

April 14th, 2020 – Christopher Hine

The Do's and Don'ts of Crawlspace Design and Construction: Revisited!

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Agenda

- The What and Why?
- Does a Crawlspace make sense for your conditions?
- Designing a Crawlspace
- Building Science in Crawlspaces
- Are we at Risk of Condensation in PA?
- Reducing Condensation Risks in Crawlspaces
- Wrap-up



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The What and Why



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What is a Crawlspace?

- A space under the first floor or a roof of a building that is not high enough to stand up in. - Merriam-Webster
- "A basement for short people" - Gord Cooke (Construction Instruction)



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Why design a Crawlspace?

- Cost effective alternative to a full basement
- Site conditions
- Flexibility



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Can a Crawlspace Save \$\$\$?

- Example:
 - 36' x 28' foundation
 - 8" x 96" full cast in place foundation wall
 - 3 ½" basement slab (no mesh or rebar)
 - 8" x 36" cast in place crawlspace wall



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Can a Crawlspace Save \$\$\$?

• Example: Cast in place wall

- Total linear length of cast in place wall – 128'
 - 96" full cast in place foundation wall @ \$38.25/lf = **\$4,896.00**
 - 36" cast in place crawlspace foundation wall @ \$26.50/lf = **\$3,392.00**
- Savings of **\$1,504.00**

7
Pricing may be different in other markets.



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Can a Crawlspace Save \$\$\$?

• Example: Slab

- 3 ½" Concrete Slab – 925 sf @ \$2.65/sf = **\$2,451.25**
- Savings of **\$2,451.25**

8
Pricing may be different in other markets.



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Potential Savings

• Total potential savings of Concrete

- Walls - \$1,504.00
- Slab - \$2,451.25
- Total - **\$3,955.25**
- Roughly \$2.00 per square foot on a 2000 sf 2-story home.

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Pricing may be different in other markets.



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Site Conditions: What We Want to See



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Site Conditions: Reality



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Site Conditions: Reality



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Rocky Site Conditions

- Often requires a hydraulic impact hammer, which equates to \$\$\$!!



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Rocky Site Conditions

- Explosive!\$!\$!



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High Water Table

- Under water



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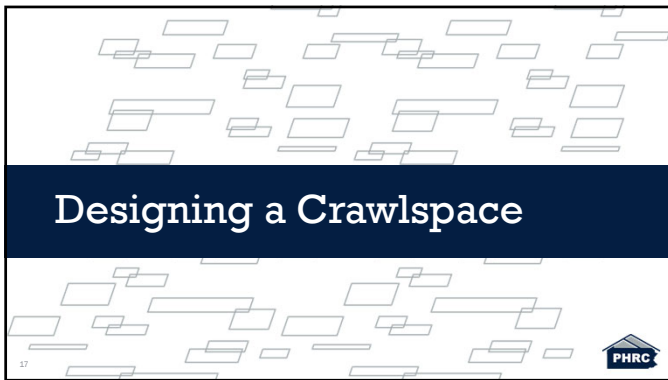
Flexibility

• Running mechanicals



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Designing a Crawlspace



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2015 IRC Requirements

• 2015 International Residential Code

- Crawlspace and Under-Floor Space are both directed to **Section R408 Under-Floor Space**
 - R408.1 Ventilation
 - R408.2 Openings for under-floor ventilation
 - R408.3 Unvented crawlspace
 - R408.4 Access
 - R408.5 Removal of debris
 - R408.6 Finished grade
 - R408.7 Flood resistance

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Vented Crawlspace - IRC R408.1

- The minimum net area of ventilation openings shall be not less than 1 square foot for each 150 square feet of under-floor space area, **unless** the ground surface is covered by a Class 1 vapor retarder material. Where a Class 1 vapor retarder material is used, the minimum net area of ventilation openings shall be not less than 1 square foot for each 1,500 square feet of under-floor space area. One such ventilating opening shall be within 3 feet of each corner of the building.

Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Openings for Under-Floor Ventilation IRC R408.2

- Ventilation openings shall be covered for their height and width with the following:
 1. Perforated sheet metal plates
 2. Expanded sheet metal plates
 3. Cast-iron grill or grating
 4. Extruded load bearing brick vents
 5. Hardware cloth of .035" wire or heavier
 6. Corrosion-resistant wire mesh

Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Openings for Under-Floor Ventilation IRC R408.2



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Unvented Crawlspace - IRC R408.3

• Ventilation openings shall not be required where:

1. Exposed earth is covered with a continuous Class I vapor retarder. All joints shall overlap a minimum of 6" and shall be sealed or taped. Edges shall extend a minimum of 6" of the stem wall and shall be attached and sealed to the stem wall.

