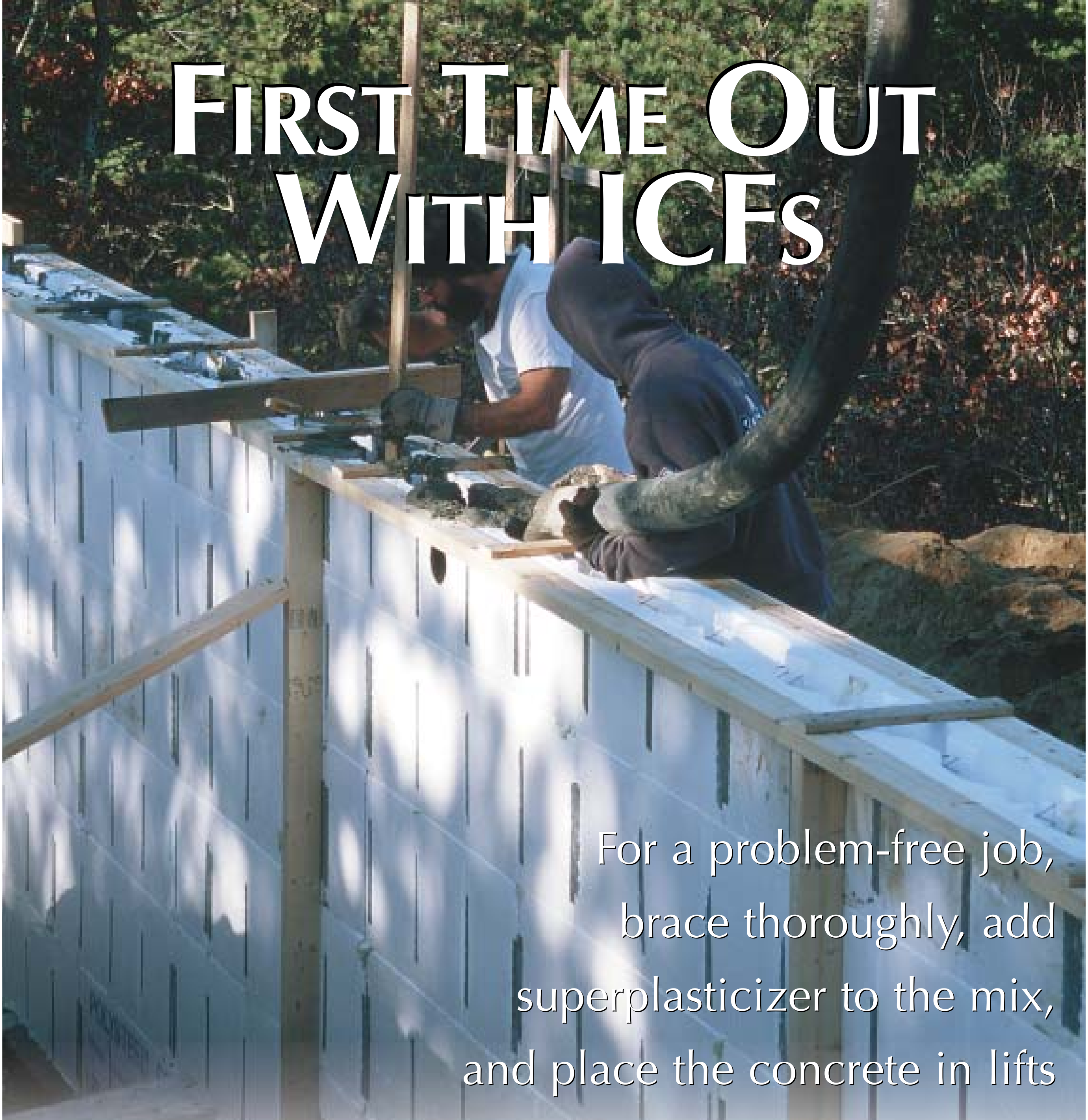
# First Time Out With ICFs



## For a problem-free job, brace thoroughly, add superplasticizer to the mix, and place the concrete in lifts

**by Malcolm Meldahl**

As a design-build contractor in an area with no shortage of upscale home buyers, I have quite a few clients who care more about getting a good product than they do about watching every dime. As a result, I often have a chance to try out new products and ideas. One thing I do with that freedom is try to steer my designs in the energy-efficient and "green" direction, while meeting the client's other objectives.

