



Frost-Protected Shallow Foundation INSULATION STRATEGIES

The foundation of your home is, well, literally the foundation of the whole structure. There are many different foundation designs depending on your soil type, house size, climate, and budget. Assuming your site does not have permafrost, one of the most affordable ways to build an energy efficient foundation is a slab-on-grade foundation.

“Slab-on-grade” means the house rests on a concrete slab directly on the ground. The edges of the slab are thick to accommodate the weight of the walls and the sub-floor consists of a solid slab of concrete. Rigid foam insulation is placed under the floor to limit heat loss to the ground. This kind of foundation offers many benefits. With the floor directly on the ground rather than exposed to the air, you lose less heat because the ground is warmer than the air in the winter. A concrete slab also makes in-floor radiant heat easier to install.

One of the problems with a slab-on-grade foundation is the potential for frost heave. In Alaska, soils can freeze to depths of 6 feet and deeper, especially if there is no snow cover (such as under house eaves). That deep freezing can creep under the edge of the house foundation and lift (heave) the

edge of the house as water freezes and expands. Movement at the edge of the house can make doors and windows hard to open, crack the foundation, and damage the structure of the house (Figure 1). The purpose of a frost protected shallow foundation (FPSF) is to prevent damage from frost heave.

An FPSF has vertical rigid insulation around the outer edge of the foundation that extends to the bottom of the foundation wall and a “wing” of horizontal rigid insulation that extends out from the foundation wall two to four feet. The wing is buried as deep as the base of the thickened edge of the slab. Since the corners are colder than the straight perimeter of the building, more insulation should be added at the corners to mitigate frost heave. Figure 2 shows a schematic of a slab-on-grade FPS foundation.

The amount of insulation the foundation needs is dependent on local climate, the amount of insulation under the slab, the ground surface, and soil characteristics. Colder locations will freeze deeper and will need thicker insulation. More insulation under the slab will mean less heat leaking under the foundation and will require more perimeter insulation



Figure 1. Frost heave of the left two pilings under the deck entry of a home in Fairbanks.

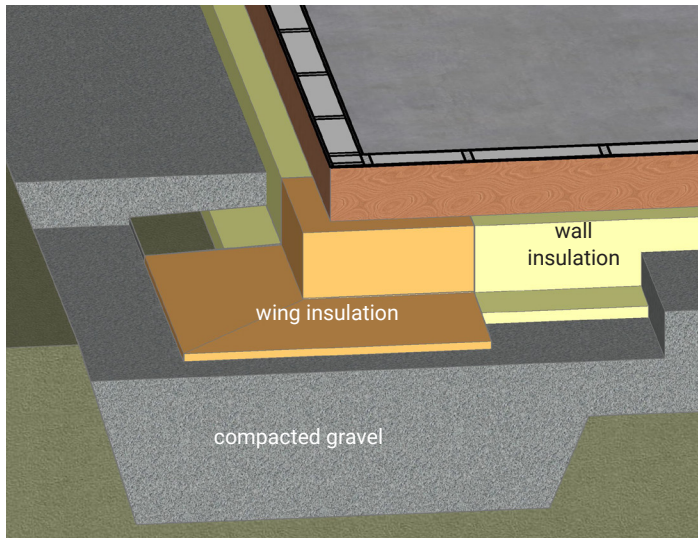


Figure 2. Schematic of a frost protected shallow foundation. The corner insulation either needs to be wider or thicker to protect the colder corners from frost heave.

The Three **W**s of Frost Heaving

WATER: water expands as it freezes, causing frost heave. Dry soils do not heave. Move water away from the foundation with gutters and proper grading away from the house.

WICKING: soil with small pores and good permeability will wick water to the freezing front and make heave worse – use non-frost susceptible soil under a foundation to limit wicking.

WINTER: slow the advance of the freezing front in winter by using insulation around the foundation. Foundation insulation slows soil freezing from the top and keeps the leaking building heat in the soil under the foundation longer.

to keep the frost line away from the foundation. A sidewalk or driveway that is cleared of snow in the winter will allow for deeper penetration of freezing (Figure 3). Different soils have different frost heave characteristics; dry gravel will not heave but will freeze faster, while wet soil will freeze slower but will heave much worse.

