GUIDE

Residential Walls and Foundations: Improving the Thermal Envelope

A comparison of ICF construction and other forms of walls and foundations

Developed and published by

proudgreenhome.com
knowledge for creating, remodeling, and sustaining extraordinary homes

Sponsored by

FOX BLOCKS
Be Clever… Build Green

Contents

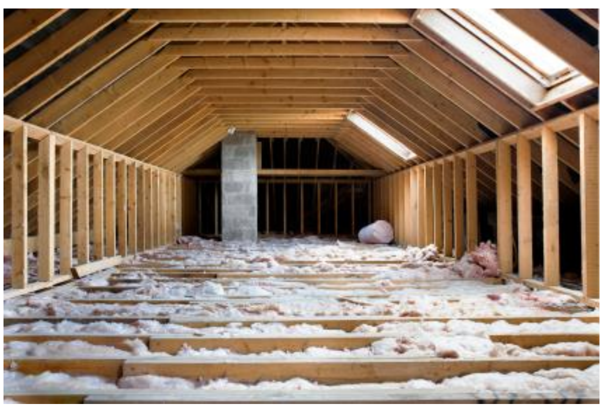
Introduction

Written by Gary Wollenhaupt

A green home is a high performance home, one that's efficient in construction and operation. A green home can offer a significant return on investment in lower utility bills, comfort and safety.

One of the first major decisions a homeowner or building professional will make is to determine the type of wall system and foundation system that will form the structure of the home.

One way of looking at the structure of the home is to consider the thermal envelope. The thermal envelope encompasses all the aspects of a house that shield the living space from the outdoors. It includes the wall and roof assemblies, insulation, air and vapor retarders, windows, and weather stripping and caulking.[1]



Traditional homes may use insulated attic floors as the primary thermal control layer

The thermal envelope is not the same as the building envelope, although in some cases such as windows, they can be the same thing. The thermal envelope is also known as the heat flow control layer that controls the movement of air through a home's structure.

Think about it this way: An insulated attic floor is the primary thermal control layer between the inside of the house and the exterior. The entire roof (from the surface of the shingles to the interior paint finish on the ceiling) comprises the building envelope.

A tight thermal envelope translates to lower utility bills and greater comfort. A flawed thermal envelope leads to excessive energy use and hot and cold spots in your home.

Why is the thermal envelope so important? The U.S. Department of Energy estimates that about 40 percent of the energy used in buildings is associated with heating, ventilation, and air-conditioning.

In northern latitudes, homeowners know that the winter heating bill can be the largest utility bill for the house. Thus, reducing heat losses from a building, and increasing the heat gain through appropriate use of windows, can have a major impact on the amount of energy consumed by a building. Reducing energy therefore reduces costs, and also reduces impact on the environment from reduced burning of fossil fuels for heating and cooling.

This guide, sponsored by Fox Blocks, a leading manufacturer of insulated concrete forms, explores some of the most popular wall and foundation systems used in green home construction today. The choices made for walls and foundation systems relate directly to the performance of the thermal envelope for the home.

It is difficult to provide cost comparisons due to regional differences in building supplies and contractor knowledge. Keep in mind that to get an accurate picture requires looking at the total cost of building and operating a home.

For instance, while ICFs may cost more than a stick-built home on a linear wall basis, the actual impact on the home's overall cost will be much lower due to faster build time, and the ability to use smaller heating and air conditioning systems, and lower operating costs.

Of course, before proceeding on any construction project, check with local authorities for the latest building code requirements in your area.

Building New Traditions

As homeowners and building professionals learn more about building science, they understand more about how to design and build homes for the ultimate in performance and comfort. Part of that learning is about the shortcomings of the traditional home construction style.

Traditionally built homes are often described as “stick built” homes. These homes are usually built with pieces of lumber that are cut and nailed together into walls and roof trusses. They are then linked together and sheathed with plywood on the exterior and drywall on the interior. The exterior of the homes is usually finished with shingles, clapboard, vinyl siding or something similar.

Even though it is how most homes are built, there are many disadvantages to this type of construction. Measuring, cutting, fitting and nailing each part of the house together can be very time consuming, and any mistakes made during this process can waste material and drive up costs. Weather can also be a factor in damaging the materials.

Once completed this type of home is also more expensive to maintain. Stick-built homes aren't very energy efficient and lead to higher utility bills. Over time, stick-built homes also can have termite, water and mold damage.

Stick-built homes aren’t very energy efficient and lead to higher utility bills. Over time, stick-built homes also can have termite, water, and mold damage.