On a recent project, I used the Polysteel insulated concrete form (ICF) system to build the foundations for three connected buildings. I'm glad I gave this system a chance: The results were everything I had hoped for, and the few minor glitches we encountered will be easy to avoid next time around.

### Why ICFs?

The high insulation value of an ICF wall wasn't my primary reason for using the system. The main thing, frankly, was convenience: ICFs gave me more control over schedule and quality, and they gave me design flexibility.

In our area, you can wait a long time for a foundation contractor to fit you into his busy life. With an ICF system, my crew and I could form the footings and walls ourselves instead of having to work around a subcontractor's schedule.

Also, with the time pressure they face, poured-wall contractors don't always produce accurate work, and anyone who builds houses knows how much trouble it can be to adapt your wooden structures to a concrete foundation that is not quite true or level. By setting our own forms, my carpenters and I knew that if the basement didn't end up the way we wanted it, we'd have only ourselves to blame. It wouldn't take us any longer to place our own forms accurately than it would to level and square the deck on somebody else's concrete work.

Finally, ICFs made it easy to accomplish my stepped foundation design. I wanted to preserve a lot of the natural landscape on the site, and I wanted the building to conform to the contours of the existing terrain. The excavator I work with is willing to do things carefully, so instead of just hogging out a giant pit for the basement and worrying about the landscaping later, I planned to shape the foundation to the hillside. I ended up with a section of full 8-foot basement, a section of 4-foot crawlspace, and a section of 6-foot partial basement. Stacking 4-foot by 16-inch ICF blocks let us easily match the walls with the stepped footings as we went up the grade.

***Energy advantage.*** Although construction efficiency was my first consideration on this job, I don't mean to make light of the energy efficiency of ICFs. Above grade, ICF walls rate an R-20 or better, and they're impressively airtight as well. R-20 is heavy insulation for a basement, and the wall's performance when buffered by earth is probably quite a bit better than even that rating would indicate. I'm not sure how much the basement affected the whole building's heat-loss calculations, but I would say that this basement feels much more snug, warm, and dry than most basements I have built.

I would have gone to some trouble to insulate this foundation even if it had been a conventional basement. But when you stud out a basement and insulate the cavities, you're stealing living space; and you sometimes encounter moisture problems, too. If you put foam on the outside of a conventional concrete basement, you can have termite and ant problems, and aligning the siding becomes a concern (typically, you have to cantilever the sill out over the foam). Either way, there's labor involved. With ICFs, on the other hand, you're insulating at the same time you set up your forms.

Cost wasn't really an issue for my clients on this custom job, so I was expecting changes during construction.

