Design Recommendations

Apartments

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1. Construction Cost Estimate

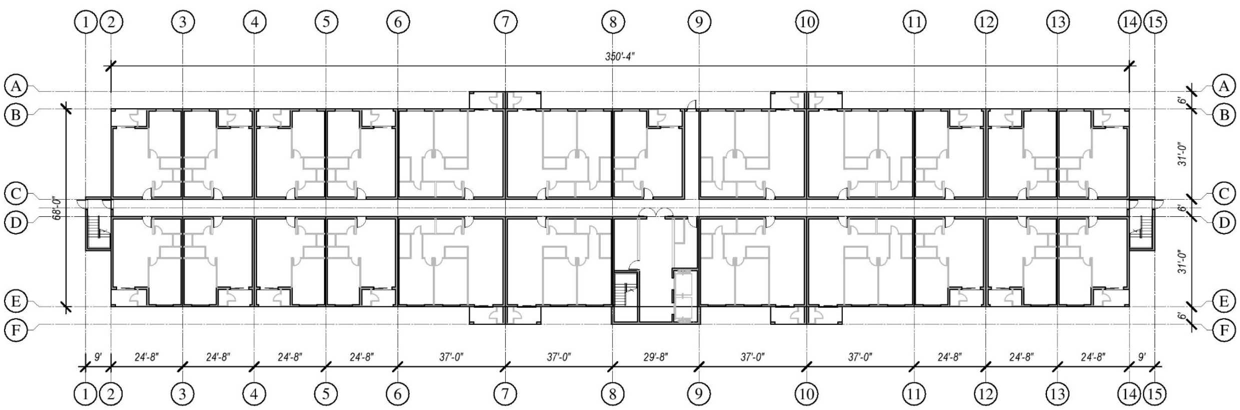
A cost estimate was conducted for a five-story apartment building. The building consists of 1 story of parking at the ground level and 4 stories of residential occupancy with approximately 25,000 square feet per floor for a total of 100,000 square feet of livable space. The cost estimate compares the construction cost of a concrete masonry exterior wall to an insulating concrete form (ICF) exterior wall. It assumed that the floors will be precast hollow-core plank. Cost estimates were derived from RS Means, the most widely known and respected cost estimating data available. The estimates below are for finished walls, assuming gypsum wall board interior finish and stucco exterior finish.

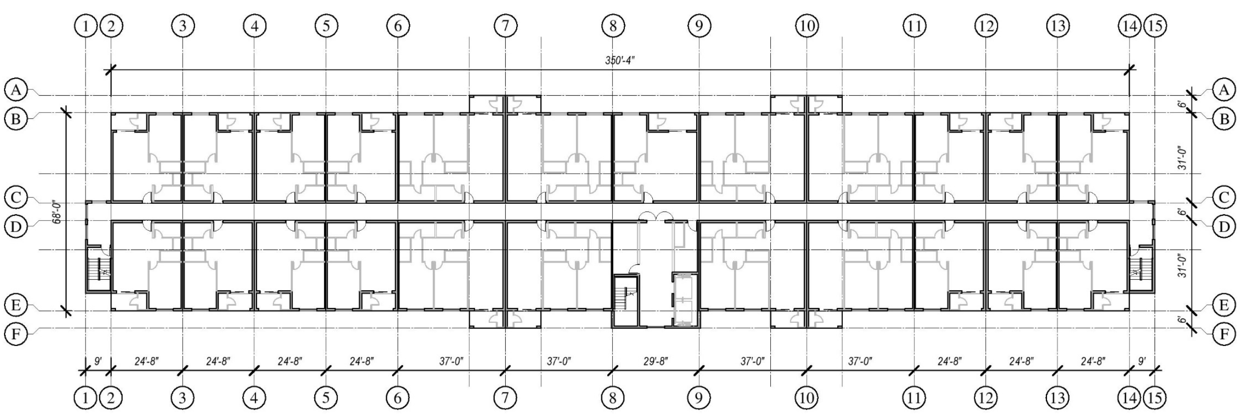
Concrete Masonry Wall Estimate	ICF Wall Estimate
$24.14 per square foot of wall	**$20.93 per square foot of wall**

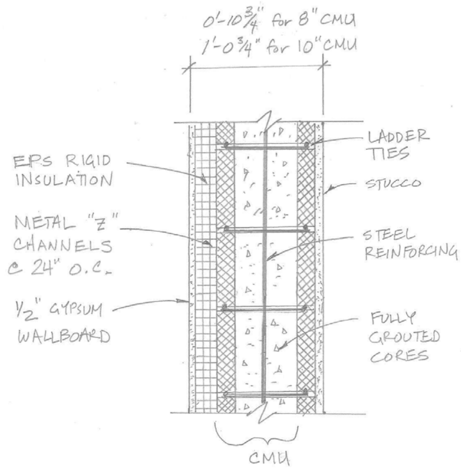
Assume the total area of exterior wall is approximately 65,000 square feet

The total cost savings of building with ICF walls will be approximately $209,000.

