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Building Science

Adventures In Building Science

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2nd Law of Thermodynamics

Heat Flow Is From Warm To Cold

Moisture Flow Is From Warm To Cold

Moisture Flow Is From More To Less

Air Flow Is From A Higher Pressure to a
Lower Pressure

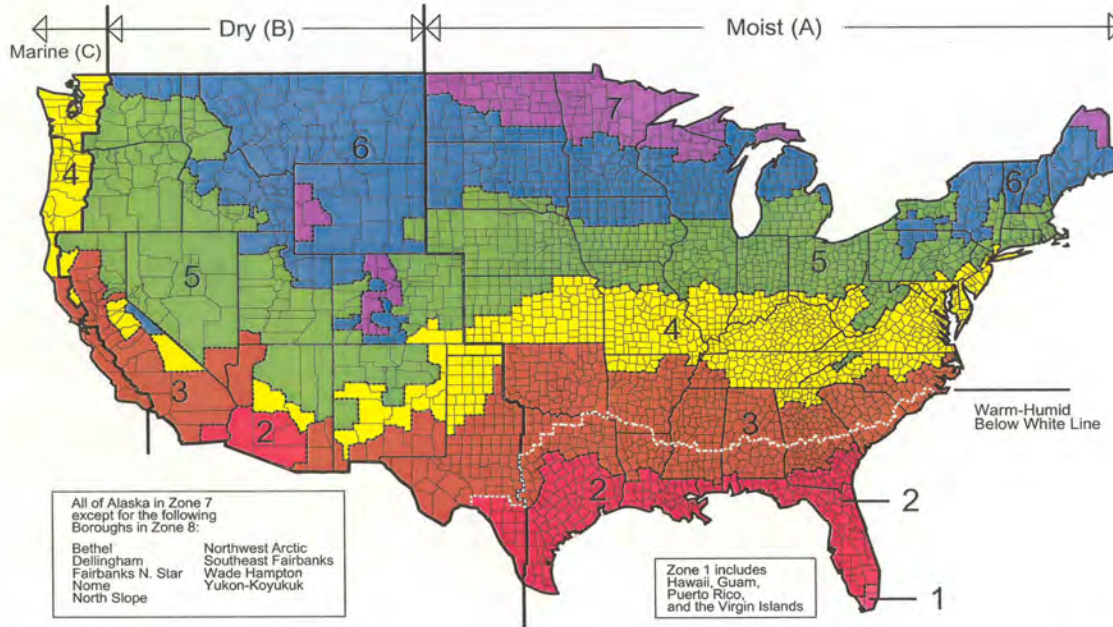
Gravity Acts Down

The Effect of Climate









Map of DOE's Proposed Climate Zones

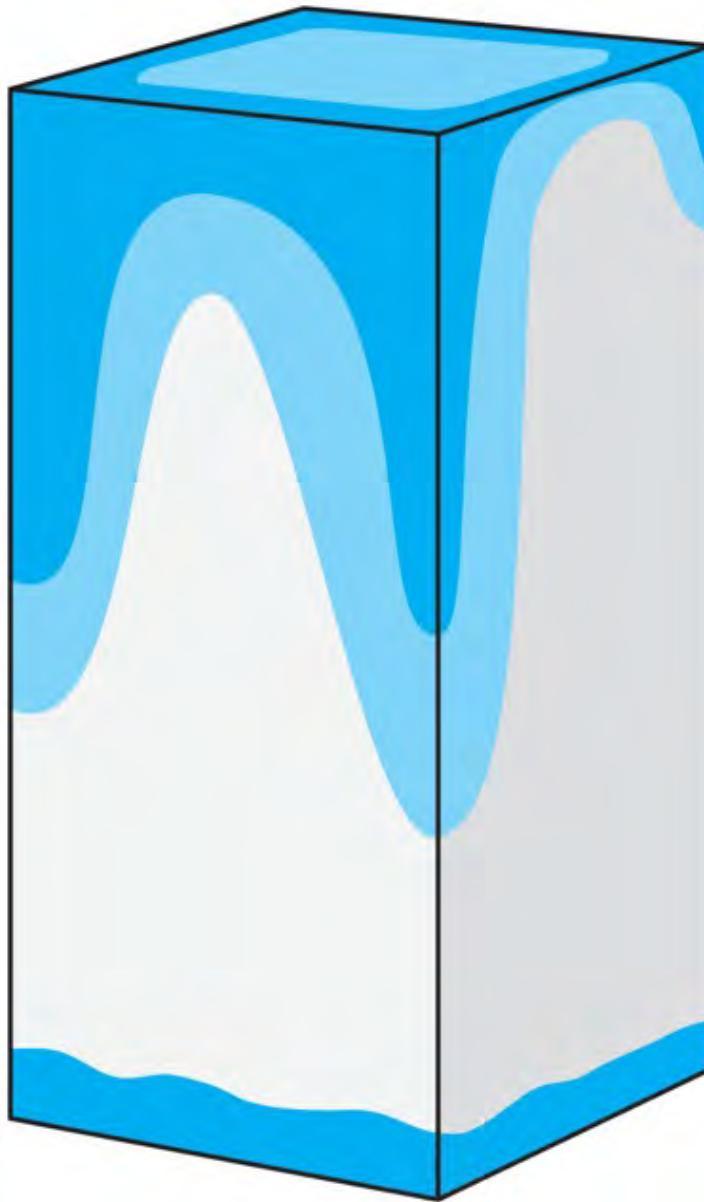


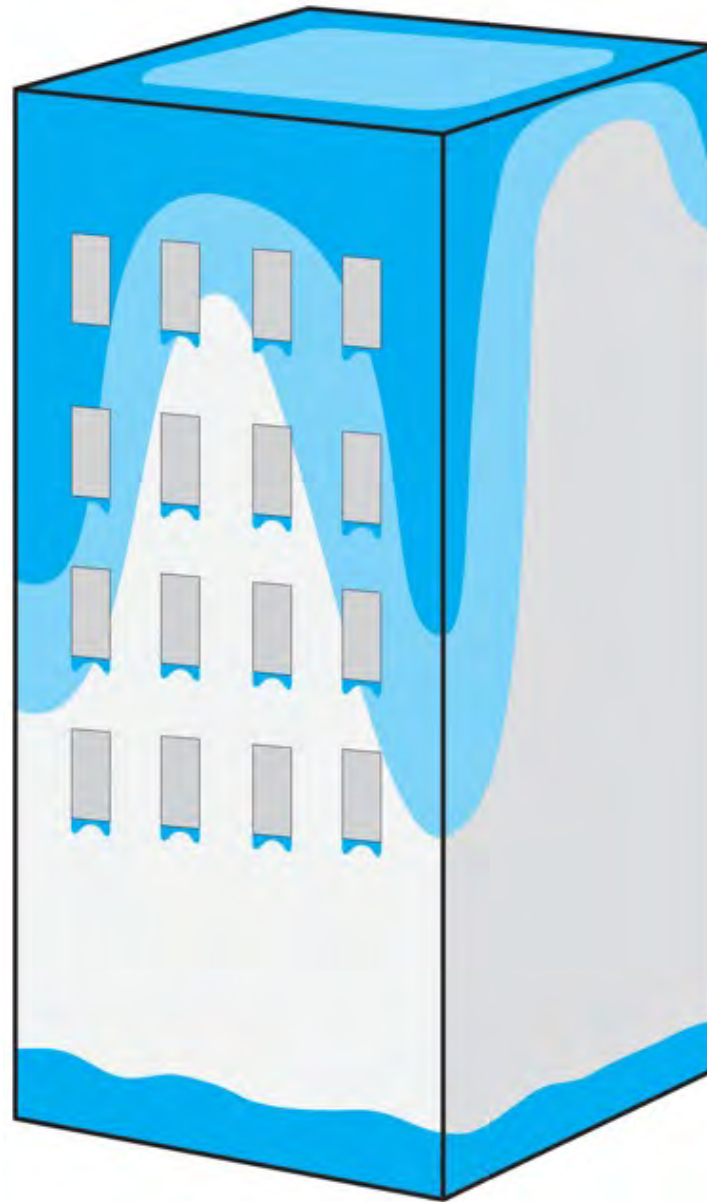
March 24, 2003



Exposure

Extreme		Over 60"
High		40" - 60"
Moderate		20" - 40"
Low		Under 20"





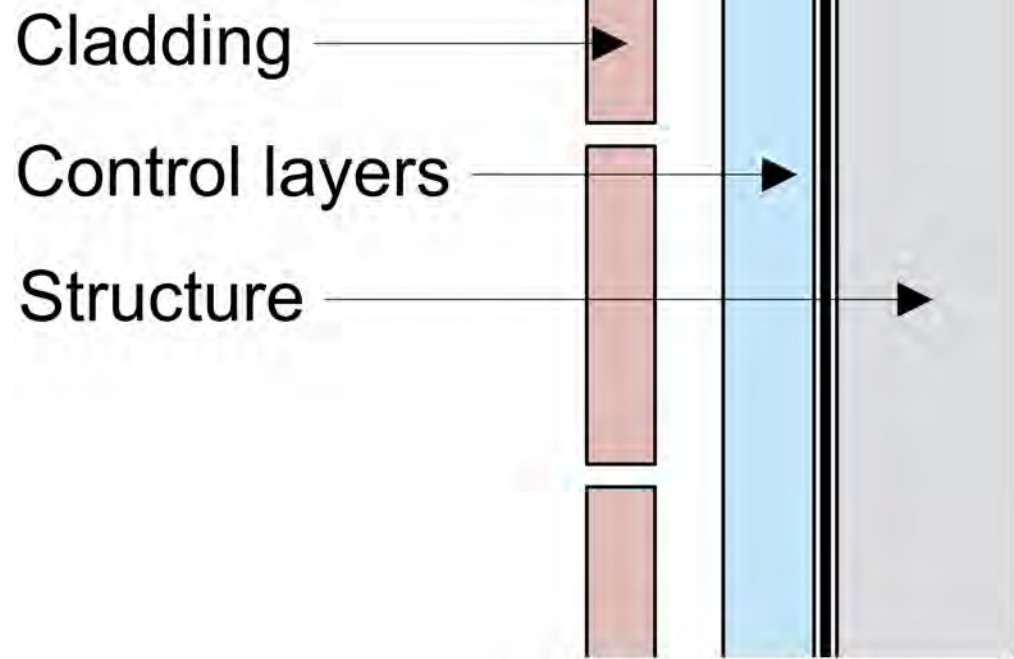
The Perfect Wall

Water Control Layer

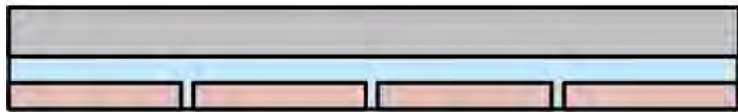
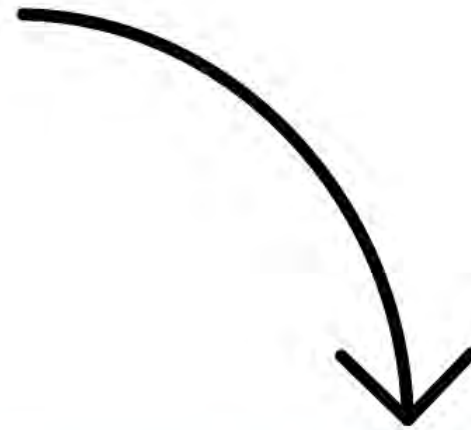
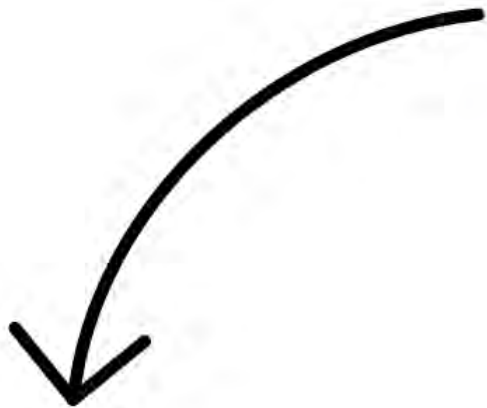
Air Control Layer

