

TOOLBASESM TECHSPECS

PROFILE Frost-Protected Shallow Foundations

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TECH @ A GLANCE

BENEFITS (+) / DRAWBACKS (-)

- + **AFFORDABILITY:** Reduced excavation; reduced foundation labor and material costs
- + **MARKETABILITY:** May increase homeowner comfort and decrease heating energy costs due to increased insulation at the perimeter of slab-on-grade foundations
- **CODE ACCEPTANCE:** Some local codes may not accept FPSFs; use of rigid foam on the exterior may be restricted in heavy termite infested areas

INITIAL COST

FPSFs offer excavation, construction, material and labor cost savings. One case study in Denver, Colo. showed savings of 15 to 17 percent compared to a conventional foundation; and an Iowa builder reported a \$10 to \$15 savings per lineal 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.

OPERATIONAL COST

Operational cost for FPSF is similar to conventional foundation types that are insulated to current energy code levels.

CODE ACCEPTANCE

Provisions for FPSFs are included in the 2000 and 2003 International Residential Code (IRC Section 403.3). The American Society of Civil Engineers (ASCE) developed a standard, "ASCE/SEI 32-01, Design and Construction of Frost-Protected Shallow Foundations," which is adopted by the 2003 IRC and International Building Code (IBC). However, use of FPSFs is still governed by locally-specified codes.

In areas of heavy termite infestation, local codes

may restrict the use of rigid foam on the outside of the foundation, or may require termite-resistant insulation.

RESULTS FROM THE FIELD

Two PATH Field Evaluations examined FPSFs: Oakwood Homes in Denver, CO and K. Hovnanian in Freehold Township, N.J.

WARRANTY

Not applicable.

MAKING THE SWITCH

FPSFs are relatively easy to implement because they are usually less expensive to install than traditional foundations. The construction schedule is usually expedited due to reduced excavation depth and concrete work. FPSFs also use conventional construction materials, and install similar to traditional foundations.



THE BASICS

Frost protected shallow foundations (FPSFs) eliminate the need for excavating below the frost line in order to protect foundations against freezing. Traditional foundations are protected from freezing because they are installed below the frost line, which can be 48 inches or more below grade. FPSFs are placed only 12 to 16 inches below finished grade, and use heat from the earth and the building to maintain sub-slab soil temperatures well above freezing, thereby effectively raising the frost depth around a building's perimeter.

Construction and excavation, labor and material costs are usually less for FPSF than for conventional foundations, and are an inexpensive method for building a well-insulated and comfortable foundation.

FPSFs use conventional materials that are readily available. The insulation used is either rigid expanded or extruded polystyrene foam (EPS or XPS), suitable for below-grade application.

Provisions for FPSFs are included in the 2000 and 2003 International Residential Code (IRC) and the 2003 International Building Code (IBC) for buildings when the interior space will be conditioned to a minimum of 64° F, year round. The American Society of Civil Engineers (ASCE) standard "ASCE/SEI 32-01, Design and Construction of Frost-Protected Shallow Foundations," is also referenced in the 2000 and 2003 International Residential Code (IRC).

DOLLARS AND SENSE

Cost savings have been realized in field evaluations of the FPSF technology. The following savings in excavation and foundation costs have been reported:

- **15 to 17 percent for 1,300 to 1,500 square foot homes (Oakwood Homes Field Evaluation)**
- **\$11 to \$15 per linear foot of foundation (Bill Eich Construction)**
- **\$750 for a 2,500 square foot home (K. Hovnanian Field Evaluation)**

THE BASICS *continued*

However, FPSF use is still governed by local building codes. In areas of heavy termite infestation, local codes may restrict the use of rigid foam insulation on the outside of the foundation, or may require termite-resistant insulation.

Cost savings of FPSFs over traditional foundations are greater in colder climates with deeper frost depths, and lower in more temperate climates.

Insulation details are critical to prevent “cold bridges” that can undermine FPSF effectiveness. Crews may need training in installation techniques to ensure proper insulation details. Exterior foundation insulation requires an exterior durable finish to protect the insulation from ultraviolet deterioration and mechanical damage.



