

PHRC Webinar Series | Tuesday, February 14 @ 1pm

Frost Protected Shallow Foundations in PA

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Description

- Frost protected shallow foundations are an economically feasible alternative to traditional foundation construction in Pennsylvania, yet they require special attention to structural and insulation detailing. This webinar will explore what a frost-protected shallow foundation looks like in PA, discuss the code requirements that allow for the construction of these foundation systems, and will examine the design considerations that drive the design and construction of these systems.

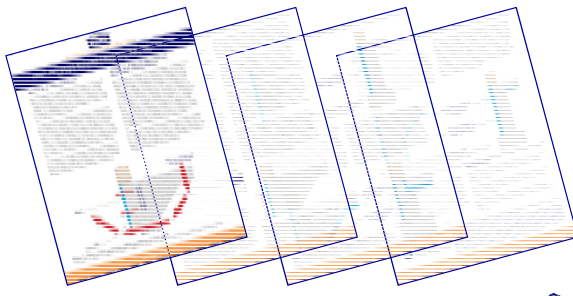


Learning Objectives

- Examine existing code requirements related to foundations, including prescriptive requirements for frost protected shallow foundations.
- Analyze the differences between conventional foundations and frost protected shallow foundations as it relates to the building enclosure and overall durability.
- Understand the material and product options available in order to provide a structurally sound frost protected shallow foundation.
- Discuss specific scenarios in Pennsylvania when frost protected shallow foundations may be utilized, analyzing the feasibility and cost effectiveness of each approach.




Builder Brief



<http://phrc.psu.edu/assets/docs/Publications/Frost-Protected-Shallow-Foundations-FINAL.pdf>


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Outline

- **What is a foundation?**
- **What is a frost protected shallow foundation (FPSF)?**
 - FPSF design criteria
 - FPSFs and the energy code
 - FPSFs and heated slabs
- **FPSFs in PA**
 - High-performance homes

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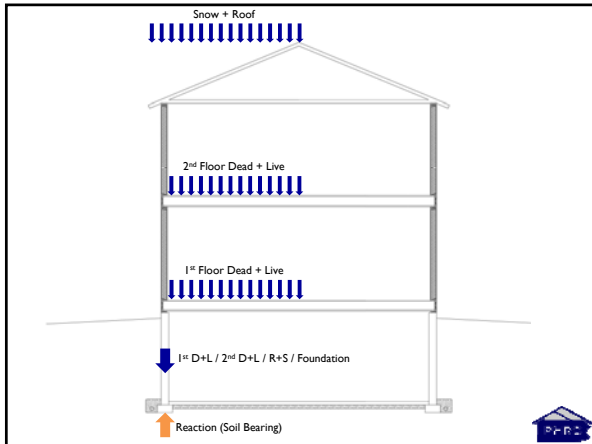
What is a Foundation?

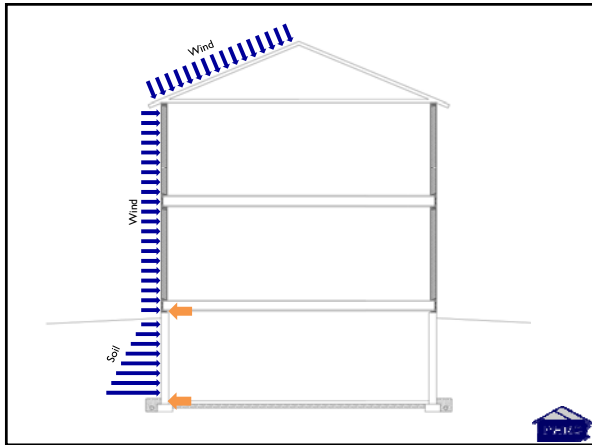
- ***“Foundation construction shall be capable of accommodating all loads according to Section R301 and of transmitting the resulting loads to the supporting soil.”***
 - 2009 IRC Section R401.2 – Foundation Requirements

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International Code Council. (2008). 2009 International Residential Code, ICC, Country Club Hill, Ill.






