Considerations for a Slab-on-Grade Foundation

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- Educational programs and publications by the PHRC address a wide range of topics relevant to the home building industry and are designed to reach a diverse audience: builders, code officials, remodelers, architects, developers, engineers, planners, landscape architects, local government officials, educators, etc. to provide professional development and continuing education

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Program Description

In this session, learn the fundamental principles, benefits, and considerations associated with using a slab-on-grade foundation for residential construction to confidently evaluate its suitability for specific construction projects. Some benefits that will be discussed when comparing slab-on-grade foundations to traditional foundations are the cost-effectiveness, ease of construction, accessibility benefits, and energy efficiency. Attendees will also be able to understand some drawbacks for slab-on-grade foundations such as limited access for utilities, moisture and radon issues, and insulation challenges.

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Learning Objectives

1. Understand the most common types of slab-on-grade foundations and how to determine if one is the best choice.
2. Compare the cost-effectiveness of slab-on-grade foundations as an effective alternative to traditional foundations.
3. Examine the pros and cons of slab-on-grade foundations when compared to traditional basements for considerations such as utility access and insulation.
4. Review the 2018 IRC requirements for slab-on-grade foundations.

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Understanding Slab Foundations

- Overview of slab foundations: What are they and how do they differ from other types of foundations?
- Advantages and disadvantages of slab foundations in residential construction.
- Considerations for choosing a slab foundation in Pennsylvania's unique climate and soil conditions.

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Common Foundations in the Northeast US

- Full Basement
- Slab on grade
- Crawl space
- Pier and beam

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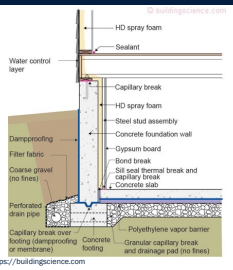
Full Basement Foundation

- This is generally the most common type of foundation found throughout the northeastern US.
- Benefits are utilities are accessible, usable space, it's a known product, better suited to steeper grade sites.
- Drawbacks are expense, potential moisture issue, time to install.



https://buildingscience.com

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Slab-on-Grade Foundation

Slab-on-grade foundations are a type of foundation where the concrete slab is poured directly onto the ground without any basement or crawl space beneath it. There are several variations of slab-on-grade foundations, each with its own advantages and considerations.

1. T-shaped slab
2. Slab on grade
3. Frost protected slab on grade or frost protected shallow foundation- FPSF

The most comment types for cold weather climates are the T-shaped slab foundation and the frost protected shallow foundation

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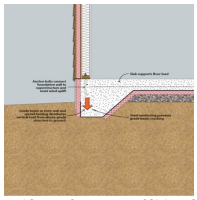
Frost Protected Shallow Foundation

- The only difference between slab on grade and frost protected shallow foundation is the addition of insulation to mitigate ground freezing in colder climates.



Structural System Components of Slab-on-Grade Foundation with Grade Beam

https://foundationhandbook.ornl.gov/

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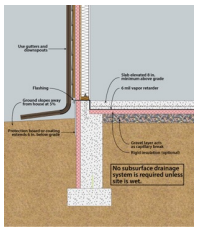
T-Shaped Slab Foundation

- T-shaped slab foundations are typically used in colder climate regions concern for ground freezing.
- They are typically done in three separate pores first the footing than the wall and lastly the slab.
- These are generally pretty straight forward to insulate, this is especially true if the framed portion of the house is going to have continuous exterior insulation.



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Crawl Space

- Benefits are accessibility to systems, ventilation, termite protection, easy to insulate, and cost-effectiveness.
- Potential problems are moisture buildup, pest infestation, and regular maintenance.

https://www.forbes.com

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Pier and Beam

- Pros are lower excavation cost, easier access to utilities, easier to do repairs.
- Cons are potential dampness issues, heating expenses in colder climates, and potential of infestations.

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Design and Construction Considerations

When designing a slab-on-grade foundation, especially in areas where soil and site conditions vary, several factors need careful consideration to ensure stability, durability, and longevity.

- Soil type
- Water tables
- Site grade
- Frost depth

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Design and Construction Considerations

Foundation are not a one size fits all choice. Lots if things go into determine what type is best for your client.

- Environment: Consider your lot characteristics—including slope, soil conditions and type, and water table levels—to narrow your choices.
- Climate: Climate zones will help narrow down what type of foundation is available to you.
- Cost: Some foundation types are more cost-effective than others, so consider your budget.
- Key features: Decide what features you want your foundation to offer, such as additional living space, easy access to utilities, or energy efficiency.

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Design and Construction Considerations

Key Features: What do you need from your foundation?

