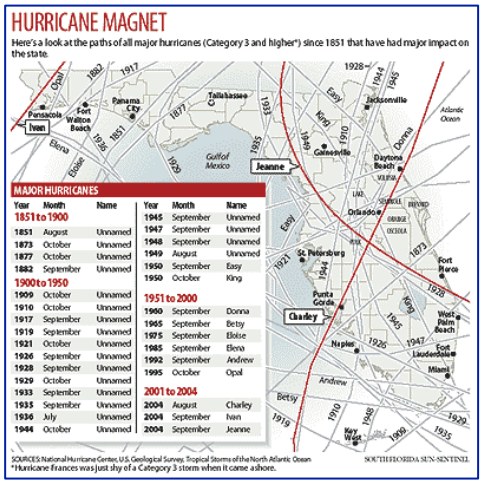
UNIVERSITY OF FLORIDA

Performance Under Pressure:
Insulated Concrete Form (ICF) Walls

Program for Resource Efficient Communities | School of Natural Resources and Environment | www.energy.ufl.edu



Since 1851, 31 major hurricanes (Category 3 and higher) have crossed paths with Florida. (***Source**: www.orlandosentinel.com*)

A History in the Cross-Hairs…

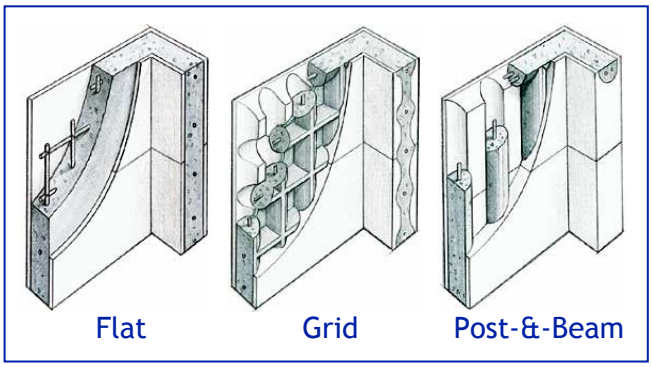
During the 20th Century, Florida was second only to Texas in the number of hurricane direct hits suffering 57 total categorized storms with 24 of those being major storms (categories 3, 4, and 5 with winds 110 mph and higher). That means homeowners somewhere in Florida were hit by a hurricane every other year.

More importantly, major storms, which account for only 20% of all tropical storms yet cause 80% of property damage, came every four years. Some scientists believe the North Atlantic Ocean is in the beginning of a more active phase in the long-term cycle of hurricane activity - much like the active phase from 1926 to 1970. If so, we can expect to see nearly twice as many major storms as during the last three decades of the 20th Century. The 2004 hurricane season brought 4 major storms to Florida and dramatically demonstrated that coastal and inland residents should make preparations to secure their property.

Building a More Durable Home

One way of ensuring a new home's safety is to build it using durable, hurricane-resistant construction systems. A great example is the insulating concrete form system (ICF). ICFs are permanent forms for cast-in-place concrete walls. By leaving the forms in place, a homeowner can reap extra benefits from the insulating materials. The three most common ICF systems are flat (ICF panels create uniformly thick concrete wall), grid (ICF waffle pattern creates concrete of varying thicknesses), and post-and-beam (ICFs create discrete horizontal and vertical concrete columns).

Our case study home in the Madera subdivision of Gainesville, FL used the flat ICF system offered by ECO-Block. ECO-Blocks are made of expanded polystyrene (EPS) panels with snap-in-place polypropolyne bridge connectors filled with cast-in-place monolithic reinforced concrete. Like many ICF systems, ECO-Block can form walls of various thicknesses, depending on your local site conditions and the desired structural qualities of your home.



The three most common ICF wall systems: flat walls, waffle/grid walls, and post-and-beam walls. (***Source**: Fine Homebuilding #128, pp. 74-81*)

This fact sheet, developed by Hal Knowles, was made possible through the support of the U.S. Department of Energy (DOE) Southeast Regional Office, Office of Energy Efficiency and Renewable Energy, Office of Weatherization and Intergovernmental Programs, and Building America.