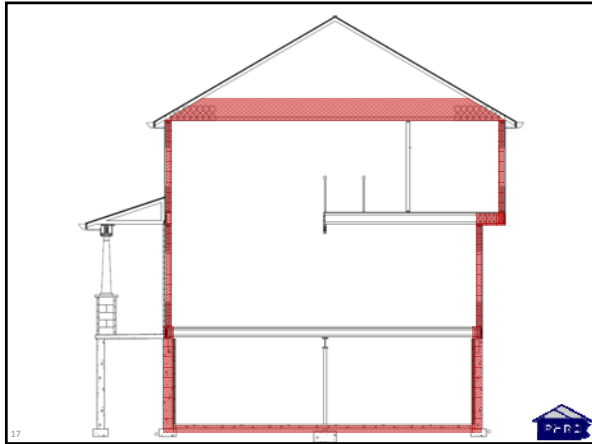


What is the Building Enclosure?

- *“That part of any building that physically separates the exterior environment from the interior environment(s) is called the building enclosure or building envelope.”*
 - Dr. John Straube, BSD-018: The Building Enclosure


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Other Considerations in PA

- **Frost depth**
 - Frost penetration can compromise shallow foundations if they are not placed below the local frost depth
 - The base of the footing needs to be below this line
 - Distance should be measured relative to final grade
- **Excavation constraints**
- **Cost**
- **Constructability**
- **Others**

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Foundation Design Process

- **Options:**
 1. Full-height basement
 2. Crawlspace
 3. Slab-on-grade

 vs  vs 

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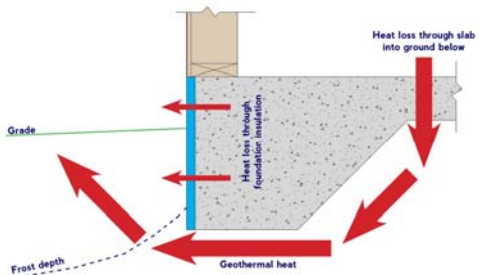
What is a Frost Protected Shallow Foundation?

- Foundation system installed at a shallower depth than the frost depth
 - Protected from frost heave through specific insulation placement
 - Insulation can raise the frost depth as it approaches the heated structure
- *“Insulation is provided to retard frost penetration below the foundation and to retard heat flow from beneath the foundation, allowing shallower footing depths to be possible with no added risk of frost damage.”*
 - ASCE 32-01

20 American Society of Civil Engineers. 2001. Design and Construction of Frost-Protected Shallow Foundations (32-01). Reston, VA: American Society of Civil Engineers



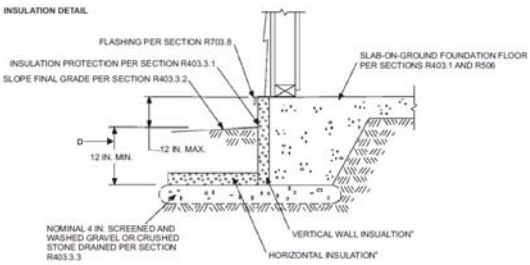
FPSF Impact on Frost Depth



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FPSFs in the 2009 IRC - Figure R403.3(1)




22 International Code Council. (2009). 2009 International Residential Code, ICC, Country Club Hill, Ill.




FPSF Assumptions & Limitations

- Simplified FPSF designs require that the building be heated and maintain a minimum monthly average indoor temperature greater than 64°F
- FPSF designs must still meet applicable energy codes

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FPSF Resources

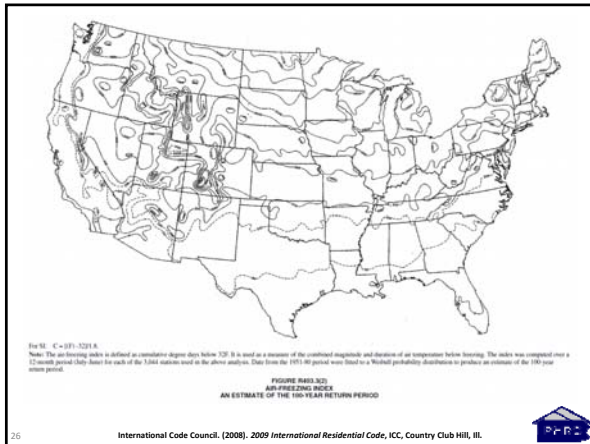
- ASCE 32-01
 - Design and Construction of Frost-Protected Shallow Foundations
- Revised Builder's Guide to Frost Protected Shallow Foundations
 - NAHB Research Center (Home Innovations Research Lab)
- 2009 International Residential Code

