Insulated Concrete Forms

Assembled with regular building skills, ICFs form airtight, insulating concrete walls that finish with standard materials

BY ANDY ENGEL

On a Saturday morning two summers ago, helped by my wife, Pat, and four usually desk-bound coworkers, I poured the concrete walls for my new home's 28-ft. by 40-ft. basement. Containing the heavy slurry of concrete were insulating concrete forms (ICFs) made of foam and plastic ties (photo above).

Setting the forms, braces and rebar took Pat and me about two weeks of part-time work. However, fretting about pouring three truckloads of concrete into forms that resembled a hybrid of take-out coffee cups and Lego blocks cost me a lot of sleep during those weeks. When full, every 5 ft. of those forms would hold 1 cu. yd. of wet concrete and weigh about 2 tons. The potential for the forms to burst, topple over or simply sneak out of plumb was real. All went well, though, and by early afternoon, the crew was sitting in the shade, drinking cold beer and grilling burgers.

I could have hired a concrete contractor and been done with my basement in days, for about the same money. But I wouldn't have gotten the insulated basement that I wanted. If the thermal mass and the air-sealing effects of the concrete are considered, industry sources claim effective R-values that push 40. I don't know if that number will stand scrutiny, but I know that from the foam alone, my basement walls have a respectable R-value of 25.

Also, I poured those basement walls during a building boom. Contractors in my area were scarce. With care, ICF walls can be built by anyone with carpentry and concrete experience, so I avoided the headaches of finding one more contractor.

If I ever build another house, I'll consider taking ICFs all the way to the roof. The cost of ICF walls is somewhat higher than that of frame construction, but this factor is less troublesome in areas where wind and seismic loads are considerable. In these areas, houses built of steel-reinforced concrete—that are well insulated to boot—make sense.

One job does not make me an expert, but it did make me curious. So I spoke with experienced ICF builders from Maine to Florida to Washington. There are over 40 ICF manufacturers, and their systems assemble in an almost-equal variety of ways (sidebar p. 76). I don't have space to explore their proprietary ins and outs. The differences mainly have to do with how the blocks attach to each other, not with how you set windows and doors, or how you brace and fill forms with concrete. Talk to your distributor for brand specifics.

It's easiest to start on level footings

Most of the builders I spoke with become concerned when the footings are ¼ in. or more out of level. All of them fix the problem with the first ICF course.

If the footing is humped, determining its height with a laser level or a transit is simple, and you can shave the bottoms of the forms to fit with a saw or a Surform plane.

Depressed footings are easily dealt with by finding the high point and shimming the ICFs level with it. Some contractors shim with mortar; others use foam scraps held in place with gunnable low-expanding foam such as Pur-Fil (Todol Products Inc.; 508-651-3818) or Enerfoam (Flexible Products Co.; 770-428-2684).

If footings need to be stepped, Chris McCormack, an ICF contractor from Hartford, Connecticut, suggests doing so in increments equal to the ICF height, thereby avoiding long horizontal cuts.

Tying walls to footings

Requirements for tying walls to footings vary geographically. Here in seismically lazy Connecticut, I grooved a keyway into the fresh concrete of my footings with a 2x4 scrap. In the process, I created a hump in my footings; check yours for level after grooving.

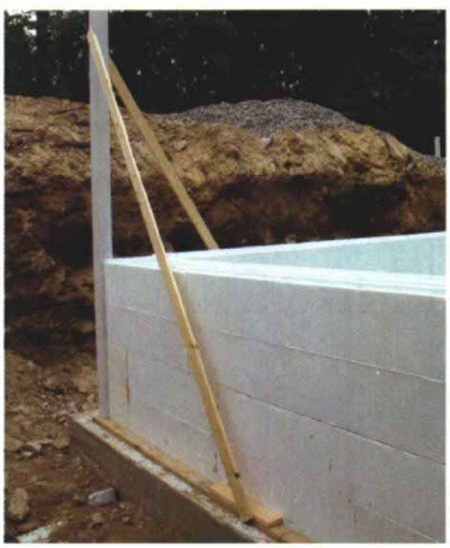
In many cases, specs call for rebar dowels to link the walls and footings. L-shaped rebar dowels cast into the footings make the strongest bond.

Where seismic or wind loads are of little concern, builders frequently set the first course of ICF blocks, then drill holes 2 in. or so into the footings for the rebar (photo below right). If done within a few days of the pour, the drilling goes fast. And accurate layout is easier, particularly with grid systems whose rebar must be centered in the form's vertical channels. Some builders epoxy rebar in place. Others simply hammer it home.