There are three factors that affect frost heave: water, wicking, and winter (see “The Three Ws”). Mitigating the danger from the “three Ws” protects a foundation from frost heave. A FPSF limits the advance of cold winter temperatures under the foundation, but using non-frost susceptible gravel

under the foundation and moving the water away from the foundation are also important ways to protect from frost heave.

If you have a site that is susceptible to frost heave, the design guides on the last page provide guidance that includes tables and graphs to help determine the amount of insulation needed for a FPSF CCHRC has taken these guides and developed an online calculator to provide some recommendations for frost protected shallow foundation design, available at foundationcalc.cchrc.org.

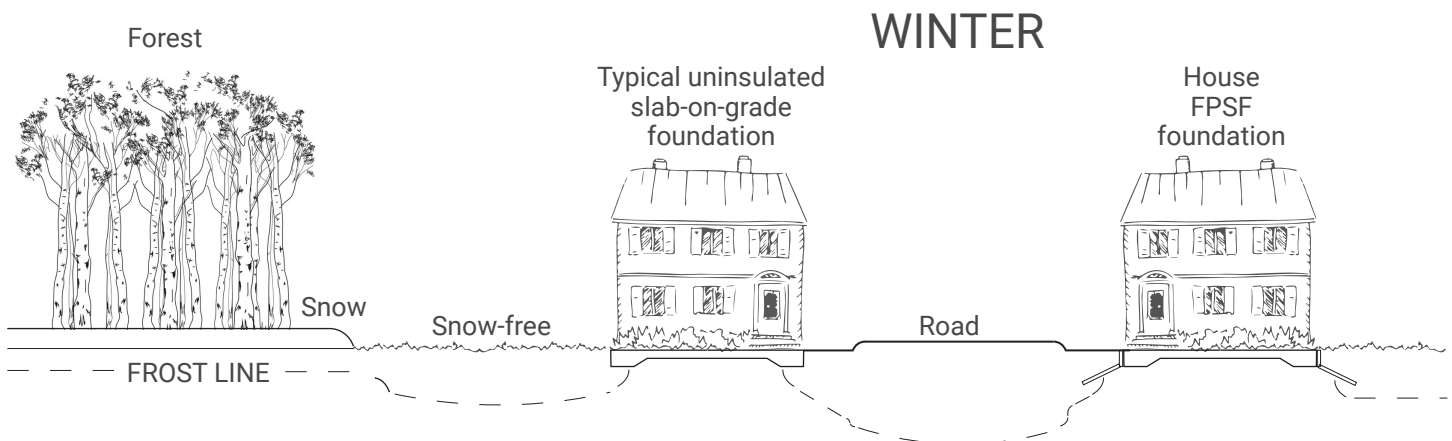


Figure 3. The frost depth line under the ground varies with exterior temperature and what is on the surface. A heated building leaks heat to the soil so that the frost line does not extend under the building. If there is too little heat leakage or there is not enough protection around the edges the frost line will creep under the foundation and can heave creating structural problems.

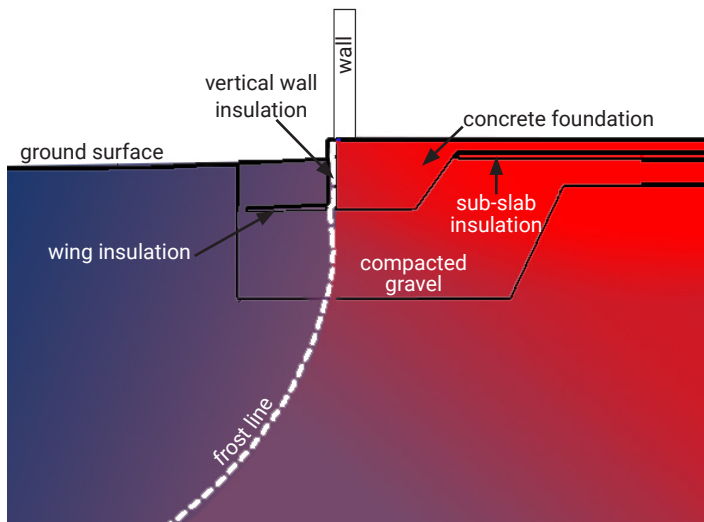


Figure 4. The dotted white line shows the freezing line under the slab edge in a Fairbanks foundation with a 2 inch thick, 2 foot wide wing. This foundation may frost heave if there are poor soil conditions.

