Perma-Columns - The most Economical of ALL Concrete Building Foundation Options

The least expensive foundation option in the world of construction is treated wood posts used in post-frame construction. Using Perma-Column precast concrete posts increases the cost on a typical post-frame building by about $10.60 per linear foot.

This amounts to a building cost increase of less than 10% on the most primitive structures, and by much less on fancier ones. For a relatively small upgrade, one can eliminate any and all concerns that the post foundation will rot.

Building on concrete increases a building's expected lifespan from 40-60 years to more than 100 years. It is a nice up-sell that increases customer satisfaction, as well as the builder's revenue.

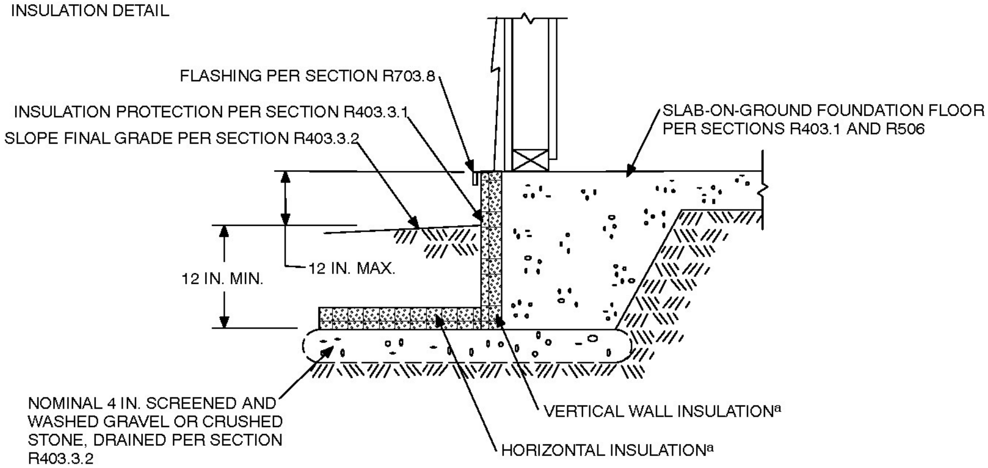
If you use Perma-Columns or Sturdi-Wall brackets set on piers that extend below the frost line, you don't have to extend the rest of the perimeter wall to the frost line as well because pre-cast or cast-in-place piers support the structure – the rest of the perimeter wall is not load bearing and therefore does not need to extend to the frost line. This can reduce the amount of concrete needed for a continuous concrete foundation by at least one-third in areas where the frost line is 36", and by more in areas where the frost line is deeper.

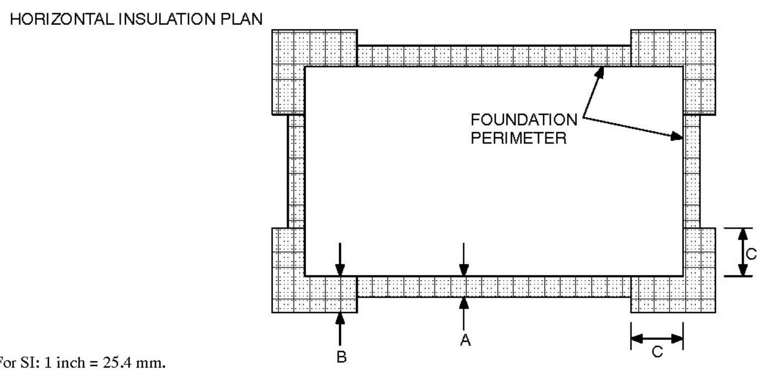
For climate-controlled structures, the international energy code describes how to insulate a concrete slab without a perimeter wall that extends all the way to the frost line:

> **402.2.8 Slab-on-grade floors. Slab-on-grade floors with a floor surface less than 12 inches (305 mm) below grade shall be insulated in accordance with Table 402.1.1. The insulation shall extend downward from the top of the slab on the outside or inside of the foundation wall. Insulation located below grade shall be extended the distance provided in Table 402.1.1 by any combination of vertical insulation, insulation extending under the slab or insulation extending out from the building. Insulation extending away from the building shall be protected by pavement or by a minimum of 10 inches (254 mm) of soil. The top edge of the insulation installed between the exterior wall and the edge of the interior slab shall be permitted to be cut at a 45-degree (0.79 rad) angle away from the exterior wall. Slab-edge insulation is not required in jurisdictions designated by the code official as having a very heavy termite infestation.**