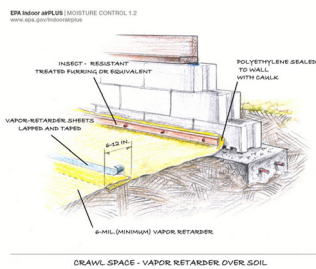
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Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Unvented Crawlspace IRC R408.3



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Unvented Crawlspace IRC R408.3

• Ventilation openings shall not be required where:

2. **One** of the following is provided for the under-floor space:

2.1. Continuously operated mechanical exhaust ventilation at a rate of 1 cfm for each 50 sf of crawlspace floor area, including an air pathway to the common area and perimeter wall insulation.

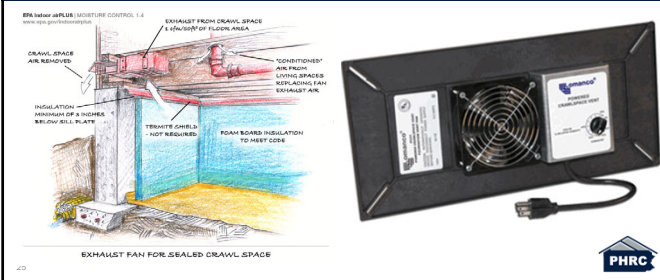
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Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Unvented Crawspace IRC R408.3



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Unvented Crawspace IRC R408.3

• Ventilation openings shall not be required where:

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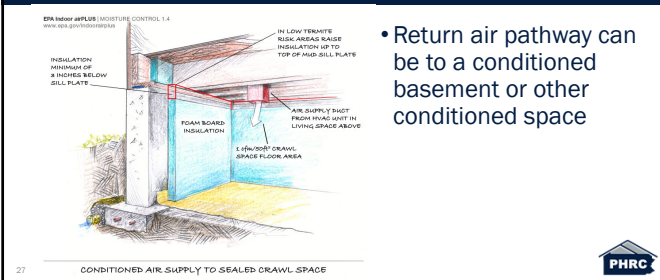
2.1. Continuously operated mechanical exhaust ventilation at a rate of 1 cfm for each 50 sf of crawlspace floor area, including an air pathway to the common area and perimeter wall insulation.

2.2. Conditioned air supply sized to deliver at a rate equal to 1cfm for each 50 sf of crawlspace area, including a return air pathway to the common area and wall insulation.

Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL

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Unvented Crawspace IRC R408.3



- Return air pathway can be to a conditioned basement or other conditioned space

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Unvented Crawlspace IRC R408.3

• Ventilation openings shall not be required where:

2. **One** of the following is provided for the under-floor space:

- 2.1. Continuously operated mechanical exhaust ventilation at a rate of 1 cfm for each 50 sf of crawlspace floor area, including an air pathway to the common area and perimeter wall insulation.
- 2.2. Conditioned air supply sized to deliver at a rate equal to 1cfm for each 50 sf of crawlspace area, including a return air pathway to the common area and wall insulation.
- 2.3 Plenum in existing structures to comply with Section M1601.5 if crawlspace is used as a plenum.
 - Per M1601.5, this is not permitted in new structures.

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Source: International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hills, IL.



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Insulated Walls for Unvented Crawlspace

• 2015 IRC N1102.2.11

- As an alternative to insulating floors over crawl spaces, crawl space walls shall be permitted to be insulated when the crawl space is not vented to the outside. Crawl space wall insulation shall be permanently fastened to the wall and extend downward from the floor to the finished grade level and then vertically and/or horizontally for at least an additional 24".

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Source: International Code Council (ICC). (2014). 2015 International Residential Code, Country Club Hills, IL.



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Envelope Changes: Zone 4

Component	2009	2015
Fenestration U-Factor	0.35	0.35
Skylight U-Factor	0.60	0.55
Glazed Fenestration SHGC	NR	0.40
Ceiling R-Value	38	49
Wood Frame Wall R-Value	13	20 or 13+5
Mass Wall R-Value	5/10	8/13
Floor R-Value	19	19
Basement Wall R-Value	10/13	10/13
Slab R-Value & Depth	10, 2ft	10, 2ft
Crawlspace Wall R-Value	10/13	10/13

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Source: International Code Council (ICC). (2008). 2009 International Residential Code, Country Club Hills, IL.
International Code Council. (2014). 2015 International Residential Code, ICC, Country Club Hills, IL.

