The Student Apartments at Western State Colorado University were built with insulated concrete forms (ICFs) to withstand high altitudes and severe winter weather.

Photo courtesy of Design West Architects

Making the Business Case for Building with Insulated Concrete Forms: Energy, Sound, and Savings

Insulated concrete form construction can help ensure energy efficiency and noise control while keeping projects on budget

Sponsored by Build with Strength, a coalition of the National Ready Mixed Concrete Association

Developers live by two rules: minimize cost and minimize risk. There is a common misconception that building with concrete is more expensive than wood frame. But the reality is that concrete building systems such as insulated concrete forms (ICFs) have made concrete construction competitive on a first-cost basis and more profitable in the long run because of their energy cost savings, lower insurance costs, and reduced tenant turnover.

CONTINUING EDUCATION

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Learning Objectives

After reading this article, you should be able to:

1. Identify the economic benefits of building multifamily projects with insulated concrete forms (ICFs), including first cost and long-term value.
2. Define the basic design criteria and construction elements of structures built with ICFs for multifamily residential projects.
3. Explain how ICF construction can benefit the health, safety, and welfare of occupants in multifamily buildings.
4. Evaluate the energy-efficiency, disaster-resilience, and noise-mitigation properties of ICFs.

To receive AIA credit, you are required to read the entire article and pass the quiz. Visit **ce.architecturalrecord.com** for the complete text and to take the quiz for free.

AIA COURSE #K2105N

Photos courtesy of Steve Bluestone

The Calvert Lancaster apartments in East Harlem, New York, survived a gas explosion in the building right next door.

With softwood lumber prices rapidly increasing and concrete prices remaining stable, more developers are choosing to build with concrete. In addition, increased risk from structure fires, along with risks from natural disasters such as hurricanes, tornadoes, and wildfires, makes concrete the material of choice for life safety and reducing long-term costs. This results in a long-term investment strategy for apartments, condos, hotels, dormitories, and long-term care facilities.

The Calvert Lancaster apartment building in East Harlem, New York City, is an example of ICFs being able to withstand a disaster, saving lives and protecting long-term investments. In 2014, a natural gas explosion in the neighborhood leveled two 5-story apartment buildings and shattered the windows of structures in the surrounding block. Eight people were killed and 70 others injured.

Immediately next door to the explosion was the four-story Calvert Lancaster building. Despite being situated just inches from the blast, no one in the building was harmed, and all of the occupants managed to evacuate safely.

Curtis + Ginsberg Architects designed the building using ICF construction. The exterior walls were "formed by pouring concrete in a rigid foam form framed with steel rebar." Curtis + Ginsberg Partner Mark Ginsberg says, "There were only a few cracks in the concrete—which is remarkable considering the impact of the explosion. The ICFs facing those two buildings got a little charred but did not burn."[1]

The 6 to 8 inches of concrete provided the building with a fire break, and the New York Building Department informed owner Steve Bluestone that amazingly, "there was no structural damage at all." There was also no damage to the cellar of the building where the boiler, hot water heater, laundry equipment, water booster pump, and fire pump were located.[2]

DEFINING INSULATED CONCRETE FORMS

ICFs combine two building products: reinforced concrete for strength and durability, and expanded polystyrene (EPS) insulation for energy efficiency. ICF walls are made up of two layers of rigid insulation held together with plastic ties to form ICF units with a cavity in the center. The ICF 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. What makes ICFs different than traditional concrete construction is that 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 envelope, fire barrier, and sound barrier.

ICF wall systems have been used for bearing-wall buildings ranging from single-story to high-rise buildings more than 20 stories tall and everything in between. In addition to ICF walls, there are also ICF floor and roof systems. The concept is similar in that the ICF form is made with rigid insulation to function as a one-sided form at the bottom surface. The forms are installed to span between concrete walls, reinforcing steel is placed, and then concrete is placed over the forms. The result is a reinforced concrete floor or roof with rigid insulation on the bottom.

