INSULATED CONCRETE FORM

Introduction

Air infiltration in buildings can represent a significant portion of the heating and cooling loads. To perform well, buildings need a well-insulated, airtight envelope. Insulated concrete form (ICF) construction can provide an extremely airtight, well-insulated and durable building. Costs for constructing ICF buildings have decreased as builders have become more familiar with the technology. For low-rise applications in particular, costs can be similar to conventional wood-frame construction, given that ICFs provide structure, insulation, and air and vapour barriers within one complete system. Even with a modest construction cost premium, well-insulated, airtight ICF construction can provide lower operating costs. The inherent durability of ICF construction is another factor for consideration for its use in affordable housing projects.

Credit: NUDURA® Integrated Building Technology

Figure 1 Insulated concrete form

Description

ICF construction typically uses hollow expanded polystyrene or extruded polystyrene foam blocks as concrete forms. Webs (typically made of plastic or steel) hold the foam sides together and provide attachment points for internal reinforcement of the concrete. These webs can also act as an attachment point for interior and exterior finishes. The blocks are stacked together to form the exterior walls of the building. Rebar is attached to the internal webs as required to provide structural support. Then concrete is poured into the forms and provides the structural strength. The foam forms stay in place, providing a continuous layer of insulation on the inside and outside of the poured concrete. The finished ICF wall provides backing for exterior cladding and internal finishes and supports interior floors and exterior windows.[1] Figure 1 shows an ICF block, complete with internal webs. Multiple blocks are stacked together to create a wall. Figure 2 illustrates a wall being filled with concrete.

Credit: Stitt Energy Systems, Inc.

Figure 2 ICF during pouring

[1] National Association of Home Builders (2012). Insulating Concrete Forms (ICF). Retrieved from http://www.toolbase.org/Construction-Methods/Concrete-Construction/Insulating-Concrete-Forms.

Some manufacturers also produce ICF panels up to 3.66 m (12 ft.) in height, which are held together with vertical fastening strips. With different types of panels, various wall types can be built on site. Wall heights in excess of 6.1 m (20 ft.) are possible in one pour.[2]

Conventional steel or wood joist interior floors are supported by ledgers attached to the concrete wall using either embedded anchor bolts or specialized ledger connection ties.[3] In commercial applications, precast hollow core concrete slabs and post-tensioned slabs have been designed in conjunction with ICF walls to help reduce the floor-to-floor height requirements.[4]

Benefits and considerations

There are many benefits to ICF construction. Walls built this way are extremely airtight, reducing air infiltration, which accounts for a very large portion of a building's heating and cooling load—particularly in the case of multi-unit residential buildings. ICFs also provide continuous insulation on both sides of the concrete. This helps to eliminate thermal bridging, which can greatly reduce the effective thermal resistance in other types of wall systems. Thermal bridging creates cold surfaces within wall systems where condensation can occur, leading to concerns about moisture damage, mould and degradation of building materials. ICFs provide good buffering between indoor and outdoor conditions, leading to improved comfort within the building.[5]

Where a conventional steel stud infill wall with RSI-3.5 (R-20) batts and 50 mm (2 in.) of expanded polystyrene on the exterior has an effective insulation of approximately RSI-2.3 (R-13), the ICF wall with 50 mm (2 in.) of extruded polystyrene on either side will have an effective insulation value of RSI-3.5 (R-20).

The enhanced thermal resistance and airtightness of ICF construction allow smaller mechanical heating and cooling systems to be installed. This can reduce the capital cost of installed mechanical equipment. Lower space heating/cooling energy usage reduces the ongoing operational costs of the building.

ICF construction is ideal for reducing sound transmission and provides very quiet indoor environments, given the inherent sound-blocking qualities of concrete. Properly constructed ICF buildings are resistant to wind loads and can be designed for all seismic zones.

Reduction in construction time can also be a significant benefit in ICF construction. The forms are simple to construct and can make it easier for a builder to complete concrete work. Additionally, the insulated forms help to protect concrete from freezing during construction, making it easier to pour during adverse weather. Canadian contractors have pointed to this being a major advantage to ICF construction, allowing for work to continue with minimal issues through the winter months.[6]

Contractors appreciate that labour costs can be saved by utilizing ICF construction, while still providing an excellent quality building envelope.

Application

Multi-unit residential buildings

ICF construction has been successfully used for multi-unit residential buildings. The use of ICF walls as the structural shell has been limited to buildings of about 8 to 10 storeys. Taller buildings may require traditional steel framing, with the ICF serving as the skin of the building.[7]

Costs

ICF full-height homes can cost between 2 and 5 per cent more than wood-framed construction (with standard cast-in-place basements). For contractors installing ICFs for the first time, total installed costs can range from 5 to 7 per cent more than wood-framed construction[8] (2012 data).

