

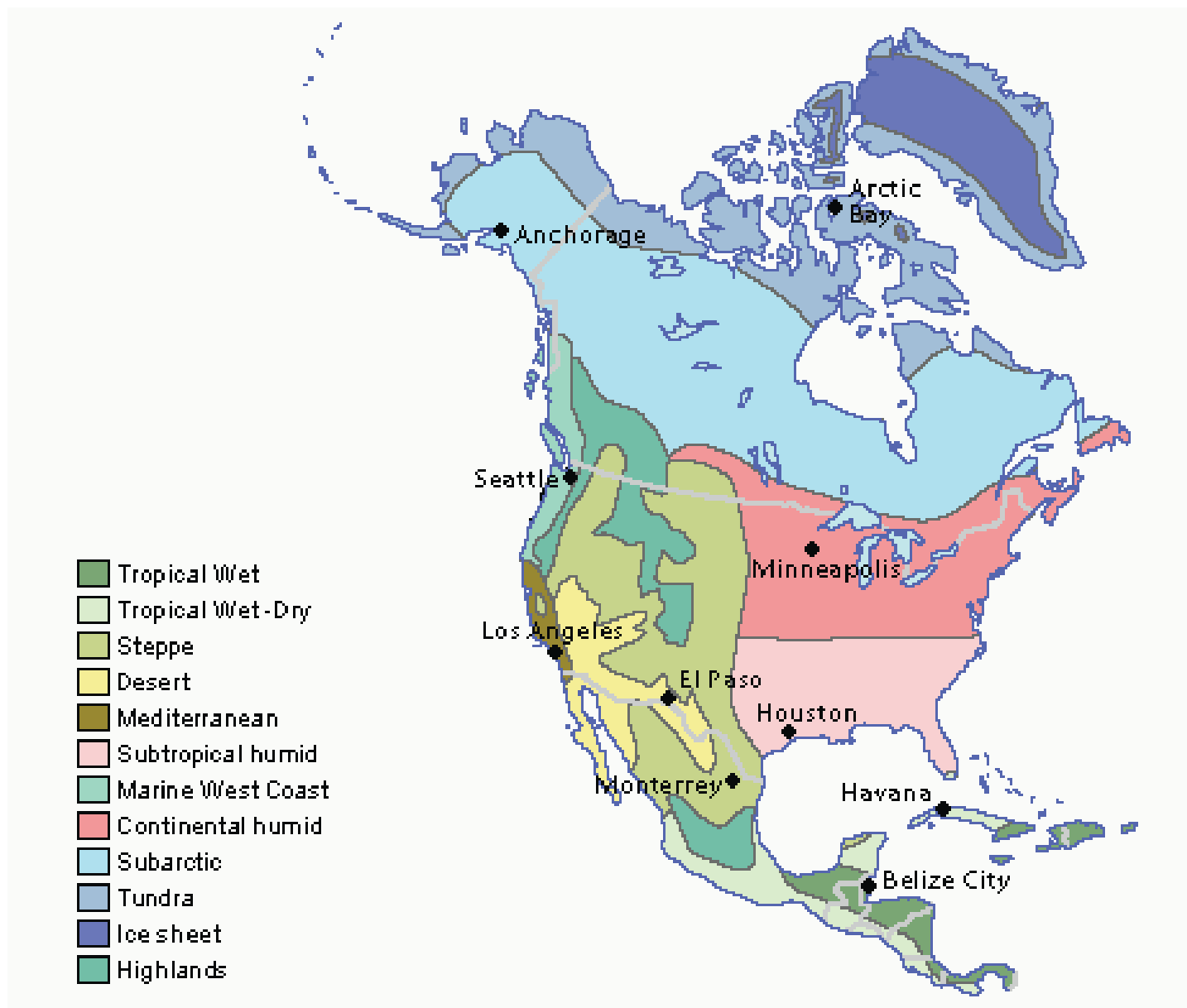


**ICAA Convention
& Trade Show**
October 10–12, 2019
Phoenix, Arizona

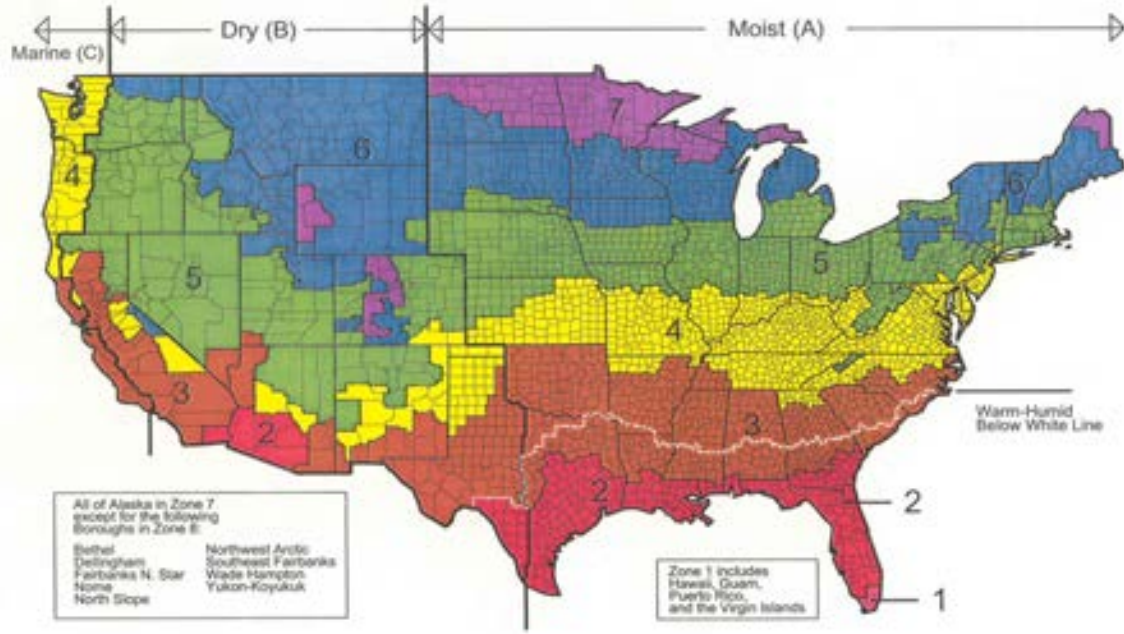
Transitioning from Traditional Insulation Contractor to Building Enclosure Expert

Joseph Lstiburek, Ph.D., P.Eng., ASHRAE Fellow





Map of DOE's Proposed Climate Zones

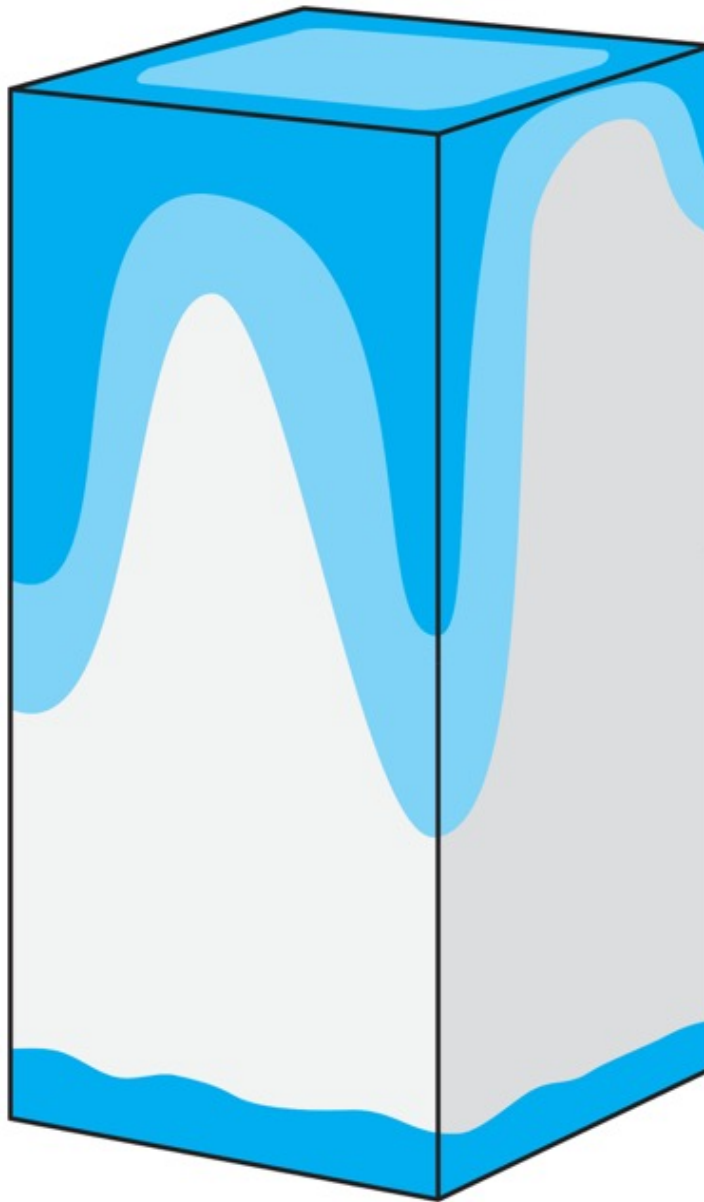


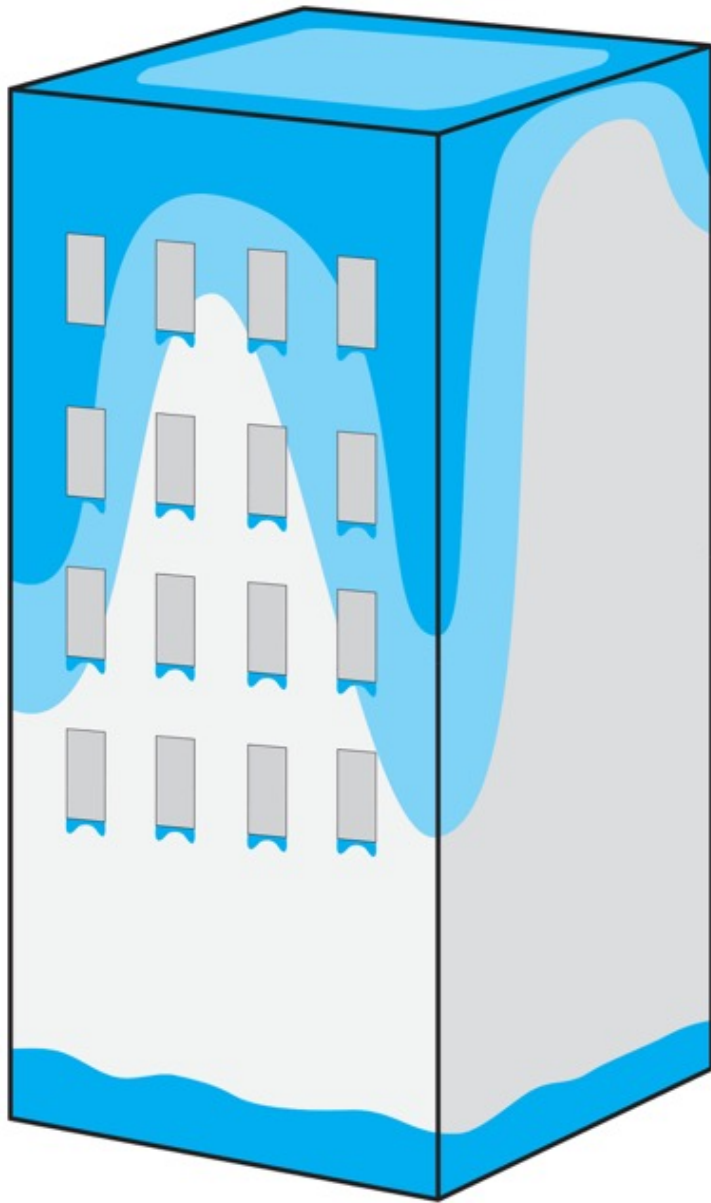
March 24, 2003



Exposure

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



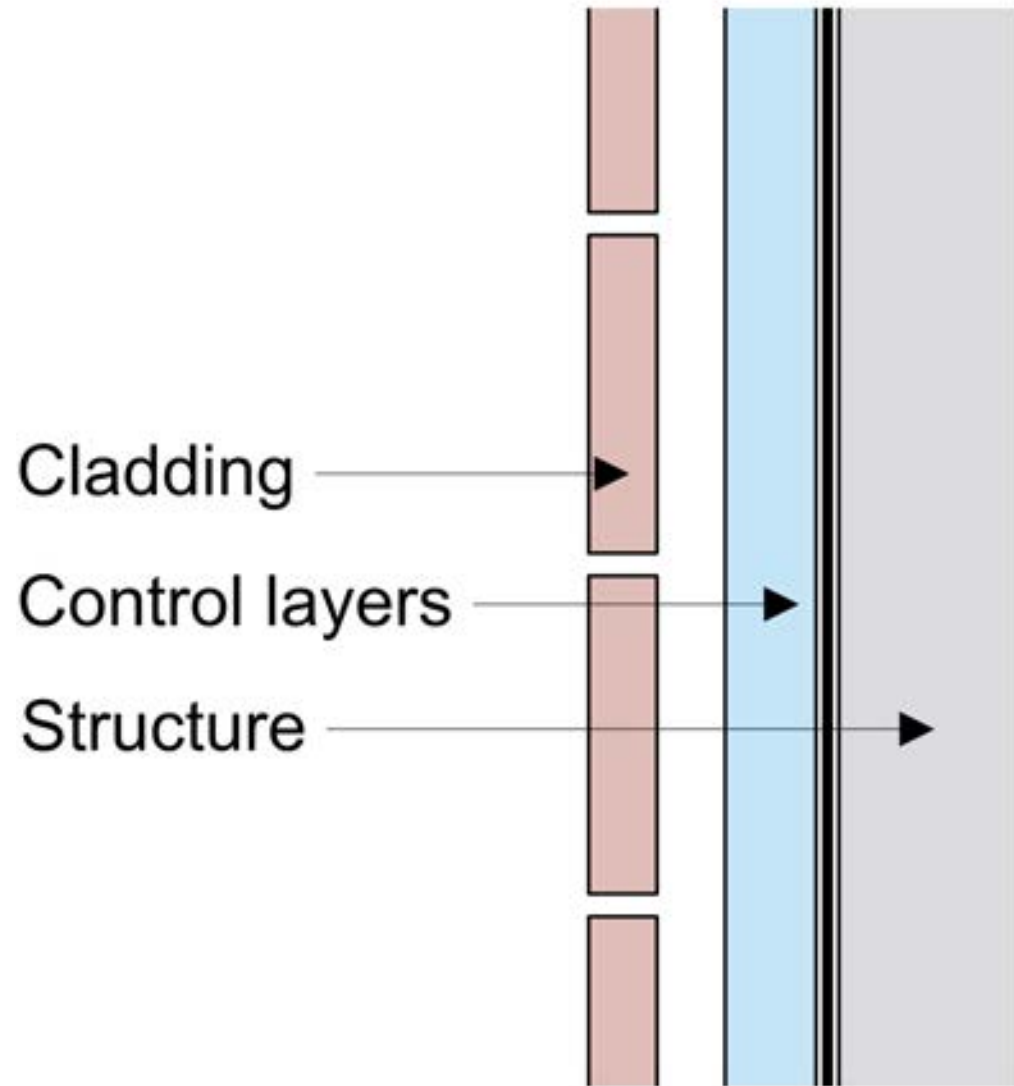


Water Control Layer

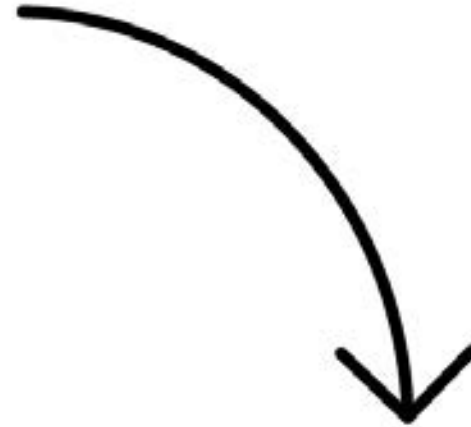
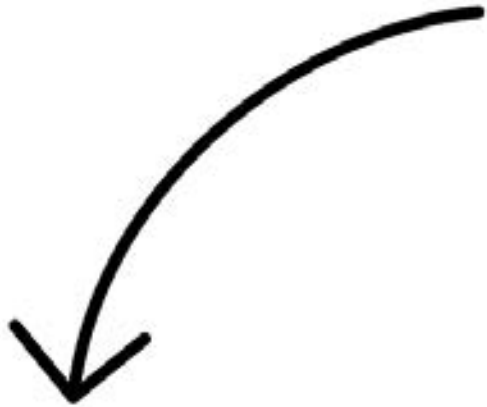
Air Control Layer