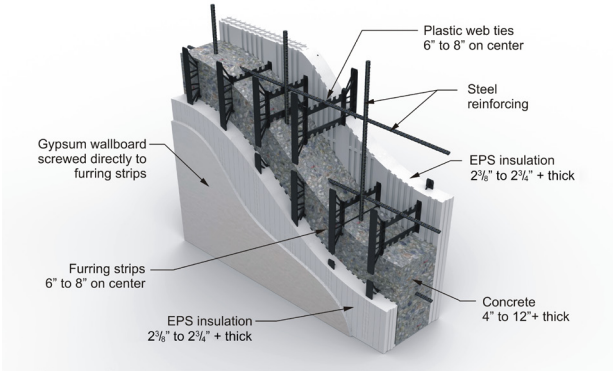
There are examples of ICF buildings all over the United States and Canada, including single-family residential, multifamily residential, hotels, dormitories, assisted living facilities, offices, health-care facilities, manufacturing, and warehouse buildings. Schools built with ICFs are popular due to low- or net-zero energy use. Theaters are also trending toward ICF construction for superior sound attenuation. Because apartments, dormitories, senior residences, and hotels and motels are typically revenue-generating properties, ICFs are particularly well-suited for this type of construction.

What makes ICFs so attractive for multifamily construction is that they are cost competitive with wood frame. 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 not only to allow occupants to evacuate but also contain the fire within a single unit, imposing less risk on firefighters and property.

ICF Wall Systems

The efficient construction process is what sets ICF building systems apart from other building systems, such as wood frame, steel frame, and masonry construction. ICF construction can help contain construction

Image courtesy of Logix



Shown is a typical insulated concrete form (ICF) wall detail.

CASE STUDY: STUDENT APARTMENTS AT WESTERN STATE COLORADO UNIVERSITY, GUNNISON, COLORADO

Photo courtesy of Design West Architects

Sitting at 8,000 feet, this Colorado mountain campus had to be built to withstand life at high altitudes and a severe winter environment. That is why Design West Architects chose a 4-story building design with insulated concrete form (ICF) walls with masonry and stucco veneer for Western State Colorado University's Student Apartments. Modern solutions help keep students comfortable in snowy but sunny surroundings. These include innovative touches like roof coverings that are a combination of high-impact concrete "S" tiles and standing-seam metal roof panels.

The strength is built in with ICFs, and the floors are a composite steel joist and concrete floor deck system. Other features include metal-framed interior walls with high-impact finishes and light-gauge metal roof trusses. All of the rooms have a view in this building with almost 90,000 gross square feet of apartment-style suites. Campus apartments offer two-, three-, and four-bedroom units, providing more than 228 beds in single- and double-occupancy bedroom options.

CASE STUDY: WEST VILLAGE STUDENT HOUSING AT TEXAS TECH UNIVERSITY, LUBBOCK, TEXAS

Photo courtesy of Mackey Mitchell Architects (left); photo courtesy of Fox Blocks (right)

Shown is the West Village Student Housing at Texas Tech University completed (left) and under construction (right).

A design-build project with Whiting-Turner, BGK Architects, and Mackey Mitchell Architects, this 230,000-square-foot West Village 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 complex contains 455 beds, community lounges, conference rooms, and designated study rooms. It 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 percent over a typical residence hall, West Village utilized insulated concrete form (ICF) walls and precast hollow core floors, which delivered a highly energy-efficient, structurally solid, exceptionally fire-resistant, and acoustically sound dormitory. Another key aspect of the project was indoor air quality. Expanded polystyrene (EPS) is a stable and durable material ideal for construction. No chlorofluorocarbons, hydrofluorocarbons, or formaldehydes are used in the manufacturing process, and there is no off-gassing.