Vapor Control Layer

Thermal Control Layer



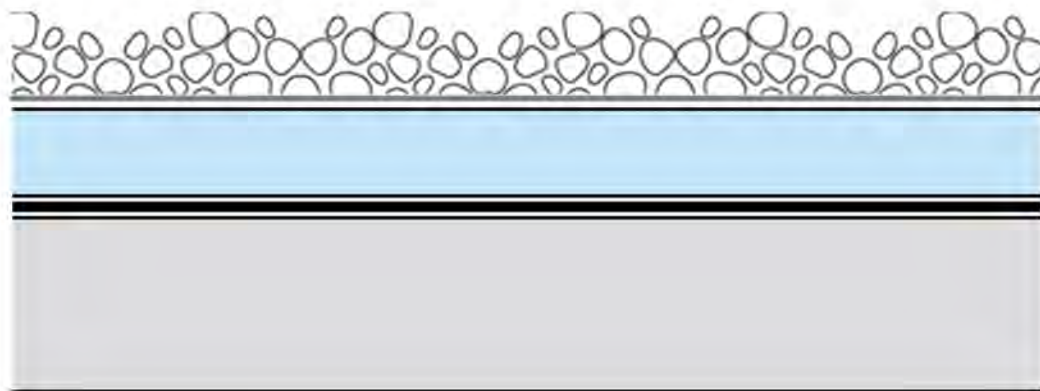
Wall



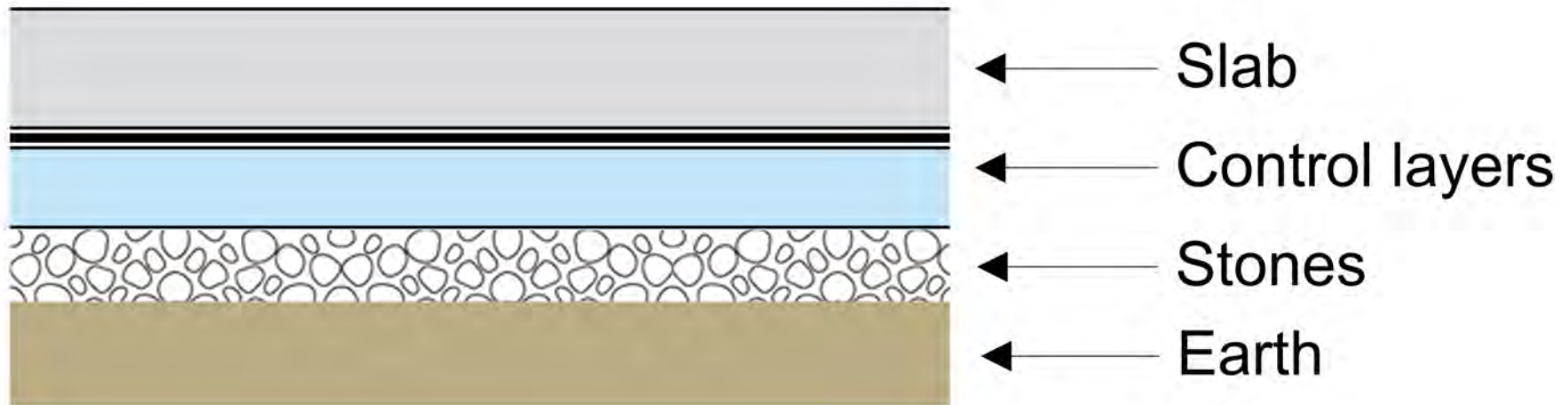
Slab

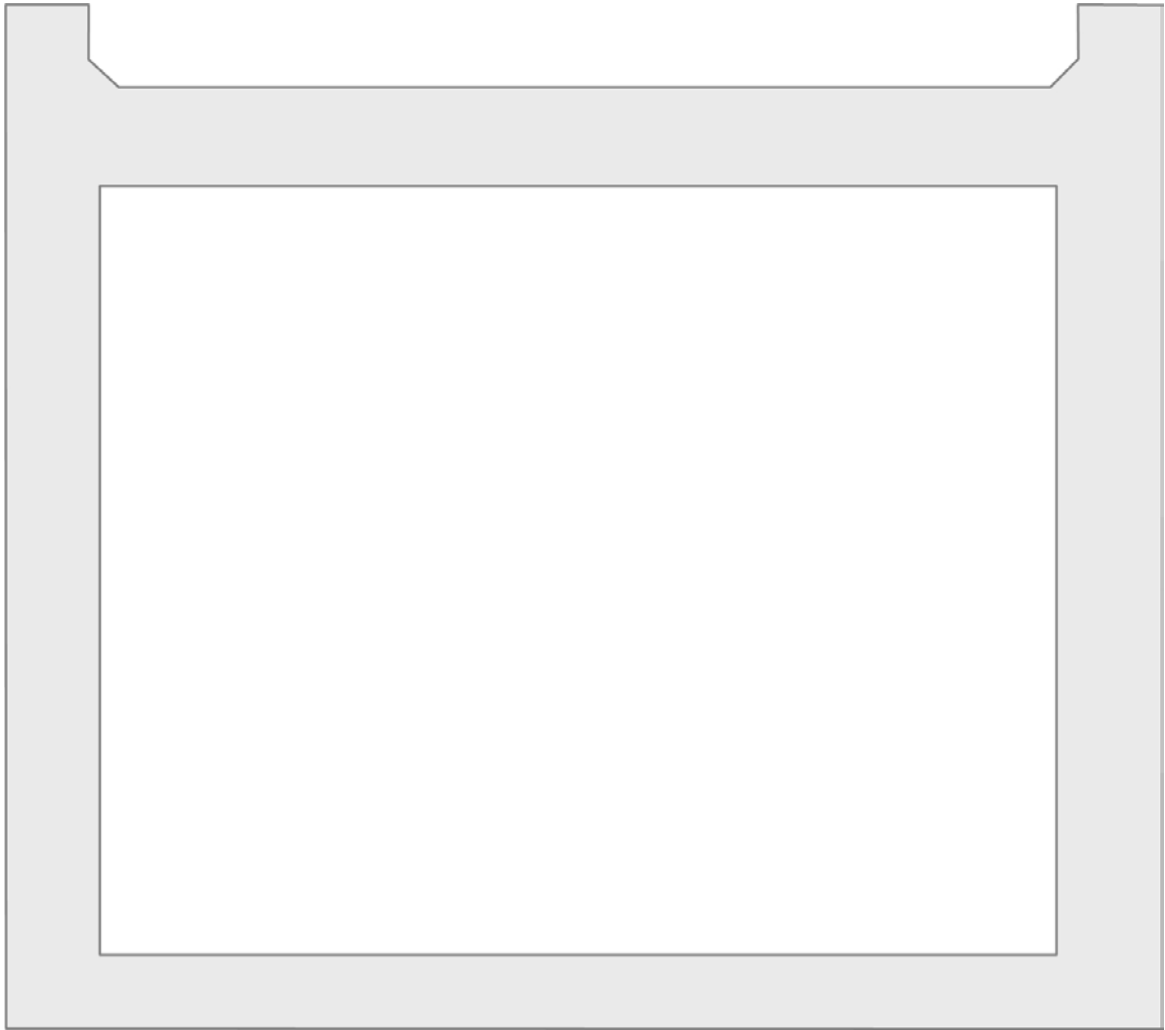


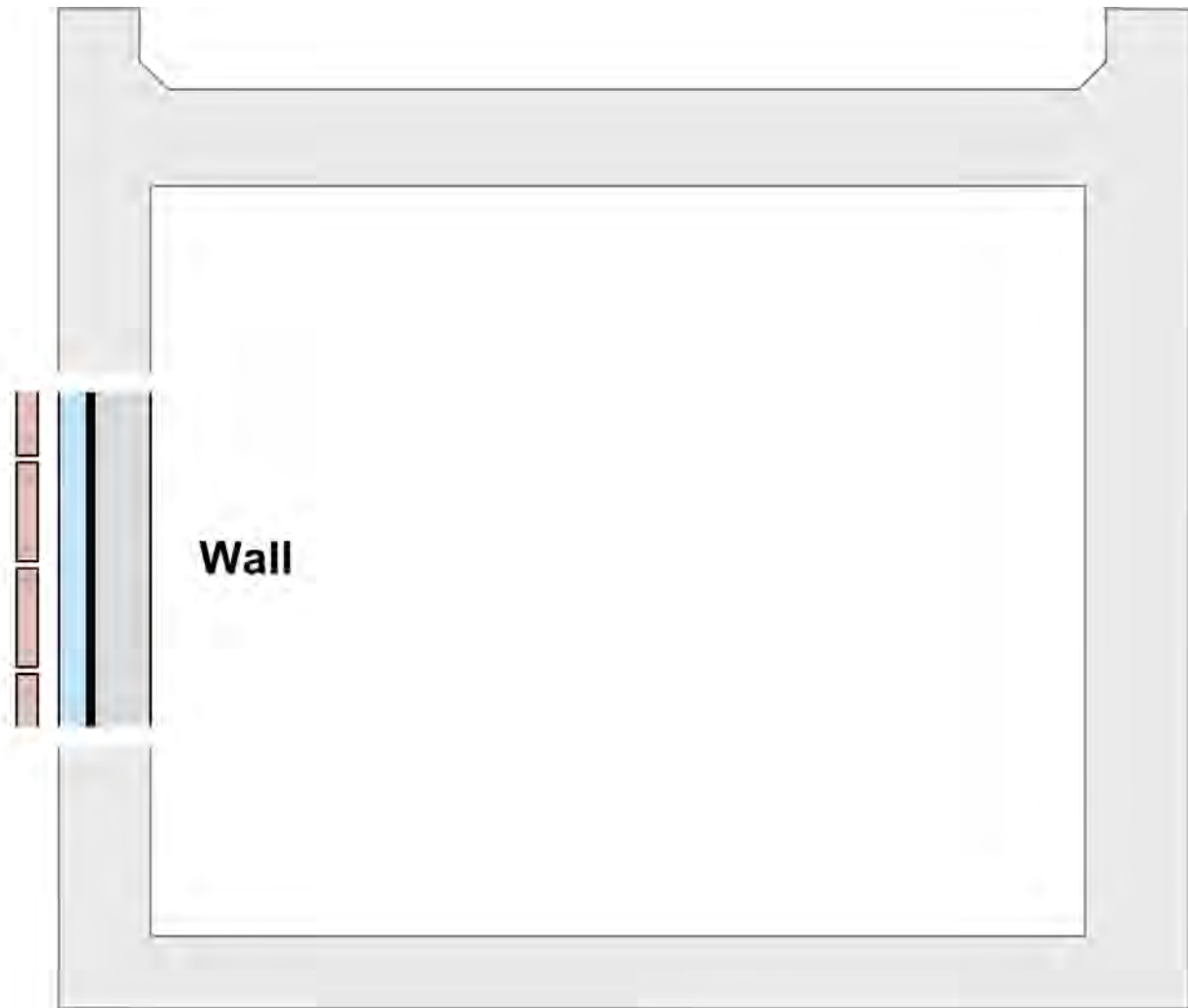
Roof

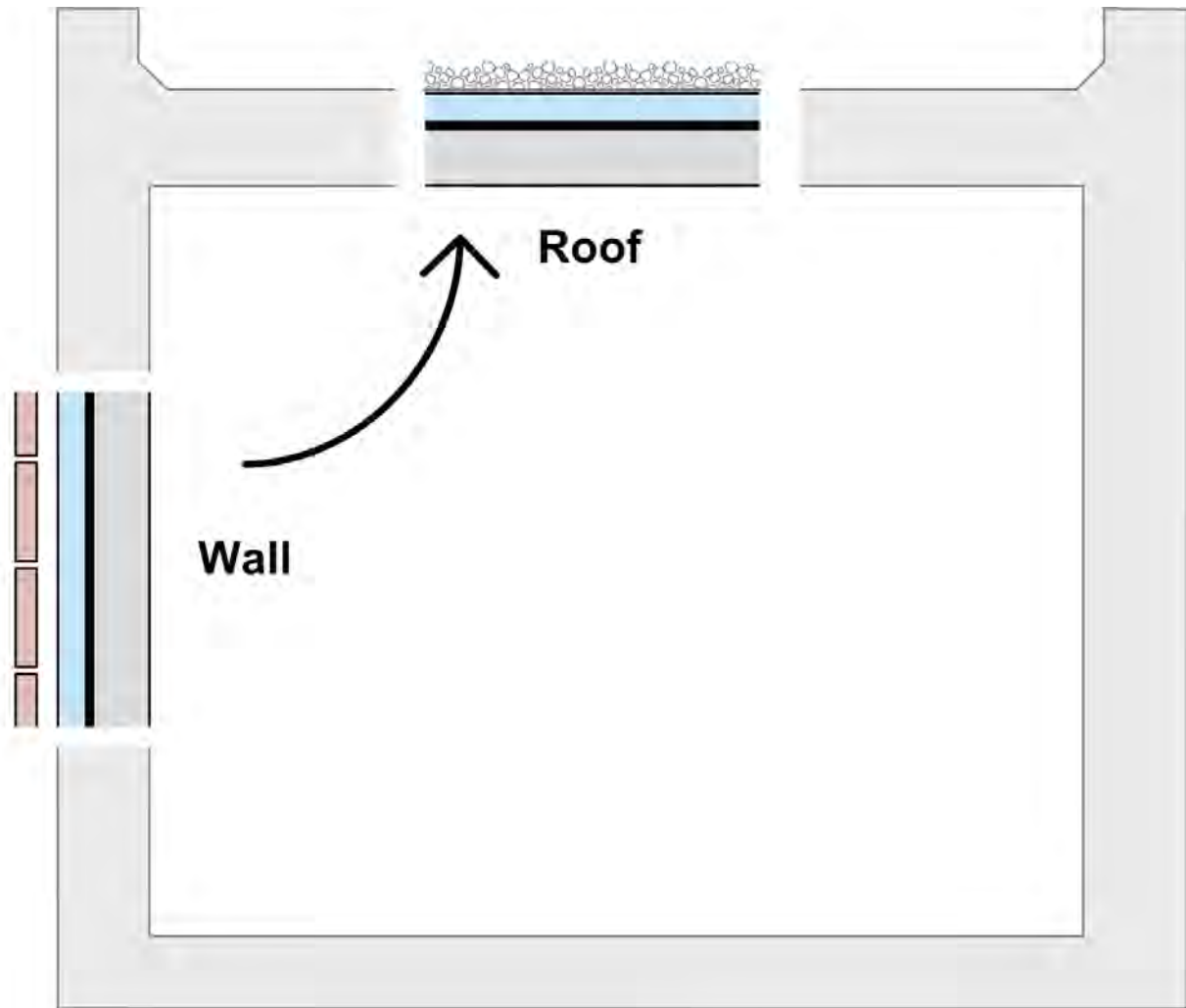


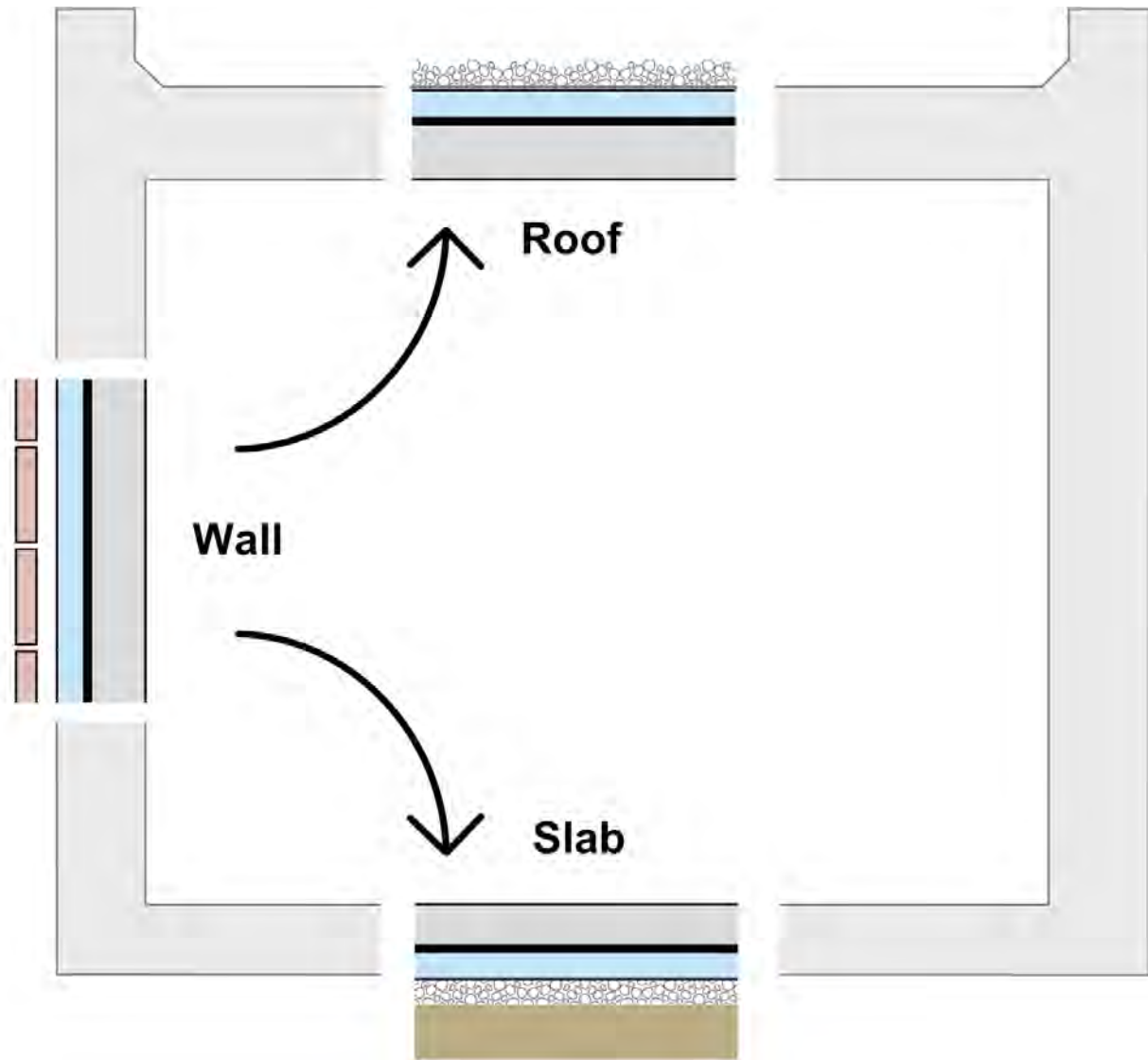
- ← Ballast
- ← Filter fabric
- ← Control layers
- ← Roof structure

