2018-2021 Washington State Energy Code-Residential FAQs:

Slabs & Below-Grade Walls: Prescriptive Path

December 2023

How are prescriptive requirements used in WSEC-R?

Both the 2018 and 2021 versions of the WSEC-R define standard prescriptive building assemblies that meet baseline energy code requirements (refer to Table R402.1.1 of 2018 WSEC-R and Table R402.1.3 of 2021 WSEC-R.) These typical constructions were defined for convenience in meeting code requirements. That is, if you follow the prescriptive assembly you do not necessarily need to worry about determining the F-factor of your slab or the U-factors of the other building components. Your submittals are simpler and require less review.

What are prescriptive slab insulation requirements for an *unheated* on-grade slab?

In 2018 WSEC-R, the prescriptive requirement for insulating an unheated above-grade slab is given as:

Slab[d,f] R-Value & Depth	10, 2 ft

This means a minimum of R-10 insulation is required around the slab perimeter, per Section R402.2.9. It may be placed on either the outside or the inside of the foundation wall. It must extend downward from the top of the slab a minimum of 2 feet or to the top of the footing, whichever is less, or downward to at least the bottom of the slab and then horizontally to the interior or exterior for a total distance of 2 feet.

In 2021 WSEC-R, this requirement has been increased from 2 feet to 4 feet with all else being unchanged:

Slab[d,f] *R*-Value and Depth	10, 4 ft.

There are a number of ways to install this perimeter insulation following this description, depending on the details of your slab and the options you choose, as illustrated in Figure 1. Referring to Figure 1, here are a number of other tips and observations to keep in mind:

- In cases (a) and (e), a practical consideration is protecting the top edge of the insulation at the edge of the slab on the interior, as well as attaching flooring materials at the edge. WSEC-R allows a maximum 2"x2" pressure-treated nailer to be installed at the finished floor elevation for attachment interior finish materials. Other strategies for protecting the top edge of the insulation are discussed in a following question and are illustrated in Figures 5 to 7 below.

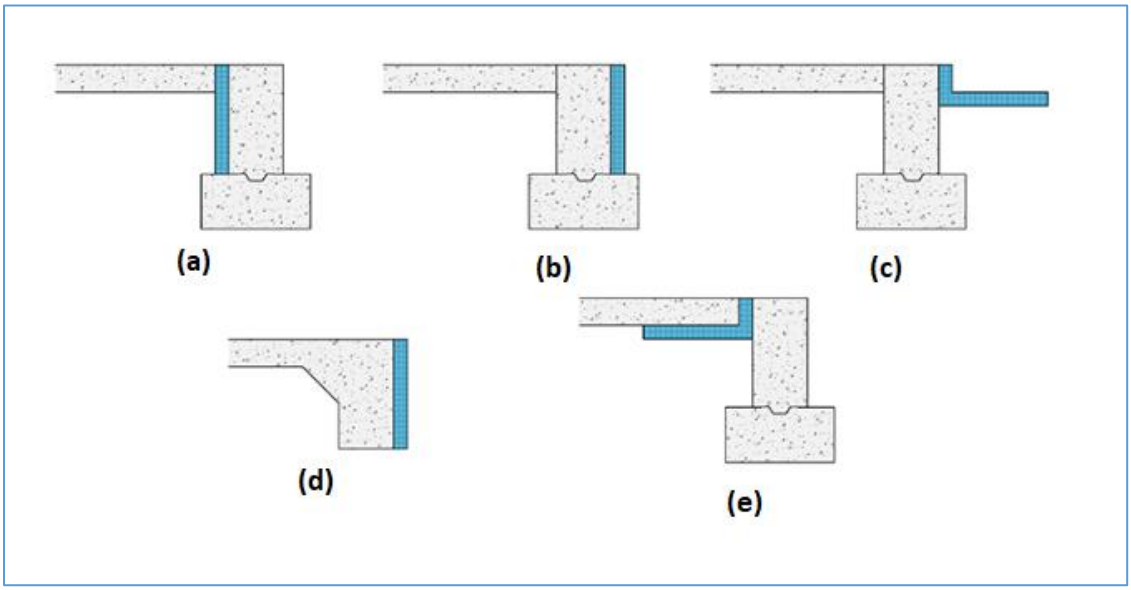
- In cases (b), (c) and (d), some of the insulation installed vertically on the exterior of the foundation is likely to be exposed above-grade. It is important that this exposed insulation is properly protected with metal flashing, a parge coat or other exterior rated trowel-on architectural coating, or other durable material rated for exterior exposure. Also the top of the insulation must be flashed with Z-flashing that extends up under the water-resistant barrier (WRB) under the siding material and down over the insulation's protective material. Best practice is to tape the top edge of the Z-flashing with a peel and stick flashing tape.