Client Input

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Slab Foundations

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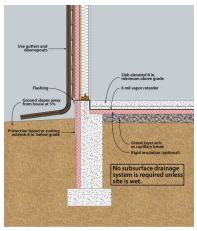
T-Shaped Slab vs. Frost Protected Shallow Foundation

T-shaped slab foundation have similarities to both traditional footer foundations and slab on grade.

- These are used in areas where the climate is colder and the ground freezes and so rely on depth of footer to mitigate frost heaving.
- Generally, 3 separate pours.
- Is a better choice for locations with steeper or uneven grade
- Does take longer to build than the monolithic slab or FPSF
- Is more expensive due to its complexity when compared to a FPSF.



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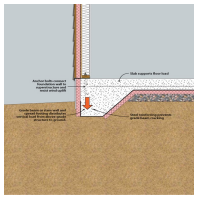
T-Shaped Slab vs. Frost Protected Shallow Foundation

A frost protected shallow foundation is a type of foundation that is used in colder climate conditions where there is a danger of ground freezing.

- Is a much simpler design since you only have a single pour for the entire slab.
- They are cost effective.
- They have been around now for a long time.
- They are used successfully in climates with extreme cold.
- Relies on a combination of insulation and building heat to mitigate frost heaving.



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FPSF Frost Protected Shallow Foundation

- Traditional frost protection is achieved through depth.
- FPSF protects from frost heave through specifically placed insulation.
- Conditions needed for frost heave:
  1. Moisture
  2. Freezing temp
  3. Susceptible soils

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Managing and Controlling Moisture

- Moisture is controlled in two states, vapor and liquid.
- Vapor- generally soil in contact with the foundation is always at 100% relative humidity, water vapor will always migrate from more humid to less humid.
- Liquid water can come from a few sources.
- Surface flows such as rain and improper grading, possible high-water table, and uncontrolled foundation assemblies.

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Managing and Controlling Moisture

- Manage excess exterior ground and surface water first by proper grading of the site.
- When possible, extend the eves of the home.
- Install proper sized gutters and downspouts that direct water away from the foundation.
- Install a drain tile if soil conditions warrant.
- Properly installed vapor retarders below the slab.
- Installing a capillary break, gravel below the slab.

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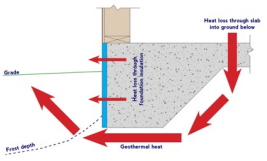
Controlling Freezing Ground Temperatures

FPSF use a combination of strategically placed insulation in conjunction with building and geothermal heat to raise the frost level.



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Codes

- ASCE 32-01
- IRC-R403.3 Frost-protected shallow foundations
- NAHB, book titles Design and Construction of Frost-Protected Shallow Foundations
- https://www.huduser.gov/publications/pdf/fpsfguide.pdf
- 2018 IRC energy codes

2018 IRC Figure R403.3(1)

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R403.3 Frost-protected shallow foundations.

For buildings where the monthly mean temperature of the building is maintained at not less than 64°F (18°C), footings are not required to extend below the frost line where protected from frost by insulation in accordance with Figure R403.3(1) and Table R403.3(1). Foundations protected from frost in accordance with Figure R403.3(1) and Table R403.3(1) shall not be used for unheated spaces such as porches, utility rooms, garages and carports, and shall not be attached to *basements* or *crawl spaces* that are not maintained at a minimum monthly mean temperature of 64°F (18°C).

Materials used below *grade* for the purpose of insulating footings against frost shall be *labeled* as complying with ASTM C578.

Premium Code Insights : Code Change Details

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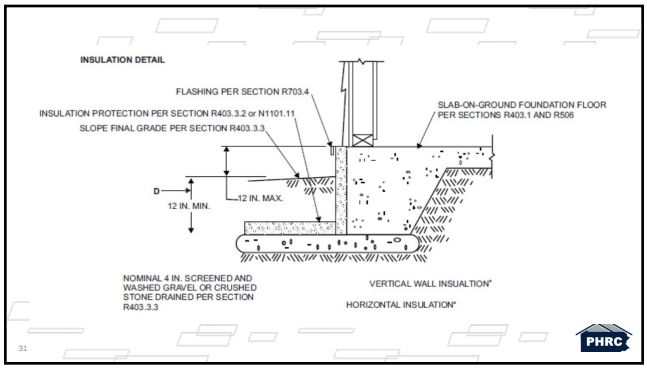

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TABLE R403.3(1)
MINIMUM FOOTING DEPTH AND INSULATION REQUIREMENTS FOR FROST-PROTECTED FOOTINGS IN HEATED BUILDINGS[a]