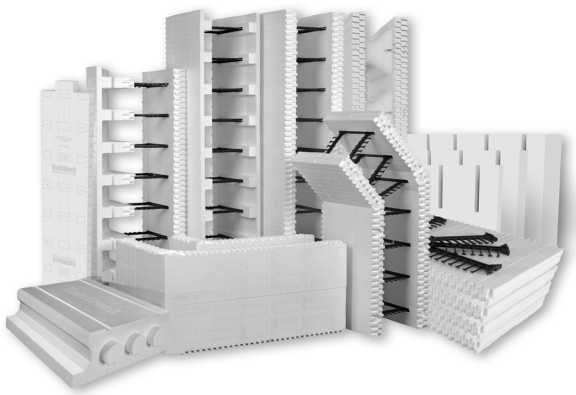
costs and reduce construction time because of the inherent efficiencies of the installed assembly, which serves nine functions:

1. Concrete form (that stays in place)
2. Thermal barrier
3. Air barrier
4. Moisture barrier
5. Fire barrier
6. Sound barrier
7. Substrate for running utilities
8. Substrate for attaching finish materials
9. Reinforced concrete structure

In other forms of construction, these functions are installed by several different trades, usually at a significant added cost. General contractors can realize a number of on-site efficiencies, including fewer trades, reduced crew size, and accelerated construction schedules. Because construction schedules are usually much shorter with ICF construction, the general contractor can finish the project both on time and within budget. This means that the building owner can put the building into service sooner, cutting short the financing costs and initiating a quicker revenue flow.

There are many different ICF manufacturers with similar ICF systems. The blocks range in size from 48 to 96 inches long and 12 to 24 inches high depending on the manufacturer. The most common configuration of an ICF unit is made up of two layers of 2⅜- to 2¾-inch-thick EPS insulation spaced 4, 6, 8, 10, or 12 inches apart depending on design requirements. The most common spacing is 6 or 8 inches for most low- to mid-rise buildings, but for taller

Image courtesy of BuildBlock



Shown are ICF wall and floor components.

buildings, taller walls, or exceptionally large loadings, thicker walls are necessary. For simplicity, ICFs are generally called out by the width of the cavity; hence, an ICF with a 6-inch cavity is called a 6-inch ICF and an ICF with an 8-inch cavity is called an 8-inch ICF.

ICF manufacturers have a variety of ICF blocks to accommodate any design condition and offer thorough technical support, including design manuals, design details, engineering support, and test reports needed for commercial construction, including fire, energy, and noise. They have special components, including straight blocks, corner blocks, brick ledges, angled blocks, curved blocks, and half-height units, minimizing the need for field modifications and further reducing construction time.

Another benefit of ICFs is that construction projects can continue through the coldest and hottest weather because of the insulating quality of the ICF forms. This means that concrete will continue to gain strength within the protective formwork despite freezing conditions and not overheat during extreme summer conditions.

Matt Green, the vice president of KB Walker based in Waukesha, Wisconsin, discusses the ability to build with ICFs in winter conditions. "One of the biggest things you

GLOSSARY

Capitalization rate (cap rate): This is a real estate valuation measure used to compare different real estate investments. Cap rate is calculated as the ratio between the net operating income produced by rental property and the original capital cost (the price paid to buy the asset) or its current market value. Generally, the higher the cap rate, the more valuable the property.
Continuous insulation (CI): This is defined by ASHRAE 90.1 as "insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings."
Expanded polystyrene (EPS) insulation: This is closed-cell insulation made from polystyrene polymers.
Insulated concrete forms (ICFs): These are made from reinforced concrete and expanded polystyrene insulation (EPS). They are made up of two layers of rigid insulation held together with plastic ties, forming units with a cavity in the center. Reinforcing steel is added to the cavity and then concrete is poured into it.
ICF blocks: These range in size from 48 to 96 inches long and 12 to 24 inches high depending on the manufacturer. The most common configuration is made up of two layers of $2^3/_8$-inch to 2¾-inch-thick EPS insulation spaced 4, 6, 8, 10, or 12 inches apart depending on design requirements
Mass wall: This provides energy efficiency by storing energy during the day and releasing it at night. It includes ICFs, concrete, and concrete block.
R-value: This measures resistance to heat flow. The higher the R-value, the greater the resistance.
Reinforced concrete: Steel is embedded into the concrete to resist stresses.
Resilience: This is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient building depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event, including natural and manmade events such as fire, wind, earthquakes, and flooding.
Thermal mass: This is a material's ability to absorb and store heat.