Vapor Control Layer

Thermal Control Layer



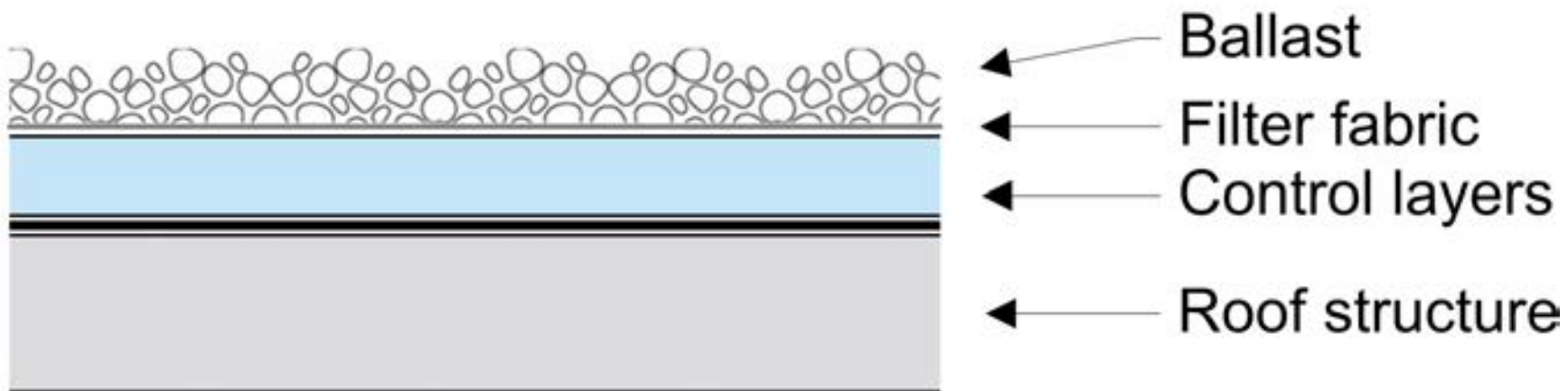
Wall

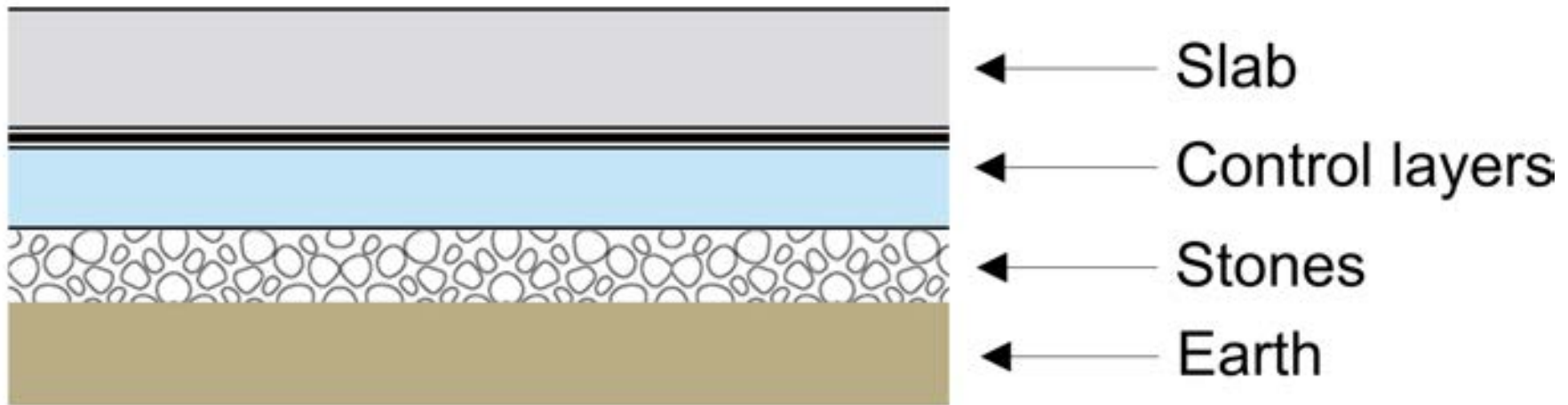


Slab



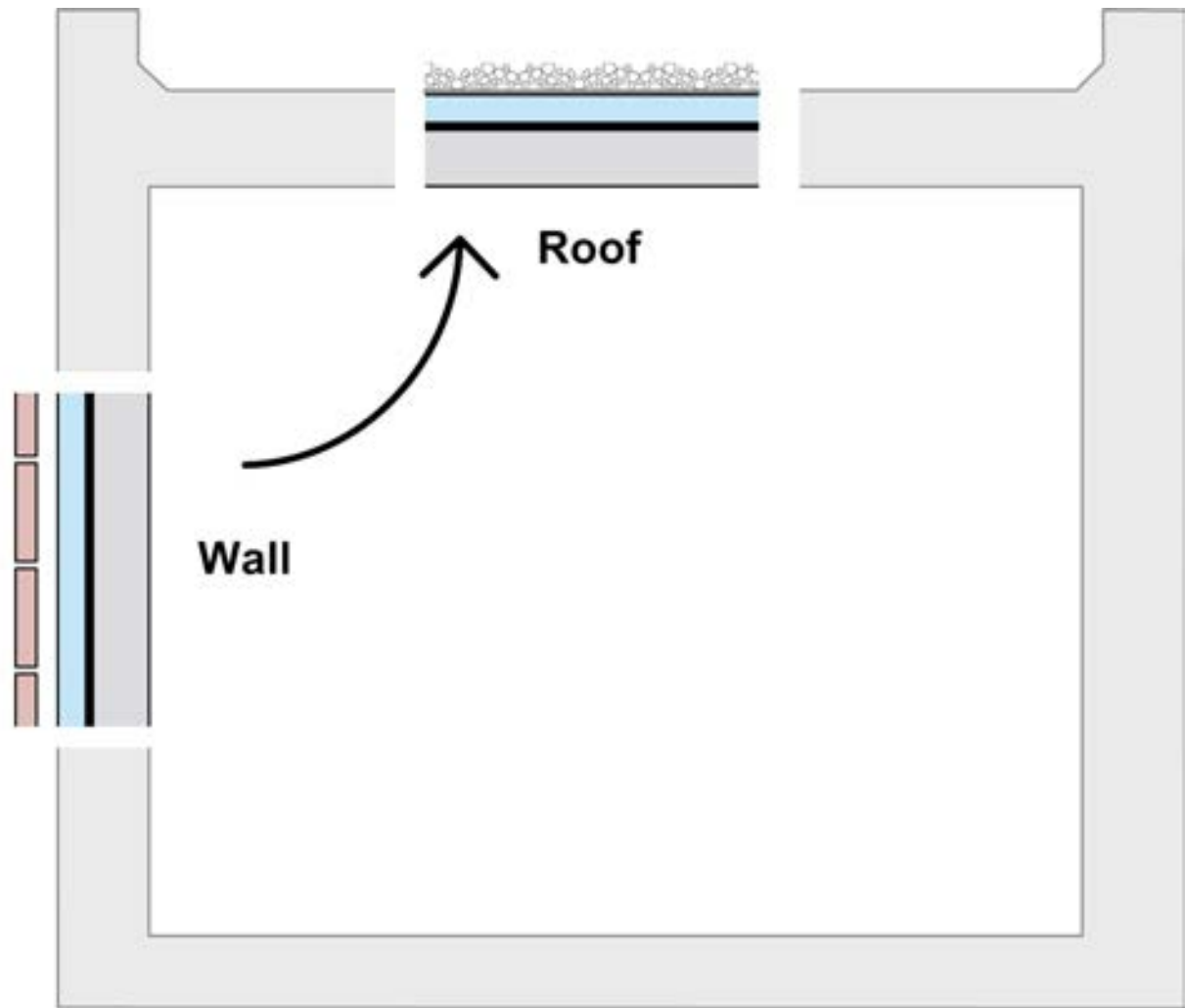
Roof

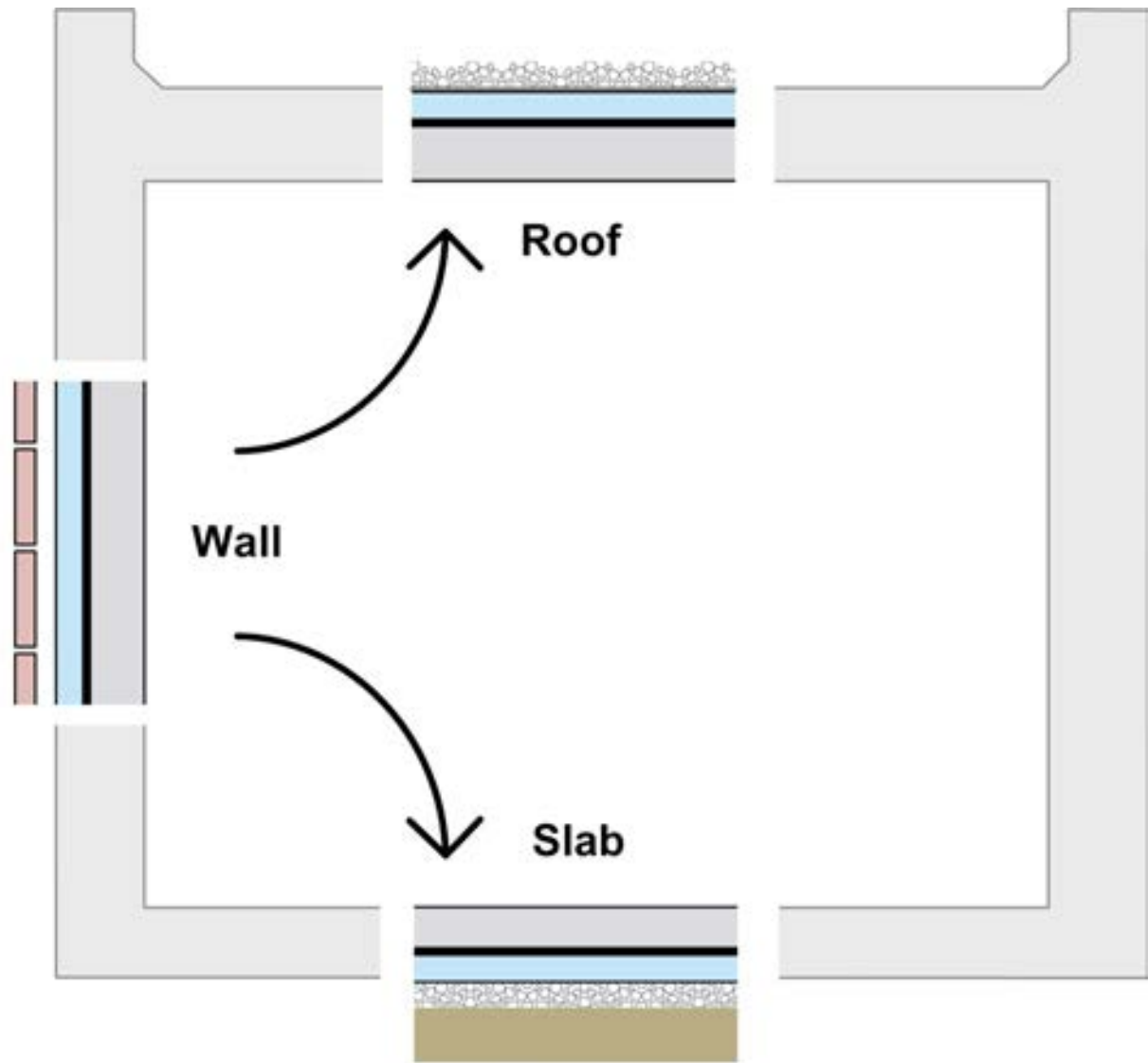


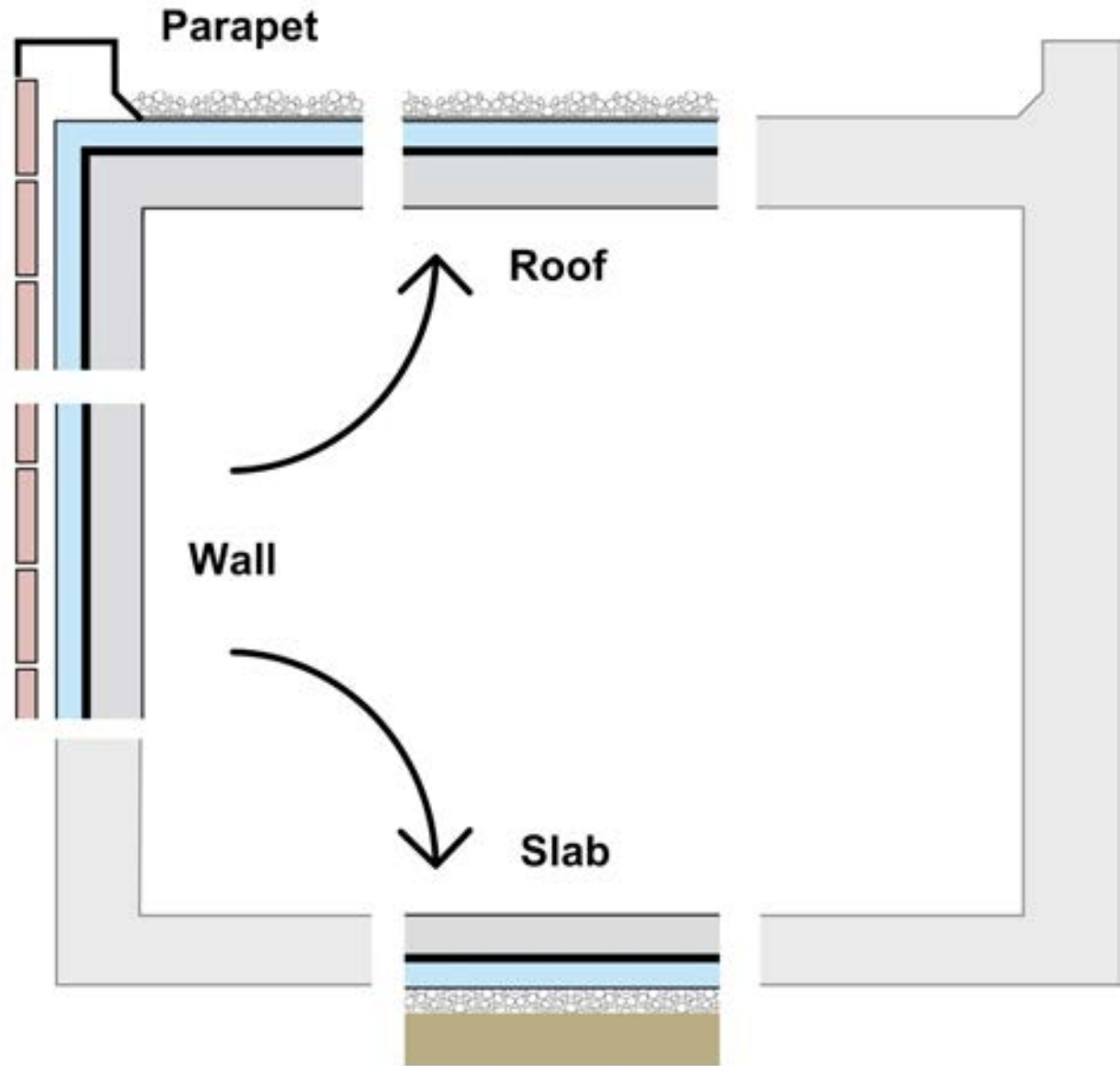


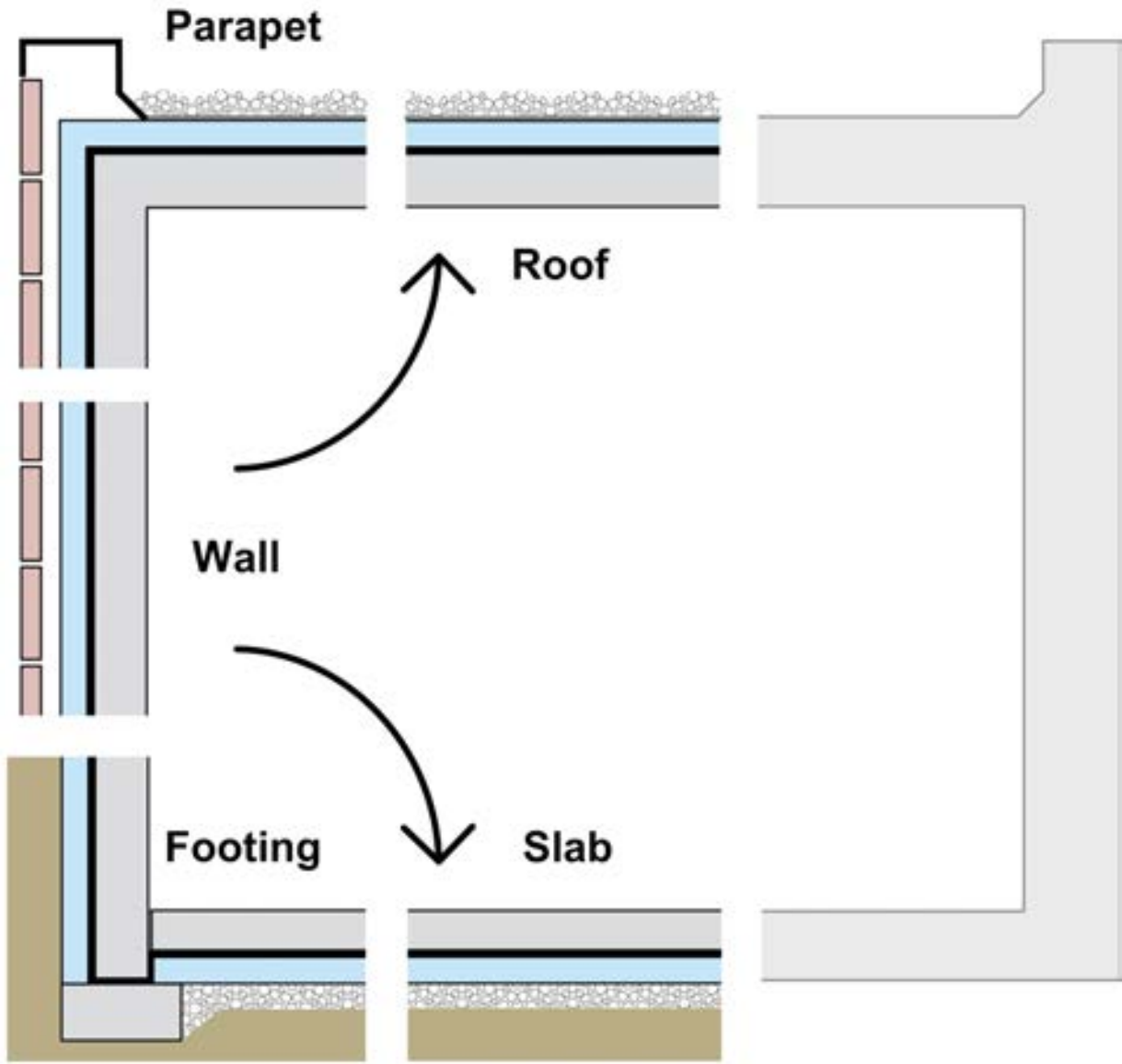


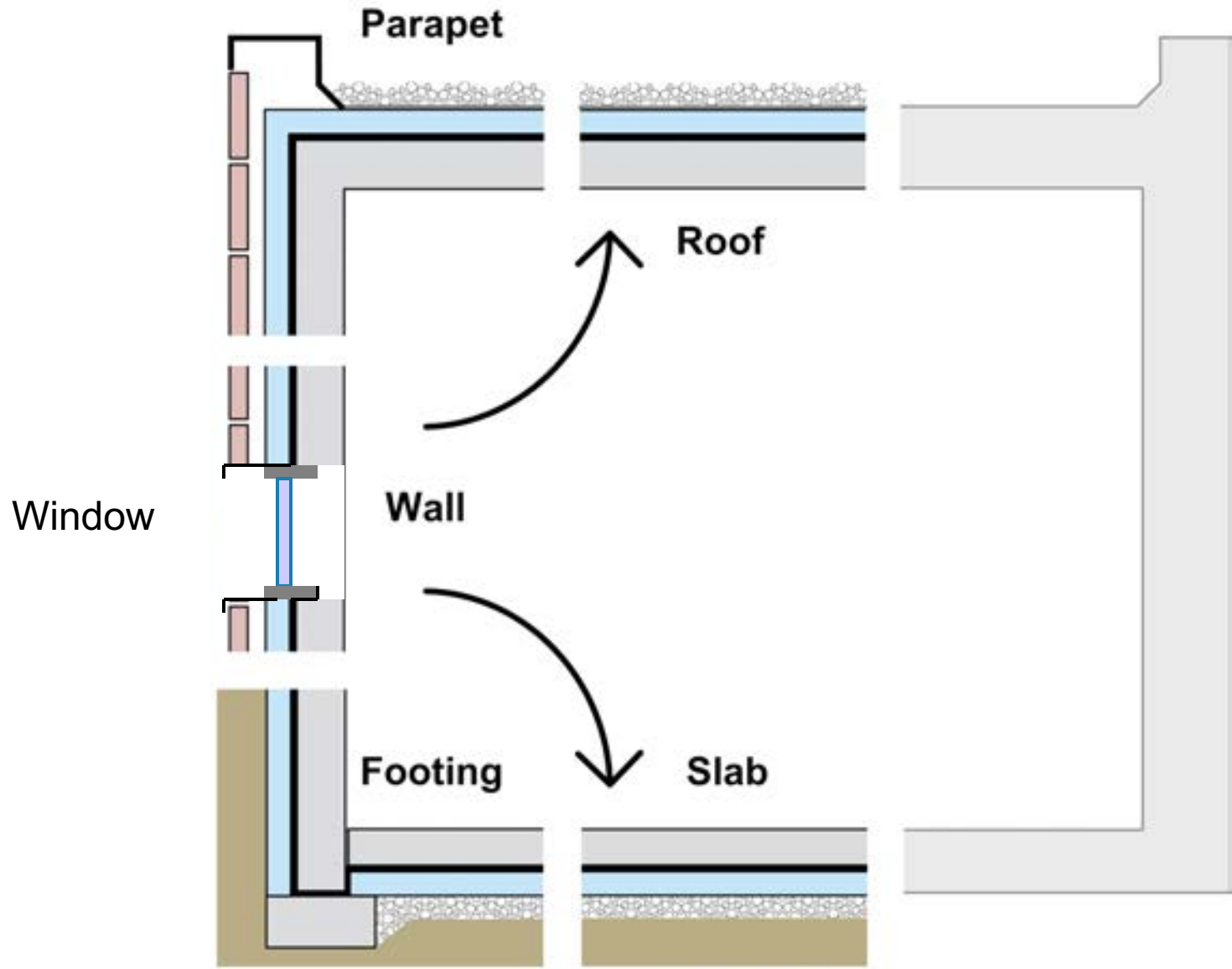




