

Waterproofing ICF Foundations:

Two Steps Forward, Three Steps Back



Figure 2 – Example of an ICF foundation under construction.

By David Campbell,
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Try to imagine that you are a homeowner in the 20th year of a 30-year mortgage, and suddenly you learn that you have to spend tens of thousands of dollars to fix a serious problem with your house. Or even worse, imagine that you have just recently purchased a 20-year-old house and therefore have no equity against which to borrow, only to learn about the same costly problem. In both cases, full disclosure laws would compel the homeowner to eventually spend the money to correct the problem in order to market the house.

Let's further imagine that the insidious nature of this problem is threefold:

- 1) The problem could go undetected for many years until it reaches its advanced stages.
- 2) All warranties have long since expired, if there were any at all.
- 3) One cannot buy insurance for this particular type of problem.

Consequently, all remedial costs would either come out of your house equity, your savings, little Christy's college fund, or a combination thereof. Unfortunately, I fear that this could become an increasingly common scenario across the country for tens of thousands of people who own a home (or any building for that matter) that was built with a below-grade insulating concrete form (ICF) foundation.

WHAT IS AN ICF WALL SYSTEM?

ICF cast-in-place concrete walls are a relatively new below-grade building practice (Figures 1 and 2). Basically, ICF enables the contractor to construct a

high-quality cast-in-place concrete wall by forming the wall with permanently installed insulation instead of the more conventional

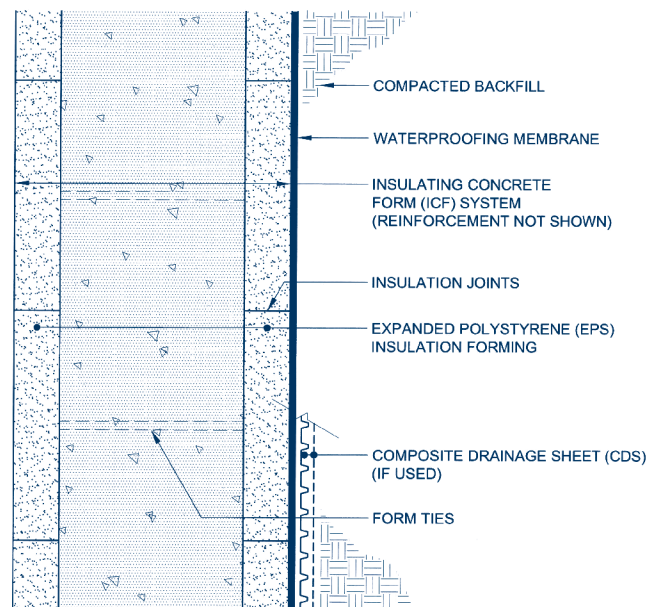


Figure 1 – ICF system foundation detail.