Using Perma-Columns, one may trench a 6"wide "ribbon" or "grade beam" in between the posts to create a continuous concrete perimeter. The concrete may either extend 2' below grade along with 2" thick Styrofoam insulation, or may extend only 1' below grade with 2" thick Styrofoam insulation if another piece of Styrofoam extends from the bottom of the "ribbon" outwards by another 1'.

The IRC illustrates this method of insulating a concrete slab with insulation extending 1' below the soil, then 1' horizontally at 1' below grade:





For SI: 1 inch = 25.4 mm.

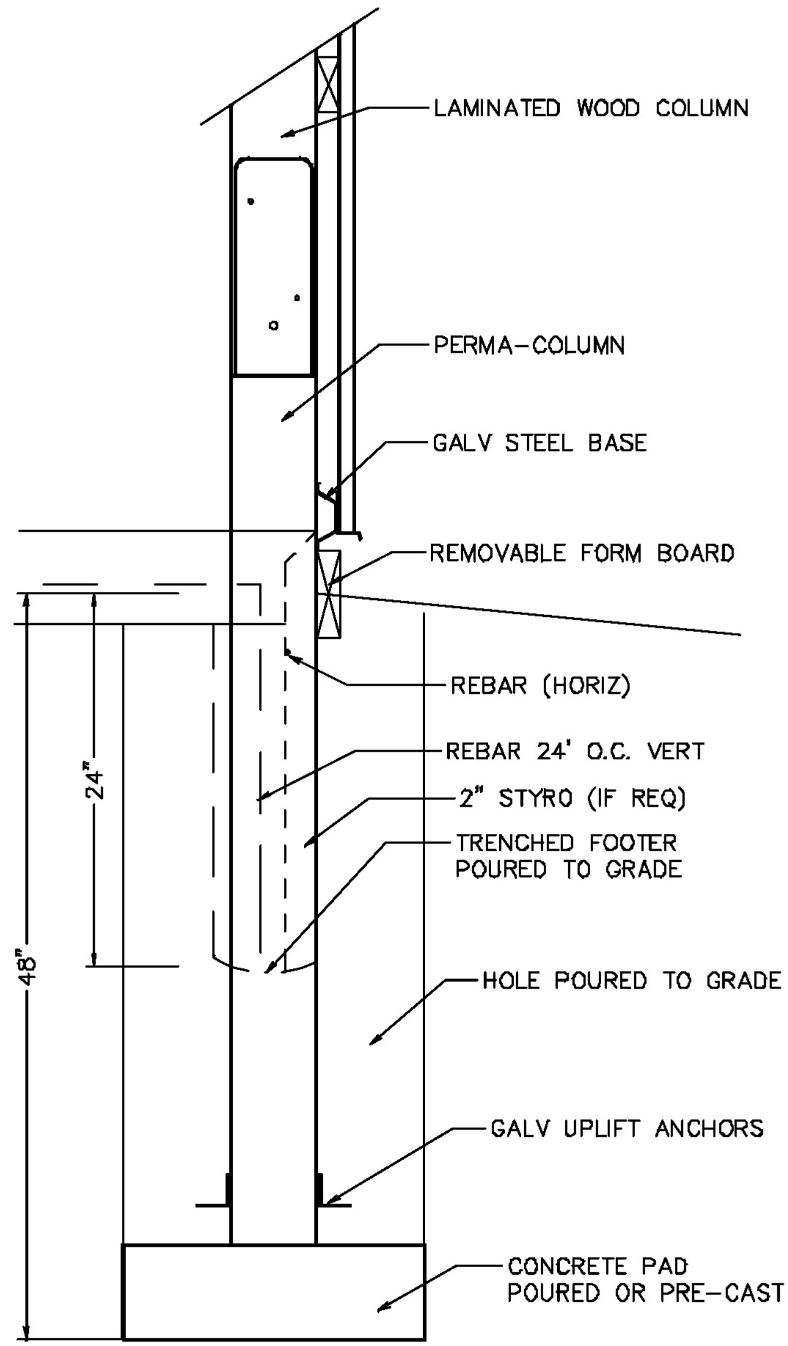
a. See Table R403.3 for required dimensions and *R*-values for vertical and horizontal insulation.