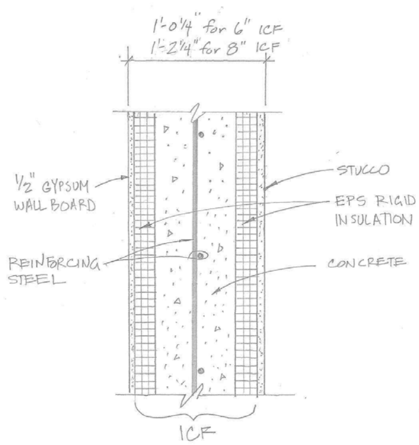
2. Assumed Project Details







TYP. CMU WALL DETAIL



TYP. ICF WALL DETAIL

3. Case Studies

There are hundreds of multifamily projects built using ICFs for walls in combination a concrete floor system. The following are just a few examples. For more examples visit www.ConcreteTracker.org.

Apartments and Condos

Beach Green North, Rockaway, New York

This 101-unit, 94,000-square-foot apartment building is built in an area devastated by Hurricane Sandy in 2012. The Bluestone Organization selected ICFs for exterior, corridor and demising walls and precast hollow-core floors for disaster resilience and energy efficiency. The building is so energy efficient it is certified by the Passive House institute. ICFs create a solid concrete wall with continuous insulation, resulting in a comfortable and airtight structure that lowers energy bills. The reinforced concrete system results in a structure that's strong, durable and can stand up to fire, floods and wind. This developer builds exclusively with concrete.

Image courtesy of The Bluestone Organization

Walker's Landing, Milwaukee, Wisconsin

Bedford Development chose ICF walls and precast hollow-core floors for thermal efficiency, fire rating and speed of construction. Walker's Landing has four floors of residential over two floors of parking. The project is located on an infill urban site requiring fire rated exterior walls. The ICF provides more than enough fire rating at a significant cost savings over wood frame. The ICFs are so energy efficient that some tenants have never turned their heat on all winter. The building also has garage heaters that have never been turned on. Bedford Developments used the vertical TF Forming Systems ICF resulting in minimal waste on the job site.

Image courtesy of Bedford Development

Central Avenue Villas, Oklahoma City, Oklahoma

Image courtesy of EPS Industry Alliance

The Villas were built with ICF exterior walls and precast hollow-core plank floors. In addition, the elevator shafts, stairwell walls and corridor walls were designed with ICFs to meet stringent fire code standards in addition to providing superior sound mitigation. The ICF portion of each level was installed in ten working days allowing the entire structural shell, floors and walls to be completed in only six weeks. ICF construction proved to be a cost-effective method to build a fire rated wall assembly directly abutting an existing structure. ICFs were used to support heavy loads on narrow columns between windows and beams in between floors. The developer promotes not only the ICFs' energy efficiency but also protection from tornadoes and superior noise reduction. The Central Avenue villas lie between I-235 and I-40 in Oklahoma City yet traffic noise is nonexistent on the interior.

The Ricchi, San Antonio, Texas


Image courtesy of Ricchi Group

The Ricchi condominiums in San Antonio are a contemporary, mid-rise building consisting of 87 luxury condominiums. This exclusive development was the first of its kind to be built in the area. The developers wanted to provide a first-class, secure and quiet building and chose ICF as part of the plan to achieve their goal. Noise reduction was a major consideration for this project. The Ricchi is located directly below the flight path for airliners approaching San Antonio's international airport and is adjacent to a US Army training camp. The sound attenuation offered by ICFs provided a solution to those concerns while creating significant energy savings. The U-shaped, luxury condo utilized more than quarter million square feet of ICFs. The higher insulation provided by the ICF walls reduced HVAC tonnage by 20 percent, resulting in significant energy savings.

Lane 1919 Apartments, Portland, Oregon

Image courtesy of Opsis Architecture

A focus on quality, reduce life-cycle costs, and the creation of value for the next 80 years drove the Lane family along with the rest of their investment and design team to create a mixed used project that paid tribute to the historic significance of the neighborhood while combining modern innovative design and construction methods. The project team's goals were not only to create a viable income-producing property for the Lane family, but also to balance energy efficiency and extended life-cycle equipment and materials. The Lane 1919 mixed-use tower is built from highly-efficient, ICF walls that provide greater thermal mass, high R-value and reduced air infiltration offering the building owner significantly reduced energy bills.

