

Full Scale Wall Testing in the Pacific Northwest

Hygrothermal Performance Comparison of 3 Continuous Insulation Types



Project Overview

A multi-year hygrothermal comparison was conducted on three steel stud wall assemblies, using three different types of continuous exterior insulation. The purpose of the study was to evaluate the performance of stone wool as an exterior insulation in the Pacific Northwest climate and compare the in-situ performance of the different insulation types while assessing the potential for moisture related risks.

The study took place over the course of 2 years, initiated in January 2015 and concluded in February 2017, at the Vancouver Field Exposure Test Facility in Coquitlam, BC. The research was led by RDH Building Science Laboratories (RDH), supported by Gauvin 2000 Construction Ltd. and W.R. Meadows Canada.

Test Assemblies

The assemblies being compared consist of a ½" interior drywall, steel framed substrate with R22.5 ROCKWOOL COMFORTBATT®, ½" exterior gypsum sheathing with WR Meadows AirShield LMP liquid applied vapor permeable water resistive barrier, exterior continuous insulation and open joint fiber cement siding.

The different exterior continuous insulation types include:

1. 2.0" (52mm) ROCKWOOL COMFORTBOARD™ 110 – R8.0 (RSI 1.41)
2. 1 ½" (38mm) extruded polystyrene¹ – R7.5 (RSI 1.32)
3. 1 ½" (38mm) foil-faced polyisocyanurate – R9.0 (RSI 1.73)

		Wall 1 ROCKWOOL™ (RW) Assembly	Wall 2 XPS Assembly	Wall 3 Polyisocyanurate Assembly
A	Interior Finish	1/2" drywall + paint		
B	Vapor Control	latex paint		
C	Thermal Insulation	R-22.5 ROCKWOOL COMFORTBATT®		
D	Framing	6.0" Steel Stud		
E	Exterior Sheathing	1/2" glass-mat gypsum		
F	Membrane/Drainage Plane	WR Meadows Air-Shield LMP [12 US perm]		
G	Continuous Exterior Insulation	R-8.0 ROCKWOOL COMFORTBOARD™ 110 [> 30.0 US perm]	R-7.5 XPS [~1.0 US perm]	R-9.0 Foil-faced polyisocyanurate [0.05 US perm]
H	Drainage Space	¾" vertical hat channel		
I	Exterior Cladding	Open-joint fiber cement cladding		

The thermal resistance values for the exterior insulation meet International Energy Conservation Code (2015), steel framed nominal R-value requirements for Climate Zone 7 and below. The vapor control layer in the assemblies is the latex paint (Class III) on the interior drywall. The exterior gypsum sheathing in combination with the fluid applied water resistive barrier is the air control layer.

Methodology

The three insulations types selected for the study had similar different vapor permeance characteristics to address the drying ability and risk of moisture accumulation within an assembly depending on the type of exterior insulation selected. This is a critical concern for areas such as the Pacific Northwest where high rainfall is experienced, with moderately cooler temperatures.

The assemblies were constructed on both the North and South orientations of the test facility. Each test wall was outfitted with a series of temperature (T), relative humidity (RH), and wood moisture content (MC)² sensors; and continuously monitored throughout the full testing period. Main sensor

¹ The extruded polystyrene required a UV protective membrane behind open-joint cladding, loose-laid over the insulation.

² As it is challenging to measure the moisture content of gypsum sheathing using moisture content pins, small wood wafers were installed against the sheathing, and the moisture content of the wood wafer was measured.

locations were selected to monitor the critical layer within the assembly and include both the interior and exterior side of the gypsum sheathing, at the top, middle and lower part of the test panel. For assemblies that incorporate both interior and exterior insulation, the exterior sheathing layer is the critical layer within the assembly as it acts as the first condensing surface³.

Wetting systems were installed mid-height on the exterior side of the gypsum sheathing (over the fluid applied water resistive membrane). These systems were used to determine the relative drying potential of the different assembly types. A total of 6 wetting events occurred throughout the test period, both in summer and winter conditions; all of which consisted of injecting 1.5 ounces (45 mL) in the morning and afternoon for 5 consecutive days.