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FPSF Design Criteria

- Simplified design approach (found in 2009 IRC) is based on:
 - Air Freezing Index (AFI)
 - Insulation R-value
 - Footing depth
- Air Freezing Index
 - Value indicating the intensity of below-freezing temperatures occurring during a given heating season
 - Regionally specific
 - All regions in PA have an AFI < 2,000

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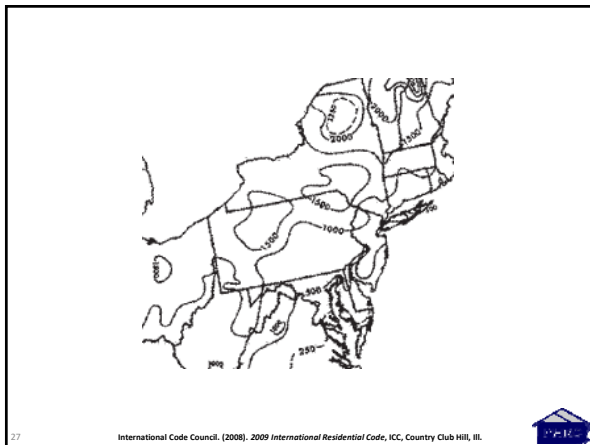


Table 1: FPSF insulation R-values and footing depths

Air Freezing Index (F-days)	Minimum Footing Depth, D (inches)	Vertical Insulation R-Value
1,500 or less	12	4.5
2,000	14	5.6

Air Freezing Index by Pennsylvania County

AFI-2000
Berks, Blair, Bradford, Cambria, Cameron, Centre, Clarion, Clearfield, Clinton, Crawford, Elk, Forest, Huntingdon, Indiana, Jefferson, Lackawanna, Lycoming, McKean, Pike, Potter, Susquehanna, Tioga, Venango, Warren, Wayne, Wyoming

AFI-1500 or less
Adams, Allegheny, Armstrong, Beaver, Bedford, Berks, Butler, Carbon, Chester, Columbia, Cumberland, Dauphin, Delaware, Erie, Fayette, Franklin, Fulton, Greene, Juniata, Lancaster, Lawrence, Lebanon, Lehigh, Luzerne, Mercer, Mifflin, Monroe, Montgomery, Montour, Northampton, Northumberland, Perry, Philadelphia, Schuylkill, Snyder, Somerset, Sullivan, Union, Washington, Westmoreland, York

Figure 2: Frost protected shallow foundation depth and insulation placement requirements
Note: Depth below grade = D. Insulation must extend to top of foundation wall. Depth requirements also apply to stem wall construction. Energy code requirements may exceed insulation depth and R-value requirements shown in Table 1.

28 International Code Council, (2008). 2009 International Residential Code, ICC, Country Club Hill, Ill.

FPSFs and the Energy Code

- 2009 IRC Table N1102.1
 - Insulation and Fenestration Requirements by Component

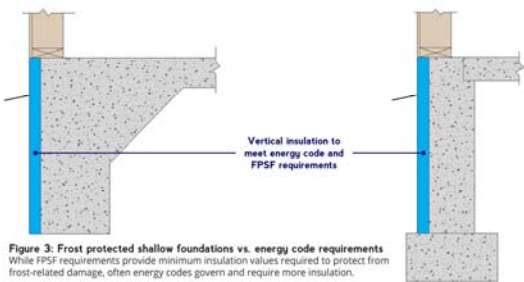
Climate Zone	Slab ⁴ R-Value and Depth
4 except Marine	10, 2 ft
5 and Marine 4	10, 2 ft
6	10, 4 ft

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International Code Council, (2008). 2009 International Residential Code, ICC, Country Club Hill, Ill.



