A Laboratory Study: Examining The Use of Mineral Fibre Insulation to Assist The Ventilation Drying of Internally Insulated Historic Solid Masonry Walls

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Introduction

- Why thermally retrofit?
- Heritage considerations
- Thermal insulation at the interior causes walls to be colder and wetter
- Cold and damp walls can cause durability issues
- Ventilation can help solid masonry dry
- Ventilation airflow can occur through air permeable insulation

Outline

- Background
- Laboratory investigation
- Hygrothermal modeling
- Discussion

Objective

- To examine the potential for air permeable insulation to promote moisture removal in wall assemblies

Approach:

1. Laboratory investigation - quantify moisture removal when air permeable insulation is used as a venting medium
2. Hygrothermal modeling – illustration of the impact of the ventilation drying on the moisture response of an internally insulated wall system

Masonry Durability

- Solid brick masonry wall construction
- Properties of wall components are variable
- Risk of freeze-thaw action, corrosion and decay

Ventilation

- Ventilation airflow in wall assemblies
  - Pressure differences due to wind and natural buoyancy
  - Friction with vent edges and airspace boundaries resists the airflow
- Moisture capacity of bulk air within cavity
  - If there is capacity, moisture can be removed

Ventilated Airspaces and Solid Brick Masonry

Ventilation at the interior of solid brick masonry walls has been investigated by researchers at the University of Toronto

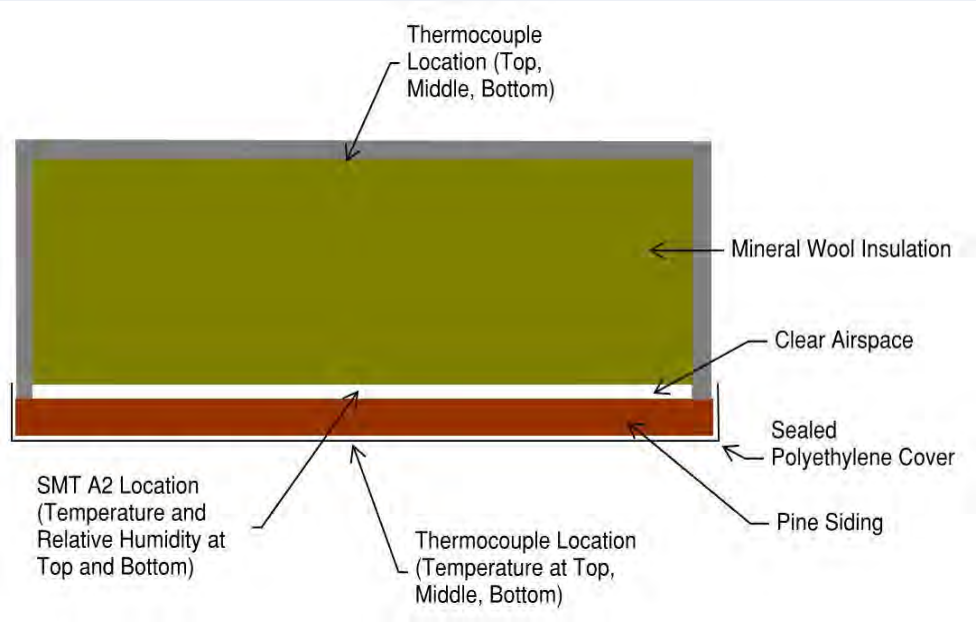
- Comparison of internally insulated solid masonry walls with and without a clear airspace in field studies
- Investigation of alternative systems to assist drying (including the use of air permeable insulation)

