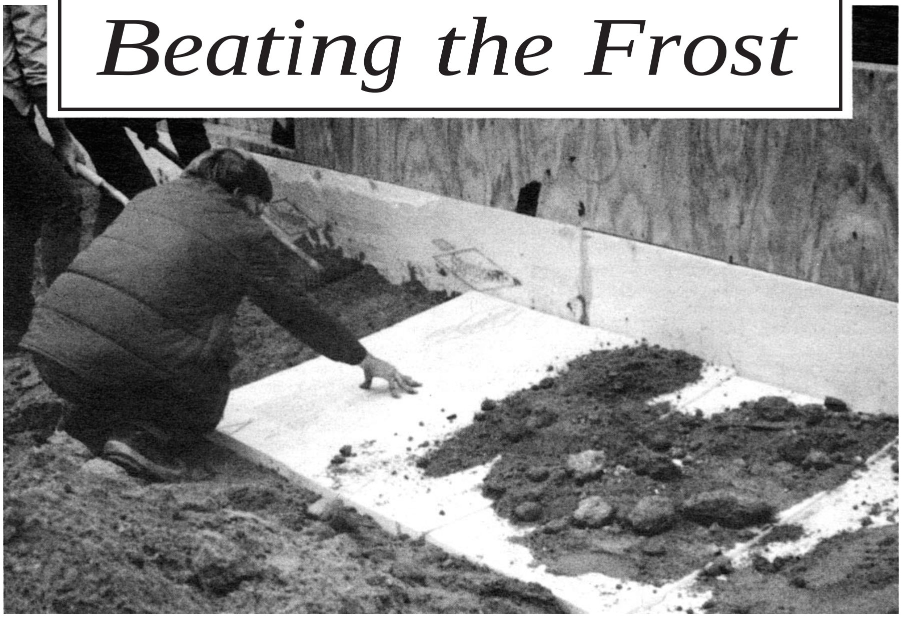
Shallow Foundations: *Beating the Frost*



A shallow layer of topsoil is shoveled onto the 2-inch polystyrene "skirt." The rigid insulation is sloped slightly away from the house to keep the soil dry around the foundation and slab – a key to preventing frost heaving.

This novel technique from Scandinavia is cutting construction costs in Iowa

by Bill Eich

Conscientious builders strive to conserve energy, improve quality, and reduce costs, but few innovative building techniques fulfill all three objectives. The frost-protected shallow-footing technique is an exception.

The concept is so basic I'm surprised it hasn't caught on sooner. Rather than build the footing below the frost line, you insulate the ground at the building perimeter to raise the frost line. If the ground never freezes, you no longer a deep footing. The technique has a long history of successful use in the Scandinavian countries (see "Thirty-Year Track Record").

With conventional slab construction, most heat loss occurs at the slab's edge. You can dramatically reduce heat loss by adding rigid foam insulation; but with a frost-protected shallow footing, you cut heat loss and construction costs. The rigid foam insulation retains heat that would otherwise be lost from the building perimeter (see Figure 1). That heat, plus residual heat from the ground below the natural frost line (a fairly constant 50-F, once you get down 20 feet), keeps the area below the footings from freezing or heaving.

Structurally, the foundation loads are distributed through the rock or gravel to the subgrade at a 45- angle. An 8-inch-wide, shallow foundation wall, bearing on foam and 4 inches of gravel, distributes the house load over the same subsoil area as a 16-inch-wide spread concrete footage (see Figure 2 on next page).

The cost savings with this technique are substantial. With conventional 48-inch-deep concrete or block walls and footings, our company used to figure $18 to $20 per lineal foot. The frost-protected shallow design costs $5 to $8 per lineal foot. (Both figures exclude insulation and excavation costs.)

Most of our homes are one-story with walk-out basements. When we build walk-out basements, we use shallow footings beneath the downhill wall, which we frame.

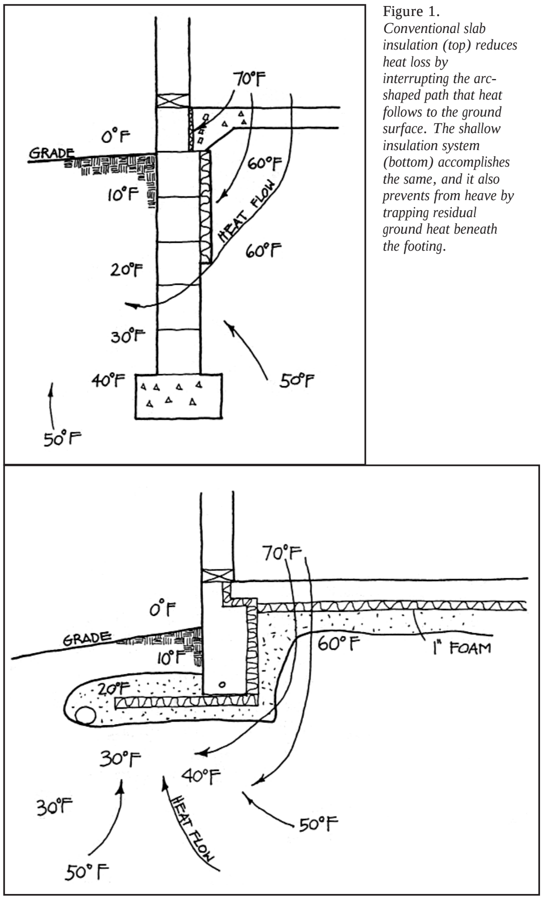


Figure 1. *Conventional slab insulation (top) reduces heat loss by interrupting the arc-shaped path that heat follows to the ground surface. The shallow insulation system (bottom) accomplishes the same, and it also prevents from heave by trapping residual ground heat beneath the footing.*