- In case (c), the horizontal insulation extends out from the building. Notice this section of insulation must be deep enough that its top surface is at or below the bottom elevation of the slab. Also, the insulation extending out must be protected by either pavement or at least 10 inches of soil, per Section R402.2.9.

- Case (e) has insulation beneath the slab. Note insulation underneath the slab allowable in WSEC-R for residential buildings, but not in ASHRAE Standard 90.1, which is applicable to commercial buildings.

- The increased length requirement in 2021 WSEC-R only impacts cases (c) and (e) with horizontal sections of insulation because 2021 WSEC-R retains the verbiage allow the insulation to extend only to the top of the footing.

Figure 1. Schematics of acceptable locations for perimeter insulation of unheated on-grade slabs under WSEC-R per Section R402.2.9. (Not all details are shown in these schematics)



Adapted from Overbey to conform with 2018 WSEC-R[1]

What are prescriptive requirements for a *heated* on-grade slab?

Footnote d modifies the prescriptive requirement for on-grade slabs if the slab is heated, such as with radiant hot water coils or electric resistance heat mats:

[1] Figure 1 is adapted from "Clarifying Slab-on-Grade Insulation in ASHRAE Standard 90.1" by Daniel Overbey, Building Enclosure, https://www.buildingenclosureonline.com/blogs/14-the-be-blog/post/88188-clarifying-slab-on-grade-insulation-in-ashrae-standard-901.

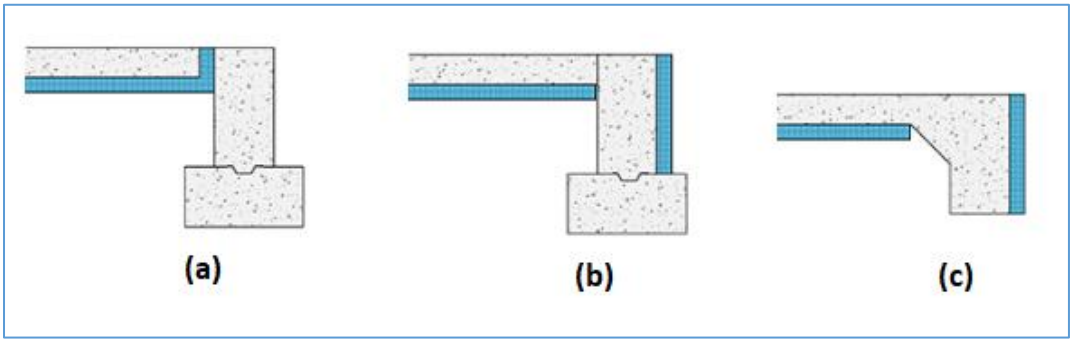
d. R-10 continuous insulation is required under heated slab on grade floors. See Section R402.2.9.1.

Heated on-grade slabs must be fully insulated under the entire slab with R-10 insulation minimum, in addition to insulating the perimeter, as shown in Figure 2. Referring to Figure 2, here are a number of other tips and observations to keep in mind:

- In case (a), a practical consideration is protecting the top edge of the insulation at the edge of the slab on the interior, as well as attaching flooring materials at the edge. Other strategies for protecting the top edge of the insulation are discussed in a following question and are illustrated in Figures 5 to 7.

- In cases (b) and (c) in Figure 2, some of the insulation installed vertically on the exterior of the foundation is likely exposed above-grade. The top and exposed sides of this insulation must be protected in the same manner as similar cases for an unheated slab above.

Figure 2. Schematics of acceptable locations for perimeter insulation of heated on-grade slabs under WSEC-R per Section R402.2.9. (Not all details are shown in these schematics)



What are prescriptive slab insulation requirements for below-grade walls and slabs?

In both 2018 WSEC-R, the prescriptive requirement for insulating below-grade walls and slabs is given as:

Below-Grade[c,h] Wall R-value	10/15/21 int + 5TB
Slab[d,f] R-Value & Depth	10, 2 ft

In 2021 WSEC-R, the required length is increased from 2 feet to 4 feet.