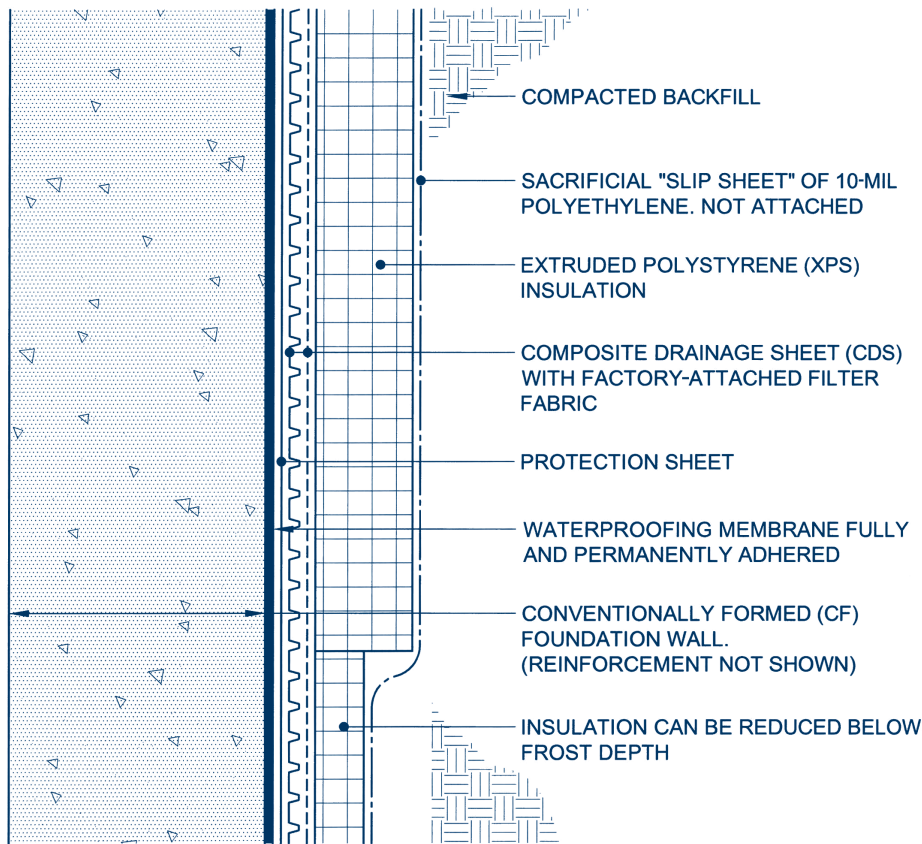


Figure 3 – Conventionally formed (CF) foundation.

wood or steel removable formwork. Leaving the insulation formwork in place permanently provides thermal barriers on both sides of the completed concrete wall. ICF systems are marketed for both above-grade and below-grade applications.

Nine major ICF system manufacturers in the United States were researched for this article. They all have their own patented nuances; however, they are all prefabricated systems that tie interior and exterior expanded polystyrene (EPS) insulation forms together by means of plastic or steel ties. The prefabricated ICF components are delivered to the site in panel or block form and are then stacked into place in incremental lifts. Next, concrete is placed between the two opposing insulation forms. The process is then repeated in subsequent lifts until the full wall height is achieved. In many respects, the ICF approach is quite ingenious, with the following advantages:

- Excellent thermal performance (R-value)
- High structural integrity
- Resists damage from storms
- High fire resistance
- Good resistance to air passage
- Resistant to mold growth
- Improved soundproofing

- Resistant to insect damage (termites)

SO WHAT'S THE PROBLEM?

It is not the intent of this article to indict all ICF walls, since the advantages bring genuine value to above-grade ICF walls. However, since all of those same advantages listed above can be true of any below-grade cast-in-place wall—whether ICF or conventionally formed (CF)—the balance of this article will be a comparison of those two types of forming methods with respect to long-term waterproofing performance only. See Figure 3 for typical CF foundation construction.

The “Achilles heel” of below-grade ICF foundation walls lies in the way they are waterproofed. The conceptual approach of the ICF system, regardless of the manufacturer, has inherent characteristics that are inconsistent with industry-established best practices for long-term below-grade waterproofing performance.

THE ROLE OF BELOW-GRADE WATERPROOFING

Before we compare ICF to CF foundation walls with respect to waterproofing, it is important to keep in mind that unlike roofing, which is intended to be

replaced periodically, below-grade waterproofing must be designed and installed to last and perform for the entire life of the structure without requiring replacement or major repairs. This is due to the high costs associated with reaccessing and replacing below-grade waterproofing. These high costs are the result of such construction activities as excavation, backfilling, re-compaction, landscaping, plant materials, irrigation, site features, and, of course, the waterproofing itself. However, when we talk about below-grade waterproofing having to perform for the life of the building, we don't necessarily mean that there are never any leaks at all.

The designer can minimize the quantity and severity of future leaks, but when you're talking about timeframes of 60 years or more, even the best-designed and most expertly installed waterproofing systems will most likely eventually develop some leaks. Therefore, the designer should be proactive and design the wall assembly in such a way so that future leaks can be detected shortly after the membrane is breached and that once detected, the leaks can be stopped with a relatively inexpensive localized repair instead of having to replace the entire waterproofing system.

The inherent characteristics of ICF that are inconsistent with industry-established best practice for long-term below-grade waterproofing performance include:

- Problematic conceptual approach of assembly
- High potential for leak water to be stored within the wall
- Long delay before leak is detected
- No leak localization characteristics

Problematic Conceptual Approach of ICF Assembly

Expanded polystyrene (EPS) insulation is used as the permanent formwork by all nine manufacturers researched, which means that the waterproofing has to be applied directly to the insulation. However, in my opinion, EPS is an inappropriate substrate for long-term waterproofing application for the following reasons:

- **Water Absorption.** There is currently an industry debate as to the water absorption characteristics of EPS insulation versus those of extruded polystyrene (XPS) insulation. Manufacturers of both claim that since their product is “closed-cell,” its absorption rate is low enough for below-grade application. However, in

a study published by the Extruded Polystyrene Foam Association (XPSA), titled “Polystyrene-Based Insulation Board Products,” a distinction is made between XPS closed cell and EPS closed cell. The study states that the XPS is a “uniform, closed-cell rigid foam insulation board with no voids or pathways for moisture to enter. This makes XPS insulation inherently moisture-resistant.” On the other hand, the same study states that the EPS method of manufacture “can result in interconnected voids between the [closed-cell] beads, which potentially can provide pathways for water to penetrate into the insulation.”

