Frost-Protected Shallow Foundations Save Time, Money

Builder's Experience

EASE OF INSTALLATION
DIFFICULT — EASY

SPEED OF CONSTRUCTION
SLOWER — FASTER

COST EFFECTIVENESS
POOR — EXCELLENT

RETURN ON INVESTMENT
IMMEDIATE — DEFERRED

COMPETITIVE EDGE
NONE — SIGNIFICANT

HOMEOWNER INTEREST
LOW — HIGH

Challenges: Permit Approval

Would she do it again? Yes

Frost-Protected Shallow Foundations Attributes:

- Affordability
- Energy Efficiency
- Environmental Performance

Builder Tips: Incorporate FPSFs early in the design process and promote the added comfort and energy saving benefits to homebuyers

Builder:

Judy Fosdick
Tierra Concrete Homes
Boone, Colorado

Builder Type:

Small Custom Builder

The Technology:

Frost-Protected Shallow Foundations

The Project:

The Abbey Road project in Pueblo County, Colorado, is a 2,700 square-foot, one-story concrete home built with a frost-protected shallow foundation. The home also includes radiant floor heating, a tankless water heater, passive solar design, and an energy recovery ventilation system. Completed in 2005, the home received a 2006 Energy Value Housing Award from the NAHB Research Center.

"I wouldn't do a foundation any other way."

– Judy Fosdick

FOSDICK'S STORY

Nearly a decade ago, an interest in sustainable design and energy efficiency led Judy Fosdick to experiment with insulated foundation techniques. What she discovered changed her business.

She could save money, she discovered, and complete foundations more quickly with a little innovation. A frost-protected shallow foundation (FPSF) could protect a concrete slab from frost heave without the need for excavating below the frost line. All of a sudden, the time, labor and equipment invested in deeper excavation disappeared. But for Fosdick—who now installs FPSFs in every home she builds—these advantages were only the beginning.

"For me, it's about comfort. The beauty of FPSFs is that they let you take advantage of the heat in the building slab and the surrounding soil to raise the frost depth. With a correctly insulated slab and footings, you don't lose that heat. You've got a warmer home. And you don't have to worry about frost heave."

Extruded polystyrene (XPS) insulation, also referred to as blueboard, is placed at the base of the horizontal wall surface to create an FPSF.

"The energy performance of our very first project with FPSFs was independently monitored by the National Renewable Energy Laboratory (NREL). The results showed that the foundation inside the insulation on the north-facing walls never dipped below 50 degrees during the winter, despite below-freezing temperatures outside. I wouldn't do a foundation any other way."

Tierra Concrete Homes was established in 1996 by Frank and Judy Fosdick, who specialize in building durable and energy-efficient, single-family custom homes. Accredited by LEED (Leadership in Energy and Environmental Design), Tierra Concrete Homes has earned eight EnergyValue Housing Awards in the last eight years. Fosdick serves on the Board of Directors for the Sustainable Buildings Industry Council and is a licensed building contractor in Colorado and California.

Why she uses FPSFs:

"It definitely saves time and money. We don't have to bring out as many forms to the project, and we don't have to set as many forms or haul them back. Excavation is faster, and we pour less concrete. But comfort is the main reason I continue to use this technology. It makes for a better home."

Field personnel work with the crane operator to line up the perimeter concrete walls. Horizontal insulation minimizes heat loss at building corners (see Fig. 1).

FPSFs offer excavation, construction, material and labor cost savings. One case study in Denver showed savings of 15 to 17 percent compared to a conventional foundation. An Iowa builder reported a $10 to $15 savings per linear foot when compared to basement foundations. Cost savings will vary by regional code-specified frost depth; colder climates offer greater opportunities for savings than more temperate climates.

Source: ToolBase TechSpecs

"Construction is similar to conventional foundations, except that you've got shallower footing depths and an insulated foundation. FPSFs don't require any special tools or materials, other than the insulation itself. It's pretty easy to incorporate it into standard building practices."

"You also realize short-run cost savings when comparing the extra time, labor, and equipment needed to excavate below the frost line to the cost of purchasing polystyrene insulation and digging shallower footings."

GAINING APPROVAL

"My company offers both design and general contracting services, so we're well positioned to recommend new technologies like FPSFs to our clients," Fosdick says. "Getting their buy-in is easy; getting approval from building department officials is a little more difficult."