Below-Grade Wall[c,h] *R*-Value	10/15/21 int + 5TB
Slab[d,f] *R*-Value and Depth	10, 4 ft.

Requirements for below-grade walls are explained in footnote c:

> c. "10/15/21 +5TB" means R-10 continuous insulation on the exterior of the wall, or R-15 continuous insulation on the interior of the wall, or R-21 cavity insulation plus a thermal break between the slab and the basement wall at the interior of the basement wall. "10/15/21 +5TB" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the wall. "5TB" means R-5 thermal break between floor slab and basement wall.

Notice the below-grade slab itself is not required to be insulated unless it is heated, such as with hot water coils or electric-resistance heat mats for space heating. Insulating either the interior or exterior side of the basement wall as required in footnote c serves both as wall insulation and perimeter insulation for the slab. If a slab is heated – whether it is on-grade or below-grade – it must be fully insulated, either underneath or over its top surface, per footnotes d and f.

Footnote h specifies that the two options with framed-walls and cavity insulation must have intermediate framing.

When is an R-5 thermal break required between the basement wall and the slab? When insulated on the interior side

Footnote c describes four ways of insulating basement walls that meet prescriptive requirements. Footnote c however is punctuated in such a way that it is not clear which of the four alternatives requires an R-5 thermal break between the basement wall and the slab.

Fortunately, Section R402.2.8 is clear that all three alternatives with insulation installed on the interior side of the basement wall require an R-5 thermal break. Section R402.2.8 reads in part: "Insulation used on the interior (warm) side of the wall shall extend from the top of the below-grade wall to the below-grade floor level and shall include R-5 rigid board providing a thermal break between the concrete wall and the slab."

Thus, the four alternatives described in footnote (c) can be described in more detail as follows:

1. R-10 continuous insulation installed on the exterior of the wall, extending from the top of the below-grade wall to the top of the footing. No thermal break is required between the wall and the slab.
2. R-15 continuous insulation installed on the interior of the wall, extending from the top of the below-grade wall to the below-grade floor level, plus an R-5 thermal break between the wall and the slab.
3. An intermediate framed-wall with R-21 cavity insulation constructed on the interior side of the basement wall, extending from the top of the below-grade wall to the below-grade floor level, plus an R-5 thermal break between the wall and the slab
4. An intermediate framed-wall with R-13 cavity insulation constructed on the interior, extending from the top of the below-grade wall to the below-grade floor level, plus R-5 continuous insulation either on the interior or exterior of the basement wall and plus an R-5 thermal break between the wall and the slab. If on the interior, the R-5 insulation should be sandwiched between the basement wall and the framed wall.

In #1 and #4, if there is exposed insulation above-grade, it must be protected with metal flashing, a parge coat or other exterior rated trowel-on architectural coating, or other durable material rated for exterior exposure. Also the top of the insulation must be flashed with Z-flashing that extends up under the water-resistant barrier (WRB) under the siding material and down over the insulation's protective material. Best practice is to tape the top edge of the Z-flashing with a peel and stick flashing tape.

At what depth is a slab considered below-grade? 2 feet

Per Section A104.2, "basements shallower than two feet should use on-grade slab coefficients. Wall areas above-grade should use above-grade wall U-factors, beginning at the mudsill."

For such shallow basements, keep in mind that the 2 foot basement wall *is also* the perimeter of the slab. Therefore, it should be insulated in the same manner as any below-grade wall. Often this is with continuous R-10 insulation on the exterior from the top of the wall to the depth of the slab, which is the same requirement for below-grade walls as for slab perimeters. The above-grade wall begins at the mudsill.

I am converting an existing unheated basement to conditioned space. Do I have to install a thermal break between the basement wall and the slab? Probably not

Although it is not mentioned in WSEC-R, we recommend waiving the requirement for a thermal break between the basement wall and slab when insulating existing basement slabs. There is typically no way to install the thermal break without demolishing the edge of the slab, which is impractical. The heat loss associated with the thermal break is small and does not justify this demolition. However, whenever the code is not clear or is silent on an issue, your building official is the final authority in approving your design. So, be sure to check with them to make sure they concur with our recommendation.

How do I insulate the perimeter of an existing unheated slab without excavating around the perimeter?

