HYGROTHERMAL PERFORMANCE OF EXTERIOR BLANKET INSULATION

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ABSTRACT

Cost-effective ways to reduce the energy use of Canadian houses is key to reducing national greenhouse gas emissions and energy use. Adding additional insulation on the exterior side of a wall cavity of a house is one of many approaches used to reduce the energy use of new and existing homes. However, this approach could also increase the potential for air leakage condensation at the sheathing and reduce the ability of drying, leading to higher risks of mold growth and structural damage. Several factors affect the drying effectiveness within a wall, one of which is the vapor permeability of the wall insulation. When insulation is installed on the exterior side of a wall cavity, the risk for air leakage condensation is higher with low vapor permeability insulation than with high vapor permeability insulation. Blanket insulation has higher vapor permeability than rigid and semi-rigid insulation, and has recently been introduced as an option for insulating the exterior side of a wall cavity in the Canadian housing market. No published field studies were found on the condensation and moisture build-up potentials with exterior blanket insulation in the cold Canadian climate. This research investigates the hygrothermal performance of blanket insulation using field measurements and computer simulation. Moisture content, relative humidity and temperature sensors were installed inside the walls of a recently renovated 1970 house located in Calgary, Alberta. Data from these sensors were recorded for one year. Analysis of the data shows a low risk of condensation and moisture build-up within the cavities of the investigated walls. Results from hygrothermal simulation also showed similar trends. This simulation was further used to compare the hygrothermal performance of the exterior blanket insulation to that with rigid and semi rigid exterior insulation.

The existing wall assembly of the renovated house consisted of 2x4 wall framing with blanket insulation between the studs, exterior plywood sheathing, building paper and a stucco finish. The stucco finish and building paper were removed during renovation and blanket insulation was wrapped around the house. Cement boards were used for the wall's exterior finish. The exterior blanket insulation is made of polyester and polyolefin fibers with an R-value of 0.88 m^2 k/W.

Wireless data loggers connected to sets of sensors were installed in the south and north wall at two locations: under a window and in a full wall without a window. Two packages of relative humidity and air temperature sensors were installed 1 meter above the main floor at under-window locations. One package was installed inside the 2x4 wall cavity and the second package was installed outside the stud cavity between the sheathing and the exterior blanket insulation. Four packages of moisture content and temperature sensors were installed at under-window locations. One package was installed on the sheathing inside the stud cavity at 1 meter above the floor, and a second package was installed on the exterior side of the sheathing at the

same height. The third package was installed on the base plate inside the stud cavity and the fourth package was installed on the exterior side of the header board. For full-wall locations one package of relative humidity and air temperature sensors and one package of moisture content and temperature sensors were installed on the exterior side of the sheathing at 1 meter above the main floor. The house indoor relative humidity and air temperature was also recorded. Outdoor climate data were obtained from the Calgary International Airport Weather Station. Measurements were recorded between March 2015 and March 2016. Due to technical problems with the sensors some data points were lost and are marked as gaps in the graphs presented here.

Hygrothermal simulation was conducted using Wufi Pro 6.0. Calgary cold climate weather and low moisture interior load profiles provided in Wufi were used for the simulation. A rain leakage fraction of 1% was added to the sheathing layer. Solar heat gain was also simulated.

All measured moisture content values were below 10%. Because the installed moisture content sensors only detect moisture content above 10% the variation under 10% was not captured and will not be represented here. Simulation results showed low moisture content for the south orientation only as can be seen in Figure 1. The moisture content for the north orientation during the summer period reached up to 25%, which is slightly higher than the specified value in National Building Code of Canada for dry wood. When rain leakage was removed from the simulation all moisture content values became below 15%. The possibility of rain leakage in the monitored walls is minimal as the insulation and cement boards were installed according to the manufacture instructions. Both the field measurements and simulation results suggest that with properly installed exterior blanket insulation it is possible to maintain dry conditions inside the wall cavities.

The potential of moisture condensation was also found to be minimal. The dew point values of the air inside the monitored walls are much lower than the temperature of sheathing as can be seen in Figure 2. Simulation results shown in Figure 3 are similar, however, the difference between air dew point values and sheathing temperature values is much lower than that found in the field measurements.