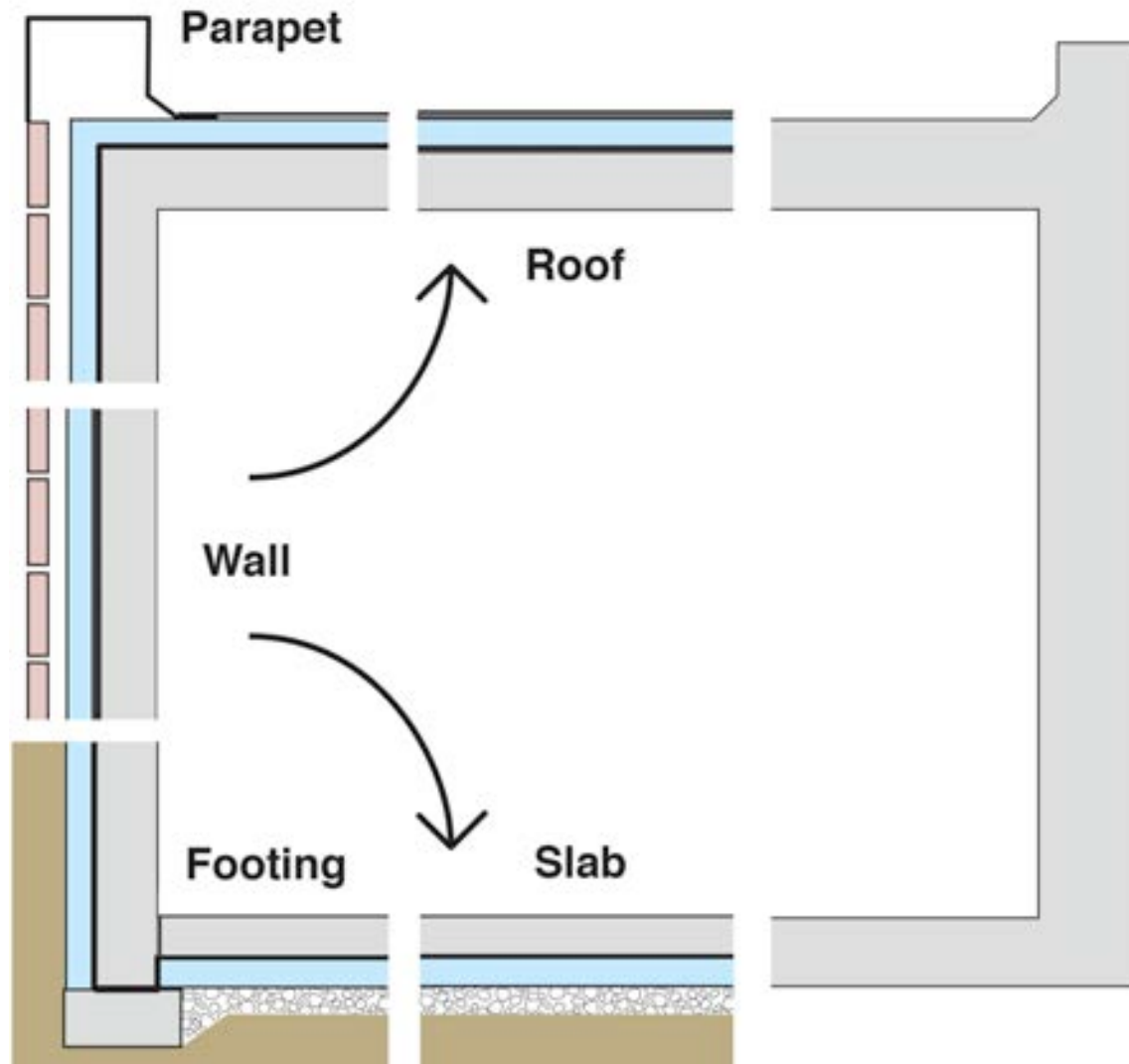




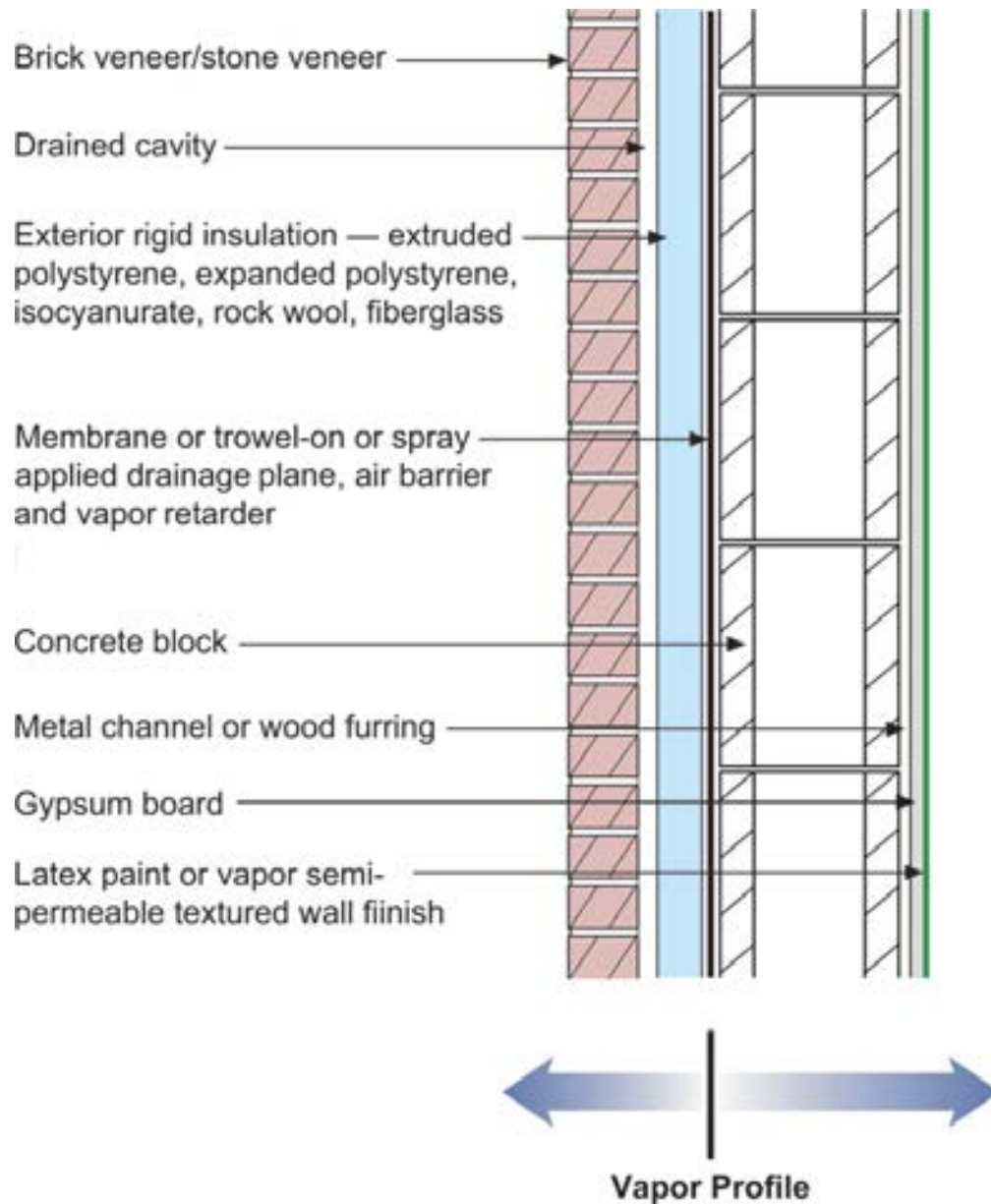


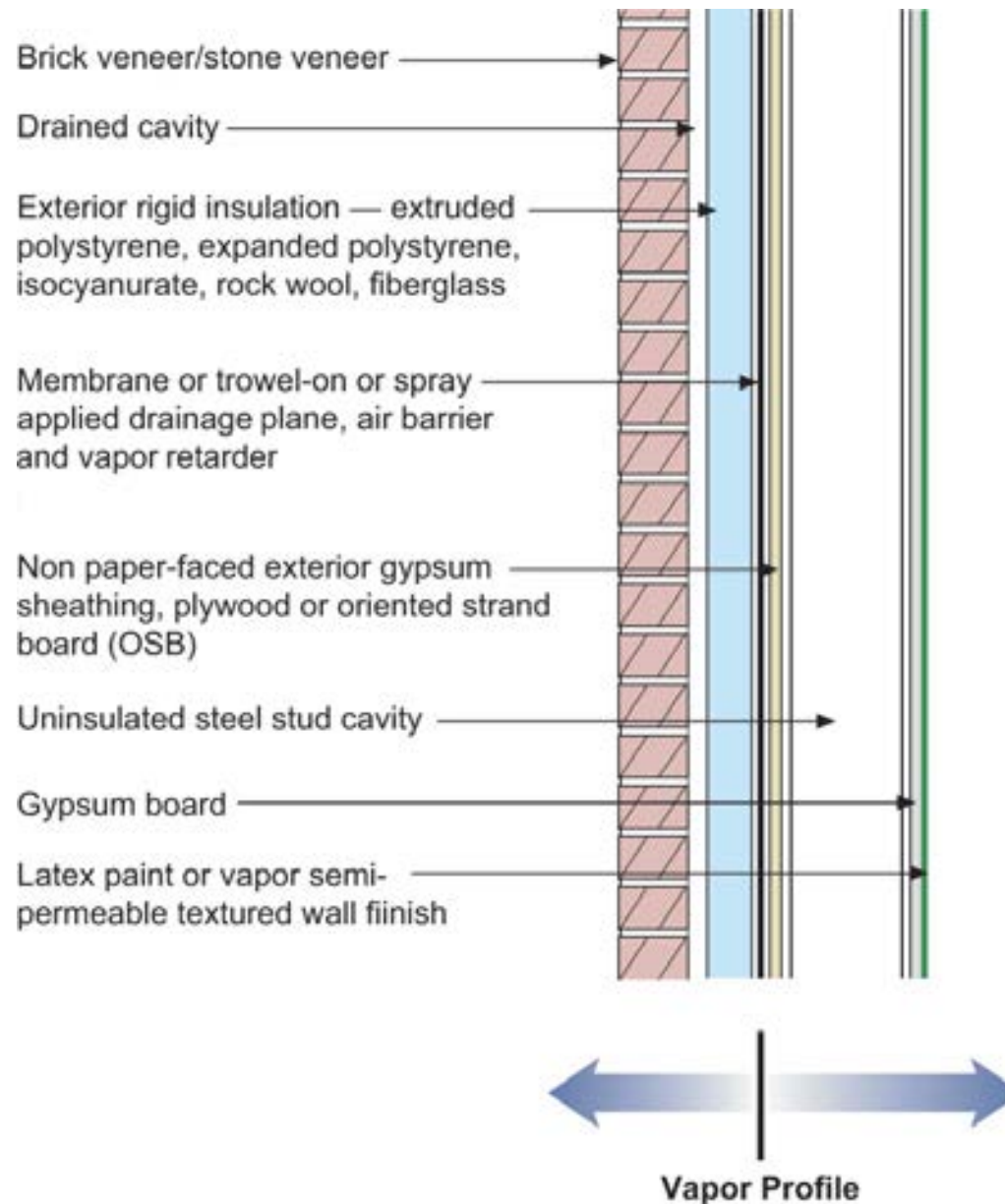


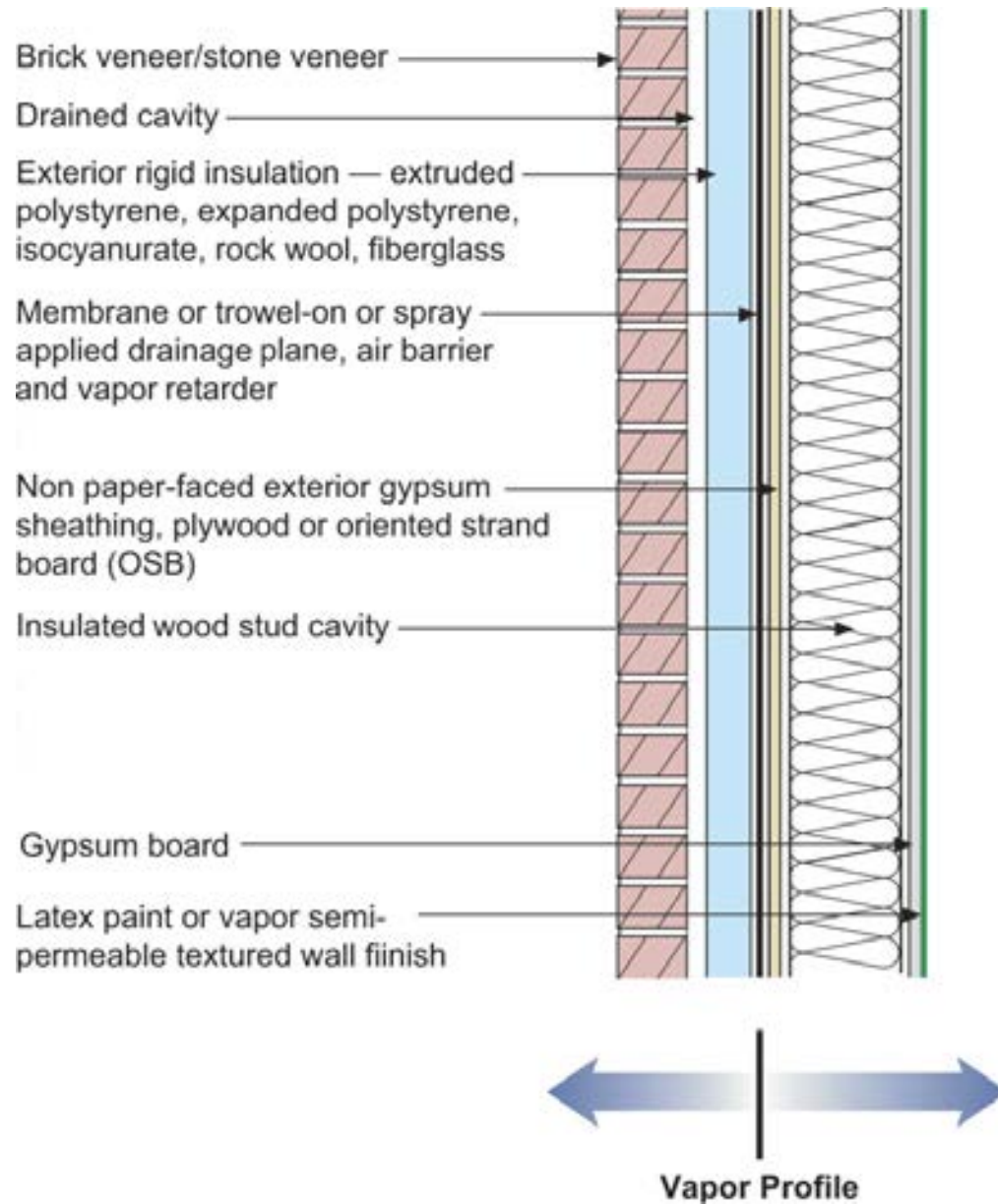


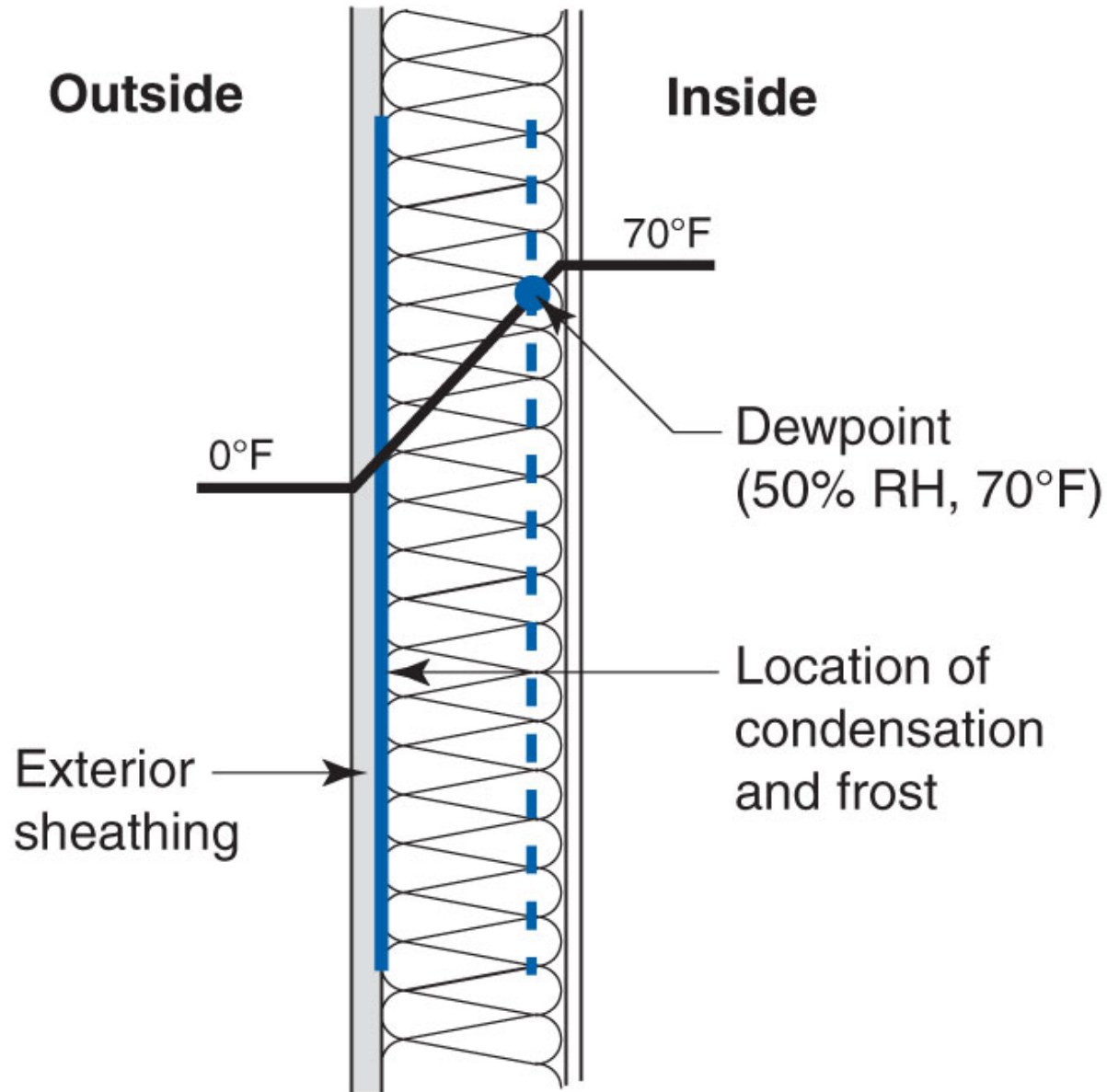


Configurations of the Perfect Wall

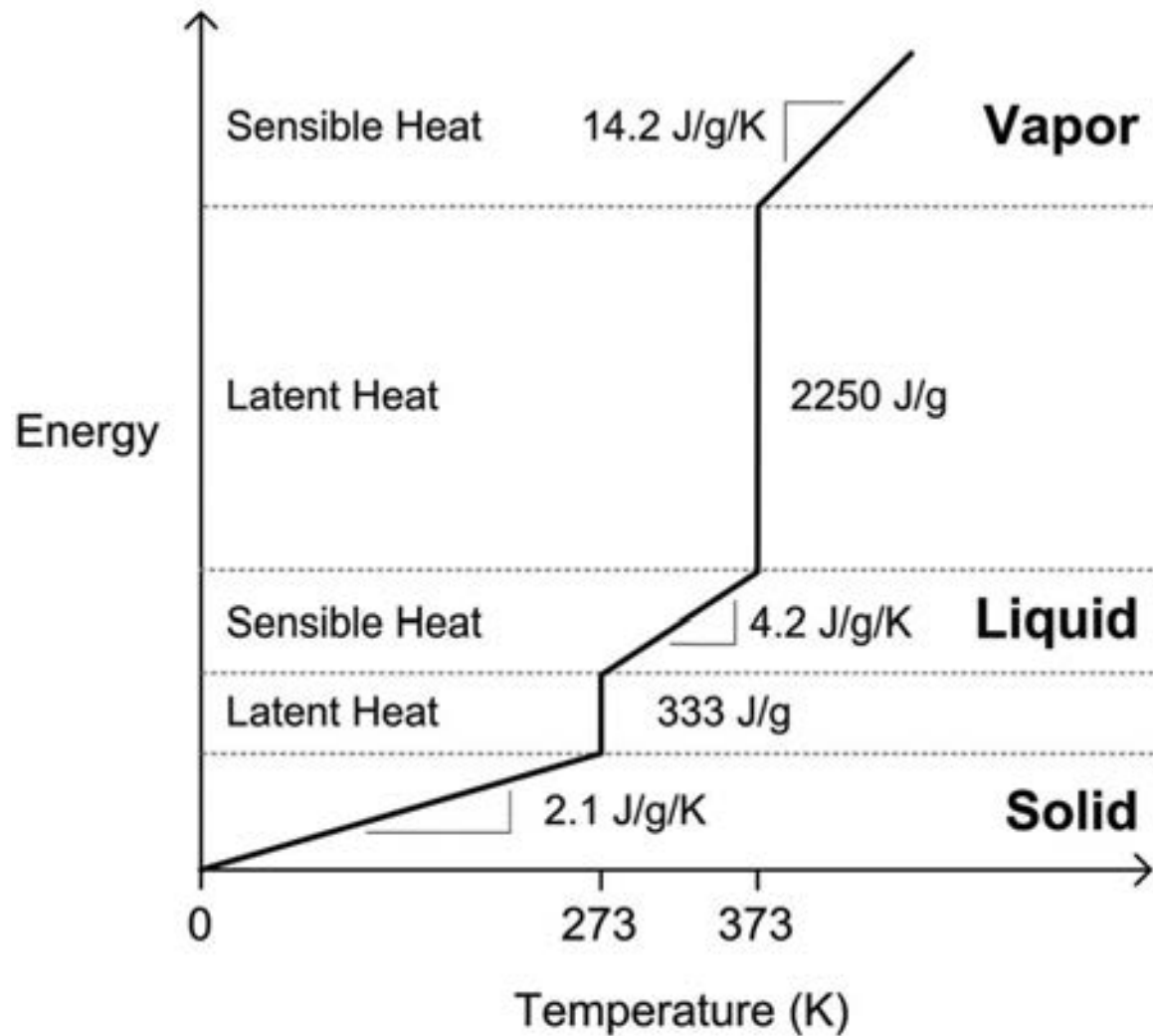






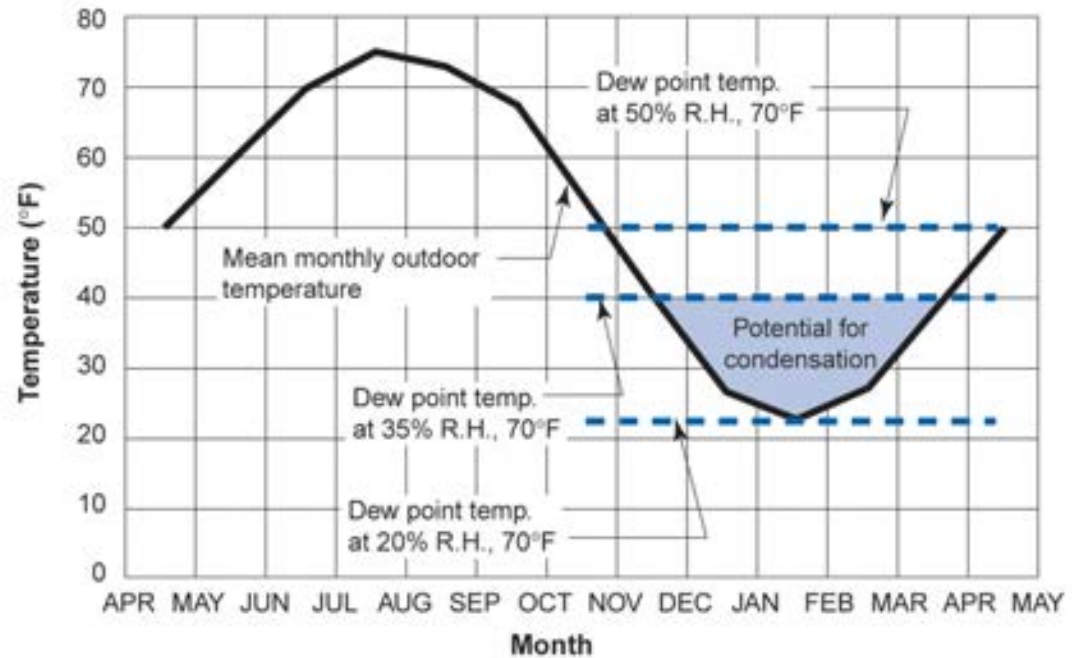