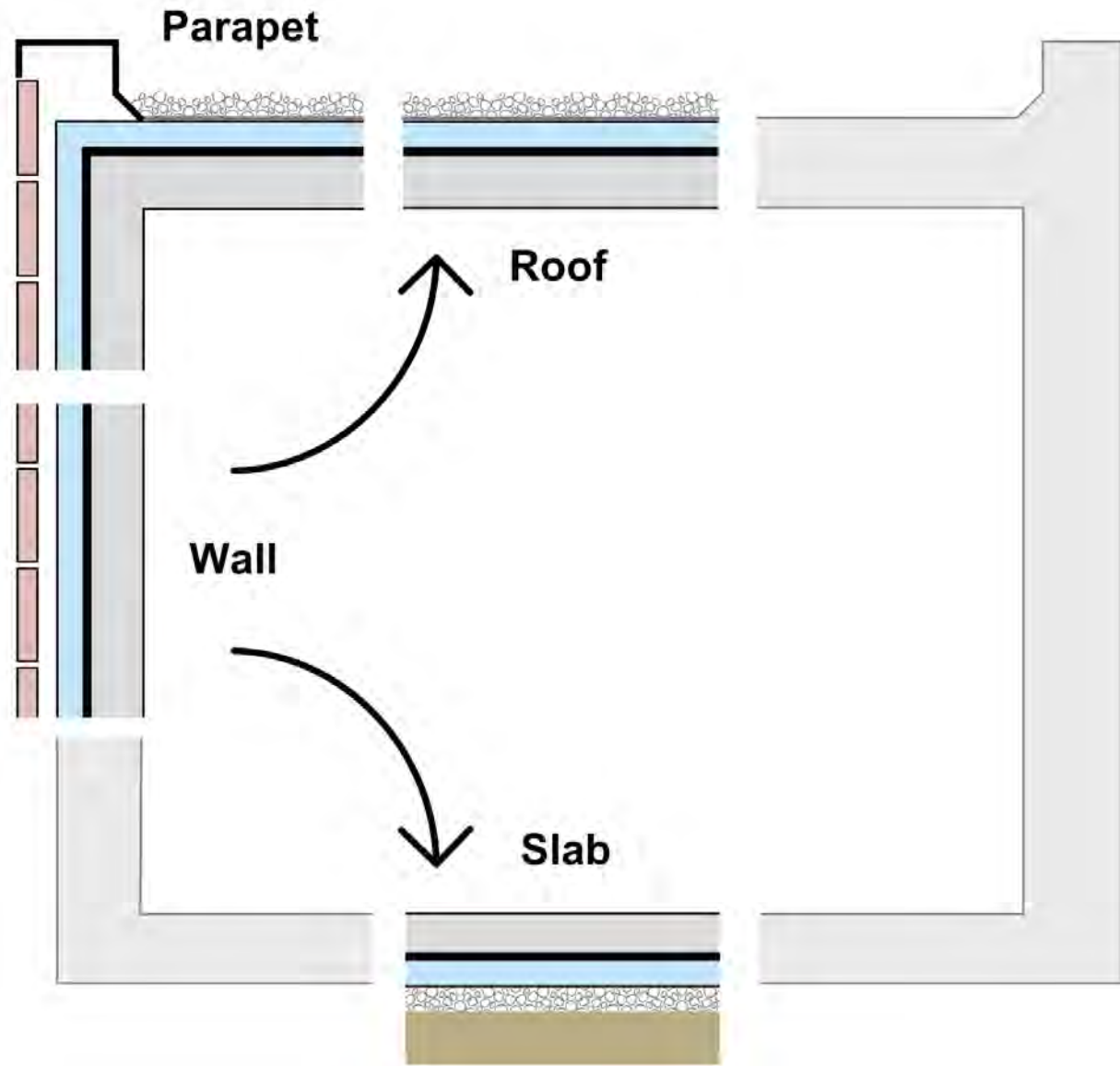


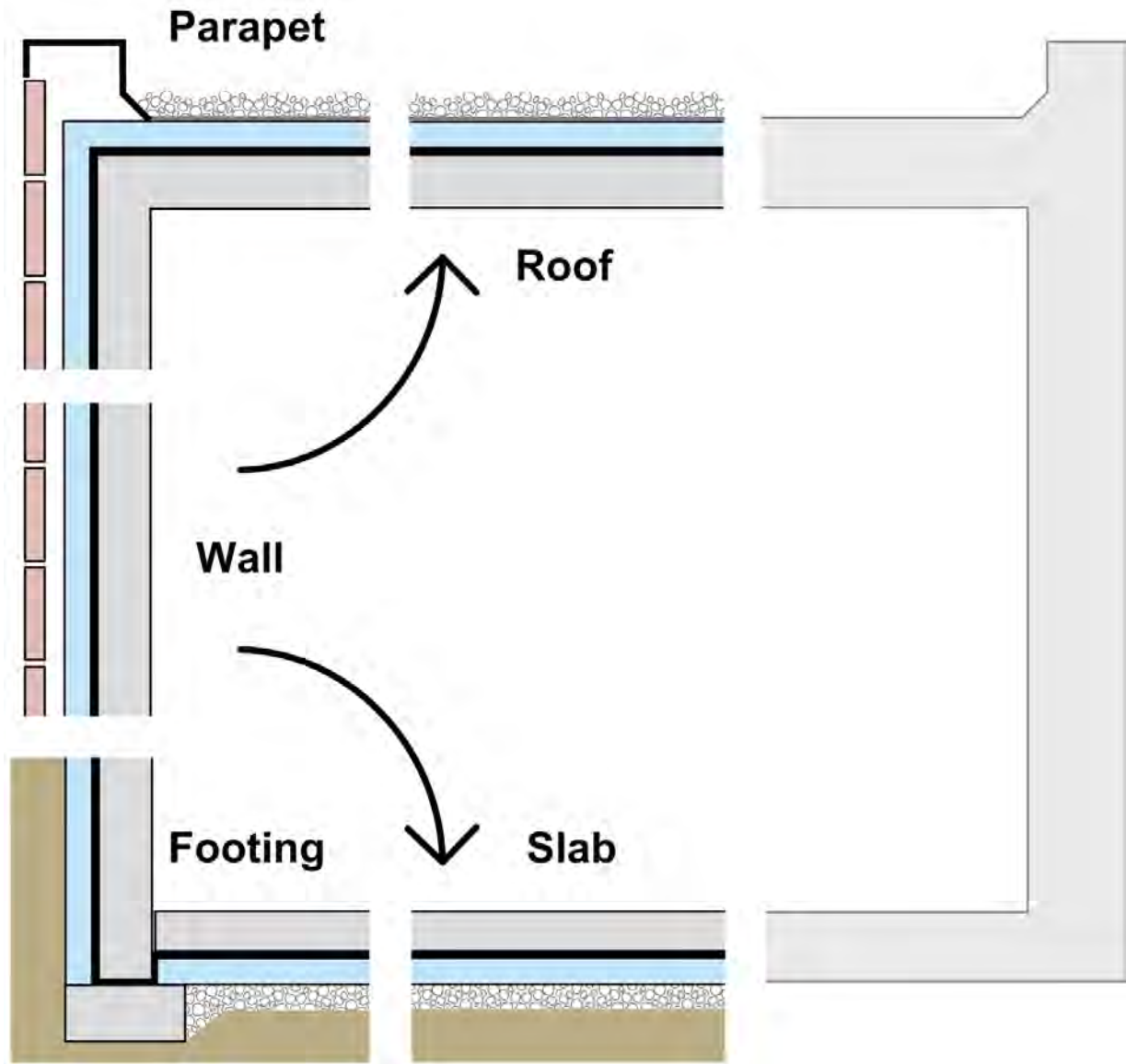


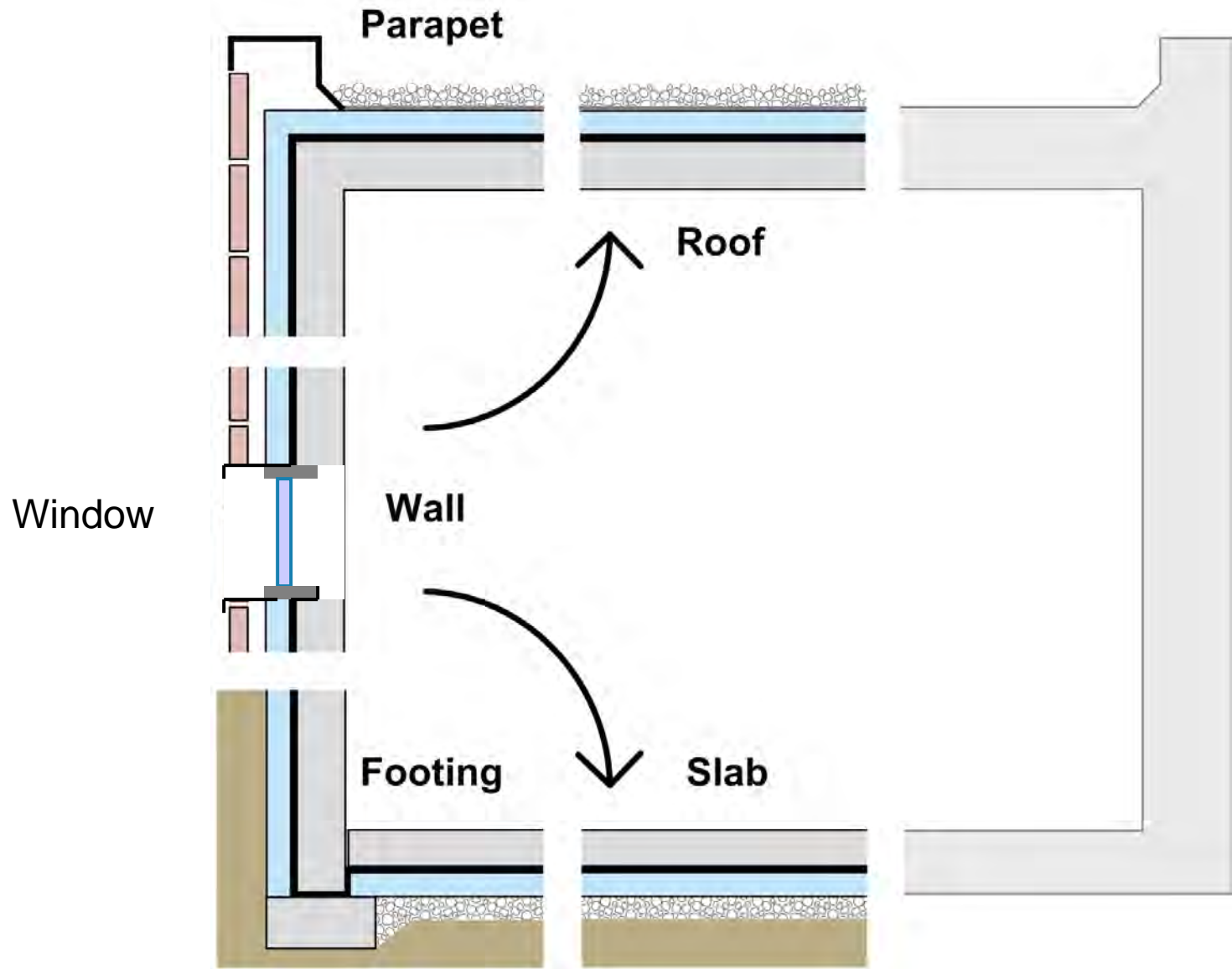










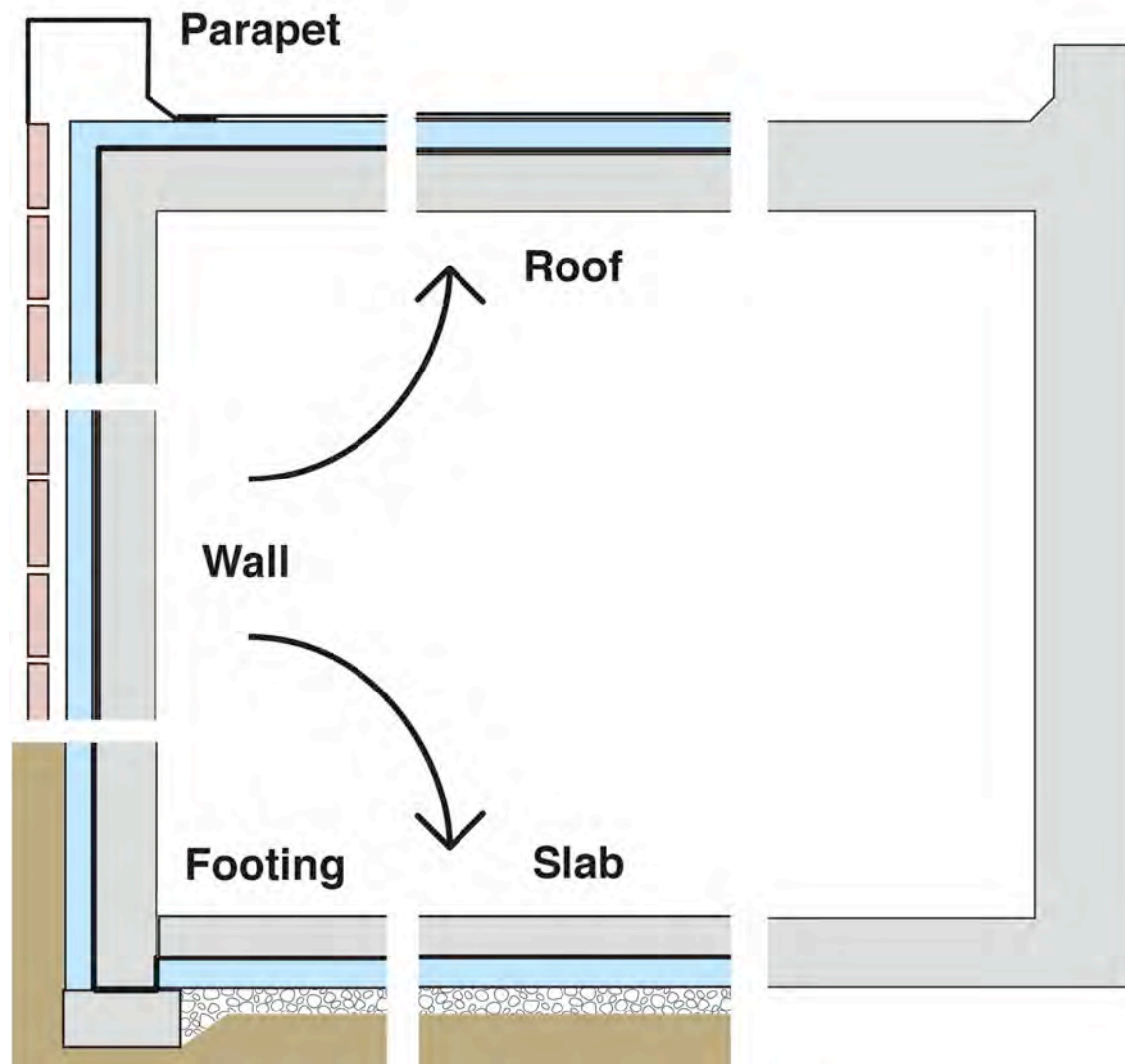


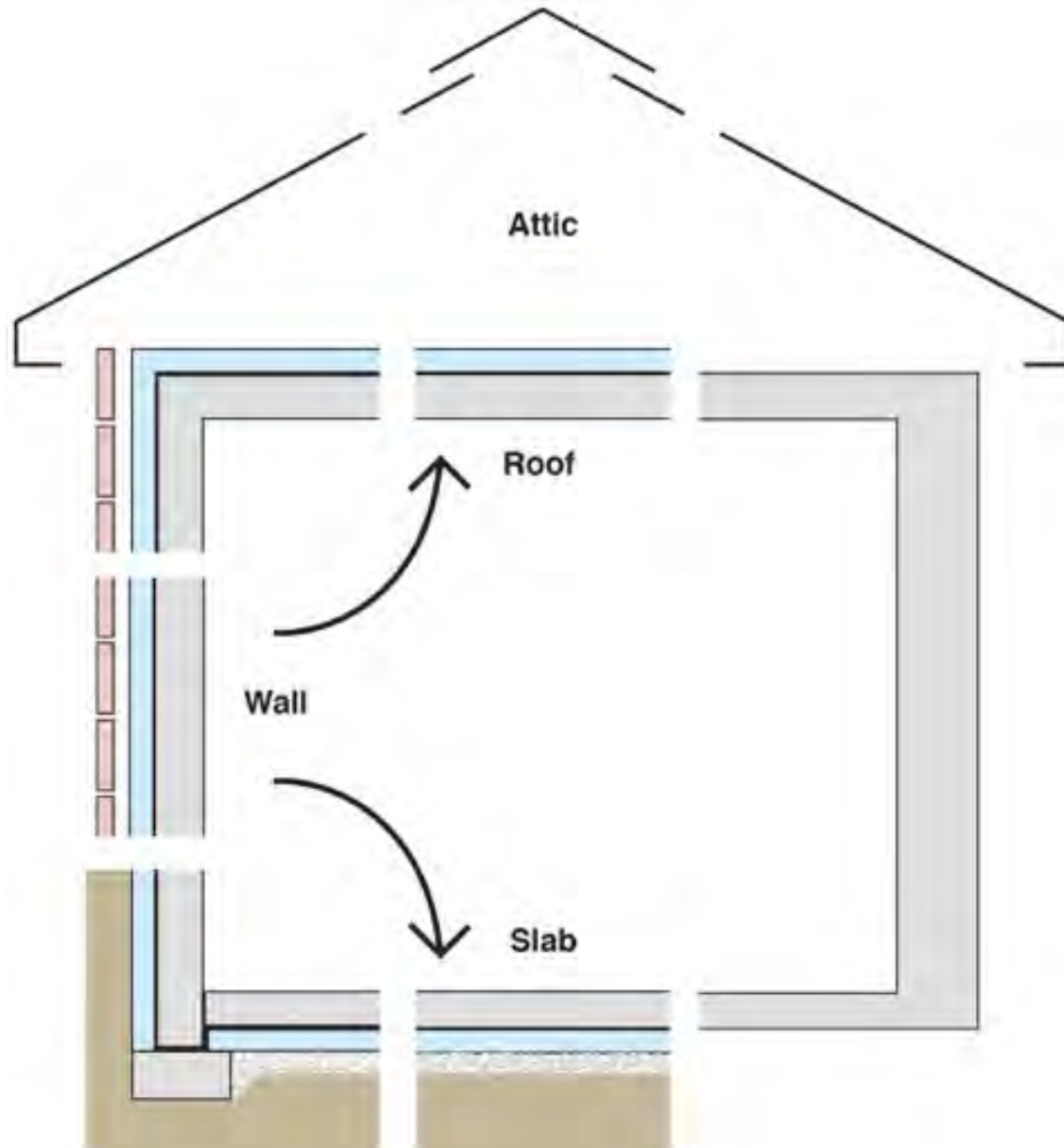


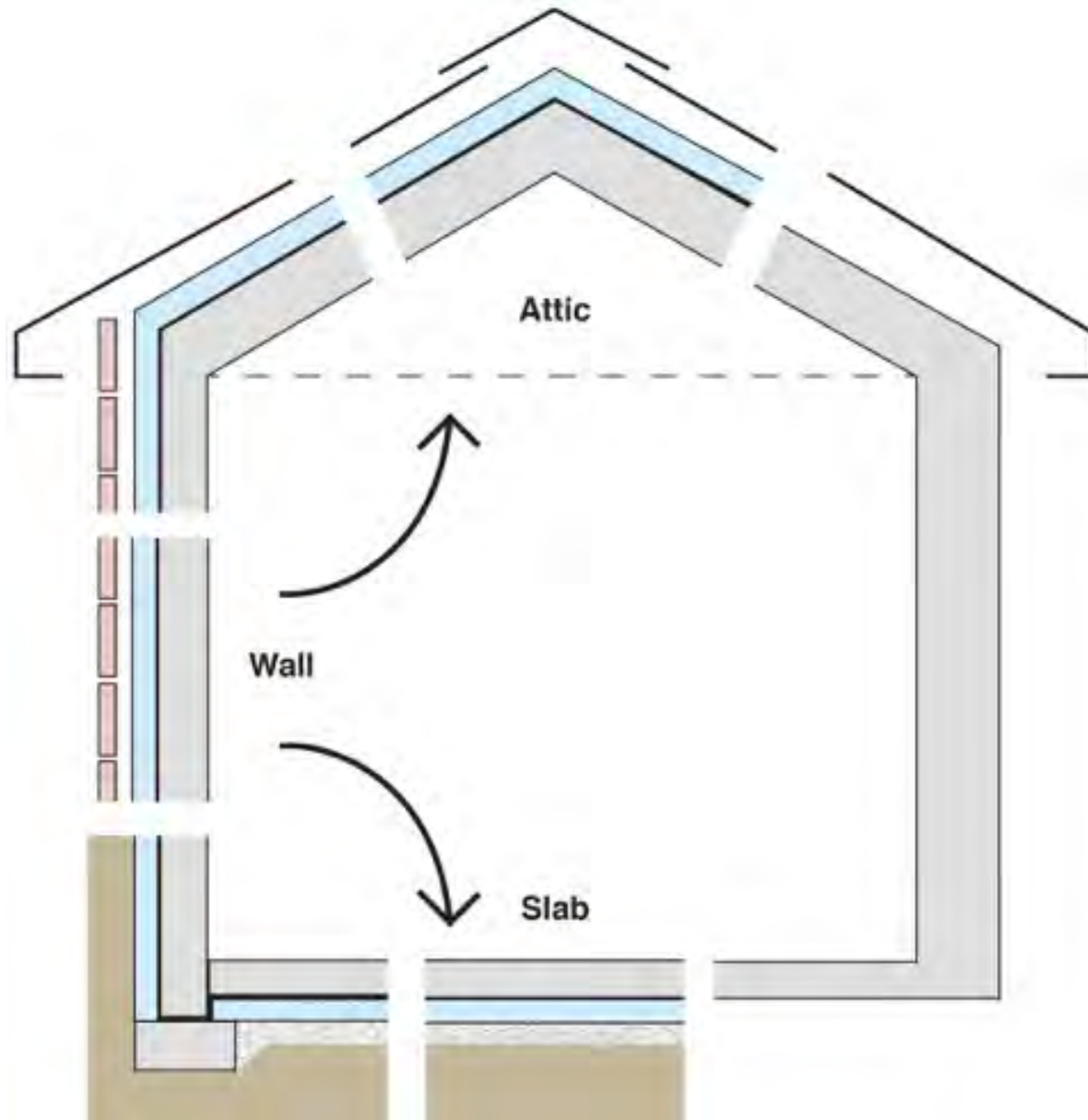
Control layer

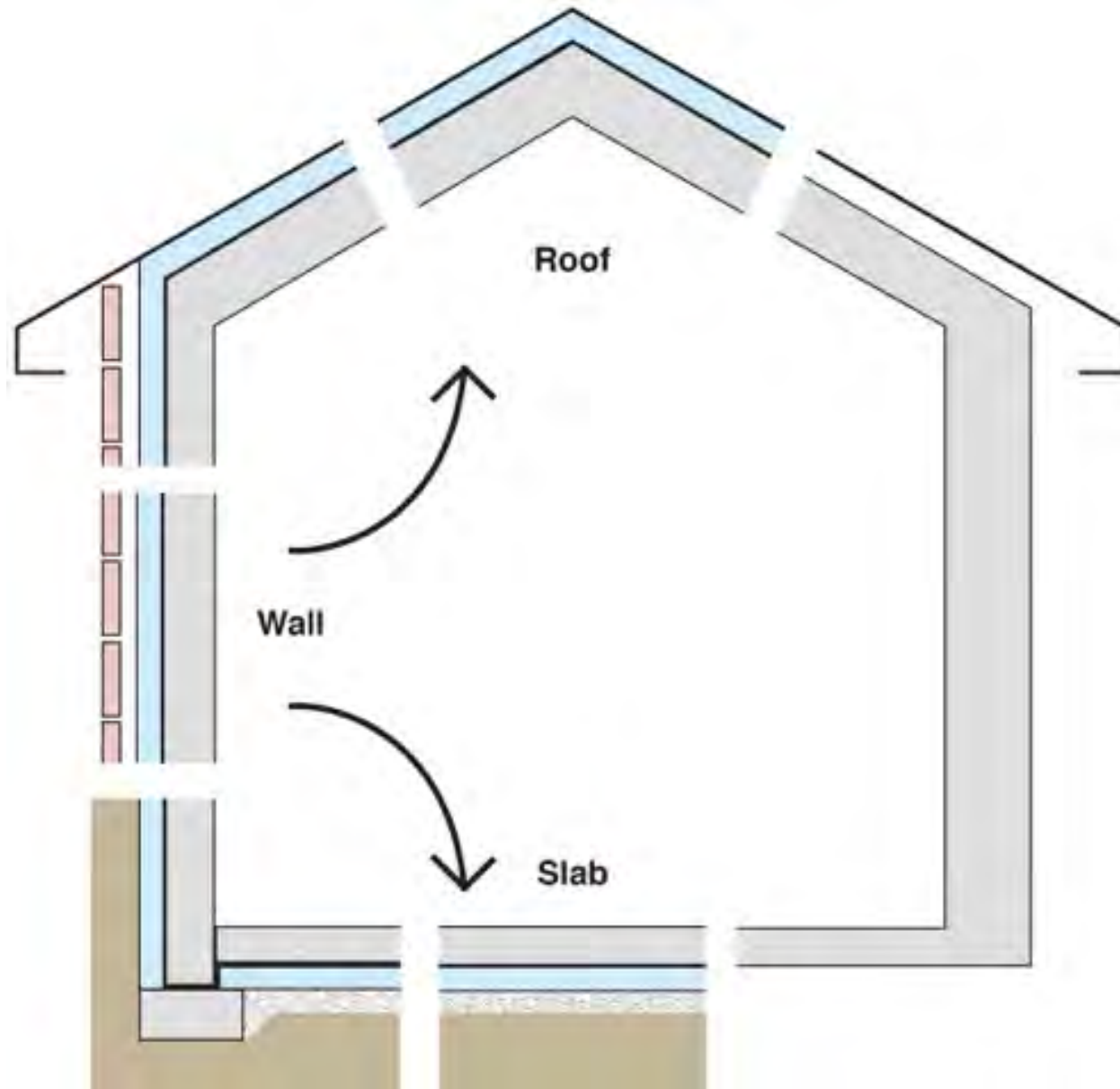
Control layer

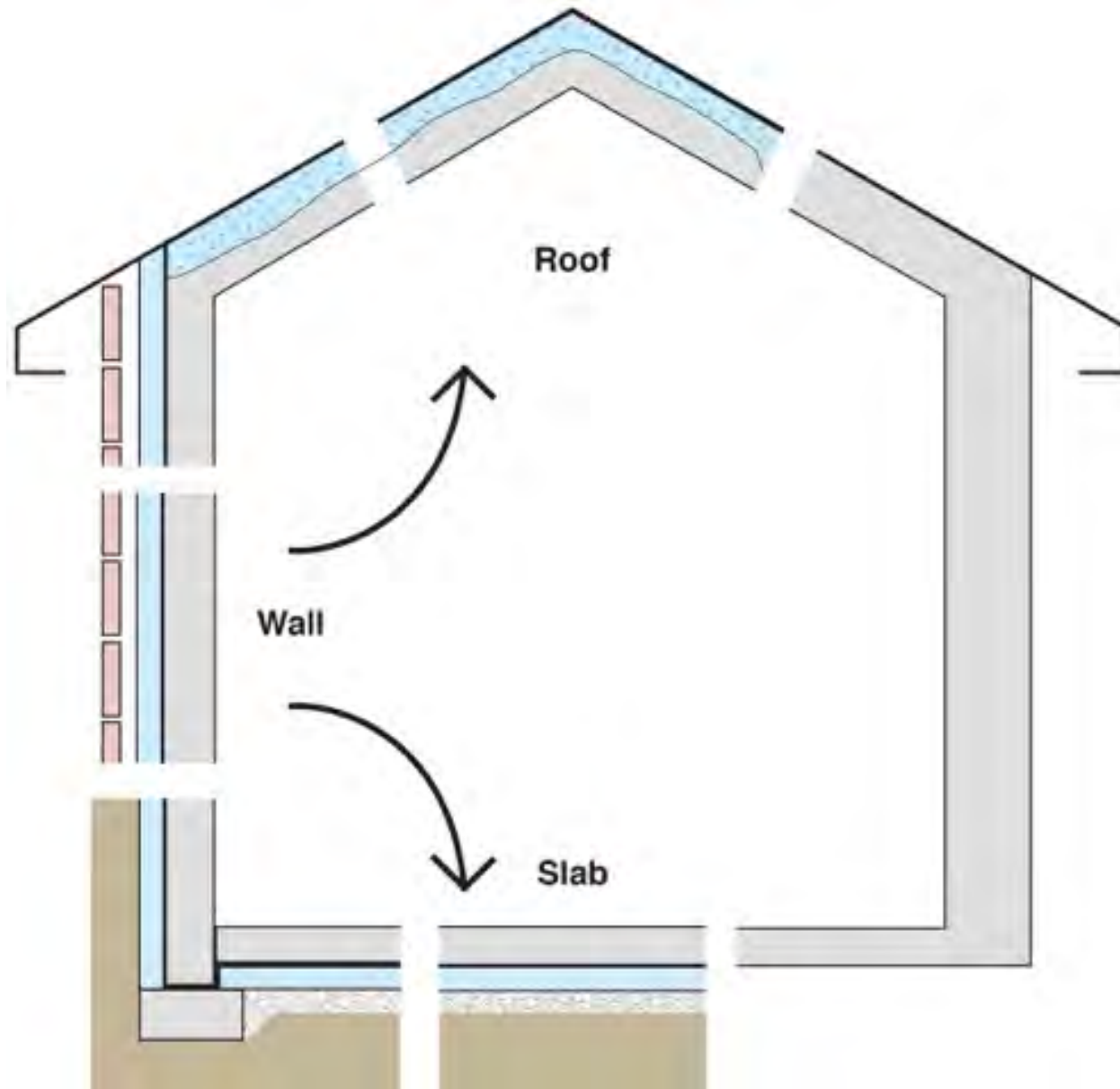
Roof structure



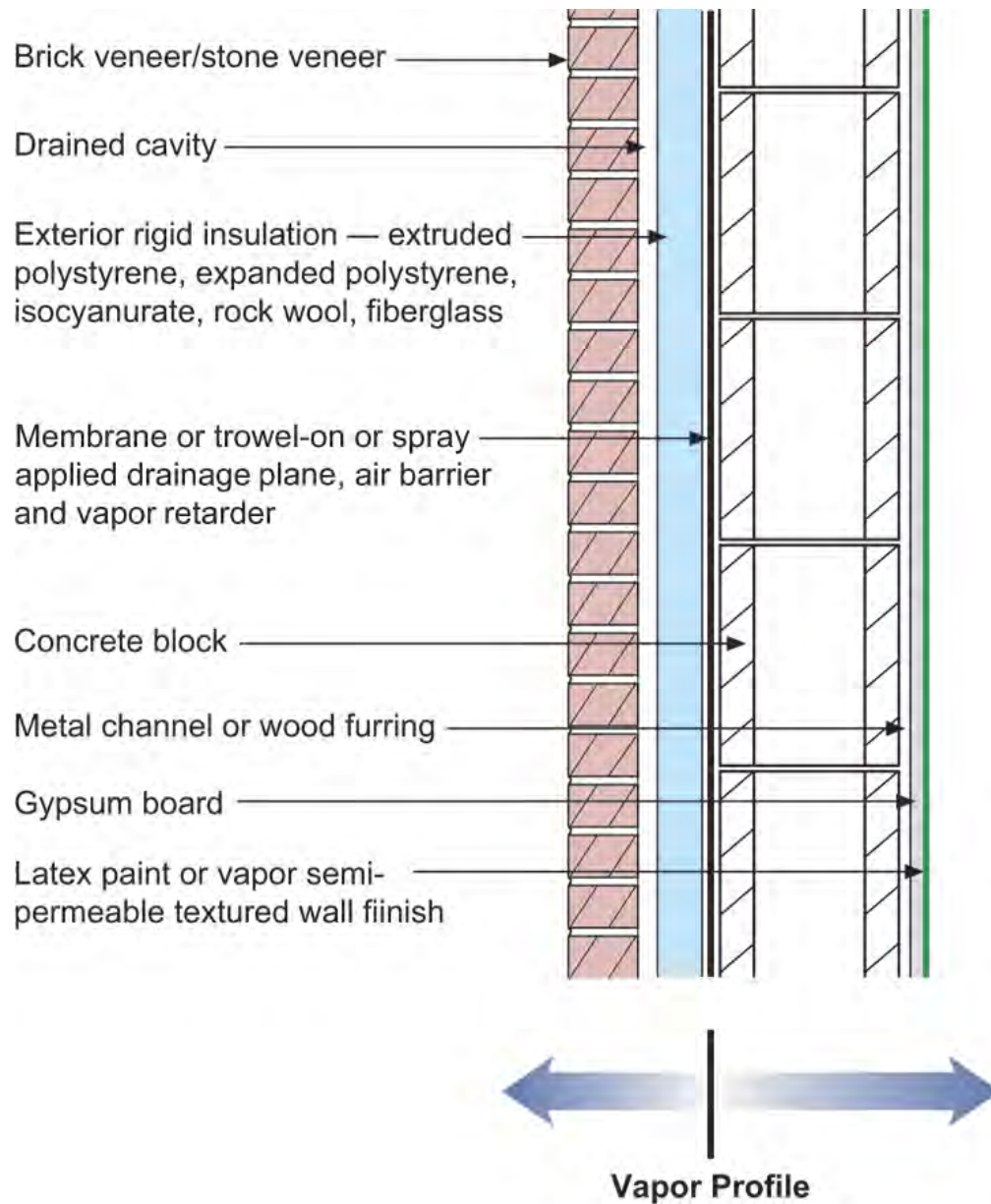


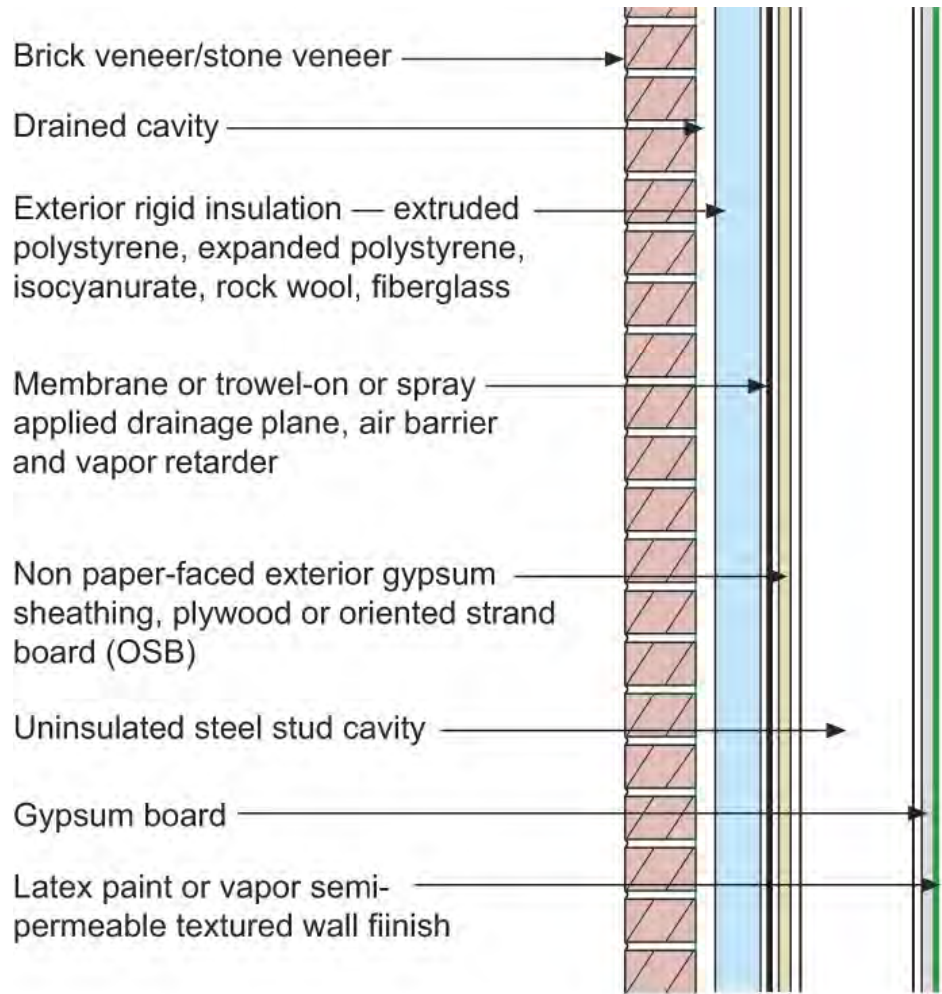


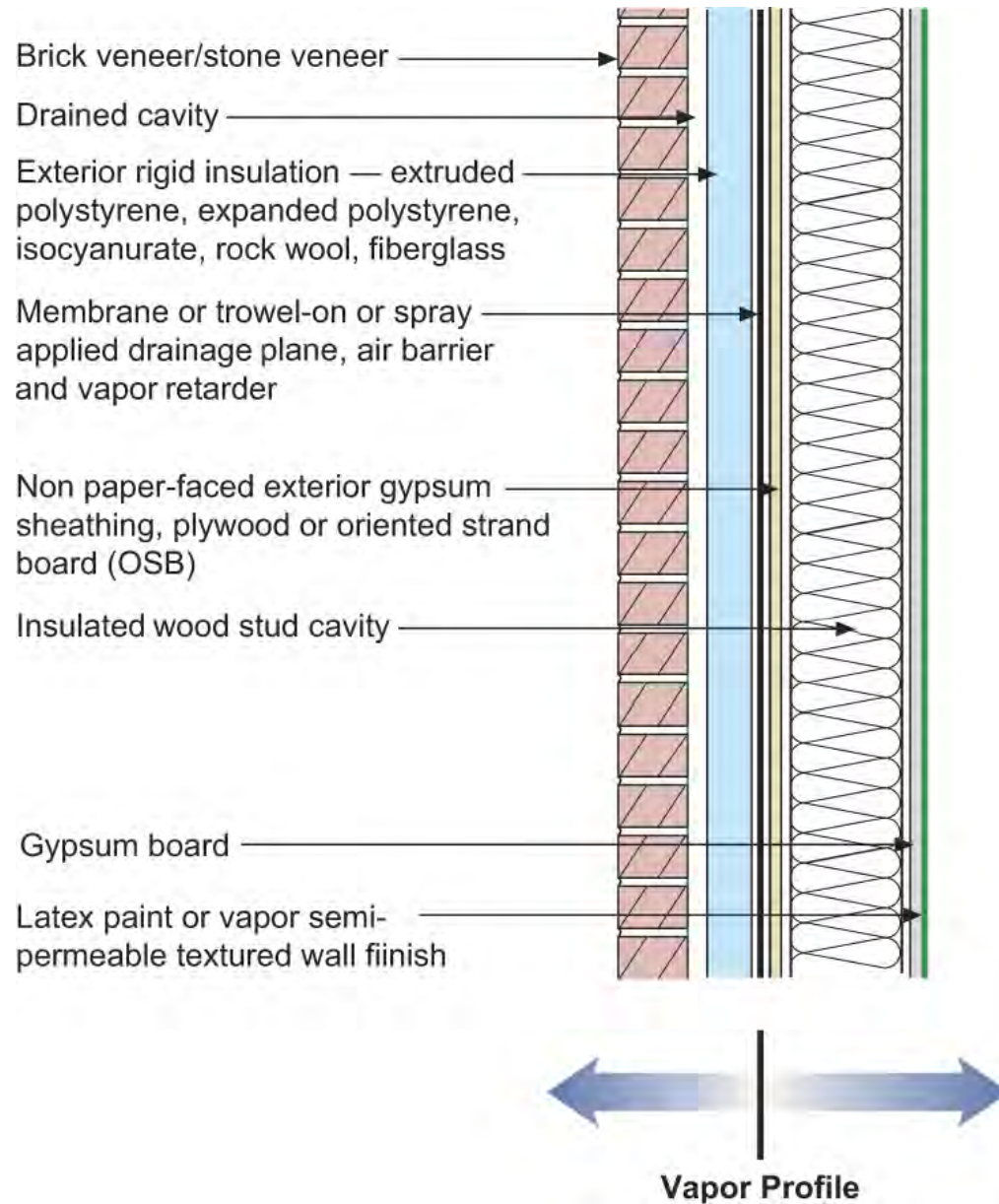




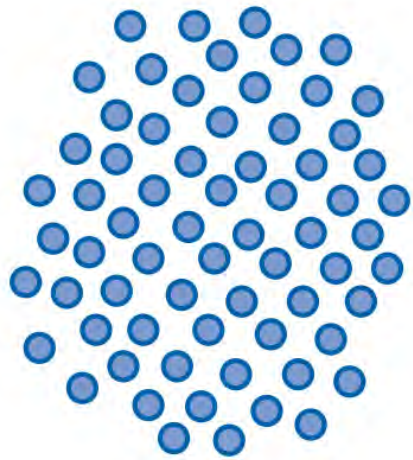
Configurations of the Perfect Wall







Air Flow and Vapor Diffusion



DIFFUSION



**Higher Dewpoint Temperature
Higher Water Vapor Density
or Concentration
(Higher Vapor Pressure)
on Warm Side of Assembly**

**Low Dewpoint Temperature
Lower Water Vapor Density
or Concentration
(Lower Vapor Pressure)
on Cold Side of Assembly**

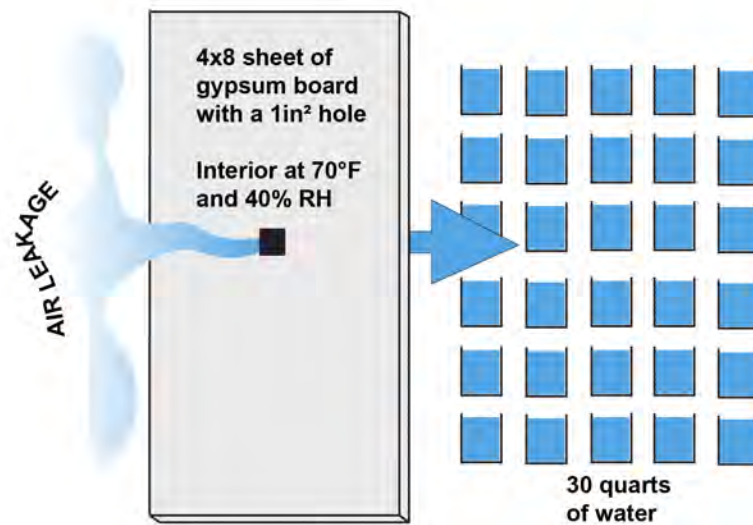
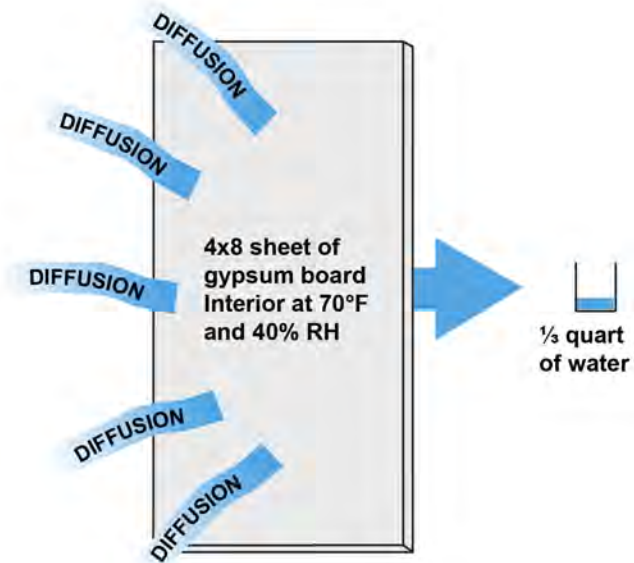


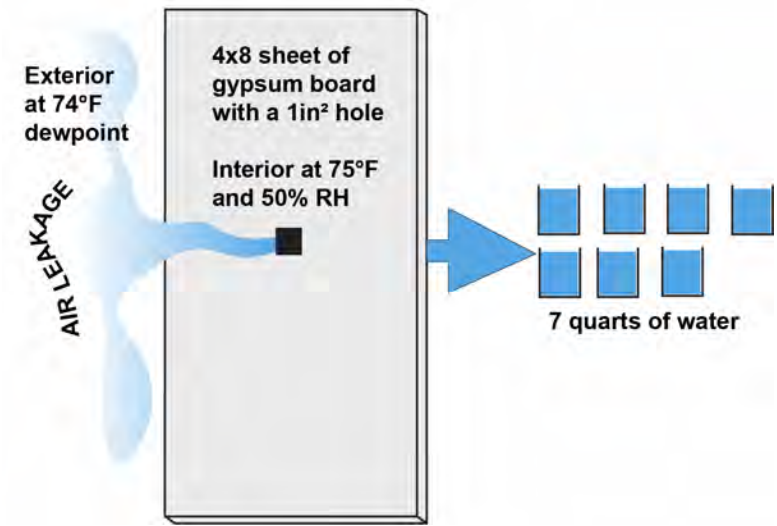
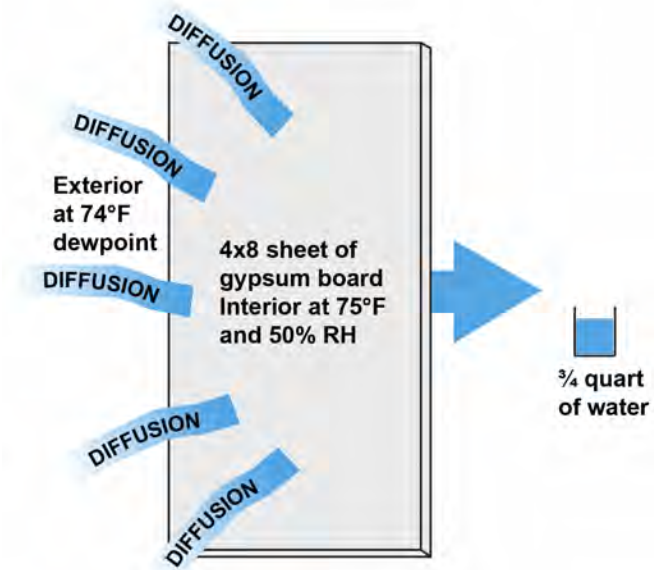
AIR TRANSPORT



