Structural Slabs WITH FOAM FORMS

by *JLC* Staff

The temporary rollbars between these custom-designed Hambro floor joists will support reusable plywood forms until the slab concrete has set. A specially designed flange along the top of each joist bonds with the concrete for extraordinary compressive strength, making it possible to cover spans of up to 32 feet.

This steel forming system for structural slabs makes it possible to build with concrete from the footing to the rafter plate

As insulated concrete forms (ICFs) have gained popularity as an alternative to standard foundation forms, many builders are also looking for ways to use ICFs above ground as well. Whether an ICF wall is used only for the basement or for additional stories, however, framing of the floor system is still one of the most difficult parts of the process (see “Step by Step With Foam Forms,” 12/95).

Canadian builders, who have a head start using foam forms, have pioneered the use of structural slabs with ICFs. Approaches range from precast systems, such as that from Coreslab, to deep- or shallow-pan steel deck forms (see Steel Deck Alternatives, last two pages). While cost and installation details differ between systems, all are capable of supporting long spans, and are especially well-suited for use with radiant floor heating. The final product is a solid floor with excellent soundproofing properties and fewer nail pops and drywall cracks in the ceiling below.

In this article, we’ll look at the Hambro composite floor system, whose unique steel joists act together with the slab concrete to provide for strong concrete floors over long spans. The system is suitable for wood or masonry walls, but is especially well-suited to ICF construction, whether in- or above-ground.

Hambro Composite Floor System

The Oke brothers of Oke Woodsmith Building Systems in Hensall, Ontario, have been building with Lite-Forms (P.O. Box 774 Sioux City, IA 51102, 800/551-3313) ICFs for several years. They have experimented with steel pan floor systems, but for the last two years have been using the Hambro composite floor system (Canam Hambro, 721 Northeast 44th St., Ft. Lauderdale, FL 33334; 800/546-9008). The system is based on top-chord-bearing steel floor joists that have a specially designed flange that bonds with the cured concrete to provide extraordinary compressive strength. The joists can be used with stay-in-place steel pan forms between joists, or with reusable 4x8 sheets of 1/2-inch plywood.

According to Randy Oke, who supervises field operations, the Hambro system has "the shortest learning curve out there." All that was needed on the Okes' first job was a 30-minute visit from the Hambro sales rep. The steel joist system has also boosted the company's overall home sales, because the concrete floor complements the above-grade ICF structure the company builds, as well as the radiant floor heating systems they typically install. Today, 90% of the company's houses are of full concrete construction.

Figure 1. To ensure that the plywood forms will interlock properly, each Hambro joist is tagged to match markings on the working drawings provided by the manufacturer. Reusable steel rollbars automatically set the on-center joist spacing. A two-man crew can form a 2,000-square-foot slab in 10 hours.

Figure 2. Interior partition locations are snapped directly on the plywood forms prior to installing radiant heat tubing and blocking out other mechanicals. Here, the plywood is also being used to brace second-story ICFs.

Fully engineered. One advantage of the Hambro system is that relatively small joists will handle long spans: A system of 10-inch-deep joists will typically span up to 24 feet; 12-inch joists will handle up to 32 feet. For longer spans, the manufacturer will design deeper joists. In fact, Hambro custom-designs the joist system for every job, based on the builder's drawings and loading data, and provides fully-engineered shop drawings. Once approved, Hambro delivers a final set of drawings that includes a letter-number combination (H-1, H-2, etc.) that matches a tag on one end of each joist. This tagging system ensures that the joists are correctly oriented during installation, which is essential for the proper interlocking of the plywood forms (see Figure 1).

The Okes try to work with a ceiling height that matches the 8-inch increment of the Lite-Form ICFs, but it's a simple matter to rip down the top course to whatever elevation is needed. While the outer panel of the foam wall form can be left high to act as a perimeter form for the slab, the Okes sometimes form and pour the floor after the above-grade walls and roof are done, particularly if cold weather is setting in. In this case, any second-story wall forms are laid on top of the Hambro form system. The walls must still be poured first, but the Hambro floor forms can be used to anchor bracing for the upper wall.