Building science has led to the development of new styles of construction for walls and foundations that offer great energy efficiency, strength and safety and comfort. One barrier to building more energy-efficient, eco-friendly homes is the perception of higher costs. While it's true that some materials are more expensive, and adding renewable energy systems such as solar photovoltaic can boost costs, it's also true that building for energy efficiency pays off. Homeowners and builders have to look at the long-term cost of designing, constructing and living in an energy-efficient residence, according to Peter Pfeiffer, a principal with Austin, Texas-based Barley & Pfeiffer Architects.

"The most sophisticated outlook is to consider what it is going to cost to own this house," Pfeiffer said. "Construction represents 15 to 20 percent of a family's cost of owning a house over the next 20 years. Other things like maintenance, insurance and energy consumption dwarf the construction cost over the next 20 years."

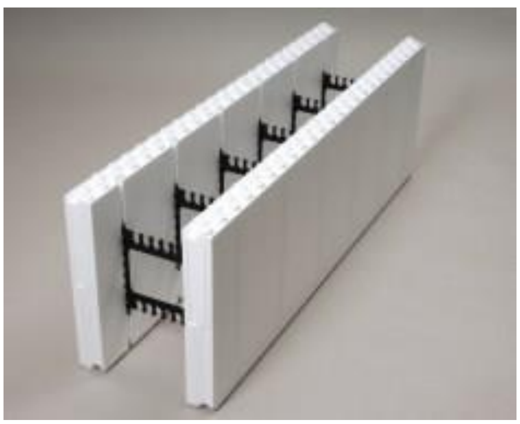
E3 Design Group compared the costs to build a masonry block wall and an insulated concrete form wall in South Florida. They found that an ICF wall costs more than a concrete block wall, but it is less than a 10 percent increase in price. However, their tests also found that ICF construction resulted in an average of 38 percent reduction in energy usage for heating and cooling.[2]

Chapter 1 Wall systems and above-grade applications overview

This section provides an overview of some of the most popular types of energy-efficient wall systems.

Insulated Concrete Forms

Insulated concrete forms (ICFs) are rigid plastic foam forms that hold concrete in place during curing and remain in place to serve as thermal insulation for concrete walls. The foam blocks or planks are lightweight and result in durable, energy-efficient construction. Because of their benefits, ICFs are desirable in above-grade applications as well as foundations.



Example of an Insulated Concrete Form (ICF)

The forms, made of expanded polystyrene (EPS) foam insulation, are either pre-assembled interlocking blocks or knock-down panels connected with plastic ties. The stay -in-place forms not only provide a continuous insulation and sound barrier, but also a solid backing with a continuous fastening stud for drywall on the inside, and lap siding, EIFS, stucco or brick and stone on the outside.

ICFs allow contractors to construct concrete walls without a significant investment in reusable wood and metal forms. Because ICFs fit together easily and remain in place after concrete is poured, they can simplify and speed up construction. ICFs increase the temperature range for pouring concrete to below freezing (freezing inhibits proper curing) by insulating the concrete until it is fully cured. ICFs can also result in stronger walls than standard cast-in- place concrete due to more constant, predictable cure during all seasons.

There are two basic types of ICFs: hollow foam blocks and 4 x 8 panels with integral foam or plastic ties.

Block systems resemble hollowed-out concrete masonry units (CMU) in size and shape, although the dimensions may vary from the typical CMU. Their edges interlock without separate fasteners, using a rabbeted edge, tongue-and-groove configuration, mortise and tenon-type configuration, or similar. Blocks arrive on site fully assembled, ready to stack with their ties, made of the form material itself, metal, or plastic imbedded in the form.[3]

Panel systems are the largest units and resemble traditional plywood forms. Panel systems allow a large section of wall area to be erected in one step, but may require more cutting in the field. The panels have flat sides and are connected to one another with metal or plastic ties.

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

Advantages over conventional construction include a reduction in the number of trade contractors required, strength, thermal efficiency, reduction in through-the-wall sound transmission, and the ease of construction.[4]

Structural Insulated Panels

Structural insulated panels are systems of rigid expanded polystyrene foam sandwiched between panels of oriented strand board (OSB). SIPs are fabricated off-site, come in thicknesses from 4 to 12 inches, and are fairly interchangeable with wood frame construction.

Little dimensional framing lumber is used, although windows and doorways greater than 5 feet across require headers, and beams are required to support longer roof spans.

Advantages of SIPs include a very high effective R- value (thermal resistance), excellent soundproofing performance and rapid on-site installation. Mechanical ventilation is typically required when using SIPs due to the resulting airtight nature of such construction.

