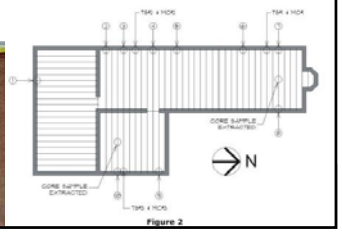
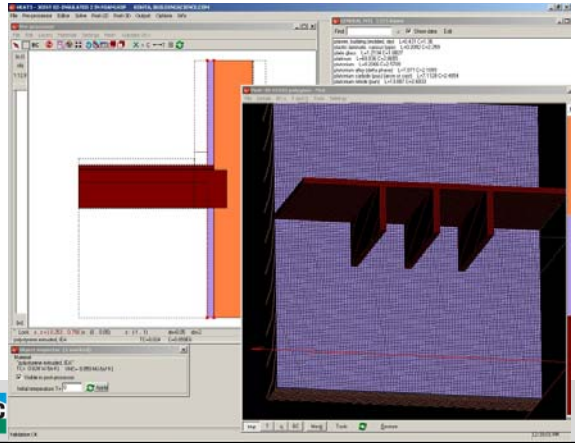


Figure 2

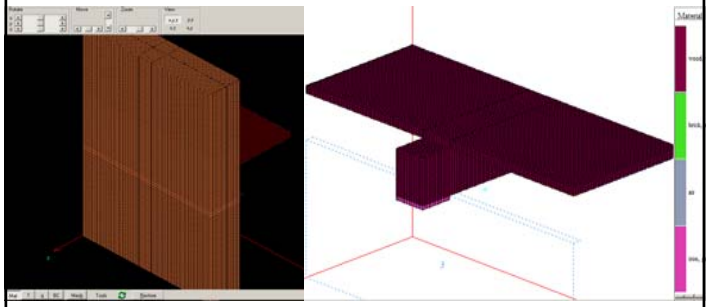
Literature Review (Con't)

- Scheffler (2009)
  - DELPHIN 2D hygrothermal simulations, steady state
  - Interior-sourced air and vapor flow risks
  - Transient simulations; beam end MCs increase w. insul.
  - Historic & modern methods to address beam end MCs
- Morelli (2010)
  - Gap in insulation above and below beam area (12" above and below → 30" left exposed)
  - 60% heat flow reduction from full insulation
  - 45% reduction with "gapped" insulation
  - "Gapped" insulation has less wetting than full insulation

HEAT 3D Three-dimensional simulations

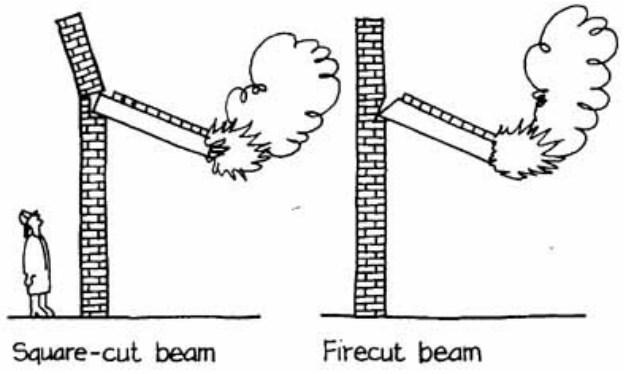


Beam Case Simulation Geometries



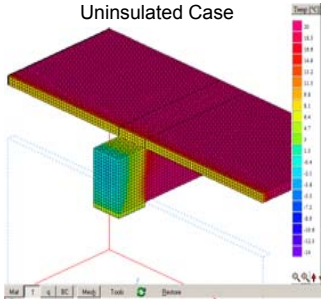
78" x 78" (2 m x 2 m) wall / 18" (0.45 m) thick / 12" x 8" (0.3 m x 0.2 m) beam
Insulated cases add 2" (50 mm) of closed-cell spray foam

Firecut Beams

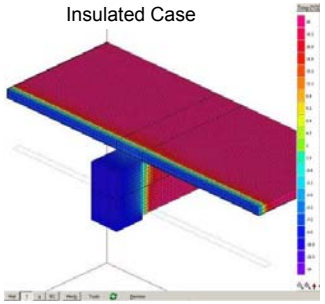


3D Heat Flow Simulations (Beam)