FIGURE R403.3(1)
INSULATION PLACEMENT FOR FROST-PROTECTED FOOTINGS IN HEATED BUILDINGS

Here is an illustration using Perma-Columns and an insulated "ribbon" extending down 2':

Meet Continuous Foundation Requirements using PERMA-COLUMNS

11-12-07



Meet Continuous Foundation Requirements using PERMA-COLUMNS

11-12-07

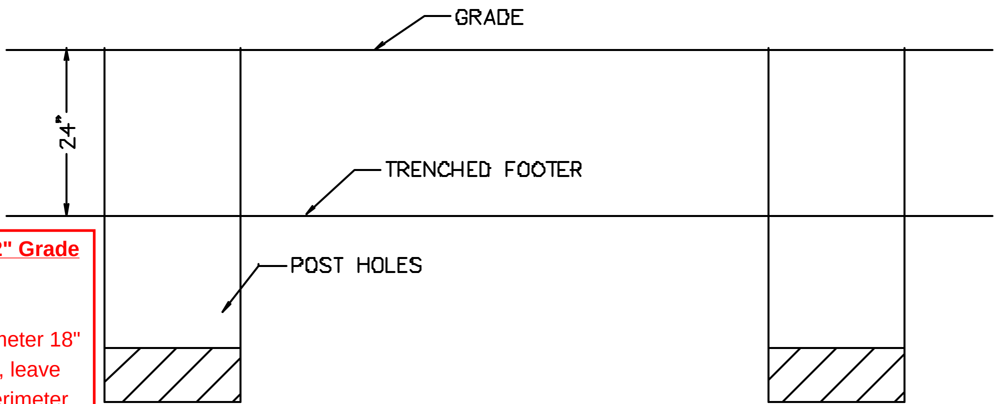
Options for 12" Grade Beam

Option A:

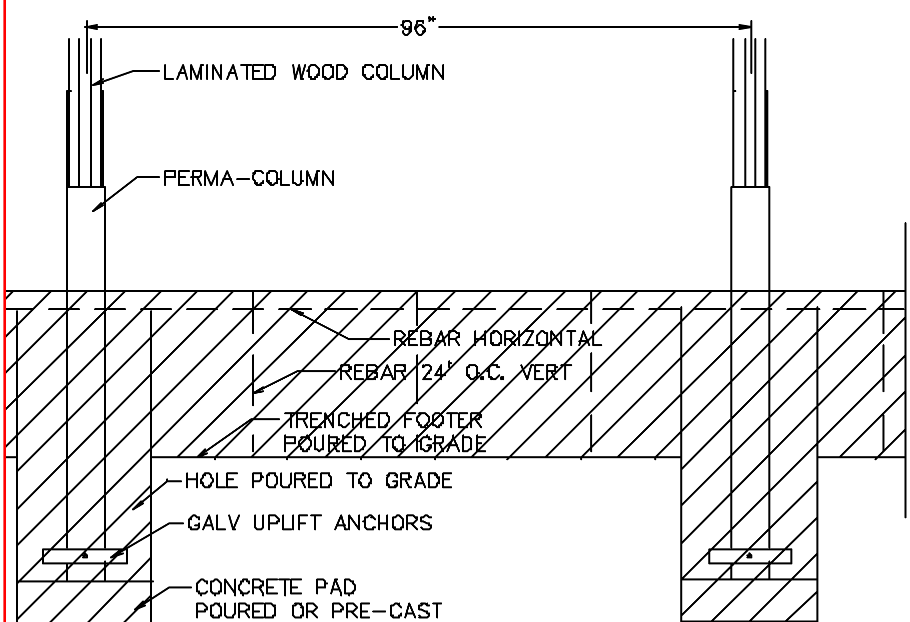
-Backhoe perimeter 18" wide, 12" deep, leave auger within perimeter
-Install 2" styro insulation 12" wide on bottom of trench.
-Brace 2" styro vertically, bottom butted to styro at bottom of trench
-Push 12" of fill back into trench on top of styro at bottom of trench
-Auger post holes, install concrete pads and go to step #2