Low-rise applications have seen costs as low as approximately $1,590 per m^2 ($148 per sq. ft.) when using ICF construction and core slabs, which is in line with the approximate cost of $1,615 per m^2 ($150 per sq. ft.) for wood-frame construction projects.[9]

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[2] Mack, D. (2006). "The new ICFs." Home Builder Magazine. Retrieved from http://www.homebuildercanada.com/1802ICF.htm.

[3] Amvic Building System (2006). Adapting Frame Construction Designs to Insulating Concrete Forms. Retrieved from http://www.amvic-pacific.com/downloads/DesignConsiderations.pdf.

[4] Personal communications conducted by Enermodal Engineering.

[5] Canada Mortgage and Housing Corporation (2011, July 27) Research Highlight: Monitored Thermal Performance of ICF Walls in MURBs. Retrieved from http://www.cmhc-schl.gc.ca/odpub/pdf/65863.pdf.

[6] Op. cit. 4.

[7] Amvic Building System (2006). Op. cit. 3.

[8] National Association of Home Builders (2012). Op. cit. 1.

[9] Op. cit. 4.

The West Village Suites (shown in figures 3 and 4) is a 19,000-m^2 (204,500-sq.-ft.) student residence in Hamilton, Ontario. This building was completed in 2008, and the ICF construction technique helped it achieve LEED® Platinum certification.

At the West Village Suites, premium ICF forms with 56 mm (2.25 in.) of extruded polystyrene enabled the envelope to achieve an effective insulation value of RSI-4.9 (R-28).

Credit: Enermodal Engineering

Figure 3 West Village Suites during construction

Credit: Enermodal Engineering

Figure 4 West Village Suites after construction

Masonry contractors indicate that ICF costs are comparable to those of standard 250-mm (10-in.) block construction. ICFs tend to increase the cost of the walls alone by 39 per cent (2012 data) when compared to block construction. When considering that the insulation and air/vapour barrier systems are already provided with ICF construction, the costs are approximately the same when the entire wall assemblies are compared.[10]

Implementation considerations

Coordination between trades is essential to ensure that chases and penetrations are provided to install required wiring, piping and supports for interior and exterior finishes. ICF construction can result in thicker wall profiles compared to conventional construction, necessitating deeper jamb extensions around doors and windows. While typical ICFs have inner concrete cores of 100 mm (4 in.) to 200 mm (8 in.), some manufacturers now offer systems with inner cores of up to 400 mm (16 in.), resulting in very thick final walls.[11]

Large windows and complicated wall geometries can prove challenging for ICF construction. Additional reinforcement at the top, bottom and sides of the windows is labour-intensive and can make pouring of the concrete more difficult. Often, in these types of applications, premium concrete aggregate must be used to ensure that the concrete will flow properly around the rebar and fill all of the voids.[12] For affordable housing applications, wall geometries should be kept simple, and windows should be limited in size to prevent excessive reinforcement requirements. This will help to keep construction costs low.

Durability

Durability is a benefit of ICF construction. ICF buildings offer good resistance to environmental loads and exceptional wind resistance. In areas prone to hurricanes or tornadoes, ICF homeowners may qualify for reduced insurance premiums, given the additional resistance of these homes to damage.[13]

ICF walls have very low risks associated with air leakage and vapour condensation within the wall structure. The main durability concern possible in ICF construction, as in any form of construction, is rainwater leakage into the enclosure. While the wall itself is not susceptible to moisture-related issues, leaks can cause problems for interior finishes. ICFs typically do not have any buffering capacity for leakage, and small leaks may be able to penetrate easily into the interior finishes of an ICF building.

[10] Ibid.

[11] Mack, D. (2006). Op. cit. 2.

[12] Op. cit. 4.

[13] U.S. Department of Housing and Urban Development (2001). *Costs and Benefits of Insulating Concrete Forms for Residential Construction.* Retrieved from http://www.huduser.org/Publications/PDF/icfbenefit.pdf.

Rain leakage control is usually addressed through the use of a drainage plane behind the exterior cladding (typically building paper or synthetic water-resistive barriers are used). Architectural details around windows, doors, other penetrations, intersections and transitions between different materials must ensure that rainwater cannot penetrate past the drainage plane and into the building.[14]

Manufacturer and industry support

Insulated concrete forms have been available in Canada for approximately 40 years, but ICF construction grew in popularity in the early 1990s. The industry has grown steadily with single-family home construction seeing an annual increase of 25 per cent.[15]

Several major manufacturers of ICF are active in Canada and are supportive of this construction technique within the Canadian market.

[14] Building Science Corporation. (2011). High R-Value Enclosure Report Case Study. Retrieved from https://buildingscience.com/documents/enclosures-that-work/high-r-value-wall-assemblies/high-r-wall-icf-wall-construction.

[15] Insulating Concrete Form Association. Retrieved from http://www.forms.org/.

Further information

Oak Ridge National Laboratory www.ornl.gov/

Partnership for Advancing Technology in Housing (PATH) www.pathnet.org

Building Science Corporation www.buildingscience.com

National Association of Home Builders http://www.nahb.org

cmhc.ca

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