Uninsulated Case



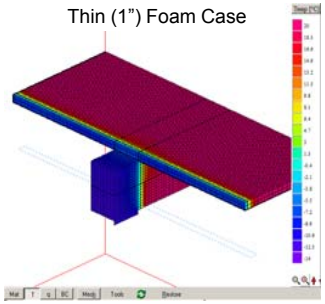
Insulated Case



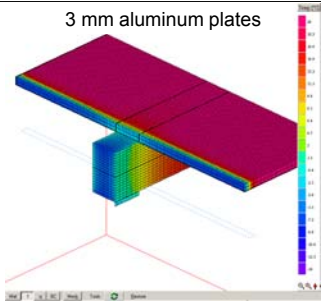
- Interior 68 F (20 C)
- Exterior 7 F (-14 C) (Boston 99.6% design T)
- Steady state (no thermal mass). Air space and no air space

3D Heat Flow Simulations (Beam)

Thin (1") Foam Case



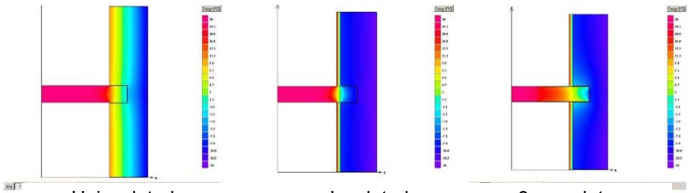
3 mm aluminum plates



- Thinned foam ~16" around beam in all directions
- 3 mm aluminum plates, sides of beam, 2x beam pocket interior depth
- Air leakage and condensation risks? 44-46 F (6-8 C) → 70 F, 35-40% RH)

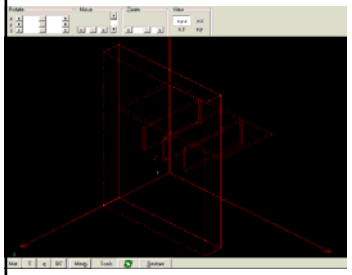
3D Heat Flow Simulations (Beam)

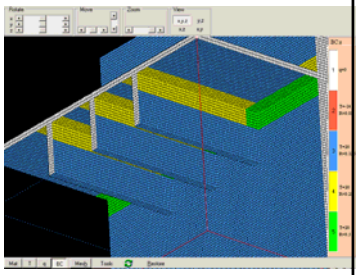
Horizontal Sections (Mid-height)



Uninsulated Insulated 3 mm plates

Joist Cases

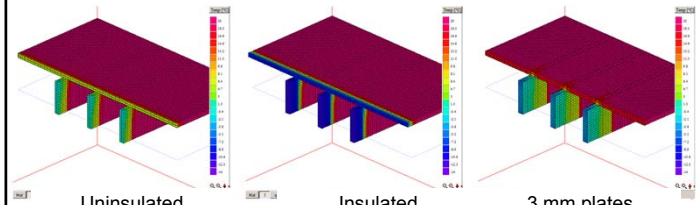




78" x 78" (2 m x 2 m) wall / 18" (0.45 m) thick
2"x12" (0.5 m x 0.3 m) wood members at 16" (0.4 m) o.c. spacing

3D Heat Flow Simulations (Joist)

Horizontal Sections (Mid-height)



Uninsulated Insulated 3 mm plates

3D Heat Flow Simulations (Joist)

