# STUDY OF GYPSUM BOARD MATERIAL PROPERTIES REQUIRED TO MAINTAIN HIGH INDOOR RELATIVE HUMIDITY IN BUILDINGS IN COLD CLIMATES


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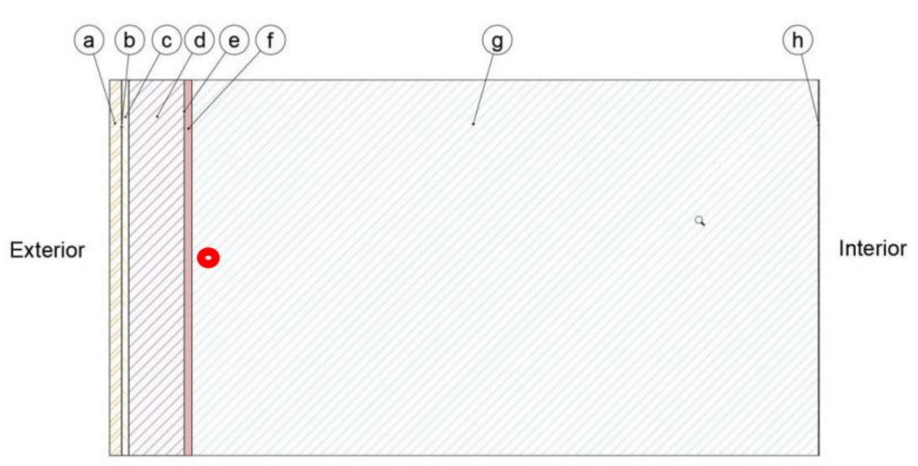
## INTRODUCTION

- Research has shown that the optimal indoor relative humidity (RH) levels at standard room temperature is 40% to 60% with regards to minimizing risks to human health.
- Common sources in residential buildings that impact indoor RH are air changes (ventilation), humidifiers, personal activity, construction materials, seasonal storage effects, and rain penetration.
- Studies show that low outdoor temperature in cold climates increase the amount of condensation in building envelope structures while decreasing indoor RH.
- The average indoor RH for cold cities in Canada is generally between 25% to 30%.
- The two most common strategies for controlling moisture within a building envelope are:
    - (1) Limiting moisture from both internal and external sources
    - (2) Choosing construction materials and designing with moisture control in mind

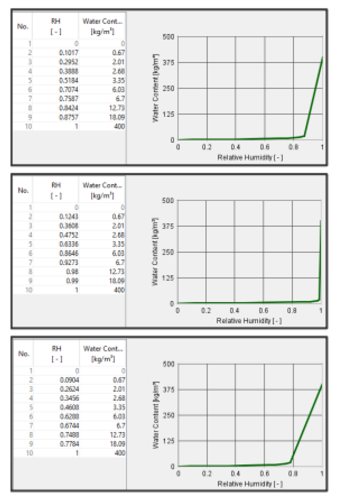
## METHODOLOGY

- The primary research objective is to determine a gypsum board material with altered material properties that would allow for an indoor RH as close to the 40% to 60% range for cold climate cities.
- WUFI Pro (version 6.5) was used as the simulation model software due to its capability of modeling 1-dimensional transient heat and mass transfer and assessing heat and moisture distribution for a variety of building materials and climate conditions.
- Boundary conditions are set on the building exterior wall (climate from a chosen city) and on the building interior wall (the desired, user-defined indoor climate).
- Simulation results show the water content in each defined building wall component.
- Wall construction model:




| Label | Material | Width [mm] |
|---|---|---|
| a | Acrylic Stucco | 19 |
| b | SBP | 0.23 |
| c | OSB | 11 |
| d | Fiber Glass | 89 |
| e | Vapor Retarder (0.1 perm) | 0.152 |
| f | Gypsum Board | 12 |
| g | Air Layer | 3000 |
| h | 3M Air and Vapor Barrier 3015 | 1 |

- User-defined gypsum board test materials:



| Label | Material Property | Value |
|---|---|---|
| Test A | Porosity (+0.1) | 0.75 |
| Test B | Porosity (-0.1) | 0.65 |
| Test C | Specific Heat Capacity (+10%) | 957 |
| Test D | Specific Heat Capacity (-10%) | 783 |
| Test E | Moisture Storage Function (-10%) | Top Figure |
| Test F | Moisture Storage Function (+10%) | Mid Figure |
| Test G | Moisture Storage Function (-20%) | Bot Figure |