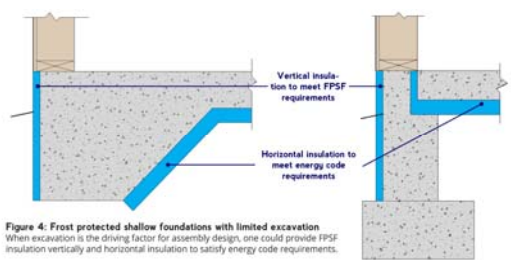
When Energy Codes Govern



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Energy Codes and Limited Excavation



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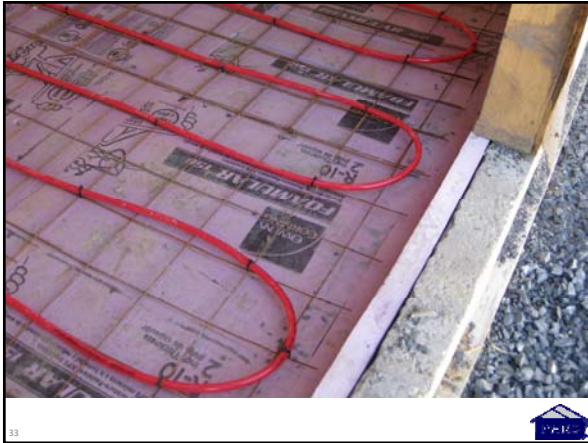


FPSFs and Heated Slabs

- It is often desirable to place heating elements (hydronic or electric) in a concrete slab
 - Insulation requirement for slabs increases when heating elements are present

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FPSFs and the Energy Code

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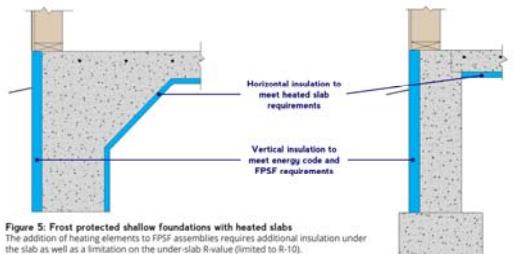
– Footnote d: R-5 shall be added to the required slab edge R-values for heated slabs.

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International Code Council. (2008). 2009 International Residential Code, ICC, Country Club Hill, Ill.



Heated Slabs



Horizontal insulation to meet heated slab requirements

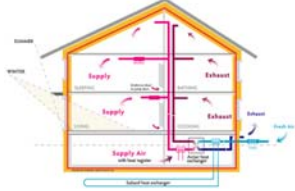
Vertical insulation to meet energy code and FPSF requirements.

Figure 5: Frost protected shallow foundations with heated slabs
The addition of heating elements to FPSF assemblies requires additional insulation under the slab as well as a limitation on the under-slab R-value (limited to R-10).

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FPSFs and High Performance Construction

- **Principles**
 - Reduce heat gain/loss through the building enclosure
 - Reduce energy consumption through the installation of energy efficient systems
- **Passive House**



Passive House Institute US – www.phius.org

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HP Housing and Basements

- **Why are most high performance homes, especially certified Passive House projects, on slabs instead of basements?**
 - Slab-on-grade foundations are often more cost effective




Photo courtesy of Pete Vargo (Nu-Tech Energy Solutions)

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FPSF Impact on Frost Depth

Heat loss through slab into ground below

Heat loss through foundation into ground below

Grade

Frost depth

Geothermal heat

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Insulation Details @ Slab Edge

- **Design considerations**
 - Structural load path
 - Can foam be load bearing?
 - Insulation continuity
 - Avoid thermal bridging or cold bridges

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Foam Compressive Strength

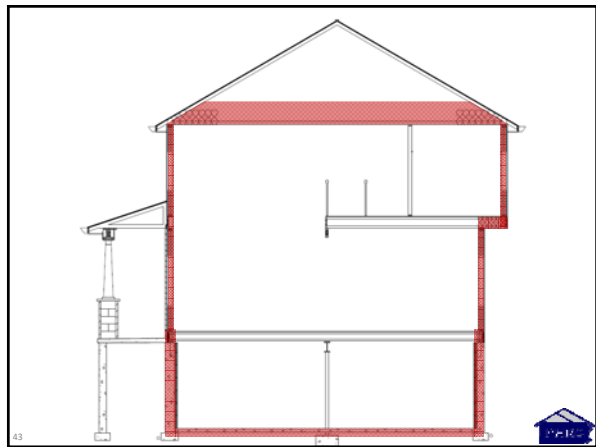
- **Common soil load-bearing design values = 1,500-2,000 psf**
 - Note: 2,000 psf = 13.9 psi
- **Common foam compressive strength**
 - XPS = 25 psi
 - Note: this comparison is oversimplified and doesn't take into account creep, shrinkage, and other loading factors (in order words, you may want to consult an engineer on this)

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What is a Cold Bridge?

