by Bill Eich

Frost-Protected Shallow Foundations

To reduce costs and save energy, protect shallow footings with rigid foam

Though he builds in deep frost country, the author uses foam insulation around the foundation perimeter to fool his footings into thinking they're in Florida. Since heat loss is greater at building corners, the apron of insulation is wider there. Walk-out foundations, like the one on this house built by the author (left), are also much easier with an FPS foundation.

Most building techniques that improve quality or save energy also increase construction costs. But the frost-protected shallow foundation (FPS foundation) is an exception: If you build in an area where frost heaves can cause trouble, frost-protected shallow foundations enable you to build a higher-quality, more energy-efficient building for less money than the traditional deep footing. Now that the technique is being accepted by the major model codes, it's time for builders to take a good look at FPS foundations.

How an FPS Foundation Works

The FPS foundation concept is so simple it's surprising that it hasn't caught on sooner in the United States. Rather than install our footings below the frostline (which is 48 inches deep in much of the northern U.S.), we insulate the ground around the perimeter of our homes with enough foam insulation to permanently raise the frostline. We make the footings think they are in Florida, where they only have to be 16 inches deep.

The technique's success is based on a fundamental principle of physics: In conductive heat transfer, heat travels from warm to cold, and it will always follow the path of least resistance (see Figure 1). The earth generates its own heat. In a deep frost footing, the soil around the foundation (along with snow cover) stores the heat and slows its movement from within the earth, keeping the deep subsoil warmer than freezing year-round. In an FPS foundation, well-placed foam insulation provides resistance that directs the heat flow under the shallow footings, where the soil, with its high heat-storage capacity, stays above the freezing point year-round.

A long history. FPS foundations are different, but not new: FPS foundations were first shown in the U.S. in Frank Lloyd Wright's Usonian home in 1936. In the mid-1950s, the Swedes and Norwegians began using the system extensively.