Grand Caribbean, Orange Beach, Alabama

Image courtesy of IntegraSpec

This 160,000-square-foot beachfront condominium project was built using ICF bearing walls throughout and concrete on steel joists for the floors. The developer chose ICFs because the building is in a hurricane area and needed to resist high winds, flying debris and water infiltration. They also used ICFs to kill sound from one unit to the next. The one thing the unit owners all talk about is how quiet the units are. A third reason is energy efficiency. The owners are happy that their power bills are so low. The Grand Caribbean captures the turn-of-the century Victorian look that is still very appealing in the housing market. The project was so impressive that the units were sold out before construction even started.

Hotels

Case Study: Hilton Garden Inn, Lewisville, Texas

With the objective of keeping their guests safe, secure and comfortable, Hilton Garden Inn in Lewisville, Texas chose ICF construction for their six-story hotel and 25,000 square foot convention center. ICFs were used for the walls and hollow-core concrete planks were used for the floors. The result is a fire resistant concrete building with the added benefits of energy efficiency, durability, and peace and quiet. Concrete has long been used as the material of choice for reducing sound transmission. No one wants to stay in a hotel or live in an apartment building where you can hear the neighbors. Concrete walls and floors can eliminate sound transmission at virtually no additional cost making them very attractive for any project in which peace and quiet is a selling point.

Image courtesy of Nudura

Holiday Inn Express, Louisville, Kentucky

This eight-story Holiday Inn Express was built with ICFs in the heavily populated Museum Row district in downtown Louisville. Standing about 100 feet tall, it’s the tallest building in the area. ICFs were selected in part because the extremely tight site meant construction materials had to be lifted from the adjacent parking garage since there were no staging areas outside the building footprint. Although Dunn Hospitality has built other hotels, this was their first ICF project. After touring another Holiday Inn project being built with ICF across the river in Ohio, they were convinced. ICFs cut three months off the already accelerated schedule. With conventional construction techniques, a typical eight-story, 145-room hotel such as this would take 14-16 months to construct but this hotel took only 10 months allowing the hotel to open just in time for the Kentucky Derby thanks to ICF construction.

Image courtesy of ICF Builder Magazine

Candlewood Suites, Omaha, Nebraska

Image courtesy of Fox Blocks

This four-story, 82-suite hotel is built entirely of ICF exterior and corridor walls. The system was selected to reduce noise from nearby Eppley Airfield in Omaha. The project, completed in 2008, is one of many hotels switching to ICFs for superior noise abatement along with superior energy efficiency, competitive construction cost and reduced construction schedule. ICF construction can help contain construction costs because of the inherent efficiencies of the installed assembly that serves nine functions including concrete form, thermal barrier, air barrier, moisture barrier, fire barrier, sound barrier, substrate for running utilities, substrate for attaching finish materials and reinforced concrete structure. In conventional construction, many of these elements are provided by several different trades, usually at significant added cost and time. As a result of using ICFs, building owners are able to put their buildings into service sooner, cutting short financing costs and initiating a quicker revenue flow.

Comfort Inn, Tifton, Georgia

Image courtesy of IntegraSpec

Dubbed the “best built hotel in our company” by Comfort Inn, the chain’s Tifton location is one durable hotel. Faced with an incredibly tight, four month building timeline, and a challenging budget, this hotel is a fantastic example of how ICFs can be used to save time and money without sacrificing durability by using stick frame. Thanks to its ICF construction, guests are kept safe and can enjoy a stay uninterrupted by traffic noise from the nearby interstate. The cost to build the hotel was $78 per square foot, similar to stick construction. Thanks to the energy efficiency benefits of ICFs, the hotel’s owners will save even more money over the building’s lifecycle.

Dormitories

Carleton College, Northfield, Minnesota


Image courtesy of EPS Industry Alliance

These two Carleton College dorms total over 91,000 square feet including 56 doubles, 26 single and 21 suites. The design team selected ICFs for optimal energy efficiency and to meet a tight construction schedule. The exterior walls are 100% ICF with a brick finish. ICF load bearing walls were used in conjunction with precast hollow-core floor slabs to create an efficient structural design. No HVAC mechanical systems were required due to the energy efficiency of ICFs. An in-floor radiant heating system was used for heat along with Individual side panel electric heating in each unit. Energy consumption is 28% less than the typical dormitory. Additional contributions to the sustainable features of the dorms include the use of a 50% recycled fly-ash in the concrete significantly reducing carbon footprint. The project was constructed in fall and winter of 2008-2009 and proceeded on schedule since ICFs can be installed in extreme conditions meaning students could move in on time for the start of the school year.