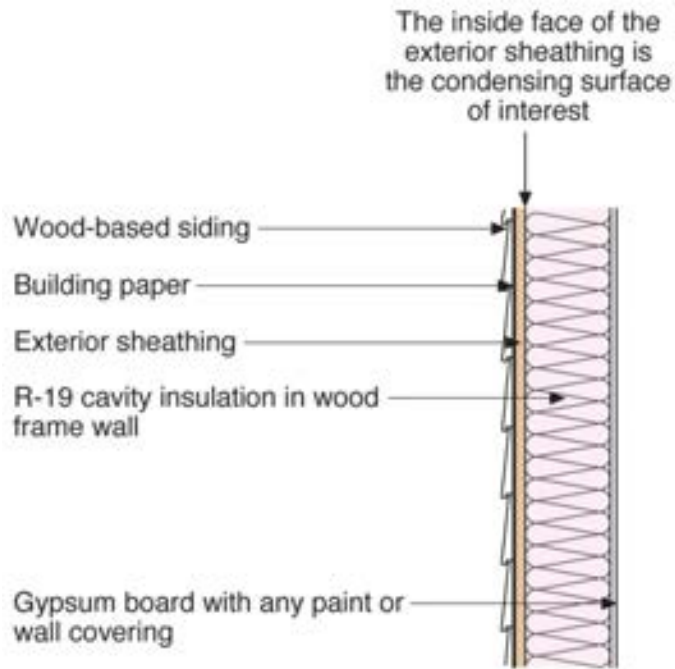


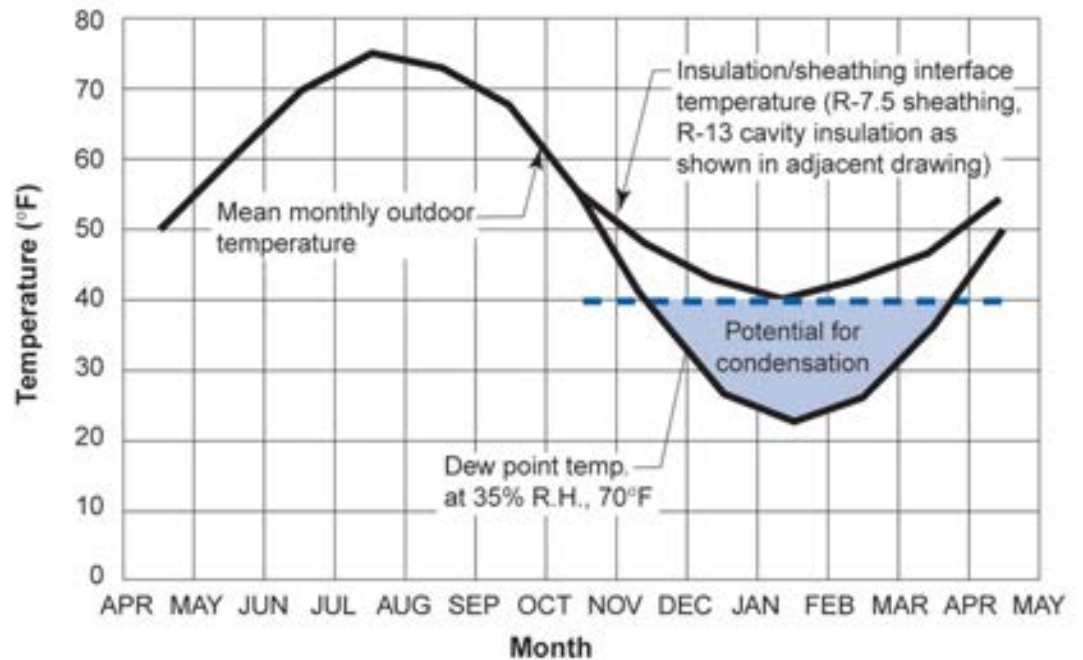
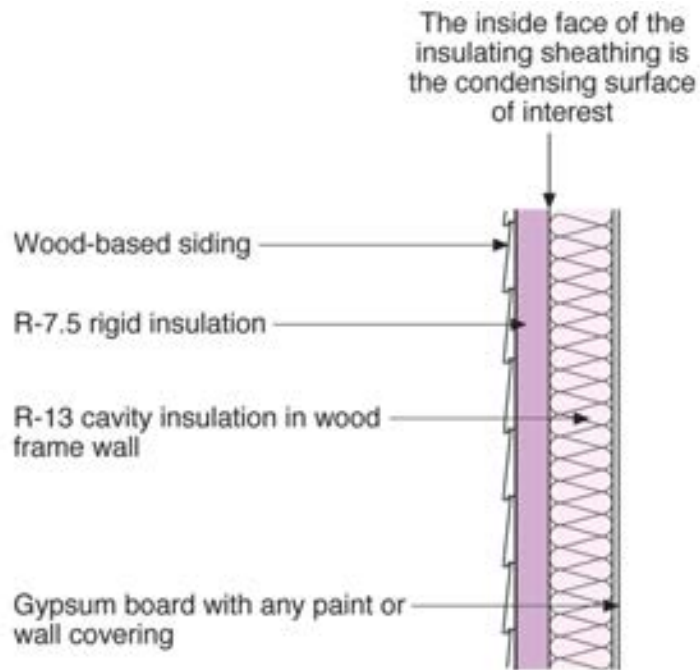




Simple linearized energy-temperature relation for water
 From Straube & Burnett, 2005







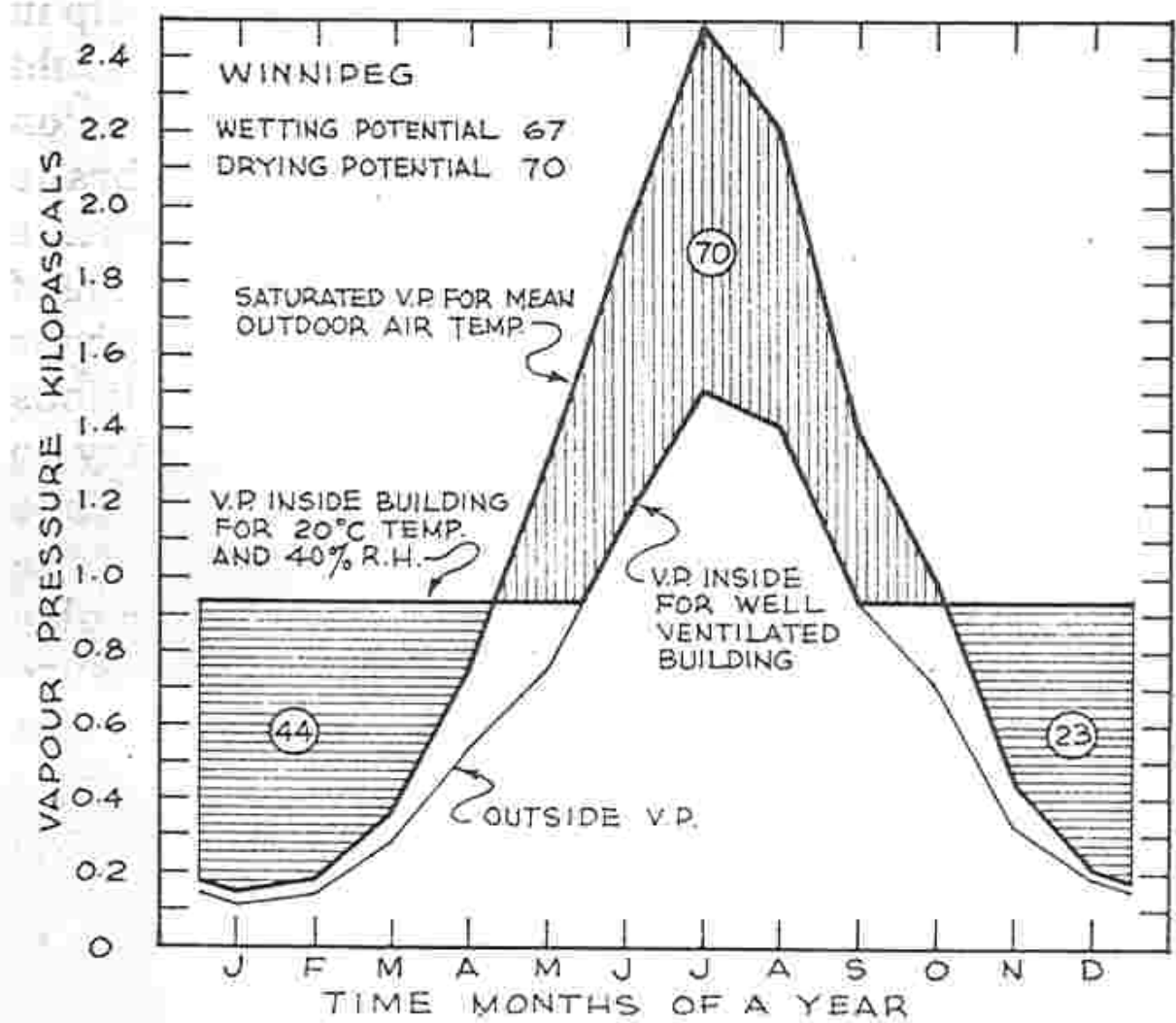
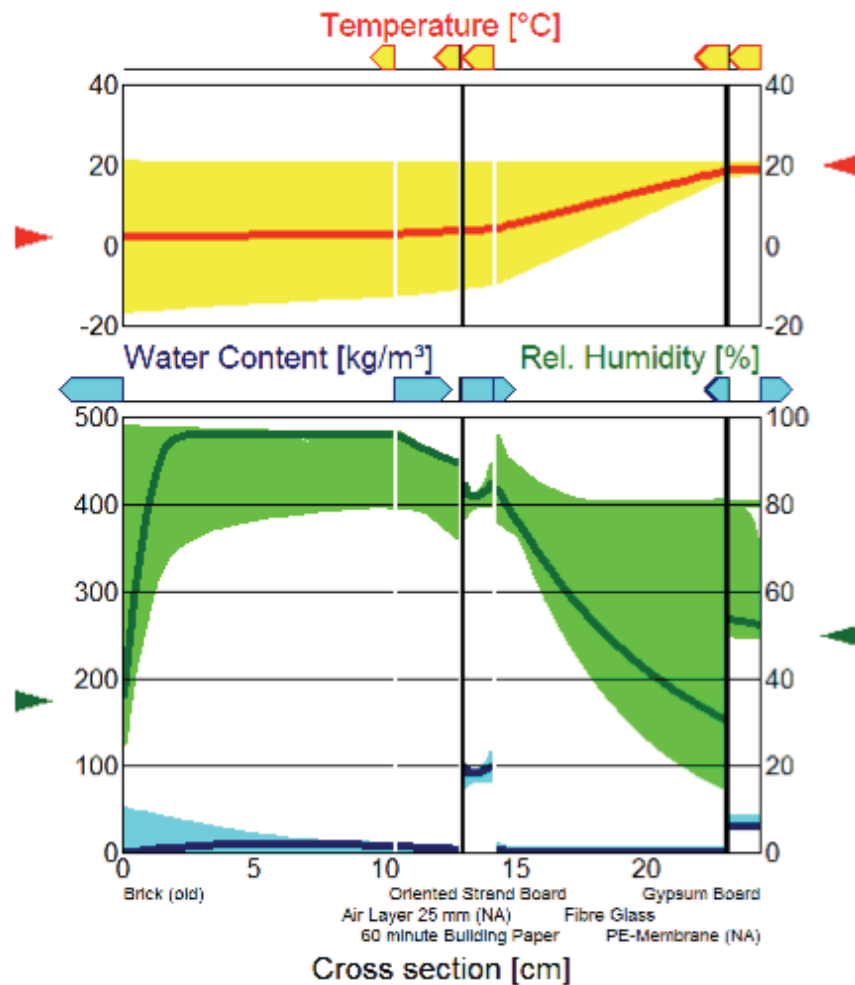


Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.