One must take into account that the study was conducted and published by advocates of XPS insulation. Nevertheless, since the low water-absorbing characteristic of XPS is not in dispute by either industry, and since so much is at stake for the building owner, it is this author’s opinion that EPS insulation should not be used in below-grade applications, such as with ICF systems, and that XPS is the only appropriate insulation for below-grade applications.

- **Soft Waterproofing Substrate.** With the ICF system, the waterproofing must be applied directly to the exterior side of the EPS insulation, which

has a relatively soft compression strength of 10-60 psi. This increases the likelihood of punctures through the waterproofing by rocks and other objects during the backfilling and compaction operations. The likelihood of this damage is increased by the fact that most of the ICF manufacturers researched did not require any protection course over the waterproofing. This would not be the case with a CF foundation, because the waterproofing is applied directly to the concrete wall itself (Figure 3).

- **Waterproofing Adhesion to EPS.** It is considered best practice to fully and permanently adhere the waterproofing to its substrate in order to prevent water from migrating between the two, should a breach in the waterproofing ever occur. In the case of ICF foundations, EPS insulation is a difficult material to which to adhere. The self-adhering and sprayed waterproofing products suggested by most of the researched ICF manufacturers may adhere well initially, but the long-term adhesion of these products to EPS has not as yet been demonstrated. On the other hand, there are many waterproofing products that have been time-tested and found to permanently adhere to concrete substrates in CF foundation assemblies.

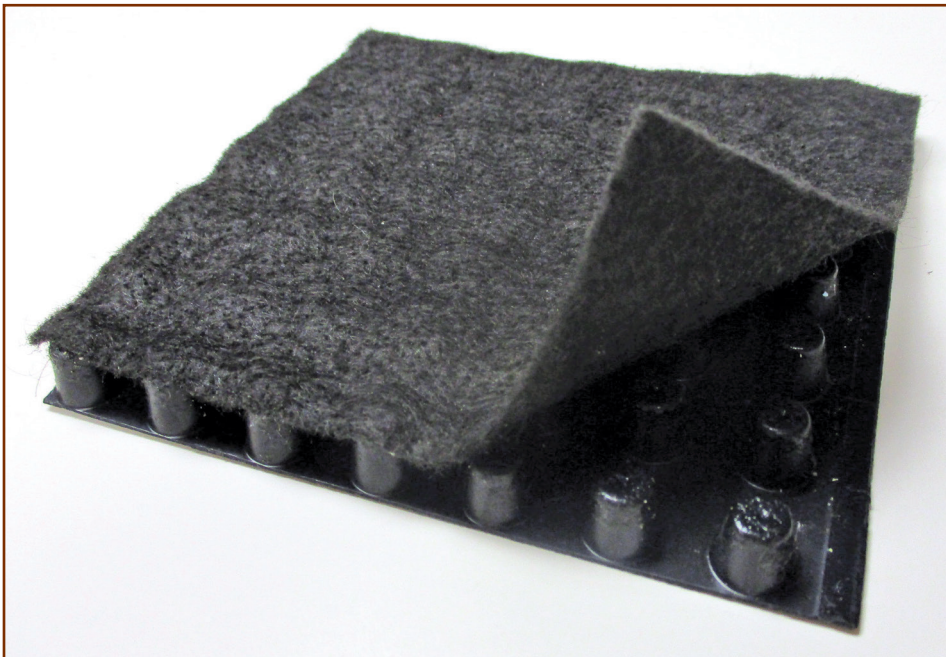


Figure 4 – Composite drainage sheet.

The Hydrotech logo, consisting of a blue stylized 'H' shape with the word 'HYDROTECH' in black capital letters inside it, is positioned at the top. Below the logo, the text 'YOU CALL ME RAIN' is written in white capital letters. A large, realistic-looking water droplet is centered, containing a detailed view of a city skyline, including the Willis Tower. At the bottom of the graphic, the text 'HYDROTECH CALLS ME OPPORTUNITY' is written in white capital letters. The background of the graphic is a cloudy sky with a city skyline at the bottom.