SIP construction can be directly competitive with frame construction, especially when compared to other high-performance R-30 wall systems. The extent of changes required in SIP construction to achieve R-30 is less than the changes required to achieve R-30 in hybrid frame wall systems.[5]

SIPs are capable of supporting typical loads for bearing walls, intermediate floors and roofs. They can provide both the primary structure and the envelope or they can be used with other structural systems such as post-and-beam construction to provide exterior envelope and insulation.

SIP construction eliminates wall cavities, reducing the potential for condensation in the middle of the wall. The large, precut panels also significantly reduce the potential for air leakage. This results in a tighter, more durable envelope, with better indoor air quality and reduced energy use.

Advantages of SIPs

- Very effective R-value
- Excellent soundproofing
- Rapid on-site installation

Disadvantages of SIPs

- Lack of familiarity in the trade
- Higher costs than standard
- Difficult to make changes

SIP systems reduce heating energy use in two primary ways. First, the panels provide continuous insulation with far fewer thermal bridges compared to a typical stud wall. That means R-values for a 6-inch SIP wall can be almost twice as high as a typical 6-inch stud-frame wall with fiberglass batt insulation. Second, the panels create an envelope with fewer seams, decreasing air leakage. The air tightness of a SIP-constructed home can be as low as a third of typical new construction. These properties also increase thermal comfort of the home by eliminating cold spots and drafts.

The disadvantages of SIP construction include lack of familiarity in the trade, higher first costs compared to standard stud-frame construction, and increased difficulty making changes such as re-locating or re-sizing doors and windows. SIPs also have higher embodied energy than stud-frame construction from the manufacturing process.[6]

Builders and contractors who have become familiar with SIP construction feel that the dramatic increase in speed of construction, especially the time needed to enclose a building, offers net cost savings.[7]

Advanced Framing and Wood Frame Construction

The building products industry has developed many variations on wood framing construction to address some of the shortcomings of this popular wood style. The new approaches attempt to reduce the amount of resources used and improve the effectiveness of the thermal envelope. One value of staying with the traditional approach is that contractors are more familiar with it and have the tools to handle the job.

Known as advanced framing or optimum value engineering (OVE), these framing techniques decrease the amount of lumber used to build a home while maintaining the structural integrity of the building.

Using advanced techniques can result in lower material and labor costs and improved energy performance for the building. While the various techniques can be applied as a whole package, many components can be used independently, depending on the specific needs of the project.

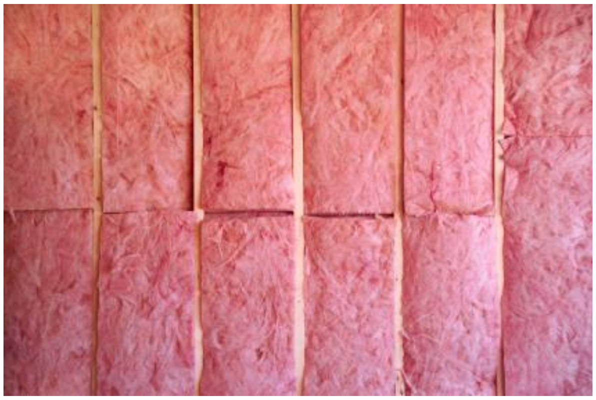
These techniques can benefit all builders who build stick-frame homes, even if only the interiors are stick-built.

Specific advanced framing techniques include:

- Designing homes on 2-foot modules to make the best use of common sheet sizes and reduce waste and labor.
- Spacing wall studs up to 24 inches on-center.
- Spacing floor joists and roof rafters up to 24 inches on-center.
- Using two-stud corner framing and inexpensive drywall clips or scrap lumber for drywall backing instead of studs.
- Eliminating headers in non-load-bearing walls.
- Using in-line framing in which floor, wall, and roof framing members are vertically in line with one another and loads are transferred directly downward.
- Using single lumber headers and top plates when appropriate.[8]

In cold climates, some contractors use 2x6 framed walls, 16 inches on center with cavities filled with batt fiberglass, blown cellulose or fiberglass, or spray foam. The whole-wall R-values for these walls vary with the type and quality of insulation and the quality of installation.[9]

One significant issue with traditional wood framing and batt insulations is that it creates a structure where a minor thermal bridge occurs at each vertical stud. Gaps can exist between insulation batts and stud surfaces, which can lead to air leaks. Insulation and framing techniques can significantly reduce the heat loss through thermal bridging.