Madera Model (1-Story)
Location | Gainesville, FL
Builder | Carter Construction
Living Space | 4/3 @ 2,919 ft^2
Total Under Roof | 3,410 ft^2
Price | $380,000
HERS Rating | 94
Wall System | ECO-Block
FL Approval | # FL2253
Miami-Dade | # 00-1024.02
Concrete | 3,000 psi (6" slump)
Vert. Rebar | #5 @ 30" O.C.
Horiz. Rebar | #4 @ 32" O.C.
Tie-Down | Simpson Strong-Tie

ECO-Block ICF wall being installed in the Madera Model embedded rebar and Termimesh subsurface poison-free termite barrier visible.
(***Source:*** *University of Florida*)

Performance Under Pressure

Sure, Insulated Concrete Form (ICF) walls sound like a durable building system, but how do they perform in the high wind load conditions of hurricanes and tornados?

In laboratory testing conducted by the Wind Science and Engineering Research Center at Texas Tech University ICF walls were far superior to both conventional wood and steel framed walls when wood stud debris "missiles" were fired at the walls in conditions simulating a tornado with 250 miles per hour winds (a speed greater than 99% of all the tornados spawned in the United States and considerably higher than the 155 mph and higher wind speeds of Category 5 hurricanes). In these conditions a piece of wind-borne debris would travel up to 100 miles per hour. An excerpt from this study is shown below.

Wall Type	Test Wall Description	Speed of Debris	Results
Wood Frame	5/8" gypsum board interior finish, 2 x 4 wood studs at 16" o.c., 3-½" batt insulation, ¾" plywood sheathing, vinyl siding exterior finish	109.0 mph	The debris "missile perforated completely through the wall assembly. Little damage to missile.
Steel Frame	5/8" gypsum board interior finish, steel studs at 16" o.c., 3-½" batt insulation, ¾" plywood sheathing, vinyl siding exterior finish	103.5 mph	The debris "missile perforated completely through the wall assembly. Little damage to missile.
ICF	Block ICF foam forms, 6" thick flat concrete wall, #4 vert. reinforcing bars, 12" o.c. vinyl siding	103.8 mph	Debris penetrated vinyl siding and foam form. No cracking, front face scabbing or back face spalling of concrete wall observed.

(***Source:*** *www.cement.org/homes/brief07.asp*)

Beyond the missile test, **ICF walls** have proven to provide safe haven from other damaging forces resulting from high wind conditions. ***NOTE, this data is for demonstration only and not to be used for design purposes.***

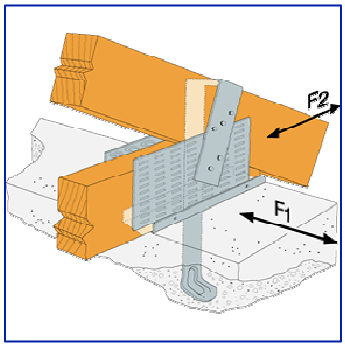
ECO-Block ICF Wall vs. 2" x 4" Wood Stud Wall with ½" Sheathing Test Conditions: ICF @ 60 psf, Studs @ 28.9 psf (~125 mph storm)		
	6" Concrete Wall	**Wood Stud Wall**
Axial Compression	**6,000** lbs/ft	**400** lbs/ft
Bending Moment	**1,000** ft-lbs/ft	**350** ft-lbs/ft
Shear	**4,100** lbs/ft	**< 400** lbs/ft

(***Source: Goldsmith Engineering, Inc. and Will Swanson.*** *ICF wall features used to obtain these capabilities = 3,000 psi concrete, 145 lbs/cf concrete density, 60 ksi steel grade, #4 @ 24" O.C. vert. rebar in middle of wall, #4 @ 32" O.C. horiz. rebar staggered side to side, 8' high by 16' long wall, Simpson HEATL20 connecting truss to wall typ. 24" O.C.*)

Variables Affecting Performance

The strength of any insulated concrete form (ICF) wall system comes from the combination of the concrete itself and the reinforcing steel utilized, ***NOT*** the insulating forms. It is important to remember that an engineer should be used to design any ICF wall system. There are a few important variables to take into consideration when designing ICF walls.