Drilling in the rebar offers a margin of job-site safety. Rebar sticking out of a footing can turn a stumble into a goring. Placing a course of forms first at least offers a visual clue to the rebar's presence.

Typically, the dowels should protrude from the footing by at least 40 diameters. This placement ensures a solid bond with the vertical rebar in the wall. So #5 rebar, whose diameter is ⅝ in., should stick out of the footing

A cleat holds the bottom course in place. It also reinforces the forms in the area subject to the greatest pressure during the pour.



Corner braces support a relatively weak spot in the forms. Setting the braces dead plumb provides a good starting point for stacking forms.

Hammering rebar into drilled holes (inset) ties wall to footing. Other methods include a keyway in the footing, L-shaped rebar cast in place and rebar epoxied into drilled holes.

Photo top left: Patricia Steed.

Diagonal braces hold pressure-treated window bucks square. Flanges capture and reinforce cut-to-fit ICFs. Wood strips on the legs will key into the concrete. Kickers and turnbuckles (photo right) hold bucks plumb for the pour.

25 in. To be sure that the wall's vertical rebar comes close enough to the dowels to establish structural connections, some builders place 2-in. sleeves of 1½-in. plastic pipe around the dowels. Once all the forms are set, the vertical rebar sets into the pipe sleeves and is wired to the horizontal.

Cleats nailed to the footings guide the first course of forms

The next step is snapping perimeter chalklines on the footing. ICF users typically snap these lines to the inside of the walls because they set the forms from inside. They then nail a cleat alongside this line to guide the first course. After setting the first course of forms, most builders nail another cleat outside the forms. The cleats reinforce the form's bottom edges, where the concrete pour generates the greatest pressure (photo top left, p. 75).

I've seen cleats made of 1x3 strapping and of 2x4. Todd LaBarge builds with ICFs on Cape Cod, Massachusetts. He nails down 2½-in. steel studs, channel up, inside the chalkline. His forms' 2½-in. thick sides firmly lock into the studs. The studs stay in place, saving him the labor of stripping the cleats.

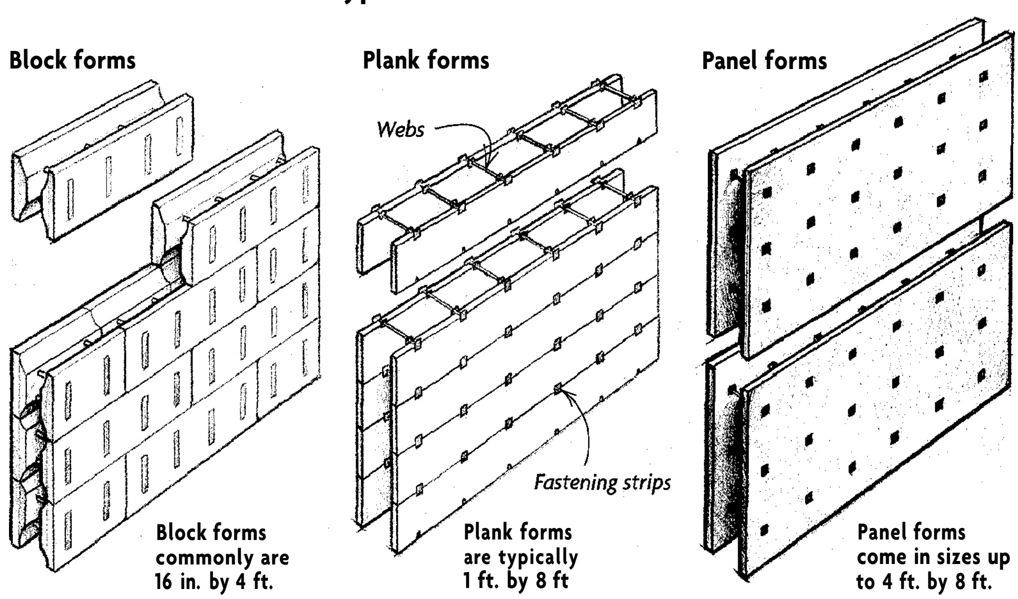
Bill St. Laurent, a builder in Kittery Point, Maine, places a cleat outside the walls. He

Choosing ICFs

There isn't space here to describe each of the 40 or so systems on the market. But generally, there are three main types of forms (drawing right). The most common are hollow blocks, whose 2-in. thick sides are held together with plastic or steel connectors that extend to the faces of the block, also providing a fastening point for wall finishes. These blocks are typically 16 in. high by 48 in. long. Their overall width depends on the concrete thickness, which can vary from 4 in. for an above-grade wall to 12 in. or more for basement walls.