Gaps between insulation batts and stud surfaces can lead to significant air leaks

More Common Variations on Wood Frame Construction

Double wall construction simply increases the thickness of the framing and thereby the insulation cavity. As with more conventionally framed walls, advanced framing strategies can save material and labor. As the inner wall is not load-bearing, framing spacing can sometimes be reduced to 24 inches on center.[10]

One major appeal of double wall systems is that framing, sheathing, window and door installation, flashing, and siding practices are very similar to construction practices in conventional framed homes. The primary construction cost is the extra labor for constructing the second frame wall.

Framed wall with foam sheathing or exterior insulation finish system (EIFS) is another option for achieving walls that exceed R-30. This technique calls for installing several inches of rigid foam board sheathing on the exterior of a conventional frame wall. Given typical construction practices, moisture concerns and availability of materials, 2x4 or 2x6 walls with blown-in insulation and 4 inches of extruded polystyrene (XPS) are valid high R-value options in cold climates.[11]

The frame wall cavity insulation can consist of blown or batt fiberglass, blown cellulose, or spray foam. Because installation is typically more uniform, a spray or blown in product is recommended to achieve the highest overall wall R-value. Of the available sprayed or blown-in options, cellulose insulation has the lowest embodied energy and offers increased fire resistance.

Types of rigid insulation typically recommended for this application include polyisocyanurate, expanded polystyrene (EPS) and extruded polystyrene (XPS). Availability and climate should be considered when selecting the right rigid insulation.

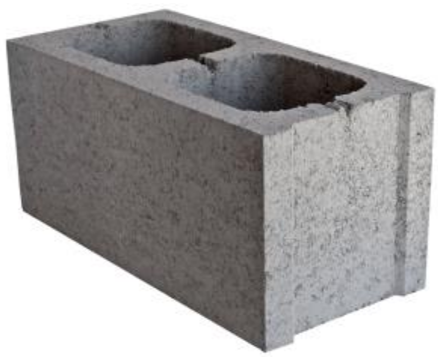
Because of the continuous insulation over the exterior of the framing, the thermal bridging from the framing becomes negligible and, therefore, the framing factor becomes much less important where the overall wall R-value is concerned.

Elimination of structural sheathing (OSB or plywood) and/or house wrap is a possibility when using rigid insulation, but builders must check with their local code departments for verification. Although elimination of these items would result in initial cost savings, doing so results in incorporating more advanced framing and drainage plane details and training for subcontractors, thus resulting in higher labor costs.

As with any high-performance wall system, air sealing is critical. Before insulating, meticulous caulking and/or foaming of exterior sheathing, top and bottom plates, and any penetration is strongly advised.[12]

Concrete Block (CMU)

A concrete block or concrete masonry unit (CMU) wall is built with hollow blocks constructed of concrete that are stacked, typically in a running bond pattern, and held together with mortar. CMUs represent a significant percentage of the United States residential foundation wall market and have a long history of residential use above grade in Arizona, Florida, Texas, and other parts of the southern United States.



Concrete blocks are used mainly in foundations, but they are also applicable in above grade construction

Concrete masonry units are an efficient use of cement and provide a strong and durable structure. They have a high embodied energy because of the heat required to process them. They can be insulated and can provide a heat-sink component to interior design. They require waterproofing, some type of internal or external insulation, and, depending on the height of the building, may require additional reinforcement, such as rebar. The more materials required for the installation, the higher the environmental impact.

Concrete masonry units have been widely used because of the material's availability, strength, durability, fire resistance, and success in the commercial and localized residential markets.[14]

Chapter 2 Key factors in selecting a wall system

Energy Efficiency

One of the primary reasons for exploring alternatives to traditional wood-frame construction is to improve the energy efficiency of a home. But it can be difficult to sort out real-world performance from marketing hype among the various manufacturers and building professionals.

One study found real-world performance-based advantages to ICF construction over wood-frame construction. In 2000-2001, Oak Ridge National Laboratories tested two houses in Knoxville, Tenn. The single-story homes were identical except one had ICF exterior walls and the other had conventional wood-frame exterior walls. The homes were empty and operated on the same schedules. The test over 12 months showed that the ICF house used 7.5 percent less energy than the wood-frame house.[15]

The ICF home had a higher R-value, which provided a higher insulation value. But there's more to the story than R-Value.