Martin Hall and New Hall B, Eastern Kentucky University, Richmond, Kentucky


Image courtesy of Brown + Kubican

ICFs are now a common form of construction for dormitories. Eastern Kentucky University chose ICFs for walls and hollow-core plank for floors for two recent dormitories–the 199,480-square-foot Martin Hall and 165,580-square-foot New Hall B. Each structure features a recreational room, private and group study areas, a community kitchen, a large multi-purpose room, and two classrooms. The concrete floor design allows for shallow floor-to-floor heights and ease of construction. Additionally, lower floor-to-floor heights saves on exterior finish and mechanical runs. The lateral load resisting system includes concrete shear walls designed to provide stability against wind and seismic forces.

West Village Student Housing, Texas Tech University, Lubbock, Texas

Image courtesy of Mackey Mitchell Architects

A design-build project with Whiting-Turner, BGK Architects and Mackey Mitchell Architects, this 230,000-square-foot student housing complex at Texas Tech University implemented fast track construction methods to deliver the project within an incredibly compressed schedule—16 months for design and construction. Opened in 2014, this $54.8 million project contains 455 beds, community lounges, conference rooms, as well as designated study rooms. The complex was designed to meet LEED certification serving as a model for Texas Tech's newly adopted sustainability initiatives. Expected to reduce energy consumption by at least 20% over a typical residence hall, West Village utilized ICF walls and precast hollow-core floors, which delivered a highly energy efficient, structurally solid, exceptionally fire-resistant, and acoustically sound dormitory.

West Village Student Condominium, Hamilton, Ontario

Image courtesy of Nudura

West Village Student Condominiums, located near McMaster University in Hamilton, Ontario, operates for less than half the cost of typical buildings of this type thanks to ICF construction. The two 9-story, 208,000-square-foot buildings house 450 students in 107 suites. The LEED Platinum certification was due in part to energy savings of 57 percent which means the owner spends about $1,000 annually per apartment, less than half what a typical apartment building costs to operate. In addition to thousands of dollars saved in energy costs each year, significant cost savings were achieved during construction by downsizing the heating and cooling systems. Additional savings were realized due to reduced construction time of ICFs—the buildings were completed in 10 months.

4. Benefits of ICF Construction

Competitive Construction Cost

In general, insulating concrete form (ICF) construction is cost competitive with wood frame construction. In most cases, ICF walls replace the wood stud bearing walls for a typical multi-family residential building such as an apartment, hotel, dormitory or long-term care facility. The key reasons for cost competitiveness is that ICF walls are less complicated to build than wood frame walls and reduce the number of trades involved in building a wall. In addition, most wood details required to meet building code requirements for energy efficiency, fire and noise have increased over the last two decades thus making ICF wall construction more cost competitive. See Section 1 for details.

Increased Operating Income

Owners of concrete buildings often experience increased operating income over wood frame buildings. The increase mainly comes from savings for energy costs, insurance and reduced losses to vacancy because of reduced noise, increased thermal comfort and lower rent plus utility costs. Concrete buildings have higher net operating income for both the individual metered and the master metered apartment building. However, the highest net operating income is for concrete building that are master metered allowing the owner to charge typical rental rates then add a utility rate that is equal to or higher than the actual utility rate charged by the utility company. See Section 2 for details.

Reduced Insurance Costs

Insurance costs for both builder's risk insurance (during construction) and commercial property insurance (during occupancy) are lower for concrete construction compared to wood frame construction according to a study conducted by NRMCA. For builder's risk insurance, the greatest difference found in the quoted cost of insurance at any location was 72% less for the concrete building and the smallest was 22% less. For commercial property insurance, the greatest and smallest differences found were 65% and 14% less, respectively.

According to the study, some agents volunteered their views on the future of insurance rates and practices for different building materials. They suggested that the gap between rates for wood frame and concrete is likely to grow in the future and that a growing number of insurers are declining to serve as sole insurer for wood-frame apartment buildings. Additionally, insurers of such buildings are increasingly requiring that the insured take extra measures to protect against loss and especially fire loss.