SIX CONSTRUCTION STEPS

The construction process when building with insulated concrete forms (ICFs) is simple, which is why construction is cost-effective. Once the foundation or structural floor is in place, these steps are 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: 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 provide a working platform.
Step 4: Concrete is pumped into the forms.
Step 5: Electrical and plumbing lines are installed into the expanded polystyrene (EPS) by cutting channels with a hot knife or another tool.
Step 6: Interior and exterior finish is installed directly to the ICFs by screwing into the embedded plastic furring strips.

Shown are the six construction steps of insulated concrete forms (ICFs).

Photo Courtesy of Nudura

When building multistory 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.

can look at with ICFs in terms of hard numbers is pouring concrete in winter conditions," he says. "In climate zones 4 and up, there are going to be temperatures below which concrete cannot otherwise be poured. However, with ICFs, we have poured concrete in temperatures as low as 5 degrees Fahrenheit."

Rather than waiting for spring to begin construction, specifiers can leverage the insulating properties of ICFs to begin building at any time of the year.

ICFs in Combination with Other Floor and Roof Systems

There are many options for floor systems that integrate well with ICF wall systems. ICF walls are simply concrete bearing walls, so any floor system that is used for other types of bearing-wall construction can be used in combination with ICF wall systems. These include traditionally formed reinforced concrete slabs, ICF slabs, precast hollow-core plank, concrete on metal deck combined with steel joists, or cold-formed joists. Wood framing systems for floor construction can also be adapted for connection to ICF walls using embedded ledger bolts.

When to Use ICFs

ICF walls are best suited for bearing-wall-type construction. If the architectural style for the building is to be floor-to-ceiling glass with large cantilevered balconies, traditional concrete flat-plate construction is the best option. However, if the building is a typical apartment building, hotel, dormitory, or assisted living facility with a significant solid exterior wall that includes punched window openings, ICFs are the ideal solution. Generally, these types of buildings have a rectangular floor plate with the elevator located in the center. Longitudinal corridors service living units on either side. Each unit has a solid wall both on the exterior and at the corridor, making them ideal to function as structural bearing walls.

Furthermore, since multifamily construction requires fire barriers between dwelling units, ICF walls create a superb demising wall. Besides providing superior protection from spreading fire (2 to 4 hours), ICFs also have excellent noise-attenuation properties. Whether designing an apartment complex or hotel, both fire safety and noise reduction are always concerns. Energy efficiency is also a major concern for apartment owners and hotel operators. ICF concrete buildings benefit from the lower energy bills resulting from the high-performance envelope.

Photo: Johnny Milano/*The New York Times*/Redux

CASE STUDY: LONE SURVIVOR, MEXICO BEACH, FLORIDA

In 2018, Hurricane Michael—a Category 4 hurricane with sustained winds of between 130–156 miles per hour (mph)—tore through Mexico Beach, Florida. In what has now become an iconic image, a nearly undamaged house on stilts is shown surrounded by devastation and flattened properties.

The house was built to specifications that exceeded local codes: It was built to withstand winds of up to 250 mph.[3] The home's base consists of 12-inch square precast, pre-stressed concrete piles. Precast concrete beams extend upward from the base, supporting the interior and exterior walls for fortification from a coastal surge.

Each of the building's 6-inch-thick concrete exterior walls was created from insulated concrete forms (ICFs) in a continuous insulation system laced with vertical and horizontal steel rebar. This method allowed siding to be anchored directly to the core of the structure, increasing the integrity overall. Concrete also bolstered the corners of the home, and space underneath the roof was minimized to prevent wind uplift.