Option B:

-Auger post holes
-Trench perimeter 8" wide, 24" deep
-Install 2" styro insulation around perimeter
-Push 12" of fill back in trench to hold up insulation
-Re-clean post holes, install concrete pads and go to step #2

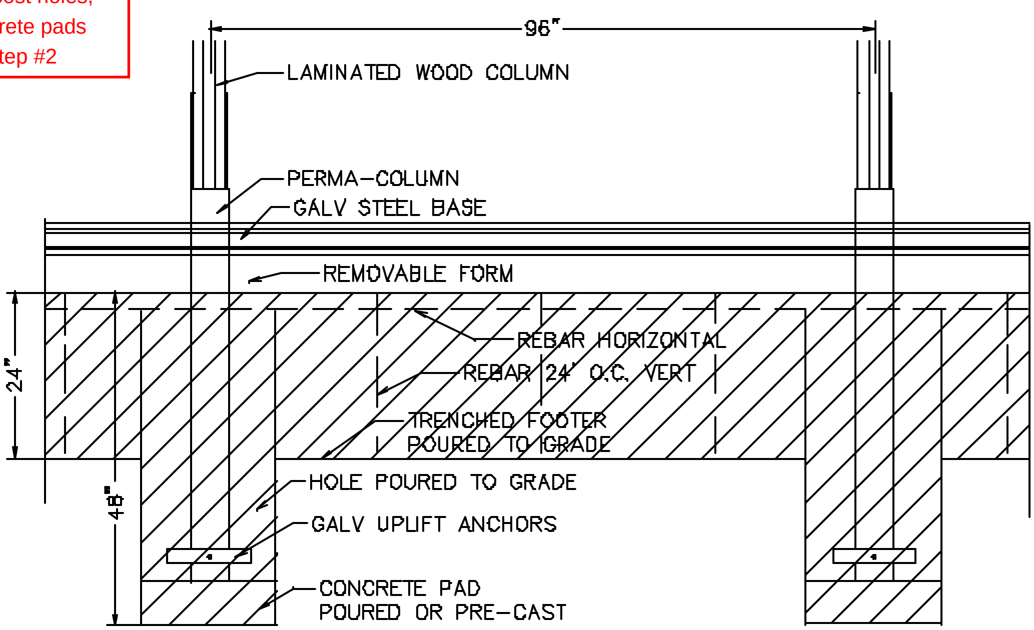


STEP #1
- DIG POST HOLE
- INSTALL CONCRETE PADS
- TRENCH BUILDING PERIMETER
- RE-CLEAN POST HOLES



STEP #2
- SET & BRACE PERMA-COLUMNS
- SET VERTICAL REBAR
- TIE HORIZONTAL REBAR (LOOP AROUND COLUMNS)
- PLACE 2" STYRO (IF REQUIRED)
- POUR POST HOLES & TRENCHED FOOTER TO GRADE
- PLACE HORIZ REBAR

Insulated Grade Beam may or may not be looped around or otherwise tied to Perma-Columns as desired
- Insulation prevents frost heave of the Grade Beam.



STEP #3
- FRAME & BRACE BUILDING
- INSTALL TRUSSES & ROOFING
- INSTALL GALV STEEL BASE
- INSTALL REMOVABLE FORM BOARD
- POUR CONCRETE FLOOR (PROTECTED FROM THE ELEMENTS)

Below-grade insulation for post-frame buildings

Part I: Preventing frost heave

By David R. Bohnhoff, Ph.D., P.E.
University of Wisconsin – Madison

It seems that recently more designers are questioning how to best insulate the foundation of a post-frame building. I attribute this to an increase in the number of heated post-frame buildings being constructed, along with an increased emphasis on reducing heat loss/gain in these buildings.

The latter is fueled by the green building movement and corresponding changes in energy conservation codes.

In virtually all cases where a post-frame building foundation is being insulated, the building has a concrete slab. The questions I get generally come from designers who have seen several different systems used to insulate these slabs, including systems that utilize exterior horizontal wing insulation (**Figure 1a**), systems that feature only vertical exterior insulation (**Figure 1b**), and systems in which insulation is placed under the concrete slab (**Figures 1c and 1d**).