Results

Under normal operating conditions⁴, all 3 assemblies displayed similar RH and MC levels on the interior side of the gypsum sheathing. Levels were consistently higher during the colder months of year, with the North orientation having the highest peak levels. On the exterior side of the gypsum sheathing (over the fluid applied membrane), differences in performance were noted between the vapor permeable stone wool insulation and the vapor impermeable foam insulations. While the stone wool demonstrated consistent levels throughout the year signifying low risk of moisture related issues, both foam insulations had high peaks in the colder months.

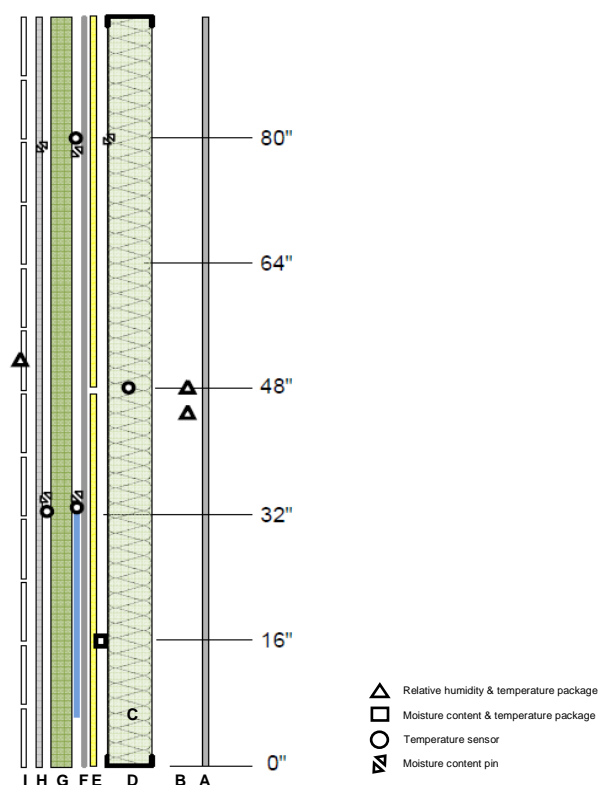


Figure 1: Schematic wall section and sensor positions, Wall 1 - ROCKWOOL assembly using ROCKWOOL COMFORTBOARD™ 110 exterior insulation.

³ To learn more about dew point and potential for condensation within a wall, refer to the [ROCKWOOL Vapor Diffusion Guide](#).

⁴ When assessing the wall performance under normal operating conditions, the sensors located near the top of the panel are analyzed as they are un-affected by the wetting system (which is located below mid-height of the panel). When assessing the performance during wetting events, the sensors located closer to the bottom on the panels are analyzed as only the lower part of the panel is affected by the intentional wetting system.

