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Energy Performance of Insulating Concrete Form (ICF) Walls

By Maref. W.; Saber, H.H.; Armstrong, M.M.; Ganapathy, G.

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This article summarizes the results of a study carried out to determine the energy performance of two ICF wall specimens installed on one side of a research house.

The National Research Council's Institute for Research in Construction (NRC-IRC), in collaboration with Canada Mortgage and Housing Corporation (CMHC) and Natural Resources Canada (NRCan), evaluated heat movement through two identical insulating concrete form (ICF) wall assemblies. The walls were tested at the NRC-IRC Field Exposure of Walls (FEWF) facility in Ottawa.

While ICF technology dates back to the late 1960s in Europe, ICF construction has become common in North America over the last two decades. Generally, modern ICFs consist of stackable formwork made of expanded (EPS) or extruded (XPS) polystyrene foam, which is filled on site with concrete, and then remains in place to provide permanent insulation.

The objective of this project was to monitor the field performance of ICF wall specimens in order to understand and quantify the impact of the thermal mass of the concrete in the ICF wall system on heat losses and gains.

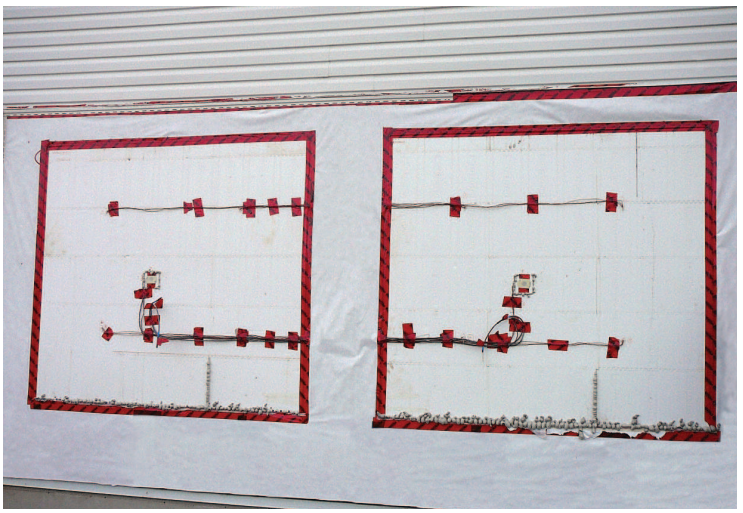

Figure 1. *Installed and sealed ICF panels*

Figure 2. *Interior of finished ICF walls and the climate control enclosure*

Methodology

The two identical ICF wall specimens were installed side by side in the FEWF test bay, located on the first floor of a two-storey research house facility (Figure 1), with western exposure. A climate control enclosure (Figure 2) provided controlled indoor conditions (~21°C, 30% humidity), and the exterior walls were exposed to the naturally occurring Ottawa climate (with an average of 4602 heating degree-days °C (Environment Canada, 2010)).

The expanded polystyrene ICF forms were assembled and temperature sensors (thermocouples) were then installed on the interior of the form prior to pouring the concrete. The ICF wall specimens measured 1828 x 1676 mm (approx. 6 ft x 5.5 ft) and featured 152 mm (6 in.) thick concrete surrounded by 64 mm (2.5 in.) of EPS foam on all sides, and 51 mm (2 in.) of EPS foam on the base.

Observations

In general, the measured heat transfer and temperature data revealed that the mass of the concrete added very little to the overall R-value of the ICF (RSI 3.77 (R21.4)) under steady, outdoor temperature conditions. However, during transient conditions, the concrete significantly moderated heat loss to and from the interior, providing an apparent 5-day buffering or moderating temperature effect. By doing so, the ICF wall was shown to reduce the peak in heat gains to, or losses from, the room.

This means that the concrete mass in ICF walls has the potential to reduce the peak heating requirement of the furnace in winter, and the peak cooling requirement of the air conditioning system in summer. This may have implications for the sizing and cost of mechanical equipment, provided cold snaps and heat flashes last less than 5 days. The buffering effect may also have the ability to reduce peak energy use on hot summer afternoons (which could produce cost savings for homeowners with smart meter pricing). In a climate where the average outdoor temperature in summer remains comfortable, with hot days and cold nights, the buffering effect of ICF walls may even enable occupants to get by without cooling altogether.

This experiment examined only a small section of ICF wall on a west-facing façade. To predict the effect of ICFs on heating and cooling equipment and energy use, it will be necessary to test an entire house and to evaluate ICFs with greater thicknesses and insulation values. The thermal performance of an entire house will be affected by other factors including solar gains through windows, and the operating mode of the house (for example, the use of free cooling at night or thermostat setbacks).

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The ICF specimens were provided by an industry partner – the Ready Mixed Concrete Association of Ontario (RCMAO).