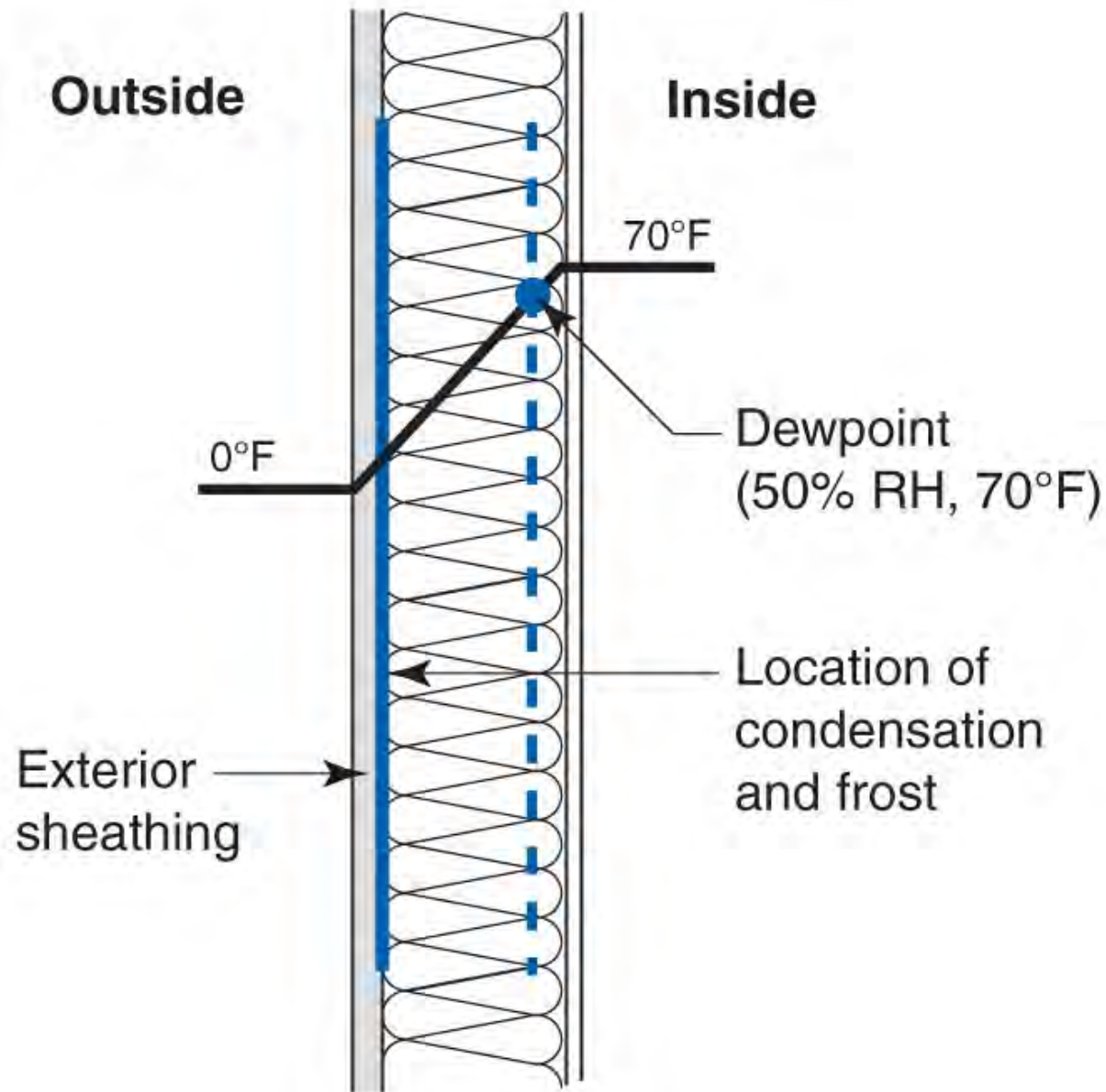
**Higher Air
Pressure**

**Lower Air
Pressure**



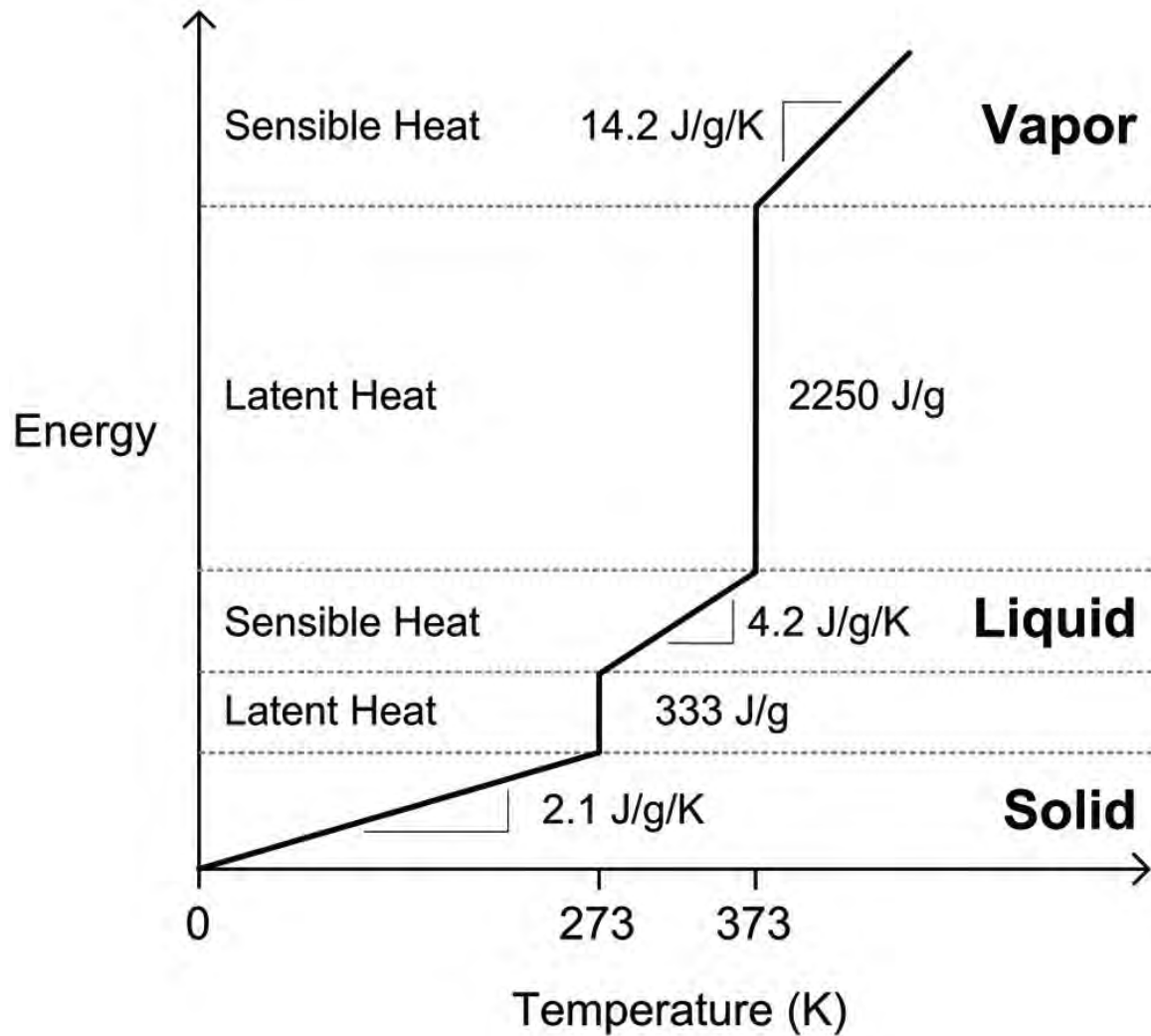


The Myth of the Dew Point





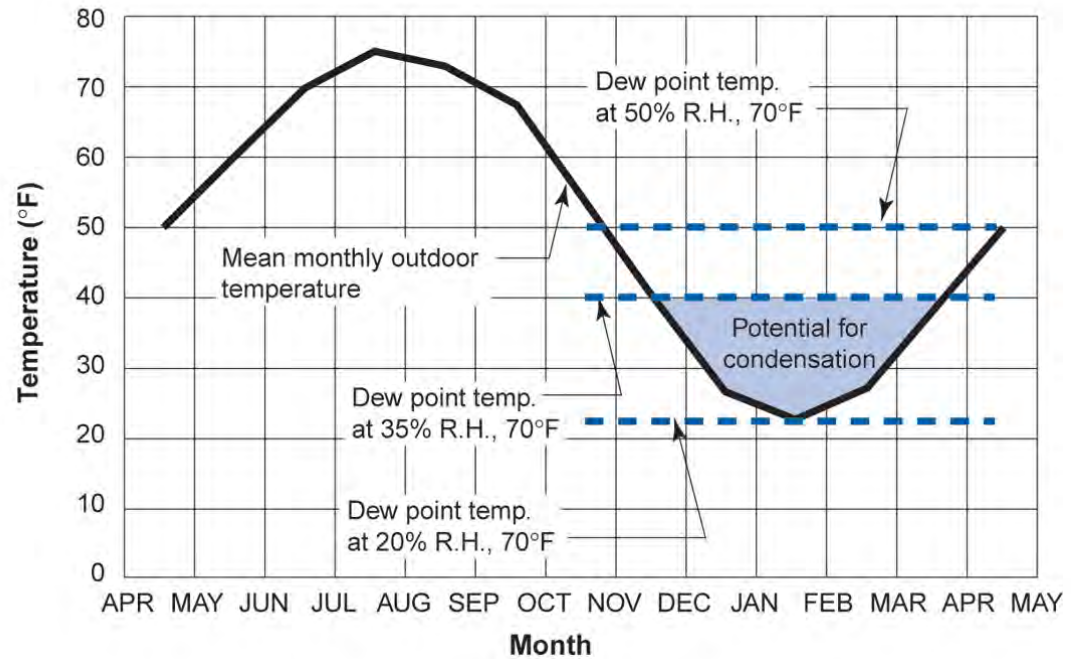
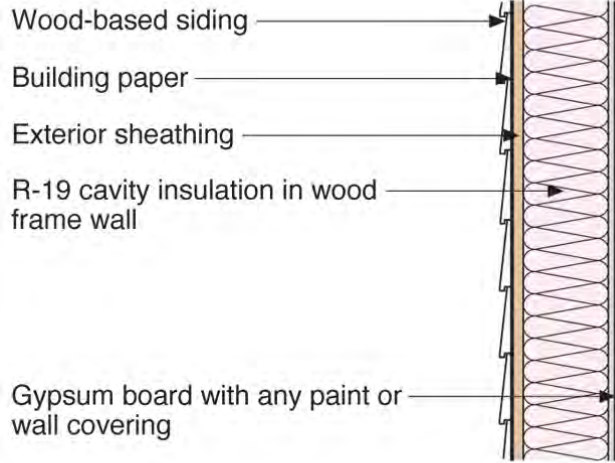


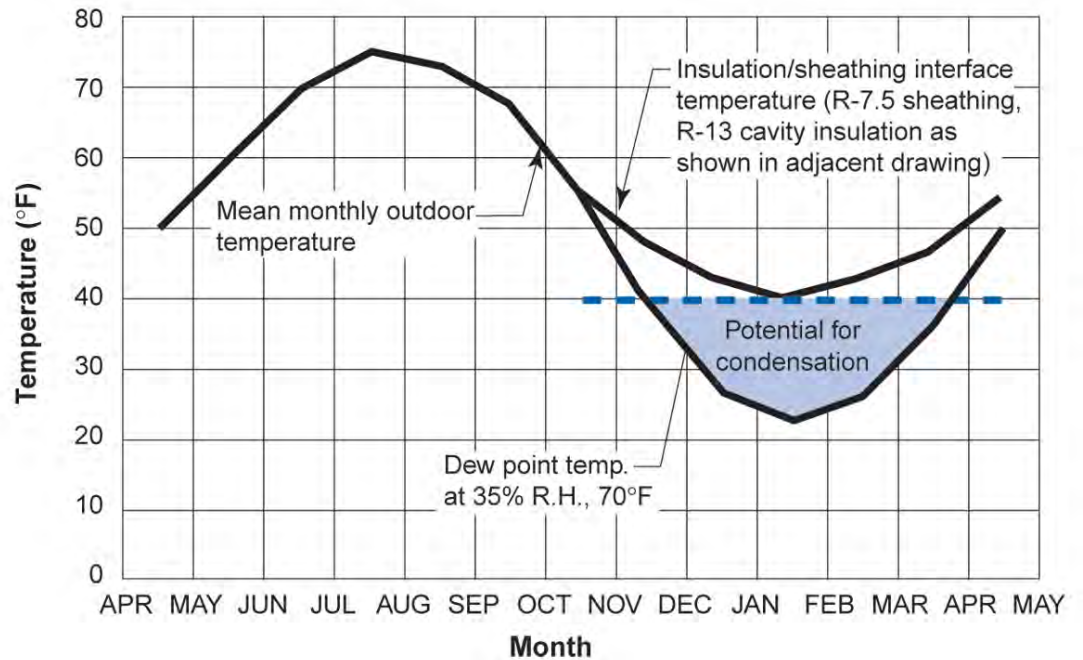
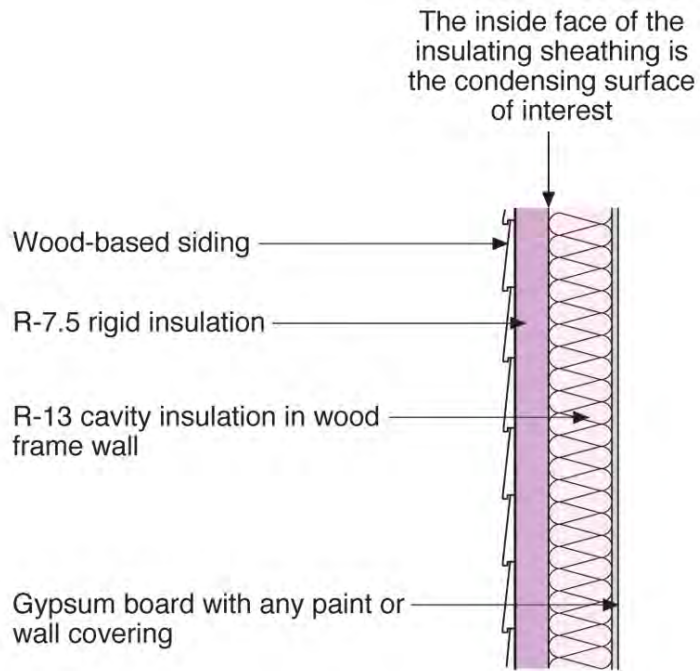


Simple linearized energy-temperature relation for water

From Straube & Burnett, 2005

The inside face of the exterior sheathing is the condensing surface of interest





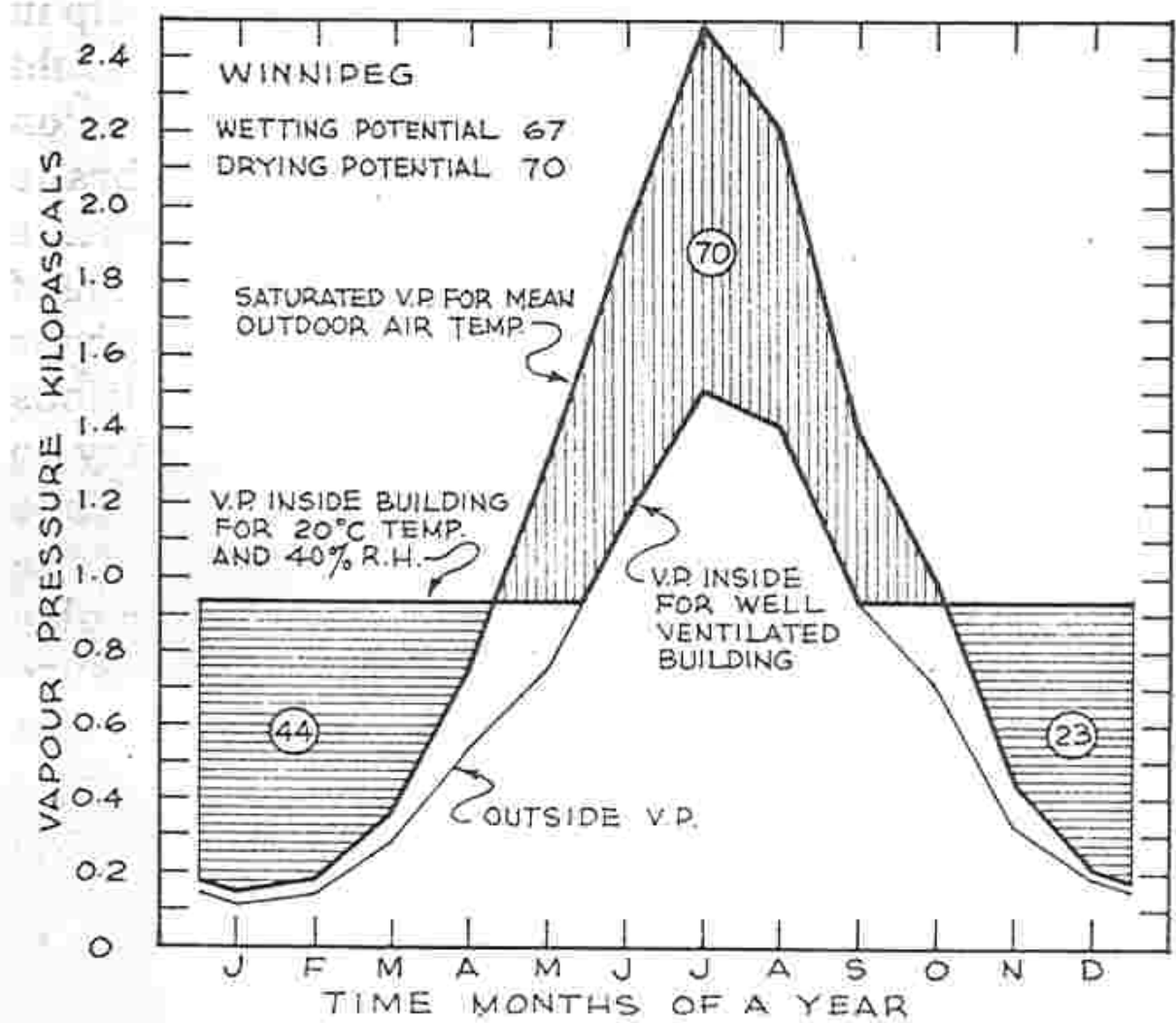
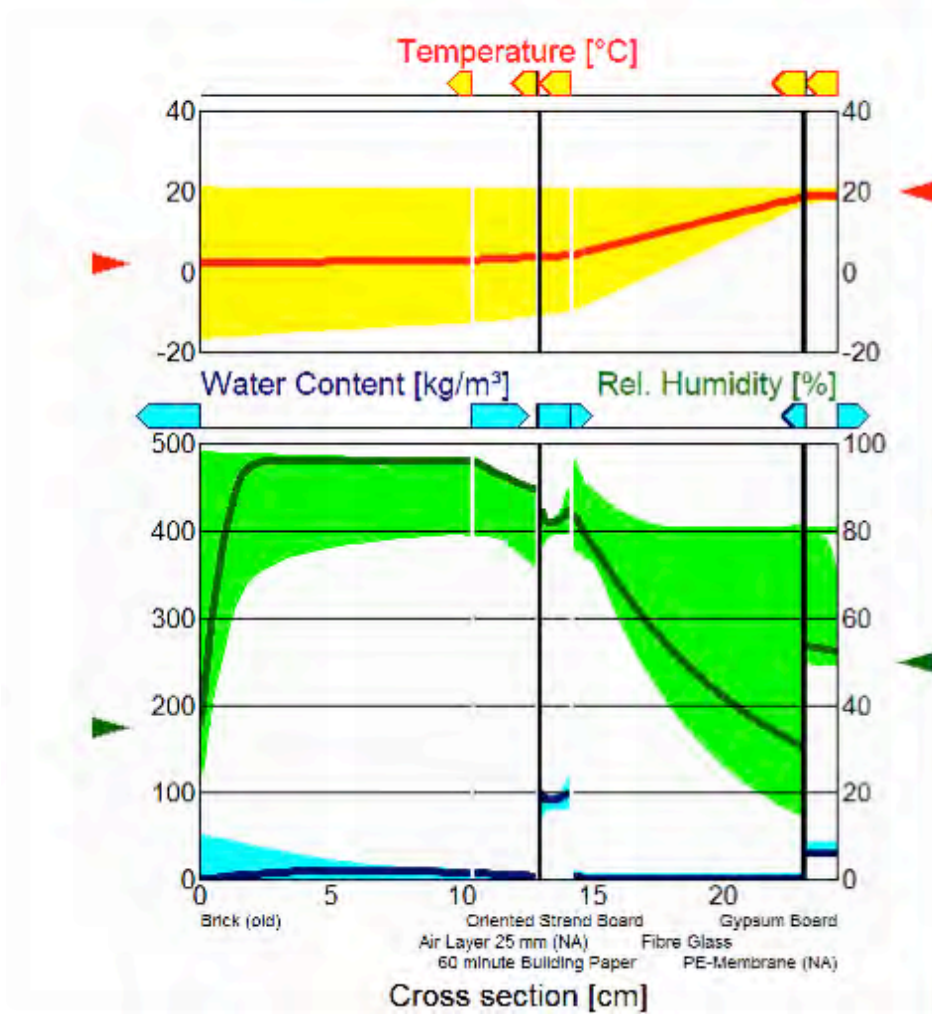


Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.



WUFI® 3.3 Pro. IBP
Run

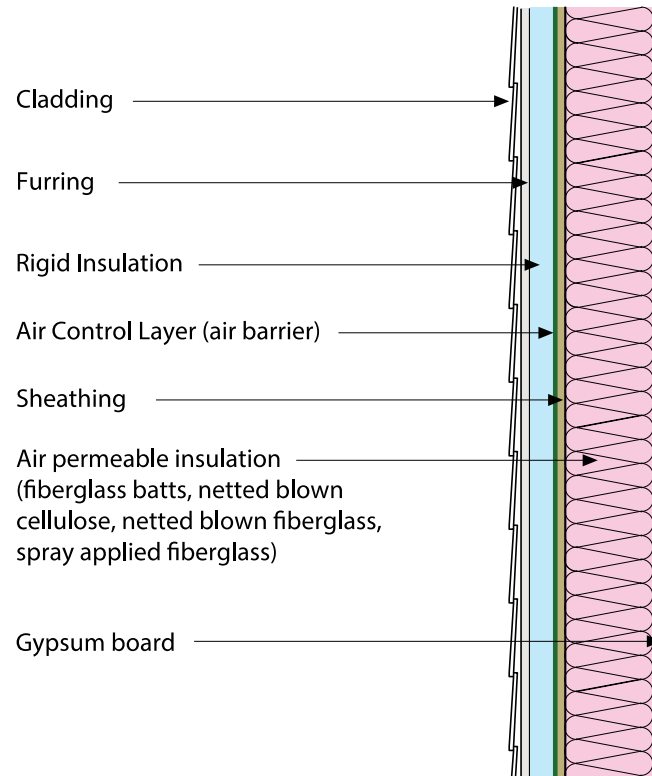
16 Feb
2001

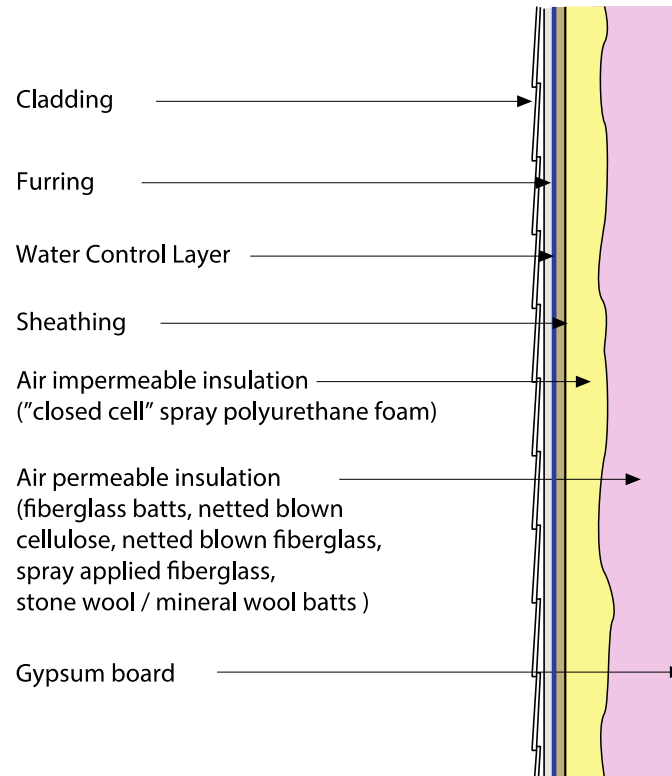
Buttons: Run, Stop, Pause, Help, and a slider for simulation time.