Relative humidity values were also examined to illuminate any possible condensation due to air saturation with moisture. The measured relative humidity values shown in Figure 4 are below 57%, suggesting low risk of condensation due to saturation. It was also observed that relative humidity values inside the north wall are in general higher than that found inside the south wall. This trend can also be seen in the simulation results shown in Figure 5. This suggests a higher condensation potential due to saturation in the north versus south walls. Overall, both field measurements and simulation results show that relative humidity inside the wall cavities did not reach saturation levels.

Moisture content in the sheathing was used to compare the moisture conditions with exterior blanket to that with extruded polystyrene insulation and rock wool insulation. Two simulation cases were developed using the same specifications of the renovated walls. For each case, the insulation thickness was adjusted to the same R-value as that of the exterior blanket insulation. As can be seen in Figure 1, the simulation results show that moisture content values are higher during the summer season than the rest of the year. The values with blanket insulation and rock wool are almost identical for the north orientation. However, for the south orientation the values with blanket insulations are lower than that with rock wool. For the north orientation, the moisture content values with blanket insulation and rock wool are lower than that with extruded

polystyrene. The values with extruded polystyrene insulation reached up to 45% during the summer and maintained a range of 40% to 45% over several months. On the other hand, for the south orientation, the three insulation types had closer value ranges. This suggests that wall orientation and type of insulation are important factors to consider when designing building envelopes. Overall, exterior blanket insulation performed well compared to other types of exterior insulations. Since this research is limited to Calgary's dry climate more research is needed to investigate the hygrothermal performance of this type of insulation in other climates.

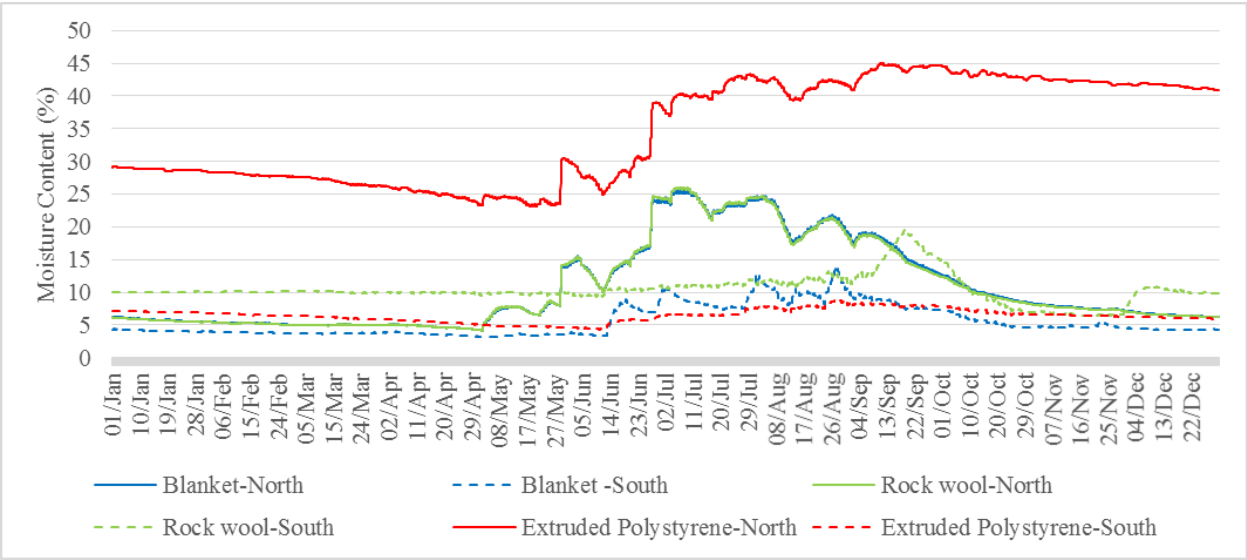

Figure 1: Moisture content profile comparison between different types of exterior insulation. Simulation results.