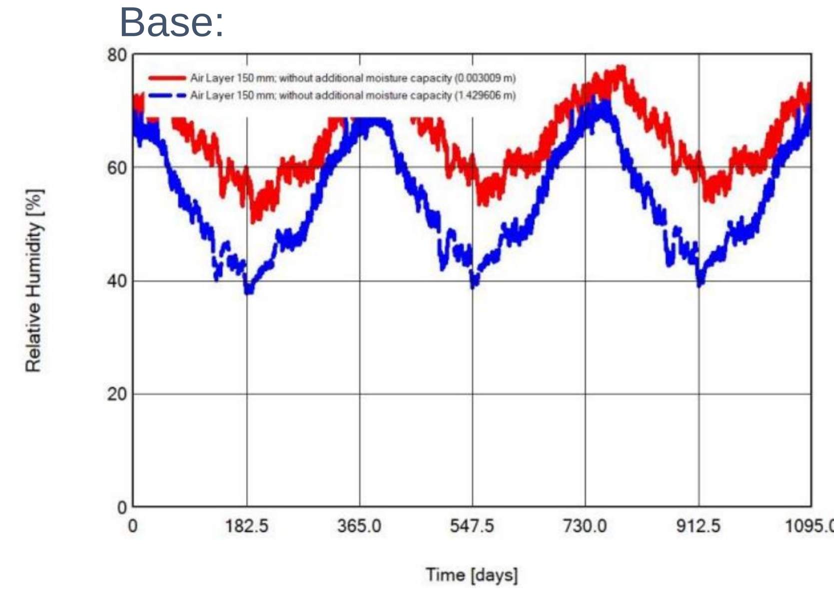
- Simulations were performed for each test materials in two locations: Vancouver, BC and Winnipeg, MB.

## RESULTS

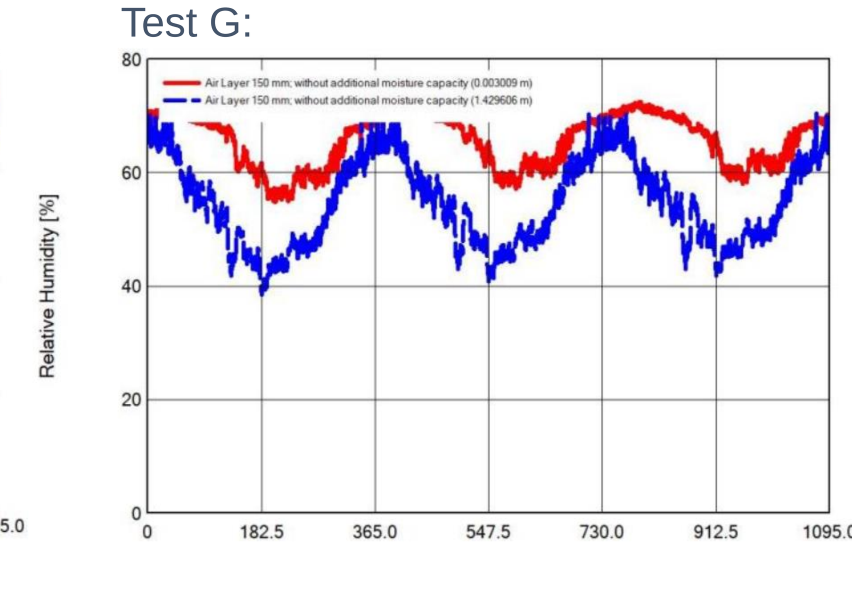
- Simulation results for Vancouver, BC:

| Label | Minimum RH [%] | Maximum RH [%] |
|---|---|---|
| Base | 53.4 | 77.9 |
| Test A | 53.4 | 77.9 |
| Test B | 53.4 | 77.9 |
| Test C | 53.5 | 77.8 |
| Test D | 53.3 | 77.9 |
| Test E | 55.2 | 76.6 |
| Test F | 51.0 | 78.2 |
| Test G | 57.2 | 72.4 |

Base:



