ToolBase.
TECHSPECS

Insulating Concrete Forms (ICFs)

TECH @ A GLANCE

BENEFITS (+)/DRAWBACKS (–)

+ ENERGY EFFICIENCY: Increased insulation (R-value) and reduced air infiltration over conventional (wood) materials
+ ENVIRONMENTAL PERFORMANCE: Fly-ash or slag waste (materials with post-industrial recycled content) can be used in place of some of the Portland cement in the concrete mix.
+ SAFETY and COMFORT: Insulated reinforced concrete walls resist fire, wind, and earthquakes. ICF walls provide thermal and sound insulation.
+ DURABILITY: ICFs resist rot, decay, mold, and moisture damage. They are also resistant to insects, including termites, and rodents.
= AFFORDABILITY: Insulating concrete form construction has higher first costs than conventional light-frame construction methods. There is need for careful planning and design. However, initial costs can be offset by the increase in the building's energy efficiency and utility bill savings.
– REMODELING: Design changes or remodeling may be costly, and would require specialty tools to cut through concrete walls.

MAKING THE SWITCH

Using ICFs requires some planning and specific design details for connections of structural floor, roof, and wall members to concrete in the foam forms. In addition, window and door frames and anchors must be detailed. Finishes, trim, cabinets, and interior partition walls may require special attachment methods. ICF manufacturers supply technical support, construction recommendations, and installation requirements.

INITIAL COST

A wide range of cost variance between ICF and conventional wood wall construction has been reported—anywhere from 5 to 19 percent—dependent upon the material and dimension of the comparison structure, geographical area of the project, etc. ICF forms have a thermal resistance of R-19 or greater, so comparing wall costs with 2x6 construction approaches similar thermal performance.

Results suggest that ICF designs should be value engineered and are likely to become more affordable as all of the trades become familiar with the method of construction. For example, after the first two homes were built at the Bruce Davis, Inc. site in La Plata, Md., the architect revised the overall building dimensions and window locations to conform with the 16¼" x 48" module size of the ICFs.

OPERATIONAL COST

Operational energy costs for structures built with ICFs are typically lower than light-frame wood buildings. The increased thermal performance of the mass walls with high insulation values result in lower utility bills.

CODE ACCEPTANCE

Prescriptive design methods for ICFs are contained in the International Residential Code (IRC) so ICFs are widely recognized as a construction method by building code officials.

In areas of high termite probability, like many southern states, an inspection strip just above grade may be required at accessible sides of an ICF wall. Removal of the foam form in this area allows physical inspection for termite tubes, which might otherwise be hidden between the foam form and the concrete.

RESULTS FROM THE FIELD

Field results indicate increased initial cost (5 to 19%) and energy efficiency (15 to 20%) over light-frame construction methods.

WARRANTY

Manufacturers offer up to 30-year limited warranties on registered buildings. Warranties cover the thermal performance of the forms.

Bruce Davis, Inc. Field Evaluation

THE BASICS

Insulating concrete forms (ICFs) are rigid plastic foam forms that hold concrete in place during curing, and remain in place afterwards to serve as thermal insulation for concrete walls, resulting in energy-efficient, durable construction. In ICF construction, the blocks or panels are stacked to form walls. Steel reinforcement bars are usually placed inside; concrete is poured to fill the forms, and is vibrated and cured as required.

ICFs most often consist of insulating foam, commonly expanded polystyrene (EPS) or extruded polystyrene (XPS). Wood-fiber composite ICFs are also available. Regardless of the materials, there are three basic form types: blocks; planks; and panels. Hollow block ICF systems come in a variety of shapes and sizes, and are often reversible, so they can be stacked in many different configurations. Plank systems consist of long, narrow foam pieces that are held together at a constant distance with plastic ties. Panel systems tend to have the largest components, as big as 4x8. They most often have flat edges, and are held together with varying types of fasteners including integral foam and plastic ties.

Depending on the type of form used, the needed performance of the home, and other factors, the internal concrete wall shape can vary. The three concrete systems used in ICF construction include flat, grid, and post-and-beam. Flat systems consist of a continuous thickness of concrete poured between the forms to create a solid concrete surface. Grid systems have varying thicknesses of concrete within the forms, and often resemble a waffle shape. Grid systems use less concrete, but maintain the structural integrity of the walls. Post-and-beam systems feature defined horizontal and vertical posts of concrete within the forms.

Regardless of the form type or concrete system used, all ICFs can be used to form various structural configurations. While building with ICFs requires careful planning, homes can be designed in any style and can easily accommodate curved walls, large openings, and cathedral ceilings in addition to more traditional designs. ICFs can be used below and above grade, and there are also ICF floor and roof systems available.

DOLLARS AND SENSE

Initial Cost – ICF homes cost more than wood-framed construction. How much more will depend on the material that is being substituted for the forms.