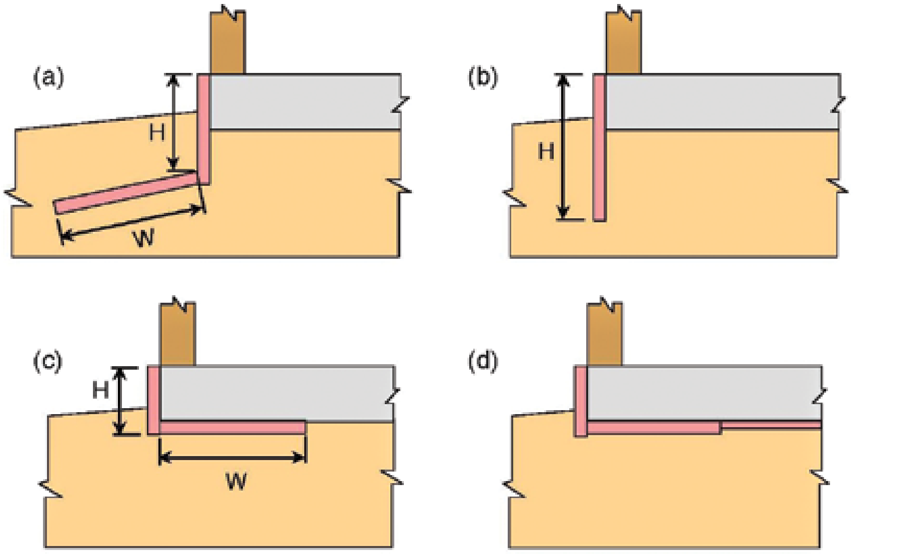


Figure 1. Below-grade insulation options for a concrete slab-on-grade: (a) vertical and horizontal wing insulation, (b) vertical insulation only, (c) insulation on outside and underside of perimeter edge, and (d) insulation on the outside edge and entire underside of slab.

Two design goals

It's important to understand that there are two principal reasons for installing below-grade insulation. The first is to control building heat loss/gain in an effort to minimize building operating costs and to reduce consumption of non-renewable natural resources associated with energy production. The second is to prevent frost from heaving a slab and causing structural damage. The latter is a concern only in colder regions with frost-susceptible soils.

Designs for control of building heat loss/gain are based largely on requirements in American National Standards Institute (ANSI) and American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2007 *Energy Standard for Buildings Except Low-Rise Residential Buildings*.

Designs for minimization of damage due to frost heave are based largely on requirements in Structural Engineering Institute (SEI) and American Society of Civil Engineering (ASCE) 32-01 *Design and Construction of Frost-Protected Shallow Foundations*.

The fact that SEI and ASCE administer the standard that addresses frost heave and ASHRAE administers the standard that addresses building heat loss/gain underscores the two distinctly different purposes for using below-grade insulation — one structural and one energy related.

This article is the first in a two-part series on below-grade insulation of post-frame buildings. As the title indicates, this first article is dedicated to building design for frost-heave control. The second article will cover design requirements for heat-transfer control, as well as design details for below-grade insulation of post-frame buildings with embedded posts. These design details will be accompanied by a discussion on their constructability.

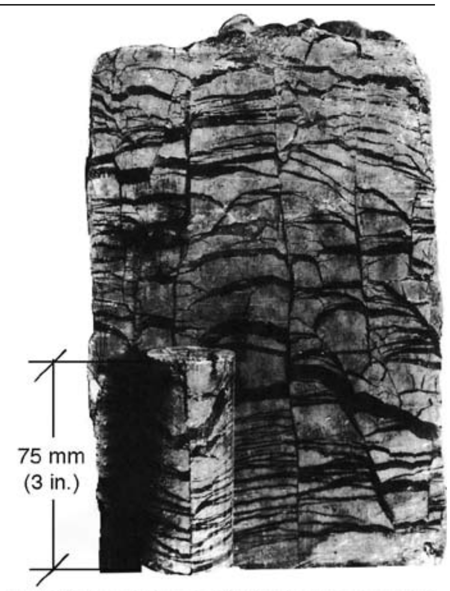


Figure 2. Sample of frozen clay showing ice segregation. From the *Canadian Foundation Engineering Manual*.