RESULTS FROM THE FIELD

This technology has been used by other builders in real-world building situations – learn from their experiences.

Denver, Colorado, Oakwood Homes (PATH Field Evaluation)

- 15 and 17 percent savings were achieved on 1,300 and 1,500 square foot homes, respectively, compared to conventional slab-on-grade with 48-inch deep footings
- For climate with an Air Freezing Index of 710° F-days, foundation depth of 12 inches and vertical insulation of R-4.5 required by code
- In order to comply with Denver’s Uniform Building Code for footings supporting two stories and a roof, and accommodate soil conditions at the site, 18-inch deep footings were required
- Trencher rather than backhoe was used to dig the footings, which reduced cost and impact of heavy machinery on site



Freehold, New Jersey, K. Hovnanian (PATH Field Evaluation)

- Builder reported saving about \$750 in foundation costs by using the FPSF system
- FPSF did not prove cost-effective for the unheated garage due to the CABO requirement for full sub-slab insulation
- Synthetic stucco proved to be best choice for providing protective covering of above-grade foam insulation

Spirit Lake, Iowa, Bill Eich Construction

- Since 1985, builder estimates savings between \$11 and \$15 per linear foot of foundation by using FPSFs

MAKING THE SWITCH

What is required to transition from your current building practices to using this technology?

Educate Yourself on FPSF Design – Use resources such as the PATH and NAHB Research Center publication *Revised Builder’s Guide to Frost Protected Shallow Foundations* (available on www.toolbase.org) to learn how to incorporate FPSFs in your area.

Consult Local Codes – Review local codes to determine if local amendments impact FPSF design in your area.

Evaluate Your Home Designs – Look for opportunities in your common home designs to use FPSFs. FPSFs can be incorporated into slab-on-ground construction, as well as stemwall, floating slab, and unvented crawlspace foundations.

Tools – FPSFs require the same tools as traditional slab on grade foundations. They can, however, allow the use of a trencher rather than a backhoe if desired.

Work With Your Trade Contractors – Work with your masonry contractor to review the design of FPSFs. FPSFs employ readily-available conventional building materials. Many steps, including rough grading, foundation layout, preparation of subgrade, wall forming, steel reinforcing, and concrete placement are similar to conventional practices.

FOOD FOR THOUGHT

This section provides some things to think about before switching to this building technology – make sure it's the right choice for you.

FPSF technology is relatively easy to implement, and is suitable for colder climate regions in the United States. Buildings must be conditioned to a minimum of 64° F, year round. Proper design and installation of insulation is key to the success of FPSFs, in order to prevent “cold bridges” and maintain above-freezing soil temperatures around the foundation. Crews may need training to learn correct insulation and forming techniques.

Initial cost savings depend on the region and local code-required frost depth. Builders in temperate climates with shallow frost depths will not have cost savings as much as those in colder climates. Additionally, use of below-ground foam plastics over the

foundation may require termite protection appropriate to the regional termite threat. Below-ground foam is not recommended in areas of “very heavy termite infestation probability,” such as South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Eastern Texas, and most of California — unless special provisions are followed. However, FPSF would not be cost-effective in those regions, anyway.

The exterior foundation insulation above grade must be protected against ultraviolet deterioration and mechanical damage by use of a durable protective coating or covering.

DEFINITIONS

Air Freezing Index (AFI)

The AFI is a measure of the combined magnitude and duration of air temperatures above and below freezing during any given winter. The 100-year return period of the AFI is available for 3,110 cities in the U.S. and Puerto Rico from the National Climatic Data Center (NCDC)

Cold Bridge

Cold bridges are created when building materials with high thermal conductivity, such as concrete, are directly exposed to outside temperatures. They result from an interruption in the integrity of foundation insulation. Cold bridges may increase the potential for frost heave, or at the least, create localized lower temperatures or condensation on the slab surface.

Mean Annual Temperature (MAT)

The MAT is used in addition to the AFI to determine design requirements for FPSFs used in unheated buildings.

TECH CHECK

Below is a checklist of steps to follow if you decide to implement this technology in your next building project.