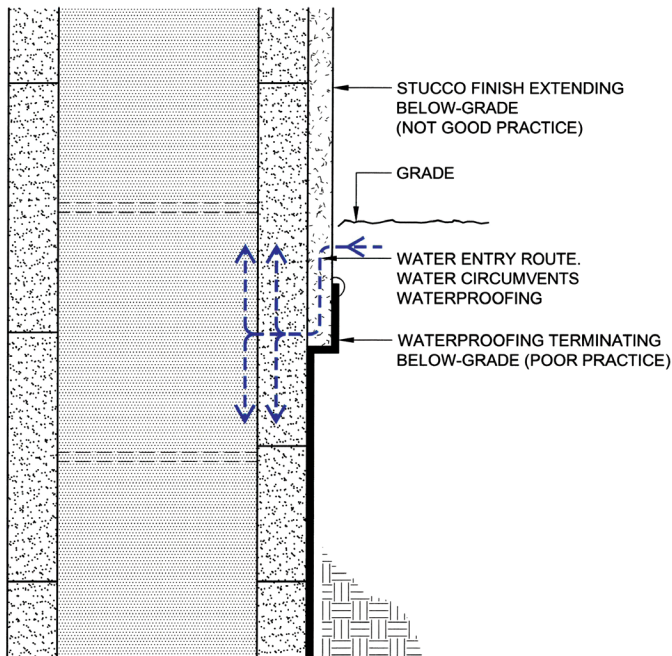


Figure 5 – ICF grade-line termination detail.

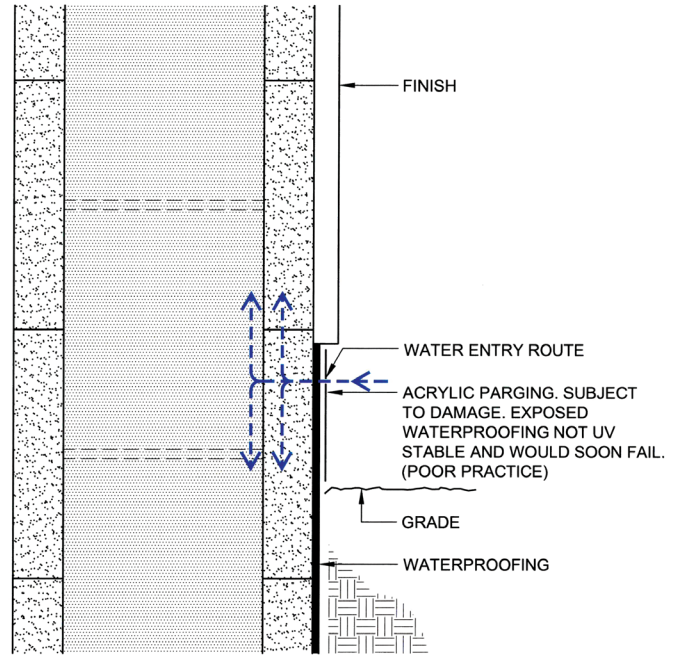


Figure 6 – ICF grade-line termination detail.

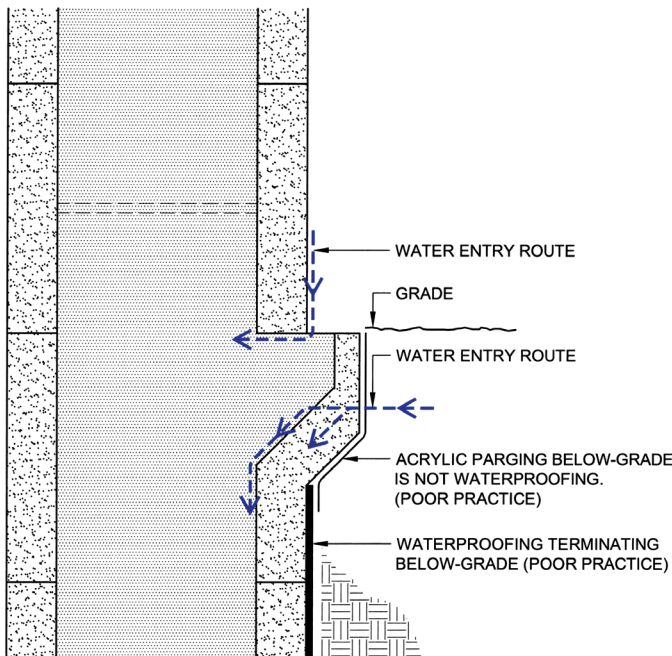


Figure 7 – ICF grade-line detail.

