West Coast R-2000 House: Airtight and Dry After 17 Years

Richmond, BC R-2000 House Case Study

Claims have been made that recent building envelope problems on the West Coast are the direct result of energy efficient construction practices. High insulation levels, polyethylene air and vapour barriers and airtight construction in a mild, wet climate have been said to be a cause of envelope failure.

Examination of one of the first R-2000 houses built in BC has shown that, after 17 years, there is no evidence of deterioration or moisture problems. A 250 sq. ft., one level addition to a R-2000 home built in 1983 offered an opportunity to review the durability of construction practices used.

There was no evidence of any moisture within the wall structure. Wood moisture content readings in the wall framing were 11 - 13%, well below the 19% moisture content considered the threshold for fungal action. By comparison, the new framing lumber being used for the addition had a moisture content of 15 - 20%.

After 17 years, the wood moisture content in the wall framing was 11 - 13%

The 1,433 sq. ft., two storey house has two bedrooms plus den, two bathrooms, and open plan living/dinning/kitchen area. The property has a high water table, about one foot below finished grade, so the concrete slab-on-grade foundation is insulated under the entire slab.

The house had maintained its air seal. In 1999 the measured leakage rate was 1.33 ACH at 50 Pascals.

Exterior walls are 2x6 with plywood sheathing on the exterior, and a polyethylene air and vapour barrier on the inside face of the framing, plus 2x3 strapping on the interior. The vaulted roof is framed with R-28 batt insulation.

South side of house, after addition.

The polyethylene air and vapour barrier appeared as good as the day it was installed (before the availability of UV stabilized poly). The sheathing paper was in good condition, although the vinyl siding was applied directly with no rain screen. arge quantities of acoustical caulking were used to achieve the air sealing. The caulking was still soft, pliable and had kept its adhesive properties.

Heating is by electric baseboards, while domestic hot water is provided by a standard gas-fired hot water tank - the only vented combustion appliance in the house. The homeowner did complain of cold drafts in the area next to the hot water tank. An uninsulated 4" combustion air duct drops straight down, ending 24" above the floor adjacent to the water tank, with no spillage protection or trap.

Ventilation is provided by a heat recovery ventilator. The HRV was inside the heated envelope of the house, but placed on top of the ceiling joists in the attic. Although the HRV was set on a foam pad, fan motor vibration created a drumming noise, so the homeowner did not run the HRV continuously.

Ducts were friction fit and sealed with duct tape which had lost its adhesive properties. 42% of the exhaust air flow through the ducts, and 17% of supply air was lost through duct leakage. When the exposed portions of the ducts were sealed, leakage was reduced to 30% of the exhaust and 13% of the supply air flow.

Exhaust and Supply inlets into the house were placed high on a gable end wall, 20 feet above the ground, making service very difficult.

Airtightness

The airtightness of the house in 1983 was 0.889 air changes per hour at 50 Pascals, well below the 1.5 ACH limit set by the R-2000 technical requirements. A test at the start of construction of the addition in 1999, showed that the house had maintained its air seal, with a leakage rate of 1.33 ACH at 50 Pascals, and a normalized leakage area of 0.60 cm^2/m^2 of envelope area (which is less than the R-2000 limit of 0.7 cm^2/m^2.) Some of the difference can be attributed to how the house was set up for the test.

Construction Characteristics		
Element	**Standard Practice, 1983**	**As Built, 1983**
Ceilings	R 20	R 28 batts
Walls above grade	R 8 batt (2x4 @ 16" o/c)	R 28 (2x6 @ 16"o/c plus 2x3 strapping)
Windows	Single glazing aluminium frame	Clear double glazing, thermally broken aluminium frame
Skylights	Single glazing, glass or acrylic	Double glazed acrylic
Exterior doors	Solid wood	Metal insulated
Slab-on-grade	R 4 along perimeter, slab uninsulated	R 10 under entire slab plus R 10 along exterior of foundation wall
Airtightness	No attention to airsealing	0.889 ACH at 50 Pa (R-2000 requirement = 1.5 ACH @ 50 Pa or NLA of 0.7 cm^2/m^2)
Air and vapour barriers	2 mil poly v.b. no special air barrier	6 mil poly v.b. caulked and sealed for air and vapour barrier
Heating	90,000 BTU gas furnace	Electric baseboard
Hot water heater	gas hot water heater	gas hot water heater
Ventilation	no ventilation	Heat Recovery Ventilator

Most of the air leakage was around the hot water heater B-vent, a sliding patio door, HRV vents, and an opening bathroom skylight.

Temperature stratification

In a well sealed, well-insulated building the stack effect should not be pronounced, and temperature stratification should be minimal. However, the owner did notice cooler temperatures on the lower floor, which were solved by installing a ceiling fan over the vaulted living area.

The house was leakier after the addition was completed. The increased leakage came about due to less attention to the air sealing details around a new direct vent gas fireplace, recessed pot lights, and a new skylight. The increased leakage contributed to a greater stack effect which was noted on a day with an outdoor temperature of 1°C. With the new direct vent gas fireplace as the only operating source of heat in the house, a 5°C temperature difference was observed between the floor level of the main floor and the ceiling of the second floor.

Energuide Evaluation

The house as renovated received an Energuide rating of 79 on a 100-point scale. An energy efficient house meeting R-2000 technical standards should rate between 80 and 90. A typical Vancouver area house built in 1983 would have a rating of 60 to 75.

HOT-2000 Energy analysis

The original energy performance analysis for the house done in 1983 showed a simulated energy consumption of 12,396 kWh per year, or 12.5 % less than the R-2000 compliance target. Using the current more refined HOT-2000 compliance tool, the simulated consumption is 11,709 kWh/yr or 10.3% less than the 13,068 kWh per year target. Actual energy consumption meets the predicted consumption.

For information on the R-2000 Program, contact your local program office, or call 1-800-387-2000