UNHEATED BUILDING

4.2 NAHB Research Center, Inc. 2004. Revised Builder's Guide to Frost Protected Shallow Foundations. Upper Marlboro, MD: NAHB Research Center, Inc.



FPSFs and Raft Slabs

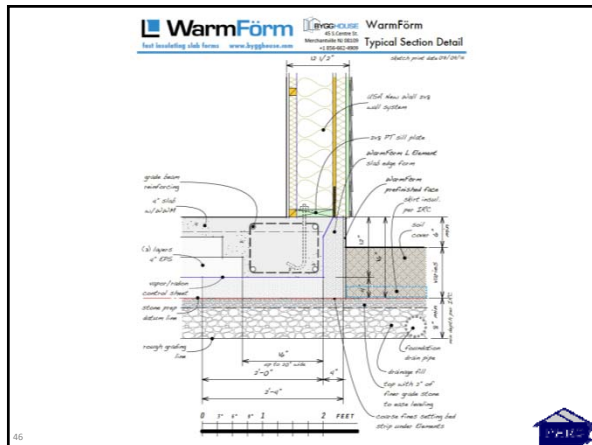
- **Raft slab is an insulated flat slab-on-grade**
 - Uniform thickness
 - Continuous insulation layer under entire slab
 - Wing insulation (horizontal) not always present
- **How does a raft slab meet FPSF requirements?**
 - Three strategies:
 - Install raft slab to prescriptive depth
 - Use non-frost-susceptible material to comply with depth requirements
 - Install wing insulation and treat system as an unheated structure

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Prefab Slab Forms



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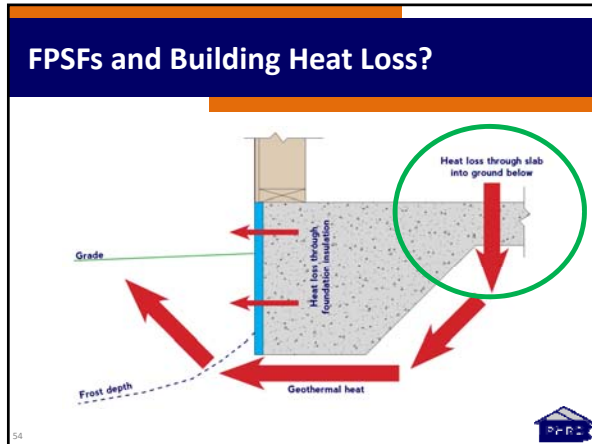
Raft Slab Example

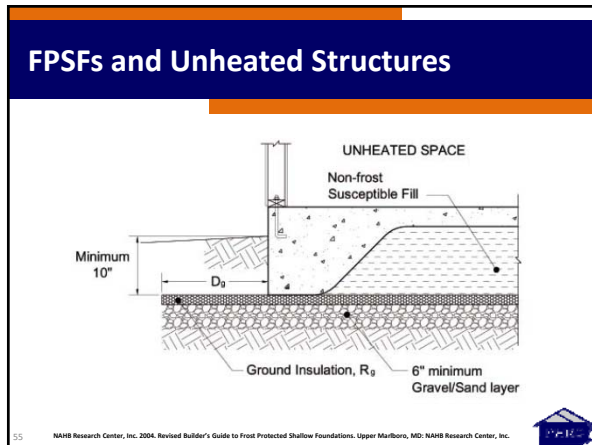


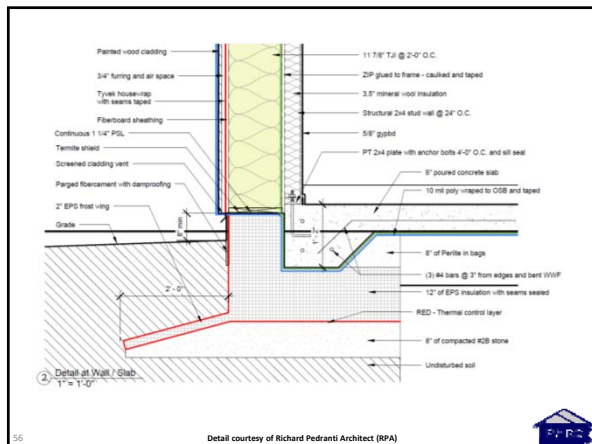
Photo courtesy of Pete Vargo (Nu-Tech Energy Solutions)