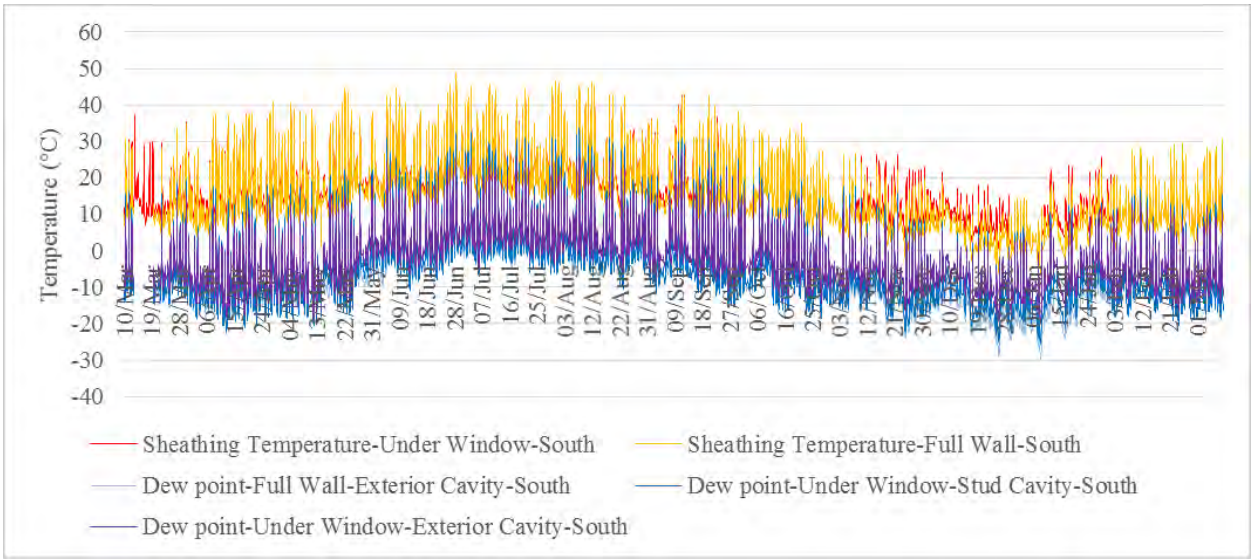

Figure 2: Dew point and sheathing temperature profiles. South wall, field measurements.

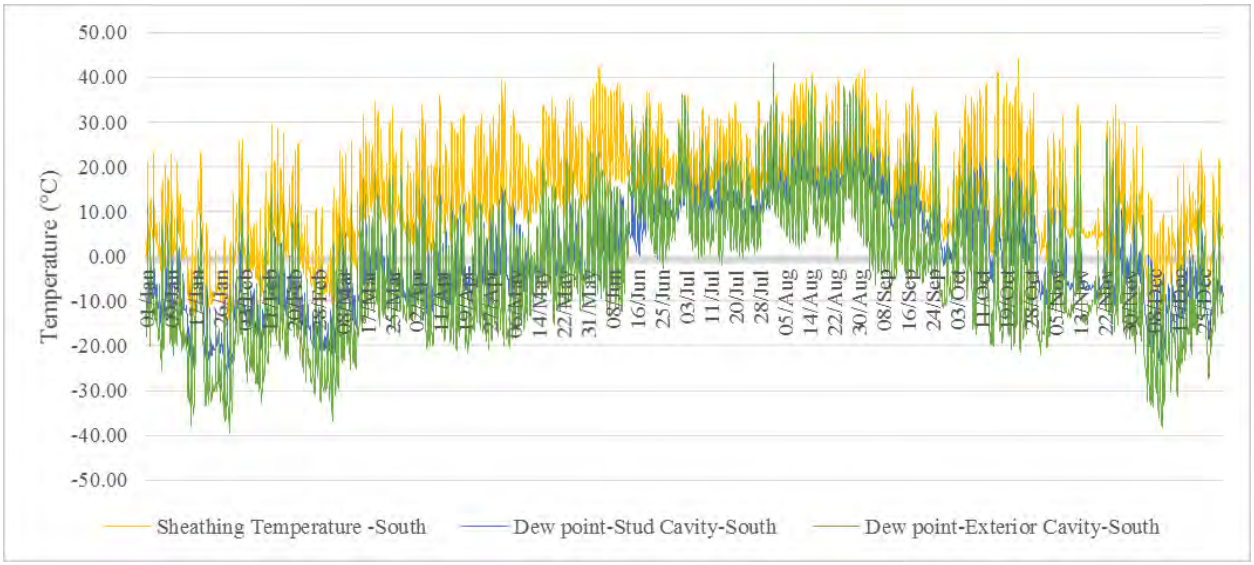

Figure 3: Dew point and sheathing temperature profiles. South wall, simulation.

