RADIANT SLAB ON A TIGHT BUDGET

by John Siegenthaler

As a heating design engineer, I spec a lot of hydronic radiant-floor heating systems for both residential and commercial jobs. I would probably spec more residential systems, however, if they weren't so expensive. Though initially interested, many homeowners are eventually scared off by the high costs.

One of the reasons for the high cost has to do with the cost of the thin slab itself. The usual method of installing the thin slab for hydronic floor heating uses a self-leveling gypsum-based underlayment, such as Gyp-Crete. The underlayment is typically poured near the end of the job, after all the walls are up and the house has been closed in. These systems must be installed by a certified installer with a factory-trained crew.

Typically, the more remote the site and the smaller the job, the higher the cost per square foot will be. In my area, for example, which is about 60 miles from the nearest certified dealer, the cost of Gyp-Crete varies from $2.45 per square foot for jobs over 2,000 square feet, to over $3 per square foot for jobs under 1,500 square feet. This pricing includes a 1 1/2-inch-thick slab with a compressive stress rating of 2,000 psi, but does not include the tubing and other materials, such as underside insulation.

Using a custom concrete mix kept costs down on this in-floor hydronic heating system

Several years ago during a lunch conversation with a heating subcontractor, Harvey Youker of UnderSun Construction in Dolgeville, N.Y., I was lamenting the cost of installing such a thin-slab system. Harvey then proceeded to describe his idea for a *concrete* thin slab that could be quickly and accurately placed over a wood-framed floor. We continued to trade ideas and refine this concept, which we dubbed the "Youker system." Then, last fall, came the opportunity to try it on a small, 900-square-foot building. The results proved very encouraging.

First-Floor Heating Tube Layout

Figure 1. *The author begins a tubing layout by picking a central location for the manifold station. In each circuit, the hottest water flows near the outside walls of each room, where the greatest heat loss occurs. Note the placement of control joints in the slab at each doorway, and in the center of any expanse over 15 feet.*

Tubing Layout and Floor Prep

With the subfloor in place, we began by marking the locations of all exterior walls and interior partitions on the deck using chalk lines. We also marked the locations of the tubing circuits on the floor deck with a chalk line and lumber crayon, following an accurately drawn layout plan (see Figure 1).

Manifold station. When drawing the layout plan for two or more tubing circuits, I first locate the manifold station where each circuit begins and ends. I always pick a central location, as shown in Figure 2. The manifold must allow all outgoing and returning tubing to come together in close proximity without the tubes crossing over each other. Also, the manifold should be easy to get to so the flow in each circuit can be balanced. To keep the manifold accessible but still hidden, I like to install an access panel to the manifold station on an inside wall of a central closet.

Slip sheet. We then covered the entire deck with a transparent 6-mil polyethylene "slip sheet." This sheet mainly acts as a bond breaker between the wooden subfloor and the thin slab, and reduces the possibilities that shrinkage of the floor deck will cause random cracks in the slab. The poly sheet also protects the subfloor from rain before the building or addition is closed in.

Subplates and floor blocking. Next, we fastened down 2x6 and 2x4 subplates to the floor deck at all wall and partition locations. The slab will be poured flush with these plates, and they provide nailing for the walls. We also installed 2-by blocking where the toilet flange and other mechanicals that won't be routed through the partitions will be located (Figure 3). Later, this blocking can be removed to run piping or ductwork through the subfloor. We cut a slight taper on the edges of these blocks and install them with the narrow side facing down; square-cut edges make the blocks tough to get out.

Tubing. After this prep work was done, we were ready to run all the floor tubing over the premarked paths. Any fastener must be approved by the tubing manufacturer, otherwise the tubing's warranty may be voided. Typically, you can use hand-nailed plastic clips, gun-driven plastic staples, or metal staples. We used metal staples driven by a specially set-up Bostitch pneumatic stapler. This gun has a special nose attachment that controls the depth-of-drive to prevent compressing the tubing.

After all piping is in place, the system should be pressure-tested the same as with any floor heating installation.