WUFI® 3.3 Pro. IBP
Run

16 Feb
2001

100%

0%

100%

0%

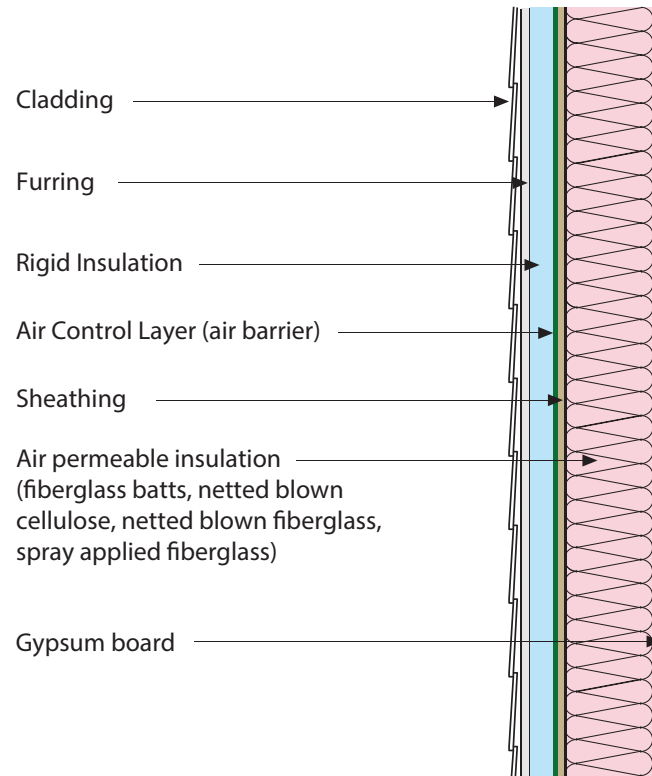
100%

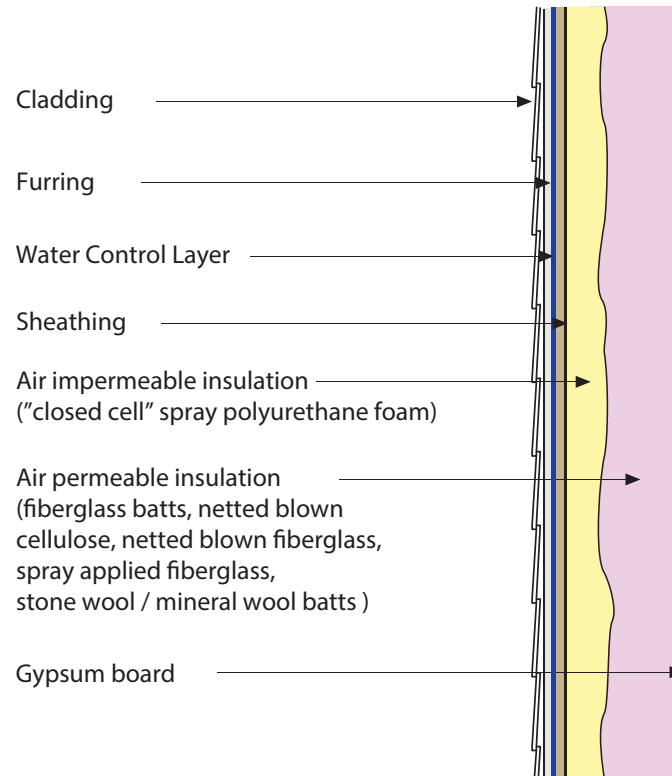
0%

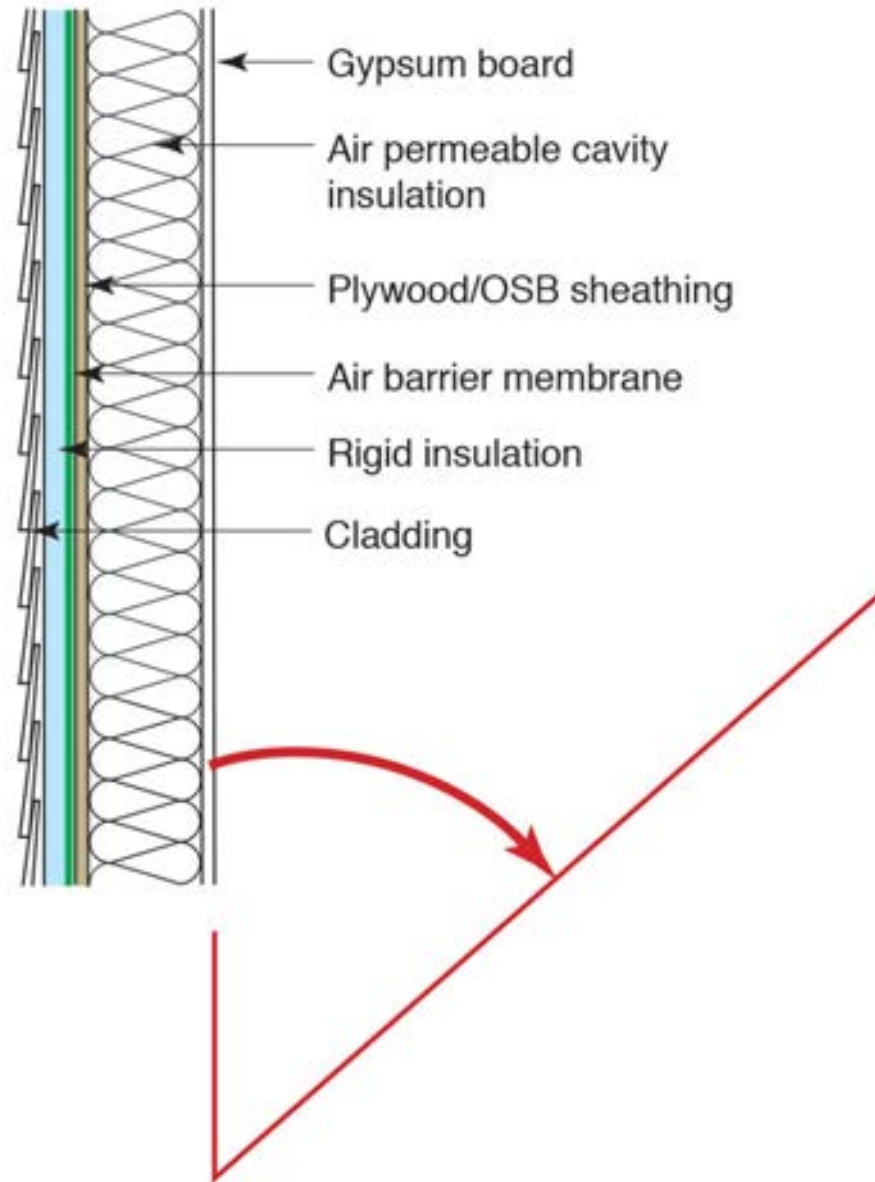
Insulation for Condensation Control*

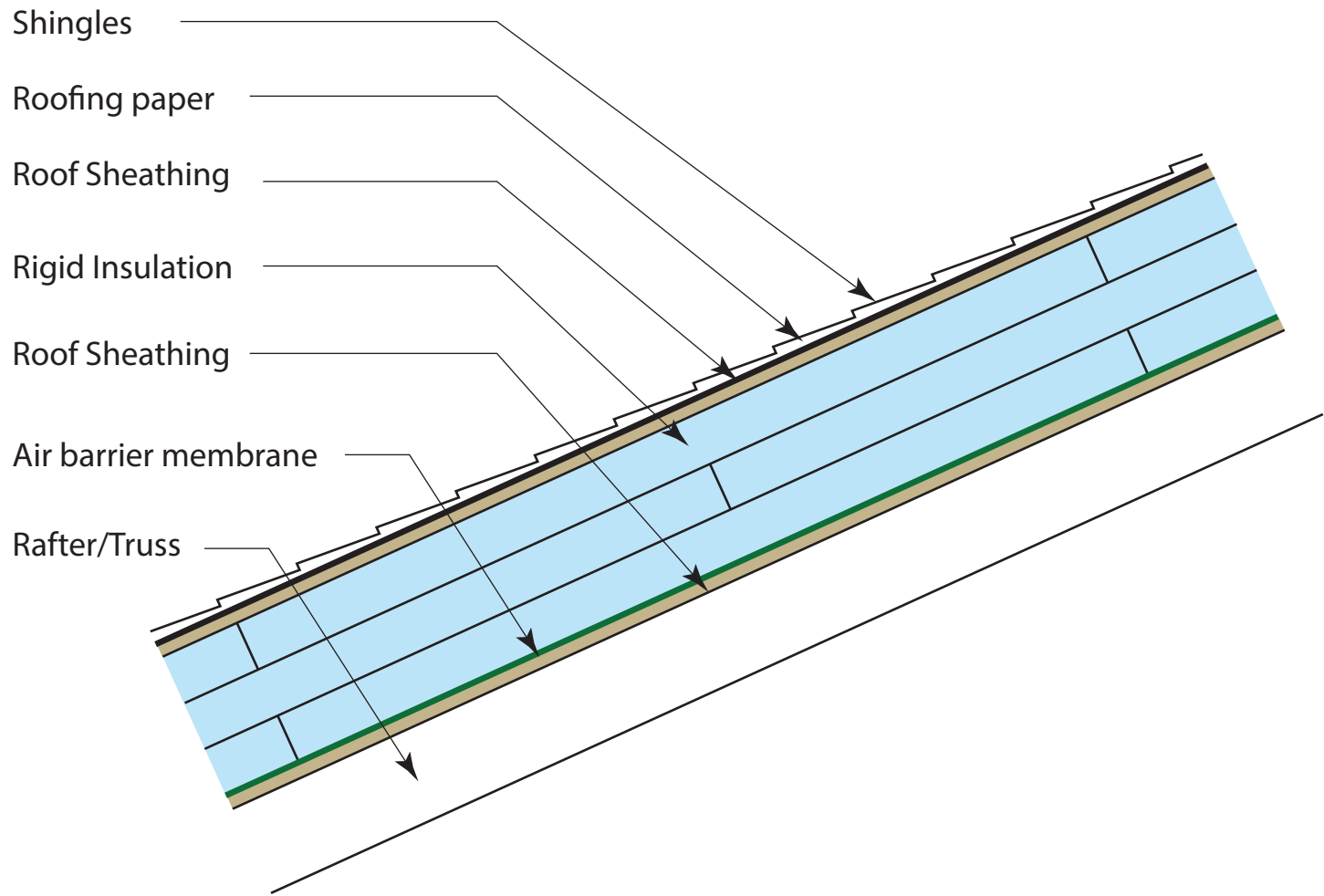
Climate Zone	Rigid Board or Air Impermeable Insulation	Total Cavity Insulation	Total Wall Assembly Insulation	Ratio of Rigid Board Insulation or Air Impermeable R-Value to Total Insulation R-Value
4C	R-2.5	R-13	R-15.5	15%
	R-3.75	R-20	R-23.75	15%
5	R-5	R-13	R-18	30%
	R-7.5	R-20	R-27.5	30%
6	R-7.5	R-13	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%

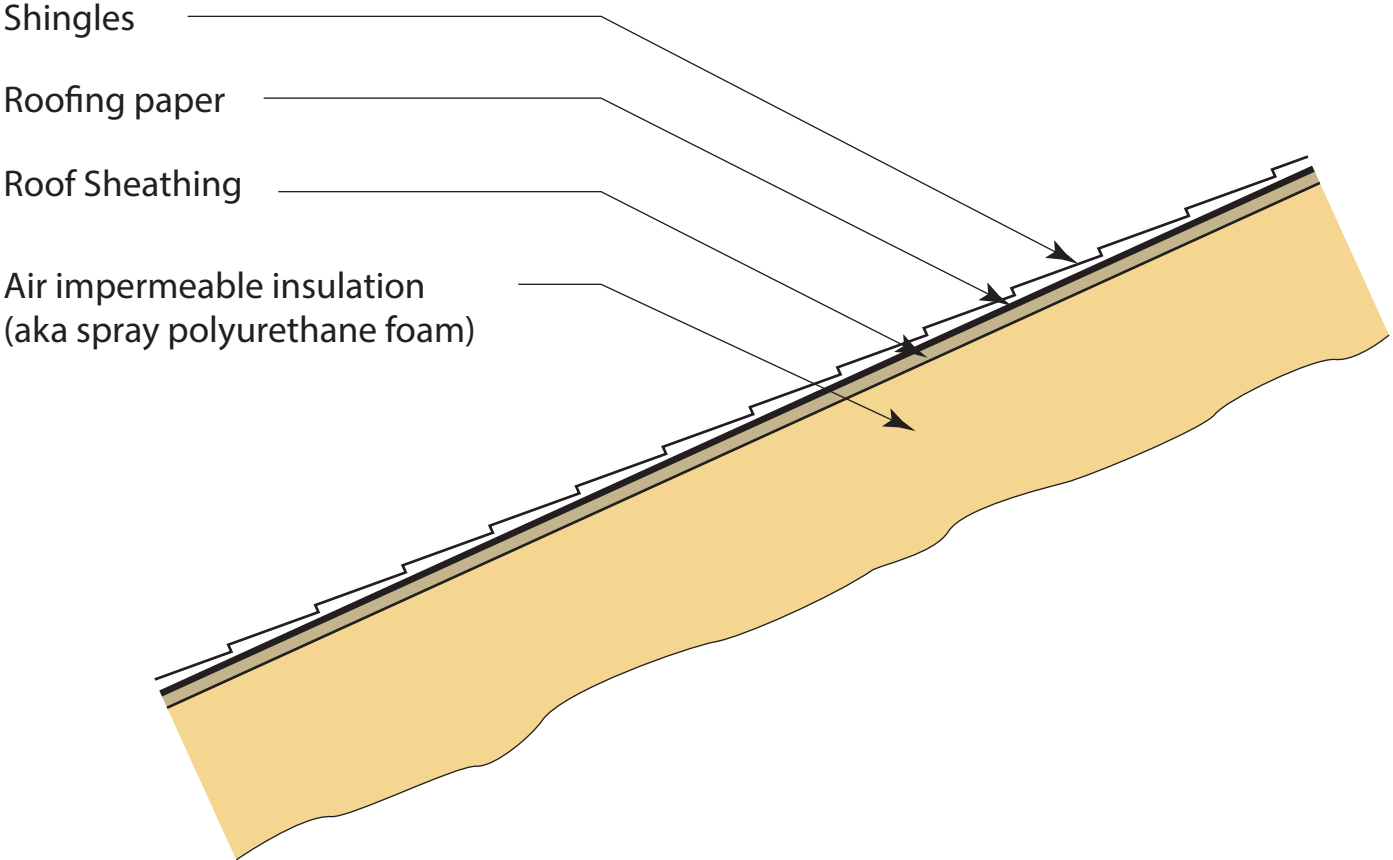
*Adapted from Table R 702.1 2015 International Residential Code