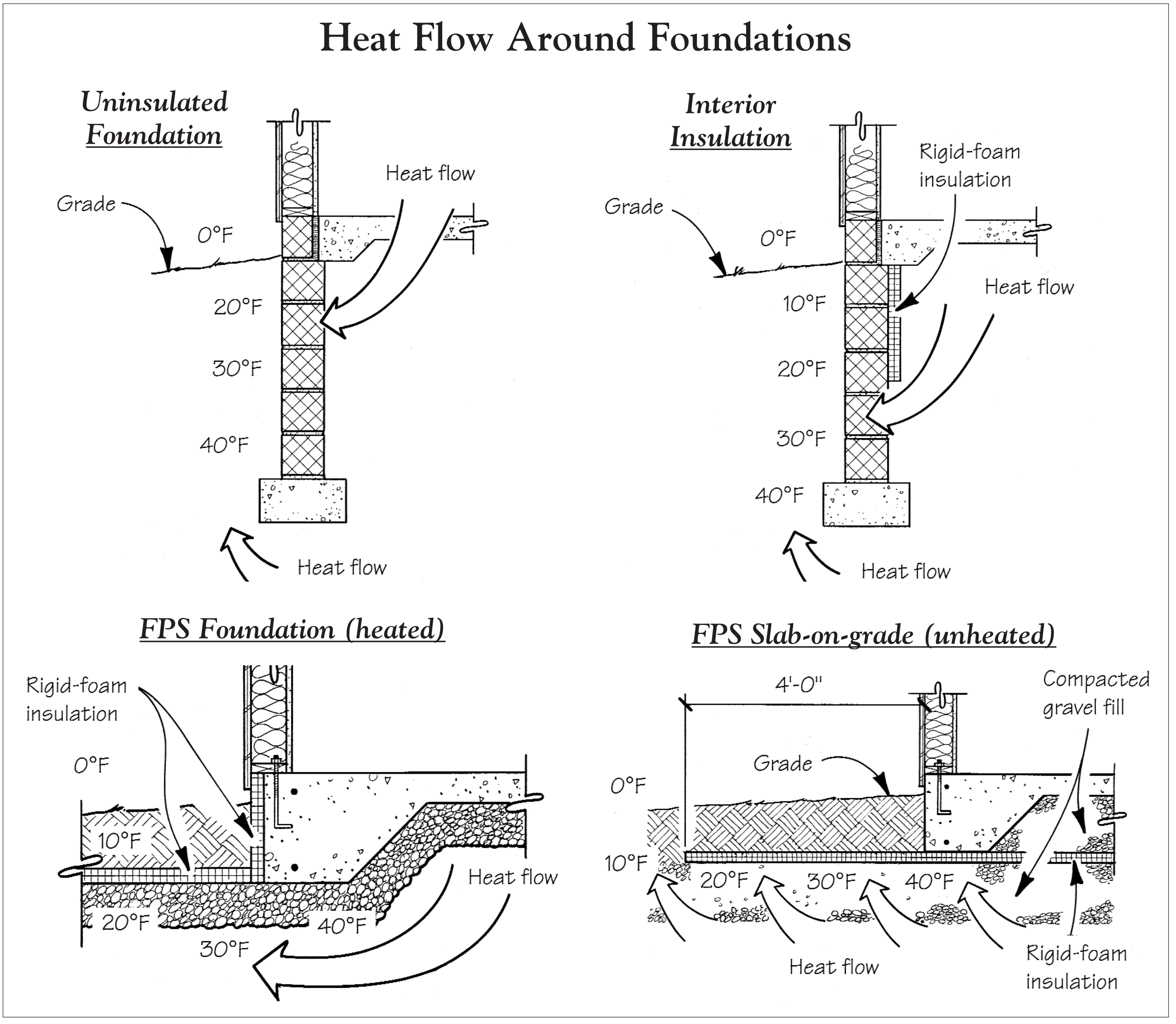

Figure 1. *In an uninsulated foundation (top left), the footing is warmed by the earth's heat, as well as by heat from inside the building. The deep soil above the footing provides the insulation and heat-storage capacity to keep the soil near the footing from freezing. With interior insulation (top right), the footings still have to be below the frostline. But in a frost-protected foundation (bottom left), foam insulation rather than soil depth keeps the soil at the footing from freezing. For unheated slabs-on-grade (bottom right), the foam is placed under the entire slab to retain ground heat. The insulation must extend horizontally 4 feet beyond the footing.*

Today, there are more than a million structures built in Scandinavia on shallow foundations.

Some U.S. builders have also demonstrated the value of the concept. My own company, for instance, has been building FPS foundations with good success for many years in Iowa, where the frostline is 4 feet deep.

Code approval. FPS foundations are finally gaining acceptance here in America. CABO (*One and Two Family Dwelling Code*) has approved shallow foundations for heated structures and is expected to revise its approval this year to include unheated structures and crawlspaces. ICBO has given a preliminary approval for both heated and unheated structures. Final ICBO approval is expected this year, with the complete text being printed in the 1997 edition of the *Uniform Building Code*. It's a good bet that when the major model codes are integrated into a single *International Building Code* — slated to happen by the turn of the century — frost-protected shallow foundations will be allowed.

Resource available. Before you actually build one, you should study the *Design Guide for Frost-Protected Shallow Foundations*, available for about $25 from the NAHB Research Center (400 Prince Georges Blvd., Upper Marlboro, MD 20774; 800/638-8556). The book contains important details that I won't cover here. But I will give you a general idea of how FPS foundations are built, show some of the options they give you, and explain how they improve energy efficiency and reduce costs.

Placing the Insulation

The placement of the insulation and the construction of the footing will vary depending on the situation. Heated buildings are insulated around the perimeter, to direct interior building heat to a point below the footing. For unheated buildings, there is no interior heat to save; instead, the insulation is placed under the slab and footing to salvage ground heat. Walk-out basements and other special situations call for their own particular details. Let's take a look at some of the options.

Heated structures. For a heated building in our climate, the design guide calls for a 2-inch layer of foam placed vertically on the footing perimeter, and another 2-inch layer of foam placed as "wing insulation," extending horizontally 16 inches out from the footing's base (see photo).

At the outside corners, where the floor area is exposed on two sides, the heat loss is greater. So more wing insulation is required there — in my climate, corners need 32 inches of wing insulation rather than 16 inches.

