FPSF

Frost Protected Shallow Foundations

Presented by Fred Dahlke, Building Inspector

BRIEF HISTORY

- 1930's Frank Lloyd Wright designed and built the first FPSFs in the Chicago area.
- 1950s – 1970s In rebuilding after WWII, Scandinavian countries studied U.S. construction and then became leaders in FPSF technology.
- 1980s – U.S. Plastics Industry and NAHB/RC begin technology transfer back to U.S.
- 1992 -1994 U.S. HUD sponsors a 5-home verification study in the northern U.S. climates; Air-freezing Index map is created; U.S. design guide developed.

BRIEF HISTORY

- 1995 CABO OTFDC – first model code recognition of FPSF in U.S.
- 2001 – ASCE standard 32 is completed (based on HUD guides for FPSFs)
- In the United States, insulation has been used to prevent frost heave in many special engineering projects (i.e., highways, dams, pipelines, and engineered buildings).
- Market Acceptance > 1,000,000 in Scandinavia (and continuing) 1,000s in the U.S. and growing. (FPSF, Applied Building Technology Group, Jay Crandell, 2018)

PROS

- They require less excavation, so smaller equipment and less labor is required.
- Less concrete is consumed.
- Monolithic slabs are formed & poured in one shot, speeding the work schedule.
- They typically cost 15 to 20% less than a conventional foundation, according to a study by the NAHB Research Center (now the Home Innovation Research Labs).

CONS

- If you live where frost depths are already shallow, don't expect any savings in labor or material, although an insulated foundation may save energy dollars later.
- Frost-protected shallow foundations aren't appropriate for steeply sloped sites or sites with permafrost.
- In areas that are heavily infested with termites, including the southeastern United States and most of California, the use of below-grade rigid-foam insulation is not necessarily a good idea.

CONS

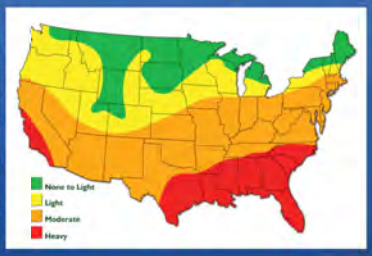
- Deep-rooted perennial plants shouldn't be planted above the shallow wing insulation that surrounds the house.
- The above-grade portions of the vertical foam insulation should be protected with a durable finish material, such as Protecto Wrap, Protecto Bond, or stucco over metal or fiberglass lath.

CONS

- Deep-rooted perennial plants shouldn't be planted above the shallow wing insulation that surrounds the house.
- The above-grade portions of the vertical foam insulation should be protected with a durable finish material, such as Protecto Wrap, Protecto Bond, or stucco over metal or fiberglass lath.

Fine Homebuilding issue 216 Martin Holloday 11/10

TERMITES



STEEP SLOPES

DOCUMENTS

Design Guide For Frost-Protected Shallow Foundations

- Prepared for the US Department of Housing and Urban Development
- Prepared by NAHB Research Center
- Published June 1994
- Approximately 50 pgs.

DOCUMENTS


DESIGN GUIDE FOR FROST-PROTECTED SHALLOW FOUNDATIONS

DOCUMENTS

Design and Construction of Frost-Protected Shallow Foundations

- Published by the American Society of Civil Engineers
- SEI/ASCE 32-01
- Published 2001
- Approximately 40 pgs.
- Standard that is referenced by UDC Table 320.24-5

DOCUMENTS

DOCUMENTS

Revised Builder's Guide to Frost Protected Shallow Foundations

- Prepared by the NAHB Research Center
- Published September 2004
- Approximately 35 pgs.

DOCUMENTS

DOCUMENTS

Where to find the documents.

1994 Guide

- https://www.huduser.gov/publications/pdf/fpsfguide.pdf

SEI/ASCE 32-01 (purchase)

- https://www.asce.org/

2004 Revised Guide

- https://www.homeinnovation.com/~/media/Files/Reports/Revised-Builders-Guide-to-Frost-Protected-Shallow-Foundations.pdf

HOW IT WORKS

Heat loss to the ground from a conditioned building raises the frost level around the perimeter of the building.