Laboratory Investigation

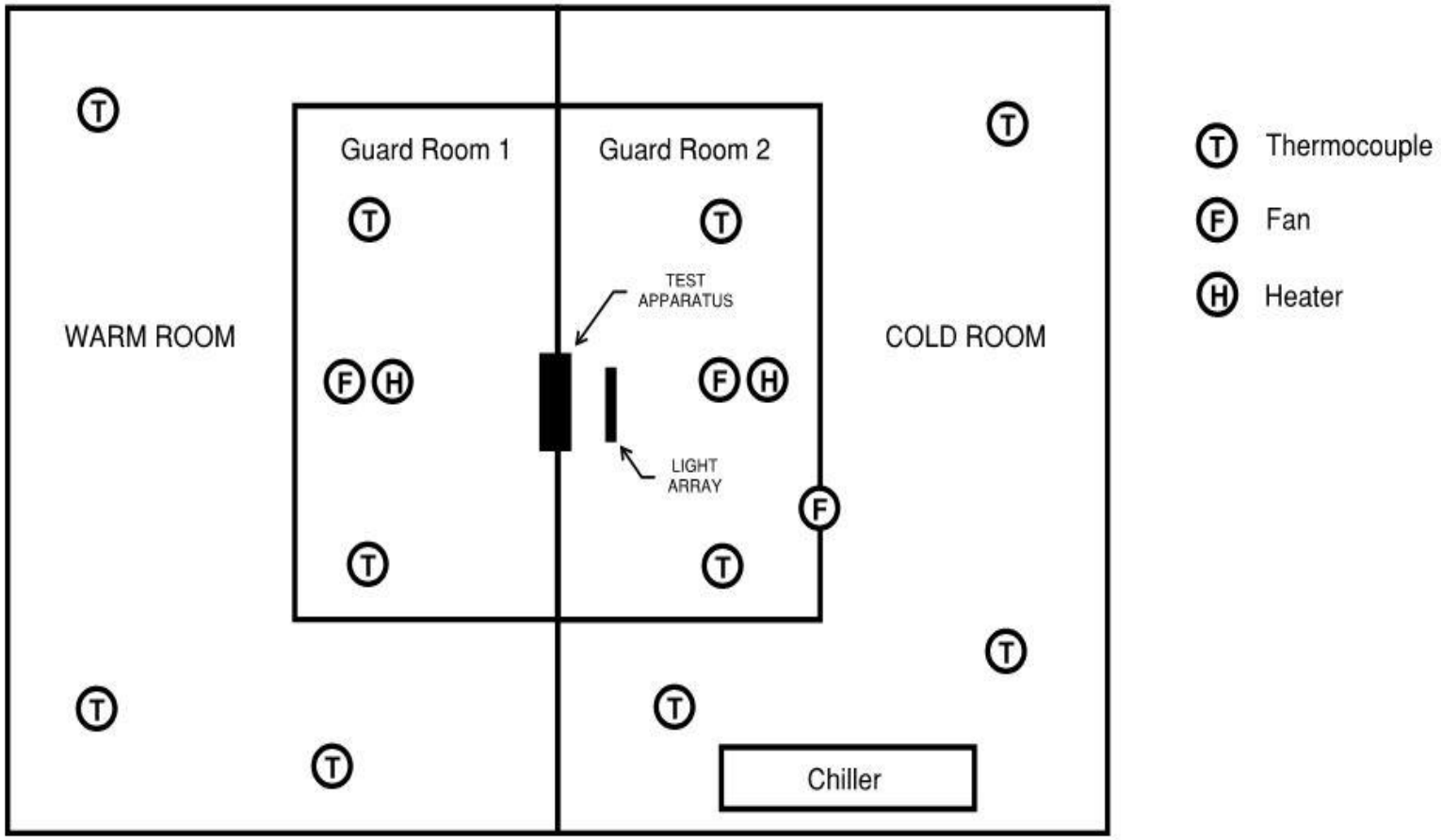
- Moisture was driven into test wall assemblies by heating a water reservoir to create a vapour pressure difference
- Moisture removed by ventilation through vent holes at the top and bottom of the wall assembly
- Quantity of moisture removed was calculated through a moisture mass balance of the test wall assembly components
- RSI4.2 (R24) mineral fibre batts were tested for their venting potential with and without clear airspaces
- Controlled variables: vent area ratio and clear airspace thickness
- Main variable of interest: quantity of moisture removed by ventilation