When converting an existing unheated garage or workshop to a conditioned space, installing insulation around the exterior perimeter of the existing slab is often not practical. There may be pavement due to driveways or sidewalks that prevent excavation or landscaping that may make excavation undesirable. Footnote f offers a possible solution by deeming insulating over the entire top surface of an existing on-grade slab with R-7.5 insulation as equivalent to the required perimeter slab insulation.

> f. R-7.5 continuous insulation installed over an existing slab is deemed to be equivalent to the required perimeter slab insulation when applied to existing slabs complying with Section R503.1.1. If foam plastic is used, it shall meet the requirements for thermal barriers protecting foam plastics.

MyBuildingPermit.com has a great tip sheet on garage conversions that provides more information on insulating over the top surface of a slab including the detail shown in Figure 3. This tip sheet is available

at https://mybuildingpermit.com/sites/default/files/inline-files/2015%20Tip%20Sheet%2025%20Garage%20Conversions.pdf.

The main disadvantage of insulating over the top surface of the slab is that raising the floor may create unacceptable tripping hazards at doorways and transitions to adjoining spaces. Also, doors and door jambs will need to be modified.

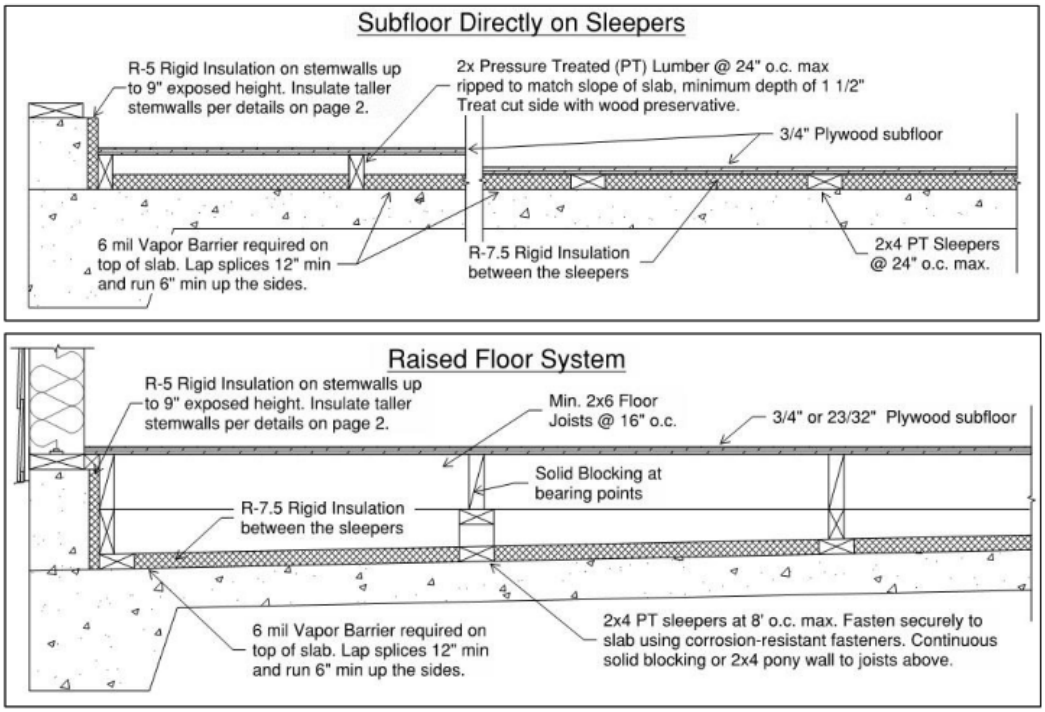
If you cannot insulate around the perimeter, you may be able to do a UA trade off with another building component to compensate for the lack of insulation. In a UA trade off, you may over-insulate some other building component – like installing lower U-factor windows or installing more ceiling insulation than is required – in an amount that offsets the lack of insulation along the perimeter. This strategy does require you to calculate the UA-value of your building's thermal envelope to determine how much insulation must be added or what type of window is required. Our Code Compliance Calculator was developed to facilitate such a UA trade off analysis. Contact our office if you need assistance getting started with a UA analysis. [2]

[2] **What is a UA-value?** The heat loss in the winter or the heat gain in the summer of a house depends not just on how well insulated it is. It also depends on the size of the home, as well as its air leakage rate. The UA-value of a building assembly equals the assembly's area A multiplied by its U-factor. In this way, the UA-value quantifies the energy efficiency of a building component taking both its size and insulating value into account. The topic of UA-values, UA trade off analyses and using the Code Compliance Calculator will be covered in an upcoming FAQ.