HOW IT WORKS

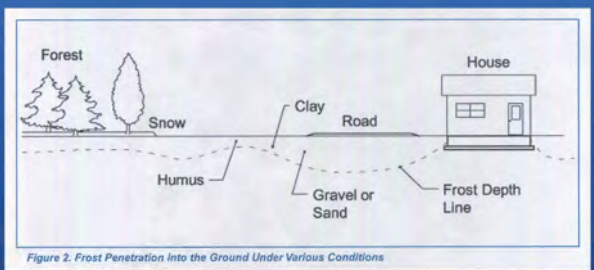


Figure 2. Frost Penetration into the Ground Under Various Conditions

HOW IT WORKS

This heat loss from the building is magnified when insulation is placed around the foundation.

HOW IT WORKS

The method also works for unheated buildings by utilizing the geothermal heat beneath the building.

HOW IT WORKS

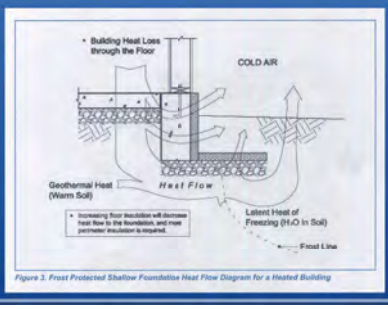


Figure 3. Frost Protected Shallow Foundation Heat Flow Diagram for a Heated Building

FPSF & THE UDC

SPS 320.16 (2) EXCEPTIONS. (a) Frost protected shallow foundations shall be designed in accordance with ASCE–32 as adopted in Table 320.24−5.

APPENDIX A GIVES THE BASICS FOR A SIMPLIFIED HEATED BUILDING DESIGN AND UNHEATED BUILDING DESIGN.

ASCE 32-01

THERMAL CLASSIFICATION OF THE BUILDING

T = MINIMUM AVERAGE INDOOR TEMPERATURE

ASCE 32-01

THERMAL CLASSIFICATION OF THE BUILDING

T = MINIMUM AVERAGE INDOOR TEMPERATURE

T ≥ 63 DEGREES	**HEATED**
T > 41 DEGREES < 63 DEGREES	**SEMI-HEATED**
T ≤ 41 DEGREES	**UNHEATED**

ASCE 32-01

3. SYMBOLS, UNITS, AND DEFINITIONS

Approved: Accepted by the building official of the jurisdiction as the result of investigations, analysis, tests, or any combination of these evaluation approaches or by reason of accepted principles or local experience.

Air-Freezing Index (AFI): Determined from cumulative degree days above and below 32°F (0°C), recorded for an annual cycle. The AFI for a given winter is the largest difference between the maximum freezing degree day cumulative total reached at the start of the winter season and the minimum total reached during the winter.

Cold-Bridges: Discontinuities in insulation that create thermally conductive pathways and increase the potential for frost damage.

Mean Annual Air Temperature (MAT): The average of all daily average outdoor air temperatures (minimum plus maximum daily temperature divided by two) in one or more years.

Non–Frost-Susceptible Soil: A soil that does not display significant detrimental ice segregation (i.e., ice lens development) during freezing. Generally, granular soils with less than 6% by mass passing a #200 sieve (0.074 mm) have low frost susceptibility, whereas silts and clays or sands and gravels (i.e., granular soils) with high fines content generally have medium to high frost susceptibility.

#200 SIEVE

.074 MM

.074 MM

Drawing was made with a .5 mm drafting pencil.

Imagine those lines 7 times smaller/narrower.

.074 MM

"GRANULAR FILL"

¾" clear stone, washed gravel, crushed stone.

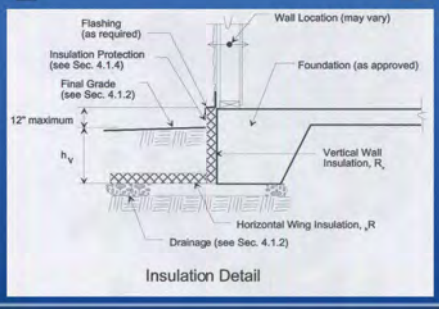
Soil that meets the USCS classification of GW, GP, SW, SP, GM, or SM.