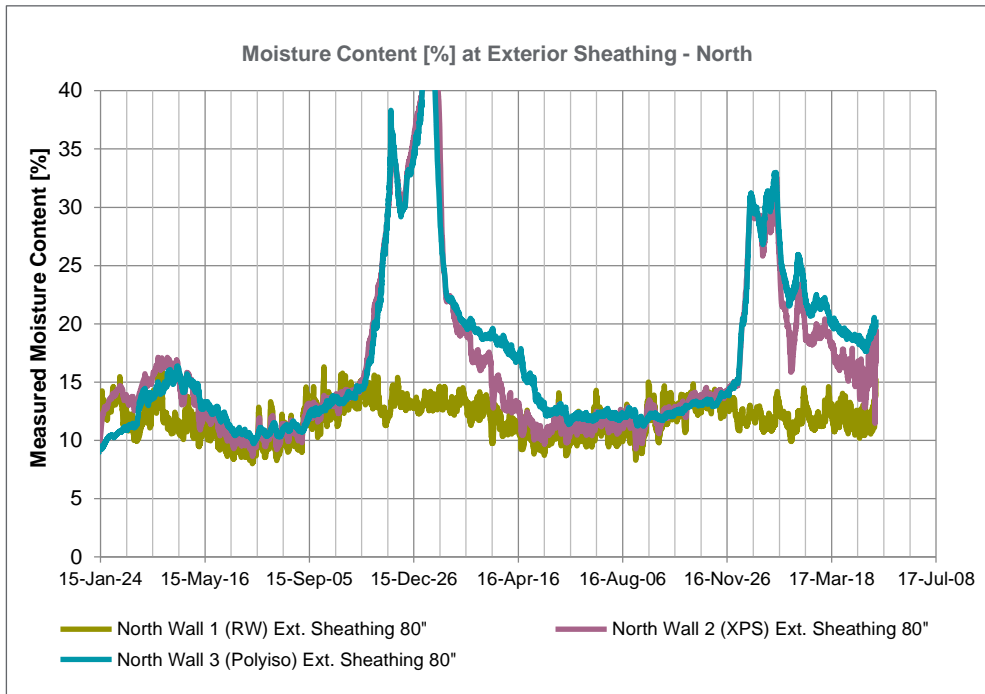


Figure 2: North orientation comparison of measured wood wafer moisture content [%] at exterior side of sheathing between fluid-applied water resistive barrier and insulation (positioned at 80" from bottom of wall panels).

During the winter wetting events, for both the North and South orientations, the stone wool assembly demonstrates a significantly higher drying rate in comparison to both foam insulation systems, at both the interior and exterior side of the gypsum sheathing. To reach equilibrium, the difference in drying time for the foam insulations is nearly double that of stone wool, reaching elevated levels for elongated periods of time.

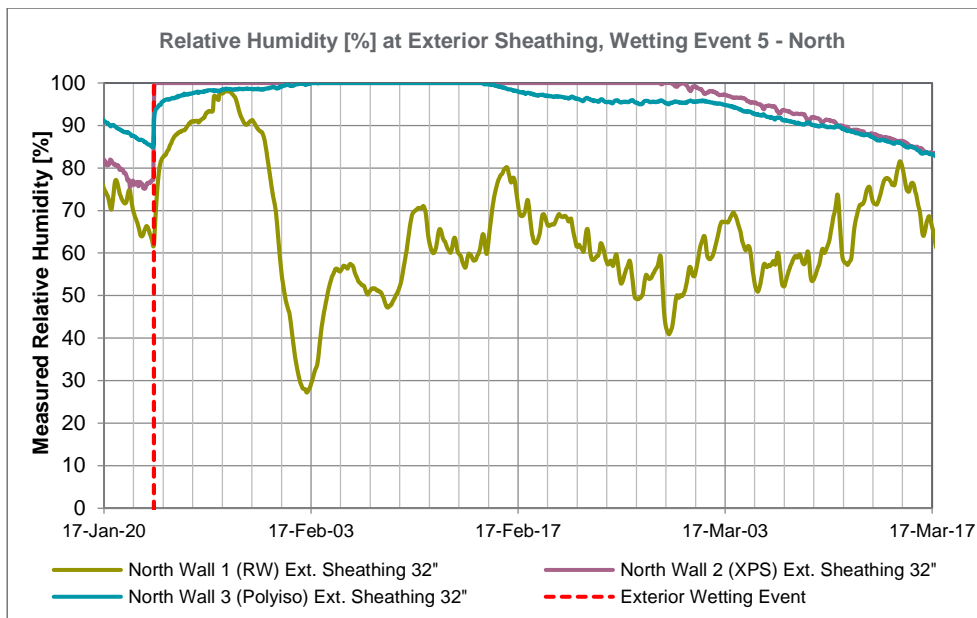


Figure 3: North orientation comparison of measured relative humidity [%] during winter wetting event. Sensor located at exterior side of sheathing between fluid applied water resistive barrier and insulation (positioned 32" above bottom of wall panels).