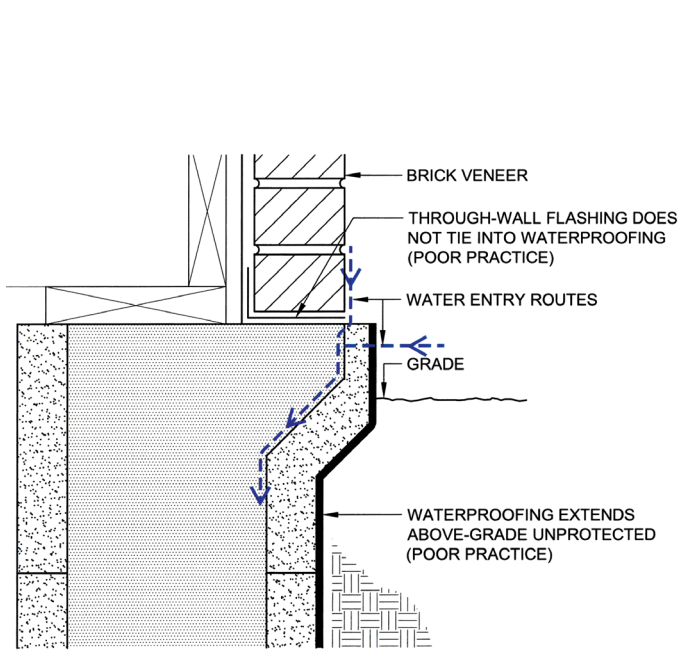


Figure 8 – ICF grade-line termination.

- Hot Fluid-Applied Waterproofing Cannot Be Used.** Since the waterproofing substrate of the ICF foundation is EPS insulation, hot fluid-applied rubberized asphalt (HFARA) waterproofing cannot be used in conjunction with ICF foundations due to the fact that HFARA would melt the EPS and due to incompatible chemistries. This is a liability for ICF, since HFARA waterproofing is one of the most long-term, time-tested, and successful waterproofing mem-

branes on the market today. On the other hand, HFARA can be and is used with CF foundations quite frequently.

- Substrate Joints.** With the ICF approach, there are inherent and extensive vertical and horizontal joints in the EPS substrate. In the case of one manufacturer, I calculated over 1500 lineal feet of EPS joints for a 1200-square-foot full basement foundation. Each joint represents a potential weak point in the water-

proofing, which is installed over the EPS. This potential is reduced, however, when a self-adhering sheet-waterproofing product is used in conjunction with the ICF system. A CF foundation has concrete construction joints, but only approximately 40 lineal feet for a basement foundation of the same size.

When a composite drainage sheet (CDS) (Figure 4) is used in conjunction with an ICF system, it can only be placed between

the waterproofing and the backfill. Since the factory-attached filter fabric component of the CDS is in direct contact with the backfill, the fabric component is susceptible to tearing caused by the drawdown effect of the backfill being compacted in lifts. As a result, the torn filter fabric allows mud and other fines into the core space of the CDS and renders the product useless over time.

In addition, the same drawdown effect can also damage the waterproofing if the CDS is adhered to it, which is usually the case. With the CF foundation approach, the CDS would be installed inboard of the insulation and not in direct contact with the backfill. In addition, a sacrificial slipsheet could be installed between the insulation and the backfill in order to prevent the drawdown effect from damaging any of the installed products.

Having to install the waterproofing over the insulation makes the critical grade-line termination detailing very difficult. This puts the waterproofing in an unprotected and vulnerable location, which is difficult to make watertight for long-term performance. Figures 5 through 8 are redrawn versions of various grade-line details found in the researched ICF manufacturers' installation manuals. In my opinion, they all show a

profound ignorance of what is required in the real world to keep water from getting behind the membrane near grade for the life of the structure.