ASCE 32-01

4. DESIGN PRINCIPLES

4.1.2 In soils OTHER THAN GW, GP, SW, SP, GM, and SM (Unified Soil Classification System, ASTM D2487), a layer of screened and washed gravel or crushed stone shall be placed beneath the horizontal insulation and drained to daylight, or an approved foundation drainage system shall be provided.

ASCE 32-01



Insulation Detail

ASCE 32-01

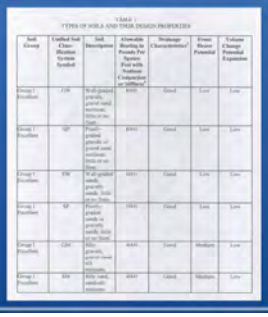
What are these soil types where can I find what they mean?

ASCE 32-01

What are these soil types where can I find what they mean?

Table 1 TYPES OF SOILS AND THEIR DESIGN PROPERTIES
Can be found in the commentary for SPS 321

ASCE 32-01



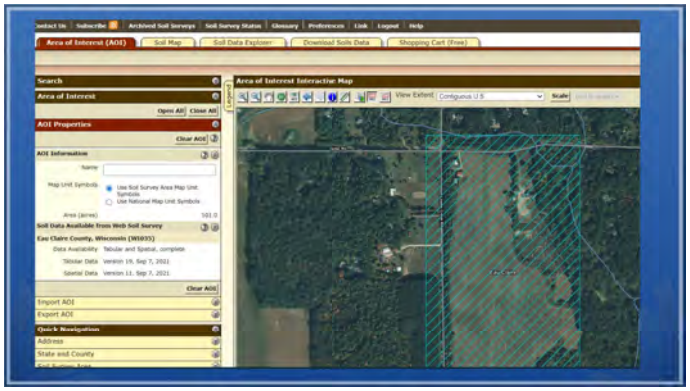
ASCE 32-01

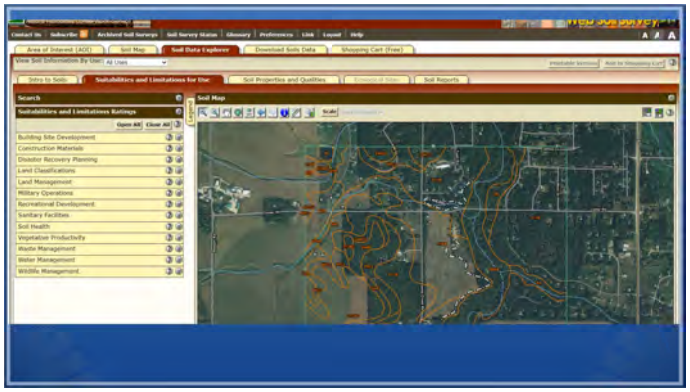
How do I know if my site has one of these soil types? (GW, GP, SW, SP, GM, and SM)

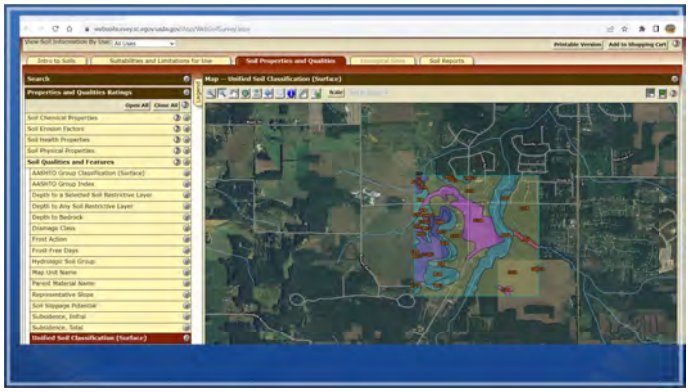
You can use the USDA Web Soil Survey Map

