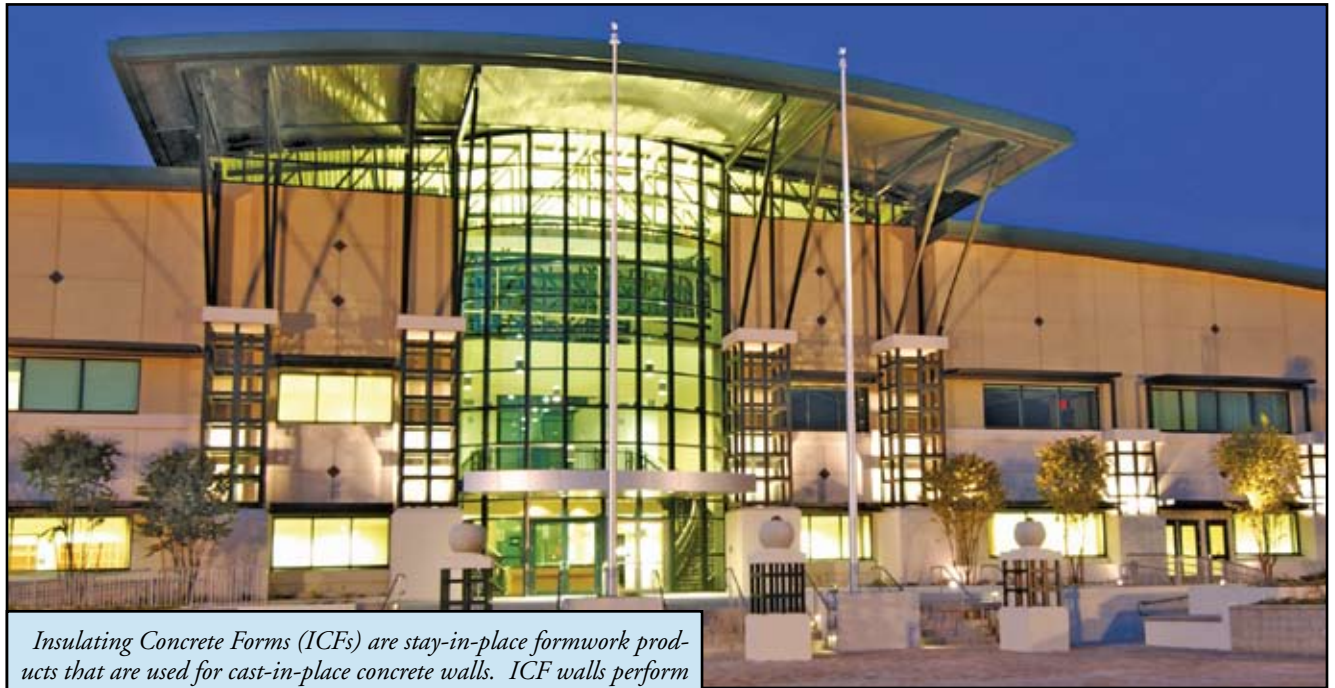


Insulating Concrete Form Design and Construction

By Kelvin Doerr, P.E.



Insulating Concrete Forms (ICFs) are stay-in-place formwork products that are used for cast-in-place concrete walls. ICF walls perform five building functions: structural support, temperature insulation, air barrier, vapor barrier, and furring attachment.

140,000-square-foot Armed Forces Reserve Center in Tampa, Florida.

Over the past several years, ICF construction has been one of the fastest growing types of construction in the country. About 75% of ICFs are being installed in residential construction and 25% in commercial construction. Some commercial applications include multi-family housing, hotels, theaters and office buildings.

ICF Characteristics

Types

There are four different types of ICFs, characterized by the shape of the concrete wall they form: flat, waffle-grid, screen grid, and post and beam. By far the most common type of ICF is the flat wall system, which is used to create traditional solid concrete walls. The most common ICF is the pre-assembled type, which comes to the job site ready for stacking to create the wall formwork. The other type, put-together forms, requires some sort of field assembly. Formwork is available as straight forms, 90-degree corner forms, 45-degree corner forms, ledge forms and tapered forms.