Among the manufacturers that were researched, the thickness of the EPS insulation used ranges between 2.25 and 2.75 inches. According to Insulation Technology Inc., the R-value of EPS is 3.85 R per inch at a mean temperature of 75°F (24°C) and 4.17 R per inch at a mean temperature of 40°F (4.4°C). For the purpose of this article, we will assume an average EPS board thickness of 2.5 inches and an average R-value of 4.0 per inch. Therefore, since ICF systems have an inside and outside insulation form board, the insulation R-value of an ICF system is 20 R (2 boards x 2.5 inches x 4.0 R). A CF foundation using four inches of XPS insulation at 5.0 R per inch achieves the same insulation R-value of 20 R (4 inches x 5.0 R). However, with the CF foundation, there is the added flexibility of locating the insulation where it is most effective: namely from grade down to frost level. From frost level down to the footing, the insulation thickness can be greatly reduced to lower cost. This insulation thickness flexibility is not possible with the ICF system. In addition, since EPS insulation absorbs water at

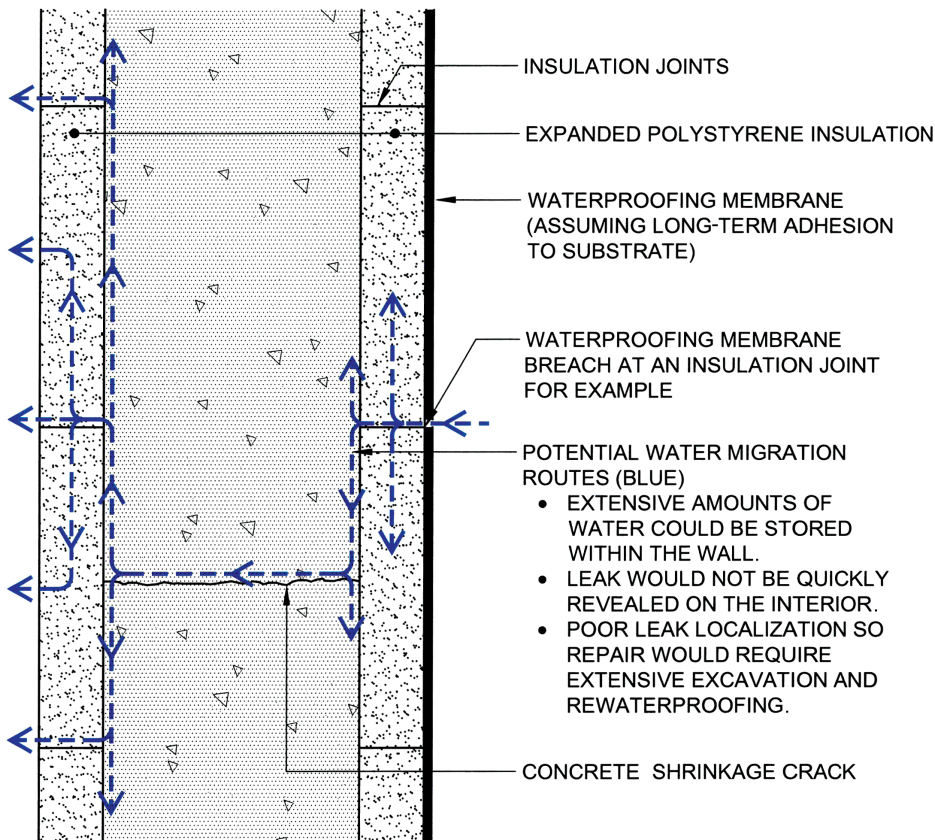


Figure 9 – Potential water migration routes within an ICF foundation.

a greater rate than XPS, the thermal performance of EPS would reduce over time at a greater rate than would the XPS.

High Potential for Leak Water to be Stored Within the Wall

It is important to note that all cast concrete develops shrinkage cracks. There are things the designer can do to minimize the number of cracks and to keep them from becoming too wide, but they will occur in both ICF and CF concrete walls. With an ICF foundation wall, the waterproofing

membrane must be applied to the exterior side of the exterior EPS insulation board, since the board is acting as a permanent form. This means that if the membrane should ever develop a breach, penetrating moisture could be stored between the EPS joints (exterior and interior sides), within the EPS insulation, between the EPS and the concrete (exterior and interior sides), and within the concrete shrinkage cracks themselves (Figure 9). This would represent a significant amount of water that would be stored within the wall. The waterproofing,

in effect, would be trapping moisture within the wall instead of protecting the structure from water. On the other hand, with a CF foundation wall, the penetrating water from a similar breach in the waterproofing membrane may not ever reach the interior unless the breach happens to be in perfect alignment with a concrete shrinkage crack, which wouldn't be likely (Figure 10).