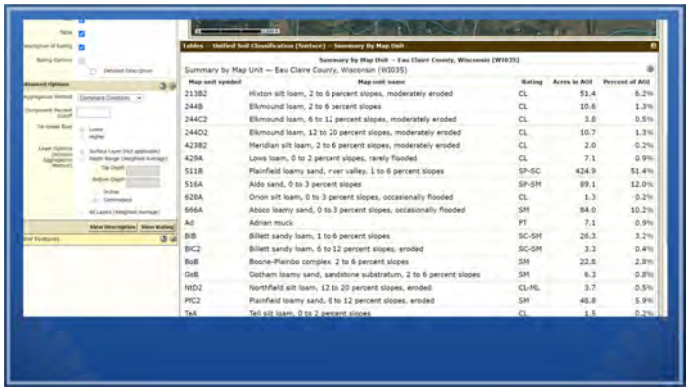
https://websoilsurvey.sc.egov.usda.gov/

USDA WEB SOIL SURVEY



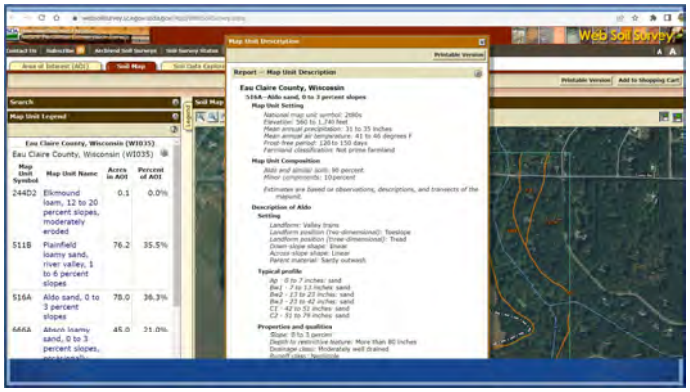






Summary by Map Unit — Eau Claire County, Wisconsin (WI035)

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
213B2	Hixton silt loam, 2 to 6 percent slopes, moderately eroded	CL	51.4	6.2%
244B	Elkmound loam, 2 to 6 percent slopes	CL	10.6	1.3%
244C2	Elkmound loam, 6 to 12 percent slopes, moderately eroded	CL	3.8	0.5%
244D2	Elkmound loam, 12 to 20 percent slopes, moderately eroded	CL	10.7	1.3%
423B2	Meridian silt loam, 2 to 6 percent slopes, moderately eroded	CL	2.0	0.2%
429A	Lows loam, 0 to 2 percent slopes, rarely flooded	CL	7.1	0.9%
511B	Plainfield loamy sand, river valley, 1 to 6 percent slopes	SP-SC	424.9	51.4%
516A	Aldo sand, 0 to 3 percent slopes	SP-SM	99.1	12.0%
628A	Orion silt loam, 0 to 3 percent slopes, occasionally flooded	CL	1.3	0.2%
666A	Absco loamy sand, 0 to 3 percent slopes, occasionally flooded	SM	84.0	10.2%
Ad	Adrian muck	PT	7.1	0.9%
BtB	Billett sandy loam, 1 to 6 percent slopes	SC-SM	26.3	3.2%
BtC2	Billett sandy loam, 6 to 12 percent slopes, eroded	SC-SM	3.3	0.4%
BuB	Boone-Plainbo complex, 2 to 6 percent slopes	SM	22.8	2.8%
GtB	Gotham loamy sand, sandstone substratum, 2 to 6 percent slopes	SM	6.3	0.8%
NtD2	Northfield silt loam, 12 to 20 percent slopes, eroded	CL-ML	3.7	0.5%
PfC2	Plainfield loamy sand, 6 to 12 percent slopes, eroded	SM	46.8	5.9%
TeA	Tell silt loam, 0 to 2 percent slopes	CL	1.5	0.2%



Eau Claire County, Wisconsin (WI035)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
244D2	Elkmound loam, 12 to 20 percent slopes, moderately eroded	0.1	0.0%
511B	Plainfield loamy sand, river valley, 1 to 6 percent slopes	76.2	35.5%
516A	Aldo sand, 0 to 3 percent slopes	78.0	36.3%
666A	Absco loamy sand, 0 to 3 percent slopes, occasionally	46.0	21.0%

ASCE 32-01

How do I know if my site has one of these soil types? (GW, GP, SW, SP, GM, and SM)

Have a soil scientist prepare a soils report for the site.

