Using Mineral Fibre Insulation as a Vented Airspace in Historic Masonry Walls

A Special Presentation for Joe’s Summer Camp!

K.D. Pressnail
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Westford, MA

Research Driving Forces?

Energy-Efficiency, Durability, IEQ and Comfort!
Challenges with Historic Buildings

- **Low envelope thermal resistance**
  - ~0.5 – 0.7 m²K/W – Walls
  - ~0.2 m²K/W – Windows

- **Uncontrolled air leakage**
  - >16 ACH₅₀ ... Ventilation difficult to control

- **Varying masonry properties**
  - Durability issues during retrofits

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Standard Retrofit Approach

- 2-Wythe of 340 mm Structural Brick
- 25-50 mm Closed-Cell Polyurethane Spray Foam Insulation
- 49 mm Steel Studs set inward 25mm
- 5-30 mm Interior Airspace Space
- 12.5 mm Gypsum Wallboard
Insulating Solid Masonry Walls

What happens to the thermal environment when we internally insulate a solid masonry wall?

Vented Masonry Retrofit

2-Wythes of 340 mm Structural Brick

20 mm Vented Airspace

25-50 mm Closed-Cell Spray Polyurethane Foam Insulation

49 mm Steel Studs inboard 25 mm

5-30 mm Interior Airspace Space

12.5 mm Gypsum Wallboard
Field Trials

**Barrymore Building**
- Two years (2011-2013)
- 20-25 mm vented cavity thickness
- South & East facade
- Temp., RH monitoring, Pressure
- 1.5-2.5 RSI Walls

**Gemini House**
- One year (2014)
- 10-15 mm vented cavity thickness
- South & North facade
- Temp., RH, Pressure, Embedded moisture, Surface water activity monitoring
- 4.9-10.3 RSI Walls
The Barrymore Building

South Elevation
Simulates drying effects

East Elevation
Simulates wetting effects

Brick/Vented Cavity Interface
Mortairvent

Gypsum/Cavity Interface
Drying and Wetting Periods

Assumptions

- Equally distributed leakage openings
- Neutral pressure plane mid-height
- Only air moving through ventilation holes is considered
- All moisture deposited in the masonry (wetting case)

Moisture Movement - South Wall

Net Drying: 1.03 kg/m² per Year
Moisture Movement – East Wall

![Graph showing moisture movement]

Net Drying: 1.09 kg/m² per Year

The Gemini House

- Owner: U. of Toronto
- Built in 1879
- 2 Storey detached
- Solid Masonry
- > 16ACH @ 50Pa
- 1220 ft² (Standard)
- 740 ft² (Core)
- 480 ft² Perimeter
Monitoring Locations

North Elevation

South Elevation

Moisture Movement– Gemini

South1: 4.3 kg/m² removed per yr.
South2: 5.7 kg/m² removed per yr.

North: 0.08 kg/m² introduced per yr.
Masonry Moisture Content

Field Measurements
North: 13% - 15%

Laboratory Measurements
26% - 30%

Gemini is a low-energy home...

• Greatly reduced drying potential
• Increased potential for concealed (interstitial) condensation
A Unique Retrofit?

- Two thermal envelopes: “core” and “perimeter” spaces that control heat, moisture, and air movement
- Perimeter used as efficient heat recovery zone during winter months

![Nested Thermal Envelope Design](image)

### Average Core, Perimeter, and Outdoor Air Temperatures in Toronto

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<th>Month</th>
<th>Core</th>
<th>Perimeter</th>
<th>Exterior</th>
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Heating Energy Use Compared to Original Building

- Pre-retrofit Model Home: 522
- OBC-2012 Model Home: 96 (82%)
- Standard Operation Model Home: 67 (87%)
- Actual Consumption: 56 (89%)
- Lower-Energy Operation: Demand Curve Analysis: 34 (93%)

Heating Energy Use Compared to a Modern Home

- OBC-2012 Model Home: 96
- Standard Operation Model Home: 67 (31%)
- Actual Consumption: 56 (42%)
- Lower-Energy Operation: Demand Curve Analysis: 34 (64%)
Supporting Laboratory Work

Purpose:
• Investigate performance of alternative vented airspace using air-permeable, rock wool insulation

Controlled Variables:
• Vent area ratio, clear airspace, insulation density

Variables of Interest:
• Moisture gain in test walls, estimated moisture removed via ventilation
Laboratory Testing – Apparatus

Lab Testing 3 Wall Types

- **Baseline Unvented No Clear Airspace**
- **Vented No Clear Airspace**
- **Vented Clear Airspace**
### Testing Summary

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<th>Wall Type</th>
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### Moisture Removal: No Clear Airspace

- Walls with No Clear Airspace (Wall D)

![Graph showing moisture removal percentages for different tests with clear airspace.]
Moisture Removal
Airspace v. No airspace

Finding Summary

• Moisture can be removed from the walls without a clear airspace with vapour permeable insulation
  • 59% - 95% with clear airspace and vent holes
  • 52% - 90% with vent holes only

• Enough air was able to move through the air-permeable insulation to dry the wall assembly.

• Drying occurs by air movement – solar heating and wind

• Vent area and insulation density can affect the amount of moisture removed
Ventilation Drying

• Is far more effective than diffusion drying
• Is dependent upon the climatic zone
• Has been used in Ontario for 100’s of years to dry sawn lumber and even firewood!

Using Fibre Insulation in Place of a Vented Airspace?

• The Canadian Building Digests: venting a flat roof through fibre insulation!
• ... and that was back in the 1960’s!
Applications of this work in suitable climates?

• Venting solid masonry as well as masonry veneer
• Venting cathedral ceilings
• Venting flat roofs

Acknowledgements

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Obama’s Inaugural Address!
January 20, 2009

And to those nations like ours that enjoy relative plenty, we say we can no longer... consume the world’s resources without regard to effect.

...each day brings further evidence that the ways we use energy strengthen our adversaries and threaten our planet.

What is required of us now is a new “Era of Responsibility”.

David Orr

This planet needs...

..people of moral courage willing to join the fight to make the world habitable and humane.
Onward and as always...
Upward!

All the best!
K.D. Pressnail
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