1. Height of wall
2. Thickness of concrete wall (inside the form)
3. Size and placement of steel reinforcing and tie-downs
4. Size, placement, and quality of windows and doors
5. Slender wall buckling
6. Shear transfer to perpendicular walls (floor and roof diaphragms, X bracing, etc.)

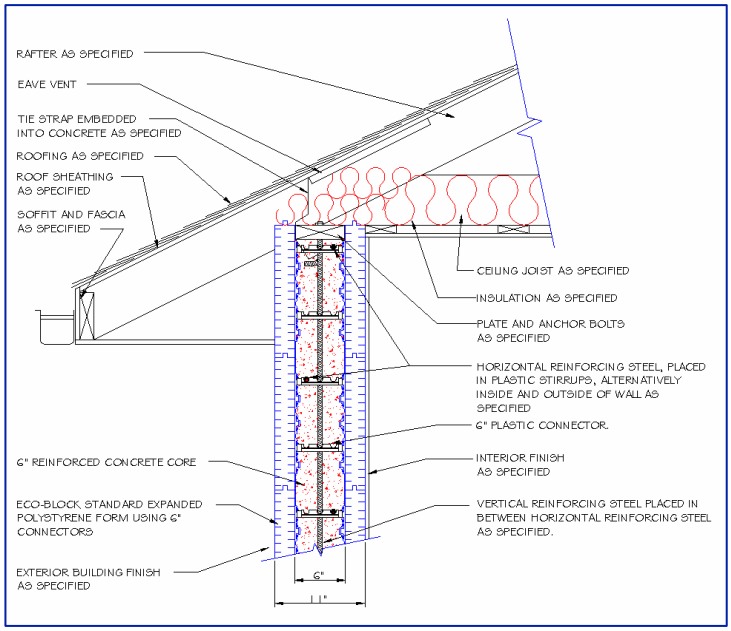


Simpson Strong-Tie embedded truss anchor (META installed with TSS).
(***Source**: www.strong-tie.com*)

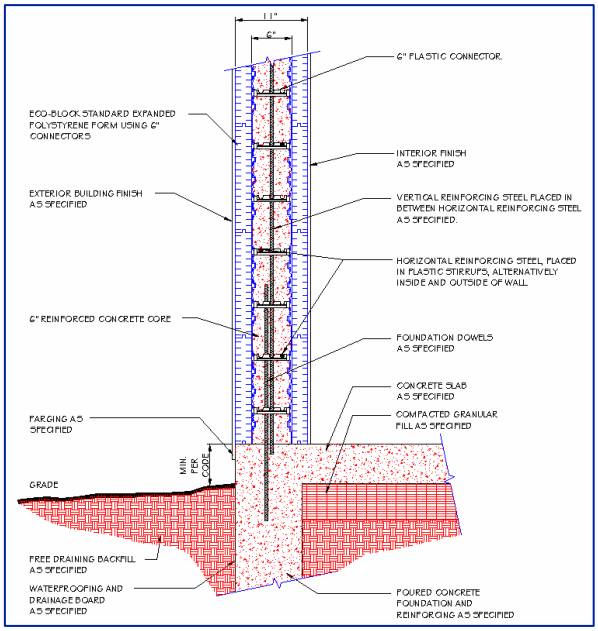
Furthermore, the Florida Building Code's Chapter 19 on ICF wall systems (Section 1916) is often misunderstood. This is a prescriptive standard with very restrictive requirements that often cannot be met for many homes due to the local wind zone and the unique specifications of the building. Many different types of ICF systems have received Florida's Certificate of Product Approval for use statewide (see website below). Utilizing an engineer to design your ICF home is allowed per the Florida Building Code's Chapter 19, Section 1918. This gives builders the flexibility to create innovative structures with performance characteristics beyond the code's prescriptive ICF standards.