Speed of Construction

ICF systems result in construction that is faster, easier and less labor intensive than other construction methods such as wood or steel framing. ICFs are lightweight, durable and offer a system that requires less skilled labor. The system combines the reinforced concrete structural system along with the thermal, air and moisture barrier in one step which reduces the number of trades required on site. Construction can continue all year long since the forms provide an ideal curing condition for concrete during the hottest and coldest weather. This all results in cutting several weeks and sometimes months off the construction schedule thus saving on costly construction loans and starting the revenue stream earlier.

Ease of Construction

Because the forms stay in place after concrete is poured there is no need for labor intensive wood, aluminum and steel formwork that requires large cranes and other expensive hauling equipment. ICFs are user friendly which means that construction crews new to the system can learn the method quickly. Many crews are familiar with the running bond stacking method used in masonry construction, but instead of stacking small, heavy blocks with wet mortar, they are installing large blocks made with polystyrene, meaning crews can install more wall area per day. The following table shows the construction steps needed for wood frame construction compared to ICF construction.

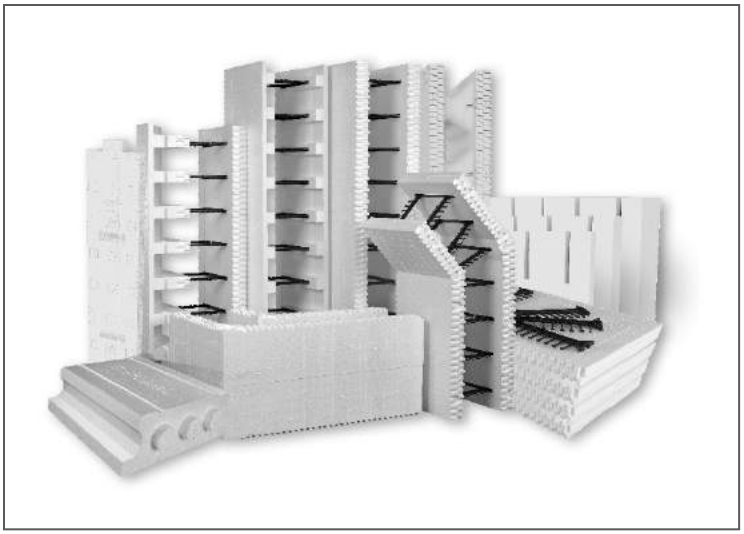


Image courtesy of BuildBlock

Wood Frame Construction	ICF Wall Construction
1. Install stud wall 2. Brace wall 3. Install fire stops 4. Install sheathing 5. Install electrical (no plumbing in exterior) 6. Install insulation 7. Install continuous insulation 8. Install house wrap 9. Install exterior finish 10. Install gypsum wallboard	1. Install forms 2. Install reinforcement 3. Brace walls 4. Pour concrete 5. Install electrical and plumbing 6. Install interior and exterior finish

Lower Floor-to-Floor Heights

One of the major areas where concrete systems can save money over wood frame is in reduced floor-to-floor heights. A typical wood floor truss system is often 24-27 inches deep depending on the soundproofing details, whereas a typical concrete floor system is only 10-12 inches deep thus reducing the floor-to-floor height by 12 inches or more. This might not seem like a significant savings; however, it adds up over 5 or 6 stories. Reduced exterior wall finishes, reduced electrical and plumbing runs among other reductions can result in significant cost savings for concrete over wood frame.

Reduced Ceiling Finish

Concrete floor systems such as precast hollow core plank have a smooth finish that does not require additional drywall or plaster. Often, the only ceiling finish required is paint. At the most, one can provide a smooth plaster coat to the underside of the slab if desired, but generally that is not necessary. This type of construction is common in hotel and dormitory construction, but can be easily adapted for apartment and condominium construction by providing soffits in the service areas such as kitchen and bathrooms. In fact, soffits often add interest and aesthetic appeal to a typical flat ceiling design.

Noise Reduction

Concrete walls and floors have long been used as the material of choice for reducing sound transmission, which is key to a better occupant experience for multi-family residential construction. ICFs are often used for their ability to isolate and dissipate noise. Noise transmission in residential buildings is also important both to reduce noise between units and from the outside. Most multifamily buildings, whether they are apartment buildings or hotels, are generally located in urban centers where car and truck traffic can affect occupants' quality of life. And no one wants to live in an apartment building where you can hear the neighbors or stay in a hotel where you can't sleep because of traffic noise. The fact that ICFs can nearly eliminate sound transmission at virtually no additional cost makes them very attractive for any project in which peace and quiet is a selling point.