Blower door tests showed that the ICF house was about 10 percent more airtight than the conventional wood-framed house. Air leakage in both houses was less than anticipated based on previously calculated values for conventional construction. The total energy consumption for the eleven months of monitoring that began in July 2000, plus an estimate for the twelfth month, showed that the ICF house used 7.5 percent less energy than the conventional house with no occupants and simple operation.[16]

ICF walls offer better air sealing performance in addition to high insulation values. The solid surface of the ICF wall dramatically reduces the possibilities of air infiltration through seams and cracks in the thermal envelope.

A test over 12 months showed that an ICF house used 7.5% less energy and was about 10% more airtight than a wood-frame house.

"Performance is not only a matter of how big the R-value is, it's a matter of how tightly built the house is," Pfeiffer said.

Up to 40 percent of a stick-built home's heat loss is due to air leakage. In an ICF home there are simply fewer seams through which air can infiltrate.

According to tests from the Oak Ridge National Laboratory, SIPs can outperform a stick-built wall of similar thickness and R-value. A SIP test room was 15 times more airtight than a stick-framed alternative. In fact, the ENERGY STAR for Homes program has eliminated the blower test requirement for SIP homes to meet ENERGY STAR requirements.

With proper attention to air sealing and insulation, advanced framing options such as the EIFS can also provide high R-values and low air infiltration.

Strength and Safety

Unfortunately it doesn't seem like building codes can fully anticipate the destruction that Mother Nature can dish out. Storms and other extreme events seem like they're happening more often, and in places that were unheard of previously.

So building a home with safety and durability in mind makes sense. And, not surprisingly, a sturdy, safe home is also likely to be very durable for the long term.

Clearly, concrete homes provide the highest level of strength and safety for the occupants. For instance, homes with precast concrete panels encased in foam boards weathered Hurricane Sandy much better than surrounding homes.

Factors in Choosing a Wall or Foundations Systems:

- Availability of materials
- Building codes
- Carbon footprint
- Climate zone
- Contractor experience
- Cost/benefit
- Damage resistance
- Durability
- Home comfort
- Speed of construction
- Construction waste generation

Depending on where the home is located, strength and durability may play a significant role in selecting a wall system.

"Above grade you can go with wood or SIPs panels, which may be less expensive, but they're not going to provide the wind safety factors in tornado or hurricane or in locations prone to wildfires or earthquakes," said Mike Kennaw, vice president of sales and marketing for Fox Blocks.

ICFs are extremely resilient and offer protection from fires, earthquakes, severe storms and flooding. ICF buildings can withstand winds of 200-300 mph (compared to the 120 mph of stick-frames) and have a 4-hour fire rating. Properly designed ICF walls will withstand seismic activity as well.

Comfort and Indoor Air Quality

Selection of a wall system also plays a role in the comfort that occupants feel in terms of temperature and air infiltration. Also, the indoor air quality is influenced by the materials in the walls and tightness of the building envelope. Indoor air quality contributes to the feeling of comfort and health of the home's occupants.

An often-overlooked component of home comfort is the role thermal mass plays in regulating the temperature. Building components with a large thermal mass, such as homes built with ICF blocks, retain temperatures longer. Think of a cool garage floor on a hot summer day. The concrete in the floor retains the coolness of the earth for a long time.

Scientists at Oak Ridge National Laboratory found that the principal benefit of thermal mass on thermal performance is to dampen fluctuations in interior conditions during significant fluctuations in outside conditions.[17]

Mold damage in houses has grabbed headlines over the years as occupants fall ill to its effects. Because ICFs are made with concrete, they don't rot or mold and are not affected by insects, as is the case with wood-frame structures.

Mold and mildew are fungi that grow in a moist atmosphere. They tend form on the interior/exterior of walls where moisture condenses as a result of surface/air temperature differences. Once the fungus forms, it can leave telltale discoloration of materials beneath it. Left unchecked, the fungus can deteriorate the home's structures and emit particles that cause unpleasant odors or affect the health of the occupants. With ICF constructions, the foam insulation does not allow condensation, which prevents mold or mildew growth on either side of a wall as there are no thermal breaks in the wall. The inside wall remains at room temperature and the outside wall remains at the outside ambient temperature.

"For mold to grow you need to have two things, humidity and a cold surface for that humidity to condense against, Pfeiffer said. "If it's hot and humid, put a glass of ice tea outside and see how it sweats, that's a cold condensing surface reacting to the humidity in the air. If you put the ice tea in a foam cup it wouldn't sweat as much, that's an example of how nice it is to have the foam forms on the concrete because it's a smart vapor barrier for air both air conditioning and heating dominated climates."

Wood-frame buildings contain chemicals and adhesives that compromise indoor air quality throughout the building's life. The concrete and EPS of ICFs are non-toxic and do not compromise indoor air quality at all.