Plank forms are similar to blocks except that the foam sides are longer and narrower, typically 1 ft. by 8 ft. Panel forms, the third type of ICF, have sides as large as 4 ft. by 8 ft. Additionally, the three form types shape the concrete within in one of three ways (drawings facing page). The simplest form flat concrete walls. Apart from the integral foam insulation, these walls are no different than traditionally formed concrete walls. Grid ICFs form walls whose concrete, if the foam were stripped away, would resemble giant waffles. In the thinnest spots, the concrete may be only 2 in. thick, and in the thickest, it will usually be 6 in. or 8 in. Grids use less concrete than do flat walls, but because the concrete can hang up in thinner areas, they are more suscepti-

ICFs come in three main types



Drawings: Bob La Pointe

sets the first ICF course, then has the basement slab poured. Pinched between the cleat and the slab, his forms stay put, and the slab gives St. Laurent a clean, level working surface.

Cleating to reinforce the forms may be overkill, however. Neither Peter Juen of Miami, Florida, nor Matt Shacklford of Mississippi—both ICF users—installs cleats; they simply glue the forms down with low-expanding foam. To speed layout, Juen lays out door and window openings on the slab before setting any forms.

Branford, Connecticut's Jim Eggert sets the first course of forms in the houses he builds before the footing sets. Bonded to the concrete, the forms need no guide boards.

Cutting weakens ICFs

Some ICF form systems have ready-made corners; others must be cut and joined on site. In either case, the outside of the corner usually doesn't have built-in ties, as does the rest of the form. It's a weak spot that most ICF builders routinely brace.

Corner braces can do double duty. Stoutly braced and plumb, they not only reinforce the forms during the pour, but they also make a reliable starting point for the succeeding courses of forms (photo bottom left, p. 75).

I made my corner braces by nailing two 2x10s into an L-shape. That decision was overly cautious. St. Laurent builds his braces from 1x4s that are primed to minimize the chances of warping (photo bottom left, p. 75). Jeff Preble, an ICF manufacturer and contractor in Gray, Maine, uses 4-in. aluminum angles that he carts between jobs, and Juen uses almost any kind of lumber that he can later reuse in the house.

Most ICF builders work inward from the corners, minimizing cuts by placing them at window or door openings. (The favored tool for cutting is a cordless circular saw.) Cuts can weaken the forms. Plastic, steel or foam webs tie together the form sides. Each web rein-

POTENTIAL TROUBLE SPOTS

Cut blocks are the weakest point. Cut blocks should include a web and be joined to the adjacent blocks with low-expanding foam (photo left). Plywood scabs provide further reinforcement. The right photo shows a misaligned cavity in a grid ICF; it reduces structural integrity and throws fastening surfaces out of sequence.

ble to voids. The third configuration is post and beam. As the name suggests, the concrete in these walls is formed into one or more beams supported by posts. The foam of the forms is all that fills the spaces within this concrete armature. Because of this fact, these systems may be unsuitable for below-grade use where they must resist a considerable amount of backfill pressure.

Grid-wall and flat-wall block systems are the most common combinations, and all call for reinforcing steel.

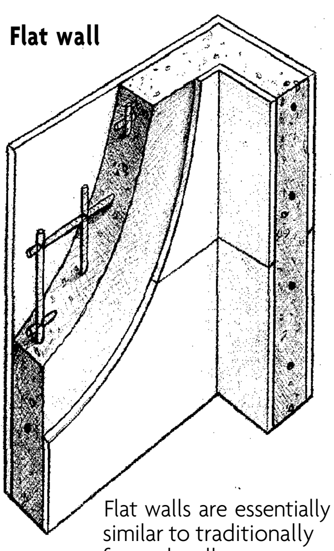
Additionally, there are several ICFs made from cement composites. The units are heavier than foam ICFs. They offer several advantages, though. Concerns have been raised that carpenter ants and termites can burrow unseen through below-grade foam and into houses. Some building codes, particularly in the South, require below-grade foam to be treated to resist these pests. Good detailing should sidestep the problem in much of the country regardless. But composite ICFs are one way that you can be more sure.