The width and thickness of the wing and subgrade wall insulation needs to be determined based on many factors:

- local Air Freezing Index (AFI)
- amount of insulation under the slab
- draingae
- soil type
- landscaping around the foundation, and
- moisture content of the soil

In Fairbanks, where the air freezing index is 7,000, the wing insulation should be at least R-10 and 4 feet wide around the perimeter; at the corners it should be R-28. Figure 4 shows a model of a Fairbanks foundation if there is too little wing insulation; the ground under the edge of the foundation is starting to freeze which makes it susceptible to heaving. Figure 5, on the other hand, models a Fairbanks foundation with adequate wing insulation, where the ground freezing line is far enough away for the foundation not to cause frost heaving problems underneath the foundation.

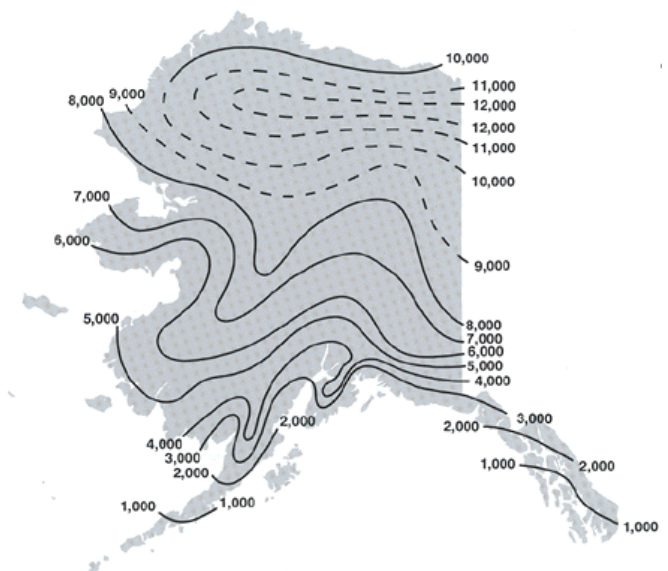
In Anchorage, which has an AFI of 3,400, wing insulation should be at least R-7 and 2 feet wide around the perimeter; at the corners it should be R-11. Figure 6 shows a model of an Anchorage foundation with recommended wing insulation.

How much insulation should go under the slab is dependent on how much energy loss to the ground you are willing to accept. Often, slabs on the ground do not have any insulation under them. From an energy efficiency standpoint, this is not ideal. However, it lowers the cost of building the foundation and the frost protection strategies can be less robust. If you

have a heated floor, some insulation is necessary to prevent excess heat loss. Two inches of EPS (expanded polystyrene, white bead board) or XPS (extruded polystyrene, blue or pink board) is the most common level of subfloor insulation, although 4 inches is also common. For a FPSF, if you use more sub-slab insulation, there is a risk of not allowing enough heat under the house to prevent frost heave. (Excess sub-slab insulation designs should use the unheated building FPSF manual; however, it is not recommended for climates much colder than Anchorage.)

CCHRC developed computer models of the foundation edge to determine if insulation under the thickened slab edge could be an option to further reduce heat loss through the floor. For a typical 1,100 sq. ft. house in Anchorage, approximately 42% of the heat loss through the floor is lost through the uninsulated thickened slab edges and floor energy loss is about 6% of the whole house heat loss. Insulated edges would also keep the edge of the floor warmer. The area under the thickened slab edge of the floor is not typically insulated in order to allow building heat into the ground to protect the edges from frost heave. The CCHRC models found that in some cases (again, depending on climate and soil type), insulation under the thickened edge might be acceptable. Adding this insulation is only an option if recommended thickness and width of foundation wall and wing insulation are followed.

Air Freezing Index



Air Freezing Index (AFI) is a measure of the severity and duration of the winter based on the air temperature below 32. Foundation insulation design relies on AFI information to help determine the amount of wing insulation. Image from National Centers for Environmental Information (NCEI)



It is imperative that the foundation of the home be built correctly. The CCHRC calculator can provide recommendations to help reduce the risk from frost heave, but it is only a recommendation. The foundation you build will need to be based on your specific location. Frost heave protection can come from three different site specific strategies. The shallow frost protected foundation insulation approach, protects the foundation from **winter** with added wing and subgrade wall insulation. Protecting the foundation from **water** with proper eaves, rain gutters, and site grading is an important strategy that is often overlooked. And finally, using non-frost susceptible gravel under the foundation will help deal with **wicking** of water up to the freezing line. If you have proper **water** and **wicking** controls you may be fine following local residential code for thermal insulation around the foundation.