Year	Location	Construction Type for Comparison	Total Square Footage	Increased Cost of Construction ($)	Added Cost per Square Foot ($)
1999	La Plata[A]	Wood-2x6	1,500	5,000	3.33
2001	Lexington, NC	Wood-2x4	2,048	14,123	6.90
2003	Annapolis, MD[B]	8" CMU	1,008	2,463	2.44

[A] Estimate furnished by builder. Not verified.
[B] ICFs were used for in-ground basement walls only. Wood 2x4 covered two stories of above-grade walls.

Operational Cost – The energy efficiency of homes constructed using ICFs will be significantly lower than for framed wall construction, in part due to the higher value of ICF walls – typically R-19 versus R-13.

FOOD FOR THOUGHT

This section provides some things to think about before switching to this building technology – make sure it's the right choice for you.

- Initial costs are higher for ICF above-grade walls than for conventional framing.
- ICF walls are usually competitive with formed and poured reinforced concrete foundation walls when the cost of basement insulation is included in the analysis.
- Concrete walls are difficult to rework once poured, so the technology does require more precise on-site preparation than light-frame above-grade walls.
- Installation of electrical wiring will require a hot knife. Other mechanical/plumbing trades should not be using exterior walls for routing installations.
- Installation times can often be reduced, but there may be a learning curve needed, resulting in additional scheduling time with inexperienced crews. Be sure to plan adequately for erection, inspection (as needed) when scheduling concrete pours, and proper curing needs after the pour.
- Because ICF structures can be more airtight than wood, planning for regular mechanical ventilation should be included in the HVAC subcontractor's scope of work.
- The high R-value and low air leakage of ICF construction can increase energy efficiency and homeowner comfort, and can lower utility bills.
- ICFs can be designed and constructed for high wind and seismic zones.

TECH CHECK

Below is a checklist of steps to follow in order to implement this technology in each of your projects.

- ☐ **Determine the form type and concrete system for the project.** Work with the manufacturer or a designer to determine the type of form and concrete pour that best fits the needs of the home. Also determine the concrete type that will be used for the pour.
- ☐ **Prepare and review plans.** Plans should have dimensions that are compatible with the chosen ICF form module size. Angle walls at bays and offsets should conform to available special forms. Know window, door, and all opening specifications and connection details. Confirm footing is sized and appropriate for ICF walls.
- ☐ **Confirm code and inspection requirements.** Become familiar with prescriptive code requirements. Some code jurisdictions may include a reinforcement bar inspection before the concrete is poured.
- ☐ **Make arrangements for trades.** Keep plumbing and mechanical trades out of exterior walls. Drywall and siding installers will need to know the recommended way to attach finishing materials, such as vertical attachment channels in the ICF form that will most readily accept and hold screws or threaded fasteners. Trim contractors will have to use non-expansive foam adhesive and screws to attach trim at outside walls. Cabinets should be attached to the vertical channels that are formed with the webs. Electrical contractors will have to use a hot knife to cut through foam, and use receptacles to house components.

RESULTS FROM THE FIELD

This technology has been evaluated by other builders in real-world building projects – learn from their experiences.

Field results indicate increased energy efficiency, demonstrated by higher HERS ratings and lower homeowner utility bills.

LaPlata, Maryland, Washington Square, Bruce Davis, Inc. (1999)

- Townhomes of 1,000 to 1,500 square feet per unit were constructed with ICFs in this age-restricted housing development to provide increased insulation, fire safety, and wind resistance, and decreased sound transmission.
- The project was the carpentry crew's first experience with ICFs. The builder estimates this added 25% to the cost of labor.
- Setting 2,600 square feet of wall forms required 5 days.
- The cost to upgrade from their baseline construction of 2x6 walls to ICFs was estimated at $5,000 per unit.
- Positive attributes cited by residents were increased energy/monetary savings, overall durability, increased acoustical value and enhanced visual appeal.

Lexington, North Carolina, Hughes Construction (2001)

- Four affordable rental duplex buildings of 2,048 square feet per structure were constructed with a different exterior wall system, similar orientation of north and south exposure, and identical HVAC systems. The four systems were conventional wood frame, ICF, autoclaved aerated concrete (AAC), and composite panel.
- The ICF duplex used the least heating energy, 12.7% less than the wood-framed baseline duplex. It also used the least amount of cooling energy, 16.6% less than the wood baseline.
- Final construction cost ($43.12 per sq ft) for the ICF duplex was 19% higher than the wood baseline ($36.23 per sq ft).
- Field sound transmission tests showed higher sound attenuation for ICF walls.

Forney, Texas, Energy Smart Solutions, PATH Case Study (2005)

- ICFs were used to construct the walls of a two-story, 13,300 sq ft home.
- The builder estimated that the homeowner would save 60 to 70% in energy costs over a light-frame home of comparable size.
- The builder estimated that using ICFs reduced construction time by 10%.
- Also resulted in reduced builder's risk insurance premium.

MAKING THE SWITCH

What is required to transition from your current building practices to using this technology?