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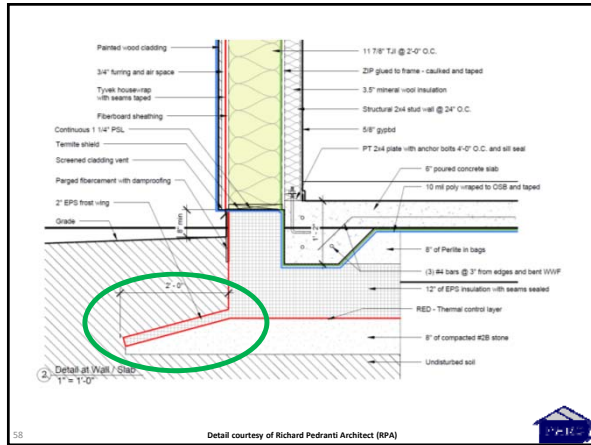
Raft Slab Prior to Wing Installation



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Photo courtesy of Pete Vargo (Nu-Tech Energy Solutions)





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Detail courtesy of Richard Pedranti Architect (RPA)



Overall FPSF/HP Homes Considerations

- Insulated slab-on-grade foundations are common on high-performance projects
- FPSF strategies can make this approach more cost effective
- Must still comply with code requirements
 - Can follow prescriptive FPSF provisions for heated buildings in the IRC or
 - Provide engineered design (based on ASCE or NAHB R.C. guidance)

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THURSDAY (3/23) WORKSHOPS

The PHRC Workshop Day
 provides additional opportunities for attendees to gain on the latest design, construction, and to receive continuing education credits.
 Each workshop is hosted from 8:30am-4:30pm on Thursday, March 23. Please note the separate registration requirements for the PCCA workshop or PCCA website.

HVAC DESIGN & INSTALLATION
 \$175 (hosted by PHRC)

TWO-FAMILY DWELLINGS & TOWNHOUSES
 \$125 (hosted by PCCA)

CONFERENCE PRICING

CONFERENCE SESSIONS (WEDNESDAY)			WORKSHOPS (THURSDAY)		
Session	Wed 3/22	Thu 3/23	Session	Wed 3/22	Thu 3/23
Standard Rate	\$180	\$210	PHRC HVAC Workshop	\$175	\$195
PHRC Member	\$160	\$190	PCCA Two-Family Workshop	\$125	\$145
Student/Childcare	\$75	\$95			
Code Official	\$65	\$85			

25th Anniversary National Registration! \$148
 Please note: Registration for all conference events after February 27th and will be \$150 for those who changed the date, plus \$148 for additional \$100.

ACCOMMODATIONS

1916 HOTEL CONFERENCE CENTER-HOTEL
 1916 Hotel, 1916
 1916 Hotel, 1916
 1916 Hotel, 1916

CONTINUING EDUCATION

Session	PHRC	PCCA	PHRC	PCCA	PHRC	PCCA
PHRC HVAC Workshop	1.0	0.0	0.0	0.0	0.0	0.0
PCCA Two-Family Workshop	0.0	1.0	0.0	0.0	0.0	0.0
PHRC HVAC Workshop	1.0	0.0	0.0	0.0	0.0	0.0
PCCA Two-Family Workshop	0.0	1.0	0.0	0.0	0.0	0.0

REGISTRATION INFO

- The registration fee covers all individual meals, program materials, lunch and breaks, registration fee responsible for all other meals and the lodging.
- Registration fee does not include travel to and from the conference location.
- Check registration tickets at 1916 Hotel.
- Do not reschedule or transfer tickets. If unable to attend, please contact the conference office for more information.
- Make a 100 day advance payment for the registration and the balance due at the time of the registration.
- Registration fee includes 200 CEU hours for the duration of the conference.
- Transfer of a session can occur at any time. Contact Tracy Thomas at 610-662-5241 to receive the discount.
- Non-refundable fee will include confirmation fee. Your registration will be confirmed with an invoice via email confirmation.

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