In an interview for *The New York Times*, former Miami-Dade building chief Charlie Danger maintains, "'It pays to rebuild structures that withstand something like that. You minimize loss of life—and the loss of infrastructure. If you lose the infrastructure, you lose everything.'"[4]

Constructing a building reinforced to this extent proved to be marginally more expensive than comparable buildings with a payback of fewer than four years with energy savings. The materials used for construction afforded the homeowners reduced insurance cost, a quieter structure, faster construction, and lower energy bills, all of which will be discussed in greater detail in upcoming sections.

When to Consider ICFs

ICFs should be considered for any building that has a long-term owner, such as a build and hold developer or a government entity. Generally, because these forms and the wall system become so energy efficient, locations, where the latest energy codes have been adopted are well-suited to building with ICFs. They are also well-suited to any kind of a wall system that has many punched openings, as the energy codes are now forcing buildings to adopt such openings, especially in multifamily construction. Any place where resilience (to fire, wind, earthquakes, and/or flooding) is an issue is also ideal for building with ICFs.

In the past, short-term building owners or build and sell developers—who oftentimes are not concerned about long-term value and are more concerned about short-term costs—usually built with the cheapest form of construction: wood frame. However, with recent spikes in soft-wood lumber prices, ICF construction has become first-cost competitive. If the building is in a location where energy codes are outdated (which is becoming

rare), constructing a highly energy-efficient building might become less compelling if the builder is intent on selling the building.

As mentioned previously, curtain walls are better suited to concrete-frame construction than ICFs. However, some structures with curtain walls have been built using ICFs, where ICFs more or less form a frame around the exterior and then spandrel glass is used in front of the ICFs.

FIRST-COST COMPARISON

Senior Living Facility: ICFs versus Wood Frame

ICFs can easily be compared to wood-frame construction to assess long-term cost savings. One example is a senior living facility in Oconomowoc, Wisconsin:

- Total size of wood-frame construction = 176,444 square feet
- Cost of wood framing including the exterior insulation = $4.32 million or $24.48 per square foot
  - The codes have stepped up to increase insulation requirements on the exterior of multifamily buildings, which also drives up the costs.
- Cost of wood framing minus the exterior walls = $3.4 million or $19.27 per square foot
  - This is the same project without exterior walls. Wood is only used on the interior (for example, trusses, floor joists, interior walls).
- Cost of ICF exterior walls = $950,000 or $5.38 per square foot
- Total for wood frame = $4.32 million
- Total for ICFs plus wood frame interior = $4.35 million

Pros of ICFs During Construction

ICFs offer the following benefits for projects like the senior living facility discussed above.

- Ability to pour stair towers and elevators shafts concurrent with structure, also making both more soundproof. For example, a mason does not have to come in to run a CMU shaft prior to the walls going up.
- Eliminate exterior vapor barrier.
- Continuous R-22 or greater continuous insulation with the added bonus of concrete thermal mass.
- Can pour in winter conditions (down to 15 degrees Fahrenheit because both sides of the wall are insulated; the contractor simply insulates the top of the wall).
- Structural integrity of the wall allows for numerous possibilities, including hanging balconies, masonry tower, or trash chute tie-offs, skip hoist tie-offs, etc.

CASE STUDY: KENDAL LOFTS

Photo courtesy of Bedford Developments

Location: Waukesha, Wisconsin
Units: 42
General Contractor: Bedford Developments
Architect: TDI Associates

One of the first projects that Bedford Developments worked on was in Waukesha, Wisconsin. The Kendal Lofts were the first of its kind: a 42-unit project with a new timber-framed interior with ICF exterior walls. Comprised of custom hardwood 8-foot doors, hardwood floors, and Amish cabinets, the project was born from an idea of Bedford Development's now-retired owner Ken Miller.

As noted by Ryan Bedford, president of Bedford Developments and Miller's son-in-law, Miller wanted to build a loft that resembled a warehouse but "did not like the thermal inefficiencies of lofts." Miller was then inspired to use ICFs alongside timber.

"Today, you hear a lot about timber-frame buildings or mass-timber buildings," Bedford says. "The issue with this is that as green and sustainable as they say they are, they are really not green." Essentially, the wood has to be cut down, transported by train to a mill, and once in the mill, it has to be glued together and transported again from one side of the country to the other. Many plants are located in Seattle, Oregon, and Canada.