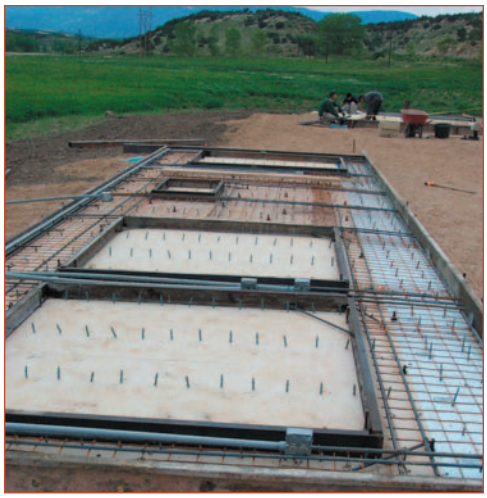
"Since building officials in Pueblo County were already familiar with FPSFs, approval wasn't a big issue, but this wasn't always the case. The first time we proposed using FPSFs, the building official had never heard of them and was inclined to disallow them, so I immediately asked about their appeals process. I got on the appeals board agenda and came in with my engineer and our pile of documentation from the NAHB Research Center. We used two case studies to educate them about the technology and were able to persuade them. The whole process only took a few weeks. NREL studied our first FPSF home. Ever since, I have used the results from their study to obtain approval from other building departments."

"The use of FPSFs are now approved by the International Code Council for residential and commercial buildings, but local code approval may still be an issue in some areas. Still, my experience has been that when armed with the right information and accompanied by a knowledgeable engineer, I can get building officials to approve the use of FPSFs."

MATERIALS

The insulation used to protect FPSFs is made from rigid polystyrene foam—either expanded polystyrene (EPS) or extruded polystyrene (XPS), also known as blueboard.

"I use XPS or blueboard for its higher R-value (4.5 per inch) and also because it is readily available," Fosdick says. "The insulation usually comes in 4'x8' sheets of varying thickness ranging from 1 to 3 inches."



Prior to tilt-up, cast-in-place concrete walls are fitted with 2" extruded polystyrene (XPS) insulation, electrical boxes, and blockouts for windows and doors.

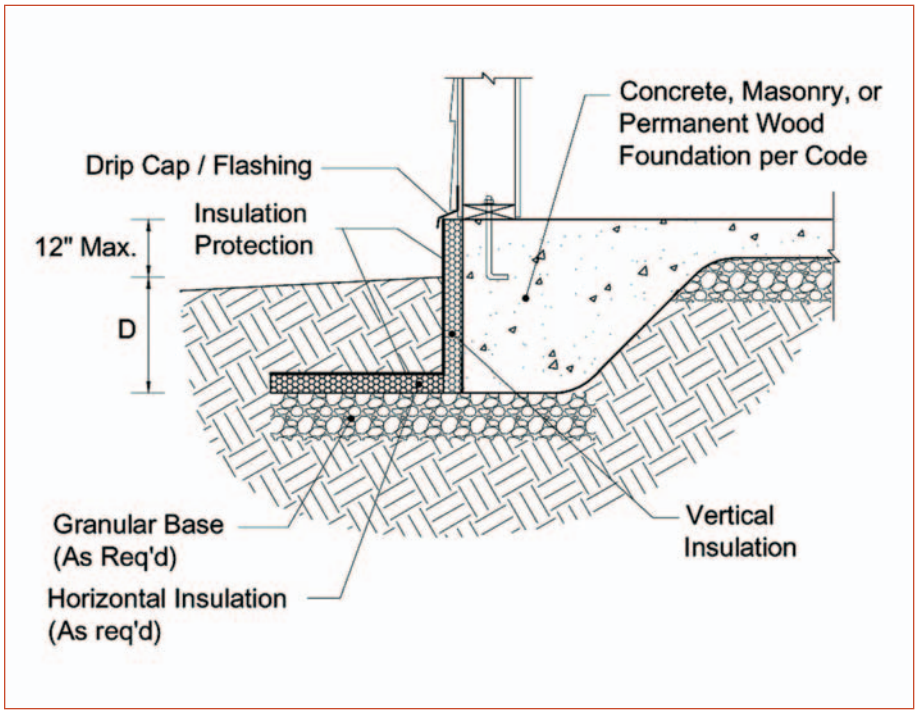


Figure 1. Section detail showing properly placed insulation protection.[1]

TECHNOLOGY HIGHLIGHTS

This project included the following PATH-profiled technologies:

- Frost-protected shallow foundation
- Pre-cast concrete walls
- Radiant floor heating
- Tankless water heater
- Passive solar design
- Energy recovery ventilation system

"In southeast Colorado, we typically use 2" XPS under the slab and on the vertical surfaces of the foundation, which provides an insulation value of approximately R-9. Since more heat loss occurs at building corners, our standard practice is to install insulation horizontally at the corners. In the colder mountain climates, we use horizontal wings that extend 12" around the entire perimeter of the home. Only XPS can be used for horizontal insulation applications, but either XPS or EPS is suitable for insulating vertical surfaces, depending on the R-value required."[1]

INSTALLATION

FPSFs are generally cost effective if the frost line is 30 inches or deeper. The NAHB Research Center's Revised *Builder's Guide to Frost-Protected Shallow Foundations* provides guidance. Use the Air Freezing Index (AFI) for your location to select the proper footing depth, the effective R-value for vertical and horizontal insulation, and the recommended size for horizontal wing insulation where needed.