We sometimes use permanent wood foundations instead of poured concrete. The cost is about the same, but in the winter, when poured concrete might freeze, it can be easier to place a wood foundation and put the shell up, then come back and pour the slab later. With the wood foundation, the foam is placed in the same position as with a shallow poured footing, but it's nailed to the wood (Figure 2).

Figure 2. *In the photo at left, wooden concrete forms are lined with foam insulation. After the monolithic slab and footing is poured, the forms will be stripped and "wing insulation" placed around the outside perimeter. In the right-hand photo, a permanent wood foundation has foam nailed against it (wing insulation hasn't been added yet). This technique lets the author work in winter: He builds the shell on the wood foundation, then pours the slab.*

Most of our buildings are framed with 2x6 walls. Typically, we offset the foundation by 2 inches all around, so the foundation insulation flushes out with the wall framing above. If that causes too much of a problem, we just taper the top edge of the foam, so water will drain off it.

Good drainage. Although the insulation can be relied on to prevent any water under the foundation from freezing, good drainage details provide further assurance — a sort of belt-and-suspenders approach. On particularly wet sites or in areas with expansive soils, we place drain tile around the perimeter of the house, or leading from a subslab gravel bed to daylight, as appropriate. All our buildings also have gutters and downspouts to direct roof runoff away from the building perimeter.

Unheated Structures

Shallow foundations also work for unheated structures like garages and sunrooms. The space inside these structures usually doesn't get quite as cold as the outdoors, but there isn't any source of heat inside that you're trying to save. So the purpose of the foam insulation is to salvage the heat from the ground below, and also to salvage heat flowing from below the attached house. To achieve that, we put 2 or 3 inches of foam insulation under the entire garage floor, extending out 48 inches beyond the outside perimeter.

The *Design Guide* tells you how thick the insulation should be for your climate. In general, the more compacted gravel you have below the foam, the less thick the insulation has to be, because the compacted gravel drains well and is not susceptible to heaving

Figure 3. *Slabs and footings for unheated buildings, such as the attached garage shown here, are placed directly on top of the foam insulation, with a foot of gravel under the foam. Stakes for the footing forms are driven through the foam (above). A trench is hand-dug inside the perimeter to form the slab's thickened edge (right).*

Walk-Out Basement

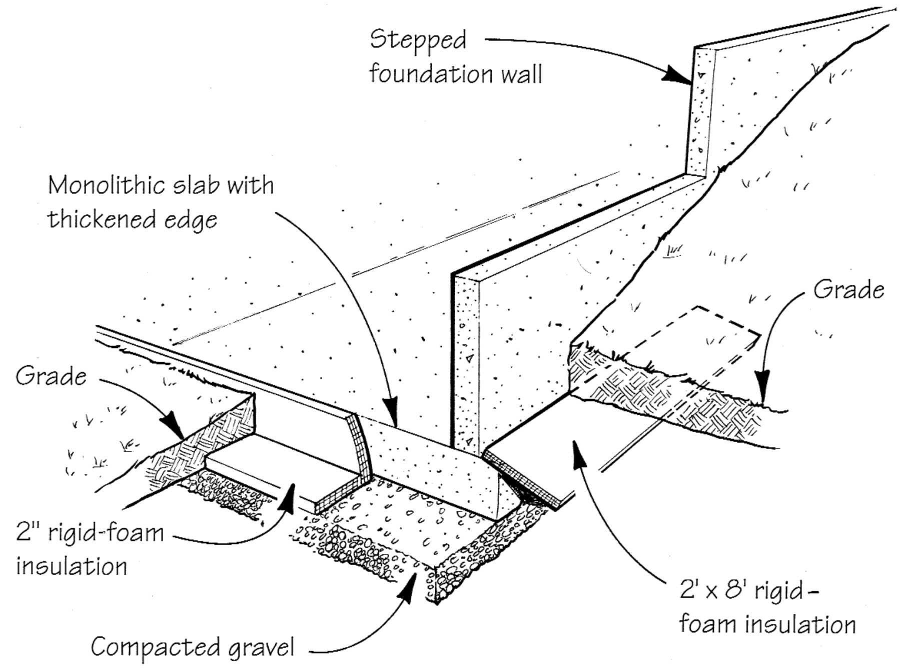

Figure 4. *The author protects walk-out basement foundations with foam to avoid having to step down the excavation. A 2x8-foot length of foam board protects the footing of the main wall at the corner where the backfill is shallow.*

when it freezes. With 6 to 12 inches of gravel, you need only 2 inches of insulation, but if you're putting the foundation directly on clay or dirt, you'll probably need 3 inches of foam.