Also, the thick concrete walls created by ICF wall systems reduce noise by 30 percent, making them the perfect option for buildings near high traffic zones. Other heavily insulated wall systems such as SIPS can also reduce environmental noise inside the home.

Green Building Terms

Air sealing: Air sealing is the process by which air infiltration—air uncontrollably leaking into the house through cracks and openings—is prevented. Air sealing reduces heating and cooling costs, improves building durability, and creates a healthier indoor environment.

Building envelope: The "building envelope" refers to the external walls, windows, roof, and floor of a building. This barrier between indoors and outdoors is important with regards to ventilation and insulation of a conditioned space.

Embodied energy: Embodied energy refers to the total amount of energy associated with the creation of a material or product up to its point of use, including energy consumed in raw material extraction, manufacture, transportation, and installation.

IAQ: Indoor Air Quality is the measure of pollutants in an indoor environment. A growing body of scientific evidence has indicated that the air within homes and other buildings can be more seriously polluted than the outdoor air in even the largest and most industrialized cities.

Oriented strand board: OSB is a wood sheathing material similar to plywood. It is typically manufactured from small diameter, fast growing trees. Unlike waferboard, it is manufactured with the wood chips, or fibers, oriented to provide maximum strength.

Radon: Radon is a naturally occurring radioactive gas, and the second leading cause of lung cancer in United States.

R-value: A measurement of a material's resistance to transferring heat. The higher the number, the higher the resistance and the better the insulation. A material's R-value is laboratory tested under ideal and controlled conditions, but actual or effective R-value is dependent on the quality of installation, the assembly within which the insulation is constructed, and the weather.

Thermal bridging: Thermal bridging refers to an area of the building with a lower R-value than surrounding areas that conducts heat across the building envelope. A steel stud or non-insulated window frame can act as a thermal bridge, undermining the overall thermal efficiency of the building.

Thermal mass: The mass in a building (furnishings or structure) that is used to absorb solar gain during the day and release the heat as the space cools in the evening.

Chapter 3 Foundation systems and below grade applications

This section provides an overview of the some of the most popular types of energy-efficient foundation systems.

Building a high performance home starts below grade level with the foundation or basement systems. A well-insulated, well-designed system can improve energy efficiency, comfort, and reduce the risk of damage from water and insects.

A foundation in residential construction may consist of a footing, wall, slab, pile or pier, or combination of two or more of these elements. Residential foundation systems in the United States are most often constructed of concrete masonry or concrete. Of these foundations, stem walls in conjunction with slabs on grade and monolithic slabs on grade are the most common in the Southeast. Basements are the most common in the East and Midwest, while crawl spaces are more common in the Northwest and West. Other types of foundations may be used depending on local tradition or special site conditions.[18]

Foundation walls and slabs should be as well insulated as the living space walls. Poorly insulated foundations have a negative impact on home energy use and comfort, especially if the family uses the lower parts of the house as a living space. Also, appliances—such as domestic hot water heaters, washers, dryers, and freezers— that supply heat as a byproduct are often located in the basement. By carefully insulating the foundation walls and floor of the basement, these appliances can assist in heating the house.[19]

Basement foundations are popular in the East and Midwest. A basement is defined as that portion of a building that is partly or completely below grade and is often used as habitable space. Basements are constructed with an independent concrete slab that is isolated from the concrete masonry walls. The basement floor is typically poured after the concrete masonry walls have been erected or partially erected.[20]

Foundation walls and slabs should be as well insulated as the living space walls.

Crawl space foundations are popular in the Northwest, West, and Mid-Atlantic regions. A crawl space is defined as that portion of a building that uses a perimeter foundation wall to create an under-floor space that is not habitable.

Insulated Concrete Form

For basements and crawlspaces, ICF construction offers an attractive alternative to more traditional methods such as poured in place or concrete blocks. Unlike poured in place walls, there are no forms to set up and remove, which cuts construction time.

Cost wise, ICF walls are usually competitive with formed and poured reinforced concrete foundation walls when the cost of basement insulation is included in the analysis.[21]

In a below-grade application, using concrete in some form is standard practice. Because of the speed of construction benefits, ICF is cost comparable to other types of below grade applications.

"In the below-grade application, ICF is something that everybody should be doing, if they're picking some other type, they're not getting the benefits of ICF," Kennaw said.

ICFs offer advantages in that there are fewer seams to seal. And the insulation remains on the walls, improving thermal performance of the home.