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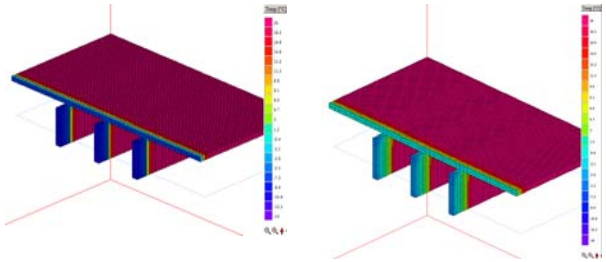
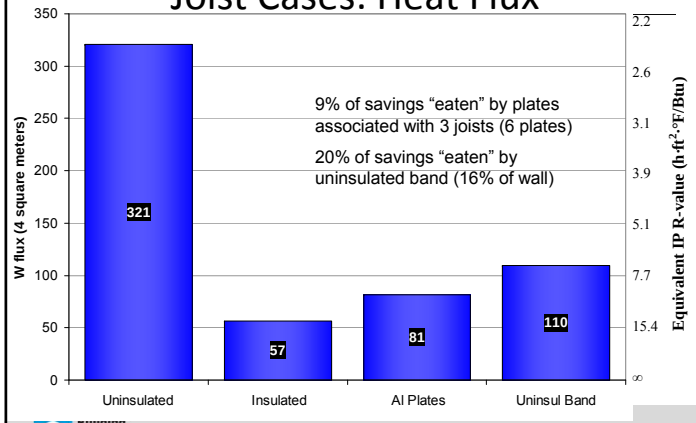


Thinned Foam Omit band insulation

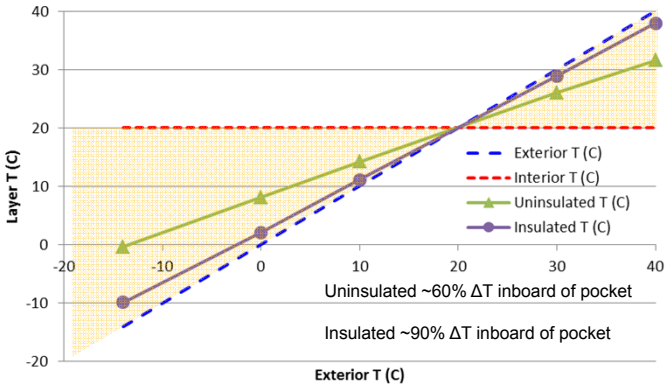
Joist Cases: Heat Flux



Hygrothermal (1D) Simulations

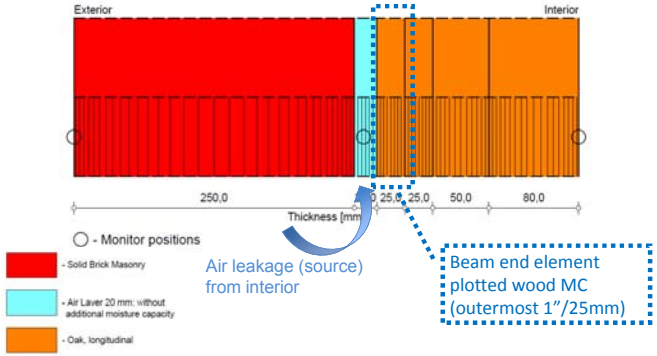
- One dimensional section same in uninsulated and insulated cases
- Modify wood material thermal conductivity, to result in correct beam end temperatures
- Needed to develop a "temperature index" at end of beam pocket from HEAT3 simulations

Beam End Temperature Index



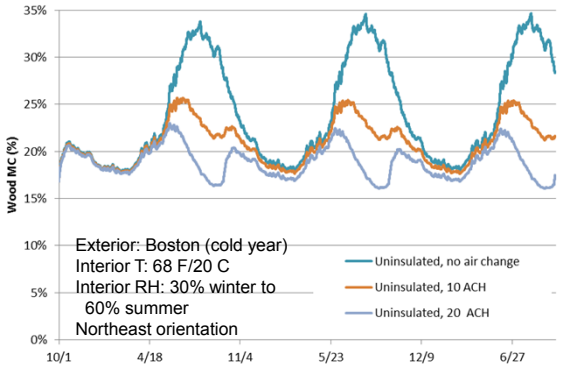
Masonry Wall Interior Insulation Retrofit Embedded Beams 17

Hygrothermal (1D) Simulations



Masonry Wall Interior Insulation Retrofit Embedded Beams 18

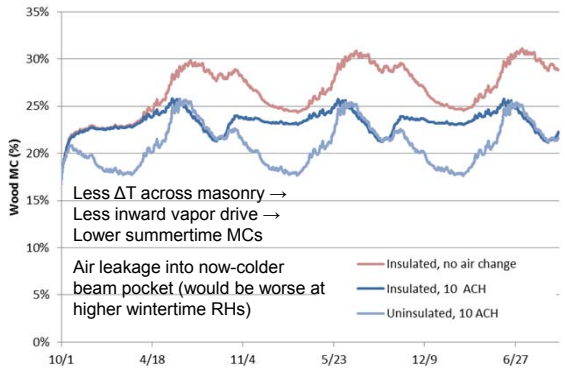
Uninsulated Beam Results



Air change plays role in drying of beams in existing buildings?