ASCE 32-01

4.3 FOUNDATIONS WITH INSULATION TO PREVENT GROUND FREEZING

Section 5 - Simplified FPSF Design Method for Heated Buildings with Slab on Ground Foundations

Section 6 - FPSF Design Method for Heated Buildings

Section 7 – FPSF Design Method for Unheated Buildings

Section 8 – Special Design Conditions for FPSF

ASCE 32-01

Buildings with foundations designed in accordance with Section 5 or 6 that are not completed and not heated before the time of first ground freezing shall have additional temporary ground protection or temporary heating of internal space in accordance with Table 1, or the foundation shall be designed in accordance with provisions for unheated buildings (Section 7).

ASCE 32-01

Section 5 - Simplified FPSF Design Method for Heated Buildings with Slab on Ground Foundations

Step 1: Select the Site's Design Air-Freezing Index

Step 2: Determine Insulation R-Value, Dimensions and Footing Depth.

Step 3: Select Insulation Types, Calculate Thickness, and Provide Protection.

ASCE 32-01

Section 6 - FPSF Design Method for Heated Buildings

Step 1: Select the Site's Design Air-Freezing Index

Step 2: Determine the R-Value for the Floor Slab

Step 3: Select the Required R-value for Vertical Wall Insulation

Step 4: Select Vertical Insulation Type, Calculate Thickness, and Provide Protection

ASCE 32-01

Step 5: Select Foundation Depth or Horizontal Wing Insulation for Walls

Step 6: Select Horizontal Insulation Type, Calculate Thickness, and Provide Protection

Step 7: Select Foundation Depth or Horizontal Wing Insulation at Corners

Step 8: Check Compressive Load on Horizontal Insulation

ASCE 32-01

6.2 UNVENTED CRAWLSPACE FOUNDATIONS

Step 1: Review Important Design Conditions

Step 2: Follow the Detailed Method for Heated Buildings

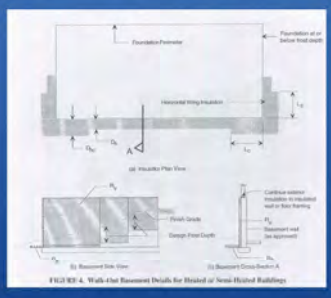
ASCE 32-01

6.3 WALK-OUT BASEMENTS

Step 1: Review Important Design Conditions

Step 2: Follow the Detailed Method for Heated Buildings

ASCE 32-01



ASCE 32-01

7. FPSF DESIGN METHOD FOR UNHEATED BUILDINGS

7.1 SLAB-ON-GROUND FOUNDATION

Step 1: Select the Design Air-Freezing Index

Step 2: Determine Placement of Ground Insulation

Step 3: Select the Required R-value of Ground Insulation

Step 4: Select Ground Insulation Type, Calculate Thickness, and Provide Protection

Step 5: Check Compressive Load on Ground Insulation

ASCE 32-01

7.2 CONTINUOUS FOUNDATION WALL

Continuous foundation walls exposed to exterior climate conditions on both sides. (i.e., vented crawlspaces)

7.3 COLUMN FOUNDATIONS

For column or pier foundations exposed to exterior climate conditions.

ASCE 32-01

8. SPECIAL DESIGN CONDITIONS FOR FPSF

8.1 SMALL UNHEATED AREAS IN OTHERWISE HEATED BUILDINGS

8.2 LARGE UNHEATED AREAS IN HEATED BUILDINGS (ATTACHED GARAGES)

8.3 SEMI-HEATED BUILDINGS

8.4 COLD BRIDGES

HEATED BUILDING

SIMPLIFIED DESIGN FOR A FPSF IN TAYLOR COUNTY

HEATED BUILDING

SIMPLIFIED DESIGN FOR A FPSF IN TAYLOR COUNTY

SELECT THE SITE'S AIR FREEZING INDEX FROM THE AIR FREEZE INDEX CONTOUR MAP.