Additionally, the entire surface of most composite ICFs accepts fasteners, compared with foam ICFs, whose fastening strips are on 8-in. or 12-in. centers. No interior drywall is needed either; there is no smoke-generating foam to cover, and a coat of plaster will finish these walls nicely.

—A.E.

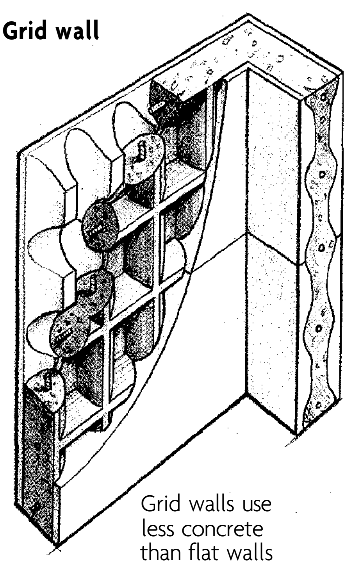
ICFs form the concrete in three ways

Flat wall



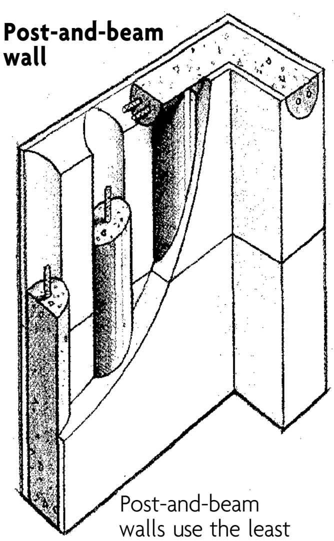
Flat walls are essentially similar to traditionally formed walls.

Grid wall



Grid walls use less concrete than flat walls

Post-and-beam wall



Post-and-beam walls use the least concrete.

Horizontal rebar is placed in block and plank ICFs as each course stacks. With panel systems, horizontal rebar slides in from the wall ends. With all systems, vertical rebar is placed from above after the top course is set.

String checks walls for straightness. Tweaking the braces will bring the wall straight. If scaffolds brace your walls, your weight on them can move the walls, so stay off them while checking for straight.

forces the form for half the span to the next web. Cutting between the webs, particularly if more than half the span remains, reduces a form's ability to withstand the pressure of wet concrete (photo left, p. 77).

When stacking ICFs, Jeff Preble cautions to be sure that the webs stack atop each other. They are where finishes—drywall, siding and the like—attach. Changing that layout halfway up a wall guarantees an angry drywaller. Preble further warns to line up the vertical channels of grid or post-and-beam ICFs (photo right, p. 77). Doing otherwise can compromise the wall's final strength.

Bucks create window and door openings

To dam the concrete at openings and to create an attachment point for windows and doors, ICF users usually build bucks from pressure-treated 2x stock (photos p. 76). The inside of the buck forms the rough opening for the window or door.

The buck stock is ripped, if need be, to the overall width of the forms. Two 2xs on the flat, sized to leave a 3-in. gap in the middle through which the concrete can be placed, comprise the bottom of the buck. Each is nailed so that its outside is flush with the buck's legs.

Most builders screw or nail flanges of 1x4 or plywood strips around the buck's perimeter. These strips capture the ends of the forms and reinforce cut forms. My ICFs were 13 in. wide, wider than the available lumber, so flanges weren't an option. I centered the bucks on the ICFs and held them in place with steel pipe straps screwed to the webs.

Bracing bucks square is critical. Because bucks must resist the weight of the concrete without bowing, most builders also brace between the bucks' sides with 2x stock. Wide openings with concrete poured above them get a few 2x posts. Pouring concrete above an opening creates a cast-in-place lintel. Rebar size and placement are critical here, especially with wide openings or heavy loads above. This place is one where an engineer can be well worth the cost.

Typically, nails, screws or lag bolts are driven into the back of the buck (but not so far that they stick out of the front) before it's installed. Concrete hardens around these fasteners, locking in the buck.

ICFs need to be braced

When the forms reach 5 ft. or so in height, most builders install vertical bracing inside the wall, usually 2x4s or 20-ga. steel studs on about 6-ft. centers. Both sides of windows, doors and corners should be braced. These vertical braces are screwed to the webs, and screwed or nailed to the guide cleats on the footing. A diagonal 2x4 kicker will fasten to the vertical brace and be staked to the ground.