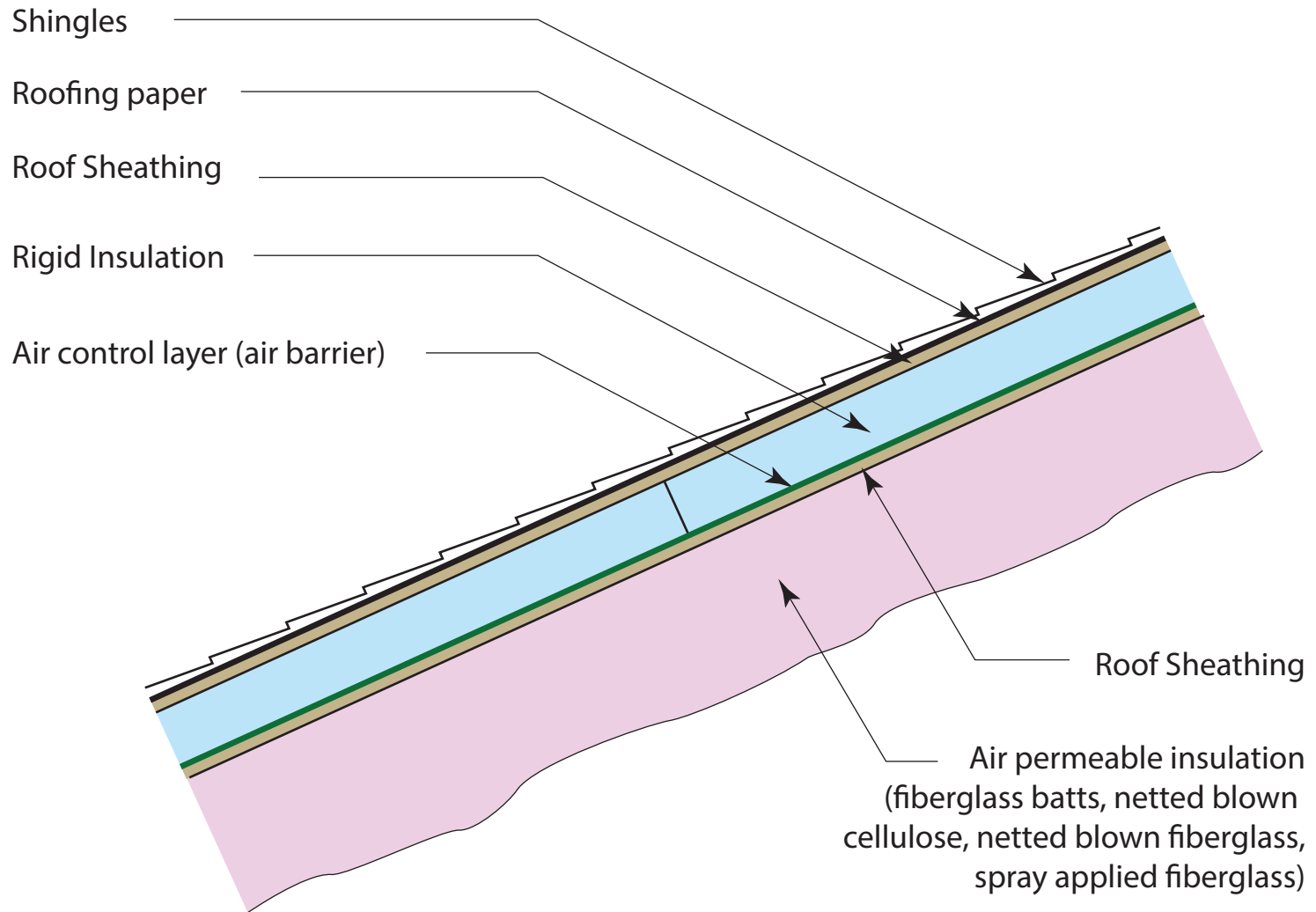










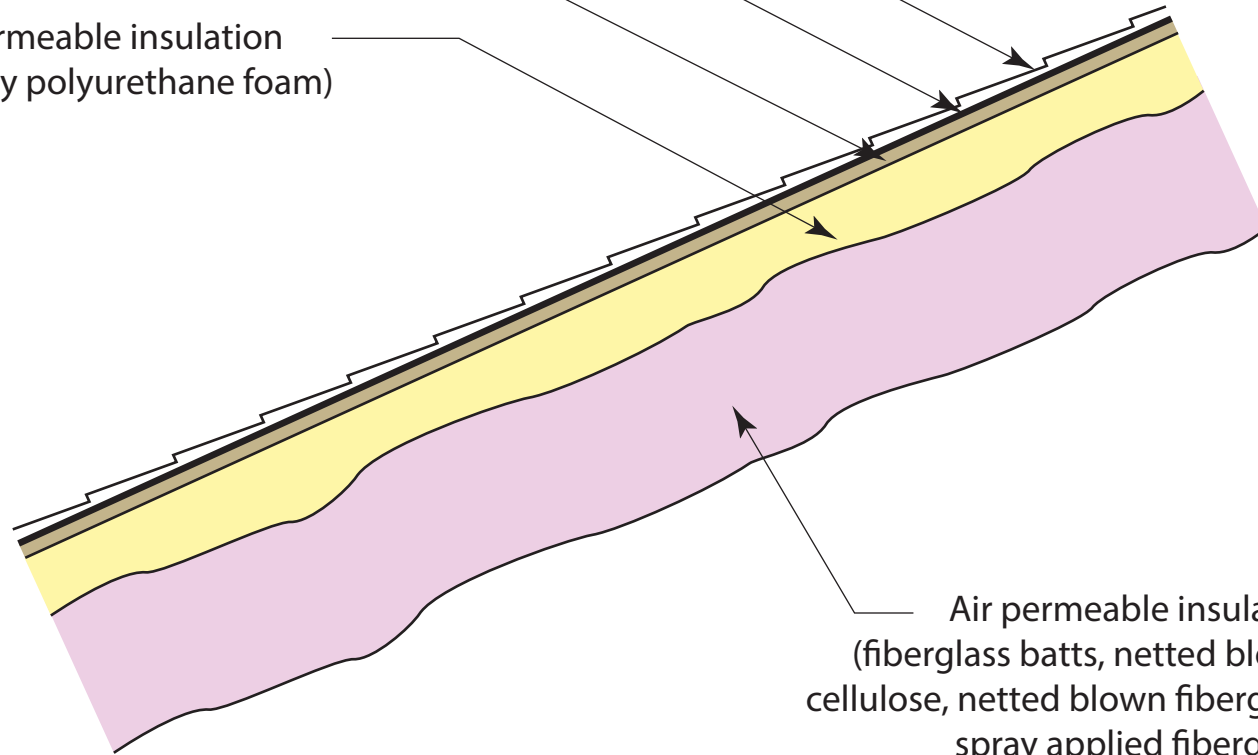


Shingles

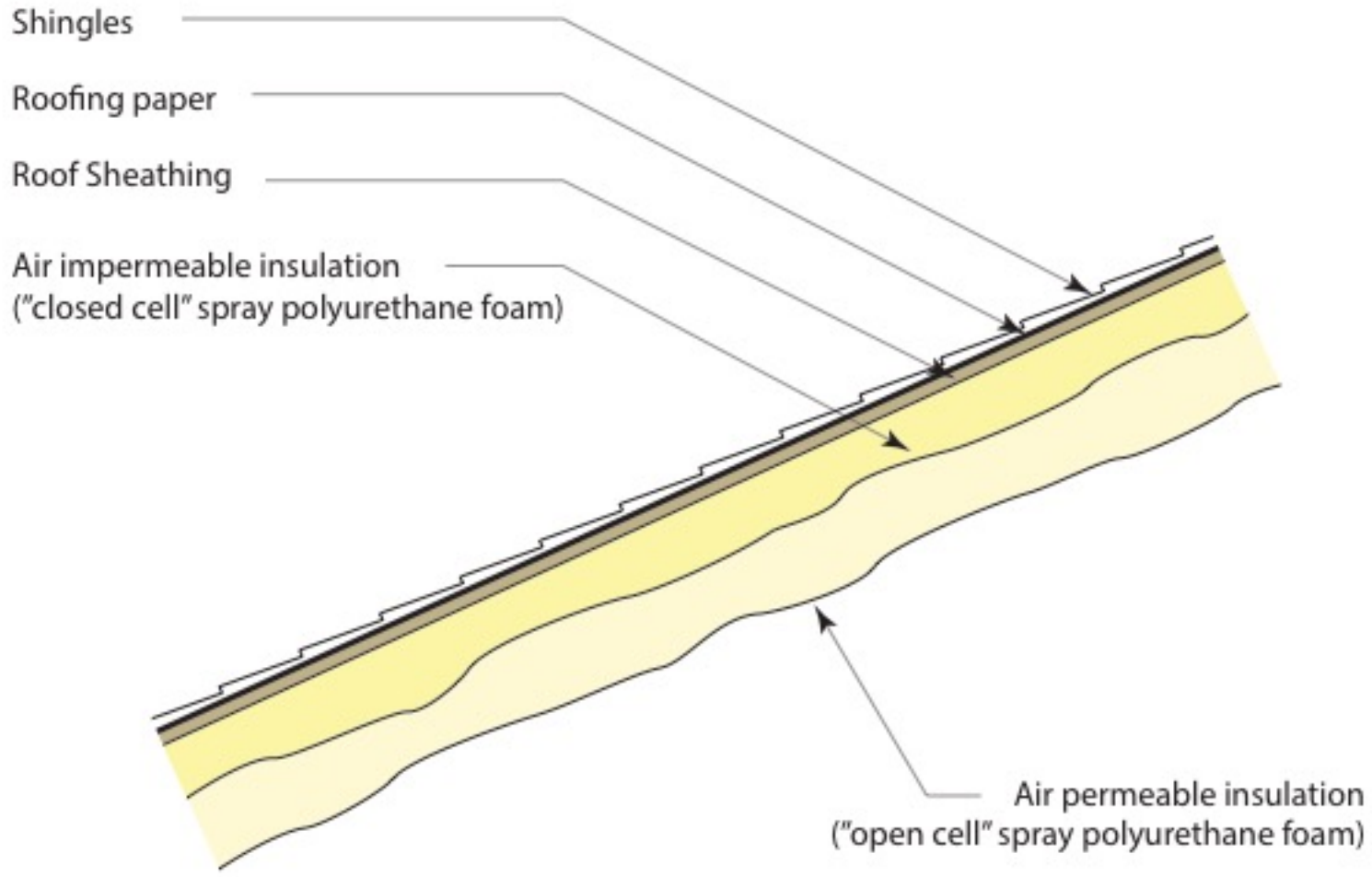
Roofing paper

Roof Sheathing

Air impermeable insulation
(aka spray polyurethane foam)