For Kendal Lofts, Bedford Developments was able to ship reclaimed timbers from a building in Chicago, re-sawing and reusing them. The aggregate for the concrete, however, was locally sourced because, as Bedford notes, "concrete is one of the most locally reliable materials you can find across the United States."

The entire exterior of Kendal Lofts is entirely ICFs. In the corresponding image, the gridwork of the timbers being placed into the ICFs and the stud walls on the interior can be seen. The post and beam timber-frame style of the interior offers the aesthetic factors of a warehouse, but the ICFs provide the building with energy efficiency.

- Improves sound transfer through the exterior wall.

The best long-term savings occur in climates where the average daytime temperature goes above and below the interior temperature. The concrete will act as a thermal mass, eliminating the need for heating or cooling spaces in those conditions. In a cold environment like Wisconsin, there are many benefits to using ICFs.

Cost Comparison: ICFs/Steel Stud versus Wood

ICFs can also be compared to wood/steel stud construction. The example below discusses a 60-unit structure in Sarasota, Florida, with 71,769 total square footage.

- Total for wood frame = $24 per square foot, $1,722,456
  - Includes Florida hurricane bracing requirements and treating the studs for termites, both of which increase the price.
- All concrete/steel stud:
  - ICFs = $920,000
  - Precast concrete with stairs and topping = $680,000
  - Steel stud interior walls = $175,000
- Total for ICFs/steel stud = $1,775,000

Pros of ICFs in Florida

As the Mexico Beach home in the introduction illustrated, using ICFs in Florida provides the following benefits:

1. Disaster resistance
2. Mold resistance
3. Termite protection
4. Energy efficiency

Overall, ICFs provide long-term value for occupants and owners. They are cost competitive with wood per square foot. However, the thermal properties and durability of ICFs often outperform wood for greater life-cycle savings.

INCREASING ENERGY EFFICIENCY AND DECREASING NOISE AND VIBRATION

Houses and mid-rise apartments are sometimes constructed poorly, often for the sake of flipping a house or apartment building for a profit. However, it is becoming readily apparent that buildings need to be designed and constructed to last for generations rather than only a few decades.

Energy Efficiency

According to a report from the Institute for Market Transformation (IMT), increasing the energy efficiency of America's multifamily buildings—nearly 18.5 million households—could save building owners and managers, residents, governments, energy-efficiency service providers, and financiers close to $3.4 billion annually. ICFs provide solutions to these growing energy concerns: their high thermal mass reduces conduction and convection. The result is a building with lower energy usage and improved comfort inside due to more consistent temperatures and lack of drafts. A more energy-efficient envelope means more money saved every year while reducing the project's carbon footprint.

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

Photo courtesy of Ricchi Group

CASE STUDY: THE RICCHI CONDOMINIUMS

Location: San Antonio, Texas
Units: 87
General Contractor: Ricchi Group
Architect: Spazio Design + Construction

The Ricchi Condominiums located in San Antonio, Texas, are a contemporary, mid-rise building consisting of 87 luxury condominiums. The development was the first of its kind to be built in the exclusive area of La Cantera Parkway. The developers wanted to provide a first-class, secure, and quiet building. They chose insulated concrete forms (ICFs) 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 International Airport and is adjacent to a U.S. Army training camp.

As a solution, the U-shaped, luxury condominium utilized more than a quarter-million square feet of ICFs. All of the exterior walls of The Ricchi, as well as the interior walls between units, carports, pool houses, and even the changing rooms, are made of ICFs. To provide views for the occupants, the architect was able to visually "break up the massive walls into smaller segments and create individual condo entrances along the 225-foot-long corridors inside."[5]

While this meant dozens of corners and a multitude of window and embeds, the architects noted that by the time they began work on the upper levels, "'things started to smooth out, and we were able to work very efficiently.'"[6]

Overall, the sound attenuation offered by ICFs provided resolved noise concerns throughout the development while creating significant energy savings. The higher insulation provided by the ICF walls reduced HVAC tonnage by 20 percent, resulting in significant energy savings.