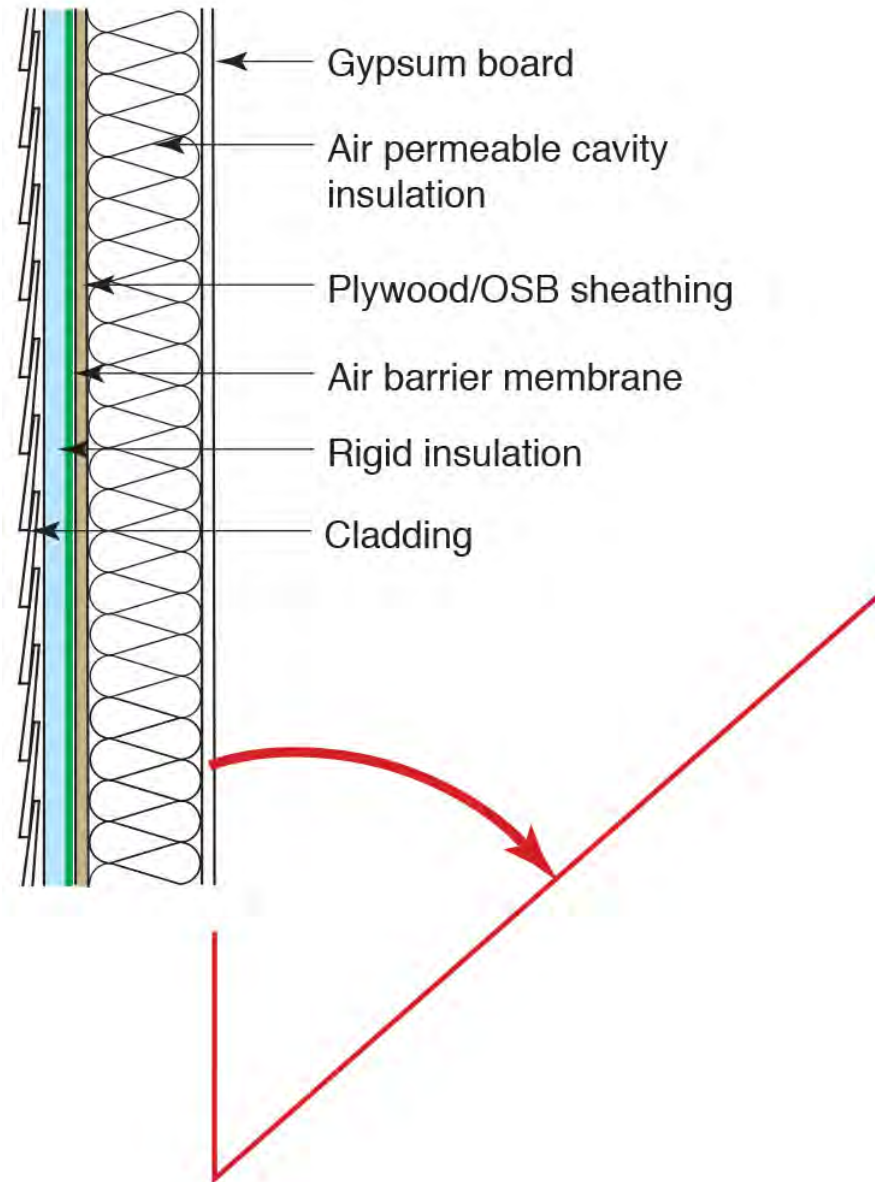
Insulation for Condensation Control*

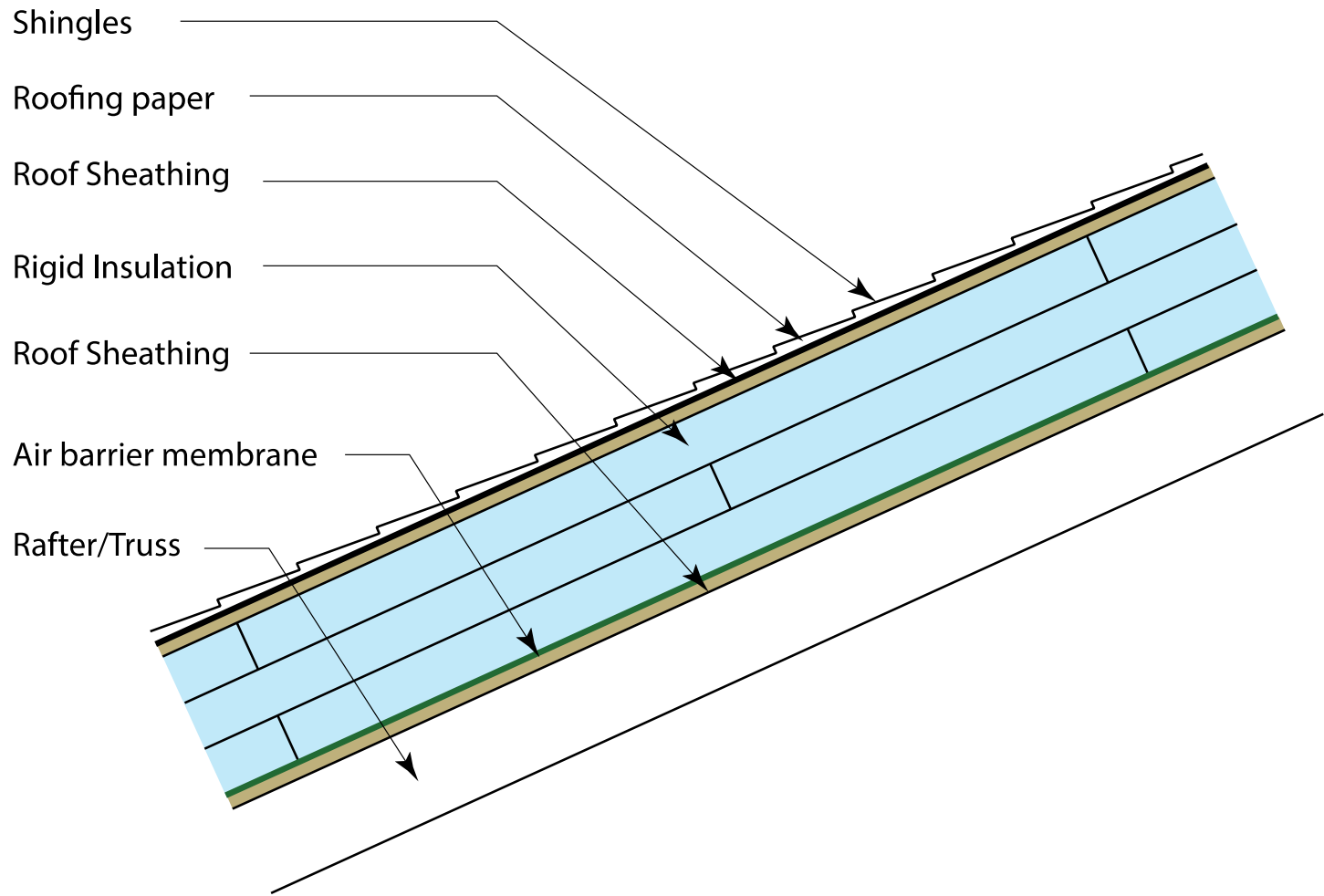
Climate Zone	Rigid Board or Air Impermeable Insulation	Total Cavity Insulation	Total Wall Assembly Insulation	Ratio of Rigid Board Insulation or Air Impermeable R-Value to Total Insulation R-Value
4C	R-2.5	R-13	R-15.5	15%
	R-3.75	R-20	R-23.75	15%
5	R-5	R-13	R-18	30%
	R-7.5	R-20	R-27.5	30%
6	R-7.5	R-13	R-20.5	35%
	R-11.25	R-20	R-31.25	35%
7	R-10	R-13	R-28	45%
	R-15	R-20	R-35	45%
8	R-15	R-13	R-28	50%
	R-20	R-20	R-40	50%

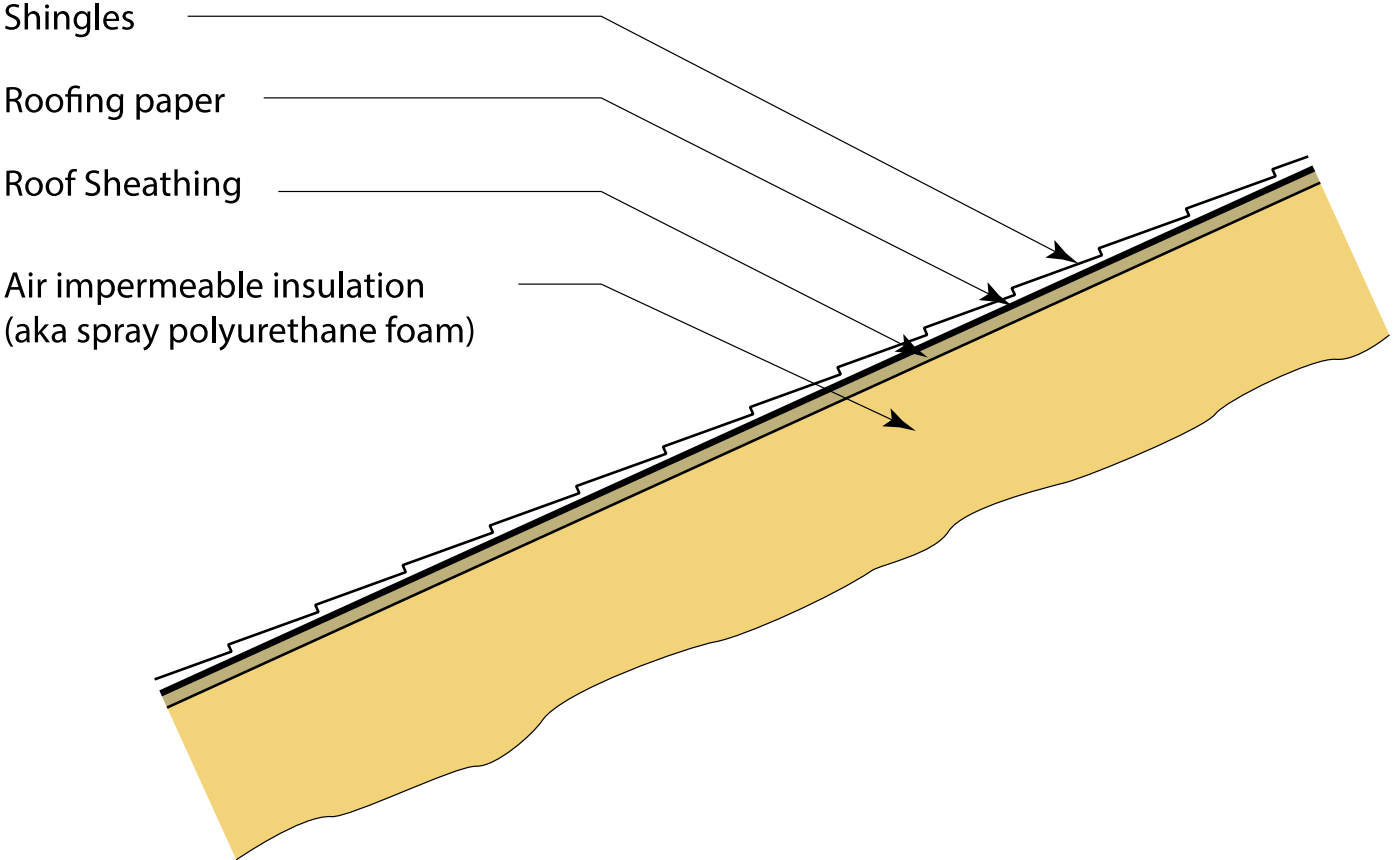
*Adapted from Table R 702.1 2015 International Residential Code

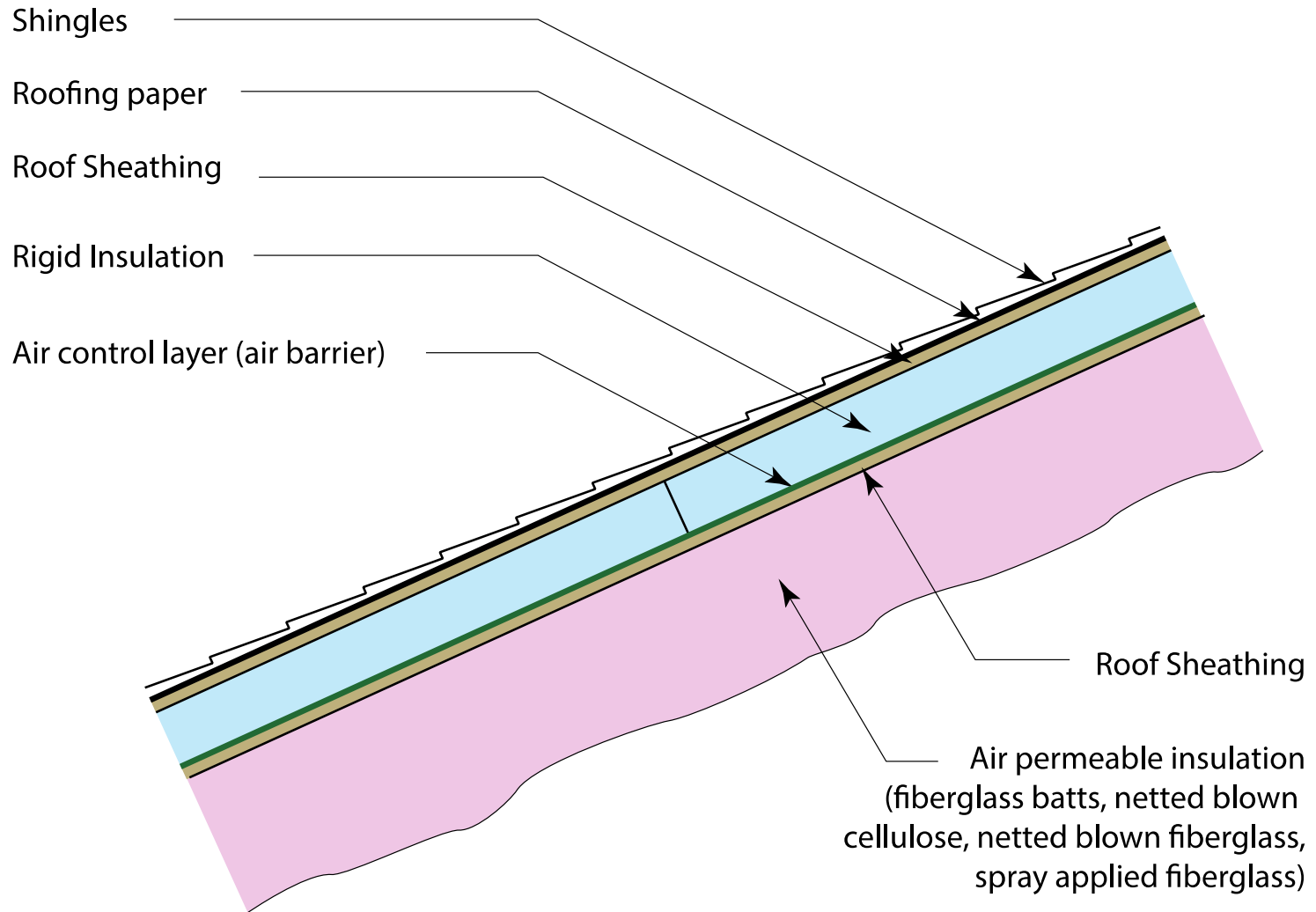










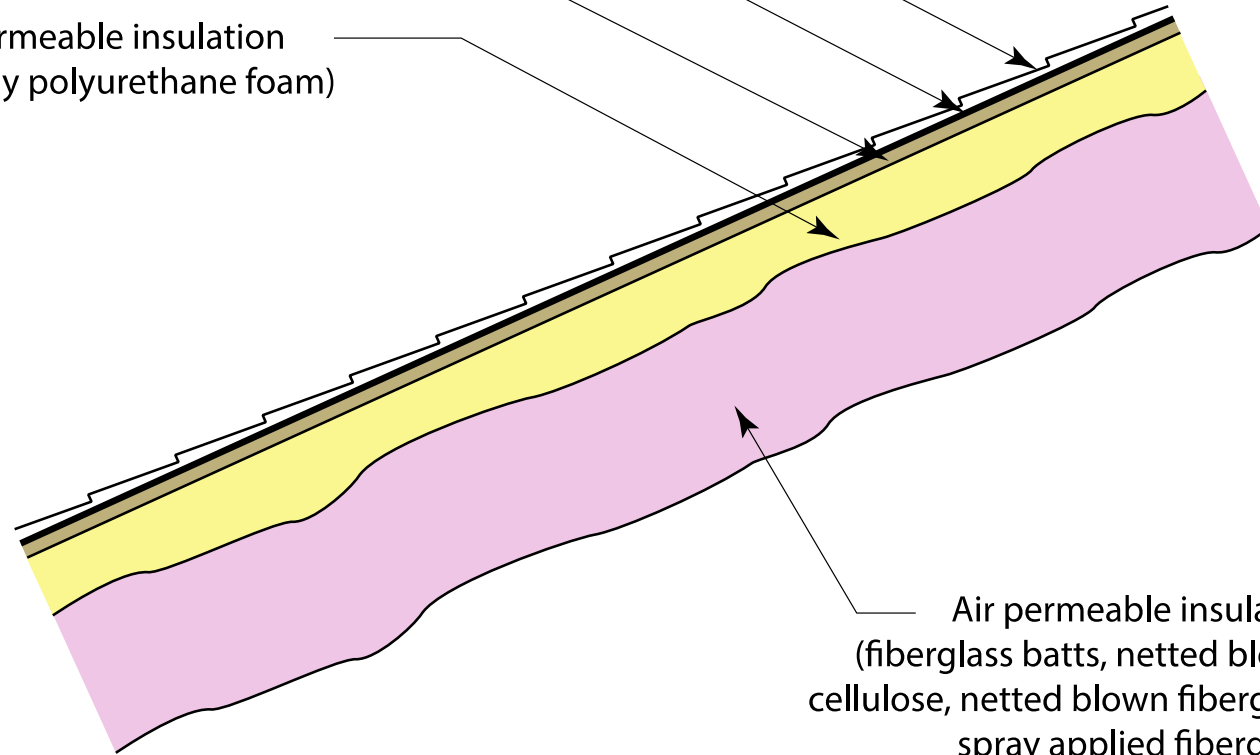


Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation
(aka spray polyurethane foam)



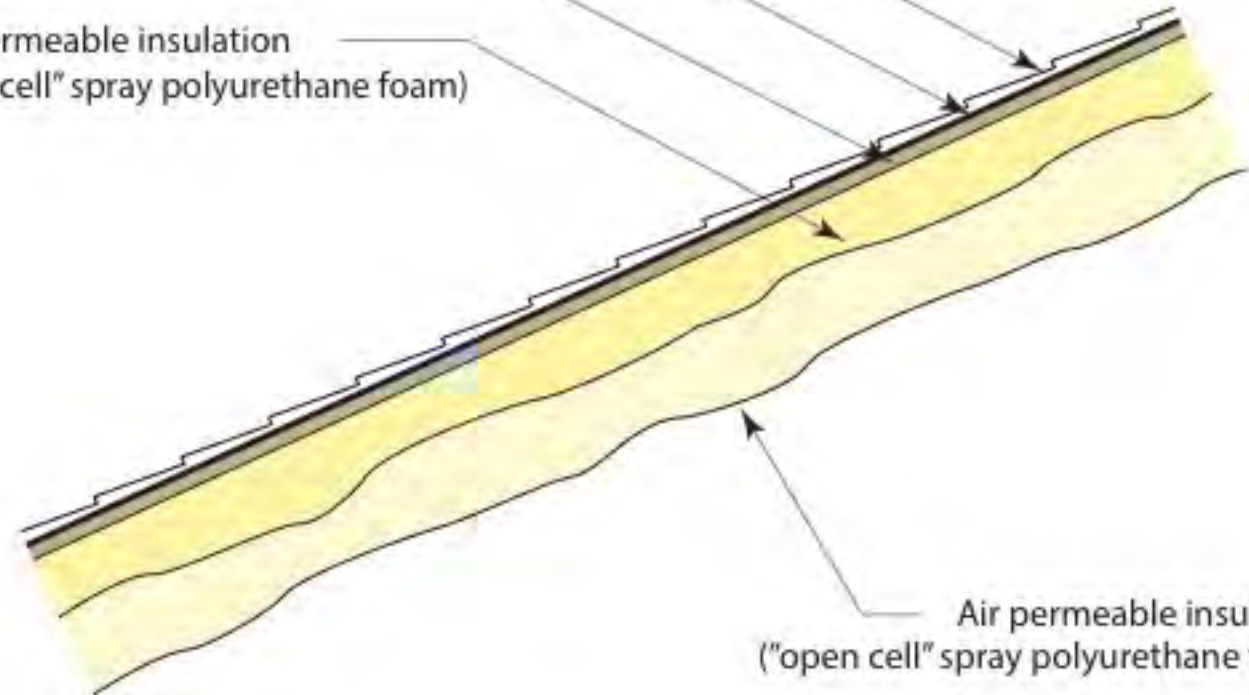
Air permeable insulation
(fiberglass batts, netted blown
cellulose, netted blown fiberglass,
spray applied fiberglass)

Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation
("closed cell" spray polyurethane foam)



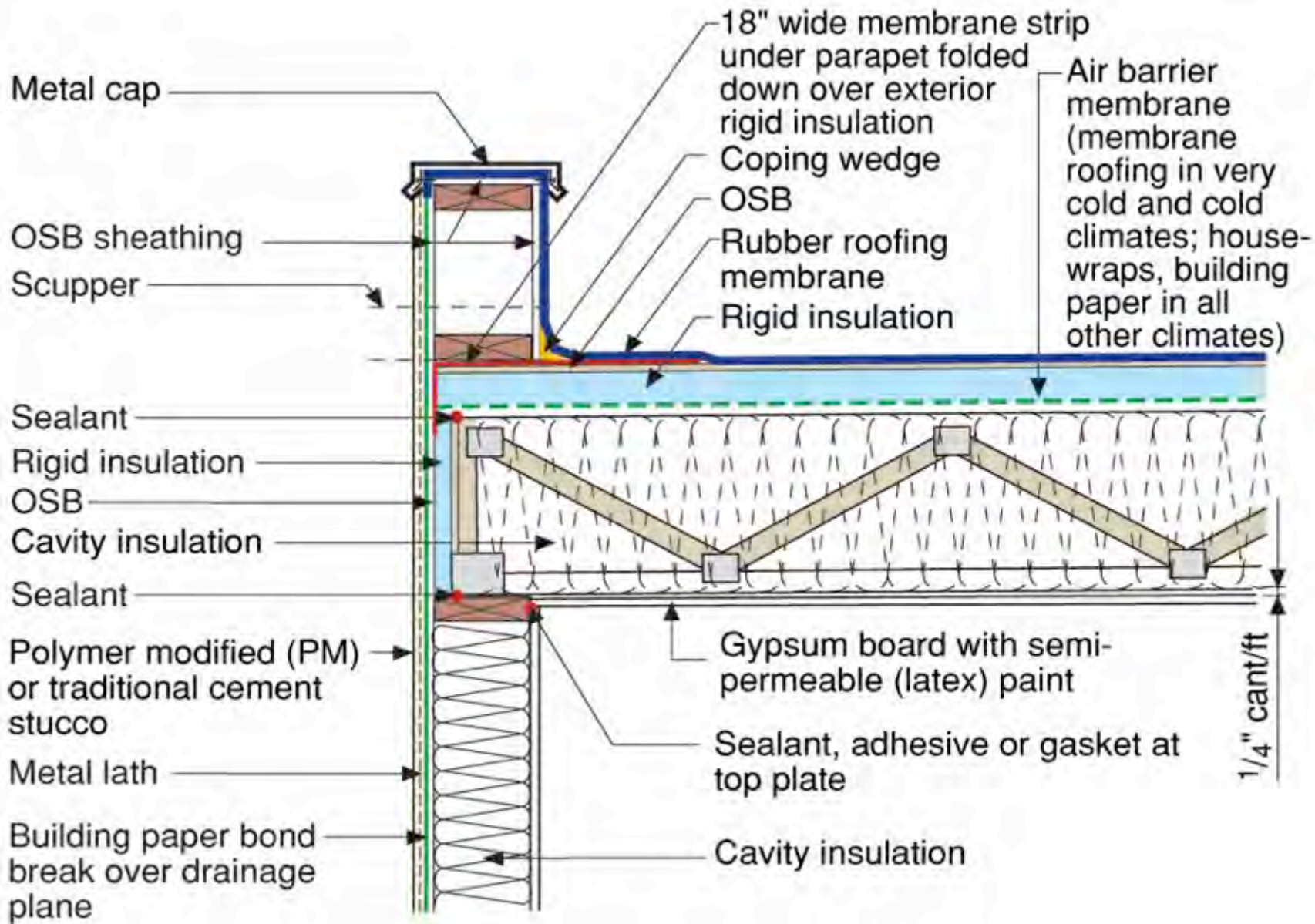
Air permeable insulation
("open cell" spray polyurethane foam)