Figure 3. Extracted from "Construction Tip Sheet 25: Converting a Garage to Living Space" from MyBuildingPermit.com, illustrating three methods of insulating over the top of an existing slab

Floor Insulation

The floor of the newly conditioned area is required to be insulated. While the energy code requires insulation under the slab, we realize that removing and replacing portions of the slab is difficult. Here are two approved insulation options above the slab that are equivalent to under slab insulation. Note: If batt insulation is to be used in raised framing without the R-7.5 rigid insulation indicated below, the minimum value is R-30, and the space below the floor joists will either need to be ventilated or filled to capacity with rigid insulation.



Source: MyBuildingPermit.com

I am converting only part of my unheated garage to a conditioned space. How do I insulate the perimeter between the heated and unheated spaces?

The slab perimeter between heated and unheated spaces is required to be insulated. There are a few ways of meeting this requirement without excavating the slab along this perimeter, which is generally impractical and not recommended.

One option is to insulate over the top surface of the slab in the heated space, per the previous explanation above. This is equivalent to insulating the entire perimeter and so meets the requirements. Another option is to insulate over the top surface of the slab in the adjacent unheated space out at least 4 feet from the perimeter. It could be that the raised floor in the heated section would create tripping hazards at doorways to adjoining spaces, but wouldn't in the unheated space.

If insulating over the top surface of the slab in either space is not practical, another option is to do a UA trade off with another building component. Refer to the previous explanation above on insulating an

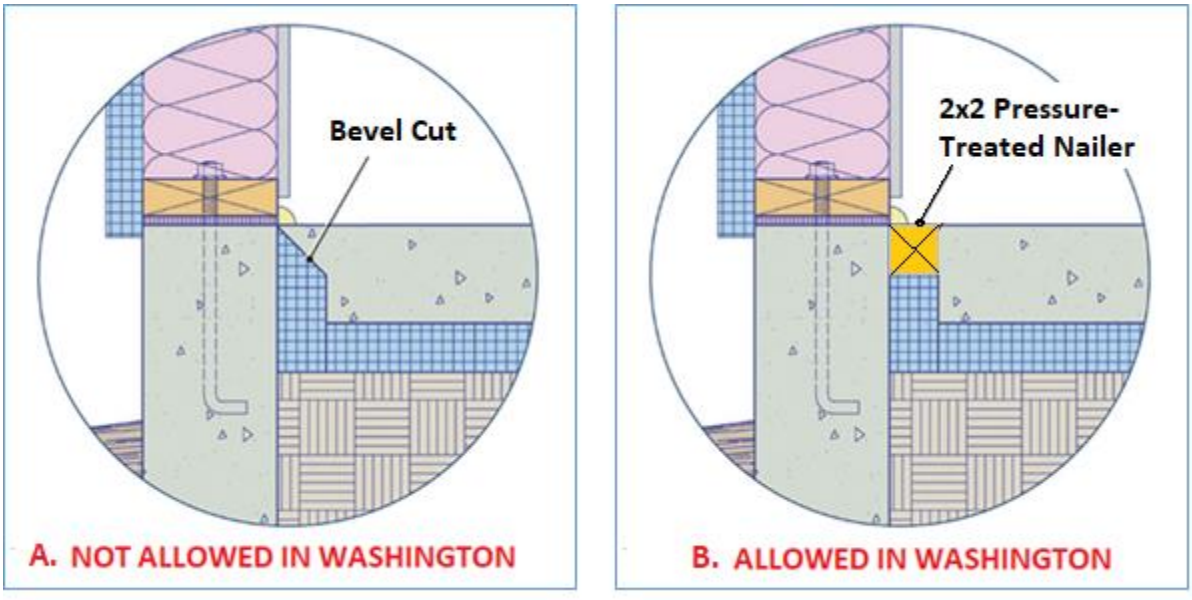
existing slab for a description of this option. Feel free to contact our office for assistance in setting up a UA trade off analysis.

The IRC allows the perimeter insulation to be bevel cut at the top edge. Is this allowed in WSEC-R? No

IRC Section N1102.2.10 "Slab-on grade floors" allows the top edge of the insulation installed between the exterior wall and the edge of the interior slab to be cut at a 45-degree angle away from the exterior wall, as shown in Figure 4A. Washington State has not adopted Chapter 11 of the IRC, so a bevel cut is not permitted. WSEC-R does allow a maximum 2"x2" pressure-treated nailer to be installed at the finished floor elevation for attachment interior finish materials, as shown in Figure 4B.