- Evaluate if FPSFs are practical in your region.** Cost savings increase in colder climates with deeper frost depths. Generally, this technology is worth considering if the frost depth is 30 inches or deeper.
 - Revised Builder's Guide to Frost Protected Shallow Foundations (Sept. 2004) to help determine proper foundation design and insulation details. The guide contains detailed drawings of prescribed methods of construction.*
- Determine insulation needs.** Builders can establish proper FPSF design for any given location with the Air Freezing Index (AFI). Unheated buildings also require a Mean Annual Temperature (MAT). Builders must calculate an effective R-value for below-ground insulation, where insulation must perform in a moist environment for the expected life of the structure.
- Review standards and design guidelines.** The American Society of Civil Engineers (ASCE) standard, "ASCE/SEI 32-01, Design and Construction of Frost-Protected Shallow Foundations," should be followed. The PATH and the NAHB Research Center published the
 - Provide necessary training for crews.** Proper installation of insulation is vital to FPSF effectiveness, and crews must be trained accordingly. However, FPSFs use no special tools or materials, which eases the learning process.
 - Excavate.** Generally, FPSFs require only minor excavation using lightweight equipment. A trenching machine may be used for FPSFs that do not require horizontal insulation.
 - Ensure the integrity of the insulation.** Completely insulate foundation edges to prevent cold bridges. Provide good drainage to prevent water from damaging insulation or collecting below the footing and freezing. Incorporate any necessary termite protection. Protect
 - above-grade vertical wall insulation to 6 inches below grade and ensure that the landscaping design does not interfere with horizontal insulation.
- Ensure good drainage away from foundation.** As with any foundation design, proper drainage is extremely important. Protect drain tile with filter fabric; surround drain tile with stone; backfill with topsoil or gravelly material
- Design landscape properly.** Avoid interference with any horizontal insulation. Keep plantings beyond horizontal insulation or at least 3 feet away from foundation.
- Complete construction.** The foundation should be completed and the building enclosed and heated prior to freezing weather.



The Partnership for Advancing Technology in Housing (PATH) is dedicated to accelerating the development and use of technologies that radically improve the quality, durability, energy efficiency, and affordability of America's housing. Managed by HUD, the PATH partnership includes the homebuilding, manufacturing, insurance and financial industries, and Federal agencies concerned with housing.

PATH addresses barriers to innovation, provides information on advanced building technologies, and advances housing technology research; making affordable, quality American homes a reality.

For more information on the PATH program, visit www.pathnet.org.

Tech Specs are Prepared for PATH by the NAHB Research Center.

RESOURCES

ToolBase Services

Information on this building technology and many others is brought to you by PATH and the building scientists at the NAHB Research Center.

www.toolbase.org

“Revised Builder’s Guide to Frost Protected Shallow Foundations”

PATH and NAHB Research Center

www.toolbase.org.

EPS Molders Association (EPSMA)

1298 Cronson Blvd, Suite 201

Crofton, MD 21114

410.451.8341

www.epsmolders.org

Extruded Polystyrene Foam Association (XPSA)

4223 Dale Blvd

Woodbridge, VA 22193

703.730.1601

www.xpsa.com

European Foundations for Seasonally Frozen Ground, Monograph 92-1

U.S. Army Cold Regions Research and

Engineering Laboratory (CRREL)

www.usace.army.mil

“Design and Construction of Frost-Protected Shallow Foundations”

ASCE/SEI 32-01

American Society of Civil Engineers

1801 Alexander Bell Drive

Reston, VA 20191-4400

800.548.2723

www.asce.org

National Association of Home Builders (NAHB)

1201 15th Street, NW

Washington, DC 20005-2800

800.368.5242

www.nahb.org

International Residential Code (IRC) and International Building Code (IBC) International Code Council (ICC)

5203 Leesburg Pike, Suite 600

Falls Church, VA 22041

888.ICC.SAFE (422-7233)

National Climatic Data Center

Federal Building

151 Patton Avenue

Asheville, NC 28801-5001

828.271.4800

www.ncdc.noaa.gov