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Envelope Changes: Zone 5

Component	2009	2015
Fenestration U-Factor	0.35	0.32
Skylight U-Factor	0.60	0.55
Glazed Fenestration SHGC	NR	NR
Ceiling R-Value	38	49
Wood Frame Wall R-Value	20 or 13+5	20 or 13+5
Mass Wall R-Value	13/17	13/17
Floor R-Value	30	30
Basement Wall R-Value	10/13	15/19
Slab R-Value & Depth	10, 2ft	10, 2ft
Crawlspace Wall R-Value	10/13	15/19

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Source: International Code Council (ICC), (2006), 2009 International Residential Code, Country Club Hill, IL
International Code Council, (2014), 2015 International Residential Code, ICC, Country Club Hill, IL



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Envelope Changes: Zone 6

Component	2009	2015
Fenestration U-Factor	0.35	0.32
Skylight U-Factor	0.60	0.55
Glazed Fenestration SHGC	NR	NR
Ceiling R-Value	49	49
Wood Frame Wall R-Value	20 or 13+5	20+5, 18+6.5, or 13+10
Mass Wall R-Value	15/19	15/20
Floor R-Value	30	30
Basement Wall R-Value	10/13	15/19
Slab R-Value & Depth	10, 4ft	10, 4ft
Crawlspace Wall R-Value	10/13	15/19

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Source: International Code Council (ICC), (2006), 2009 International Residential Code, Country Club Hill, IL
International Code Council, (2014), 2015 International Residential Code, ICC, Country Club Hill, IL



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Access IRC R408.4

- Access shall be provided to all under-floor spaces with a minimum opening through the floor of 18" x 24" OR through a perimeter wall that shall not be less than 16" x 24".



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Removal of Debris IRC R408.5

- The under-floor *grade* shall be cleaned of all vegetation and organic material. All wood forms used for placing concrete shall be removed before a building is occupied or used for any purpose. All construction materials shall be removed before a building is occupied or used for any purpose.

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Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Finished Grade IRC R408.6

- The finished *grade* of under-floor surface may be located at the bottom of the footings; however, where there is evidence that:
 - Ground water table can rise to within 6" of the finished floor at the building perimeter

OR

 - Surface water does not readily drain from the building site
- The *grade* in the under-floor space shall be as high as the outside finished *grade*, unless and approved drainage system is provided

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Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Flood Resistance IRC R408.7

- For buildings located in flood hazard areas as established in Table R301.2(1):
 1. Walls enclosing the under-floor space shall be provided with flood openings in accordance with Section R322.2.2.
 2. The finished ground level of the under-floor space shall be equal to or higher than the outside finished ground level on at least one side.

- **Exception:** Under-floor spaces that meet the requirements of FEMA TB 11-1.

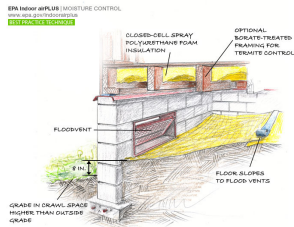
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Source: International Code Council (ICC), (2014), 2015 International Residential Code, Country Club Hill, IL



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Flood Resistance IRC R408.7



CRAWL SPACE/FLOOD ZONE VENTED CRAWL SPACE WITH "FLOOD VENTS"

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Building Science in Crawlspaces



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Understanding Humidity (absolute)

- **Absolute Humidity** is the total amount of water vapor present in a given volume of air.
 - This can be expressed as:

Grams of water per cubic meter of air

OR

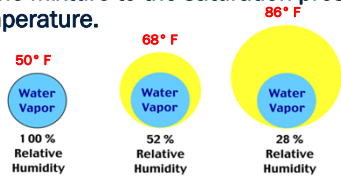
Grains of water per cubic foot of air



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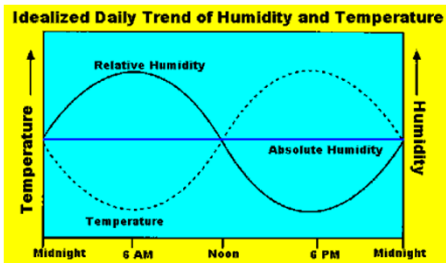
Understanding Humidity (relative)

- The *Relative Humidity* of an air-water mixture is defined as the ratio of the partial pressure of water vapor in the mixture to the saturation pressure at a given temperature.