Control joints. Be sure to provide control joints within the slab. These joints allow the slab to crack along predetermined lines as the concrete cures and the wood deck shrinks. We

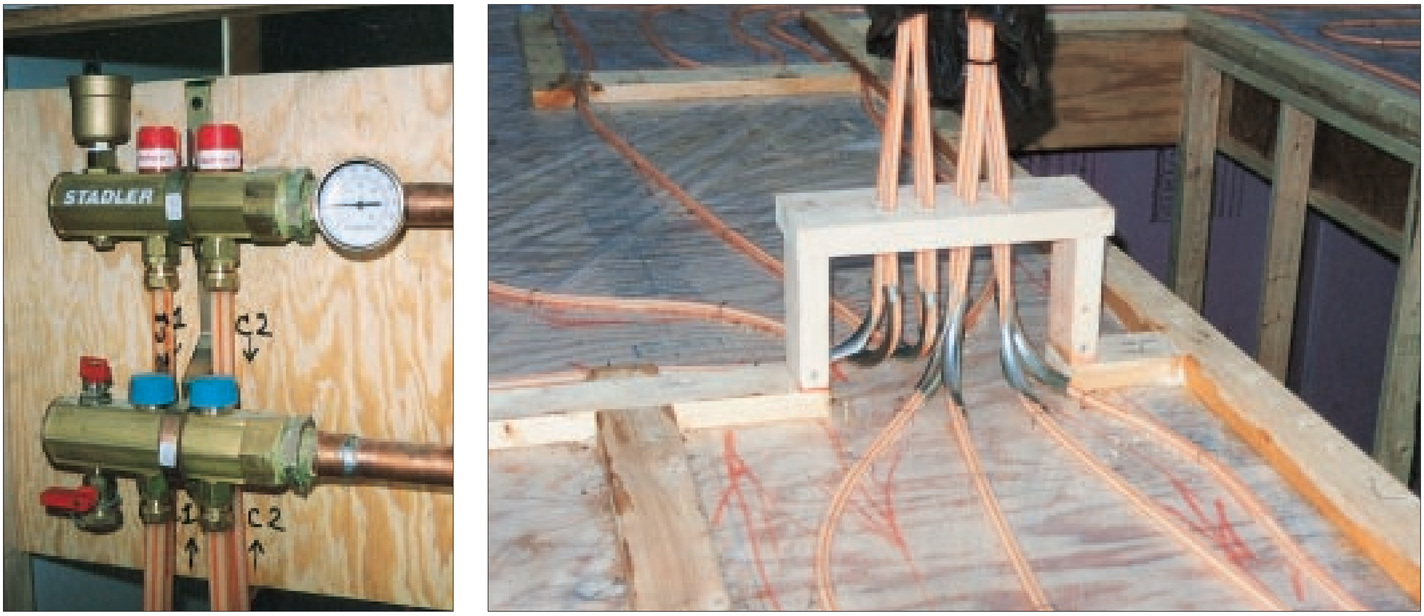


Figure 2. *The four tubing circuits begin and end at a manifold station located in a wall inside a closet (left). Metal bend supports, supplied by the tubing manufacturer, protect the tubing from kinking as well as from the concrete finisher's trowels (right).*

used 1x1-inch PVC drywall corner bead to make the control joints (Figure 4,). We stapled the corner bead to the subfloor, placing them across all doorways, and in the center portion of large rooms to break the slab area up into smaller segments (no more than 15 feet in any one direction).

To further guard against random cracking, we coated the edges of the 2-by subplates with form-release oil. This prevents the concrete from adhering to the side of the plates, thereby reducing tensile stresses within the concrete as it cures and shrinks. The form oil can be applied with either a brush or a small paint roller. One coat is sufficient.

The Concrete

The Youker system relies on a thin concrete slab instead of the more typical gypsum-based underlayments. Concrete not only costs less and is more readily available, but once cured, it is not adversely effected by water. Gypsum-based underlayments can soften with continued exposure to water. Although normally this is not a problem, a leaking pipe or large spill at some point in the building's life might lead to major problems with the flooring. Also, the thermal conductivity of concrete (with a limestone aggregate) is about twice that of gypsum-based underlayments. This allows better lateral heat flow away from the tubing within the floor slab, producing less noticeable variations in the surface temperature.

Mix design. The mix design we used is shown in the table on the next page. Before adding the superplasticizer, this mix will have a slump of 2 to 3 inches. Once added, the superplasticizer increases the slump to 7 or 8 inches. This high slump, in combination with the small "pea stone" aggregate, allows the mix to easily flow around the tubing and makes for excellent thermal bonding. The water-reducing agent controls shrinkage of the concrete as it cures. The fibermesh provides tensile reinforcement to further resist shrinkage cracking.