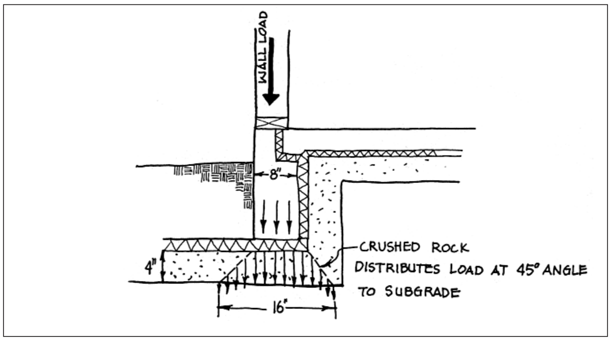


Figure 2. *An 8-inch foundation wall, bearing on insulation and gravel, distributes the house load over the same subsoil area as a 16-inch spread footing.*

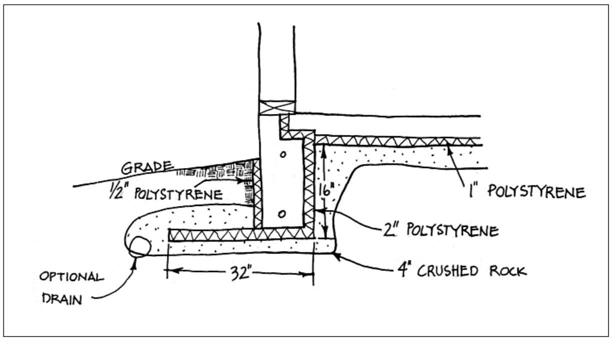


Figure 3. *The shallow foundation only works as a complete system: Four inches of crushed gravel beneath the footing keeps water from wicking up. Half-inch foam on the outside of the foundation wall keeps frozen soil from lifting up the foundation. The subsurface drain keeps water from ponding near the footing.*

For the other walls, we use either a wood foundation or concrete. We normally have about 50 to 60 lineal feet of frost footings. That translates into about $700 in savings per home. The money we save allows us to build other features into our homes and still remain competitive.

On one project, a 3,500-square-foot slab-on-grade commercial building, my bid was nearly the same as a competitor's, but I offered a frost-protected shallow-footing option that saved the owner $2,700. I got the job, and today that competitor also uses the frost-protected shallow footing!

Fine-Tuning the Design

Insulating the ground is not the only thing that makes this system work. Good site drainage, capillary moisture control, and an isolation joint are also necessary for your peace of mind when the temperature drops below -30-F.

To keep water from ponding near the foundation, the final grade should slope away from the structure a minimum of 5 inches in the first 10 feet, and roof rain water must drain away from the house. Both are sound building practices.

You must also control capillary moisture by providing a moisture break. Just as water wicks up a sponge, capillary moisture flows up through the soil, even if the water table is several feet below. Four inches of washed gravel or rock form an effective capillary moisture break (see Figure 3).

One final detail that you won't find in conventional construction is an isolation joint to prevent ad-freezing. In ad-freezing, certain soils, particularly expansive clays, freeze and adhere to the side of a foundation. The soil alongside a foundation can sometimes exert enough upward pressure to heave a foundation, even if the footing is below frost line. Dow Chemical's 1/2-inch foam board has a protective film that works well in this application, though you could use insulation without a film. The film keeps the board from breaking, making it easier to handle in the field. The isolation joint only needs to extend to the top of the final grade.

A 2-pound-density expanded polystyrene (beadboard) or extruded polystyrene (blueboard) make acceptable foundation insulations. You can use either on vertical applications or under concrete slabs, but under bearing walls you should only use the extruded polystyrene. We find that blueboard is a little more expansive than beadboard, but it's easier to handle and saves labor.

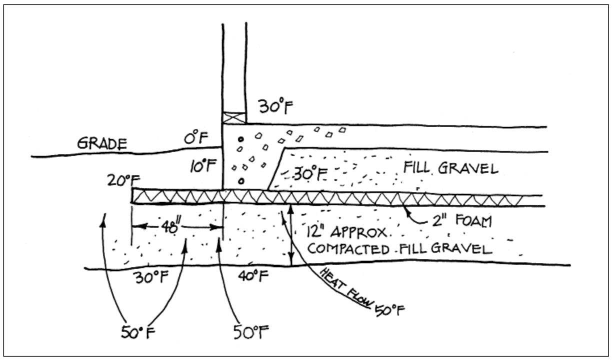


Figure 4. *Unheated garages must use 12 inches of gravel and 2 inches of foam. The system uses more foam because it depends on trapped residual heat from the ground to prevent excessive frost heave.*

With our foundation system, the footings actually bear on 2 inches of Dow Styrofoam as shown in Figure 3. If that makes you a little nervous, consider that the compressive strength of Dow Styrofoam is 25 psi or 3,600 psf. The bearing capacity of the soil beneath the footings is normally about 2,500 psf.