Ledge forms are used to support masonry exterior finishes and also can be turned to the inside of the building to support floor systems. Taper top forms are used at the top course of a wall to provide more bearing area on the concrete wall.

Sizes

Different manufacturers have different sizes of forms, but the most common form length is 4 feet, and the most common form height is 16 inches high.

The overall form width depends on the foam thickness and the concrete core thickness. The most common concrete thicknesses are 4, 6, 8, and 10 inches. If the foam panels are 2½ inches on each side, then the overall form width would be 9, 11, 13 and 15 inches. The concrete thickness is usually determined by the wall's strength requirements, sound characteristics, or fire rating.

Foam Panels

ICF units consist of two foam panels held together by ties or webs. The most common foam material is expanded polystyrene (EPS). The EPS thickness of each panel is usually 2 to 2¾ inches, with the most common thickness at 2½ inches.

The EPS foam is combustible material that has a flame retardant in it. It meets the building code's surface burning requirements for flame spread and smoke development. Although there are no code requirements for toxicity, EPS resin testing

has shown that such foam has a toxicity value less than that of wood.

Even though the EPS foam is a combustible material, the 2006 *International Building Code* identifies specific tests that can be passed to allow the ICF product to be used for non-combustible Type I, II, III, IV or V type construction. These tests include the NFPA 259 Potential Heat, the ASTM E119 Fire Resistance, the NFPA 285 Multi-Story Fire Test, the ASTM E84 Surface Burning Characteristics and the NFPA 268 Ignition test.

continued on page 22



The design for this 7,550-square-foot home in Tesuque, New Mexico, created by Jon Dick with Archaeo Architects, is based on a traditional Mexican hacienda courtyard, but with contemporary detailing. The home features steel and fabric canopies on the exterior and a three-coat elastomeric stucco exterior finish.



Construction of Waterside condominiums in Ft. Myers, Florida.

Ties

The material for ties can be plastic or steel ties, or internal ICF webs. Ties hold the outside foam panels in place during concrete placement, are used to position horizontal steel rebar, and can act as attachment for exterior and interior finishes. The ties are spaced at 6, 8 or 12 inches on center, and closer spacing provides for stronger formwork and more attachment areas. A good tie design will not impede concrete flow.

Performance Benefits

Because of the high cost of energy, thermal efficiency is becoming more important in the design of buildings. The majority of ICF products provide a steady state static R-value of R-22. Due to the thermal mass and lower

air infiltration rates, the ICF wall will perform better than its static R-value.

Many ICF companies have listed fire ratings from 1 to 4 hours, depending upon the concrete wall thickness. ICFs create a solid concrete wall assembly and sound testing of ICF wall assemblies has shown significant through-wall sound reduction. ICF walls have standard STC ratings from the mid-40s to mid-50s, versus the mid-30s for a standard framed wall.

Introduction to ICF Wall Construction

Wall Openings

Bucks are installed around the wall openings using wood, vinyl, or metal bucks. Some projects will install temporary bucks that are

removed after the concrete cures. In these cases, the doors and windows are attached directly to the concrete wall. Concrete lintels can be reinforced to handle the large loads above wide openings.

Floor Connections

Wood or steel frame floors can be connected to an ICF wall by a side connection or by direct bearing. The methods for side connection include a ledger board fastened to the wall by embedded anchor bolts, a proprietary ICF Connector, or by embedding an ICF connector.