Laying the Joists

Before the joists can be laid, all internal bearing walls must be in place and precisely located from the working drawings. The Hambro joists bear on the top chord, which has a welded plate at each end that lays on top of the supporting wall. With wood, concrete, or masonry construction, 3 inches of bearing are required; at steel girders, only 2 1/2 inches of bearing are needed. The bearing plates are predrilled and can be fastened with two nails into wood wall plates or with two bolts or a tack-weld to a steel beam. No fastening is required with concrete walls, however, because rebar ties the concrete wall and slab together.

There is no need to lay out the joist centers beforehand. The Hambro system includes a series of rollbars, which serve both to provide temporary support for the plywood forms and to maintain proper spacing between the joists. After setting the first joist, a full rollbar will automatically space the adjacent joist at the proper on-center dimension. Adjustable rollbars that span down to 24 inches are used to make up odd dimensions at the end of a run. For joist spacing smaller than 24 inches, Hambro recommends putting the short increment in the middle of the run and letting the plywood handle the span. If the short dimension falls against the wall, the Okes fill in with 3/8-inch rebar supports.

All joists and rollbars are typically installed before laying the plywood (Figure 2), but if enough people are available, the plywood can be laid at the same time. Where plywood sheets butt, a special spanner rollbar catches both edges. Because the Okes use 3/4-inch aggregate in the concrete, even a gap of 1/4 inch will only allow a small amount of cement paste to leak through the joint. A strip of felt paper tacked over the joint provides extra protection when needed.

The Okes often don't use a release agent on the plywood unless they won't be stripping the forms the next day. They do, however, use new 1/2-inch plywood for every pour, because after stripping they use the plywood forms to sheath the roof. The company has occasionally used 5/8-inch plywood, but the tighter fit at the joists is much more difficult to strip.

Floor Openings and Point Loads

To mark all second-floor interior walls, the Okes snap lines directly on the plywood forms. This helps to locate rough openings and makes it easier for subtrades to rough in their work before the pour (Figure 3). Large slab penetrations, such as for stairwells, are blocked out with 2x4s. Foam blocks will work for plumbing and wiring penetrations, but the Okes prefer to use empty soup or paint cans because foam blocks are more difficult to secure and are more easily damaged.

If the design calls for a large point load supported by a footing in the basement, the Okes provide a knockout in the floor and drop the post in later. For point loads supported at the level of the slab floor, Hambro will design a clear-span steel beam. For smaller point loads supported by the slab, Hambro will design a beefed-up joist.

The concrete pad can be cantilevered up to 2 feet. Hambro will provide material to lower the Hambro formwork to thicken the slab beneath the cantilever, but the extra formwork has to be fabricated by the contractor.

The Okes have also used the Hambro system for exterior decks over living space. To waterproof the floor where it covers living space, the slab is covered with 1/2-inch black-

Figure 3. Openings for electrical and mechanical systems are blocked out with empty paint cans or cut with a concrete saw. Stairwells and other large rough openings are blocked out with 2x4s fastened to the plywood forms.

Figure 4. When laying radiant floor heat tubing, lines snapped directly on the plywood forms help installers to avoid interior partitions. The tubing is laid on top of and tied to welded wire mesh.

Figure 5. To support the finish ceiling, heavy steel channel is hung from the joist bottom with tie wire. With 1/2-inch drywall, a 31/2-inch slab achieves a 2-hour fire rating and a sound transmission class (STC) of 57.

board and EPDM; the finish surface is typically ceramic tile over a cementitious leveling coat on top of another layer of blackboard.

Pouring the Slab

The final step before pouring the concrete is to lay down welded wire mesh and radiant tubing if needed (Figure 4, page 35). Flat sheets work better than rolls, because they're easier to control. The flange along the top chord of the joist acts as a chair to hold mesh at the proper height.

Structurally, the slab only needs to be 23/4 inches thick, but when radiant heating is used, a 4-inch thickness of concrete provides better coverage and more thermal mass. Vibrating the concrete is essential, because as the concrete cures, it locks around the flange at the top of the joists and actually improves the compressive strength of the steel. On the Okes' jobs, in fact, there is one member of the crew whose only job during the pour is to make sure that the vibrator is held against the end of each joist to ensure a good bond. Vibrating also pulls the mesh up about 1 inch off the plywood, the ideal location.