The reason Washington did not adopt this Section is because beveling the insulation significantly compromises the insulation right at the point where heat loss from the slab is the greatest. It does not make good sense to do this when there are other strategies that do not compromise the insulation. Three alternatives to beveling the insulation that do not compromise insulation value at the edge illustrated below in Figure 5 to 7.

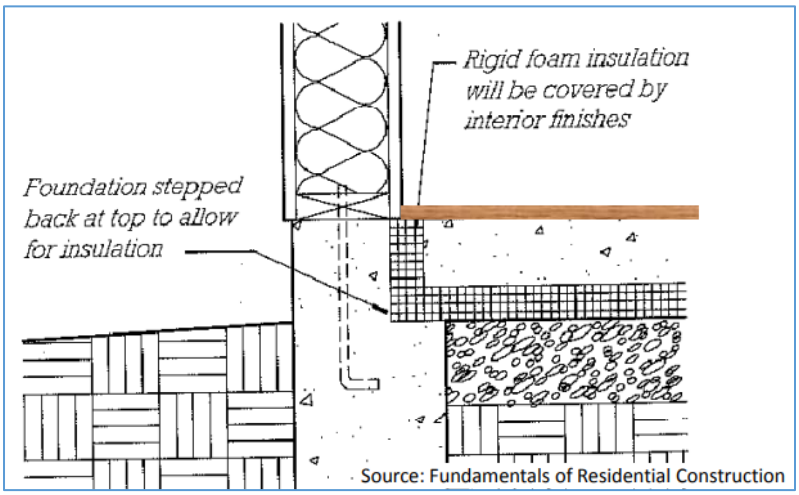
Figure 4. (A) NOT ALLOWED IN WASHINGTON STATE: Illustration of insulation bevel cut in edge insulation allowed under IRC Section N1102.2.10. Chapter 11 has not been adopted in Washington. (B) ALLOWED IN WASHINGTON: Illustration of maximum 2x2 pressure treated nailer at slab edge.



Source: Adapted from Holladay, "Fine Homebuilding" to conform with requirements of WSEC-R

In many cases the top of the rigid foam insulation will be covered by interior finishes, as shown in Figure 5. In this case, there is no need to bother with beveling the insulation.

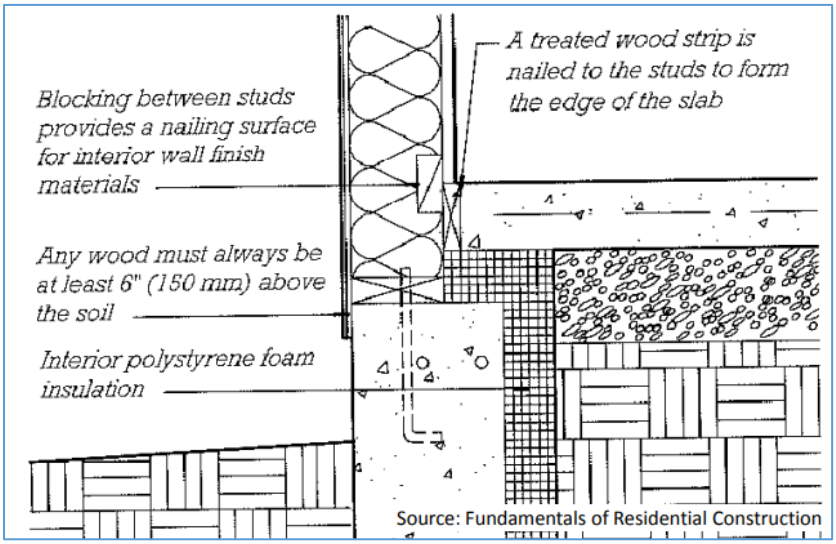
Figure 5. Strategy to avoid a bevel cut in perimeter insulation: cover top edge of insulation with interior flooring



Source: Turns, PHRC

The second option is to pour the slab over the insulation above the elevation of the stem wall, as shown in Figure 6. A treated wood strip is installed to form the edge of the slab, separating the slab and the above-grade wall. Install blocking in between studs as nailers to install wall finish materials.