HEATED BUILDING

HEATED BUILDING

SIMPLIFIED DESIGN FOR A FPSF IN TAYLOR COUNTY

SELECT THE SITE'S AIR FREEZING INDEX FROM THE AIR FREEZE INDEX CONTOUR MAP.

TAYLOR COUNTY HAS AN AFI OF 3000.

HEATED BUILDING

TAYLOR COUNTY HAS AN AFI OF 3000.

DETERMINE INSULATION R-VALUE, DIMENSION, AND FOOTING DEPTH FROM TABLE 4.

HEATED BUILDING

HEATED BUILDING

TAYLOR COUNTY HAS AN AFI OF 3000

DETERMINE INSULATION R-VALUE, DIMENSION, AND FOOTING DEPTH FROM TABLE 4.

VERTICAL INSULATION R-7.8

ALONG WALLS R-6.5

AT CORNERS R-8.6

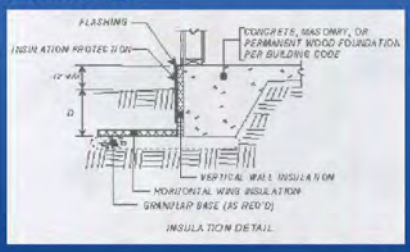
HORIZONTAL INSULATION DIMENSIONS

A=12" B=24" C = 40"

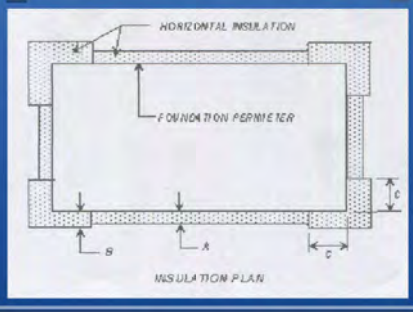
DEPTH OF FOOTING = 16"

HEATED BUILDING

DEPTH OF FOOTING = 16"



HEATED BUILDING

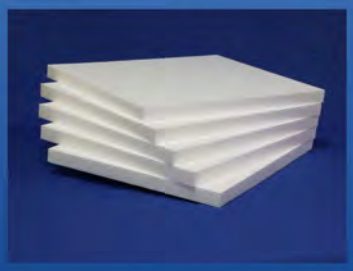


INSULATION TYPES

Vertical insulation shall be expanded or extruded polystyrene insulation.

Horizontal insulation shall be extruded polystyrene insulation.

EXPANDED POLYSTYRENE



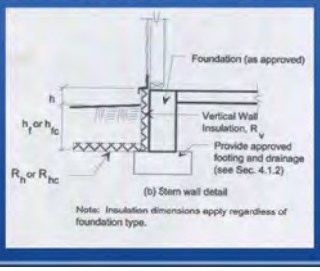
EXTRUDED POLYSTYRENE

STEM WALL

CAN YOU DO A FPSF AS A STEM WALL?

STEM WALL

CAN YOU DO A FPSF AS A STEM WALL?



(b) Stem wall detail

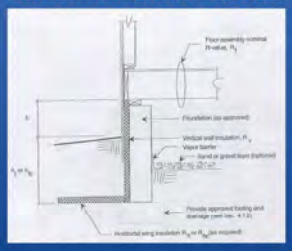
Note: Insulation dimensions apply regardless of foundation type.

CRAWL SPACE

CAN YOU DO A FPSF WITH A CRAWL SPACE?

CRAWL SPACE

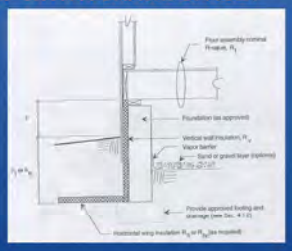
CAN YOU DO A FPSF WITH A CRAWL SPACE?



CRAWL SPACE

CAN YOU DO A FPSF WITH A CRAWL SPACE?