Concrete costs. When poured $1^1/2$ inches thick (the same thickness of the wall subplates), one cubic yard of concrete will cover about 210 square feet of floor area. Our cost for the concrete mix was \$73 per yard — or about 35¢ per square foot — delivered to the site. Labor costs for placing and troweling added about 50¢ per square foot. With an allowance for placing the poly slip sheet, the extra wall plates, and coating the plate edges with form oil, the approximate in-place cost for the slab totaled \$1 to \$1.10 per square foot. This is less than half the cost of a gypsum-based thin slab in our area.

Pouring the Slab

We unloaded the concrete from the truck just like any concrete, using the truck chute and wheelbarrows. The concrete crew used a scrap of plywood under the nose of the wheelbarrow as it was dumped to prevent pinching the tubing. In many places, the 2-by sub-

Figure 3. *Prep for pouring the slab includes installing subplates for all the interior and exterior walls, and blocking for the toilet flange and other mechanicals.*

Figure 4. *To prevent random cracking of the slab, control joints were created by nailing PVC drywall corner bead to the plywood subfloor (left). Control joints across doorways (right) and in the center of large rooms ensure that the slab cracks only in these locations.*

plates served as screeds; in larger rooms where these plates could not be reached, temporary 2x4s were screwed down to the deck to serve as screed guides.

We found that a single worker on the wheelbarrow could keep up with two workers placing the concrete. For the 900-square-foot slab, this three-person crew placed, screeded, and floated 4½ yards of concrete in about 45 minutes. We were able to continue framing the next day. Cracks over the control joints appeared a few days after the pour.

Added Dead Load

The concrete we used had a dry density of about 144 pounds per cubic foot. At a thickness of 1½ inches, this added about 18 pounds per square foot to the dead loading on the floor. By contrast, a 1½-inch-thick gypsum-based underlayment adds about 14.4 pounds per square foot.

In either case, it is critical that the floor framing is designed to handle the extra loading. In many cases, deeper or closer-spaced joists will be required. In our project, we used wood I-joists designed for the extra loading. It's important to inform the supplier of extra loading requirements when ordering the joists.

On all projects, I prefer to size the floor framing to limit deflection to no more than 1/480 of the clear span under full live loading. This results in a very solid deck. The extra cost associated with beefing up the floor deck will, of course, add to the square-foot cost of any thin-slab system.

Insulation. Any type of thin-slab floor-heating system also requires insulation under the subflooring to limit downward heat flow. I specify R-11 insulation when the space beneath the floor is fully heated, and R-19 over partially heated basements. The cost of installing this insulation should also be factored into the square-foot cost of the system if it would not otherwise be present.

Thin-Slab Cost

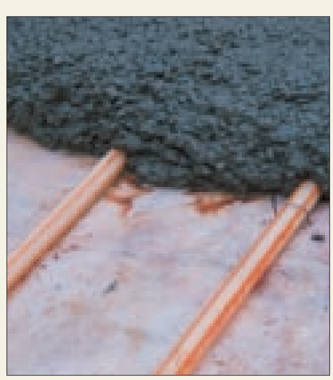
The installed cost of our heated floor system, including tubing (12 inches on-center), the 1½-inch-thick slab, and R-11 underside insulation, totaled about $2.60 per square foot. This doesn't include the boiler, controls, manifolds, or finish flooring. The same thin slab using a gypsum-based underlayment would have cost us a minimum of $4.50 per square foot on this project.

While this system can be modified for use in retrofit work, we found the key to using it on our project was to incorporate it into the design of the building as early as possible. This allowed us to optimize the floor framing for higher loading, and to adjust the procedure so we didn't have to worry about the heights of windows, doors, cabinets, and stair risers to compensate for an extra 1½-inch-thick slab. ■

John Siegenthaler, P.E., owns and operates Appropriate Designs, a building systems engineering firm in Holland Patent, N.Y. He is the author of Modern Hydronic Heating for Residential and Light Commercial Buildings *(Delmar Publishers; 800/347-7707).*

Youker Mix Design

Type 1 Portland cement	517 lb.
Concrete sand	1,630 lb.
#1A (¼" maximum) peastone	1,485 lb.
Air-entrainment agent	4.14 oz.
Hycol (water-reducing agent)	15.5 oz.
Fiber mesh	1.5 lb.
Superplasticizer (WRDA-19)	51.7 oz.
Water	about 20 gal.



Note: *These mix proportions make one cubic yard of 3,000-psi concrete floor topping (strength rated at 28 days). The high-slump concrete recipe creates an easy-to-pour mix that flows well around the tubing, providing excellent thermal conduction between the tubing and the concrete.*