Most of the garage foundations my company builds rest on at least a foot of fill gravel. For an FPS foundation, we use the gravel to our advantage. When we place and level our fill, we bring it up to within about 14 inches of the point where the top of the finish slab will be. Then we place the 2-inch foam on top of the gravel and form the perimeter of our garage slab with 2x10s, driving our stakes right through the insulation (Figure 3). We fill the inside with 5 inches of compacted gravel. Then we spade out a thickened edge around the perimeter by hand, put two pieces of reinforcing steel in the trench, and pour a monolithic slab footing.

In this design, the footing and slab are bearing on top of the foam. Some builders worry that the foundation concrete may crush the foam. But it turns out that this is not a problem. For residential footings, the soil that the footing bears on is typically required to have a compressive strength of 2,000 lb./sq. ft. The foam used for frost-protected slabs has a density of 2 pounds per cubic foot and a compressive strength of around 3,500 lb./sq. ft., so it actually can bear more weight than the soil it rests on. If that margin of safety is not enough for you, there are foams available with even higher compressive strengths.

The CABO code allows for either a 2-pound density expanded foam ("beadboard") or extruded foam for vertical insulation, but only allows extruded foam for horizontal applications. (When the code was written, the expanded foam was disallowed for horizontal applications because of concern about potential moisture absorption.)

Be careful to get the right foam. Most expanded foam stocked by lumberyards is only 3/4-lb. or 1-lb. density and lacks sufficient compressive strength. Several extruded foam manufacturers make a 15-psi product, which works out to 2,160 lb./sq. ft. These products are fine for applications below grade around the perimeter, but should not be used under load in shallow foundations, according to code. (For manufacturers of suitable foam, see "Sources of Supply".)

Where FPS Foundations Shine

Frost-protected shallow foundations have particular advantages in a number of special situations:

Complex plans with angles are much easier to do with the FPS foundation. Try to get a backhoe operator to dig an octagonal foundation and you'll see what I mean. With a shallow foundation on grade, you just scrape off a flat area and you're ready to go.

Room additions on narrow lots are also much easier. Often you can hand-dig a shallow foundation, avoiding all the disruption of bringing heavy equipment on site.

Foundations over uneven, sloping terrain are easier. Houses with crawlspaces on sloping lots can be done "half and half": The footing on the uphill side is backfilled with enough earth to keep it from freezing, but on the downhill side you can use insulation to keep the footing from freezing rather than stepping down the footing.

Walk-out basements are simpler. Where one wall of a basement is a walk-out, we don't have to excavate, form, and pour the traditional step-down footing. Instead, we use a frost-protected footing for that wall, usually with a monolithic slab (Figure 4).

Near the corners, the backfill above the footings of the full basement walls may not be deep enough to prevent freezing. So we place wing insulation above the footing as needed. In most cases, we just lay one 2x8-foot piece of 2-inch foam over the footing at the corner, then backfill.

You can winterize existing buildings that don't have a deep foundation. In one case we did this for a restaurant that had an unheated porch on two sides. Instead of putting a deep foundation under the porches, we insulated the perimeter of the porch foundations, and saved the customer almost $3,000. He turned around and spent that savings with us to extend his project beyond the original proposal.

Post-and-pier foundations for decks and porches can be frostproofed, too. In some soils, even a 48-inch-deep post footing will sometimes be heaved up by frost because of adfreezing: Tough clay soil will freeze to the surface of the foundation and lift the post. Although there is no provision for this situation in the design guide, we've found from experience that a 4-foot strip of foam around that post footing can keep the ground below from freezing and solve the problem (Figure 5).