The Okes use a pump truck only if they're pouring on the second story; otherwise, they prefer to use wheelbarrows, which is much less expensive. Occasionally, a ready-mix truck is available that's equipped with a conveyor system that can reach up to 35 or 40 feet.

Screeding. It's critical to load each joist entirely before screeding, because of the built-in camber (a 32-foot-long joist, for example, has a 11/2-inch camber). It's also important to avoid deep mounds of concrete that might overload the joists. To ensure uniform loading, the Okes first place concrete directly over each joist; once the floor is completely loaded, they use a laser to spot a few screed points. Then, the surface is floated and troweled as with any slab.

Curing. In cold weather, it's easier to supply heat to the curing slab if the building's roof is on before the pour; if that's not possible, heat can be provided from below. Additives such as Hi-Early also help, although calcium should be avoided because it will attack the steel reinforcing.

Stripping the Forms

Once the concrete has set (the slab is walkable in 24 hours), the joists no longer need any bridging, so all rollbars can be removed. The rollbars can be stored for reuse on another job or returned to Hambro (the Okes do not own any rollbars).

The plywood forms are stripped using a flat bar to pry down one long edge of each sheet till it clears the joist; the other end can then be pried from the slot in the other joist. The Okes usually pour the basement slab early and work off a rolling scaffold both to install and strip the forms.

Finishes

To prep for drywall, the joist bottoms are strapped with steel channel (a heavier version of resilient channel) that's fastened using tie wire and a rebar twister (Figure 5). The concrete and steel system is so stable that nail pops and cracking rarely occur.

Back on top of the slab, all partition locations are snapped onto the concrete before framing begins. This is especially important with a radiant floor to avoid piercing the tubing. If there's any doubt about the location of the heat tubing, the concrete floor makes it easy to solve the mystery: After turning the heat on, spray the slab with water; the water will evaporate faster over heating tubes, leaving a clear pattern on the floor.

Oke Woodsmith has been using the Hambro system for two years. A three-man crew can form and pour 1,800 to 2,000 square feet of floor in one 10-hour day. The total cost is between $5.50 and $6 per square foot, including the Hambro joists, concrete, and labor. Radiant floor tubing adds about 25¢ per square foot.

Steel Deck Alternatives

The steel joists and plywood of the Hambro system have a lot of appeal to builders accustomed to working with trusses, but it's not the only way to form a structural slab. Archie Duiker of Fastform in Orageville, Ontario, who uses Blue Maxx ICFs (840 Division St., Cobourg, Ontario K9A 4J9 Canada; 800/293-3210) and has some experience with the Hambro joist system, has also formed floors using shallow- and deep-ribbed steel pans (Figure A), as well as precast panels. He notes that these deck systems produce less leakage during a pour, and leave a cleaner finish appearance on the underside. More important, with shallow pans and pre-cast panels, the entire floor system is only 6 inches deep, so Duiker saves on both the number of ICF courses and the amount of siding. Plus, the shallower 6-inch floor keeps the overall elevation of the house closer to the ground.

Steel Pans

The procedure for installing steel pan forms differs from the Hambro joist system primarily in the need for intermediate bracing of long spans. Both shallow (3-inch) and deep (8-inch) corrugated steel pans are stamped with a regular pattern of dimples designed to bond with the concrete (Figure B). The steel acts in tension to form a "composite deck" that can span up to 15 feet once the concrete has cured. But until the concrete has set, the pans must be temporarily supported. Duiker typically uses 6x6 or 4x4 headers midway between and running parallel to the bearing walls on a maximum of 8-foot centers. Where the clear span of the slab exceeds 15 feet, Duiker typically uses structural steel or a reinforced concrete grade beam for permanent support (Figure C).

Steel pans come in lengths of up to 32 feet. To reduce labor costs and to take advantage of the increased strength of continuous pans supported at the ends as well as at midspan, Duiker typically uses pans that span the entire building. Adjacent pans are locked together using a crimping tool that secures the trough of one to the lip of the next. The 20-gauge pans are easily cut to length with a 12-inch abrasive saw, and are fastened at the perimeter with one or two Tapcons per sheet — just enough to hold the pans in place.