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Comparison of Humidity



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Are We at Risk of Condensation in Pennsylvania?



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Condensation

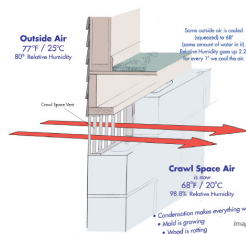
- Air typically contains a certain amount of water vapor. Warm air can contain more water vapor than cold air.
- Relative humidity represents the percentage of water vapor present in the air. How much water vapor the air can hold at that temperature.
- Condensation can occur in two ways:
 - Occurs when **water vapor is added**, and relative humidity reaches 100%
 - Occurs when the **temperature cools**, and relative humidity reaches 100%



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Condensation

How Summer Venting Makes a Crawlspace Moisture Problem Worse



- What is the condensation risk?



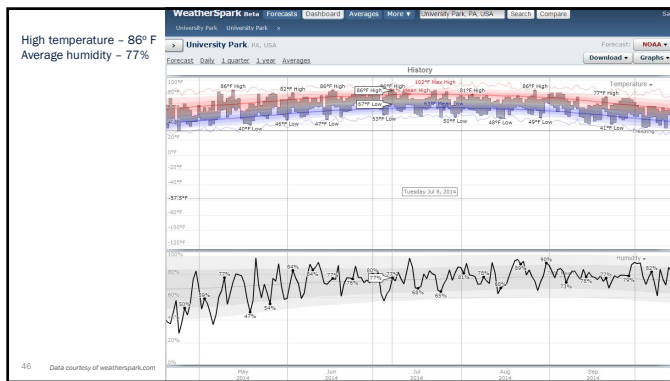
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July 8th, 2014

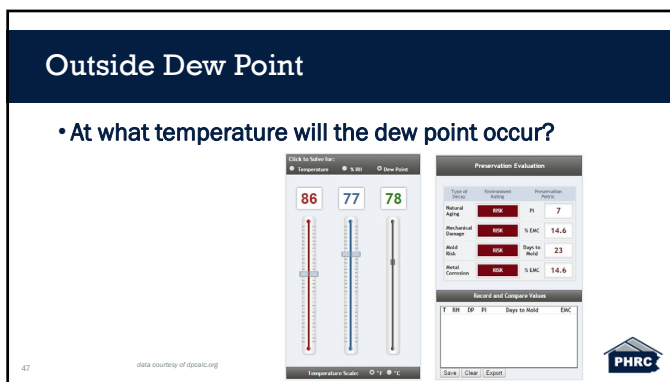
- Let's take a look at a summer day in central PA.



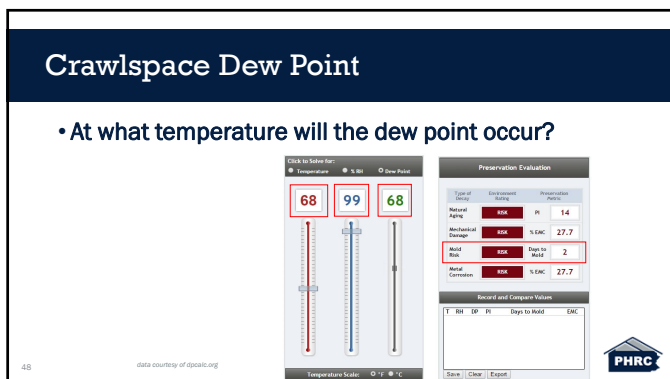
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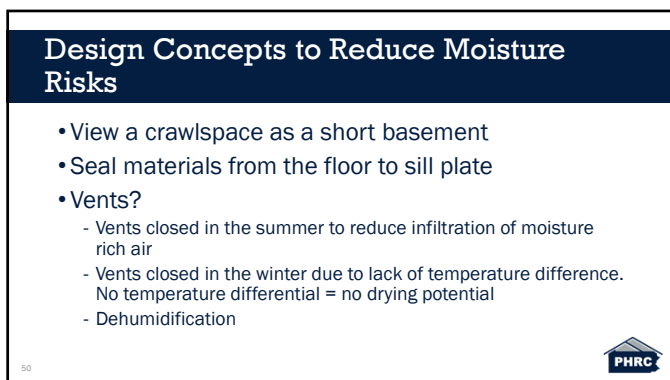
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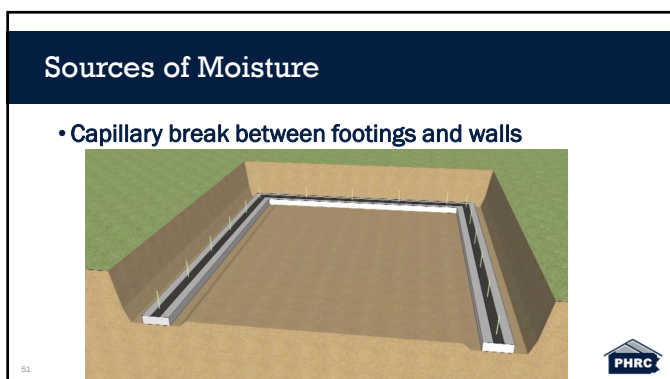
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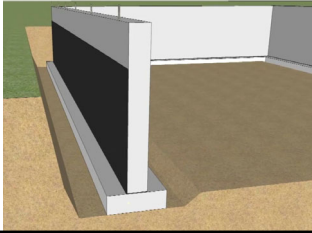
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Sources of Moisture