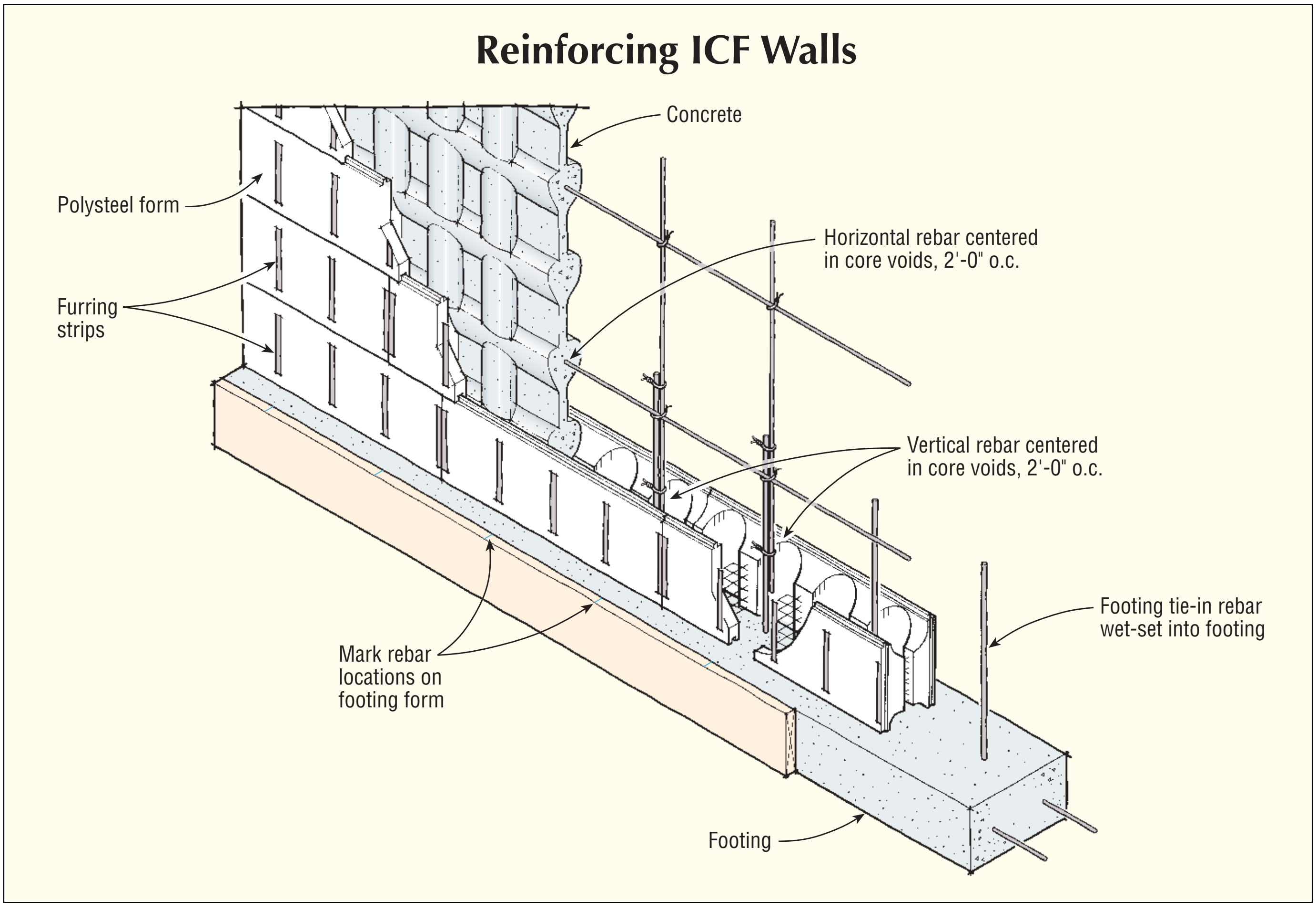



**Figure 1.** Rebar stubs must be accurately set into the footings to ensure that the vertical bars are centered within the core voids. The exterior of the completed wall has flat, parallel faces, but the waffle-shaped interior reduces the amount of concrete needed while still providing a high-strength product.

**Figure 2.** Walls are stacked one course at a time; corners are laid up using alternating left-hand and right-hand corner blocks. Polyurethane foam is used as "glue" between trimmed forms that lack the usual tongue-and-groove connection, but added exterior reinforcement is also needed in those areas.

And I was right: We ended up moving some windows on the first and second floors. Needless to say, I was glad those above-grade walls were not cast in concrete.

For a fixed design, however, such as a row house, I can certainly see some advantages to using ICFs for the whole house. The day may come when I take a chance on building a whole-ICF home.

## Choosing a Manufacturer

This was my first ICF project, and I don't know enough about the different ICF systems to recommend one over another. Quite honestly, I picked Polysteel (American Polysteel, Inc., 800/977-3676, www.polysteel.com) because they had a distributor not too far away, and because they were the quickest to supply us with useful information. Their instruction booklet is clear and comprehensive enough that I didn't need to call the company for any help or advice during the project. They also sent us their video, which the crew and I watched together; that convinced us all that we'd be able to handle the job without any trouble.

Polysteel also has the advantage of being treated with borates to resist ant and termite infestation. That saved us from having to install termite shields between the foundation and the house frame, and it let us bury the foam and stucco over the above-grade portion, without any concern that bugs would cause hidden damage. If you chose a brand with no borate treatment in the foam, you'd need to think about the insect protection issues.

I was very happy with the way the Polysteel forms worked. They were easy to assemble, and the steel fins on the outside face accepted screws readily, so it was easy to fasten bracing to the forms and to make splices when we needed to cut a form to length. Other forms might have other advantages, but all in all, I was satisfied with my choice.