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

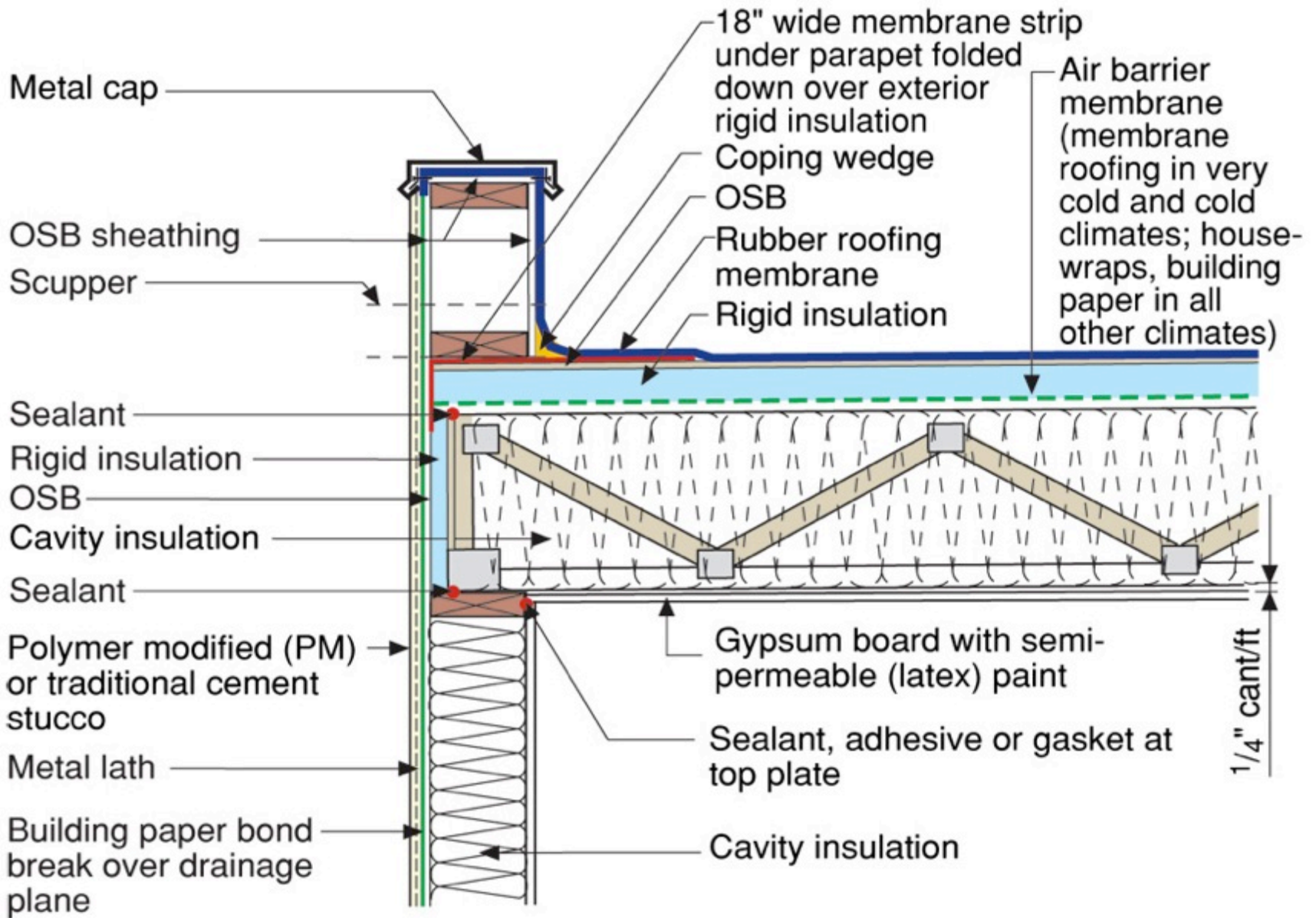


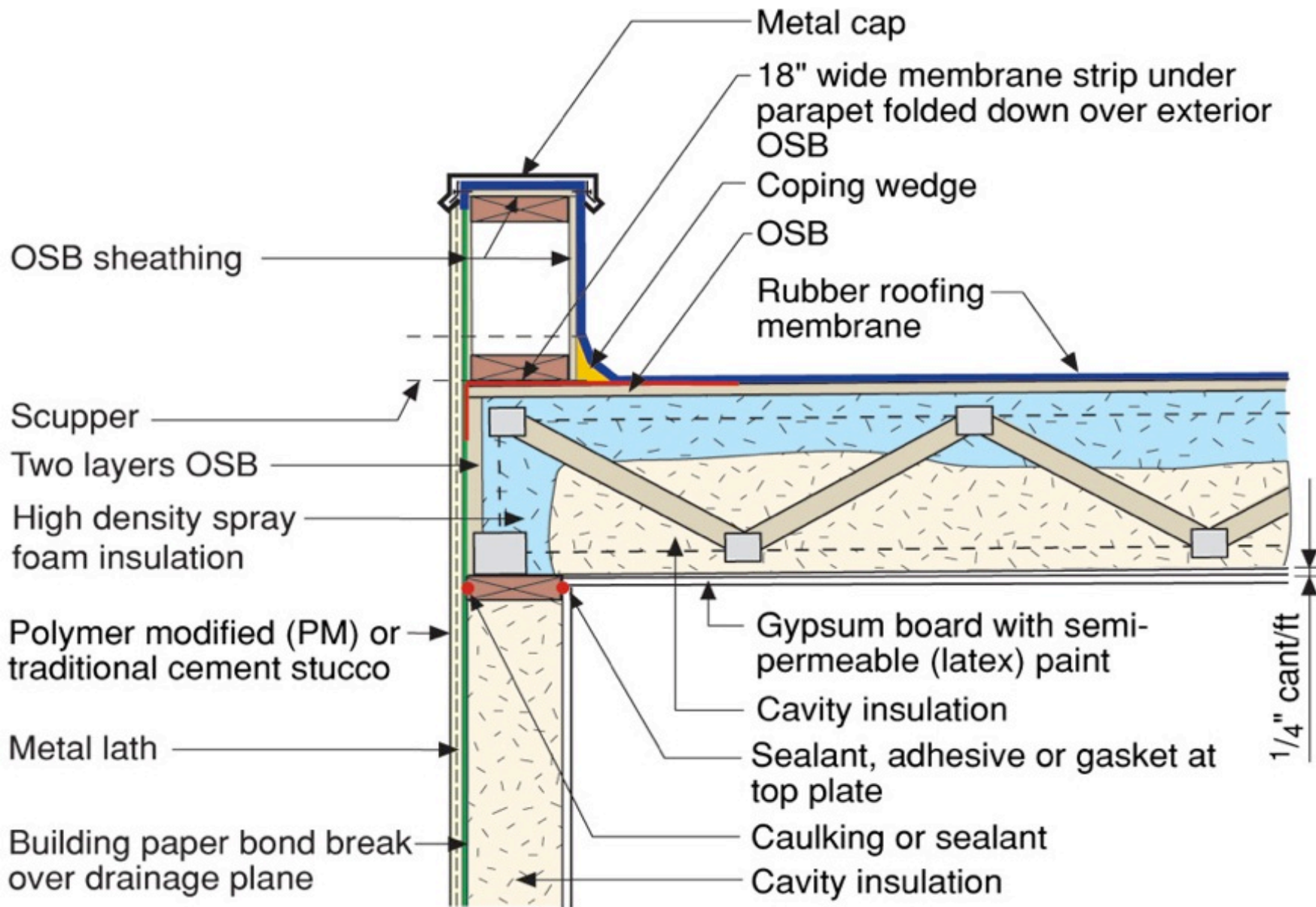
Insulation for Condensation Control*

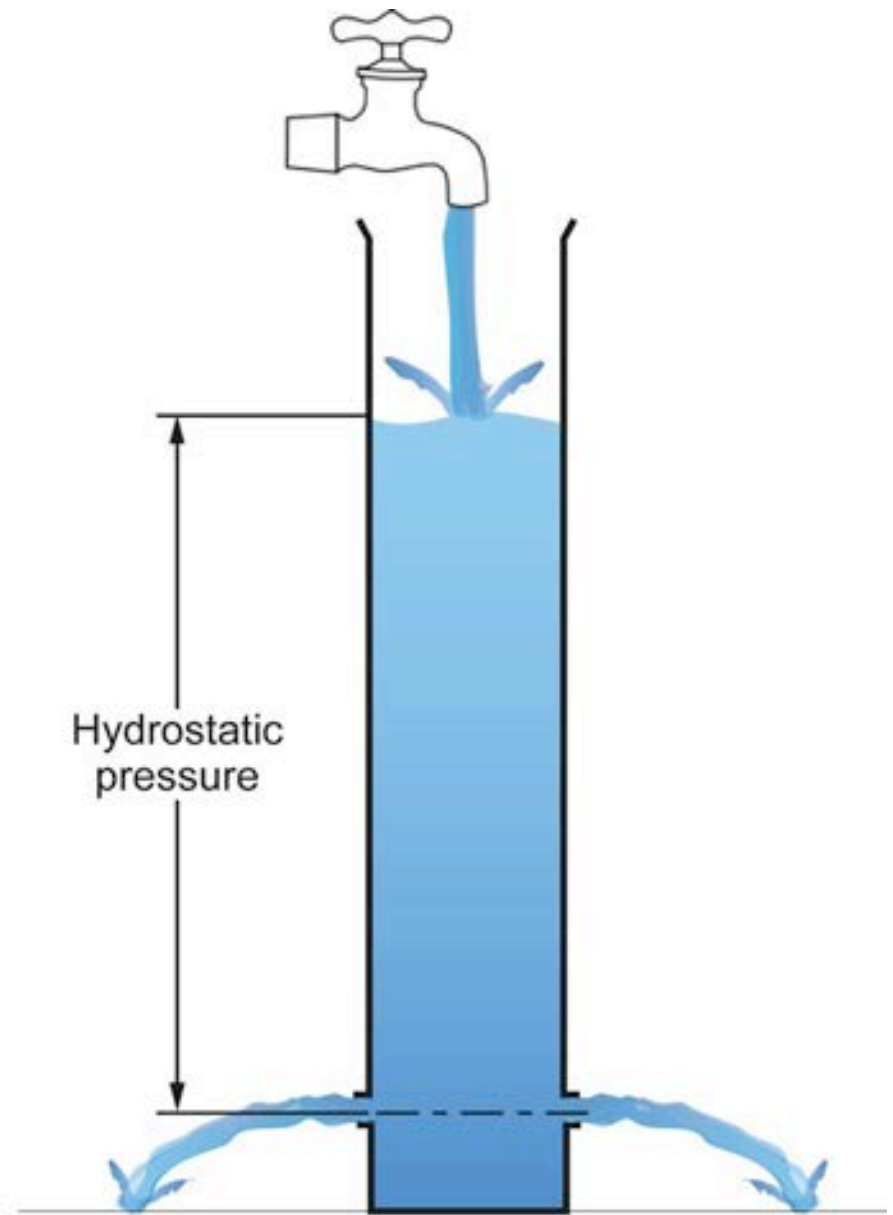
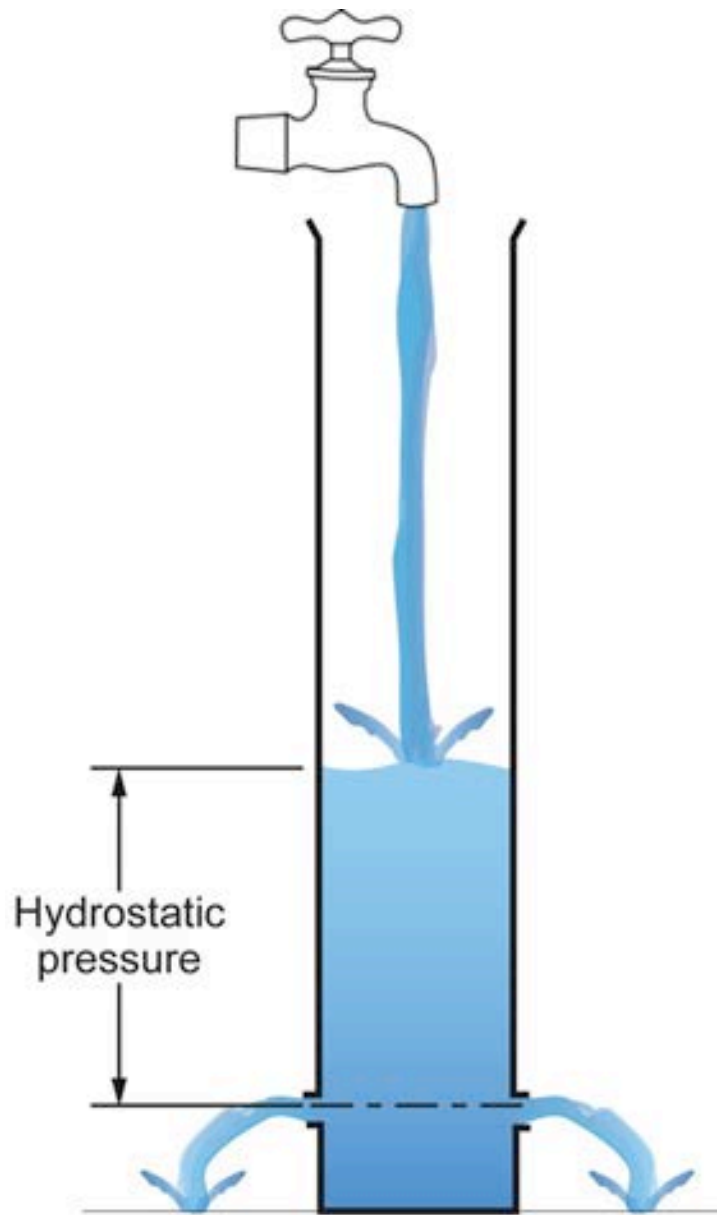
Climate Zone	Rigid Board or Air Impermeable Insulation	Code Required R-Value	Ratio of Rigid Board Insulation or Air Impermeable Value to Total Insulation R-Value
1,2,3	R-5	R-38	10%
4C	R-10	R-49	20%
4A, 4B	R-15	R-49	30%
5	R-20	R-49	40%
6	R-25	R-49	50%
7	R-30	R-49	60%
8	R-35	R-49	70%