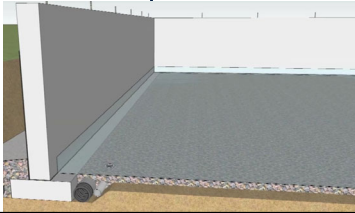
- Exterior waterproofing on concrete walls



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Sources of Moisture

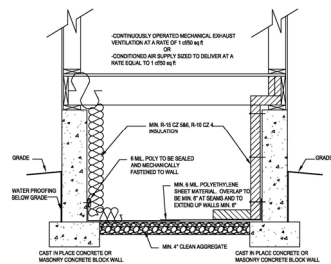
- Class I vapor retarder on grade with all seams taped / sealed and extend up stem wall minimum of 6"



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Crawlspace Construction Detail

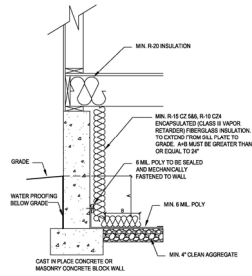
- Best practice construction detail



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Crawlspace Construction Detail

• Encapsulated fiberglass batt insulation

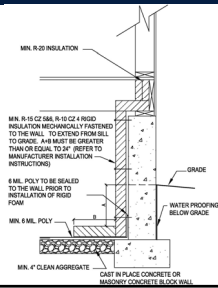


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Crawlspace Construction Detail

• Rigid foam insulation



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Wrap-up

• Why?

- Review site conditions
 - Rock
 - Water table
- Financial implications
 - Site conditions
 - Material
- Flexibility
 - Mechanicals

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Wrap-up

• How?

- Vented
 - Either 1 square foot per 150 square feet or 1 square foot per 1500 square feet
 - Unvented
 - Class I vapor retarder
- And one of the following**
- Continuously operated mechanical exhaust vents
 - Conditioned air supply
 - Plenum in existing structures

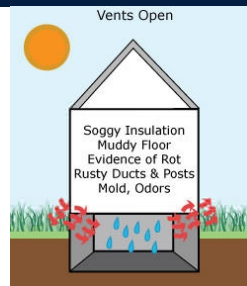


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Wrap-up

• Building Science?

- Vented in the summer?
 - Potential for outside air with high relative humidity to condense



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Wrap-up

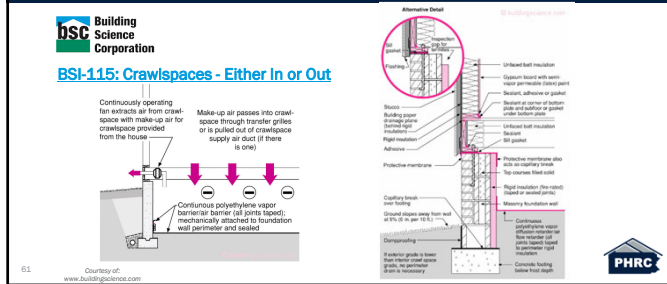
• Building Science?

- Vented in the winter?
 - Potential for outside cold air freezing pipes and the decreased temperature difference limits drying potential



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Additional Resources



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Wrap-up

- Unvented crawlspace
- Insulated walls
- Minimum 6 mill poly vapor barrier
- All seams lapped, sealed and taped
- Mechanical ventilation or conditioned air
- Humidification



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The Do's and Don'ts of Crawlspace Design and Construction: Revisited!

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