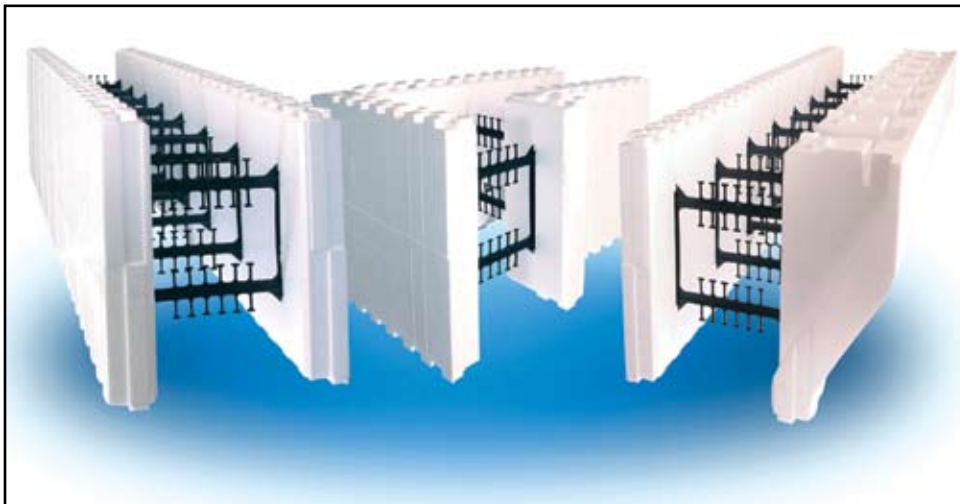
Direct load bearing a floor system onto an ICF wall can be accomplished by using a ledge form or by transitioning from floor-to-floor with reduced wall section above.

Concrete Floor Systems

Several commercial construction applications and some residential applications utilize concrete floors. Pre-cast hollow core slabs and post-tensioned slabs have been designed and constructed in conjunction with ICF walls.



42,632 square-foot Hampton Inn hotel in Horseheads, New York.



Reward Wall Systems insulating concrete forms (ICFs) from iForm product line.

Exterior and Interior Finishes and Waterproofing

The exterior and interior of an ICF home or building looks no different than a building built with a different type of construction. Any type of exterior finish can be attached to the ICF wall including any type of siding, brick or stone veneer, cultured stone, and traditional and acrylic stucco coatings.

The interior generally requires a 15-minute thermal barrier (typically 1/2-inch or 5/8-inch gypsum wallboard fastened directly to the wall) to cover the foam plastic face.



ICF-built home on lot deemed "unbuildable" by builder, John Vogstrum in Minnesota.

Structural Design

Concrete walls provide superior strength and toughness to resist extreme wind loads and related phenomena, such as the penetration of wind-borne debris. This is documented by the tests conducted at Texas Tech University, where it was shown that a 2x4 shot out of a canon at over 100 mph was stopped by ICF walls and not by a framed wall. Additionally, there have been cases of a tornado hitting a residential area where the wood framed homes were leveled and an ICF home remained structurally intact.

Homes and commercial buildings are being designed to be more open on the interior.



Example of tall wall ICF construction - Megaplex 20 movie theater in South Jordan, Utah.

With more open areas comes larger point loads from longer spans. The high allowable bearing strength of ICF exterior walls easily allows for these spans and loads. Commercial construction can also incorporate ICF walls as in-fill non-load bearing walls, which

can provide the building with several non-structural benefits, such as increased thermal mass. While many projects will use ICFs for just the exterior walls, when fire resistance and sound attenuation are a priority, the ICF construction works well as interior walls.

continued on page 24

ADVERTISEMENT - For Advertiser Information, visit www.STRUCTUREmag.org



LIMCON

A Windows-based application for the Design of Steel Connections

Based on the latest codes for AISC LRFD/ASD, Limcon is a powerful design aid for all types of connections. Sold separately or as an integrated solution within AutoCAD, LIMCON is easy to use and allows you to see the connections dynamically before placing them in your model.

Automatically produce details of connections and generate analysis reports

- ✓ Engineering, Detailing and Fabrication Software are available as a suite or can be purchased separately
- ✓ Based on the latest reference material for AISC LRFD/ASD BS 5950 and AS 4100
- ✓ integrated detailing with dxf output
- ✓ Seamless integration with ProSteel 3D, for ACAD based 3D modeling and drawing production
- ✓ Shear, moment, HSS connections and splices
- ✓ AISC multiple row moment end plate connections
- ✓ Bolt and weld groups
- ✓ Virtual reality view of connections
- ✓ SI metric or US customary units
- ✓ Professional support - immediate response