Apparatus

- Box constructed of sealed plywood designed to fit within stud cavity of guard room separation wall acts as the test wall
- Pine siding boards act as moisture reservoir
- Gap between insulation and pine boards maintained with spacers
- Vent holes are located at the top and bottom of the test box in pine boards
- Polyethylene and construction tape to seal the system



Laboratory Set-up



Method

- Mineral fibre and moist pine siding weighed before assembly
- Assembled test box exposed to the light array for 6 hours driving water vapour into the test box
- Apparatus components reweighed after disassembly
- Moisture mass balance was carried out to determine the quantity of moisture removed during the test

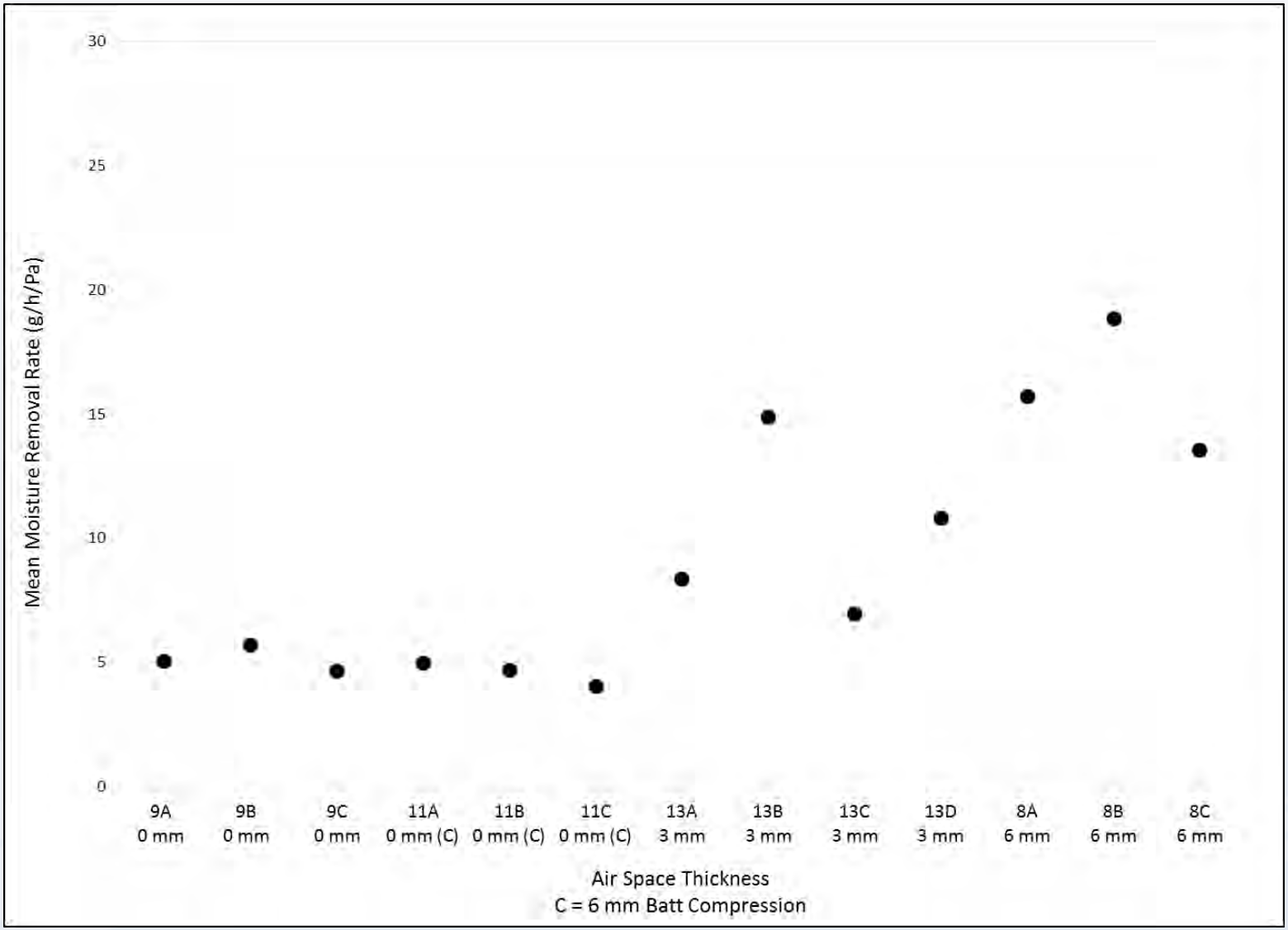
Moisture Removal

Moisture Removed via Ventilation (g) = Moisture Lost from Pine Siding (g) - Moisture Recovered in Test Apparatus (g)

Base test indicates unaccounted for moisture = 10%

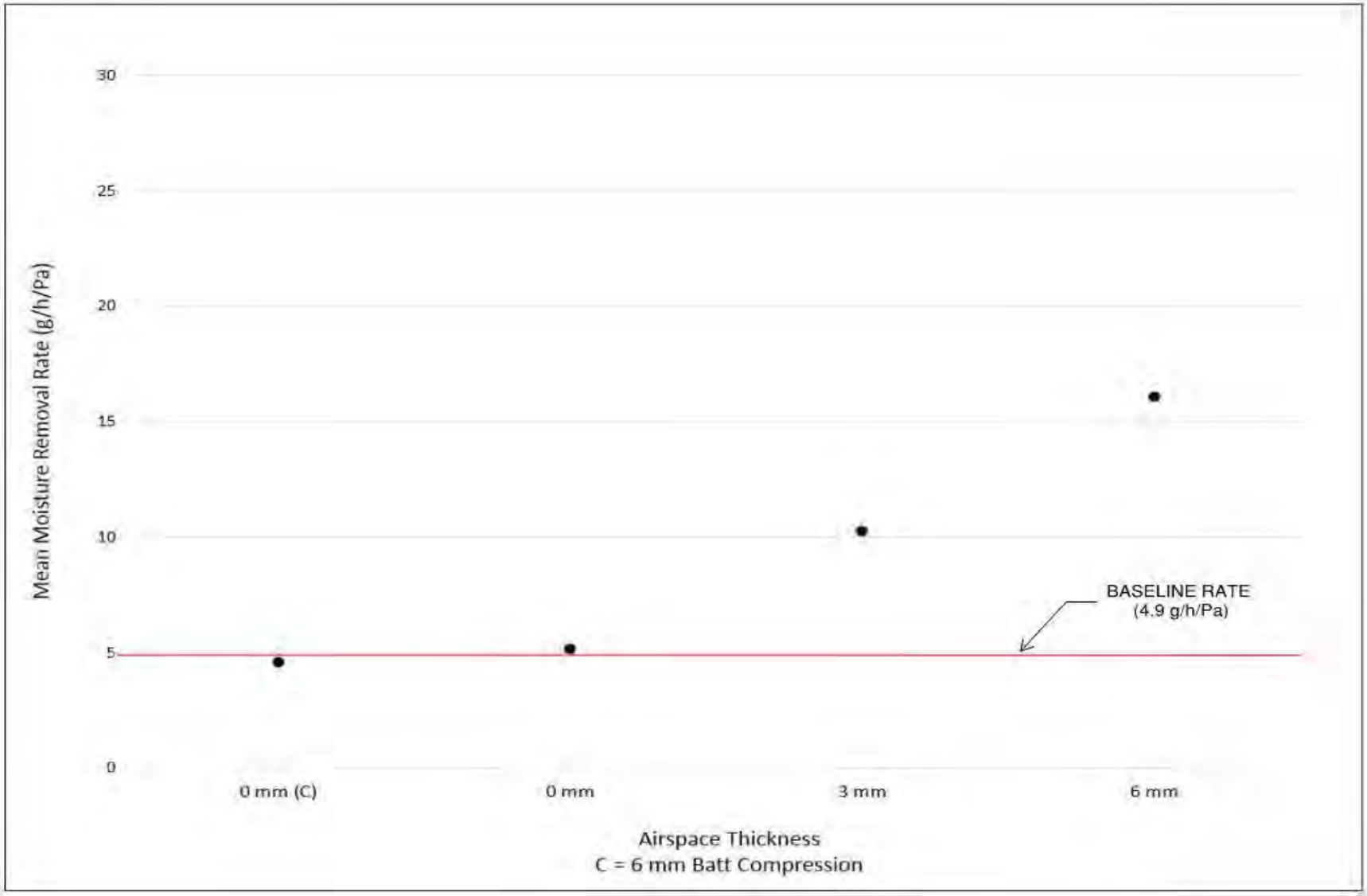
- Difficulty in estimating evaporation
- Likely unintended air leakage
- How much is removed by ventilation?