Photo: © Peter Mauss/Esto

CASE STUDY: BEACH GREEN DUNES, ROCKAWAY, NEW YORK

Completed in 2017, the 101-unit, 94,000-square-foot Beach Green Dunes apartment building is built in an area that was devastated by Hurricane Sandy. The Bluestone Organization selected insulated concrete forms (ICFs) for exterior, corridor, and demising walls, and precast hollow-core floors for disaster resilience and energy efficiency. The building is so energy efficient that 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 creates a structure that is strong, durable, and can stand up to fire, floods, and wind. The Bluestone Organization builds exclusively with concrete.

The project, designed by Curtis + Ginsberg Architects, incorporates many innovative features to achieve record-breaking low energy and water consumption levels. These include the use of ICFs, energy-recovery ventilation, a large rooftop solar photovoltaic system, and a natural gas fired cogeneration system that produces electricity, all of the building's hot water needs, and serves as a backup emergency generator to supply power to safety systems in the event of a future power outage.

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 climate 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 the 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.

Noise and Vibration

Concrete walls and floors have long been used as the material of choice for reducing sound transmission, which is key to a better guest experience in the hospitality sector and better retention rates in multifamily housing. Occupant retention rates and financial savings will be discussed in more detail in the following section.

ICFs are often used for hotel and hospitality projects for their ability to isolate and dissipate noise. Noise transmission in residential buildings is also important to reduce noise both 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. The fact that ICFs can eliminate sound transmission at virtually no additional cost makes them attractive for any project in which peace and quiet is a selling point.

The concrete core of ICFs offer excellent noise control in two ways. First, it blocks airborne sound transmission over a wide range of frequencies. Second, concrete 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 (IBC) 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 a sound transmission classification (STC) rating of 55. Higher STC ratings of up to STC 70 can be achieved with additional gypsum wallboard or special isolation channels. For ICF floors, most meet STC 50 or higher and an impact insulation class (IIC) rating of 50 or higher depending on the floor and ceiling finish as required by the IBC.

THE OWNERSHIP BENEFITS OF BUILDING WITH ICFs

For architects, owners, or developers considering working with ICFs, there are four key factors to consider:

1. **Retention.** This is especially important when considering senior living and multifamily apartments. If residents are

Photo courtesy of EYC Companies (left); Photo courtesy of Amvic (right)

Shown are the 17 South Apartments in Charleston, South Carolina, completed (left) and under construction (right).

CASE STUDY: 17 SOUTH APARTMENTS, CHARLESTON, SOUTH CAROLINA

The builders of this 220-unit multifamily apartment complex, EYC Companies, knew that strength and durability of the building directly affects the safety of its tenants. This is why they opted for insulated concrete forms (ICFs) for the exterior walls for their showcase development. Not only are these buildings safe from high winds and coastal flooding, but they are also extremely energy efficient, allowing EYC to master meter the entire complex and pass the energy savings onto the tenants. In addition, EYC opted to self-perform the ICF walls, which further saved time and money during the construction process, ultimately making the project a win-win for both the building owner and his tenants.

comfortable, safe, and saving money on electric and gas bills, they are more likely to stay in their units. If the occupant turnover rate is reduced, the owner saves money.

In wood-frame buildings in the United States, units experience approximately 30–40 percent turnover rates. With ICFs, the turnover rate is 15–25 percent. It should be noted that some turnover rates are because renters are moving from one- to two-bedroom units in the same building. Owners still pay some of the turnover cost, but the tenant is not actually leaving.

Example: If there are 100 units in a wood-frame building and each has a rental cost of $500, a 30 percent turnover equates to $15,000. With ICFs, a 15 percent turnover amounts to $7,500.

Result: $7,500 increase to net operating income (NOI) or $136,000 of value at 5.5 percent capitalization rate (CAP).