Height from exterior ground to the underside of joists cannot exceed 24"



ATTACHED UNHEATED GARAGE

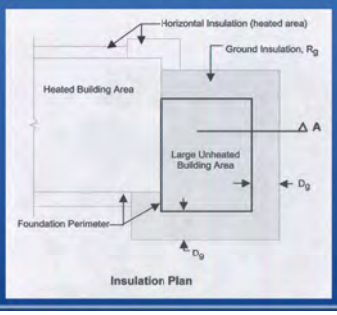
The UDC is "silent" on this.

Doesn't address or provide a detail on this situation.

ATTACHED UNHEATED GARAGE

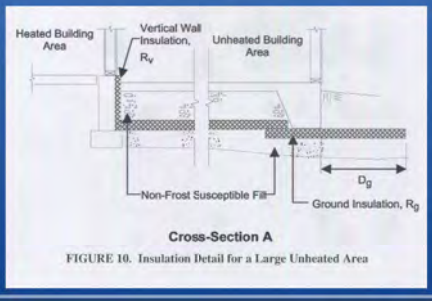
ASCE 32 sections 8.1 & 8.2 cover small and large unheated areas in heated buildings.

ATTACHED UNHEATED GARAGE



Insulation Plan

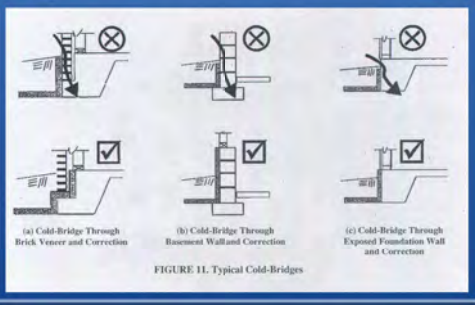
ATTACHED UNHEATED GARAGE



Cross-Section A

FIGURE 10. Insulation Detail for a Large Unheated Area

COLD BRIDGES



(a) Cold-Bridge Through Brick Veneer and Correction

(b) Cold-Bridge Through Basement Wall and Correction

(c) Cold-Bridge Through Exposed Foundation Wall and Correction

FIGURE 1L Typical Cold-Bridges

FPSF & THE REST OF THE UDC

All minimum requirements of the UDC must be complied with.

Compliance with a FPSF design doesn't necessarily mean compliance with the entire code

FPSF & THE REST OF THE UDC

All minimum requirements of the UDC must be complied with.

Compliance with a FPSF design doesn't necessarily mean compliance with the entire code.

SPS 321.10 Protection against decay and termites.

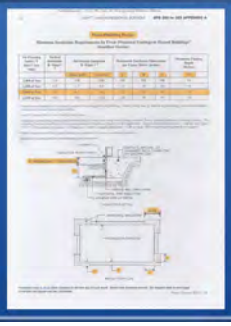
SPS 321.12 Drainage. (1) Grade. The finished grade of the soil shall slope away from the dwelling at a rate of at least ½" per foot for a least 10'

SPS 322 Energy Conservation

FPSF & THE REST OF THE UDC

SPS 321.10 Protection against decay and termites.
(1) Wood used in any of the applications under this section shall meet all of the following requirements:
(a) The wood shall be labeled and pressure treated with preservative in accordance with an AWPA standard or shall be naturally durable and decay−resistant or shall be engineered to be decay resistant.
(b) The wood shall be pressure treated with preservative or shall be naturally ermite−resistant unless additional steps are taken to make the wood termite−resistant.
(2) Wood used in the following locations shall be as required under sub. (1):
(f) 1. Siding and sheathing in contact with concrete, masonry or earth and within 6 inches above final exterior grade.

FPSF & THE REST OF THE UDC



FPSF & SPS 322 THE ENERGY CODE

A FPSF design using any amount of a non-renewable resource (Electric, propane, natural gas, ccal, heat pump, ect.) for generating heat has to comply with the requirements of SPS 322.

FPSF & SPS 322 THE ENERGY CODE

A FPSF design using any amount of a non-renewable resource (Electric, propane, natural gas, ccal, heat pump, ect.) for generating heat has to comply with the requirements of SPS 322.

The R-values and insulation dimensions from the table for the heated building design are going to change.