## Stacking the Forms

Polysteel forms are 4 feet long, and they come in 1-foot, 2-foot, and 16-inch heights. The top, bottom, and ends have a tongue-and-groove profile, so they stack precisely and the forms lock together to a certain extent. Setting up the forms is simple. You pour your footing using conventional methods, and snap lines for your foundation footprint the same way you would for conventional forms. The first course of forms is adhered to the footing with a thin, continuous bead of polyurethane foam. From there on up, setting the forms is something like building with toy Lego blocks: You just stack them up, using a little dab of foam at all abutting edges to "tack" things together. (We cemented all the blocks together with a continuous bead of foam because we had plenty on hand, and that worked fine — just don't use so much foam that it pushes things out of alignment as it expands.) When you come to a corner, you use a right-hand or left-hand corner form.

***Layout.*** The footprints of my three connected buildings had a few jigs and jogs in them, but they weren't especially complicated, and there were only right angles — no odd bends or curves. So I didn't have to learn any of Polysteel's methods for making mitered

**Figure 3.** Polysteel's instruction manual includes a reinforcement table that specifies the rebar size and placement for any soil condition, wall height, and wall thickness. Wire saddles placed across the forms keep the bars centered in the concrete core section (right). If saddles aren't used, the vertical and horizontal bars must be tied together with wire (below).

corners (although their handbook provided detailed instructions for that, and it doesn't look too tough). For the sake of efficiency, I based my plans as much as possible around the 4-foot and 2-foot modules. A few odd wall lengths required us to trim forms, and this was not a big problem, even though we had a minor incident during the pour when a splice started to give way. For the sake of simplicity, it's nice to avoid the odd dimensions if you can.

A more critical layout concern has to do with how you place your rebar. Every wall gets some amount of reinforcing steel, and the vertical bars within the wall are tied into short stubs that are wet-set into the footings. The rebar has to sit in the middle of the 1-foot-on-center core voids in the waffle forms, starting with a bar rising up the center of the corner cavity (see Figure 1, page 2). So it's important to know how your foam forms will lay out, and to mark the footing forms for the proper rebar locations (or else be ready to measure carefully as you place your rebar stubs into the footing).

***Placing forms.*** You stack the blocks up one course at a time, always beginning in a corner (Figure 2, previous page). If your foundation is the right size, you can go all the way around the footprint without cutting any forms until you get back to where you started. But you'll usually have to cut at least one form at the end of the circuit, and you may need to cut one in every length of wall as you approach the corner. In any case, you alternate left and right corner forms as you go up the wall, and stagger the end joints of the form blocks so they don't fall out above one another.

***Cutting and splicing.*** Whenever you cut a form, you're trimming off the tongue-and-groove connection, and you need to replace it with a strong splice. Running a bead of polyurethane foam between the cut forms helps keep them in alignment, but the easiest way to provide the needed structural strength is to place a small piece of plywood to span over the joint and screw it to the nearest steel furring strips on the forms. In our experience, it's worth taking time with splices, and even providing each splice with its own brace back against the soil. The only time we had trouble during our pour was when a splice started to give way.

***Reinforcement.*** Polysteel's specs call for a minimum rebar placement of #3 bar at 2 feet on-center, horizontally and vertically. They also say to consult local building codes, but they provide a reinforcement engineering table that tells you how much rebar to place for walls of any height or thickness in various soil types. It's a lot more rebar than most contractors place, I'd bet. On our job we placed the bar 2 feet on-center as specified, but I went up from #4 to #5 bar, just to be conservative. The added cost was insignificant, but, according to the table, this change increased the strength of the wall considerably. We placed the bar as we stacked the forms (Figure 3). The vertical bars sit beside the stubs sticking out of the footings.

Horizontal bars lie in metal chairs, or hammocks, that span the forms and keep the bars centered within the wall space. When you use the metal chairs, you don't need to tie the horizontal and vertical bars together with wire.

***Window openings.*** There were two windows and a door in one of my basement spaces. Since Polysteel is designed for above-grade as well as basement walls, the company has given windows a lot of thought. They're not hard to deal with: You just build a window buck of pressure-treated wood to the rough-opening dimensions and add bracing to hold them in place during the pour (Figure 4). The permanent attachment between buck and wall is provided by 1/2-inch lag screws, 4 inches long, which are driven through the wood into the form voids. When the concrete sets up around the lag screw threads, the whole assembly is firmly locked in place.