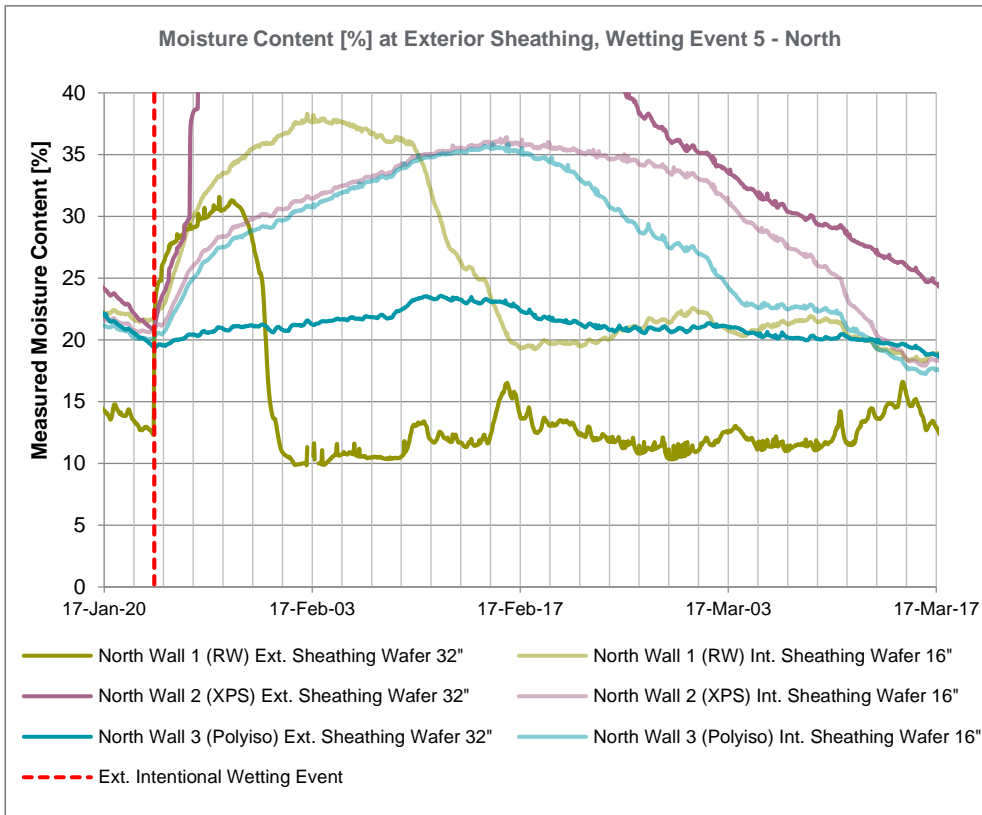


Figure 4: North orientation comparison of measured wood wafer moisture content [%] during winter wetting event. Sensors located at exterior side of sheathing between fluid applied water resistive barrier and insulation (positioned 32" above bottom of wall panels) and interior side of sheathing (positioned 16" above bottom of wall panels).

During the summer wetting events, while the levels on the interior side of the gypsum sheathing for the stone wool assembly demonstrates increased drying rate in comparison to the foam insulations, the difference on the exterior side is not as significant as the interior side. This is due to the increased solar energy drive during the summer months.