Careful design and planning: Using ICFs requires planning. Provisions for bringing in service connections, e.g., water, sewer, gas, and electric must be made and through-wall penetrations for plumbing or utilities should be pre-planned and sleeved, to avoid subsequent drilling through the concrete. Details for floor, window, door, and roof truss connections must be designed. Frequently, window and door openings are formed with dimensional lumber of a width that approximates the thickness of the ICF. The wood is left in place to provide a fastener base for door and window assemblies. These jambs provide the area where air leakage is noticed in an ICF structure if they are not properly detailed with caulk or spray foam.

Site preparation considerations: Because of the insulating value of the forms, concrete can be placed at temperatures below freezing. Pumping concrete into the foam forms is usually accomplished in 4'-0" (wall height) lifts to avoid putting too much weight from the concrete on the wall form that could result in a blowout. As with other reinforced concrete designs, the top and bottom of foundation walls should be braced by floor and slab construction prior to backfilling against the wall, after waiting the prescribed time for the concrete cure.

Trade considerations: ICFs allow trade contractors to construct concrete walls without a significant investment in wood or metal forms; however, scaffolding and bracing are required. ICF foam forms are assembled in a running bond pattern, similar to laying large concrete blocks, only ICFs are lighter. Often, concrete is placed at every four to six feet of wall forms, so several pump rentals and concrete deliveries may be required for each house. In some cases, unskilled labor has been employed in ICF form installation, but most often, a skilled carpentry crew has proven to be most successful on ICF jobs.

Electrical subcontractors will have to master a new tool, the hot knife for cutting foam, and use shallow receptacle boxes (designed for remodeling applications) for successful integration of wiring, receptacles, and switches into ICF-constructed walls. The building designer should take care to keep all ducts and plumbing supply and vent lines out of outside walls so that these trades are unaffected by the ICF exterior. Plumbing supply lines to toilets and sinks on outside walls should be installed through the floor/cabinet base. Kitchen sinks on outside walls can be supplied through the floor and vented within the cabinet using air admittance valves (AAVs).

Finishing considerations: Drywall is typically fastened to ICF walls at steel or plastic strips that are molded into the forms, though this may vary by the manufacturer. Attachment must be made with screws rather than nails. Traditional drywall adhesives may dissolve the polystyrene foam of the form, so the same non-expanding foam that is used for joining the forms may be used for drywall attachment.

As with drywall attachment methods, exterior cladding is fastened to the integral strips at the webs in the form, and screw fasteners should be used. Stucco and synthetic stucco are additional selections for the exterior surface finishing of ICFs.

Products used with EPS foam cannot be petroleum-based. In below-grade applications, there are water-based foundation damp proofing products and non-expanding foam adhesives available that are compatible.

Equipment choice and placement: Because ICF buildings can be well air sealed, builders may want to review the ACCA Manual J calculations to see if the HVAC equipment can be down-sized, and timed mechanical ventilation may be necessary. Building designs should route all plumbing – drains, supplies, and vent stacks – through interior walls, and employ AAVs where needed. Likewise, HVAC supply and return ducts should be routed within the conditioned space of the building and avoid exterior walls.

Hopke Buildings and Grounds Field Evaluation

Bruce Davis, Inc. Field Evaluation

DEFINITIONS

Fly-ash
A solid by-product from the combustion of coal.

Slag waste
A solid by-product from the process of smelting. Smelting is used to separate a metal from its ore.

Hot knife
A blade that is has an electric element and control to heat it in order to make more precise and defined cuts in polystyrene foam. Because of the foam's brittle nature, cutting with a conventional blade will produce uneven and jagged open edges.

Air admittance valve (AAV)
Pressure-activated, one-way mechanical vents, used in a plumbing system to eliminate the need for conventional pipe venting and roof penetrations (see ToolBase TechSpec on Air Admittance Valves).

Buddy Hughes Field Evaluation

PATH Partnership for Advancing Technology in Housing

The Partnership for Advancing Technology in Housing (PATH) is dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, and affordability of America's housing. Managed by HUD, the PATH partnership includes the homebuilding, manufacturing, insurance and financial industries, and Federal agencies concerned with housing.

PATH addresses barriers to innovation, provides information on advanced building technologies, and advances housing technology research; making affordable, quality American homes a reality.

For more information on the PATH program, visit www.pathnet.org.

TechSpecs are prepared for PATH by the NAHB Research Center.

NAHB Research Center
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Upper Marlboro, MD 20774
www.nahbrc.org

RESOURCES

General information about insulating concrete forms and their installation in homes:

ToolBase Services

Information on this building technology and many others brought to you by PATH and the building scientists at the NAHB Research Center

www.toolbase.org

ICFA – Insulating Concrete Form Association

1807 Glenview Road
Glenview, IL 60025
(847) 657-9730

www.forms.org

PCA – Portland Cement Association

(Several Technology Briefs have been published)

5420 Old Orchard Road
Skokie, IL 60077-1083
(847) 966-6200

Info@cement.org

www.cement.org/homes/

Three students help fill ICF forms with concrete; LCCTC Lancaster PA Field Evaluation