The concrete core of ICF offers excellent noise control in two ways. First, it effectively blocks airborne sound transmission over a wide range of frequencies. Second, concrete effectively absorbs noise, thereby diminishing noise intensity. Because of these attributes, ICF walls and floors have been used successfully in multifamily and hospitality applications. The International Building Code has requirements to regulate sound transmission through interior partitions separating adjacent dwelling units and separating dwelling units from adjacent public areas. Six-inch ICF walls easily achieve STC 55 (Sound Transmission Classification) rating. Higher STC ratings up to STC 70 can be achieved with additional gypsum wallboard or special isolation channels. For concrete floors, most meet STC 50 or higher and IIC (Impact Insulation Class) of 50 or higher depending on the floor and ceiling finish as required by the IBC.

Energy Efficiency and Thermal Comfort

ICF walls are considered by the IECC and ASHRAE 90.1 as mass walls with continuous insulation. Typical whole wall ICF assemblies have an R-value between R-24 and R-26 depending on the exterior and interior finish materials compared to R-11 and R-19 for 2x4 and 2x6 wood frame. Thermal resistance (R-value) does not take into account the effects of thermal mass, and by itself does not fully describe the beneficial properties of ICFs. The damping and lag effect of thermal mass means fewer spikes in heating and cooling requirements since the mass buffers indoor temperature fluctuations, contributing to occupant comfort. Thermal mass shifts energy demand to off-peak time periods when utility rates are lower, reducing costs further. ICF walls can exceed the requirements for all climates zones for both residential and commercial thermal envelopes above and below grade because of the combination of extreme R-value and thermal mass.

Achieving a high-performance building envelope also means minimizing air leakage and ICF walls are tighter than wood-frame or light gauge steel walls. In tests, they averaged about half as much air infiltration as wood frame. In many cases the air infiltration rates are as low as 0.5 air changes per hour. Thermal bridging is also eliminated with ICF walls when compared to wood and light gauge steel. Since energy consumption of ICF buildings are lower, the HVAC systems can be smaller and more efficient, adding to energy savings. The result is energy savings ranging from 20 percent to as much as 50 percent depending on other energy efficiency strategies employed for the building.

Fire Resistance

The U.S. Fire Administration reports that fire kills more Americans than all natural disasters combined. In 2015, there were 1,345,500 fires reported in the United States. According to the National Fire Protection Agency, these fires caused 3,280 civilian deaths, 15,700 civilian injuries, and $14.3 billion in property damage. Of all the construction materials used today, concrete is the most fire resistant. This gives the noncombustible concrete structure important safety advantages over traditional combustible wood frame structures.

Unlike wood, concrete cannot burn; and unlike steel, it won’t soften or bend. Concrete will only break down at temperatures of thousands of degrees Fahrenheit, which is far hotter than the temperature of a typical structure fire. Fire safety is important for any building occupancy, but it’s especially critical for residential type construction where people sleep. Concrete has long been recognized as the most fire resistant of all building materials and there are decades of testing available to demonstrate this. However, as with all building assemblies, they must be tested using standard fire tests to demonstrate their fire-resistant capabilities.

Most ICF manufacturers have tested their products in accordance with standard fire testing protocol including ANSI/UL 263-13th Edition and ASTM E119-07. In general, 4-inch ICF walls achieve a 2-hour fire rating, 6-inch ICF walls achieve a 3- or 4-hour fire rating and 8-inch and thicker ICF walls exceed a 4-hour fire rating. Generally the assemblies tested include reinforced concrete with a minimum compressive strength of 2,900 psi and 1/2-inch gypsum wall board on each side.

In addition to fire resistance rating of wall assemblies, it is important to understand the behavior of the EPS under fire conditions. The EPS used for ICFs is manufactured with flame retardants that render the EPS insulation completely unable to support a flame without an outside flame source; it is approximately five times better than wood at stopping flame spread from materials burning in close proximity. That means an extra margin of safety for occupants and first responders. EPS used for ICFs is strictly required to have a flame spread index of less than 25 and smoke developed rating of less than 450 when tested in accordance with ASTM E84 & ANSI/UL 723. ICF companies that maintain national evaluation reports from ICC-ES or other accredited testing agencies have all conducted a long list of materials tests in order to comply with national safety standards.

Disaster Resilience

The heart of ICF construction is reinforced concrete. Reinforced concrete walls and floors have long been the building material of choice for resisting structural loading from wind, earthquakes, flooding and fire. There are many examples of concrete buildings surviving natural disasters while surrounding buildings built with less durable materials simply don’t have the strength and durability to resist the loading. Concrete walls and floors are designed using traditional requirements of the ACI 318 Building Code Requirements for Structural Concrete. The same analysis and design techniques used on traditionally formed concrete buildings are used on ICF buildings. What makes ICF structures even stronger and more durable is the fact that the walls and floors are tied together with overlapping reinforcing steel creating a solid monolithic structure.