Speed of construction and inherent insulation make ICF cost comparable to other types of below grade applications

While the cost of a bare block or poured wall is less, ICF construction also provides insulation and furring strips, and is ready to finish, making it a cost effective and less labor-intensive choice.

Concrete Block (CMU)

Also known as a concrete masonry unit, or CMU, concrete blocks are modular pre-cast hollow concrete bricks, which are used in construction, often with steel reinforcing.

A concrete block basement foundation with installed reinforcement provides a stable, long-lasting construction with high fire resistance and the potential for good moisture control.

CMUs are an efficient use of cement and provide a strong and durable structure. They have a high-embodied energy because of the heat required to process them. They can be insulated and can provide a heat-sink component to interior design. They require waterproofing, some type of internal or external insulation, and, depending on the height of the building, may require additional reinforcement, such as rebar. The more materials required for the installation, the higher the environmental impact.

ICFs typically have greater R-values than poured concrete and CMU foundation walls. This allows ICF's to recoup their initially high-embodied energy and global-warming pollution with energy savings over the lifetime of the foundation.[22]

Poured Concrete Foundation

A poured concrete basement foundation with installed reinforcement provides a stable, long-lasting construction with high fire resistance and the potential for good moisture control.

However, concrete by itself is moisture permeable and a high quality waterproofing system is recommended (petroleum-based in most cases). In addition, exterior insulation is recommended to create an energy efficient assembly and reduce problems with moisture condensation on cold concrete surfaces.

Concrete has an inherently large environmental impact, but is an extremely durable and long-lasting construction material, ideal for use below grade. Inclusion of waste products such as fly ash and blast furnace slag reduce the need for cement, and can thereby reduce CO2 emissions and related air and water pollution associated with concrete.[23]

Slab-on-grade Foundation

A slab-on-grade foundation can be a low-cost foundation choice. A conventional slab foundation requires a foundation wall and footing extending below frost depth. Rigid insulation is placed vertically inside or outside the stem wall and horizontally beneath the slab.

An alternative that saves material and cost is a frost-protected shallow foundation with rigid insulation extending horizontally out from the slab edge.

The main drawback of a slab-on-grade foundation is that many people perceive this option as a lower quality foundation with a floor that is harder and colder than a wood floor.

Another consideration is that a slab-on-grade foundation can reduce the street presence of the house as compared to surrounding houses with floors raised above grade. A wood floor raised above grade may be more appropriate in an inner-city neighborhood where it responds to the scale and street elevation of neighboring houses.

Other issues with slab-on-grade foundations include the need to place all utility and storage functions above grade, and the inaccessibility of ducts, pipes and wires installed below the slab.[24]

Chapter 4 Key factors in selecting a foundation system

When properly constructed and insulated, the choice of foundation does not significantly impact the thermal performance of the house located above grade.

However, basements do provide additional space that has a natural thermal advantage since it is located below grade where ground temperatures are relatively stable.

Because basements are earth-tempered, they retain heat in the winter and are cool in the summer, which can reduce heating and cooling loads in basement spaces when compared to above-ground spaces. Overall energy costs per square foot of habitable space decrease when a basement is built and finished as livable space.[25]

Comfort and Indoor Air Quality

Indoor air quality in basements is a particular concern since the space is located below grade where it is more susceptible to water, humidity, and soil gases that negatively impact air quality.

Maintaining a healthy indoor environment in the basement requires special attention to IAQ strategies for design, construction, and occupation. Design and construction strategies include water-managed foundations that keep rain away from the foundation wall perimeter (including strategies such as gutters, overhangs, downspouts, and proper grading).

As with any below-grade concrete application, handling of moisture is critical for the best performance of ICF blocks. A drain system is critical for keeping water away from the foundation. Waterproofing is also usually required to ensure moisture does not enter the space beneath the living area.

Other strategies provide drainage away from the sub-grade foundation walls (drain pipes, porous backfill, damp proofing, or waterproofing). In addition, soil ventilation systems should be combined with proper foundation design and construction techniques to limit possible absorption of radon, water vapor, herbicides, methane, or other toxins.

Wood foundations create another concern for indoor air quality. The toxic chemicals used to treat the wood have been found to leach into the surrounding soil. Concrete foundations do not off-gas and are considered inert after curing.[26]

Wood foundations provide a food source for termites or other insects

In addition, ICF blocks do not provide a food source for termites or other insects. However, sealing of the home is critical to ensure that termites don't tunnel through the foam blocks to reach a food source elsewhere in the home.

Strength and Safety

When cured, the concrete in ICF walls cures up to 50 percent stronger while using 30 percent less concrete than traditionally poured walls.

