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Rousseau, M. Z.

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Research on Building Envelopes for Extreme Climates

By M.Z. Rousseau

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This article reports on NRC-IRC research undertaken to assess innovative wall assemblies for use in northern Canada.

Building envelope technologies commonly used in Canada's "South" are not necessarily effective in the Nordic parts of the country, i.e., regions near and above the 60th parallel, where the conditions of exposure and construction can be very different. Considering the high cost of construction and operation of buildings in remote locations, significant benefits can be reaped by improving the energy performance and service life of the housing stock. With that in mind, four years ago, NRC-IRC, along with Canada Mortgage and Housing Corporation (CMHC), Natural Resources Canada (NRCan), and the Program of Energy Research and Development undertook research to assess innovative technologies for wall assemblies, from the perspective of energy and hygrothermal performance. As the price of energy rises and the trend towards sustainable development and near-zero energy housing continues, it may well be that highly insulated envelopes could also become more popular in less cold parts of Canada. Upcoming NRC-IRC research will consist of laboratory evaluations in a climatic chamber and a modelling study using the hygIRC 2D numerical hygrothermal model developed by NRC-IRC.

Activities completed to date include a literature review on innovative technologies currently used in Canada or elsewhere, measurements of indoor air temperature and humidity levels in houses in the north, analysis of climatological data pertaining to the North, and consultation with communities in the three Canadian Territories. Five innovative wall construction methods for extreme cold climates have been selected for assessment, and will be benchmarked against a R20 2X6 stud frame wall assembly (see table for description).

Highlights of measurements in homes

Over a one-month period, indoor air temperature and relative humidity (RH) levels were continuously measured in eight houses in each of three locations: the northern coast of BC, in the Yukon and in the Northwest Territories[1].

Some of the findings did not support the popular belief that higher levels of occupancy and excessive moisture-generating activities are the main contributors to moisture problems. The homes with reported moisture problems did not experience systematically higher relative humidity indoors than those without reported moisture problems. The

[1] These surveys were conducted with the assistance of the Inuvik Housing Corporation, the Prince Rupert Housing Corporation and the Yukon Housing Corporation, as well as two regional building technology firms, Sheltair in BC, and Arctic Energy Alliance in NT.

homes with the most occupants did not necessarily experience more moisture problems or higher RH than those with fewer occupants.

In Prince Rupert (cool and humid climate), the average daily indoor RH in May 2005 in the eight homes surveyed ranged from 36 to 65%. In Inuvik (very cold and dry), the average daily indoor RH in the eight homes surveyed in November 2006 ranged from 9 to 29%.

Other findings

- "Wet" rooms (bathrooms and kitchens) experienced peaks of RH much higher than the average RH. Bathroom peaks reached 100% RH daily in all houses surveyed. Monitoring in other rooms indicated more stable and lower RH conditions.
- In the Carmacks survey, extreme indoor temperature fluctuations were a major contributor to moisture problems. Seven of the eight homes surveyed in January-February 2006 were heated with a central wood stove without a heat-distribution system, and the indoor temperature fluctuated between 8 and 34ºC.
- A large range of airtightness levels (5 to 19 ACH @ 50 Pa) was noted among the 24 homes [2]. None of the houses could be considered very airtight (e.g., 1.5 ACH@ 50 Pa), even though some were fairly new (less than five years old).

The monitoring of these 24 houses, which varied widely in construction and occupant lifestyle, has proven instrumental to NRC-IRC researchers in their quest to identify realistic extreme indoor conditions of RH and T. This information will provide the basis for the laboratory evaluations of the moisture control performance of wall assemblies that appear promising for these climates. The evaluations will start in the summer of 2008. The assemblies will be subjected to indoor temperature and relative humidity and pressure fluctuations, while at the same time extreme outdoor climatic conditions will prevail.

This fall and winter, NRC-IRC will present its Building Science Insight 2008-09 (BSI) seminar series entitled *Single and Multi-Family Houses: Improving Performance Through a Systems Approach* in 15 locations across Canada. In Whitehorse, Yellowknife and Iqaluit, the program will include two presentations specific to the outcomes of this northern research project. For more information on BSI 08/09, visit: http://bsi.gc.ca

For more information on the outcomes and progress of the project, visit the website http://irc.nrc-cnrc.gc.ca/bes/hmpe/north60_e.html.

Description of wall assemblies selected for assessment

Test Frame [1]	**Test Specimen**	**Test Wall Specimen**
No. 1	**W1**	Typical R20 2X6 construction Painted wood lap siding, housewrap, OSB, R20 glass fibre batts, poly, painted gypsum board

[2] In NRCan's EnerGuide for Houses energy audit, a fan depressurization test to quantify the air leakage of the home was carried out without closing off intended openings, such as exhaust fan outlets).

	W2	Prefinished structural smart panel siding, housewrap, 2X6, 5.5 in. mineral fibre, poly, 2X3 strapping and 2.5 in. mineral fibre semi-rigid insulation, painted gypsum board
No. 2	**W3**	Hardboard lap siding, 1X3 strapping, housewrap, OSB, 2X8, 7.5 in. batt, poly, 2X4 strapping, 3.5 in. mineral fibre insulation, painted gypsum board
	W4	Hardboard lap siding, housewrap, load-bearing 6.5 in. SIP (with EPS), poly, 2X2 strapping with 1.5 in. mineral fibre semi-rigid insulation, painted gypsum board
No. 3	**W5**	Hardboard lap siding, housewrap, OSB, 7.5 in. I-joist and cavity filled with mineral fibre insulation, poly, 2X2 horizontal strapping filled with 1.5 in. mineral fibre insulation, painted gypsum board
	W6	Prefinished structural smart panel siding, housewrap, 2X6 with 5.5 in. mineral fibre insulation, 2 in. gap filled with mineral fibre insulation, poly, 2X4 studs with 3.5 in. mineral fibre insulation, painted gypsum board

1.Two test wall specimens will be evaluated side-by-side in the climatic chamber. An insulated and airtight separation between specimens will minimize lateral flow of heat and air.

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Photo caption: Typical winter scene in Canada's north, with fine snow blown onto walls and windows.

Madeleine Z. Rousseau is a researcher in the Building Envelope and Structure program of the NRC Institute for Research in Construction (NRC-IRC): madeleine.rousseau@nrc-cnrc.gc.ca