Abstract

As energy certification programs and mandatory governmental building codes demand better building energy performance, the development of durable, highly insulated wall systems has become a top priority. Wood framed walls are the most common form of residential wall in North America and the materials used are vulnerable to moisture damage. This damage typically occurs first at the wall sheathing in the form of mould, fungal growth and rot. Increased thermal resistance can lead to two potential issues related to moisture durability: 1) increased potential for air leakage condensation at the sheathing and 2) decreased ability of the wall to dry after a wetting event.

A natural exposure experimental study was performed at the University of Waterloo's BEGHUT test facility to evaluate the hygrothermal performance of exterior insulated wall systems utilizing 3 different insulation types. These walls had approximately 2/3 of their total thermal resistance interior to the sheathing and 1/3 exterior to the sheathing. These walls were compared to a standard construction wall and a highly insulated double stud wall system. The test walls were evaluated during as-built conditions and during imposed wetting conditions. Moisture was introduced into the walls in two phases. The air injection wetting phase was designed to evaluate air leakage condensation potential during winter conditions, and the wetting mat wetting phase simulated an exterior rain leak and was used to evaluate the drying potential of the test walls. Hourly temperature, relative humidity and moisture content measurements were taken at multiple locations within each test wall. This data was analyzed to determine the air leakage condensation potential and the drying capability of each test wall.

Results showed that the effective thermal resistance of the polyisocyanurate (PIC) insulation was significantly less than its nominal R-value rating under cold and moderate temperature conditions, and slightly higher under hot conditions. The effective thermal resistance of the extruded polystyrene (XPS) insulation was slightly less than its rated value under cold and moderate temperature conditions and significantly less under hot conditions. The rockwool (RW) insulation performed slightly above its rated thermal resistance under cold and moderate conditions and slightly less under hot conditions.

Results also showed that only the double stud wall was vulnerable to winter-time interstitial condensation during the as-built (air-sealed) condition. This was a result of the hygroscopic nature of the cellulose insulation and a large temperature gradient across the insulation cavity. During the air leakage wetting phase, all of the exterior insulated walls showed a significantly decreased risk of air leakage condensation compared to the Datum and Double stud walls. During and following the wetting mat wetting phase, the PIC and XPS walls showed significantly reduced drying capability, while the RW wall showed a small reduction in drying capacity compared to the Datum and Double stud walls.

It was concluded that adding insulation exterior to the wall sheathing can be an effective method to minimize air leakage condensation. The minimum ratio of exterior to interior insulation, however, must be suitable for the local climate and interior humidity conditions. Exterior insulation materials with low vapour permeability can significantly reduce the drying capacity of a wall system, but may be appropriate where exterior solar vapour drive is a concern or sufficient drying to the interior is available. Exterior insulation materials with high vapour permeability facilitate drying to the exterior and dry nearly as well as wall systems with no exterior insulation.