To discover more about ICFs and the systems approved for use in Florida, visit the following websites:

- Florida Department of Community Affairs Building Code Information System - Product Approval Search Page
  - www.floridabuilding.org/pr/pr_srch.asp
- Portland Cement Association – Insulating Concrete Forms: A Better Way to Build a Better Home
  - www.cement.org/homes/ch_bs_icf.asp



Cross section detail of ECO-Block wall to roof connection.
(***Source**: ECO-Block, LLC*)



Cross section detail of ECO-Block foundation to wall connection.
(***Source**: ECO-Block, LLC*)

Other Benefits of ICF Walls and the ECO-Block System

Energy Efficiency and Comfort

- ICF walls have a high thermal mass, which reduces home energy costs by decreasing the energy transfer between the outside and inside of the walls. These walls create more comfortable homes by minimizing interior temperature fluctuations and drafts.
- ICF walls often have R-values about 2x higher than conventional wood frame construction. ICF walls typically range from R-18 to R-35 while wood frames range from R-12 to R-20.
- ICF walls can help homeowners pursue Energy Star® ratings and energy-efficient mortgages.

Noise Suppression

- Due to the insulating capabilities of ICFs and the properties of concrete walls, these systems also reduce noise transmission.

Class A Fire Rating

- An ICF system with a 6" solid monolithic concrete wall offers 3-hour fire protection.

Improved Indoor Air Quality

- ICF walls resist moisture, mold, and mildew.

Durability

- ICF walls are virtually termite and rot proof.

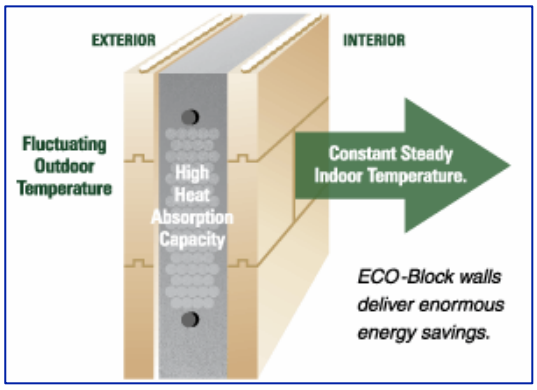


Diagram of ECO-Block thermal properties.
(*Source: ECO-Block, LLC*)

Sources

ECO-Block – Promotional Materials
- www.eco-block.com

Florida Department of Community Affairs Building Code Information System – ECO-Block Product Approval Page
- www.floridabuilding.org/pr/pr_detl.asp?IPT=2253&RV=0&fm=ROSrch

Goldsmith Engineering, Inc.
- Engineering calculations for the ECO-Block wind-load performance data

NOAA - National Hurricane Center: U.S. Mainland Hurricane Strikes by State, 1990-1996
- www.nhc.noaa.gov/paststate.html

Orlando Sentinel – Long-term Storm Cycle Puts State at Risk
- www.orlandosentinel.com/orl-asechcycle10101004oct10,1,6168197.story

PATH Technology Inventory – Insulating Concrete Forms (ICFs) In-Depth Analysis: Summary
- http://www.toolbase.org/tertiaryT.asp?DocumentID=2011&CATEGORYID=1081

Portland Cement Association – Insulating Concrete Forms: A Better Way to Build a Better Home
- www.cement.org/homes/ch_bs_icf.asp

Portland Cement Association – Technology Brief 7: Concrete Homes: Built-In Safety
- www.cement.org/homes/brief07.asp

SBCCI Public Safety Testing and Evaluation Services, Inc.
- Report No. 9845A (ECO-Block, LLC)

Simpson Strong-Tie - META/HETA/HHETA/HETAL/TSS Embedded Truss Anchors and Truss Seat Snap-In
- www.strongtie.com/products/connectors/META-HETA-HHETA-HETAL-TSS.html