Long Delay Before Leak Is Detected

As revealed in Figure 9, the various routes that penetrating water could travel within the wall are extensive. It could conceivably take years for the penetrating water to navigate through everything until it was finally revealed on the interior. If the interior side were finished with furring and gypsum board, it could take even longer. During this delay between the time that the membrane is breached and when the water appears on the interior, an extensive amount of moisture could be deposited within the wall long before it becomes apparent that there has been a waterproofing breach.

No Leak Localization Characteristics

One of the most critical components of waterproofing best practice is leak localization. When a waterproofing assembly is designed to have good leak localization, a direct relationship is maintained between the waterproofing breach location and where the water appears on the interior surfaces. This facilitates a local and, thereby, less expensive repair, since the exact location of the breach on the exterior is known. Such leak localization is impossible with an ICF foundation, because of all the various routes the penetrating water can take (Figure 9). Consequently, if the waterproofing of an ICF foundation should breach, the home or building owner would have no choice but to excavate and rewaterproof a large area of foundation, if not the entire foundation, at considerable cost, and would require that the damp exterior EPS be removed so that the replacement waterproofing could be applied directly to the concrete.

A CF foundation is better suited for leak localization because the waterproofing can be adhered directly to the concrete. This facilitates a local and considerably less expensive repair on the foundation exterior directly opposite the location of the water evidence on the interior (Figure 10). In fact, unless the waterproofing breach were in direct alignment with a concrete crack, the

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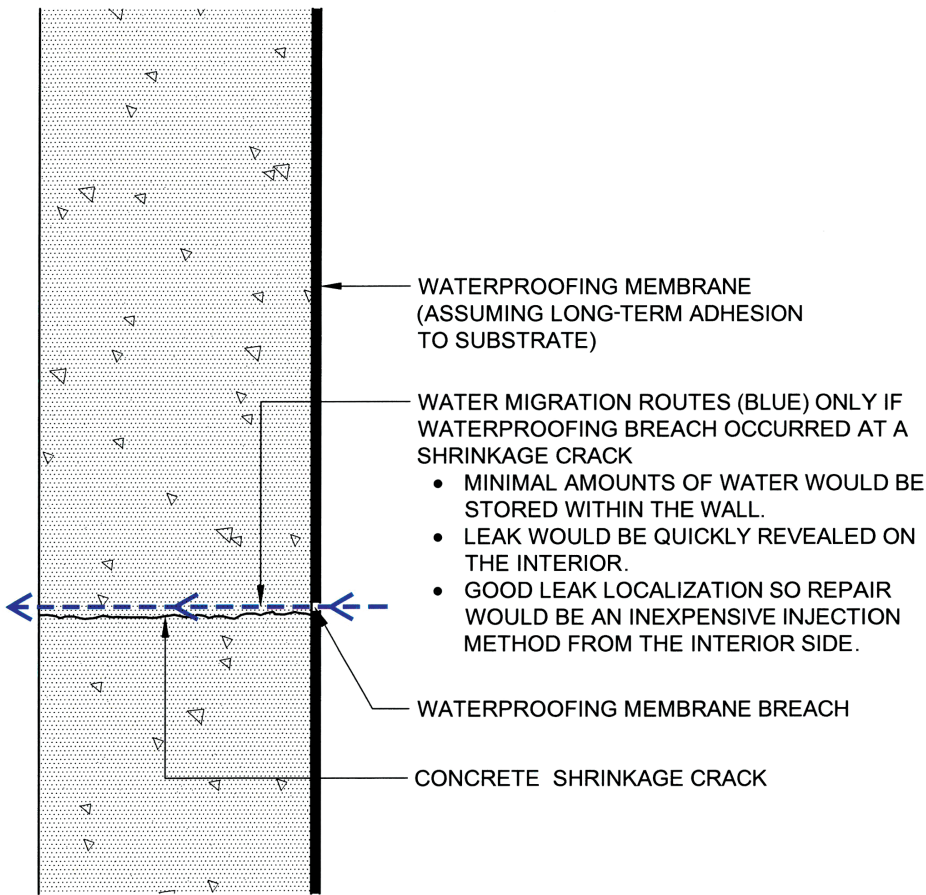


Figure 10 – Potential water migration routes within an CF foundation.

water would never even enter the wall, since it cannot migrate between the membrane and the concrete.