Setting the upper forms and pouring the concrete is easiest from a scaffold. One-time ICF builders often make a scaffold support with a 2x4 top and plywood sides that fasten to the vertical brace. The kicker slides between and is fastened to the plywood sides. Turnbuckles at the bottom of the kicker, commonly used on traditional concrete forms and available at most masonry-supply yards, push or pull the wall plumb.

Similar rigs are available from the E.M.M. Group (613-835-2600), Easy-Wall Bracing & Alignment Systems (419-222-5578) and ReechCraft Inc. (888-600-6160). AAB Building Systems (800-293-3210), an ICF manufacturer, rents a scaffold and bracing system with its forms.

TWO WAYS TO SUPPORT A FLOOR

In one variation, steel joists are set and encased in concrete (left). Supported below on a ledger, the floor is sheathed and provides a work platform for pouring walls. In another variation (right), bolts support a ledger. Forms are cut to bring concrete to the ledger, providing a surface for bolts to pinch the ledger against.

Placing rebar

Installing utility penetrations is easiest before placing rebar. Commonly, builders install a sleeve the next size up from whatever size pipe is called for. To make a perfectly sized core drill, make a series of saw kerfs in the end of a piece of sleeve material that's about 1 ft. longer than the wall is thick (photo below). I braced the forms around the sleeves with 12-in. squares of ¾-in. plywood whose centers were cut out to fit around the sleeve. The universal fastener, 1⅝-in. drywall screws, held the plywood to the webs.

Every ICF contractor I asked installed the horizontal rebar as the forms rose. The webs holding together the forms also support the rebar, and it's a simple matter to lay it in place as you go (top photo, facing page). My ICFs called for one horizontal rebar every course. Rebar placement is critical, and you should look to your ICF manufacturer or engineer for sizing and spacing guidance.

Forming to support a floor

Because I built only my basement from ICFs, I treated the top of the wall as any foundation. After the pour, we smoothed the concrete and inserted anchor bolts. Todd LaBarge cuts the mudsills to length, drills them and then inserts the anchor bolts, washers and nuts while the sills are on the sawhorses. Before the concrete sets, he snaps chalklines and sets the sills.

A PERFECT FIT

Homemade hole saw neatly inlets utility sleeves. A few saw kerfs in the end of a pipe make a quick and accurate drilling tool.

Bill St. Laurent uses no mudsill, instead setting steel joists directly in the concrete (photo above left). He braces forms from the outside, rather than the inside, using turnbuckles and 2x4 kickers (photo right, p. 76). Because the slab inside is already poured, moving a stepladder or rolling scaffold to set the upper forms *is* easy. After straightening the walls, St. Laurent sets the joists, flush with the wall's top and about halfway in, through slots cut in the top form. A 2x4 ledger screwed to the webs and supported by vertical 2x4 posts props up the joists. He sheathes the floor, making a perfect working platform for the pour. St. Laurent says that this process insulates the floor's edge and also eliminates air leaks common with traditional mudsills and rim joists. His system works with either a conventionally framed house or one built entirely of ICFs.

Jim Eggert takes a similar tack, instead using wood I-joists whose ends he wraps with plastic to protect them from the concrete's moisture. Matt Shacklford sometimes uses a narrower form when doing his top course, forming a ledge where the joists will rest.

Affixing a pressure-treated ledger to the ICFs with anchor bolts and fastening the joists with joist hangers is another way to install a floor. For the ledger to attach solidly, though, the ledger must contact the concrete, at least around the bolts (photo above right).