Vertical wall insulation should be installed first. If wing insulation is required around the entire perimeter, it should have at least 10" of ground cover and be installed directly on the subgrade, flush with the vertical wall insulation.

"As with any type of foundation, proper drainage is crucial. Insulation works better when dry, so ensuring that water drains away from the building is very important," Fosdick says. "Creating a gravel or sand base improves drainage and helps create a smooth surface for horizontal wing insulation as well. We cover exposed insulation above ground with stucco to protect against UV rays and below-ground portions with sheetmetal to protect against termite damage. Stucco systems, durable coatings, and pre-coated insulation products are just a few methods to consider. Sheetmetal flashing can be effective from a durability and cost standpoint."

"When you have a walkout basement where the grade comes down the sides of the house, you also have to be mindful of the critical above- and below-grade marks and where dampproofing is required. When we first start a job, we grade the site, excavate the foundations, prepare the subgrade, and place either sand as a base or washed gravel with a French drain, if required by the engineer. For the base under the slab, we use a 3/8 minus, free-flowing material to ensure proper drainage. Since our exterior walls are made of concrete, we have our wall forms laid out around the perimeter of the house."

"After laying out forms, we place our insulation on a sand bed. Blueboard is placed at the bottom 20" of the wall

[1]The 2004 NAHB Research Center's *Revised Builder's Guide for Frost-Protected Shallow Foundations* contains tables, figures, and more detailed instructions on how to install FPSFs. See Tables 4 and A1 in the American Society of Civil Engineers, *Design and Construction of Frost-Protected Shallow Foundations*, SEI/ASCE 32-01, 2001. This document includes design tables, climate maps, and other data needed to complete a frost-protection design.

The finished product is a comfortable, high-performance home that earned a 2006 Energy Value Housing Award.

and polyiso board above the blueboard from 3" above the finish floor level to the top of the wall. Panel tie connectors are used to attach the polyiso insulation to the concrete walls. The special connectors that anchor the polyiso in place are arranged in a pattern consistent with code requirements for mesh attachment: every 2 feet horizontally, and every 6 inches vertically, allowing for conventional stucco application over the polyiso board."

"We set in electrical boxes and blockouts for windows and doors and then pour the concrete walls on the ground. We stand the perimeter walls, and place them inside the footing trench on leveling pads. After footing trenches are backfilled to support perimeter walls, the slab is poured over reinforced steel, polystyrene insulation, and a sand base to create a concrete home insulated from frost penetration. Our construction time just for the slab and concrete walls is typically three to four weeks for a larger custom home (2,200-3,500 square feet) and only one week for a smaller home (1,400-1,800 square feet)."

"For the Abbey Road project, we had to come up with a method of termite protection that would meet stricter code requirements. We used sheetmetal flashing at the transition between the polystyrene below grade, and polyiso above ground to create the termite barrier required to meet stricter code requirements. The homeowner was adamantly opposed to any type of pesticide or soil treatment anyway, so the sheetmetal flashing was the proper solution."

SCHEDULING, AVAILABILITY, & JOB SITE STORAGE

"Lead-time and transportation have not been a problem for us," Fosdick says. "When storing the 4' x 8' sheets of insulation at the jobsite, be sure to place plenty of weight on top to avoid losing sheets to the wind. On a previous job, we learned wooden pallets were not heavy enough and found ourselves chasing sheets. Protecting polystyrene foam stored on the jobsite from sunlight is also important since exposure to UV rays can damage the insulation."

TRAINING

"All of Tierra's concrete work is performed in-house, so our crew is familiar with FPSFs," Fosdick says. "The insulating panels are built into our shop drawings and easily incorporated into the process of building walls since the insulation is the first thing we place in our casting form. After the first house, our crews were competent installers and it became part of our standard wall construction method. There were no major learning curves."

"Training for subcontractors is critical. On a previous project, a plumber didn't understand the necessity of the insulation barrier. He was careless about replacing insulation that was damaged when he put pipe penetrations through the foundation walls. Training for subcontractors is mainly a matter of getting them to respect that the insulation and its placement is important to the integrity of the home."

A WHOLE BUILDING APPROACH

"When considering new technologies, it is important to not isolate or compartmentalize," Fosdick says. "Instead, take a whole-building approach, starting with the design and building envelope. The combination of several well-chosen technologies—in this case passive solar design with thermal mass for heat storage, proper insulation, quality windows, high efficiency equipment, ENERGY STAR® appliances and ENERGY STAR lighting—will improve the quality and durability of the home much more than any measure on its own."

The Partnership for Advancing Technology in Housing (PATH) brings together builders, manufacturers, researchers, government agencies, and other members of the housing industry. PATH partners work to improve the quality and affordability of new and existing homes. The program is administered by the U.S. Department of Housing and Urban Development's Office of Policy Development and Research. To learn more, visit www.pathnet.org.

The opinions expressed in this document represent those of the builder and do not necessarily reflect the views of PATH.