AIR FREEZING INDEX (°F-days)[b]	MINIMUM FOOTING DEPTH, D (inches)	VERTICAL INSULATION R-VALUE[c, d]	HORIZONTAL INSULATION R-VALUE[c, e]		HORIZONTAL INSULATION DIMENSIONS PER FIGURE R403.3(1) (inches)		
			Along walls	At corners	A	B	C
1,500 or less	12	4.5	Not required	Not required	Not required	Not required	Not required
2,000	14	5.6	Not required	Not required	Not required	Not required	Not required
2,500	16	6.7	1.7	4.9	12	24	40
3,000	16	7.8	6.5	8.6	12	24	40
3,500	16	9.0	8.0	11.2	24	30	60
4,000	16	10.1	10.5	13.1	24	36	60

For SI: 1 inch = 25.4 mm, °C = [(°F) - 32]/1.8.

a. Insulation requirements are for protection against frost damage in heated buildings. Greater values could be required to meet energy conservation standards.
b. See Figure R403.3(2) or Table R403.3(2) for Air Freezing Index values.
c. Insulation materials shall provide the stated minimum *R*-values under long-term exposure to moist, below-ground conditions in freezing climates. The following *R*-values shall be used to determine insulation thicknesses required for this application: Type II expanded polystyrene (EPS)-3.2 R per inch for vertical insulation and 2.6 R per inch for horizontal insulation; Type IX expanded polystyrene (EPS)-3.4 R per inch for vertical insulation and 2.8 R per inch for horizontal insulation; Types IV, V, VI, VII, and X extruded polystyrene (XPS)-4.5 R per inch for vertical insulation and 4.0 R per inch for horizontal insulation.
d. Vertical insulation shall be expanded polystyrene insulation or extruded polystyrene insulation.
e. Horizontal insulation shall be expanded polystyrene insulation or extruded polystyrene insulation.

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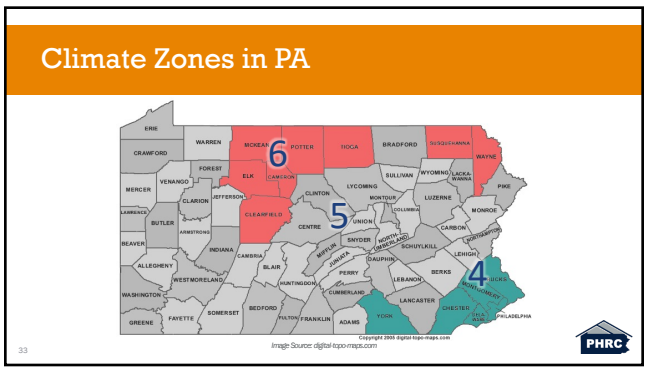

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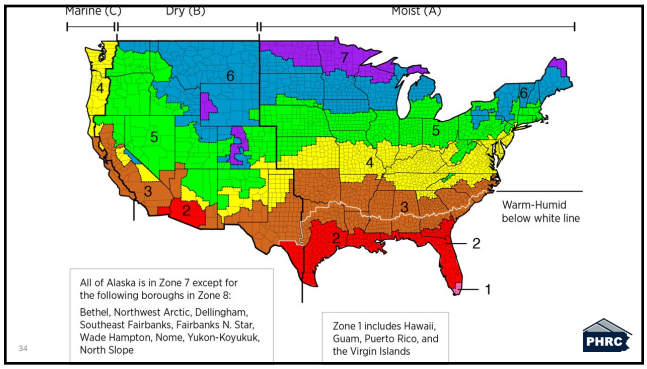

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2018 IRC Table N1102.1.2

Table N1102.1.2 (R402.1.2)
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT [a]

Climate Zone	Fenestration *U*-Factor	SKYLIGHT[b] *U*-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING *R*-VALUE	WOOD FRAME WALL *R*-VALUE[i]	MASS WALL *R*-VALUE	FLOOR *R*-VALUE	BAWSEMENT[c] WALL *R*-VALUE	SLAB[d] *R*-VALUE & DEPTH	CRAWL SPACE[c] WALL *R*-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13 + 5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.32	0.55	0.40	49	20 or 13 + 5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.30	0.55	NR	49	20 or 13 + 5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.30	0.55	NR	49	20 + 5[h] or 13 + 10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

Source: International Code Council (ICC). (2017). 2018 International Residential Code, Country Club Hill, Ill.

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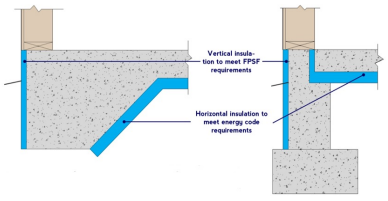
FPSF and Energy Codes

Energy Codes still need to be met.