To get the benefits of the frost-protected shallow footings, you do not absolutely need to place insulation beneath the footings. Instead, you could place the 2-inch polystyrene on the outside of the foundation wall. In this case, the foundation bears directly on the pea gravel and a horizontal sheet of 2-inch foam extends 32 inches from the outside of the footing. Use a protective coating on the foam above grade. We use this technique frequently.

Creep or settlement of the foam apparently has not been a problem for Scandinavian builders. However, Dow Chemical recommends using a safety factor of three when using foam under footings. This should limit deformation of the foam to under 2%. For most single-story residential buildings, standard 25-psi Styrofoam is adequate (assuming a footing load of 8.5 psi). For heavier building loads, you might need to step up to a stronger product such as Dow's High-Load 40 commercial foam, which has a bearing capacity of 40 psi. (Dow's Technical Service Group can assist you in product selection; call 614/587-5580).

Construction Flexibility

The foundation is versatile enough for use in new construction, remodeling, and even in unheated garages. In new construction, you can build safely on problem soils. In one development, where we've built 30 houses, highly expansive clays and frost-heave lifted unprotected patios and decks 3 to 4 inches in winter. Even in these extreme conditions, we've had no problems with our shallow footings.

Remodelers will find that the freedom from deep excavation gives them many new options. How many times have you done small room additions when you didn't have room for a backhoe and had to hand-dig a deep footing? What about the mess excavating equipment causes in a landscaped yard, or the damage that a deep excavation can do to a nearby tree?

On one of our remodeling jobs, the owner wanted to enclose and finish a porch that didn't have a deep footing. Rather than tear out the existing footings, we insulated them and saved the owner money, which he spent on additional work. One doesn't have to think very hard to come up with dozens of applications.

We are also going to start using these foundations on unheated attached garages. Because the space is unheated, we have to modify the system slightly (see Figure 4). First, we place approximately 12 inches of compacted gravel fill. (Most of our garages require fill anyway.) Then we install 2 inches of foam to a distance of 4 feet beyond the building perimeter. We spread 6 more inches of gravel on top of the foam, and place the garage floor as a monolithic slab with a 12-inch thickened-edge footing. This system uses more foam because it depends entirely on the heat from the ground below to prevent frost heave. You may still find a small amount of frost heave (1/2-inch), but not enough to cause significant damage.

Code Approval

The frost-protected shallow footing is establishing a good track record. Currently, the NAHB is working on getting the technique approved in the national building codes and expects the CABO One-and-Two-Family Dwelling Code and the Standard Building Code will contain language approving this foundation by next year. The BOCA code has a provision that says footings need to be protected from frost. The building official makes the judgment call on whether shallow footings qualify.

Whether or not your local code explicitly allows the technique, building officials in any jurisdiction have the option of approving a building method if they determine that it meets the intent of their code in providing for the public health and safety.

For More Information

To help educate yourself and your local officials, you might want to order a copy of the book, entitled Frost-Protected Shallow Foundations: Current State-of-the-Art and Potential Application in the U.S., by Richard A. Morris, NAHB/NRC. The manual costs $15 and is available from the Society of the Plastics Industry, Expanded Polystyrene Division, 1275 K Street, N.W., Suite 400, Washington, DC 20005.

Bill Eich is a builder and owner of Bill Eich Construction Company in Spirit Lake, Iowa.

Thirty-Year Track Record

Though the shallow footing idea is new to most builders, in 1936 Frank Lloyd Wright used it on his "Usonian house," where he showed a concrete slab with a shallow, monolithic perimeter footing. Under-slab hydronic heating reduced potential frost damage.

Scandinavian builders have had 30 years to perfect the technique. Nearly every new building today in Sweden, Norway, or Finland employs a shallow foundation with insulation protecting it from frost damage.

About 10 years ago I tried a similar technique on a low-cost home. My results were less than satisfactory because I didn't have the technical information to do the job right. I only used 1-inch foam 12 inches vertically and 24 inches horizontally, and I had no capillary moisture break. The slab heaved about 1/2-inch and cracked. I didn't realize it at the time, but I wasn't very far from a workable system.

Five years ago I first heard about the Scandinavian shallow-footing technique from several Canadian building scientists, but it took me two years to get the nerve to try it again. Finally, I decided the system was too logical to fail.

Today, we have built over 30 buildings in northwest Iowa (8,000 heating degree days, 48-inch frost depth) with frost-protected shallow footings. I haven't had problems with any of them. – B.E.