The cause of frost heave

In areas where average daily temperatures stay below freezing for extended periods of time, soil heaving due to ice segregation can be a major concern. *Ice* *segregation* is the formation of discrete ice layers or lenses within the soil due to the migration and subsequent freezing of pore water, which is water in the spaces between soil particles. *Frost heaving* (also known as *soil heaving* or *frost action*) directly results from the fact that water expands approximately 9% in volume when it freezes.

The temperature at which pore water freezes depends largely on solute concentrations. Pore water with low solute concentrations will freeze within a fraction of a degree of 32ºF, whereas pore water with high solute concentration may not completely freeze until its temperature has dropped to 25ºF.

If pore water present near the soil surface at the beginning of winter were the only water to turn to ice, there would be no real frost heaving issues. Large ice layers and lenses (and hence problems) result when pore water turns to ice and then sucks water from warmer areas by capillary action. The suction that ice exerts on warmer soil water is termed *cryosuction*. As cryosuction feeds capillary water to the underside of ice layers and lenses, their thickness grows. The term *ice segregation* is used to describe this ice formation action because it segregates regions of previously mixed soil and water into regions of ice and dry soil.

Segregation ice often forms regularly spaced layers as shown in **Figure 2, page 55.** As each layer forms, it tends to suck the soil beneath it dry. When the force of cryosuction is no longer able to lift water from below, thickening of the current layer ceases, and cooling proceeds downward until a new ice layer can begin to form at a greater depth.

It is important to understand that ice segregation (and hence soil heaving) requires the presence of three components: frost-susceptible soils, water, and freezing temperatures. Remove any one of these three, and frost heave does not occur.

Table 1 Frost Susceptibility of Soils

Soil type	Frost susceptibility
Gravels and sands	None to low
Silty and clayey gravels	Low to medium
Silty and clayey sands	Low to high
Clays with a high plasticity index	Medium
Silts with a high plasticity index and clays with a low plasticity index	Medium to high
Silts with low plasticity index	Medium to very high

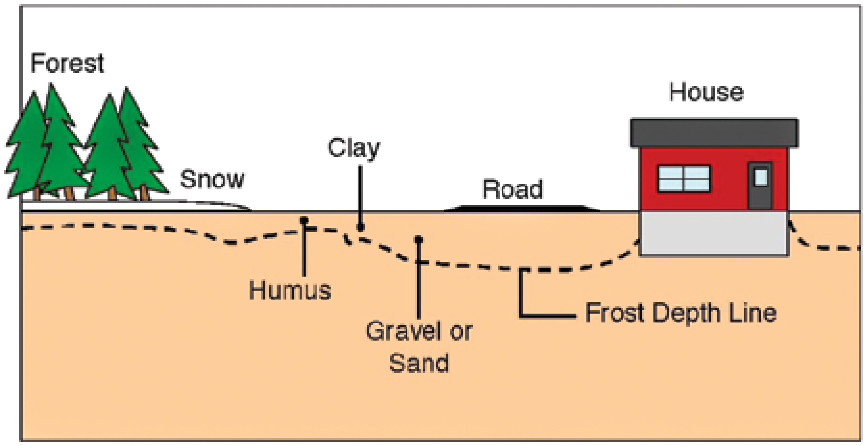


Figure 3. Effect of soil cover and soil type on frost penetration depth.

Table 2 Example of Freezing Degree Day Calculation

Day	Maximum daily temperature, ºF	Minimum daily temperature, ºF	Average daily temperature, ºF	Freezing degree days per day[(a)], ºF•day	Cumulative freezing degree days[(b)], ºF•day
1	20	10	17.5	14.5	14.5
2	15	8	16	16	30.5
3	17	6	21.5	10.5	41
4	26	21	31	1	42
5	36	28	35	-3	39
6	34	20	30.5	1.5	40.5
7	27	16	13.5	18.5	59

(a) A negative sign indicates a day when the average daily temperature was above 32ºF and thus more thawing than freezing occurred.
(b) Assume Day 1 start of freezing season.