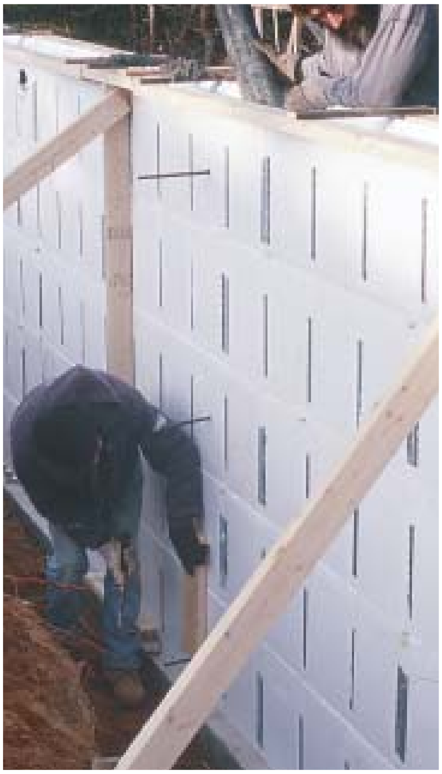
***Bracing.*** Adequate bracing is a critical part of any concrete pour, and this is especially true of ICFs. Don't try to get by with fewer braces than the instruction manual specifies. We shot 2x4s into the footings on both sides of the wall at the bottom and then made a sort of ladder built of 2x4s to lie along the top edge of the forms (Figure 5). These upper and lower frames are connected with vertical 2x4 members spaced about 8 or 10 feet apart, and we braced them to stakes driven into the ground with additional 2x4s.

We also attached a working platform

**Figure 4.** Window openings are created with simple site-built window bucks made from pressure-treated 2x10 stock. A slot between the two spaced 2x4s that serve as the bottom sill makes it possible to pour concrete into the forms below the window opening. Temporary wooden flanges help position the bucks (the inside flanges are not yet in place in this photo), while added exterior bracing keeps them plumb during the pour.

**Figure 5.** Vertical 2x4 braces spaced about 8 feet on-center tie into a 2x4 "ladder" laid over the top of the forms to stiffen them. Diagonal braces run from the vertical braces back to the ground (above), and a working platform tied into the bracing system provides easy access to the tops of the forms (right). It's important to use at least the minimum bracing specified in the manual.

**Figure 6.** A concrete pump delivers a 3,000-psi mix using small aggregate, and the mix is treated with a superplasticizer (right). The author's concrete sub did not use a 2- or 3-inch reducing adapter on the pump hose, which would have made the pour more manageable. Rapping the forms with a hammer and a block of wood during the pour helps consolidate the concrete and prevents the formation of voids and air pockets (below).



of 2x10s to the vertical braces at about half-wall height wherever access was at all difficult. It would be tempting to dispense with this working platform, but that would be a big mistake: It's very helpful to have good, comfortable access to the whole top of the wall as you pour, so you can easily move the hose along and manipulate it.

## The Pour

The waffle shape of the wall system conserves concrete: A Polysteel wall uses about 25% less concrete than a conventionally formed wall of the same nominal thickness. Polysteel's handbook provides a formula for estimating concrete quantities based on the number of form blocks you use, and it seemed accurate — we had enough concrete and little waste. The handbook recommends a 3,000-psi mix at a 5-inch slump, with superplasticizer added at the job so the mix will flow easily into the forms and around the reinforcing.

To reduce stress on the forms, it's important to pour in 1-foot to 2-foot lifts, at a total rate of about 4 vertical feet per hour. The superplasticizer wears off quickly, and the concrete in each lift stiffens enough that the pressure will not build up too high as the pour progresses.

***Pumps and hoses.*** The standard way to place concrete in foam forms is to pump it (Figure 6). A 4-inch hose won't fit between the forms and work around the form ties and rebar, so Polysteel's instructions say to use a reducer to adapt the pump hose from 4 inches down to 2 or 3 inches. This lets the hose reach all the way to the bottom of the forms, allowing you to gently deliver the concrete into the bottom of the form on the first lift, rather than dropping it from a height of 6 or 8 feet.

We did not use a hose adapter on our job, and the effect was noticeable. At the beginning we were dropping the concrete several feet, and at the bottom of the forms I later noticed some bulging — as much as $^1/_2$ inch of convexity between vertical braces in a few places. Since there was no finish issue in our case, this wasn't a big concern, but I did think to myself that we were approaching the strength limit of the forms. Compared to conventional methods, using foam forms takes a bit of a delicate touch — the bracing and the placing methods really matter, because there is not a lot of tolerance for carelessness.