Another drawback to the ICF approach over that of CF is that with the CF method, a leak could be repaired by a relatively inexpensive method called water control injection. A waterproofing resin is injected into the crack in the concrete from the interior side. This is a permanent repair and would avoid the expense and disruption related to exterior excavation and waterproofing repairs.

ADDITIONAL ISSUES

Thermal Mass Benefits

Several of the researched manufacturers tout the energy benefits of ICF foundations through the use of thermal mass, since the wall is so well insulated. The idea of thermal mass—or the thermal “fly wheel,” as it is sometimes called—is based on the concept of storing conditioned space energy in a massive component of the building when it is not needed, with the intent of drawing that stored energy back into the conditioned space when needed, thereby reducing energy-related costs. This concept relies on the efficient transfer of energy from

conditioned space to building mass and then back again.

In the case of ICF, this efficient transfer of energy is greatly compromised, if not eliminated altogether, by the interior layer of insulation, which thermally isolates the mass of the concrete wall from the interior space. It’s true that a well-insulated wall mass retains energy, but the energy has to first enter the wall. This is not an issue with a CF foundation, since all of the insulation is typically on the exterior side, thereby allowing efficient thermal transfer from interior conditioned space to the mass of the concrete wall and back again.

Sustainability Claims

Several of the researched manufacturers market their ICF systems as being sustainable approaches to wall construction. However, with respect to below-grade ICF foundations, just the opposite may be true. Assuming that there are energy efficiencies inherent to the forming method of ICF over that of CF foundations, the embodied energy use represented by the extensive re-excavation and rewaterproofing due to leaks would more than offset the energy saved during initial construction.



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Basement Finishing

Some of the researched manufacturers make the claim that the ICF system allows the homeowner to more easily finish the basement space because the interior insulation is already in place and all that needs to be done is adhere gypsum board directly to the insulation. This is all true; however, there is no need to insulate on the interior if the wall has been adequately insulated on the exterior as with a CF foundation. Also, if you do not want to finish the basement (which is very common), then you do not have a solid, exposed, paintable concrete wall. The owner of an ICF foundation has to look at white EPS until he can afford to finish the basement. This may be a small point, but one a building owner should consider before deciding on an ICF foundation.


Warranties

As with most product manufacturers, all of the nine researched manufacturers of ICF systems offered only a materials warranty, which should not be confused with a water-

tightness warranty. This is understandable, since the manufacturer has little or no control over the installation workmanship. However, given the likelihood of eventual water intrusion issues and the high cost of correction, it is highly recommended that before choosing an ICF system over a CF system, the building owner verify that a minimum 15-year watertightness warranty will be issued upon substantial completion by the general contractor (or builder) and the waterproofing installer jointly, and that both have been in business for at least ten years. The watertightness warranty should be worded to cover any and all costs related to the correction of water infiltration. Such a warranty is commonly made available with CF systems.

IN SUMMARY

The ICF method of concrete wall forming has its advantages in an above-grade application. However, it is this author's opinion that any short-term advantages that the below-grade ICF method may offer do not

offset the potential long-term unintended consequences related to water intrusion and the high repair costs thereof. 



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received numerous awards for his work in failure investigation and design, and is a recipient of the Richard M. Horowitz Award for excellence in technical article writing from RCI. He also provides expert testimony in litigation cases.

Florida Relaxes Roofing License Laws After Irma

Due to catastrophic building losses following Hurricane Irma, the Florida Department of Business and Professional Regulation (DBPR) has suspended certain regulations concerning contracting of roofing work. The suspension applies to the 37 counties under the Federal Emergency Management Agency's (FEMA's) Disaster Declaration. Roofing work under the emergency order includes flat roofs and roofs made with wood shakes, asphalt or fiberglass shingles, tiles, or metal.

Under the order, licensed general, building, and residential contractors are permitted to repair and install roofs, a practice they would previously have had to subcontract to a specially licensed roofer. Local governments have also been

given leeway to issue local and specialty contracting licenses for businesses that already have more general licenses so that they can perform roof repairs.

Florida Governor Rick Scott stated, "Families across the state are beginning the challenging process of repairing and rebuilding their homes and businesses after the impact of this massive storm. It is incredibly important that we do all we can to make it easier for these families to quickly and safely recover, which is why I have directed DBPR to take immediate action to suspend certain regulations that would hinder or delay recovery efforts. ...Florida's high building standards and safety requirements will not be affected."

Jacksonville Beach, Florida, roof removed by Hurricane Irma. Photo by Ben Becker.