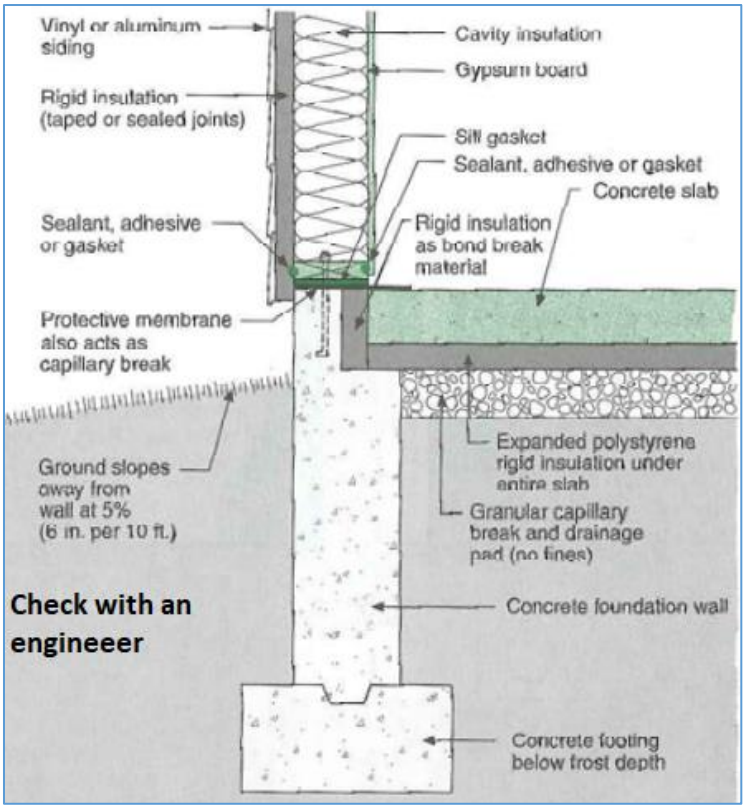
Figure 6. Strategy to avoid a bevel cut in perimeter insulation: pour slab over top edge of insulation



Source: Turns, PHRC

The third option is to cantilever the sill plate out over the exposed edge of the insulation, as shown in Figure 7. If you choose this option, be sure to check with an engineer to ensure that the narrower stem wall at the top does not compromise your structure.

Figure 7. Strategy to avoid a bevel cut in perimeter insulation: cantilever the sill plate of the above-grade wall out over the top edge of the insulation.



Source: Turns, PHRC

What if I want to insulate my slab differently than any of the prescriptive options?

If you do not choose any of the prescriptive options, then you must determine the F-factor for your above-grade slab or the U-factor and F-factor for your below-grade wall and slab. These must be less than or equal to the maximum equivalent U-factors specified in Table R402.1.3 in 2018 WSEC-R or Table R402.1.2 in Table 2021 WSEC-R.

The F-factor of many common slab configurations are tabulated in Appendix A of the WSEC-R. F-factor for on-grade slabs are in Table A106.1. The U-factor and F-factor of below-grade walls and slabs of basements are found in Table A104.1.

For example, from Table A106.1 shown in Figure 8 below, you will find that an on-grade slab with two feet of vertical R-10 insulation has an F-factor of 0.54.

As another example from Table A104.1 in Figure 9 below, a basement that is on average 7 feet deep with a basement wall that is insulated with a wood-framed wall with R-19 cavity insulation without a thermal break has a wall U-factor of 0.036 and a slab F-factor of 0.54. Notice if the slab is only 3.5 feet deep on average than the U-factor and F-factor are greater at 0.041 and 0.62, respectively.

Figure 8. Extract from WSEC-R Appendix A Table A106.1 for default F-Factors for on-grade slabs. The F-factor for the case of 2 feet of R10 vertical perimeter insulation is circled in red.

TABLE A106.1
DEFAULT F-FACTORS FOR ON-GRADE SLABS

Insulation type	R-0	R-5	R-10	R-15
Unheated Slab				
Uninsulated slab	0.73	--	--	--
2 ft Horizontal (No thermal break)	--	0.70	0.70	0.69
4 ft Horizontal (No thermal break)	--	0.67	0.64	0.63
2 ft Vertical	--	0.58	0.54	0.52
4 ft Vertical	--	0.54	0.48	0.45
Fully insulated slab	--	--	0.36	--
Heated Slab				
Uninsulated slab	0.84	--	--	--
Fully insulated slab	--	0.74	0.55	0.44
R-5 Center (With perimeter insulation)	--	--	0.66	0.62
R-10 Center (With perimeter insulation)	--	--	--	0.51
3 ft Vertical	--	--	0.78	--

Figure 9. Extract from WSEC-R Appendix A Table A104.1 for default wall U-factors and slab F-Factors basements. The factors for the cases of basement with an average depth of 3.5 feet and 7 feet and walls insulated with R-19 insulation on the interior with no thermal break are circled in red for comparison.