Frost susceptibility of soils

The frost susceptibility of a soil is largely a function of the amount and relative size of smaller soil particles. Smaller particles fill spaces between larger particles, thus reducing the effective size of soil pores. The smaller the effective pore size, the greater the capillary action within the soil.

In the *Canadian Foundation Engineering Manual*, soil scientist Arthur Casagrande reports that "under natural conditions and with sufficient water supply, expect considerable ice segregation in uniform soils containing more than 3% of grains smaller than 0.008 inches and in very uniform soils containing more than 10% smaller than 0.0008 inches. No ice segregation was observed in soil containing less than 1% of grains smaller than 0.0008 inches, even if the groundwater was as high as the frost line." The manual also states that "the borderline between soils that are frost-susceptible and those that are not is not distinct, and those which appear to fall just clear of the Casagrande criteria should be treated with caution."

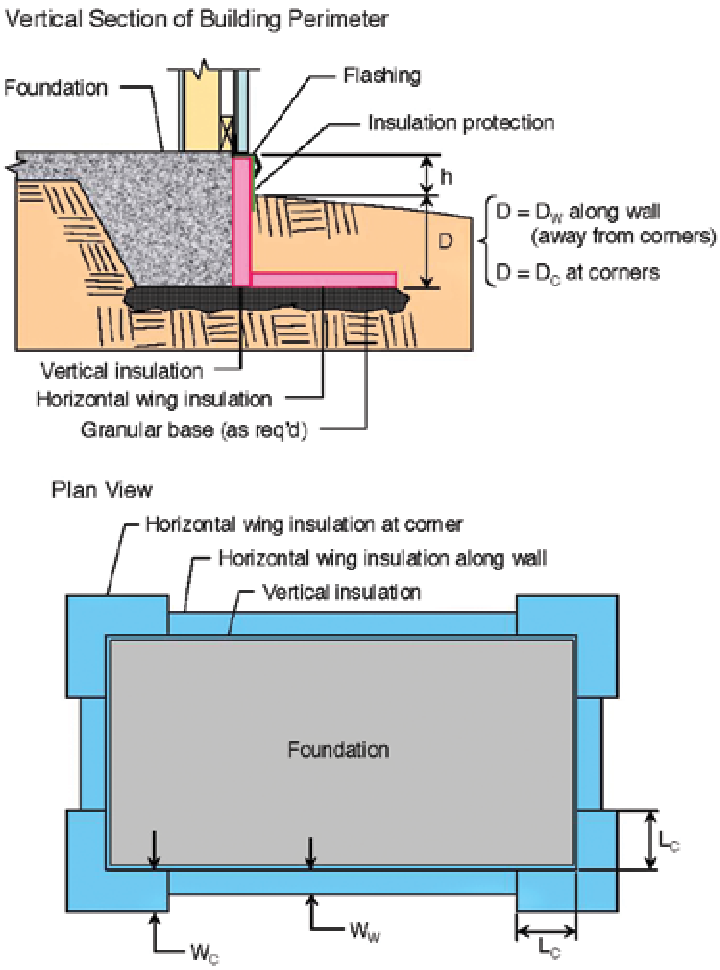


Figure 7. Frost protected shallow foundation dimensions. The floor height above the finished grade (dimension h) is limited to a maximum of 12 inches when the simplified FPSF design method is used.

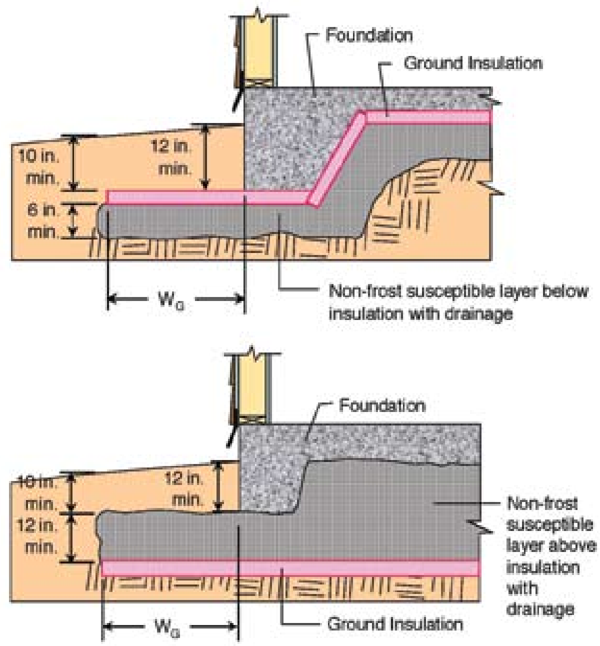


Figure 8. FPSF dimensions for an unheated building.

out exposing the foundation wall or other thermally conductive materials, as shown in **Figure 7**.