The corrugations make block-outs slightly more labor intensive. At stairwells and other openings, Duiker uses a sheet-metal angle to close off the ends of the pans, then forms the rough opening with ply-

Figure A. Thorough vibrating during the pour ensures a good bond between slab concrete and the steel pan forms.

Figure B. Both shallow-pan (left) and deep-pan forms (above) are available. With temporary supports removed, the concrete-and-steel "composite" deck can span long dimensions and leaves a clean appearance on the underside.

wood, which provides for a clean finish appearance. Penetrations for plumbing, electrical, and mechanical systems are blocked out directly on the steel deck. To rough in a toilet, for example, an ABS closet flange is typically set in place with a short length of pipe penetrating the steel pan. The flange is sealed to the pan with scraps of fiberglass insulation or with expanding spray foam. For ductwork and other large penetrations, Duiker glues blocks of foam built up to the proper size and cut to roughly conform to the pan corrugations.

On structures of up to 3,000 square feet, two workers can install the steel deck and all shoring in one day, assuming any structural steel beams are already in place. The average installed cost, including overhead and profit, is between $5 and $6 per square foot, not including the cost of any structural steel or radiant heat tubing.

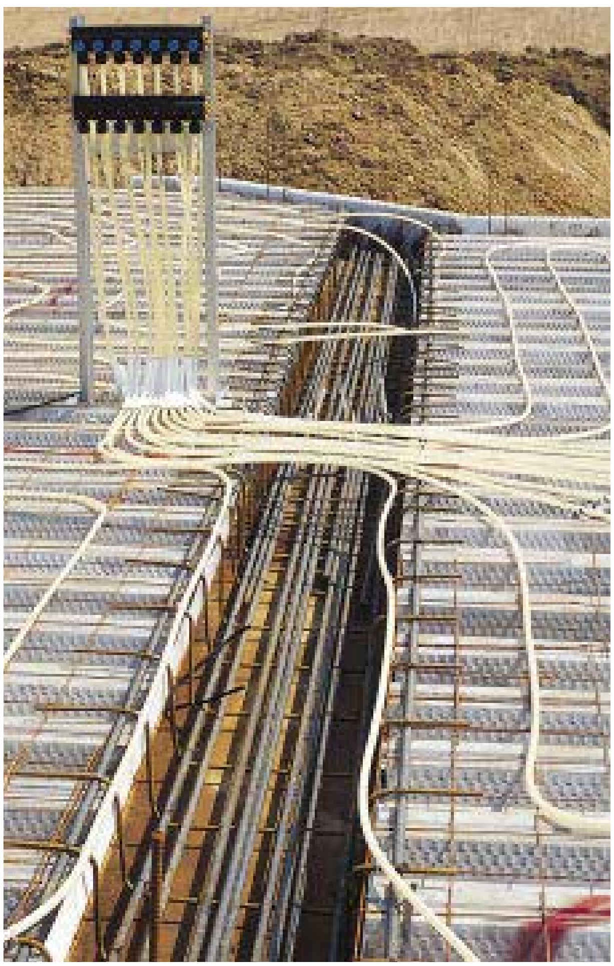

Figure C. Long spans are permanently supported with structural steel or, as shown here, by a reinforced grade beam poured monolithically with the slab.

Precast Panels

Duiker has also used precast concrete panels from Coreslab (13425 Lime Creek Rd., Cedar Park, TX 78613; 512/250-0755) for his concrete floors. The prestressed panels are manufactured in 4-foot widths at depths of 8, 10, and 12 inches, and in spans up to 52 feet. The panels are cast with a regular pattern of cylindrical cores (Figure D), which both reduce the weight and serve as raceways for mechanical and electrical systems. The panels are installed by specially trained crews using a crane. The cost is usually higher than for other concrete floor systems on buildings smaller than 6,000 square feet. Precast panels are also less well-suited to radiant floor heating because the tubing must be set in a layer of concrete topping at additional cost.

Figure D. These precast concrete panels are fabricated with hollow cylindrical cores that can be used to run wiring and piping. Installation is typically handled by special crews using a crane or boom truck.