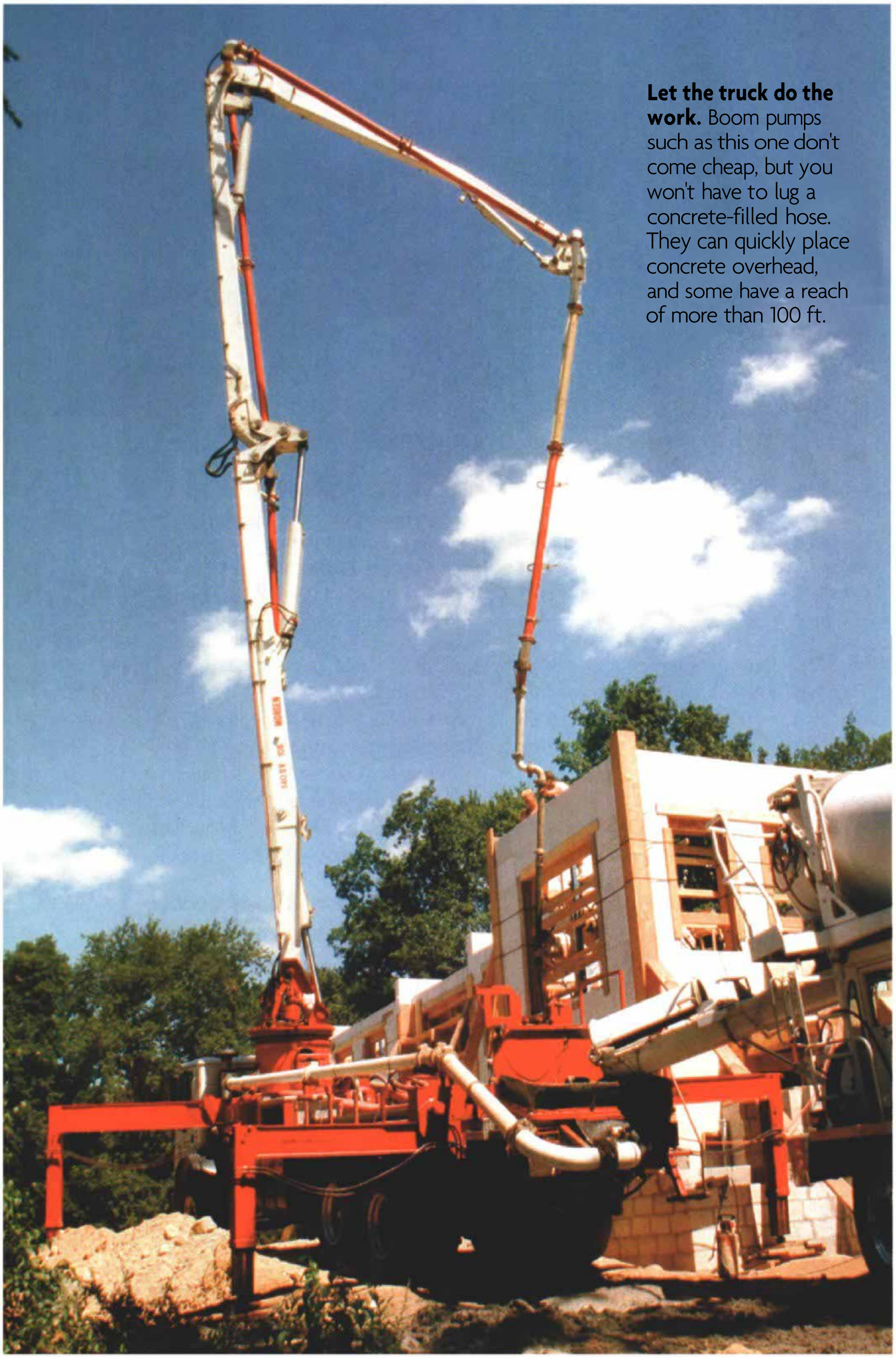
At least one manufacturer, Southeastern Metals Manufacturing Co. Inc. (800-737-7327), makes joist hangers that set directly into the concrete of an ICF wall. If you plan to build additional ICF walls atop the first, you'll need to set rebar dowels just as in the footing.

Straighten the walls, and double-check everything

Everyone I asked checks the top of their forms for straightness with string (bottom photo, facing page). While most builders aim to get the walls straight and plumb at this point, a few lean them slightly toward the braces. Braces exert more force pushing than pulling, so if the wall goes out during the pour, a quick spin of the turnbuckle will put it right. Most builders recheck their walls immediately after they're done pouring.

Foam is lighter than concrete, and top courses have been known to float during the pour. Vertical braces usually prevent this, but to be sure, Todd LaBarge glues down the top two courses with foam. I held mine together with filamented strapping tape.

With conscientious installation, blowouts are rare. Even so, it's a good idea to have a patch on hand. Two 2-ft. squares of ¾-in. plywood with holes in their centers, some ½-in. threaded rod and two nuts will handle most blowouts. Blowouts occur when a form, weakened by cutting, damage or defect, lets go between two webs. When blowouts happen, move the pour to a different part of the wall and shovel up a wheelbarrow or so of concrete. Patch the foam back in, push the threaded rod through the forms, and place the plywood on the rod. Tighten the nuts, and



Let the truck do the work. Boom pumps such as this one don't come cheap, but you won't have to lug a concrete-filled hose. They can quickly place concrete overhead, and some have a reach of more than 100 ft.