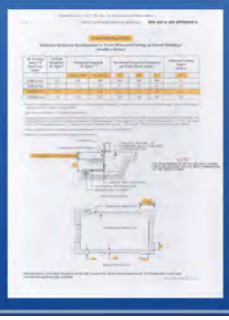
FPSF & SPS 322 THE ENERGY CODE

A FPSF design using any amount of a non-renewable resource (Electric, propane, natural gas, ccal, heat pump, ect.) for generating heat has to comply with the requirements of SPS 322.

The R-values and insulation dimensions from the table for the heated building design are going to change.

If you have in-floor heat the R-values will change even more.

FPSF & THE REST OF THE UDC



FPSF ASCE 32 ODDS & ENDS

Simplified FPSF design method for heated buildings – Insulation placed below the floor slab shall not exceed a nominal R-value of 10.

FPSF ASCE 32 ODDS & ENDS

Simplified FPSF design method for heated buildings – Insulation placed below the floor slab shall not exceed a nominal R-value of 10.

FPSF design method for heated buildings – Where the R-value of the entire slab exceeds 28, follow the design procedures for unheated buildings.

PICTURES

PICTURES

PICTURES

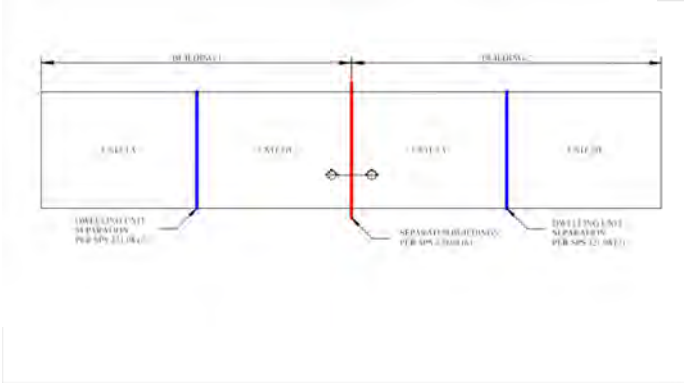
PICTURES

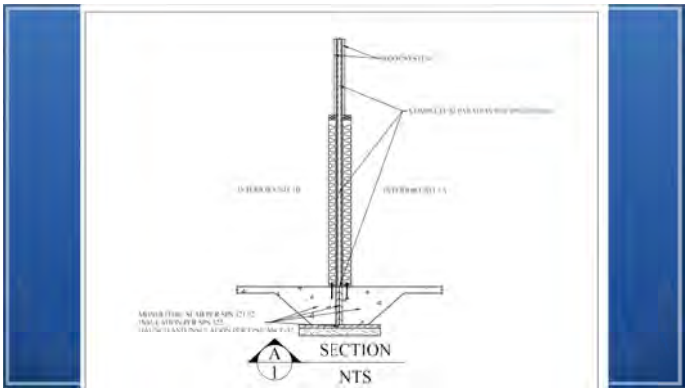
PICTURES

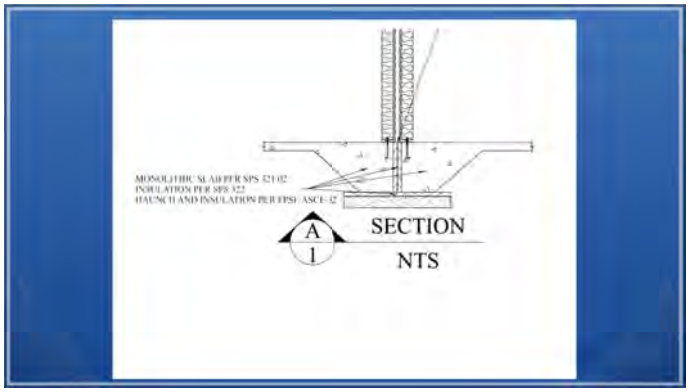
PICTURES

PICTURES

FPSF & SEPARATE BUILDINGS






MONOLITHIC SLAB PER SPS 121-02
INSULATION PER SPS 322
HAUNCH AND INSULATION PER EPSI/ASCE-32
A
1
SECTION
NTS