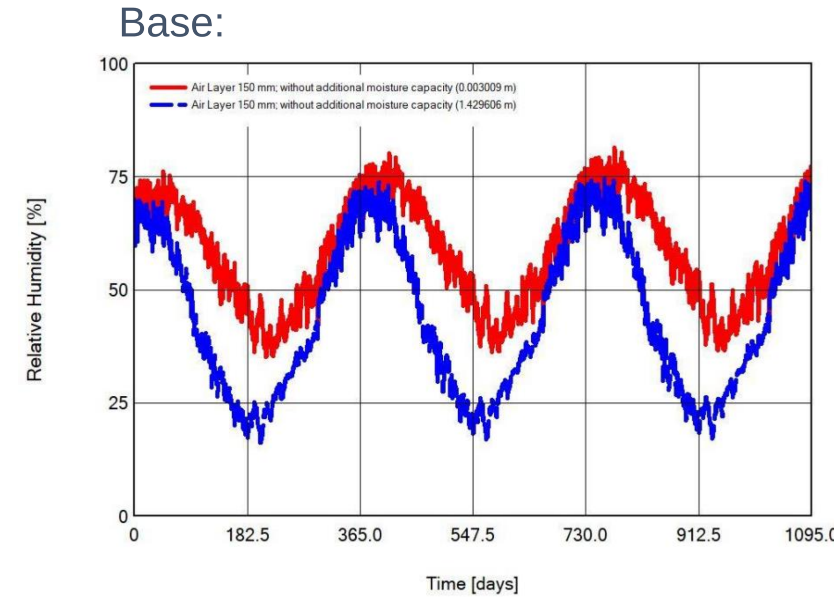

Test G:



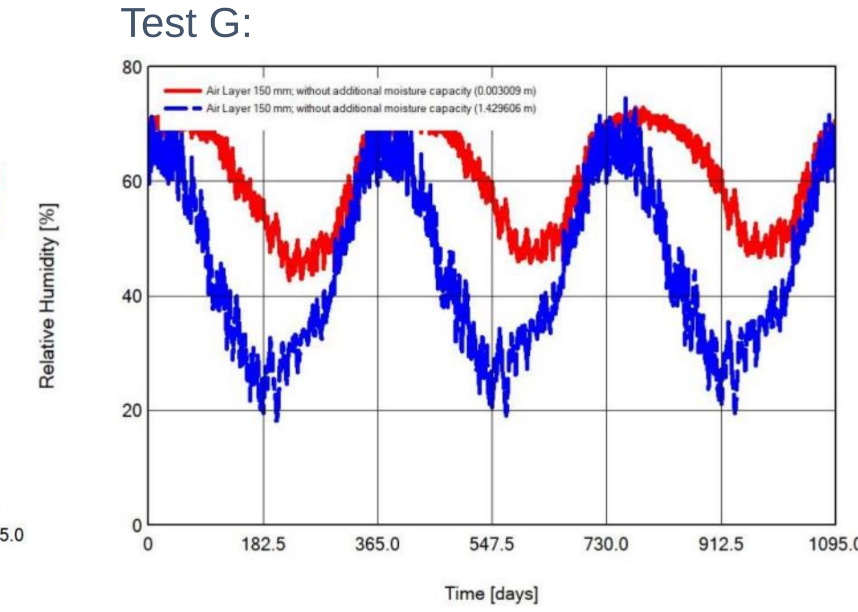

- Simulation results for Winnipeg, MB:

| Label | Minimum RH [%] | Maximum RH [%] |
|---|---|---|
| Base | 36.3 | 81.5 |
| Test A | 36.3 | 81.5 |
| Test B | 36.3 | 81.5 |
| Test C | 36.3 | 81.4 |
| Test D | 36.3 | 81.6 |
| Test E | 37.8 | 77.6 |
| Test F | 35.4 | 81.9 |
| Test G | 45.8 | 72.9 |

Base:




Test G:




## CONCLUSIONS

- Test A and Test B (changes in porosity):
    - Negligible effect on indoor RH
- Test C and Test D (changes in specific heat capacity):
    - Negligible effect on indoor RH
- Test E, Test F, and Test G (changes in moisture storage function):
    - Increased water content per RH → ΔRH decreased
    - Decreased water content per RH → ΔRH increased
- Best Test Case: Test G (Moisture storage function -20%)
    - Vancouver, BC: 57.2% to 72.4% (Test G) vs 53.4% to 77.9% (Base)
    - Winnipeg, MB: 45.8% to 72.9% (Test G) vs 36.3% to 81.5% (Base)

## AREAS OF FUTURE WORK

- Compare results with different software due to required boundary conditions for WUFI Pro
- Additional micro-changes to moisture storage function parameter
- Research what is physically required to alter a material's moisture storage function
- Produce and test material experimentally to verify simulation results

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