Protecting a Pier

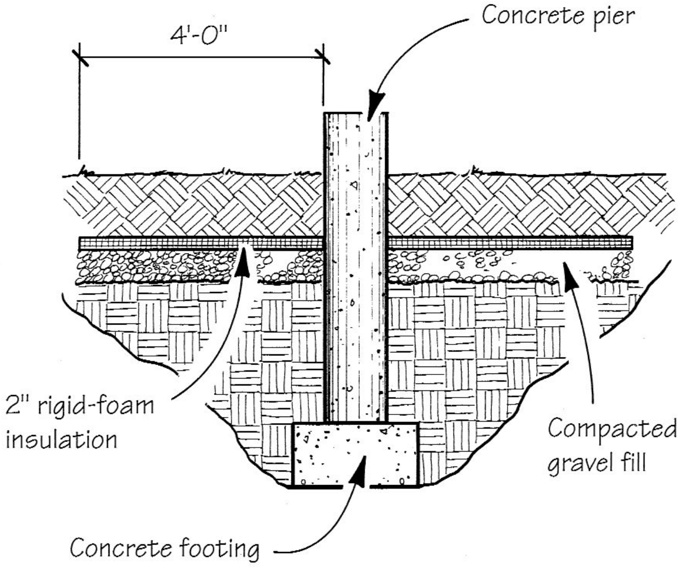

Figure 5. *To prevent frost heaving of pier foundations, the author places 2-inch foam horizontally around the piers about a foot below grade.*

Advantages of Shallow Foundations

Using the shallow foundation approach cuts my company's costs in many ways. We don't just save on the cost of concrete, we also spend less on excavation and backfill — there is just less fill to store on site or haul away. In general, we find that while we spend $20 to $25 per linear foot for a 48-inch-deep foundation, we spend in the range of only $9 to $10 per linear foot for shallow foundations.

Job-site convenience is also a factor. We don't have to work around the overdig from the foundations, or worry about storing the fill, hauling it off, and putting it back in — and there's no concern about trench safety. All of this means scheduling is also easier with shallow foundations: The whole job moves faster when you take a few steps out of the process.

Shallow foundations allow us to extend our concreting season into December. We use the foam insulation to protect the ground prior to digging, and the foundation foam protects the footing before and after the pour.

We've also found that buildings on frost-protected shallow foundations provide better customer satisfaction. One big benefit is warm floors, even in homes with forced-air heating systems ducted through the attic and slab-on-grade construction.

With FPS foundations, we can offer better value in the home: Because of the money saved on foundation and site work, the customer will be able to spend more on amenities like whirlpools or skylights. And compared with a crawlspace, slab-on-grade construction reduces sound transmission, resulting in a quieter home.

Another big advantage is energy savings. An insulated perimeter foundation significantly reduces heating bills. If you're considering radiant floor heat, the added insulation in an FPS foundation makes that option more cost-effective.

Convincing Customers

One disadvantage with a less well known technique like this is that you have to sell customers on the idea and *also* convince reluctant building officials. Selling the customer is usually easy. I've found that when a customer is offered the choice between 4 feet of concrete below the ground or a luxury master bath with whirlpool, the luxury bath wins every time.

If your local code doesn't include FPS foundations yet, bear with your code officials. They take a lot of risk when they approve something that isn't specifically written into the code. But there is a lot of technical printed information available on FPS foundations, with sound engineering proof behind it. So if you keep a positive attitude, an open-minded code official may be willing to work with you, not against you. ■

Bill Eich is a builder and remodeler specializing in energy-efficient homes in Spirit Lake, Iowa.

Sources of Supply

The following companies supply foam insulation products suitable for use in frost-protected shallow foundations. Be sure to ask for high-density foam with a compressive strength of at least 25 psi.

AFM Corp.
P.O. Box 246
Excelsior, MN 55331
800/255-0176

Amoco Foam Products Co.
2907 Log Cabin Dr.
Smyrna, GA 30080
800/241-4402

Cellofoam North America
P.O. Box 406
1961 Industrial Blvd.
Conyers, GA 30207
800/241-3634

Dow Chemical Co.
2020 Dow Center
Midland, MI 48674
800/232-2436

ICE Block Building Systems
2114 Tomlynn St.
Richmond, VA 23230
800/423-2557

Insulated Building Systems
22377 Cedar Green Rd., Suite 2B
Sterling, VA 20166
703/450-2366

Premier Building Systems
4609 70th Ave. East
Puyallup, WA 98371
800/275-7086

UC Industries
3 Century Dr.
Parsippany, NJ 07054
800/828-7155