

A Hygrothermal Analysis and Structural Performance of Wood-Frame Wall Systems with Low-Permeance Exterior Insulation

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Abstract : Increasing the level of exterior insulation in residential buildings is a popular way for improving the thermal characteristic of building enclosure and reducing heat loss. However, the layout and properties of materials composing the wall have a great effect on moisture accumulation within the wall cavity, long-term durability of a wall as well as the structural performance. A one-dimensional hygrothermal modeling has been performed to investigate moisture condensation risks and the drying capacity of standard 2x4 and 2x6 light wood-frame wall assemblies including exterior low-permeance extruded polystyrene (XPS) insulation. The analysis considered two different wall configurations whereby the rigid insulation board was placed either between Oriented Strand Board (OSB) sheathing and the stud or outboard to the structural sheathing. The thickness of the insulation varied between 0 mm and 50 mm and the analysis has been conducted for eight different locations in Canada, covering climate zone 4 through zone 8. Results show that the wall configuration with low-permeance insulation inserted between the stud and OSB sheathing accumulates more moisture within the stud cavity, compared to the assembly with the same insulation placed exterior to the sheathing. On the other hand, OSB moisture contents of the latter configuration were markedly higher. Consequently, the analysis of hygrothermal performance investigated and compared moisture accumulation in both the OSB and stud cavity. To investigate the structural performance of the wall and the effect of soft insulation layer inserted between the sheathing and framing, forty nail connection specimens were tested. Results have shown that both the connection strength and stiffness experience a significant reduction as the insulation thickness increases. These results will be compared with results from a full-scale shear wall tests in order to investigate if the capacity of shear walls with insulated sheathing would experience a similar reduction in structural capacities.

Keywords : hygrothermal analysis, insulated sheathing, moisture performance, nail joints, wood shear wall

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