2. **Reserves/deferred maintenance.** This is an important issue with people that are acquisition buyers for apartments, but ground-up developers frequently do not do a good job with reserves or deferred maintenance costs on projects. With ICFs, these reserves can be reduced by about 30 percent. Typically, about $250 a unit per year goes into a reserve fund; however, this can be reduced primarily because there are no issues with water intrusion and mold on the exterior. Often, when siding is replaced, owners end up having to replace the substructure and the OSB that is there because of unexpected mold.

   Example: 100 units at $250 a unit is $25,000 for a wood frame. With ICFs, the cost is approximately $17,500, which is another savings of $7,500.

   Result: $7,500 increase to NOI or $136,000 of value at 5.5 percent CAP

3. **Energy efficiency.** Conservatively speaking, there is an estimated 50 percent in heating and cooling savings. Depending on construction methods and the efficiency of the products used, energy savings often are more than 50 percent.

   Example: 100 units with average heating and cooling costs for common areas is $2,500 a month. Wood frame is $30,000; ICFs are $15,000.

   Result: $15,000 increase to NOI or $272,000 of value at 5.5 percent CAP

4. **Insurance.** Owners have the opportunity for a possible savings of 10–15 percent off annual insurance premiums as builder's risk policies have been increasing for wood-frame construction. From an ownership standpoint, there is an average of 10–15 percent annual savings, which sometimes amounts to 30 percent.

   Example: 100 units at $400 a unit per year.
   Wood frame: $40,000
   ICFs: $34,000–$36,000
   Result: $4,000 to $6,000 increase to NOI or $72,000 to $109,000 of value at 5.5 percent CAP.

   In total, owners would save $34,000 to NOI or $618,000 of value at 5.5 percent CAP. There are additional savings if the owner is responsible for utilities or if the building is a hotel.

   Example: 100 units, $100 average monthly heating and cooling costs.
   Wood frame: $120,000/year
   ICFs: $60,000/year
   Result: $60,000 addition to NOI or $1,090,000 in value at 5.5 percent CAP.

   Overall, while the upfront costs of building with ICFs might be slightly more, the savings over time are more substantial than the initial increase in construction cost.

CONCLUSION

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.

Photos courtesy of Fox Blocks

Shown is the Holiday Inn Express in Louisville, Kentucky, completed (left) and under construction (right).

CASE STUDY: HOLIDAY INN EXPRESS, LOUISVILLE, KENTUCKY

This 8-story Holiday Inn Express was built with insulated concrete forms (ICFs) in the heavily populated Museum Row district in downtown Louisville, Kentucky. Standing about 100 feet tall, it is the tallest building in the area. ICFs were selected in part because the extremely tight site meant that 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 its first ICF project.

After touring another Holiday Inn project being built with ICFs across the river in Ohio, it was convinced. ICFs cut three months off the already accelerated schedule. With conventional construction techniques, a typical 8-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.

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 also continue all year long since the forms provide an ideal curing condition for concrete during the hottest and coldest weather. 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.

All of this leads to a construction system that is ideal for today's competitive construction environment. ICFs are also ideal for building owners, providing retention, deferred maintenance, energy efficiency, and insurance benefits and savings without sacrificing design quality.

As Matt Green of KB Walker maintains, "Design and functionality should coexist. As the world becomes more interconnected and cities become denser, ICFs will continue to offer bigger and bigger advantages." He notes that developers, owners, builders, and architects alike will "want to make sure their buildings are as insulated from man-made disasters as from natural disasters. And the best thing you can do to make sure your bottom line is not impacted through any sort of adverse activity is to build with concrete."

END NOTES

[1]"The Benefits of Using ICF: One Architect's Perspective." *Architect*. Web. 23 April 2021. <www.architectmagazine.com/design/buildings/the-benefits-of-using-icf-one-architects-perspective>.

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[3]Mazzei, Patricia. "Among the Ruins of Mexico Beach Stands One House, Built 'for the Big One.'" *The New York Times*. 14 October 2019. Web. 23 April 2021. <www.nytimes.com/2018/10/14/us/hurricane-michael-florida-mexico-beach-house.html>.

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