Moisture Removal Rate



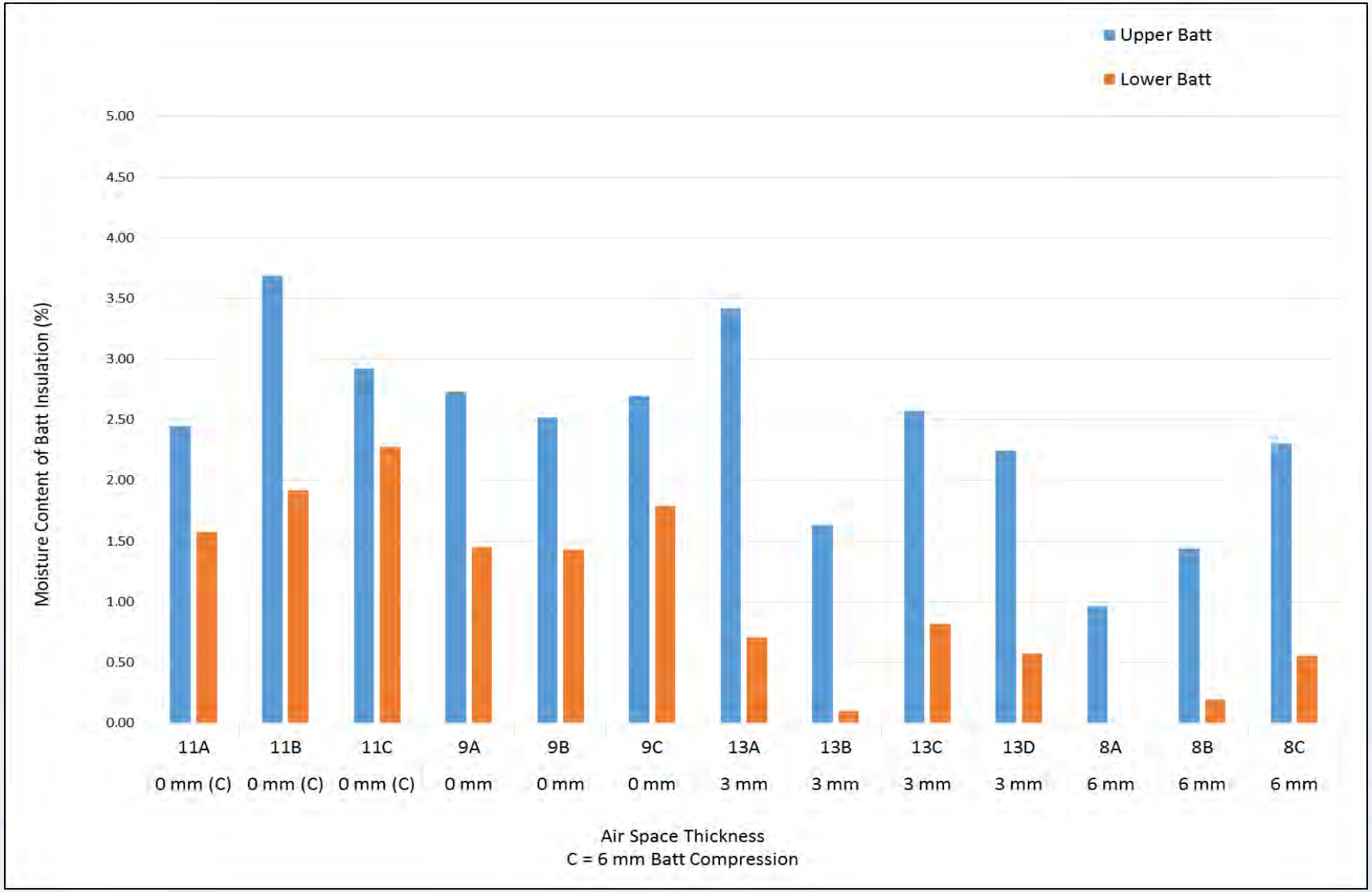
Average Normalized Moisture Removal Rate for Various Air Space Thicknesses