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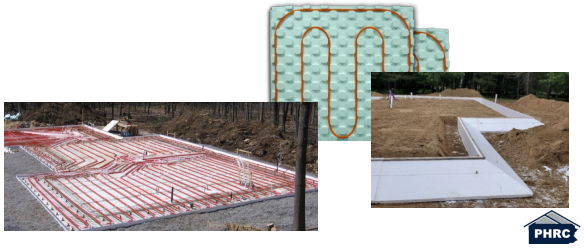
Slab-on-Grade Prefab Kits



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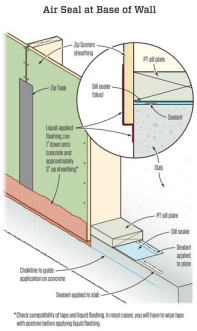
Air Sealing

Does the builder do anything different from a traditional basement when air sealing? No you still follow the same procedures when air sealing between the bottom plate and foundation.



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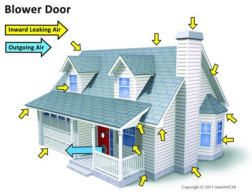
Blower Door Testing

Does a slab on grade differ from a traditional basement blower door test? No, it is the same test with the same required outcome of 3 ACH50.

Mathematically having no basement does make a difference since you no longer have the cu. ft. of the basement included in the overall cu. ft. of the home.



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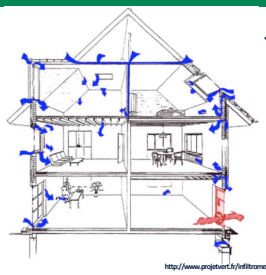
Airtightness Requirement: 3 ACH50



- Measured in Air Changes Per Hour at 50 Pascals (ACH50 / ACH$_{50}$)
  - 50 pascals – equivalent to 20 MPH wind on the house

Value we need (Air Changes Per Hour @ 50 Pascals) | Value from the blower door pressure gauge (Cubic Feet Per Minute @ 50 Pascals) | Constant (60 minutes per hour)

$$ACH_{50} = \frac{CFM_{50} \times 60}{V} < 3$$

Volume of the House (Cubic Feet)

http://www.projetvert.fr/infiltrometrie/permeabilite-a-lair/

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Preplanning Utilities

- One of the other drawbacks most talked about with slab-on-grade foundations is running utilities, particularly plumbing.
- Its is important to make sure that all plumbing drains are installed during the correct sequence before any concrete is poured. Effecting repairs and installing drains is difficult and costly after the fact
- Most other mechanical systems can be installed once the framing is complete.

www.waddelleng.com

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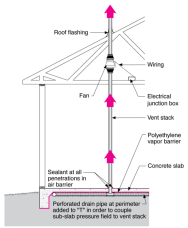
Radon

Because local radon levels may vary from those shown on the county-level EPA radon map, because the amount of radon that will accumulate in a home can't be determined until the home is built, and because the easiest time to install a radon mitigation system is during initial construction, the best practice recommendation is to install a passive ventilation stack in all new homes.

https://basc.pnnl.gov/resource-guides/radon-fan#edit-group-description



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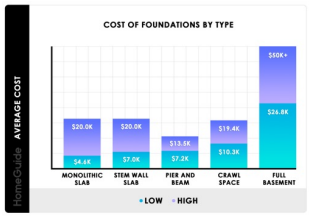
Cost Comparison

1200 sq ft. House
Full Basement
$38,400.00
Monolithic Slab
$12,800.00

$26,100.00
Price Difference



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Additional Benefits of FPSF

- Faster Build Time
- Lower Cost
- Easier Pest Management
- Lower Maintenance
- In Floor Heating

No Muddy Swimming Pools

http://blog.armchairbuilder.com/

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Cons of Slab Foundation

- Inaccessible Utilities
- Settling
- Cracking
- Upheaval

Like any building system you need to pay attention to the details.

https://hdfoundationrepair.com/

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Maintenance and Long-Term Performance

- Maintenance requirements for slab foundations.
- Long-term performance considerations and durability of slab foundations in Pennsylvania's climate.

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Maintenance

- Monitor water and moisture around your property
- Maintain good drainage
- Proper landscaping
- FPSF- maintain adequate temp inside during colder months

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Long-Term Performance

- Slab on grade foundations have been used successfully for more than a century in the US, These were put in before our understanding modern building techniques to help deal with moisture related issues.
- Frost protected shallow foundations have been used for more than 50 years through out Scandinavia and Canda with very successful outcomes.

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Summary

- Slab-on-grade foundations are an excellent alternative to a traditional basement foundation. Like any other decision during the design and construction process certain questions need to be asked as to whether it's a good fit for a particular site location as well as client needs.

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Questions?

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