It's also easy to cover the walls in an ICF basement to meet the thermal barrier requirement. As required by building codes, unfinished walls in habitable spaces must have a 15-minute fire rated covering (usually a half-inch gypsum wallboard). The webs found in ICF blocks provide built-in furring strips, saving additional labor over CMU and poured-in place construction types.

Wind, pest resistance and impact resistance makes CMU masonry walls the most common type of construction in South Florida.[27]

Conclusion

As the U.S. housing market recovers, the desire for green, energy-efficient homes will grow. ICF construction is poised to gain market share as homeowners and building professionals learn more about the value and performance inherent in the system.

According to the *SmartMarket Report: New and Remodeled Green Homes* from McGraw-Hill Construction, green homes share of the construction market was 17 percent in 2011, equating to $17 billion, and is expected to rise 29 percent to 38 percent by 2016, potentially a $87–114 billion opportunity.

The report revealed that two of the key factors driving this market growth are the fact that green homes are seen as having higher quality and that they save consumers money.

ICF construction hits the sweet spot for homeowners and building professionals by offering tremendous value for the dollar. David Maher, an architect in Appleton, Wisc., has designed and built a number of custom homes using ICF construction. He likes to pair ICF walls with a geothermal heating and cooling system for a very energy-efficient home.

"ICF homes are really taking off, they have double or triple the insulation value of a wood-frame home, depending on how you measure it," he said. "An ICF wall is seamless from the footing up to the rafter so there's no air exchange through the walls. They're highly insulated and they perform very well."

While construction costs might be nominally higher than builder-grade wood framing, the long-term performance in terms of reduced operating costs more than offset any differential. Add on to that enhanced comfort, better indoor air quality and higher resistance to weather and seismic events, and ICF construction becomes a very attractive value proposition.

About the sponsor: *Fox Blocks is a leader in developing and manufacturing industrial strength insulated concrete forms (ICF). As the fastest growing manufacturer in North America, Fox Blocks is known best for its ease of use, product engineering and speed of construction. Fox Blocks are manufactured regionally across the U.S. and Canada and backed by the Airlite Plastics Company, a privately held company, with more than 60 years of high-end plastic and EPS foam-product manufacturing experience. Fox Blocks provides a complete range of products used in commercial and residential construction. Recognized as a best-in-class sustainable green building solution, Fox Blocks has produced over 40 million square feet of ICF wall surface for the construction industry. For more information please visit www.FoxBlocks.com*

Sources Cited

1. "Elements of an Energy-Efficient House," Information Services Program, DOE Office of Energy Efficiency and Renewable Energy, 2000.
2. "ICF Walls In Residential Construction In Hot And Humid Climates," E3 Design Group Inc., June, 2008.
3. "Insulating Concrete Form Systems (ICFs) Research Report," National Association of Home Builders, May 20, 2000, p. 3.
4. *Ibid.*, p. 4.
5. Aldrich, Robb A., et al, "Practical Residential Wall Systems: R-30 and Beyond," Steven Winter Associates, Inc. Norwalk, CT. p. 30.
6. Minnesota Sustainable Housing Initiative Knowledge Base, "Foundations." University of Minnesota Center For Sustainable Building Research.
7. Aldrich, p. 31-32.
8. "Advanced Wall Framing Technology Fact Sheet," Office Of Building Technology, State And Community Programs Energy Efficiency And Renewable Energy, U.S. Department Of Energy, 2000. p. 1.
9. Aldrich, p. 2.
10. "Tech Set 2: Durable Building Envelope," PATH, 2008. p. 2.
11. *ibid., p. 4.*
12. Aldrich, p. 31.
13. "Concrete Masonry Homes: Recommended Practices," U.S. Department of Housing and Urban Development Office of Policy Development and Research, Washington, DC, 1999. p. 5.
14. *ibid.*
15. Petrie, Thomas W., et al. "How Insulating Concrete Form vs. Conventional Construction of Exterior Walls Affects Whole Building Energy Consumption: Results from a Field Study and Simulation of Side-by-Side Houses," Oak Ridge National Laboratory, 2002. p. 1.
16. *ibid.*, p. 11.
17. *ibid.*, p. 2.
18. Concrete Masonry Homes, p. 13.
19. Elements, p. 5.
20. Concrete Masonry Homes, p. 15.
21. Tech Set 2, p. 2.
22. Minnesota.
23. *ibid.*
24. *ibid.*
25. *ibid.*
26. *ibid.*
27. ICF Walls, p. 2.