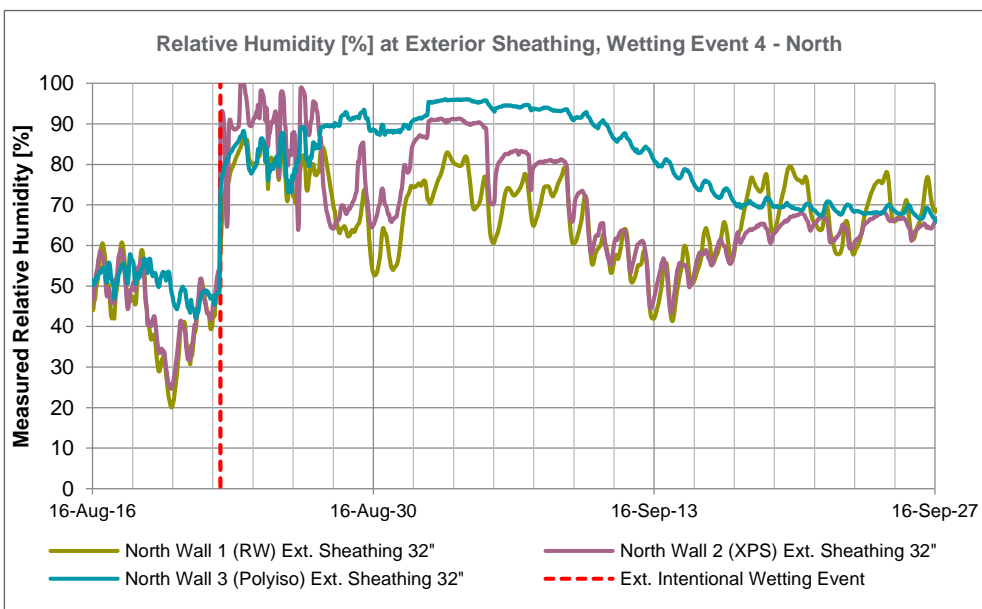


Figure 5: North orientation comparison of measured relative humidity [%] during summer wetting event. Sensor located at exterior side of sheathing between fluid applied water resistive barrier and insulation (positioned 32" above bottom of wall panels).

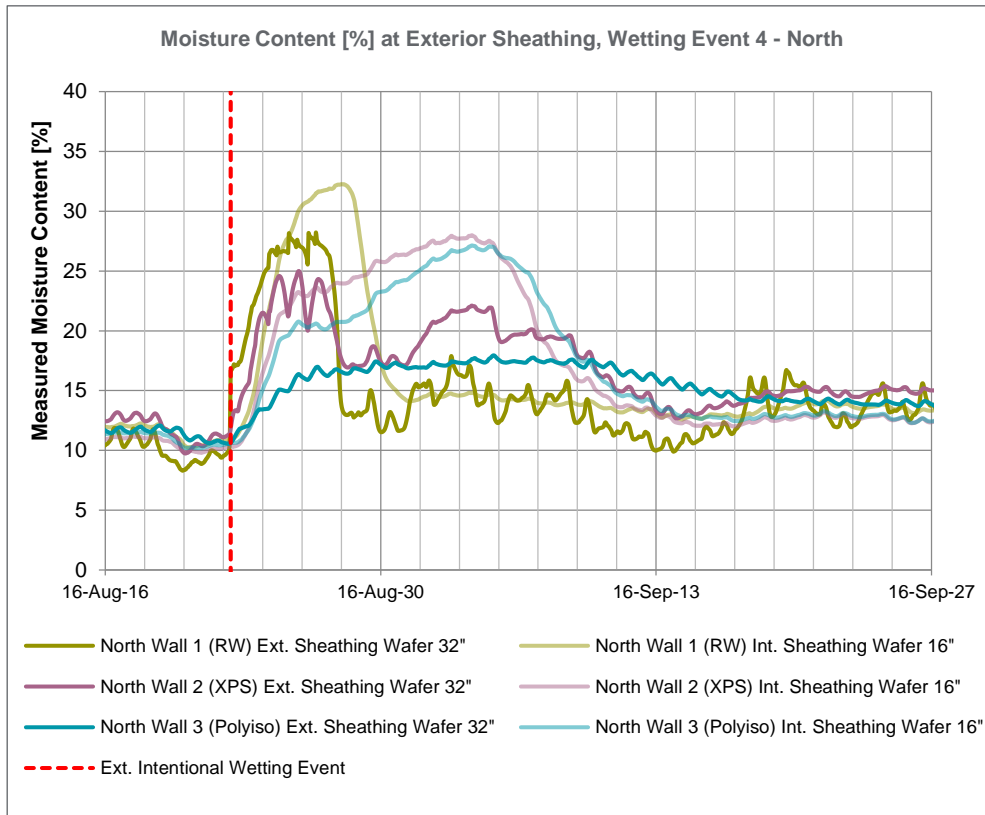


Figure 6: North orientation comparison of measured wood wafer moisture content [%] during summer wetting event. Sensors located at exterior side of sheathing between fluid applied water resistive barrier and insulation (positioned 32" above bottom of wall panels).

Conclusions

Overall, the hygrothermal performance analysis indicates that using stone wool insulation results in a lower risk for moisture accumulation when compared to assemblies using foam insulation. This is due to the high vapor permeance of stone wool insulation which enables the assembly to dry out approximately 2x faster than the other assemblies. Moreover, under intentional water insertion into the assembly which would be representative of leaks that may occur, mainly at penetrations and connections, the stone wool assembly has a demonstrates a significantly higher drying capability over the other assemblies.