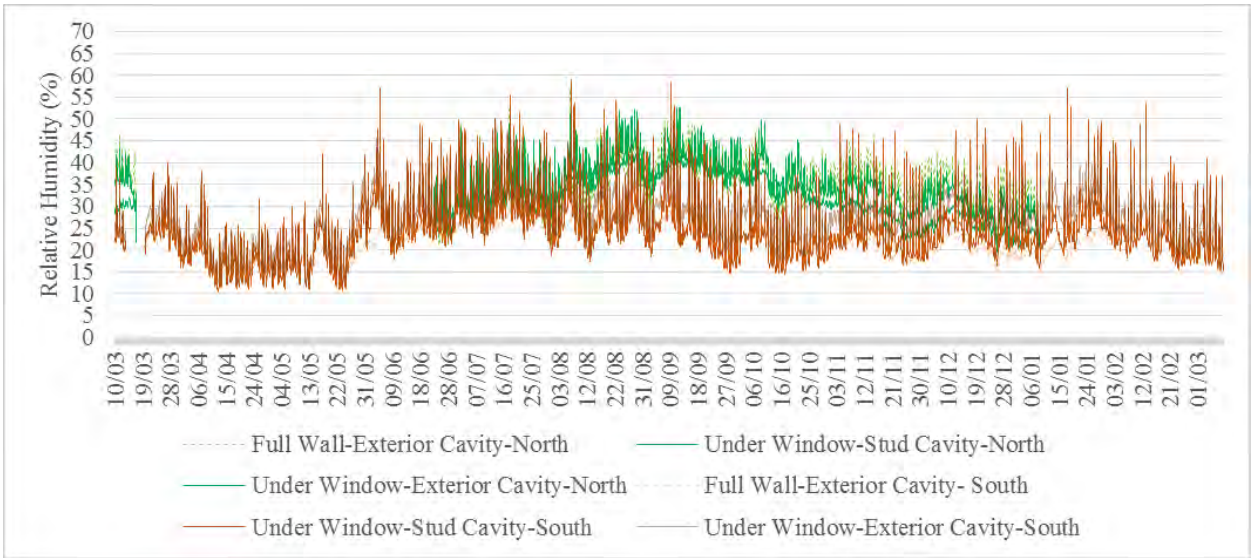

Figure 4: Relative humidity profiles. South wall, field measurements.

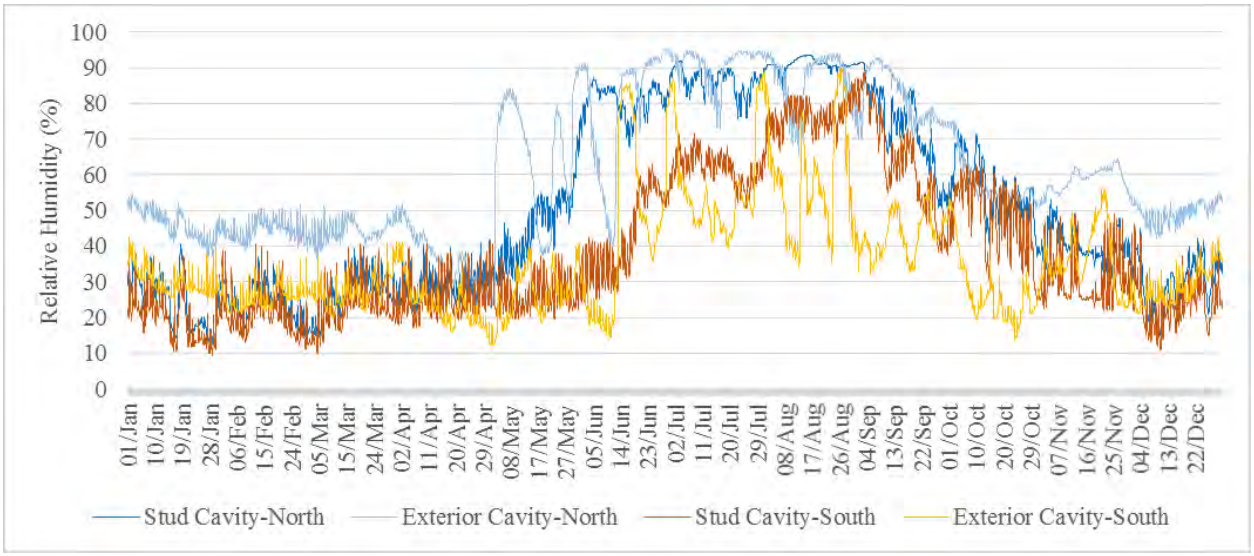

Figure 5: Relative humidity profiles. Simulation.