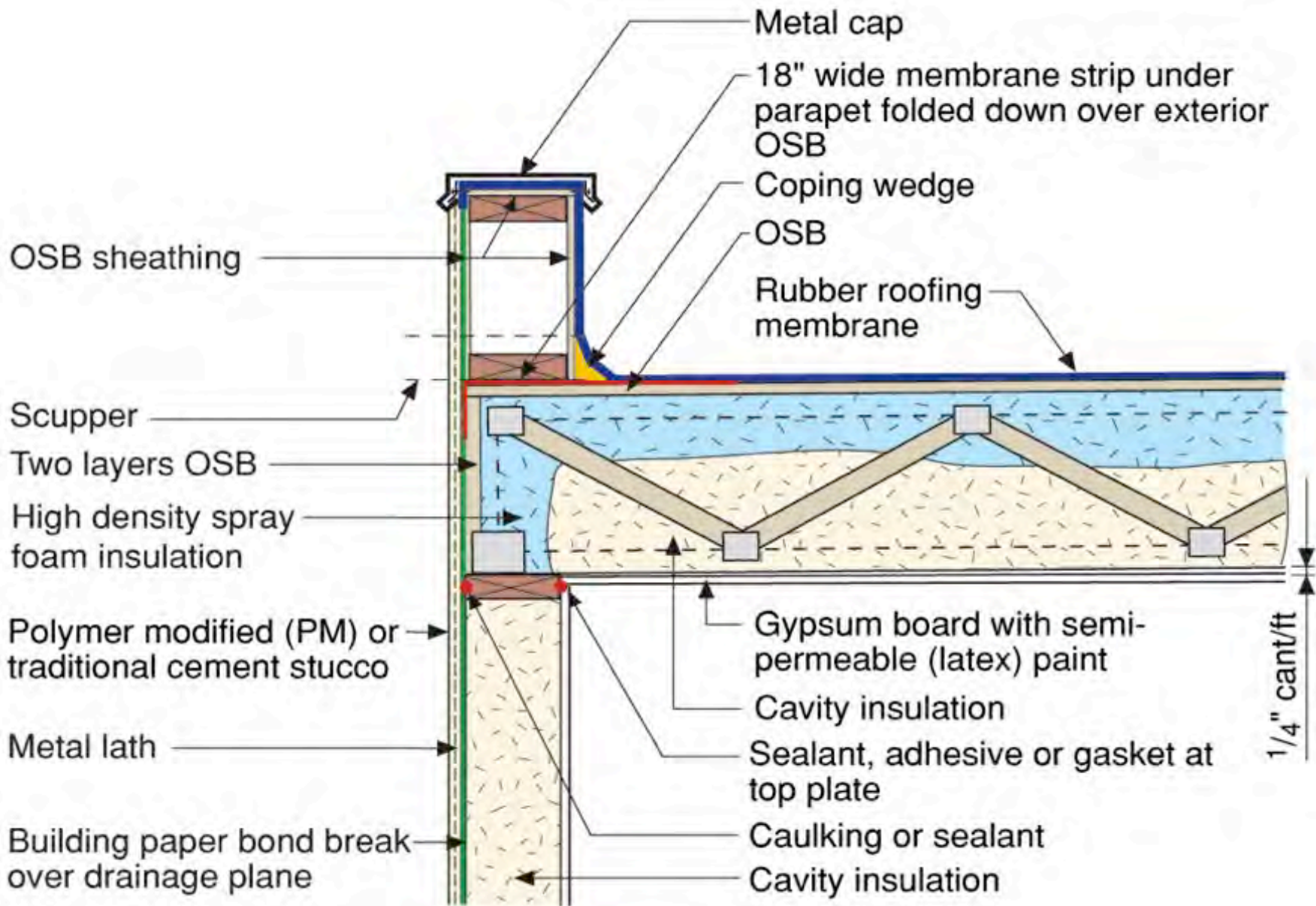
Insulation for Condensation Control*

Climate Zone	Rigid Board or Air Impermeable Insulation	Code Required R-Value	Ratio of Rigid Board Insulation or Air Impermeable R-Value to Total Insulation R-Value
1,2,3	R-5	R-38	10%
4C	R-10	R-49	20%
4A, 4B	R-15	R-49	30%
5	R-20	R-49	40%
6	R-25	R-49	50%
7	R-30	R-49	60%
8	R-35	R-49	70%

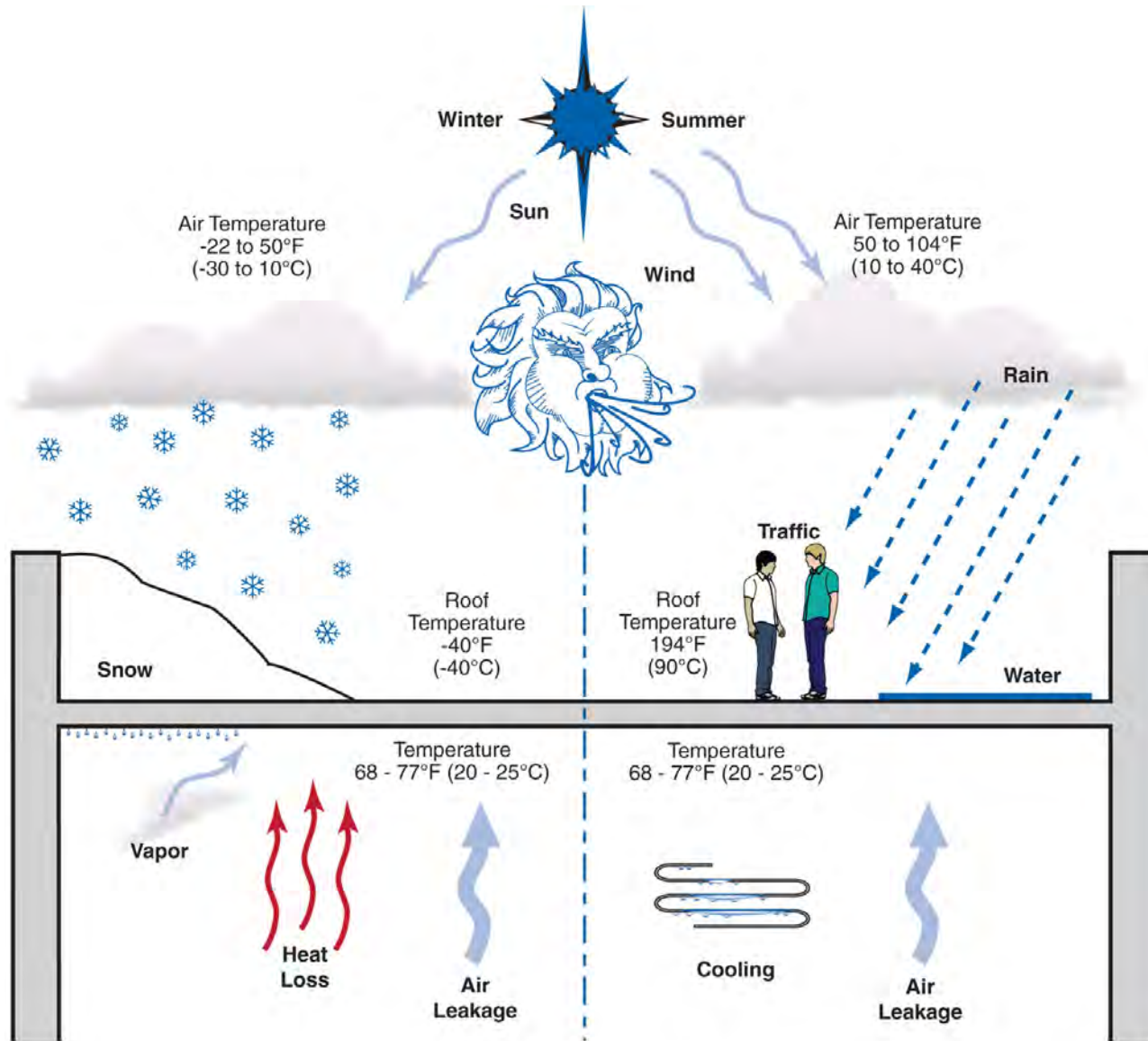
*Adapted from Table R 806.5 2015 International Residential Code

Table 1

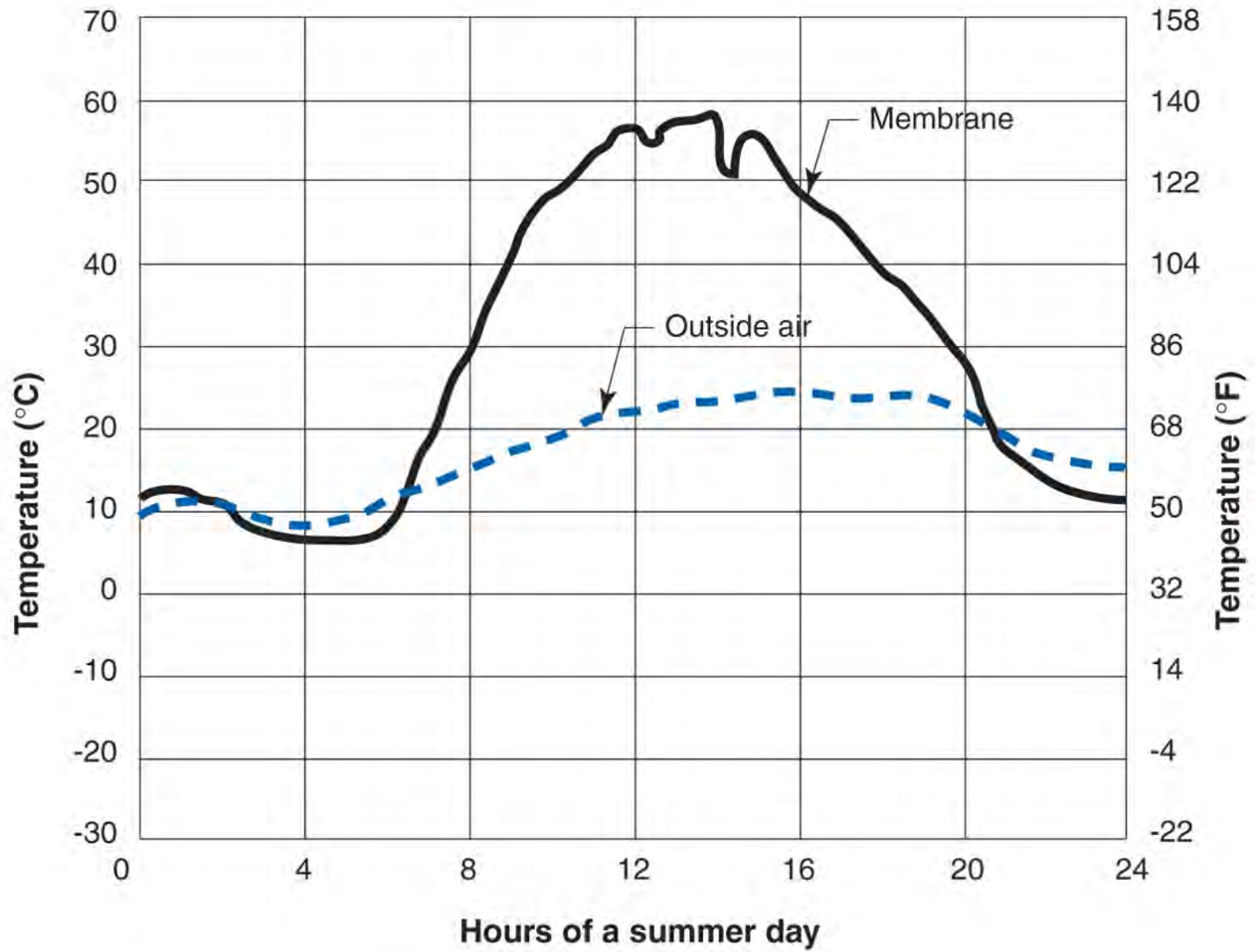




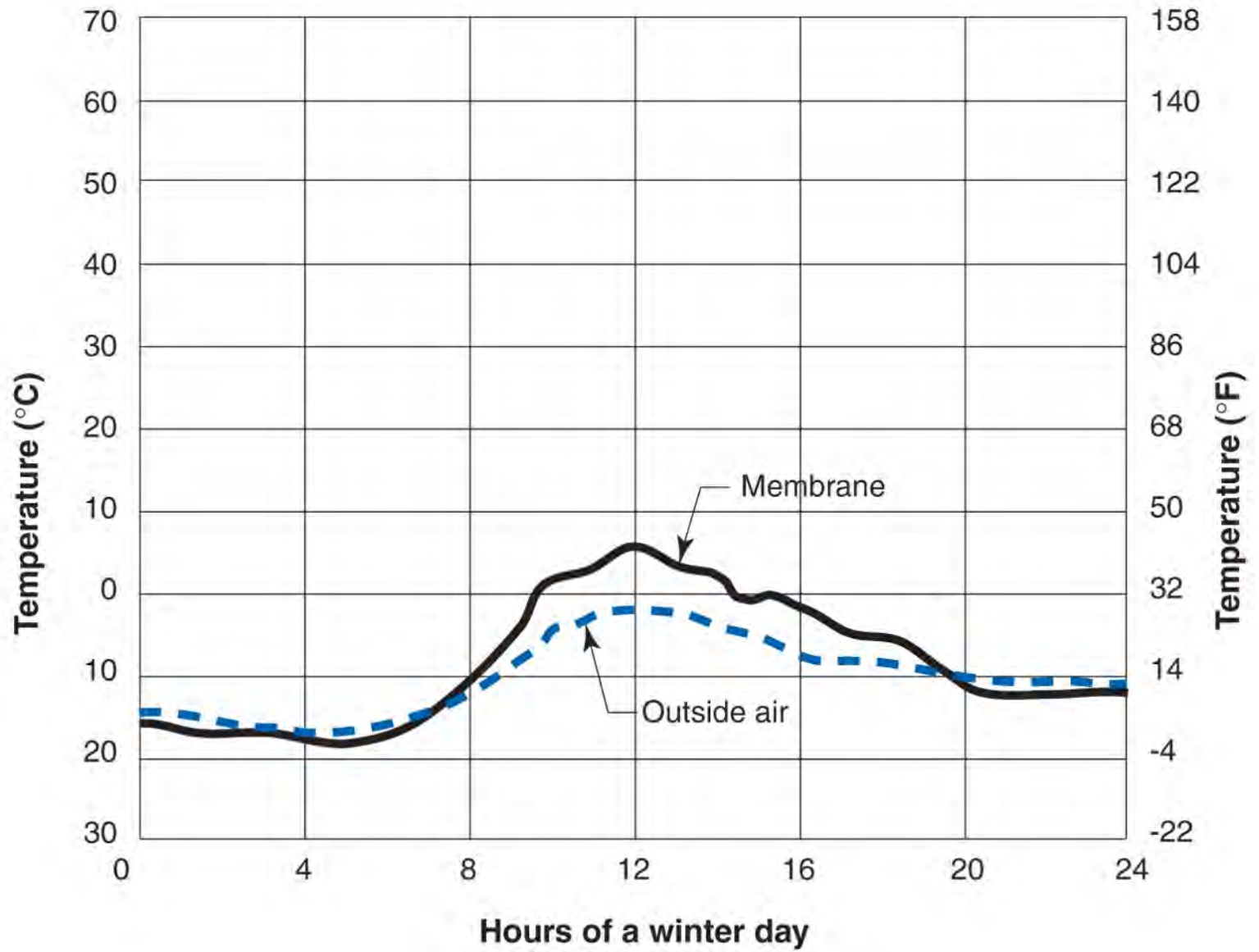
Roofs



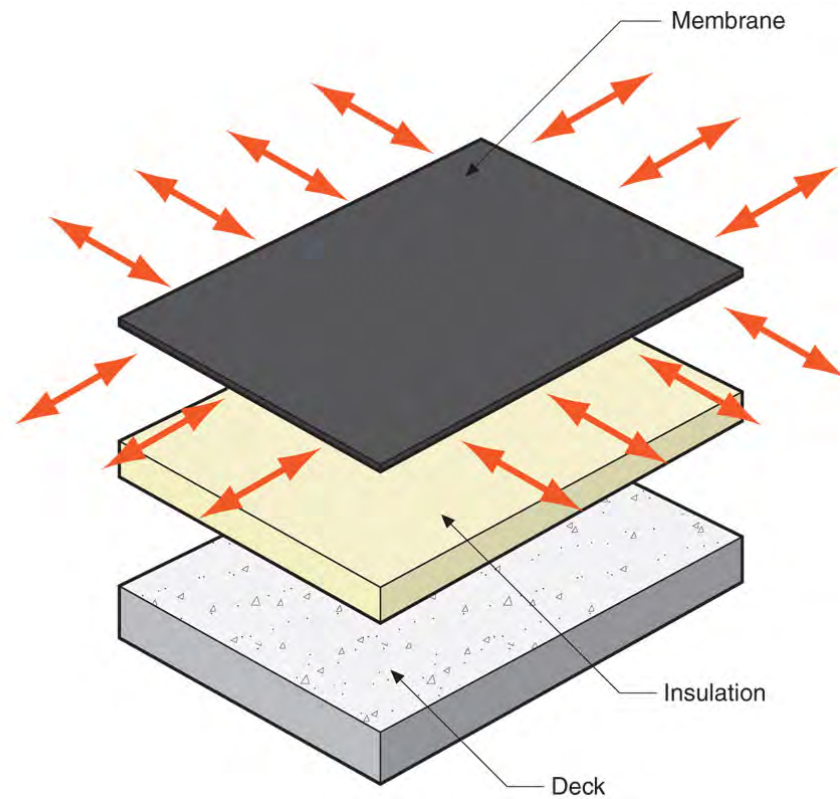
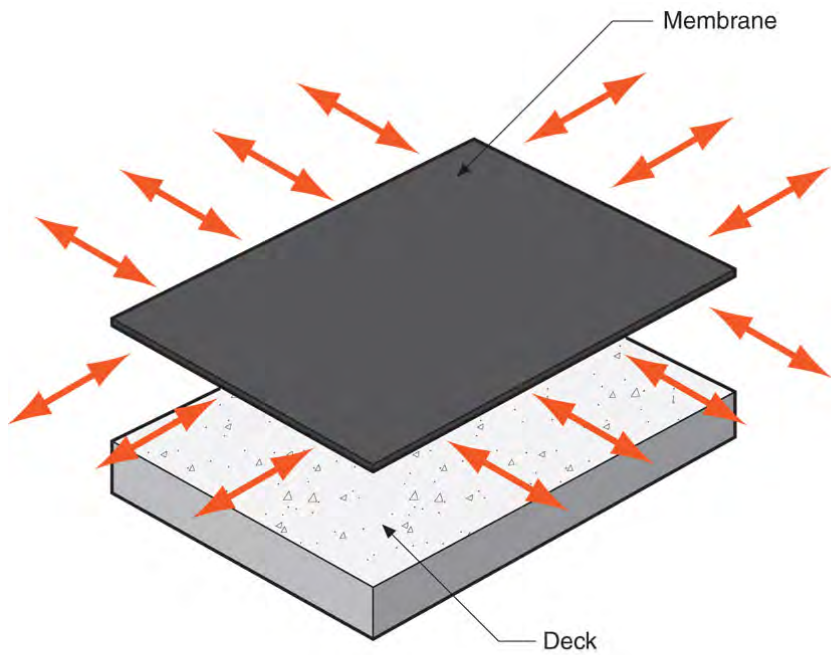
Adapted from Baker, M.; *Roofs*, 1980;
 Courtesy National Research Council of Canada



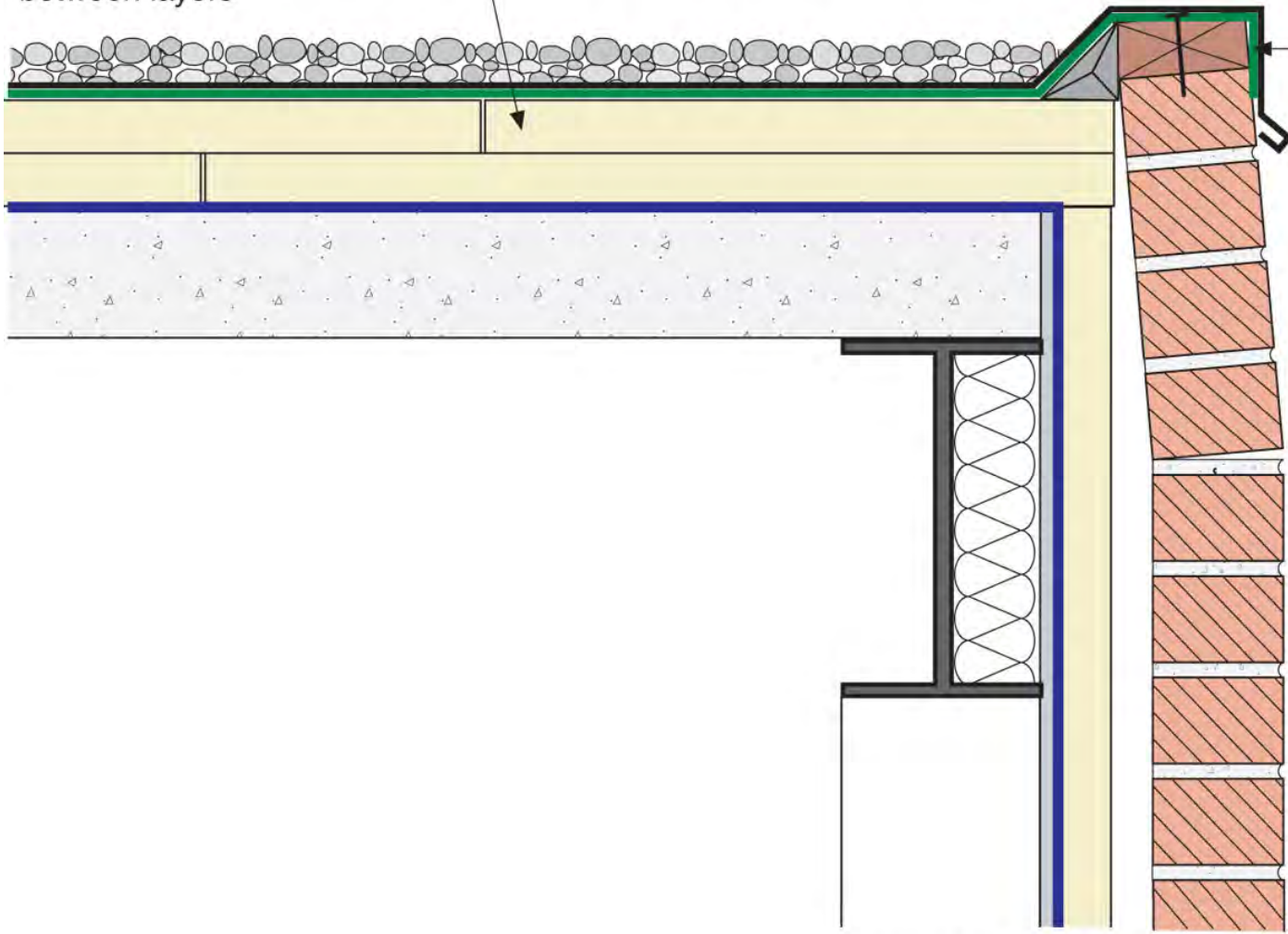
From Baker, M.; *Roofs*, 1980



From Baker, M.; *Roofs*, 1980

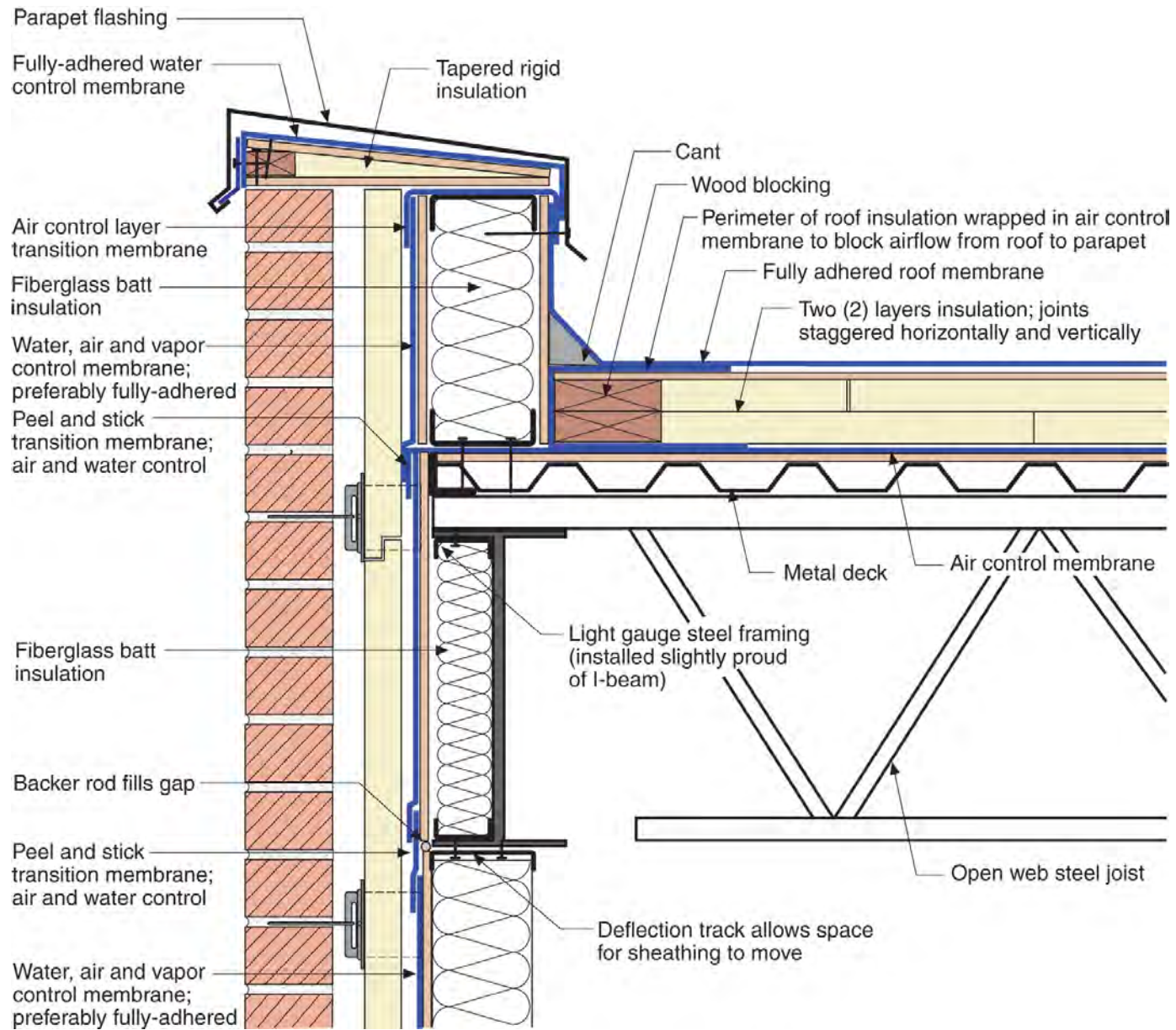


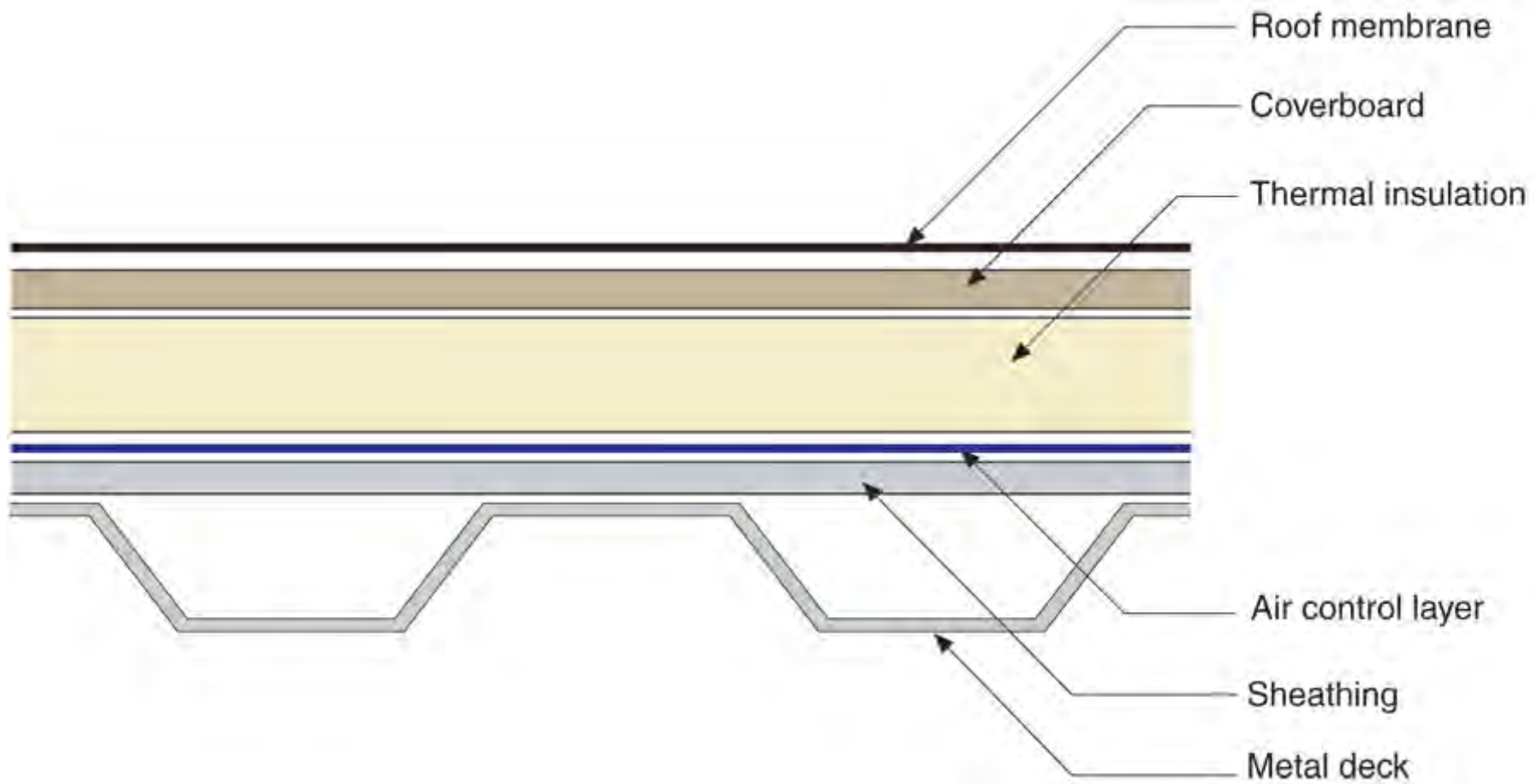
Insulation moved because of poor adhesion to deck and between layers