StrucSoft
S.O.L.U.T.I.O.N.S

WWW.STRUCSOFTSOLUTIONS.COM 1-877-810-7575



Design Tip

Steel Strong-Wall®

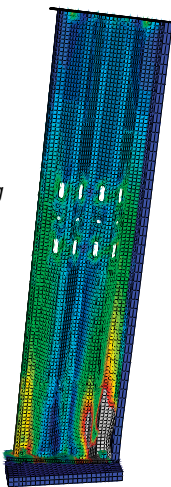
IMPORTANT INFORMATION ABOUT CUMULATIVE OVERTURNING

When specifying a pre-manufactured shearwall for a project, a critical factor in multi-story applications is accounting for cumulative overturning.

Calculating Cumulative Overturning for Pre-manufactured Shearwalls

Designers typically select a shearwall based on its ability to meet or exceed the design shear requirement. What can get lost when considering shear capacity only is that the shearwall is not only governed by shear, but also by a combination of other limit states, including *drift, tension and compression, flexure, anchor rod tension, and concrete or wood bearing stress*. Additional care must be taken in the analysis of multi-story shearwalls to account for the way the loads are distributed over the height of the building.

Simpson's Steel Strong-Wall® rendered in Finite Element Analysis (FEA). When evaluating the performance of complex structural components, our engineers use this computer simulation to complement our full-scale testing program.



Cumulative Overturning and Stacked-Wall Applications

When specifying stacked shearwall applications, it's important to consider cumulative overturning. The design procedures for Simpson's stacked Steel Strong-Wall applications reflect the impact of cumulative overturning.

To learn more about cumulative overturning and Simpson's Strong-Wall testing, visit www.strongtie.com/co or call 800-999-5099.



©2007 Simpson Strong-Tie Company Inc. SSW-DTFA07



Best Western hotel in Fort Lauderdale, Florida.

Due to concrete's inherent ability to be formed to any monolithic shape, ICF construction is a popular choice for different architectural looks. ICFs also offer the flexibility of specifying one type of construction for both above and below grade walls.

Structural Design and Building Codes

ICF structural design is based on the design of plain or reinforced concrete wall according to ACI 318 for a cast-in-place concrete wall. There are also several prescriptive design resources and tables available for residential applications. The Portland Cement Association (PCA) and HUD have published *Prescriptive Design of Insulating Concrete Forms in Residential Construction*, which provides tables for below grade and above grade walls, as well as lintels. The *Structural Design of Insulating Concrete Form Walls in Residential Construction*, published by PCA is also helpful. The *2006 International Residential Code* contains information in sections R404.4 and R611.

The 2006 IRC has referenced ACI 332-04, *Requirements for Residential Concrete Construction*. The ACI Committee 332, Residential Construction Work, is currently working on adding ICF construction to their guide (*Guide to Residential Concrete*) by adopting below grade ICF walls, above grade ICF walls, and ICF lintels.

Design of foundation walls may also be in accordance with:

- IBC Section 1805 and Tables 1805.5 (1), 1805.5 (2) and 1805.5 (3)
- IRC Sections R404.1 and R404.2, and Tables R404.1(1), R404.1(2), R404.1(4)
- BNBC Section 1812.3.2 and Tables 1812.3.3(1) and 1812.3.2(2)
- SBC Section 1804.6 and Table 1804.6.1 (A)

Additionally, many ICF companies can provide their own prescriptive design tables upon request. They also may have ICC ES evaluation reports that have shown their products comply with the building codes.

Building Applications

ICF walls can be load bearing or non-load bearing walls for either below grade or above grade walls. They are typically used as exterior walls but there are advantages in using them as interior walls as well. Additionally, the fire and sound ratings make the walls attractive for certain applications such as walls between duplexes, town houses, condo dwellings, hotel rooms, or movie theaters.■

Kelvin Doerr, P.E., is Vice President of Engineering and Technical Services for Reward Wall Systems, Inc., located in Omaha, NE. He can be reached via email at kdoerr@rewardwalls.com.

All photos courtesy of Reward Wall Systems, Inc.