These types of structures are extremely resistant to high loading and provide significant redundancy which avoids catastrophic failure. The solid walls act as shear walls to resist wind and earthquake loading. They also provide protection from flying debris from hurricanes and tornadoes. Because concrete and EPS are water resistant, even when a building is subject to flooding, the structure survives. This property protection is vital for communities to withstand and recover from disruptive events.

5. ICF Wall Systems

Often, insulating concrete forms (ICFs) are used for the exterior, corridor, demising and fire walls in bearing wall type buildings. ICFs combine two well-established building products, reinforced concrete and expanded polystyrene (EPS) insulation. The ICF form units are stacked in the shape of the wall, reinforcing steel is added into the form cavity and then concrete is placed into the form. The result is a reinforced concrete wall with a layer of insulation on each side. The forms remain in place after the concrete is cured to provide thermal insulation. The combination of reinforced concrete and insulation provides an ideal load bearing wall, thermal and moisture envelope, fire barrier and sound barrier.

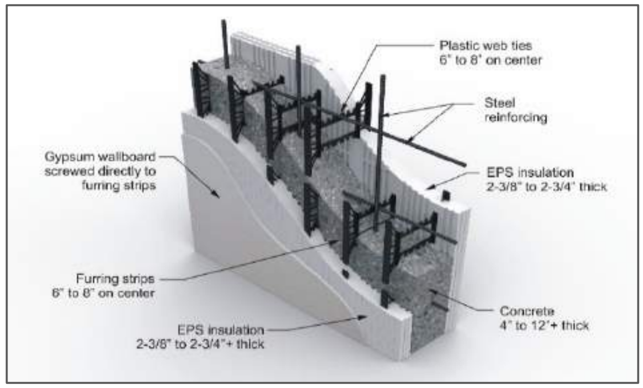


Image courtesy of Logix

Image courtesy of Fox Blocks

ICFs are cost competitive and can be used for all types of commercial and residential construction – from single family to low- to mid-rise multifamily to high rise office and residential. A building owner gets a building that is more disaster resilient and energy efficient at or nearly the same cost. Fire safety is a key element of multifamily construction since occupants sleep in these buildings and are often challenged to evacuate during a fire. Concrete walls and floors provide the fire resistance needed to not only allow occupants to evacuate, but contain the fire within a single unit, imposing less risk on fire fighters and property.

Insulation

Expanded Polystyrene (EPS) insulation used for ICFs is governed by ASTM C 578, Type II closed cell foam with an R-value of 4 per inch. Polystyrene beads are first expanded with steam forming high density beads, which are injected into a mold to form the desired shape. Once removed from the molds and cured, EPS is a stable and durable material ideal for construction. No chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs) or formaldehydes are used in the manufacturing process and there is no off-gassing. EPS is moisture resistant, non-absorbent and resistant to mold and rot. EPS contains a flame retardant and the smoke from burning is non-toxic. In addition, EPS is recyclable at its end of life.

Plastic Ties/Furring Strips

The plastic ties that hold the two wythes of the block together are generally made with polypropylene plastic, but it does depend on the manufacturer. They are designed to withstand the liquid concrete pressure during construction. Most manufacturers design their ties to secure horizontal and vertical reinforcing bars into notches in the ties to minimize the need to use tie wire. The most common spacing is 6 or 8 inches. The ties have no thermal bridging, they do not rot or rust over time, and all ties have furring strips embedded in the EPS for screw-on attachment of exterior or interior finishes.

Reinforcing Steel

Reinforcing steel used in ICF walls is the same used for any other type of concrete structure. Typically, smaller diameter bars are used such as #4, #5 or # 6, but thicker bars can be used for higher loading, concentrated loads and pilasters. In some cases, steel fibers have been used in place of horizontal steel in ICF walls, but most common applications use both horizontal and vertical steel reinforcement.

Concrete

Concrete is typically placed in ICF walls using a boom-type concrete pump, though line-pumps or even conveyor belt equipment can be used. Specified compressive strength used in ICF walls can be whatever is required to resist structural loading, but most common are a 3000 psi or 4000 psi concrete pump mix. The recommended maximum aggregate size should be ½-inch aggregate for 4- and 6-inch cavity forms and ¾-inch aggregate for 8-inch and larger cavity forms. The required concrete slump is 6 inches but could be up to 8 inches or more to accommodate pumping using high-range plasticizers and mid-range water reducing admixtures to achieve necessary flowability.