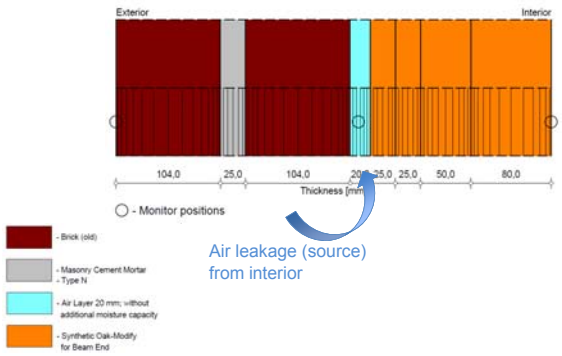
10 ACH = 0.0013 m/s air velocity (1/3 in & 1/3 out)

Insulated Beam Results

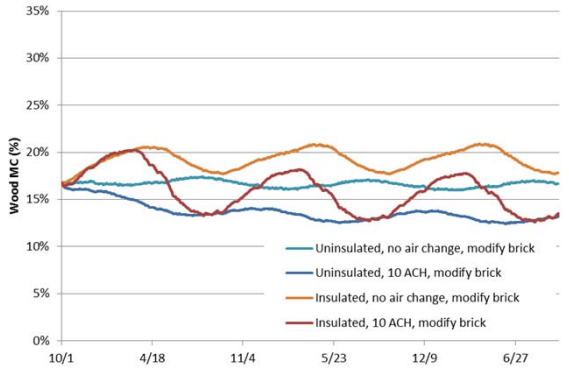


Masonry Wall Interior Insulation Retrofit Embedded Beams 20

Alternate Masonry Assemblies



Alternate Masonry Assemblies Results



Conclusions: Thermal simulations (2D)

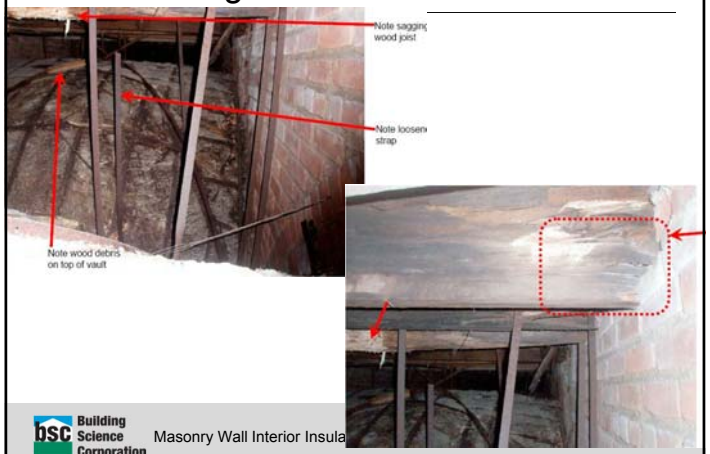
- Addition of insulation makes ends of embedded wood members colder in winter
- Metal plates add heat at beams; risks of condensation and air leakage
- Thinned insulation shows little effect on beam end temperatures
- Elimination of rim joist insulation results in higher beam end temperatures, but with an energy performance penalty

Conclusions: Hygrothermal simulations

- Air leakage has a strong effect on beam end moisture contents—likely occurring in reality
- Airflow lowers moisture content in some cases, but can raise MC in wintertime (insulated case vs. uninsulated with airflow)
- Alternate material assemblies can have strong effect on results
- Substantial uncertainty in actual behavior—simulations here were a “workaround”
- Use of 2-dimensional hygrothermal simulations?
- Field monitoring of actual behavior (wood MCs)
- New structure inside? Use of “hygric diode” material?

Future Work (Beam MC Monitoring)

Beam damage w/o insulation



Questions?

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