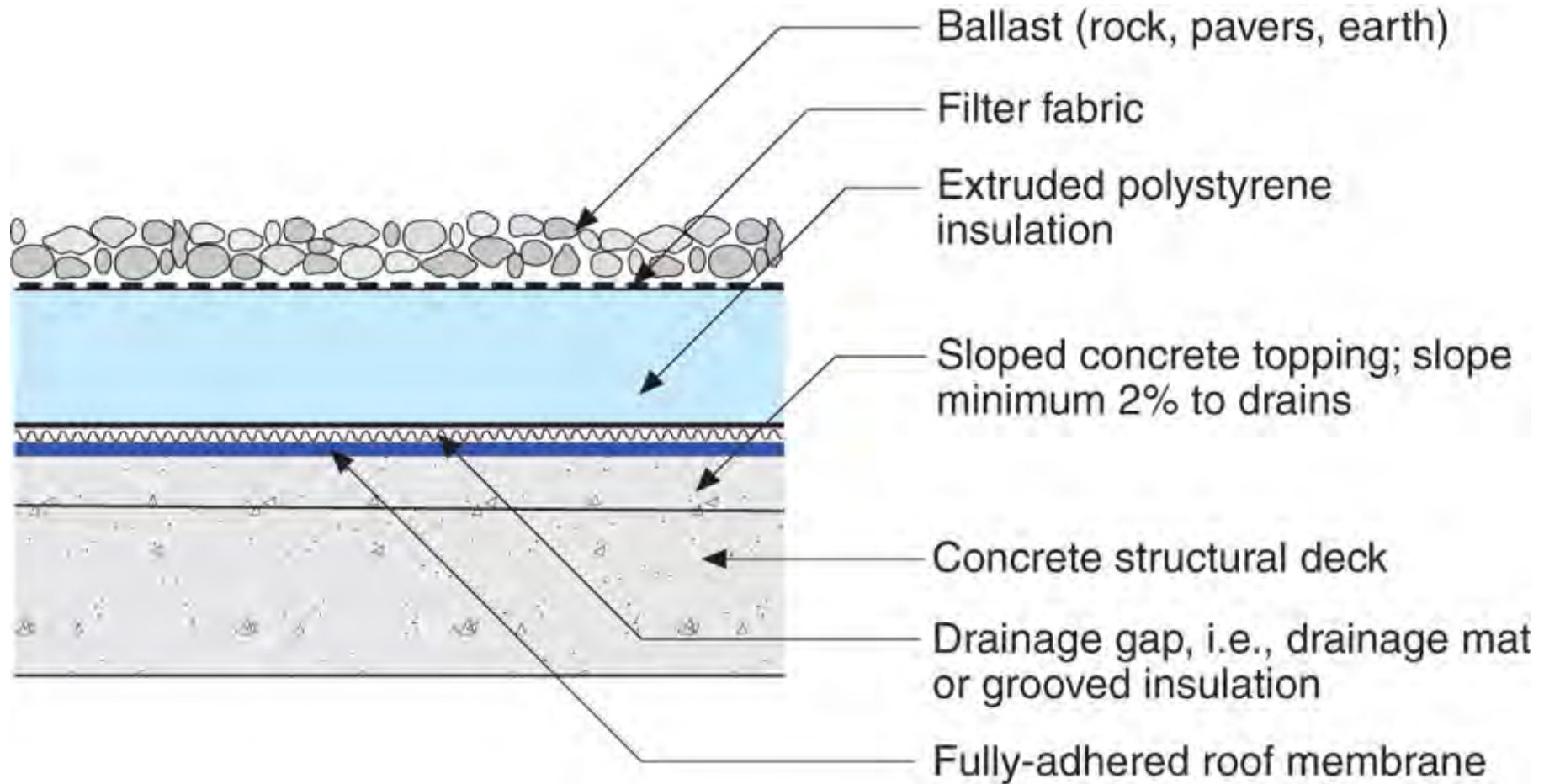


Top four courses of brick and wood blocking pulled inward by contracting membrane

Adapted from Baker, M.; *Roofs*, 1980; Courtesy National Research Council of Canada