Step 5: Use **Table 7** to select insulation dimensions for situations in which no wing insulation is desired, or where wing insulation is desired at corners only. Note that this wing insulation must have an R-value of 5.7 h•ft²•°F/Btu. Alternatively, use **Tables 8** and **9** to determine wing insulation dimensions and R-values for applications where the depth D of all vertical insulation (i.e., that along the wall and at corners) will be fixed at 16 inches.

Step 6: Select an adequate thickness for required wing insulation by dividing the required minimum R-value of the insulation by its effective horizontal R-values, r_{eff}, listed in Table 4.

FPSF design method for unheated buildings

Geothermal energy is solely relied upon to keep frost-susceptible soils beneath the foundation of unheated buildings from freezing. As **Figure 8** shows, this energy is prevented from rapidly leaving the soil by a continuous layer of insulation placed under

4H

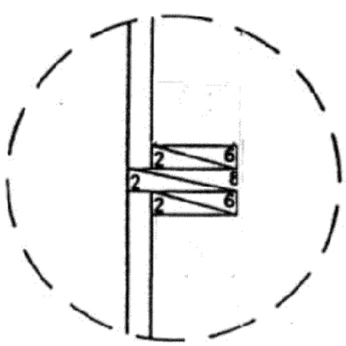
Photo illustration of the least expensive of all continuous concrete foundation options using Perma-Columns:

Less concrete is used, costing less and using fewer resources.

Perma-Columns offer the most economical, efficient and eco-friendly of ALL concrete foundation options.

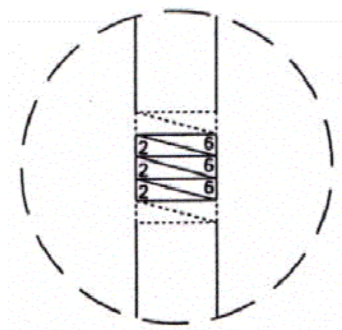
Interior Wall Finish Options

Standard Wall Frame - Interior girts for finished walls



Staggered laminated post for interior Standard Wall Frame

Flush Wall Frame



Flush Wall Frame diagram. Flush wall girts may also be installed by toe nailing or using brackets.

Figure 1 Flush Wall Frame with Insulation. Drywall may be installed horizontally over the 2' on center girts.

Wide bay spacing allows installation of wide batt insulation with minimum interruptions.

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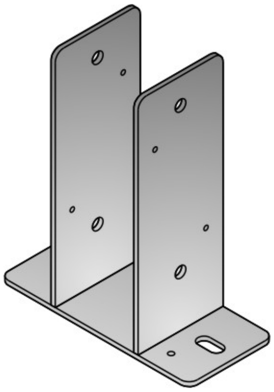
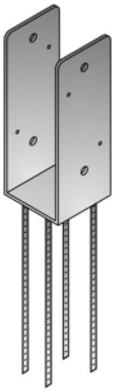
Interior girts hold insulation in place before installation of a steel or other interior lining. Other types of insulation, such as reflective insulation or insulating boards such as Thermax, may also be used along with batt insulation to achieve amazing R-values

Myth: It's not practical to put a basement in a Post-Frame Building





Fact: Post-frame buildings may accommodate a basement if a Sturdi-Wall or Sturdi-Wall Plus bracket from Perma-Column (www.permacolumn.com) is set upon a concrete basement wall.

Post-frame may also accommodate basements that do not extend all the way to the outside walls. Superior Walls (www.superiorwalls.com) now offers pre-manufactured basement walls that may be placed under almost any type of low-rise structure, including post-frame buildings.