We actually did have a couple of minor blowouts — nothing catastrophic, but enough to cause some yelling and running around. One happened when the guy who was directing the pour mixed up his signals with the concrete pump operator. Instead of stopping the pump, the operator kept the crete flowing, and very quickly we had a high mountain of concrete at one spot in the wall. Under the increased pressure, a splice in a cut form about a third of the way up the wall bulged out and threatened to give way. Fortunately, we were able to contain the damage by jamming a piece of plywood over the tender spot and shoving in some new 2x4 braces against the side of the trench. We had a similar problem partway up a low section of wall where there was relatively little pressure involved (Figure 7, next page). In that instance, we hastily shoveled some backfill back into the trench and tamped it down to offset the pressure of the concrete.

In hindsight, I think it would be wise to create some sort of augmented through-ties at any location where the form's strength is at all dubious. I would also make the plywood gussets stronger and thicker next time and brace them back more thoroughly. It's best not to allow wishful thinking into the work at all. Next time, I'll definitely use the adapter, even though it's tiring to have to continually slide the business end of the hose into the forms and lift it out again as you progress around the walls.

***Curing.*** When you use ICFs, you're doing your concrete a huge favor. The insulation contains the warmth that the concrete creates as it sets, and it keeps the moisture from evaporating. The temperature stays more uniform across the entire concrete section, and the concrete cures moist. That decreases the internal stress that often forms within a mass of concrete as it dries and cools differentially from the outside in. As a result, the shrinkage cracks that form will tend to be fewer and smaller. Also, a moist cure adds significantly to the concrete's final strength — it's reasonable to estimate that concrete cured inside ICF forms would end up at least 25% stronger than concrete that is wet-cured for seven days, and perhaps double the strength of concrete that is exposed to air a day or two after the pour.

***Capping off.*** As you finish the pour, you place anchor bolts into the wet concrete just as you would for a conventional wall. In a few days, when the concrete is hard enough, you apply a pressure-treated sill in the usual way, although the sill itself is wider. The added thickness of the forms means that a nominal 6-inch wall is actually $9^1/4$ inches across, which makes for a nice fit with a 2x10 sill. A nominal 8-inch Polysteel wall gets a 2x12 treated-wood sill cap.

The portion of the foam form on the exterior surface that's above grade, between the ground and the house, needs to be protected. We used a cementitious stucco called California Stucco, from Silpro (www.silpro.com). It comes dry in a sack, and you mix it with water on site. Polysteel's literature says you can apply the stucco directly to the foam if you rough up the foam with a wire brush first, and it's true — that's what we did, and the stucco does adhere. But in the future I think I would use expanded galvanized-metal lath, because the stucco we applied has developed some fine cracking. Another option would be to screw pressure-treated wood to the steel furring strips in the foam, or to apply some kind of fiber-cement sheet material.

**Figure 7.** Inadequate bracing at a spliced form and a too rapid pour in one area caused a section of form to bulge outward (left). The affected area was located partway up a low section of wall, so the damage was contained by tamping backfill against the bulging form (below).

## Would I Do It Again?

When the forming and pouring were all done, and we stepped back to assess the results, my crew and I were impressed. I've got a crew of the usual cynical home-building types — each of my guys has been doing this kind of work for 25 or 30 years. And everybody, myself included, felt that this system was worth the effort and lived up to its promise.

I'm still not sure how the cost of this job would compare to the cost of bringing in a regular poured-wall subcontractor. There were a lot of wild cards in this particular project, including the unusual wall heights and my desire to protect the site. And as I mentioned, this was not the kind of job where I needed to work up precise bid figures or compare all the alternatives. This customer was ready to pay for quality.

But when I do figure up all the costs, I won't be surprised if I find that this way was actually cheaper as well as better. I avoided the separate cost of insulating, and I avoided having to bear the cost of a specialty contractor's markup and the cost of any delays caused by working around his schedule. The well-insulated basement space saves energy for the homeowner and is also more comfortable and livable than the usual basement.

In addition, by including a generous amount of steel reinforcement and by curing the concrete under ideal conditions, we've built what I am convinced is a very strong and durable wall.

I'll be using ICFs on my next basement, even though I'll be working at the opposite end of the market, building a small, bare-bones house with a tight budget. Even for a client who is by no means a moneybags, I think this system is worthwhile.

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