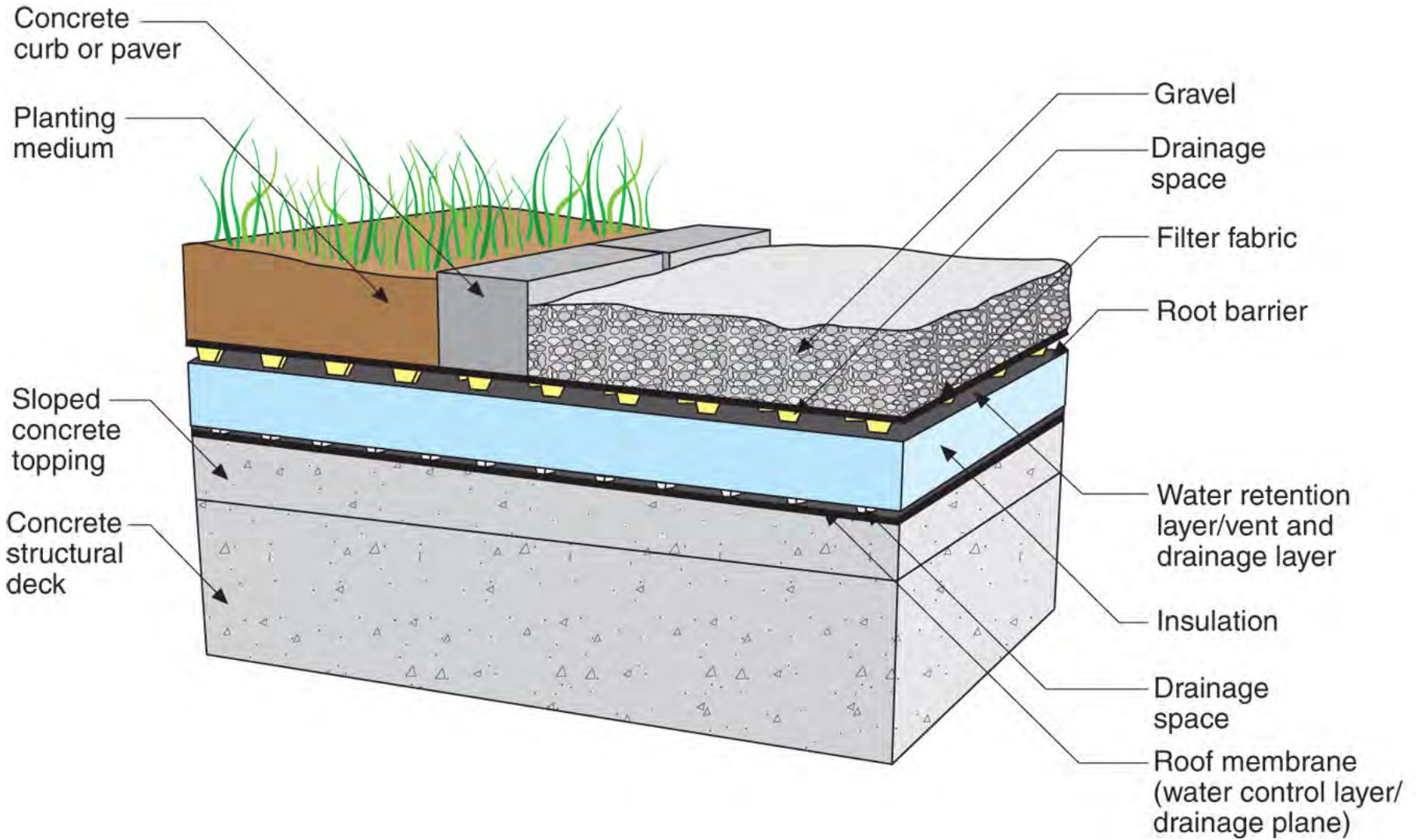




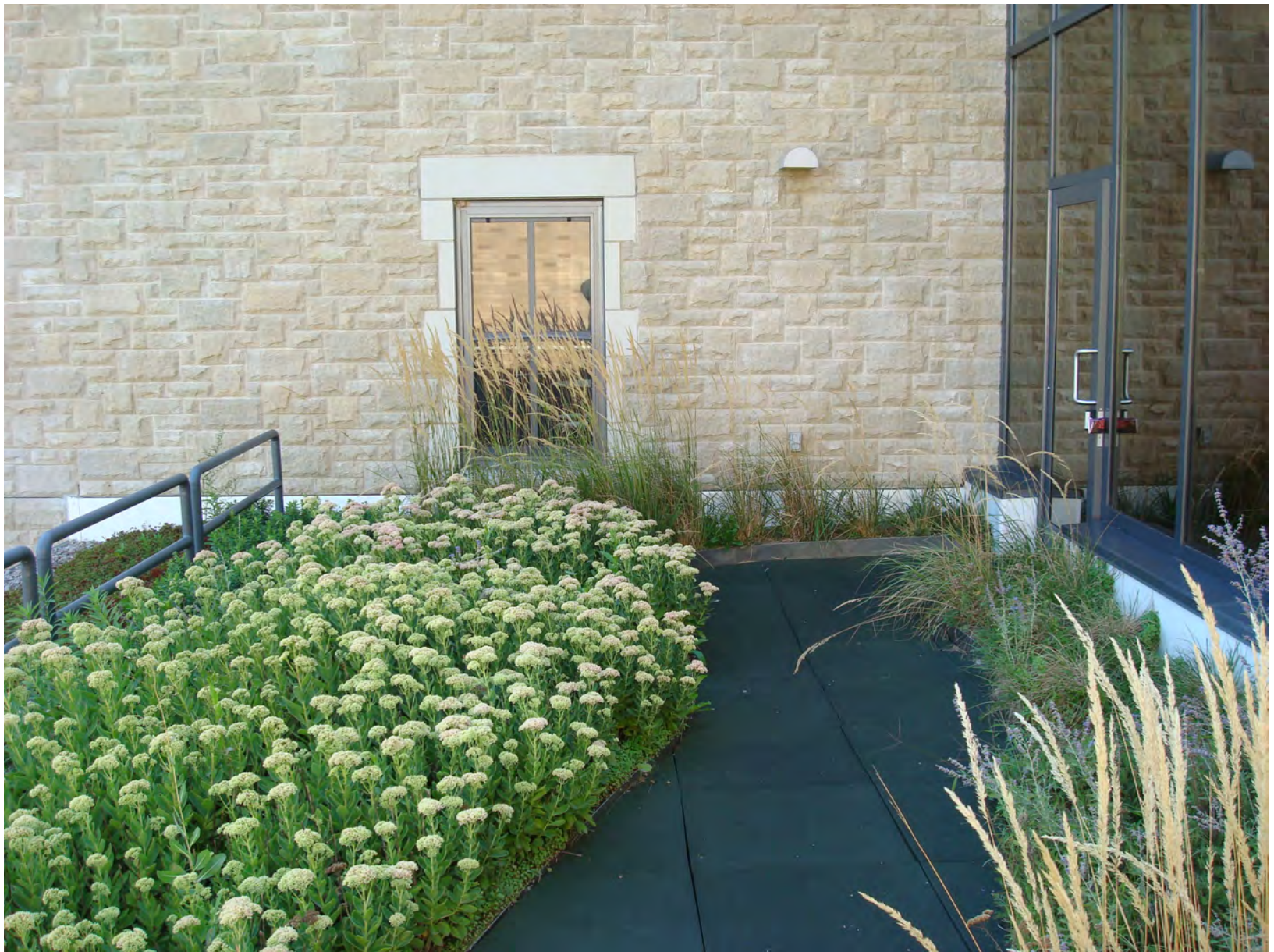


**Really Heavy
Pink Stuff**

**Liquid Waterproofing
over Concrete Deck**

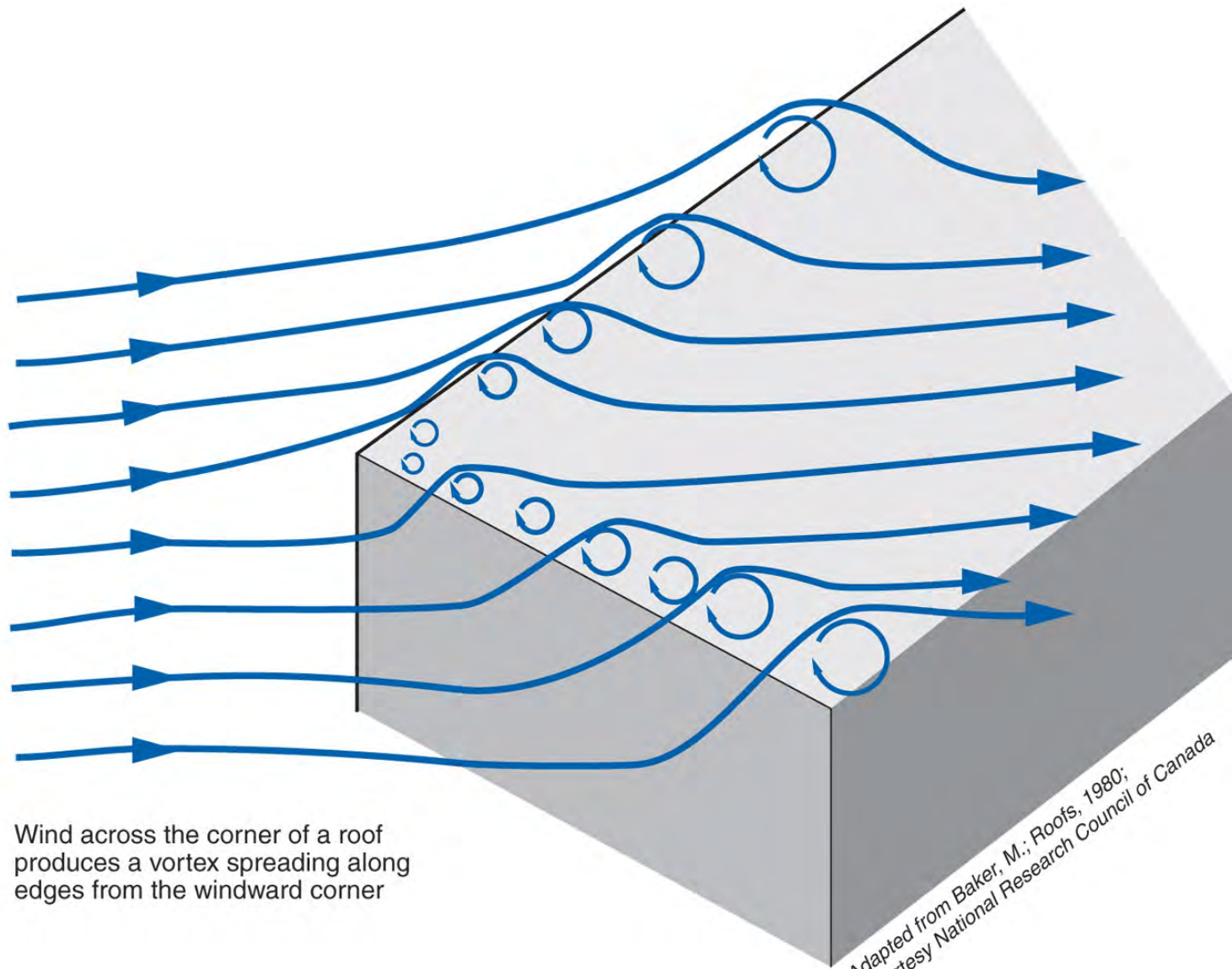






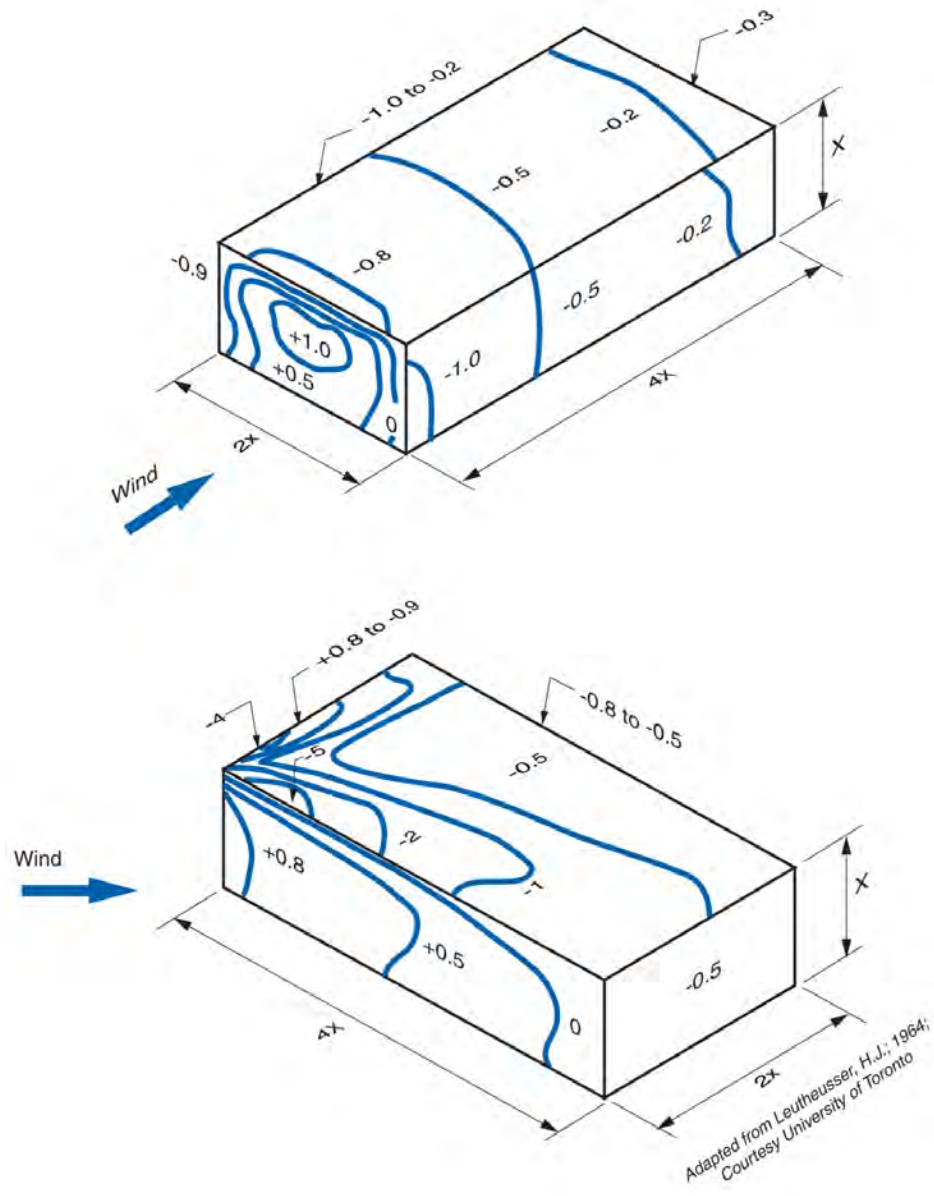


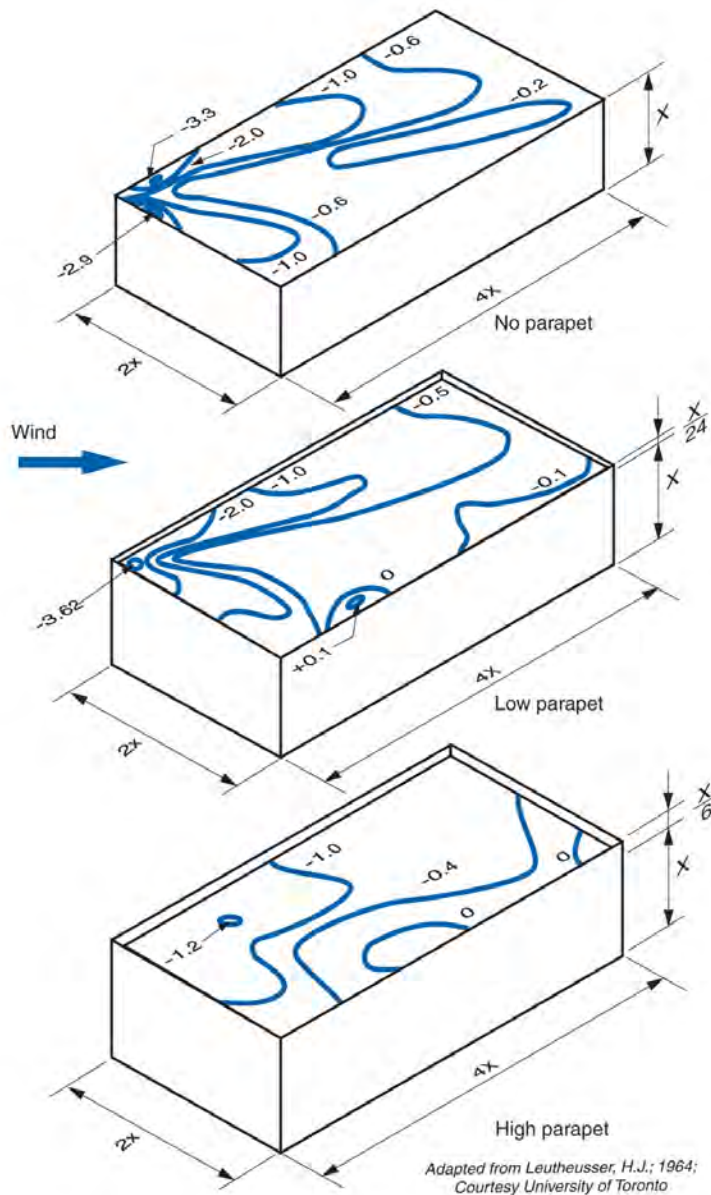


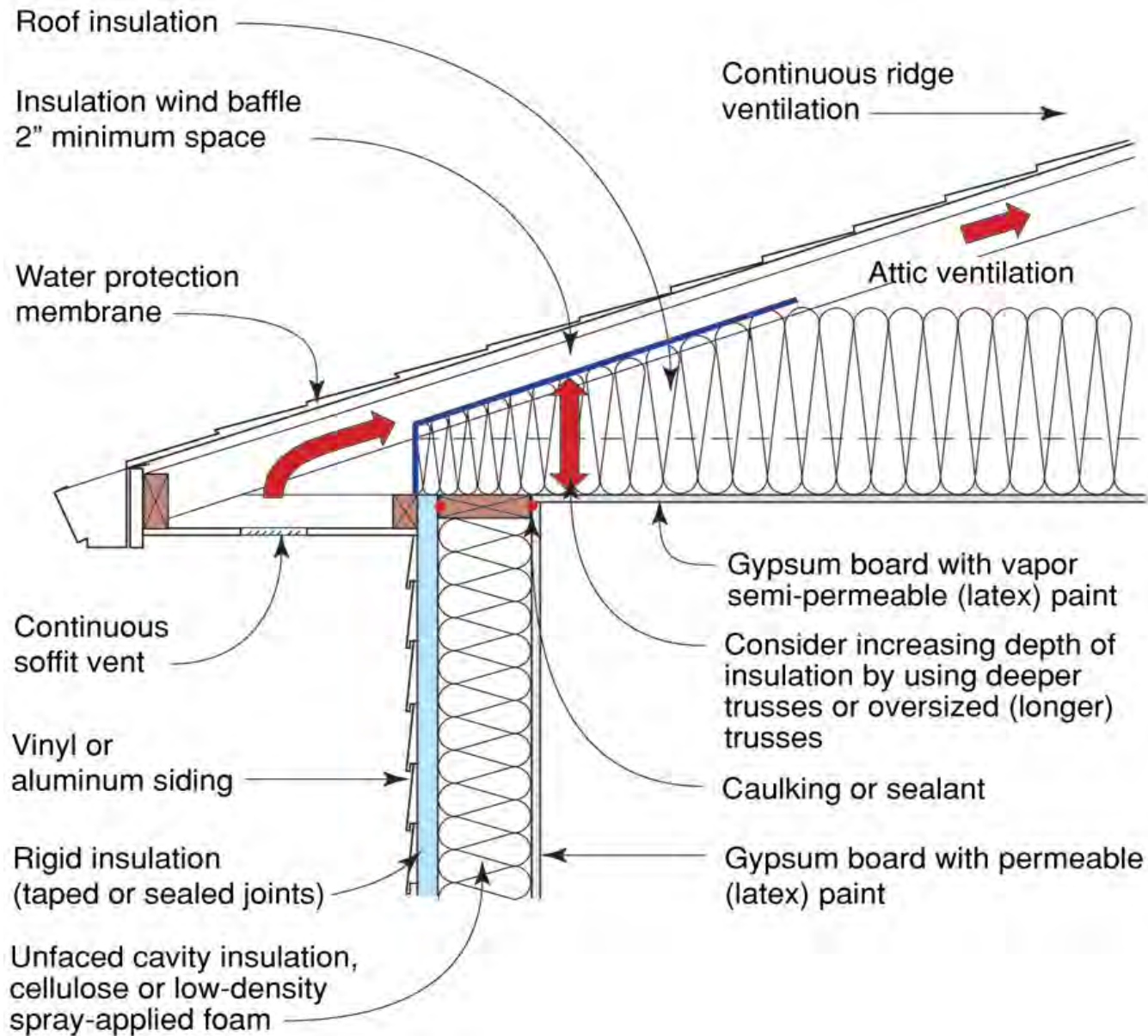


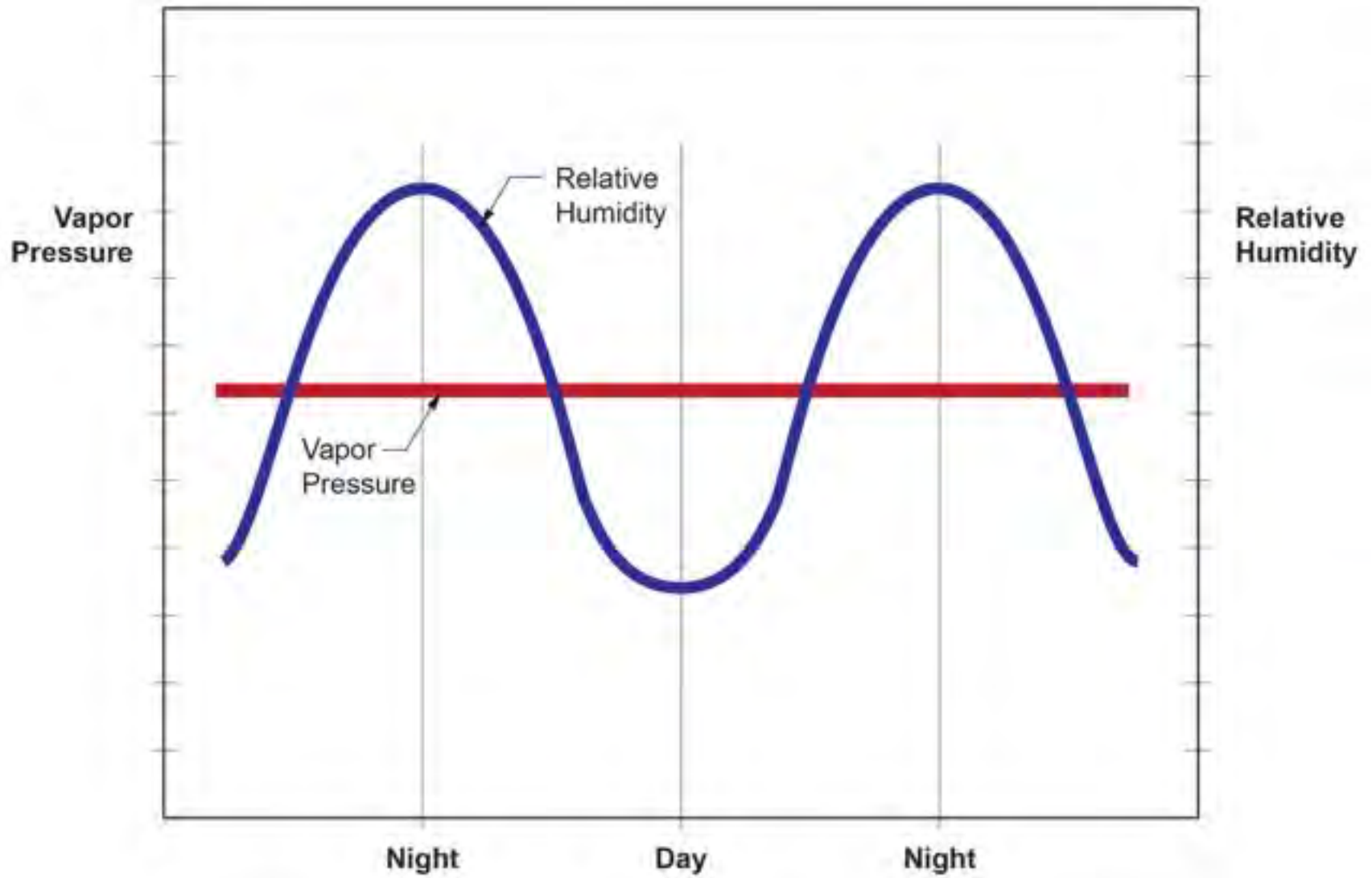
Wind across the corner of a roof produces a vortex spreading along edges from the windward corner

Adapted from Baker, M.: *Roofs*, 1980;
Courtesy National Research Council of Canada

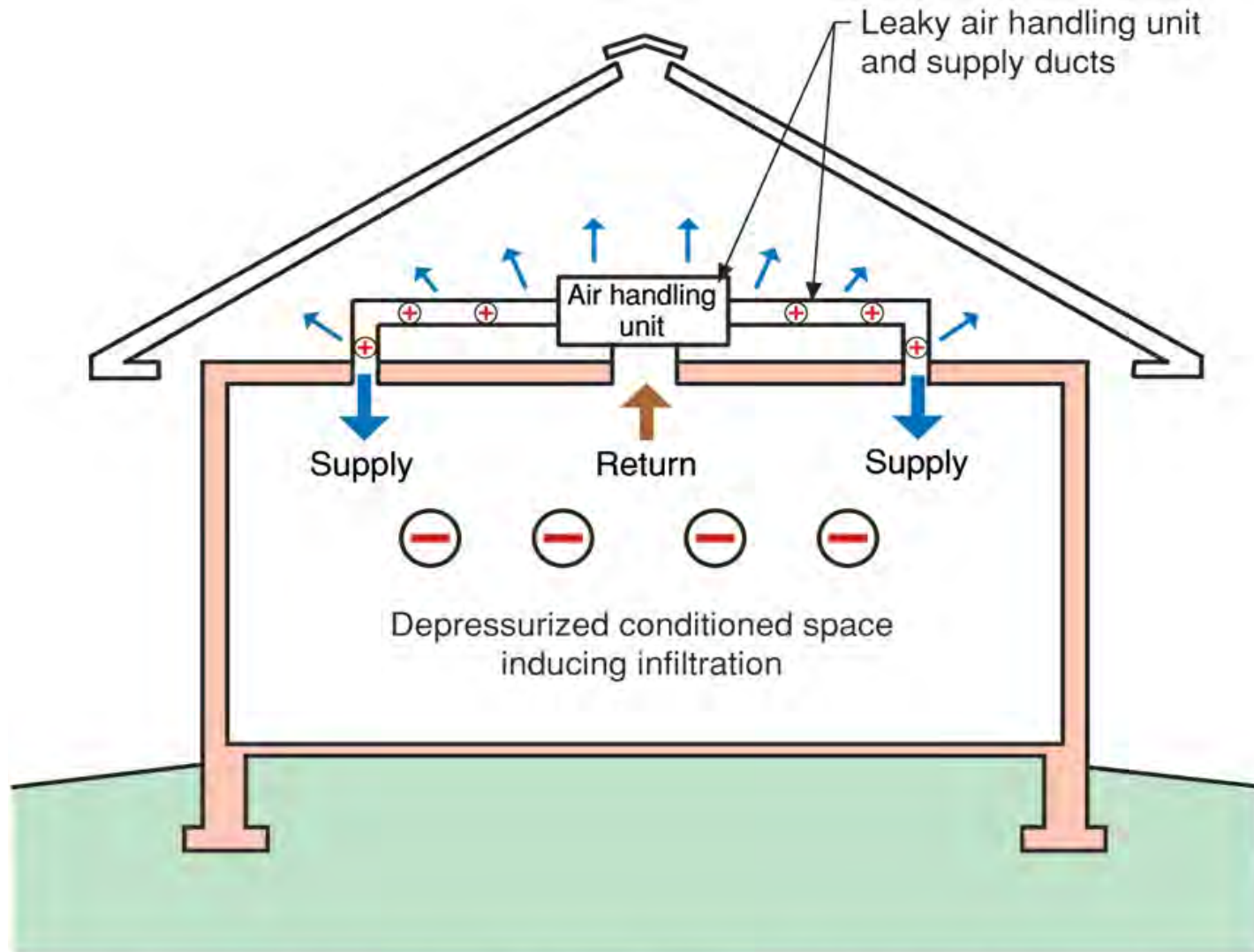












Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

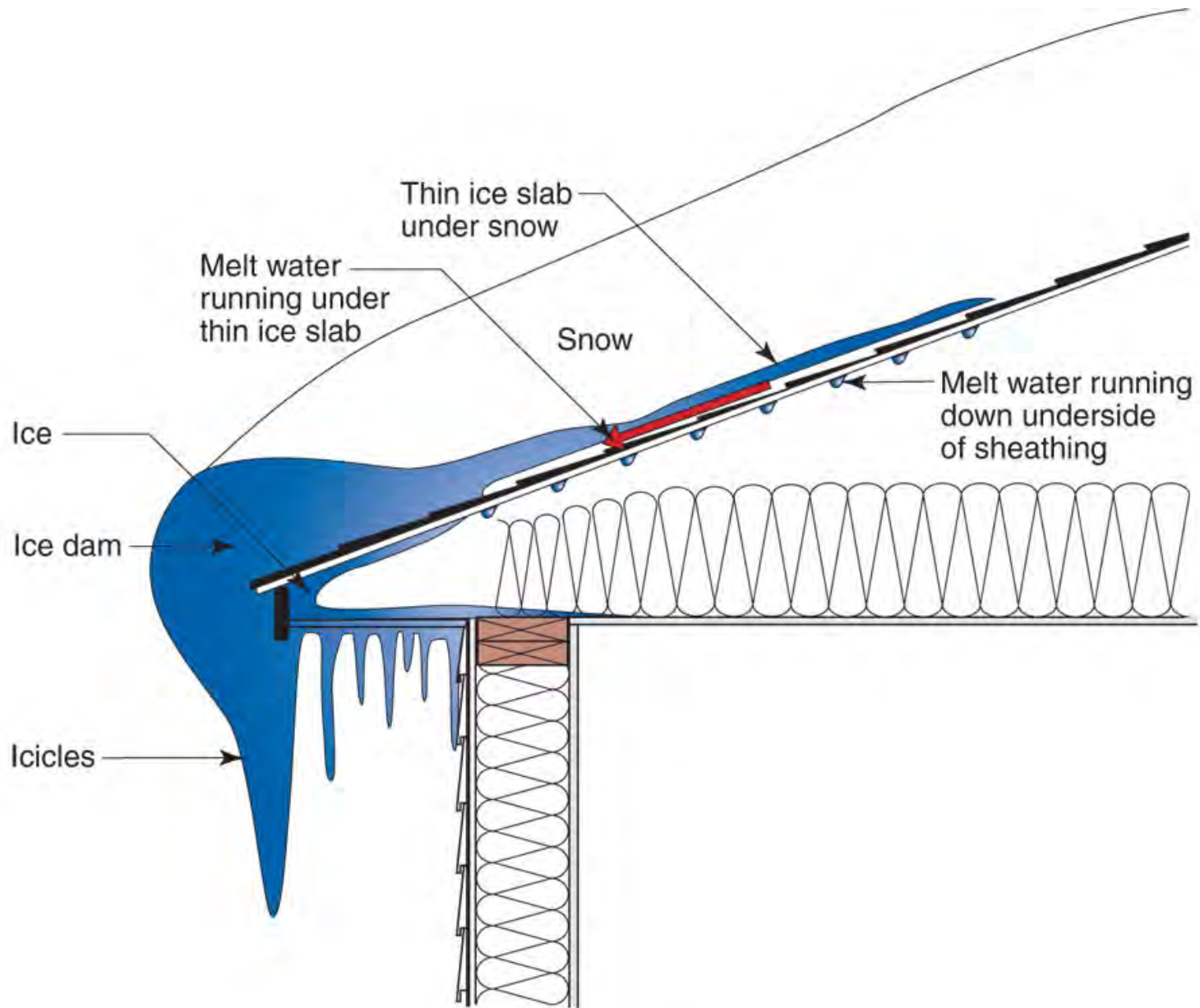




Ice Dams













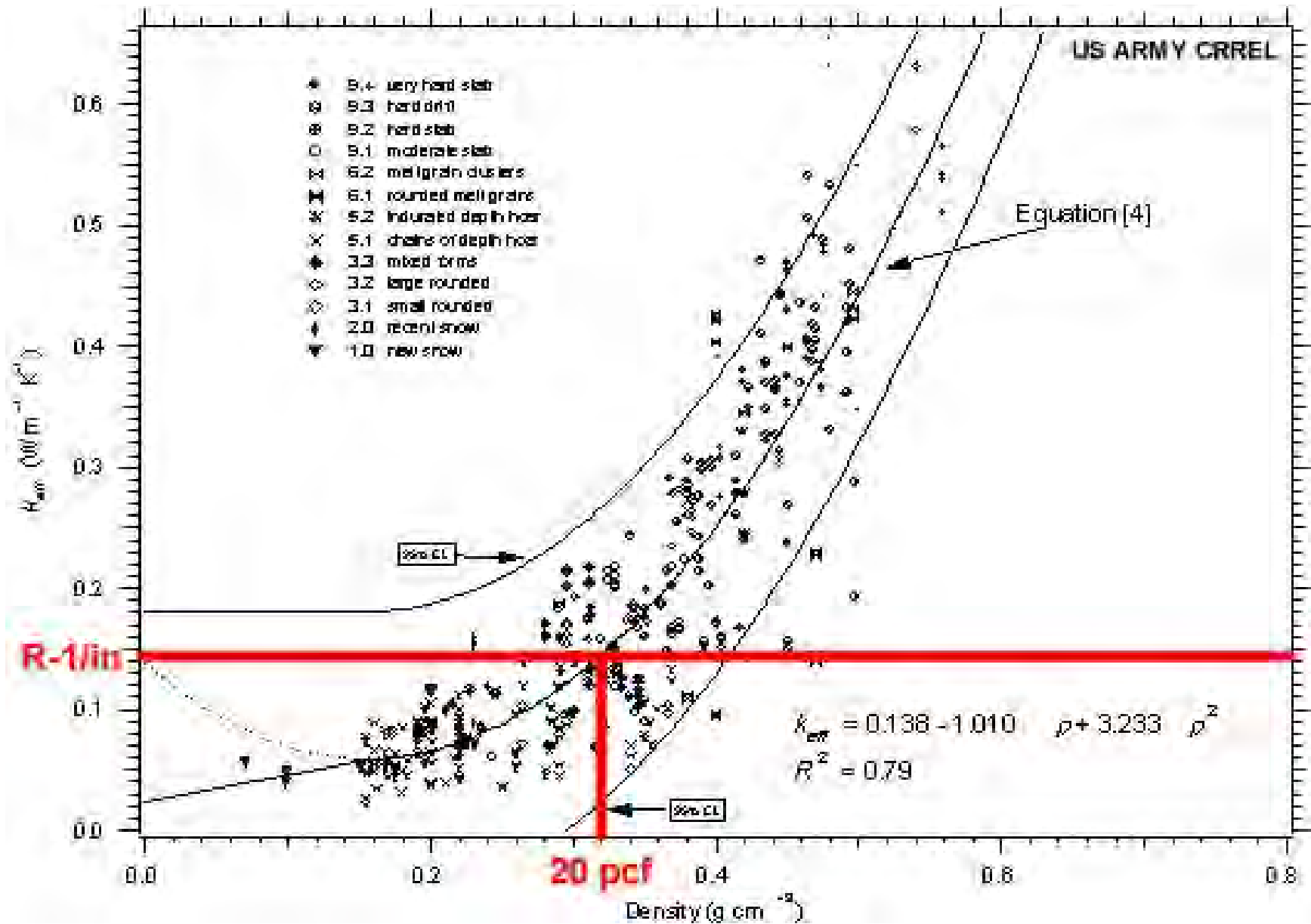






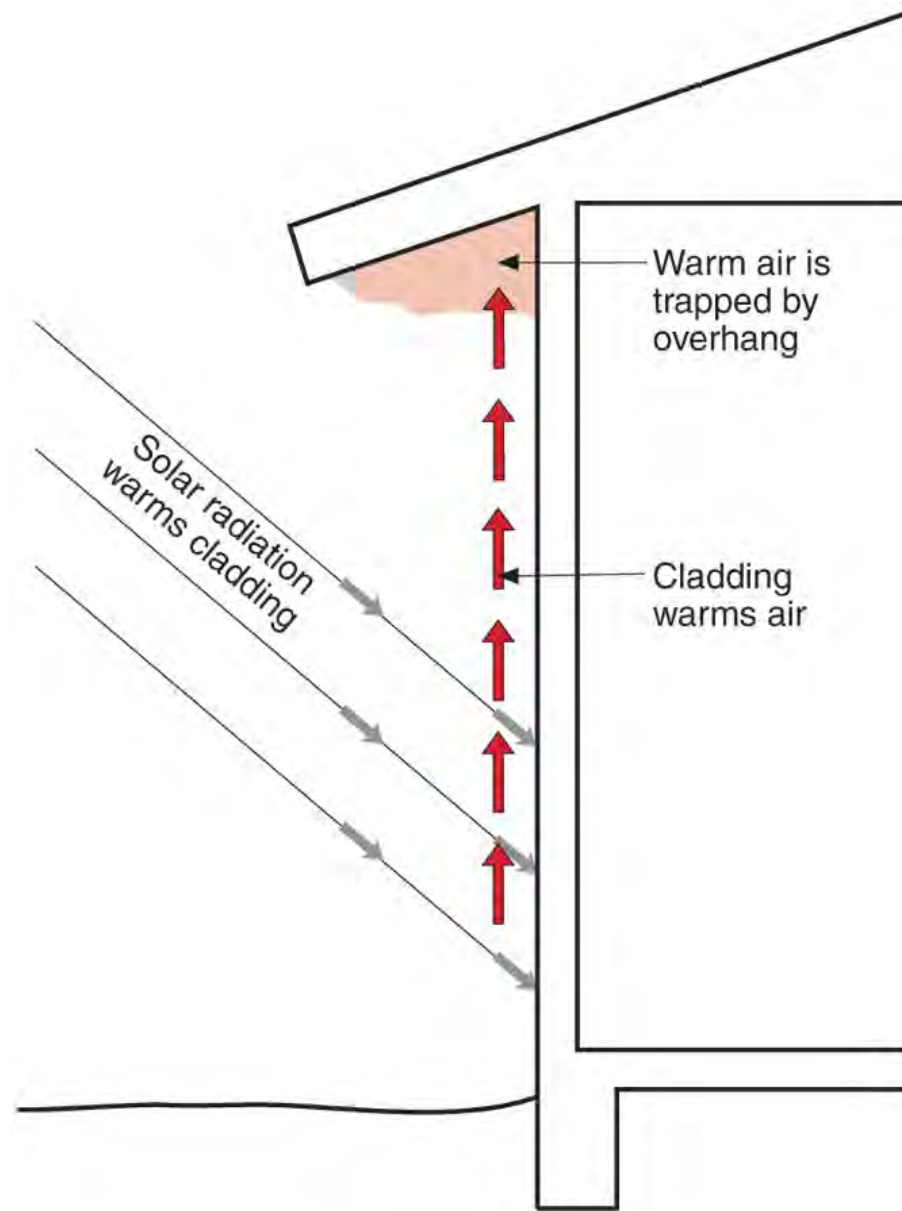










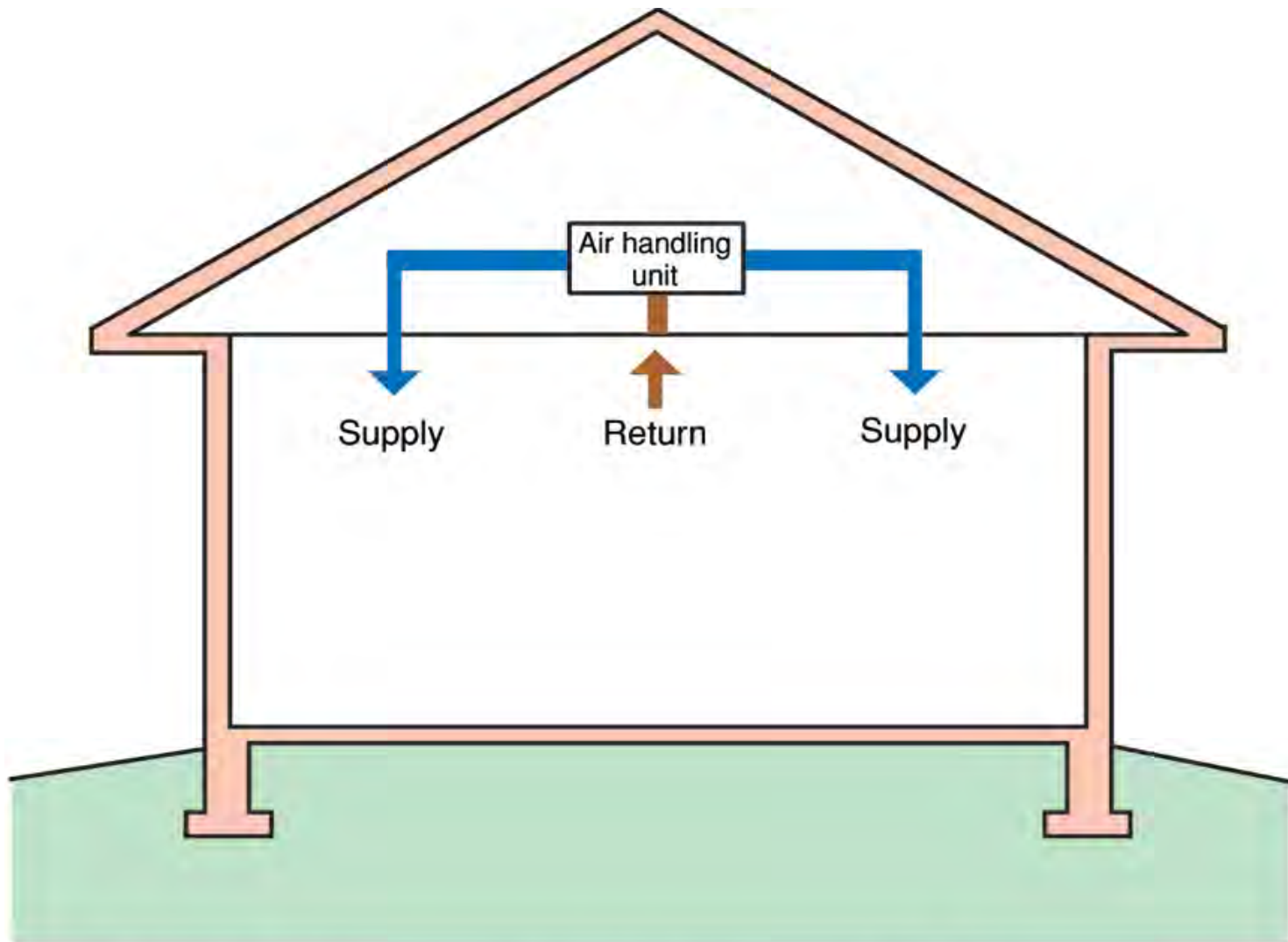












Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.