Wet concrete exerts tremendous hydraulic pressure. Aim the concrete at webs to break its fall, and pour in lifts of perhaps 4 ft. It's also important to fill both sides of corners and bucks evenly.

Pour the windows first. Pouring up to the bottom of the bucks first and moving on lets the concrete set. Pressure from adjacent concrete then won't cause the first pour to well up in the buck.

you're set. Many builders skip the threaded rod and screw the patch to adjacent webs.

ICFs usually bulge before letting go. Caught bulging, the fix is easy. Move the pour, and screw a piece of plywood to the form's webs over the bulge.

Ordering the right concrete mix is critical

Concrete must flow well to fill the forms, but not be so liquid as to increase the hydraulic pressure dangerously within the forms. A 3000-psi mix at a slump of 5 or 6 is about right, although some builders get a 3500-psi mix. Most use smaller ⅜-in. aggregate because it is less likely to hang up on the rebar or the webs and is easily pumped.

Jeff Preble has his supplier add a midrange water reducer to the mix. Water reducers make concrete flow better, without the loss of strength that would happen if water were added to improve flow. Preble also worked with his supplier to develop a custom mix that uses more sand than coarse aggregate. Additional portland cement in the mix makes up for the reduction in strength caused by reversing the usual sand-to-aggregate mixture. The mix flows so well that Preble doesn't vibrate or even tap on the forms to consolidate the concrete (more on consolidation later).

A concrete pump is well worth the money

For speed and controlled placement, concrete pumps are hard to beat (photos above). Still, they're an expense that can be avoided on basement jobs that have good access for trucks, which is how I poured mine. Two things eased my pour. The first was a simple plywood funnel that provided a bigger target for the concrete, greatly reducing spills. The second was front-discharging trucks. Because the driver can see to place the chute precisely without ever leaving the cab, these trucks are great time-savers.

You may not have good site access, or you may be pouring walls higher than the chute of a concrete truck. Then you must pump.

There are two types of concrete pump. The easiest to work with—and the most expensive—is a boom pump (photo left, facing page). Some booms reach more than 100 ft., so the truck can park almost anywhere on site and reach where it's needed. The ready-mix truck fills a hopper, and the pump pushes out the concrete through a 4-in. hose.

Boom trucks generate enough pressure to damage ICFs, so have the pump supplier provide a reducer that narrows the hose end to 3 in. or 2 in. To slow the concrete further, ask for two 90° elbows to configure the end of the hose as an S.

Line pumps (photo right) are less aggressive than boom pumps. They usually come with a 3-in. hose that reduces further to 2 in. Their disadvantage comes with manhandling a 3-in. hose that's full of concrete. While I watched, Jeff Preble spent three hours pouring a foundation using a line pump. In that time, 66 tons of concrete passed through his hands.

Filling the forms with concrete

No matter how you transport the concrete from the trucks to the forms, wet concrete exerts hydraulic pressure that can damage ICFs. All the contractors I spoke with aim the concrete at webs to break its fall (photo top right, facing page).

All the manufacturers' manuals that I read and most of the contractors I spoke with stress pouring the concrete in lifts (or layers) of 2 ft. to 4 ft. Peter Juen suggests that the higher the wall is to be, the shallower that the first lift should be because concrete falling from a greater height exerts more pressure. If you work around the house, by the time you return to the starting point, the first lift will have had enough time to set a bit and won't transmit as much hydraulic pressure.

Consolidating the concrete well is critical with ICFs, so one way or another, most contractors vibrate the concrete. Some use so-called pencil vibrators, mechanical vibrators with thin 1-in. or ¾-in. shafts that don't hang up on webs and rebar. These devices take experience because mechanical vibration can blow out ICFs.

More commonly, builders use impact vibration, which means that they place a 2x4 over a web and then whack it with a hammer. Some hold a wood block over a web and vibrate it with the foot of a disbladed Sawzall or with a palm sander.

Voids in the concrete are most likely going to be around windows and doors. The rebar and the fasteners that protrude from the bucks can create dams that keep concrete from filling all the spaces.