TABLE A104.1
DEFAULT WALL U-FACTORS AND SLAB F-FACTORS FOR BASEMENTS

	Below Grade Wall U-factor	Below Grade Slab F-factor
R-12 Exterior	0.061	0.60
3.5 Foot Depth Below Grade		
Uninsulated	0.271	0.51
R-11 Interior	0.058	0.61
R-11 Interior w/TB	0.061	0.55
R-19 Interior	0.041	0.62
R-19 Interior w/TB	0.042	0.55
R-21 Interior	0.038	0.63
R-21 Interior w/TB	0.040	0.56
R-12 Exterior	0.057	0.57
7 Foot Depth Below Grade		
Uninsulated	0.185	0.43
R-11 Interior	0.051	0.541
R-11 Interior w/TB	0.053	0.49
R-19 Interior	0.036	0.54
R-19 Interior w/TB	0.037	0.50
R-21 Interior	0.035	0.56
R-21 Interior w/TB	0.035	0.50
R-21+R-5 Interior	0.027	0.56
R-21+R-5 Interior w/TB	0.028	0.51
R-21+R-7 Interior	0.025	0.57
R-21+R-7 Interior w/TB	0.026	0.51
R-10 Exterior	0.058	0.47
R-12 Exterior	0.050	0.42

TB = Thermal Break

Are there flooring products that incorporate continuous insulation? Yes

While we can't recommend specific products, we are aware that there are flooring products that incorporate continuous extruded polystyrene (XPS) insulation with a subfloor material. These products snap together into a floating floor. The finished flooring, such as tiles or stone, are laid right over the insulated panels. Such products avoid the need to install nailers and a subfloor. It also reduces thermal

bridging, so a thinner layer of insulation and flooring is required to obtain the same F-factor. To determine the F-factor of these products knowing the thickness of the XPS insulation, contact our office for assistance or refer to the upcoming FAQ "What is a Slab F-Factor?"

What if I can't find my slab configuration in Appendix A?

Please refer to the upcoming FAQ "What is a Slab F-factor?" for more information on determining your slab's F-factor if you can't find it in Appendix A. Please also feel free to contact our office for assistance in determining the F-factor of your slab.

For More Information:

ASHRAE, American Society of Heating, Refrigerating and Air-Conditioning Engineers, *Handbook of Fundamentals*, 2021

Baylon, David and Mike Kennedy, "Calculating the Impact of Ground Contact on Residential Heat Loss", https://web.ornl.gov/sci/buildings/conf-archive/2007%20B10%20papers/092_Baylon.pdf

https://mybuildingpermit.com/sites/default/files/inline-files/2015%20Tip%20Sheet%2025%20Garage%20Conversions.pdf

"Clarifying Slab-on-Grade Insulation in ASHRAE Standard 90.1" by Daniel Overbey, Building Enclosure, https://www.buildingenclosureonline.com/blogs/14-the-be-blog/post/88188-clarifying-slab-on-grade-insulation-in-ashrae-standard-901.

Fine Homebuilding, "Insulating a Slab-On-Grade Foundation", By Martin Holladay, Issue 245, Aug/Sept 2014, https://www.finehomebuilding.com/project-guides/foundations-and-masonry-work/insulating-a-slab-on-grade

Green Building Advisor, "Getting Slab-Edge Insulation Right", By Neal Ezell, July 29, 2020, https://www.greenbuildingadvisor.com/article/getting-slab-edge-insulation-right

Building Science Corporation, "Insight: Slab Happy", By Joseph W. Lstiburek, April 2012, https://buildingscience.com/sites/default/files/document/bsi-059_slab_happy_c.pdf

International Residential Code, https://codes.iccsafe.org/content/IRC2018/chapter-11-re-energy-efficiency?site_type=public

PHRC, "How to Properly Insulate a Slab", PowerPoint presentation by Mike Turns, Associate Director, PHRC, April 10, 2012, https://www.phrc.psu.edu/assets/docs/Webinars/SlabInsulation.pdf

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