Moisture Removal Rate



Average Normalized Moisture Removal Rate – Mean of Set at Airspace Thickness

Evidence of Airflow in Batt



Moisture Content of Batt Insulation as a Percentage

Discussion

- Moisture removed with no clear airspace
- Evidence of airflow within the batt
- R24 insulation roughly equivalent to a 3mm clear airspace
- Masonry wall roughness may contribute to airspace thickness
- Higher density insulation may be desired for design and constructability purposes

Hygrothermal Modeling

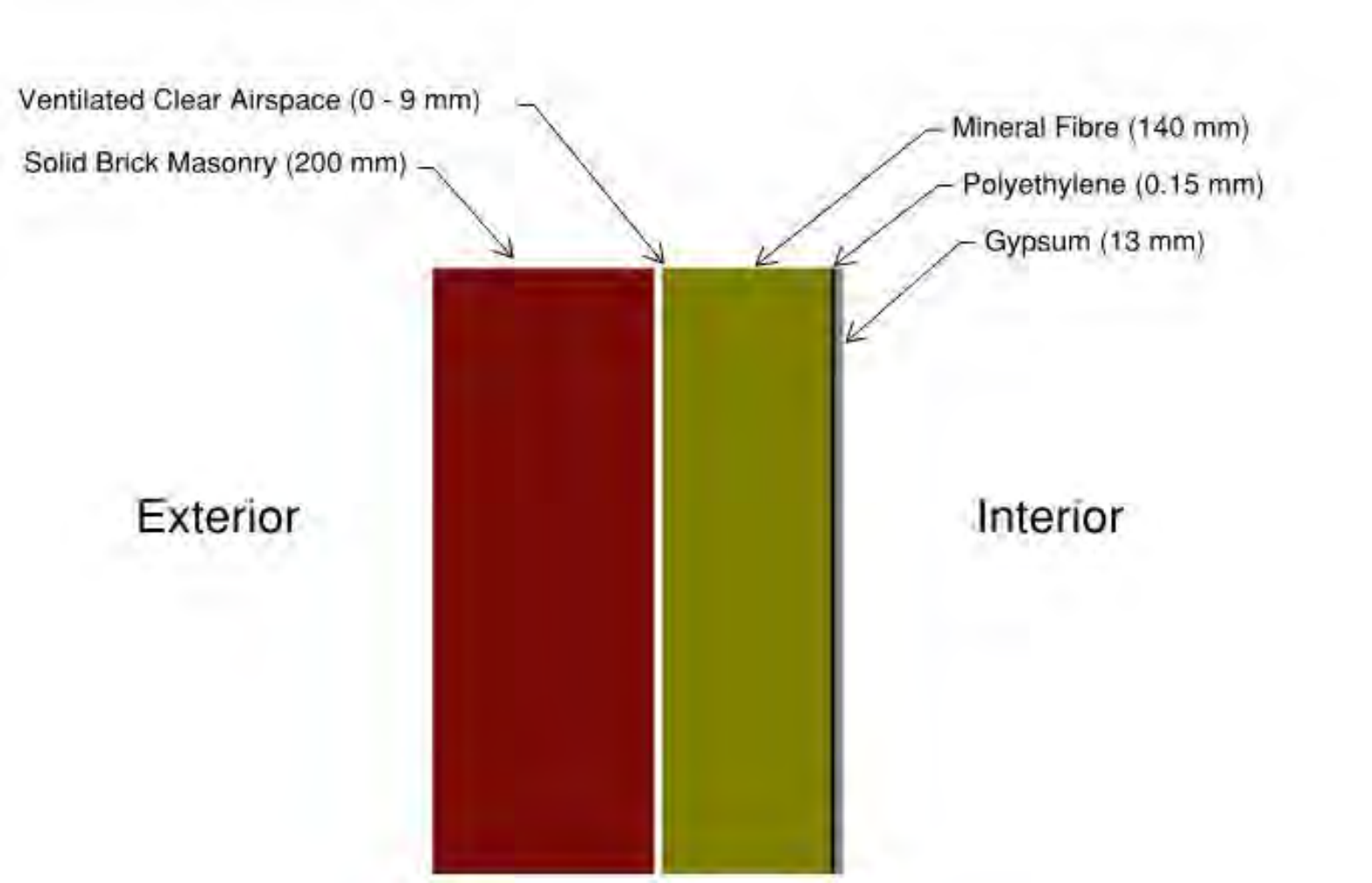
- To illustrate moisture removal response of an internally insulated wall system
- WUFI 6 Pro modeling software
- 4 modeled cases (no venting, 3mm, 6mm, 9mm)
- 3mm of modeled clear airspace assumed to be venting in mineral fibre
- Constant ventilation rate: ACH 0-100

Model Inputs

Model Parameter	Input
Orientation	South / East
Rain Exposure	ASHRAE 160
Initial Material RH	80% (default WUFI value)
Simulation Runtime	5 years
Simulation Time Step	1 hour
Interior Boundary Conditions	23°C (1°C amplitude) 39% RH (15% amplitude)
Exterior Boundary Conditions	Toronto Cold Weather Year

Based upon field studies at the Gemini House in Toronto

Modeled Wall Assembly



Results

- Reduction in average moisture content of brick masonry
- Reduction in relative humidity throughout the wall assembly
- As expected, more benefit as airspace thickness and ventilation rate are both increased
- MC and RH higher at east face due to driving rain events and less solar exposure in Toronto
- Limitations include the use of generic materials and a constant ventilation rate

Investigation Conclusions

- Ventilation drying can occur through air permeable mineral fibre insulation if appropriate vents are provided
- When combined with a vent area ratio of 1175 mm^2/m^2, RSI 4.2 mineral fibre insulation can ventilate moisture at a rate comparable to a 3mm clear airspace
- In a drying climate like Toronto ON, introducing ventilation into solid masonry wall assemblies can help reduce the risk when internally insulating walls
- Properties of materials vary so designers should always consider the durability of wall components when specifying retrofit insulations

Acknowledgements

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For Further Information

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E. Tzekova, “Improving the Thermal Performance and Durability of Historic Masonry Buildings.” PhD. Thesis, Department of Civil Engineering, University of Toronto, 2015.