Most ICF contractors begin pouring at the windows (photo bottom right, facing page). Because the buck bottoms are open, pouring higher than this level at once can cause concrete to well up through the opening. Pouring up to the bottom of the windows and then moving on gives this concrete time to set. It doesn't take long to stiffen enough that concrete placed nearby won't force the initial concrete out of the buck.

Next come the corners, both sides of which should be filled evenly to balance the pressure. On successive passes, it's important to fill evenly on both sides of bucks as well. Then, it's around and around the foundation until the forms are all full, the anchor bolts installed, and you're sitting in the shade with a cold beer. □

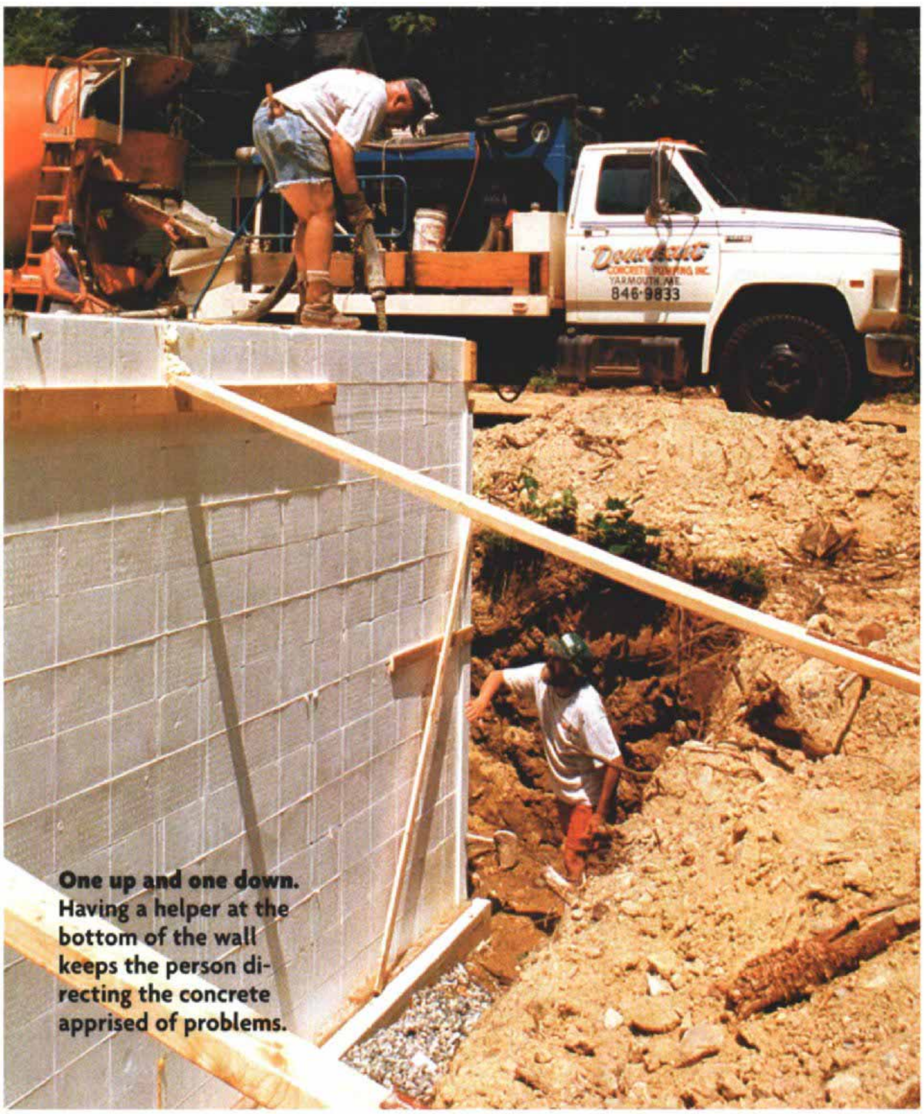
Andy Engel is an associate editor at *Fine Homebuilding*. Photos by the author, except where noted.

Where to find out more

Most ICF manufacturers belong to the Insulating Concrete Form Association. Contact them at (847) 657-9730 for a membership list.

For books and videos on ICFs, contact the Portland Cement Association at (847) 966-6200.

In researching this article, I found the Web site www.ICFWeb.com to be a great resource. It has a good discussion board and links to manufacturers of ICFs and their accessories.



One up and one down. Having a helper at the bottom of the wall keeps the person directing the concrete apprised of problems.