Image courtesy of Quad-Lock

Electrical, Plumbing and Finishes

As construction continues, electrical and plumbing lines can be embedded into the interior layer of foam by cutting channels with a hot-knife or other tool. Interior or exterior finishes can be applied directly to the surface by screwing into the plastic furring strips. Gypsum wall board on the interior, and stucco, brick or siding on the exterior are common finishes ideally suited to ICF construction but nearly any finish can be applied.

Construction Process

The construction process is simple which is why ICF construction is so cost effective and helps reduce construction time. When building multi-story buildings, the walls are generally erected and cast one story at a time. Structural floors are installed and finished before continuing with walls on the next level.

There are also examples of walls being placed several stories at a time and installing structural slabs later. Some contractors have panelized ICF walls off site to further reduce construction time. Others are beginning to use steel fibers in place of horizontal shrinkage and temperature reinforcement which can also significantly reduce construction time.

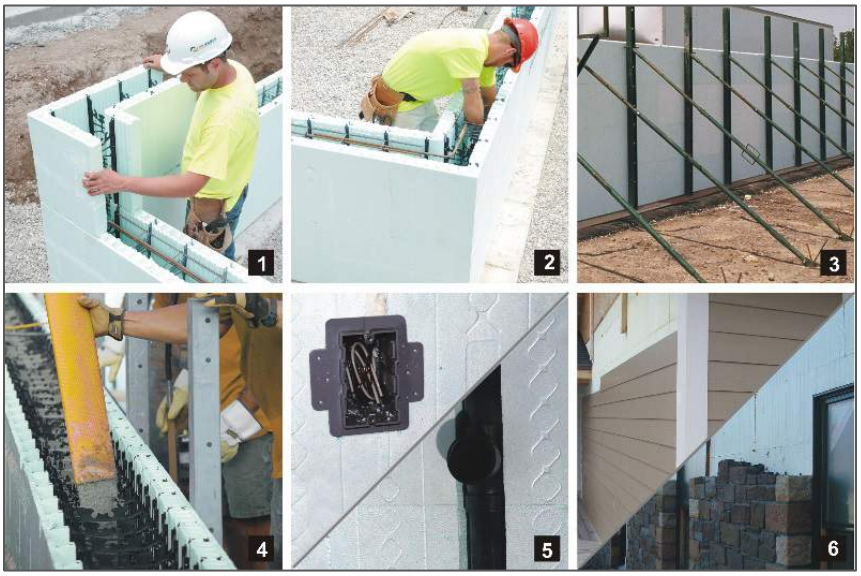


Image courtesy of Nudura

Once the foundation or structural floor is in place, the following process is followed:

- Step 1: ICFs are stacked in the shape of the wall and openings for windows and doors are formed using bucks made of treated wood or plastic.
- Step 2: Then steel reinforcing is placed into the forms and secured in place.
- Step 3: Bracing and scaffolding are installed to keep the wall straight, plumb and secure and to provide a working platform.
- Step 4: Concrete is pumped into the forms.
- Step 5: Electrical and plumbing lines are installed into the EPS by cutting channels with a hot knife or other tool.
- Step 6: Interior and interior finish is installed directly to the ICFs by screwing into the embedded plastic furring strips.

6. Concrete Floor and Roof System

Image courtesy of Amvic

There are several concrete floor and roof systems used in combination with ICF wall construction. Precast Hollow-Core Plank for the floor and roof system, one of the most popular systems for multifamily construction. Typically, ICF walls are installed one story at a time (including concrete) and then precast planks are placed on top of the walls, bearing directly on the concrete. Sometimes a concrete topping is placed on the plank or a thin leveling layer is used to even out the floor to accommodate any finish. For some buildings, the ceiling is simply painted or parged with plaster and painted to conceal the joints between planks. There are dozens of hollow-core plank manufacturers around the U.S. and Canada that can supply product for ICF projects and several have developed special details specifically for ICF construction.

8. Disclaimer

This report has been prepared solely for information purposes. It is intended solely for the use of professional personnel, competent to evaluate the significance and limitations of its content, and who will accept full responsibility for the application of the material it contains. The National Ready Mixed Concrete Association and any other organizations cooperating in the preparation of this report strive for accuracy but disclaim any and all responsibility for application of the stated principles or for the accuracy of the content or sources and shall not be liable for any loss or damage arising from reliance on or use of any content or principles contained in this report.