Frost protected shallow foundations are not for areas with underlying permafrost. You should always have your location evaluated for permafrost before designing and building a foundation. Please discuss foundation options with an engineer.

Resources for FPSF

Anchorage area:

The National Association of Home Builders' Revised Builder's Guide to Frost-Protected Shallow Foundations, 2004, <https://www.homeinnovation.com/~media/Files/Reports/Revised-Builders-Guide-to-Frost-Protected-Shallow-Foundations.pdf>

ASCE 32-01 Design and Construction of Frost-Protected Shallow Foundations, 2001

North of Anchorage:

For colder locations, UAF Professor Paul Perreault developed a guide:

Frost Protected Shallow Foundations for Interior Alaska, Freezing Indices between 4,000 and 8,000 Degree Fahrenheit Days, 2008, http://www.cchrc.org/sites/default/files/docs/Draft_Final_Report_FPSF_CCHRC-6-15-08.pdf ASCE 32-01 Design and Construction of Frost-Protected Shallow Foundations, 2001

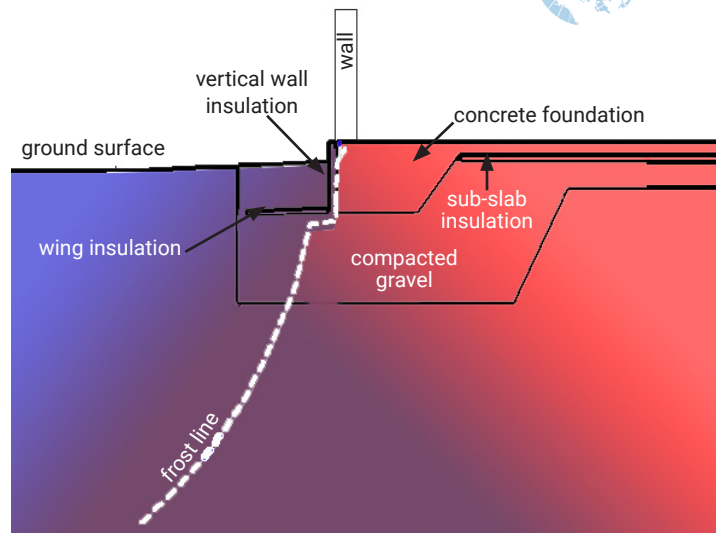


Figure 5. The frost line under a FPSF in Fairbanks with 4 feet of wing insulation and 2 inches of EPS under the floor and the thickened edges of the floor.

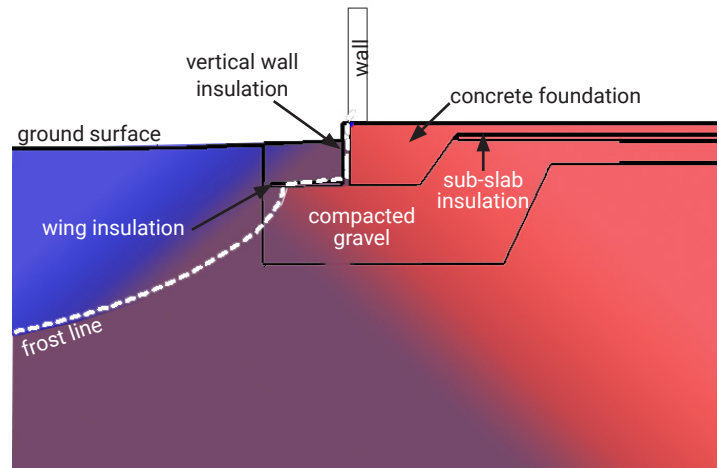


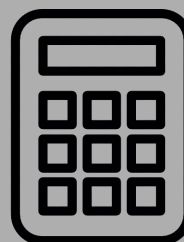
Figure 6. The frost line under a FPSF in Anchorage with 2 feet of wing insulation and 2 inches of EPS under the floor and the thickened edges of the floor.

Thank you funders & contributors

Alaska Housing Finance Corporation

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**Calculate your own
foundation insulation at
foundationcalc.cchrc.org**