*Adapted from Table R 806.5 2015 International Residential Code

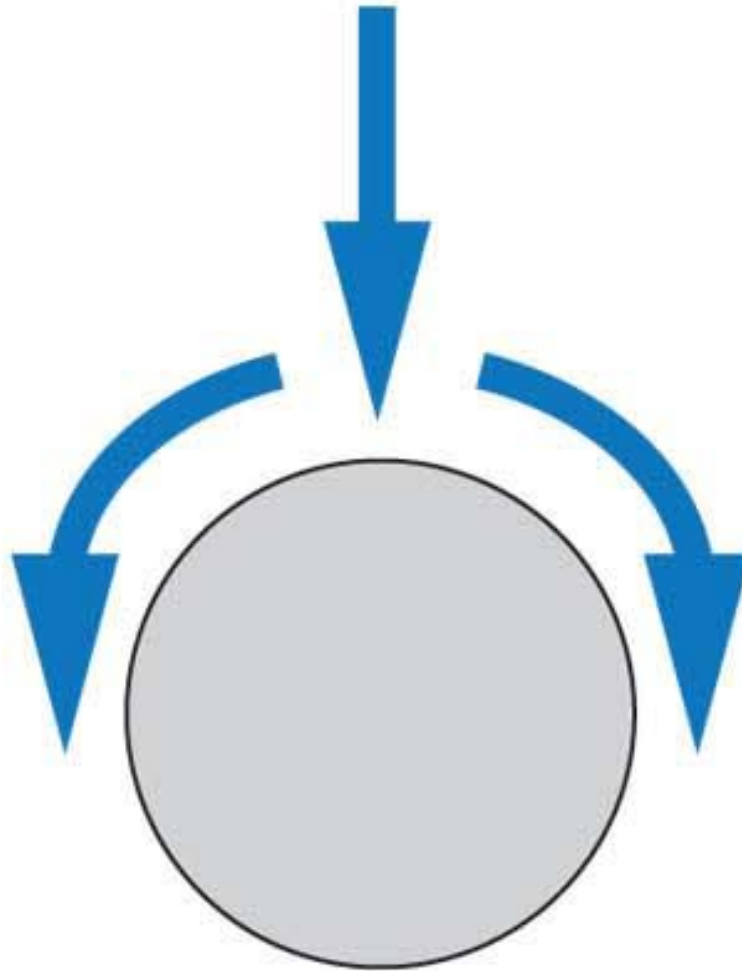
Table 1

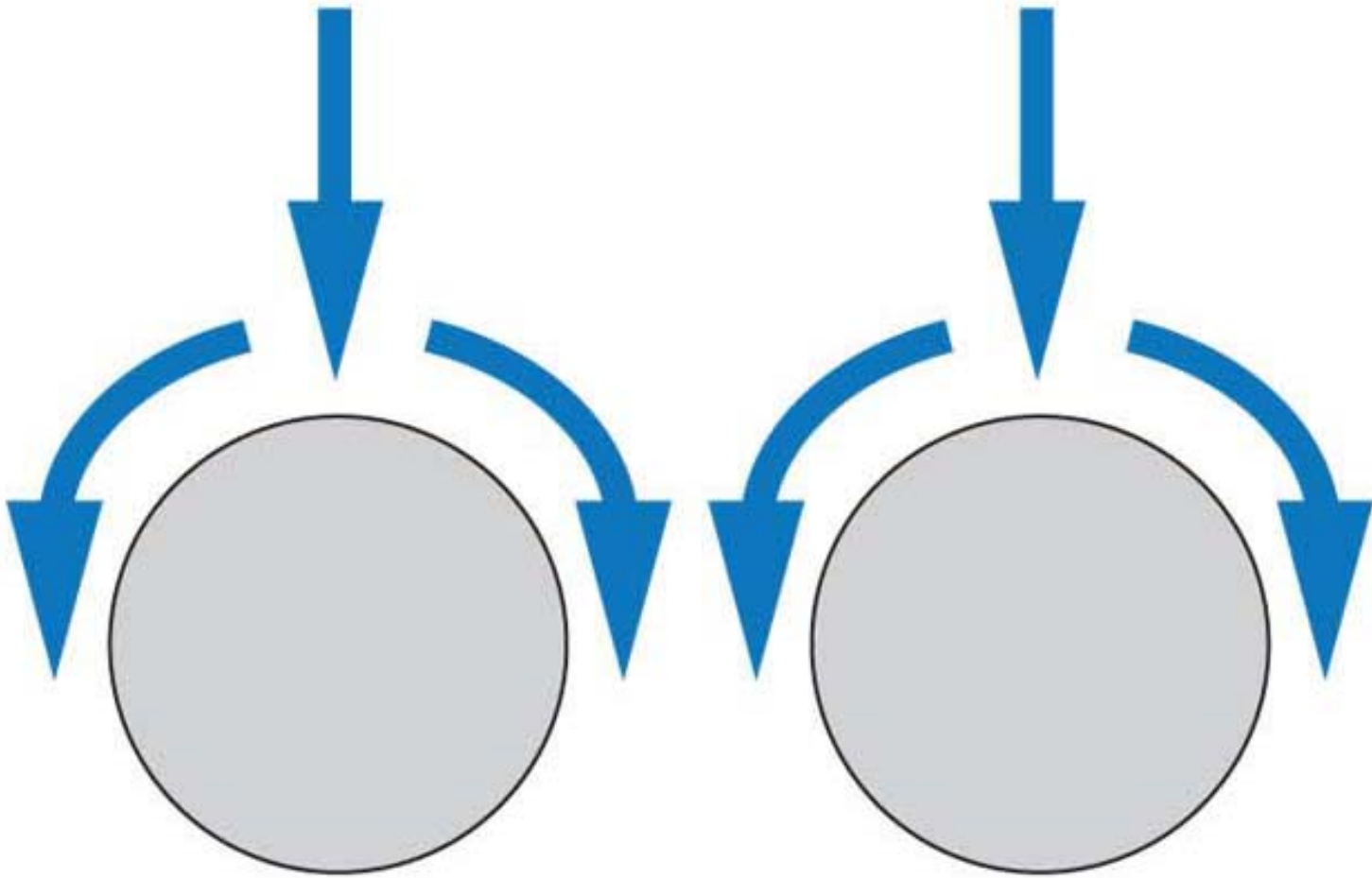


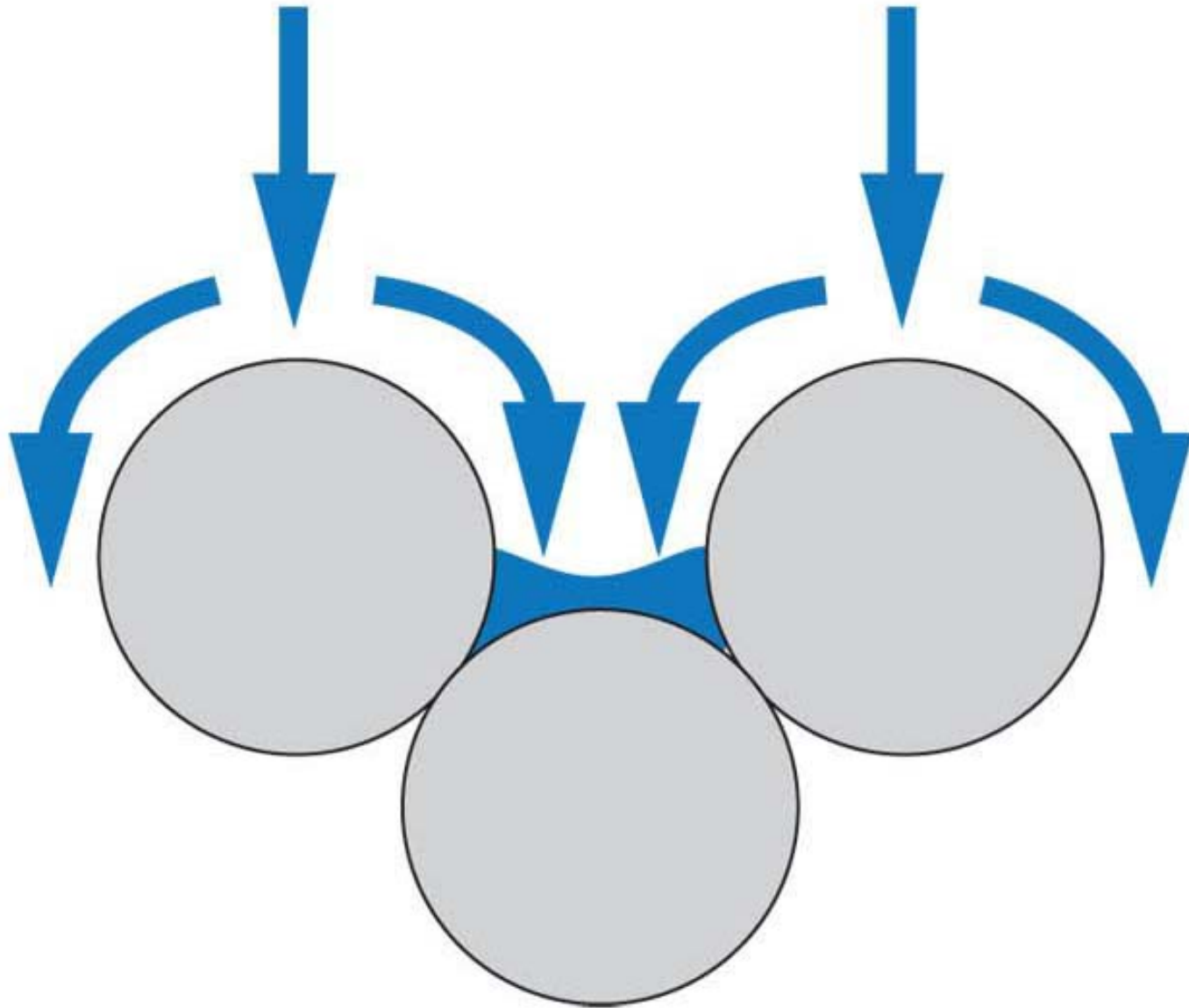




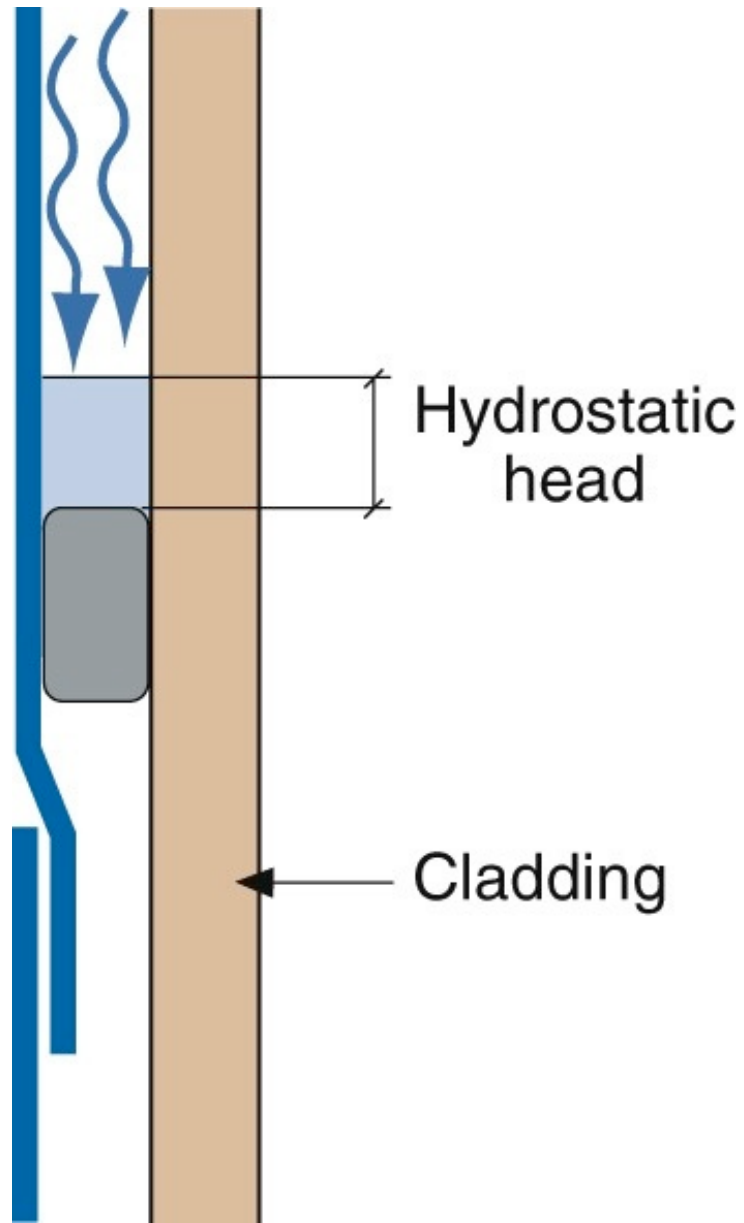


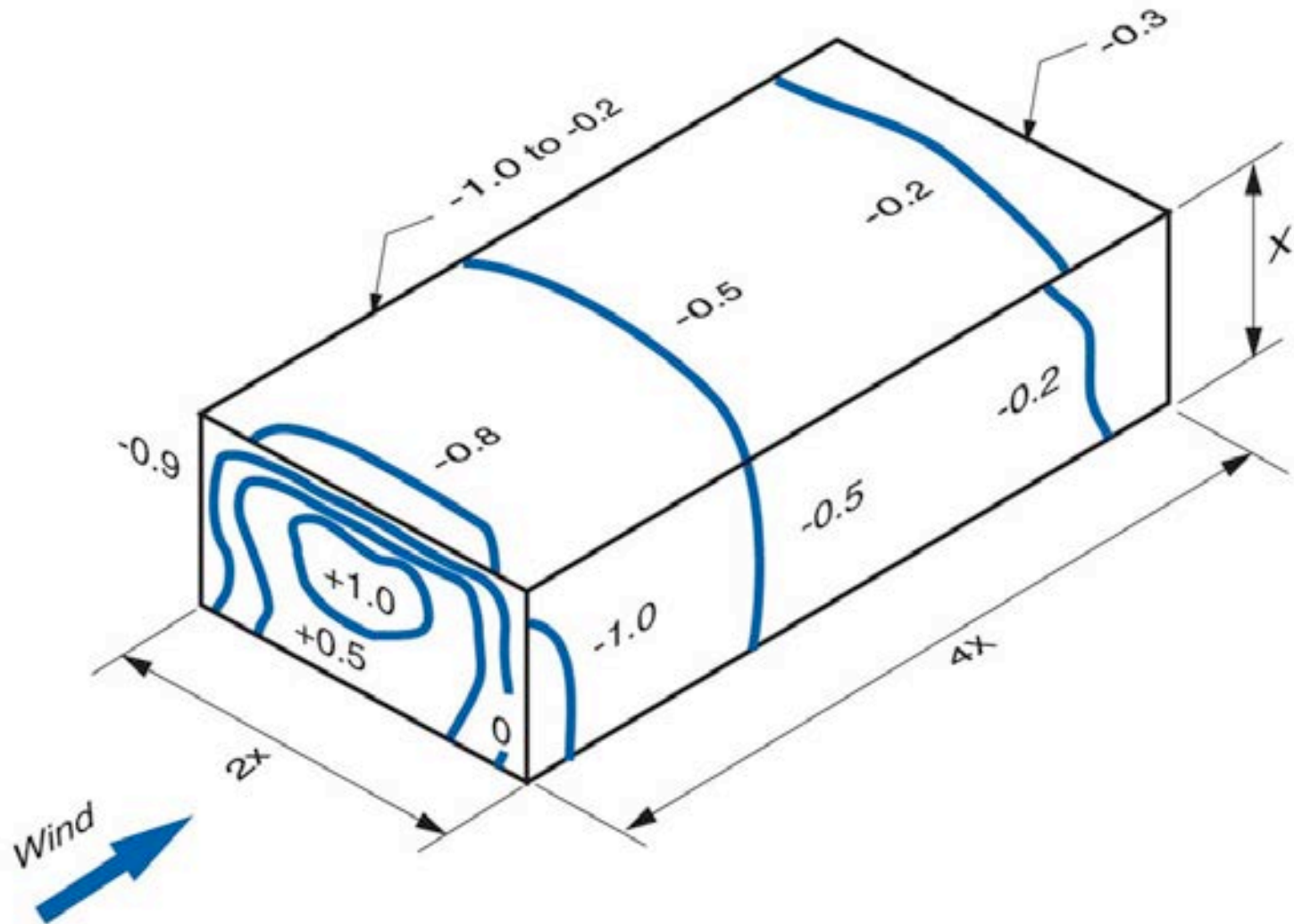






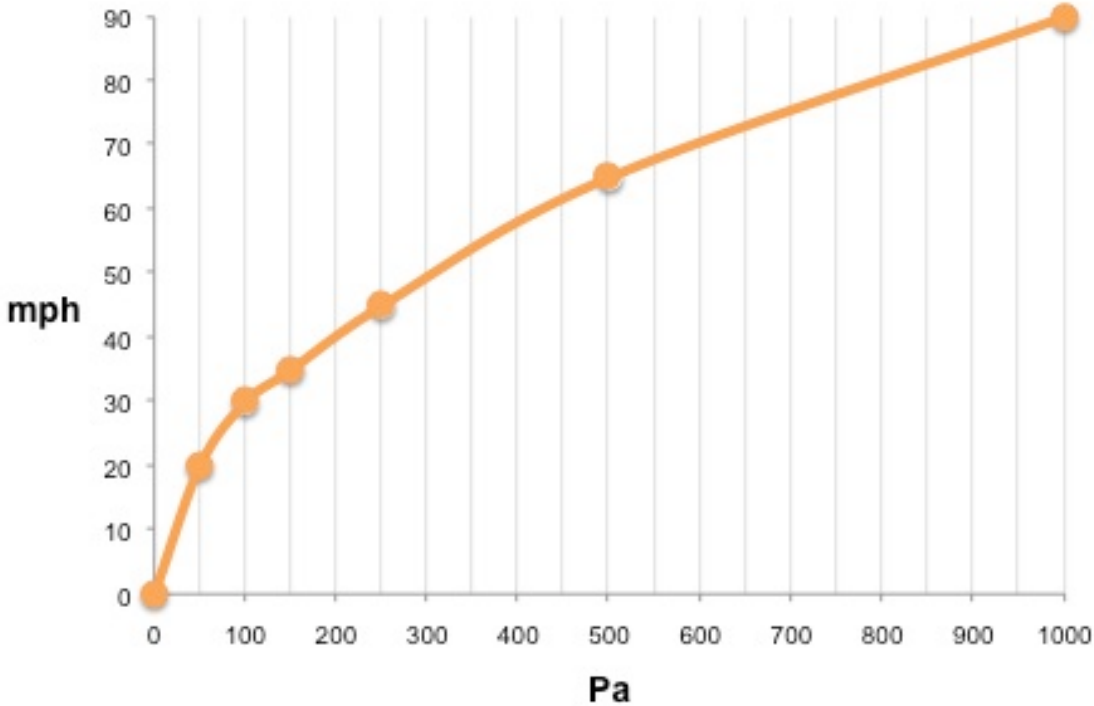




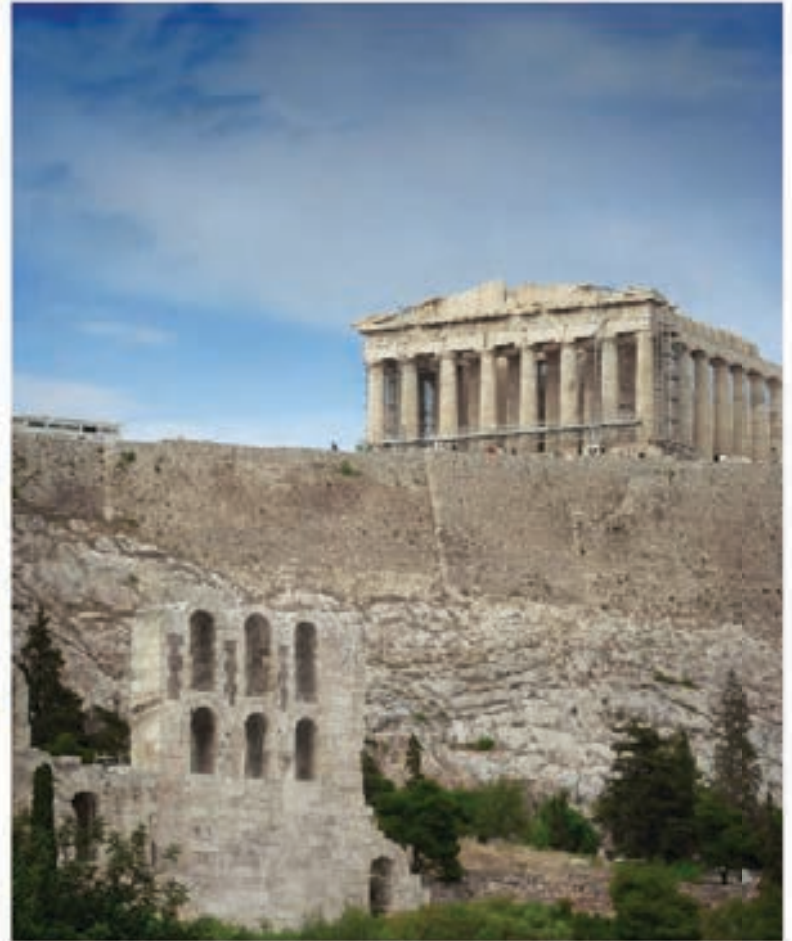


Pascals	mph
50	Pa = 20 mph
100	Pa = 30 mph
150	Pa = 35 mph
250	Pa = 45 mph
500	Pa = 65 mph
1,000	Pa = 90 mph

Wind Speed (mph) vs. Stagnation Pressure (Pa)











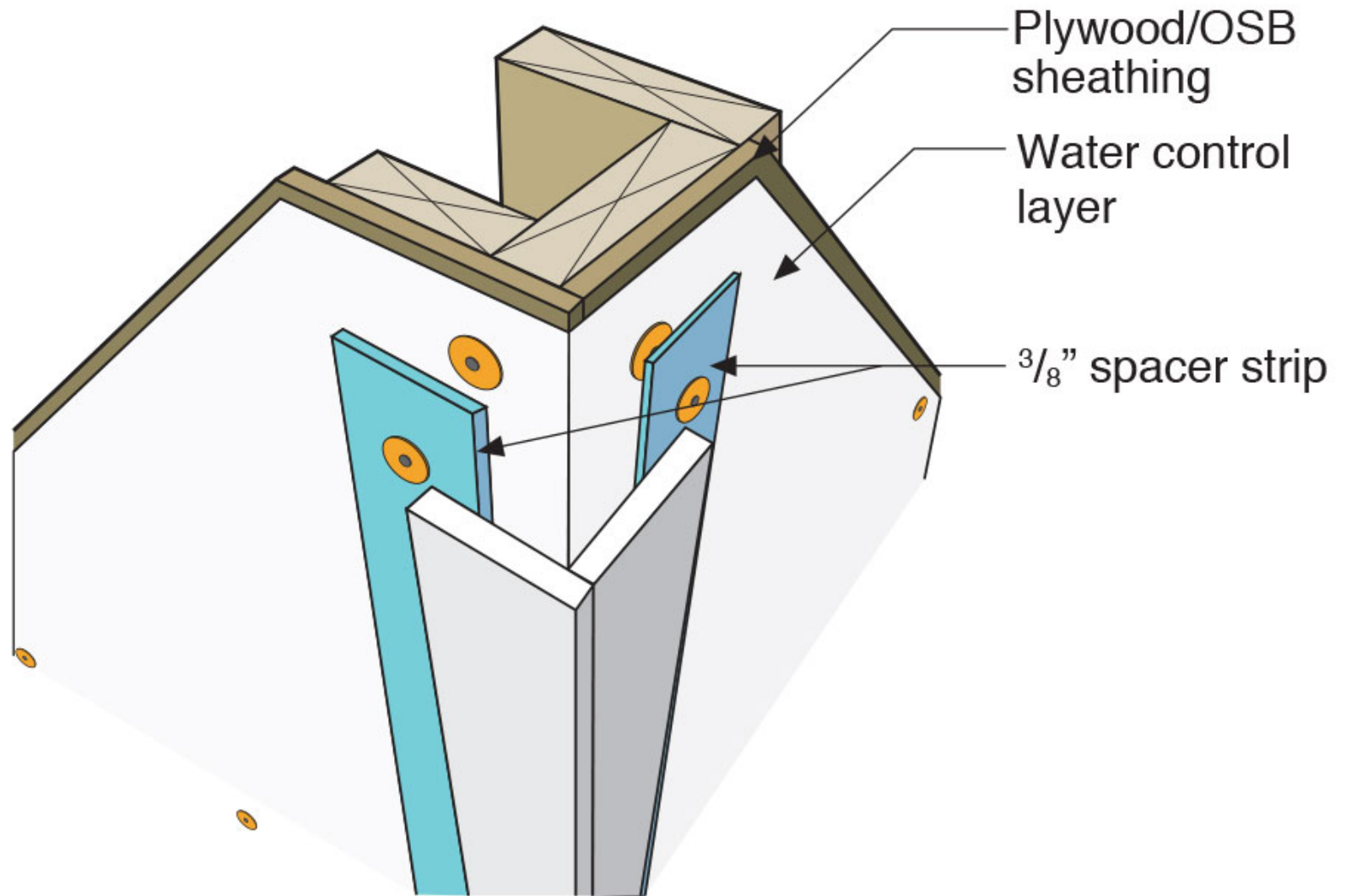


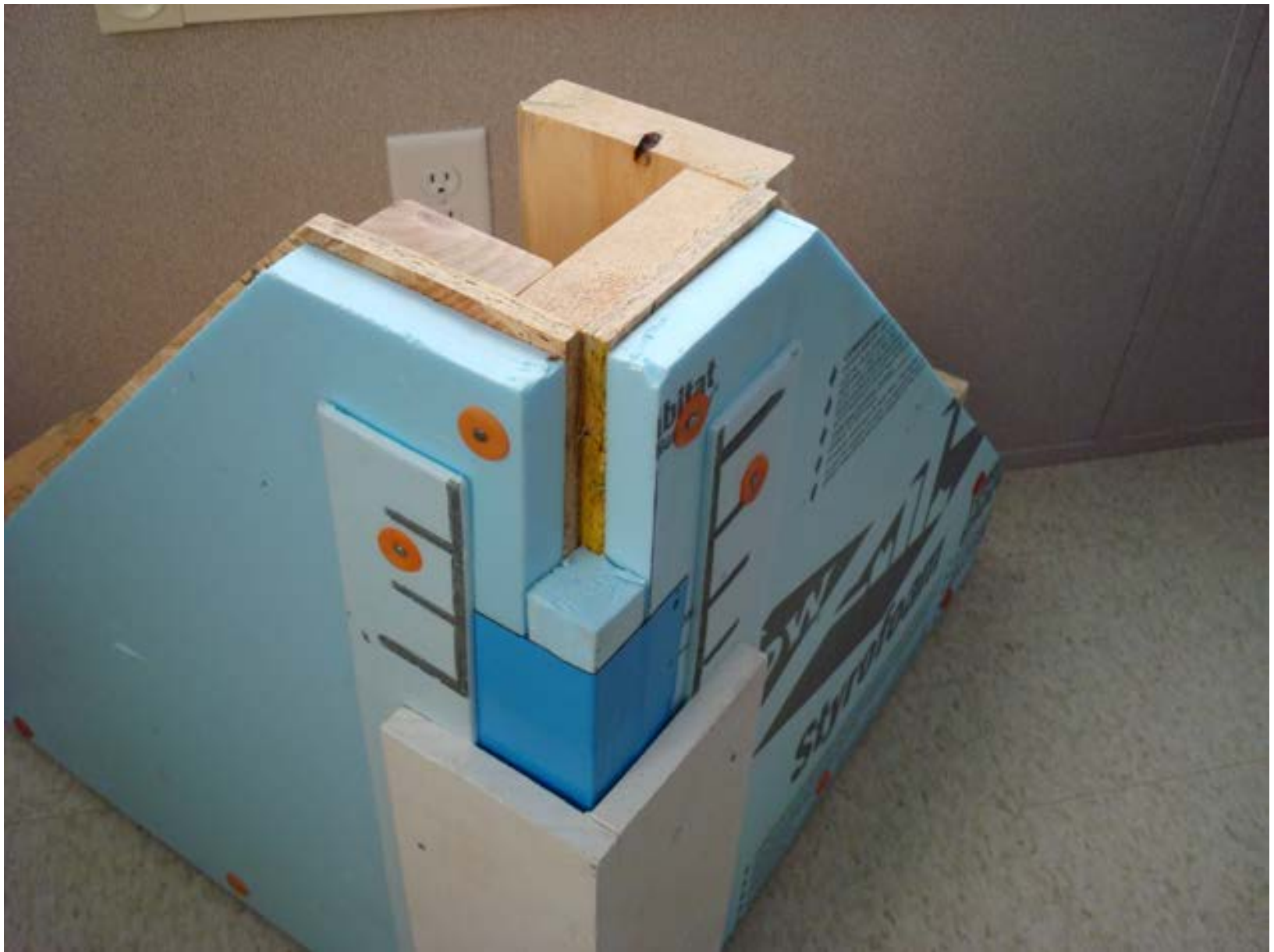




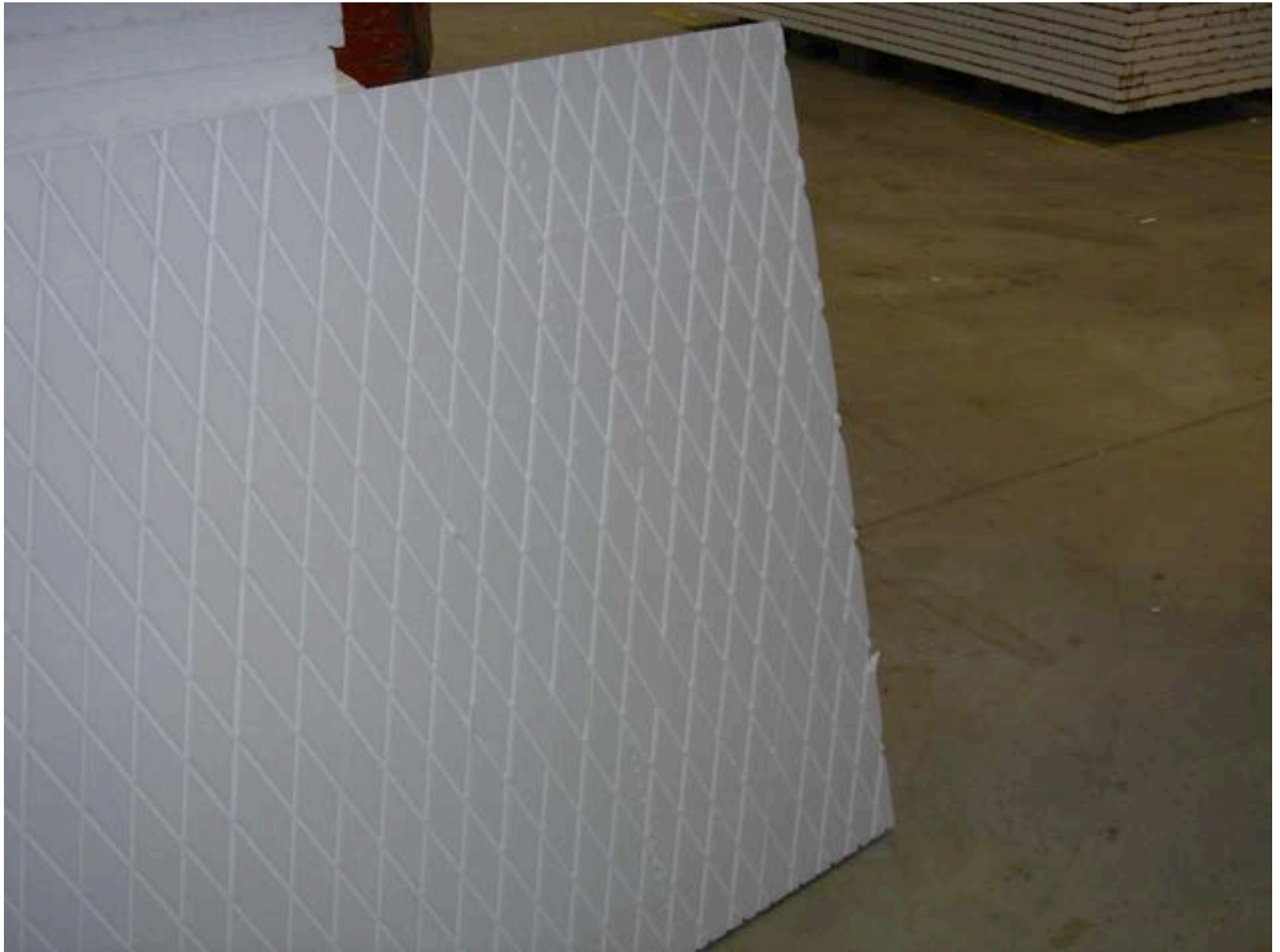




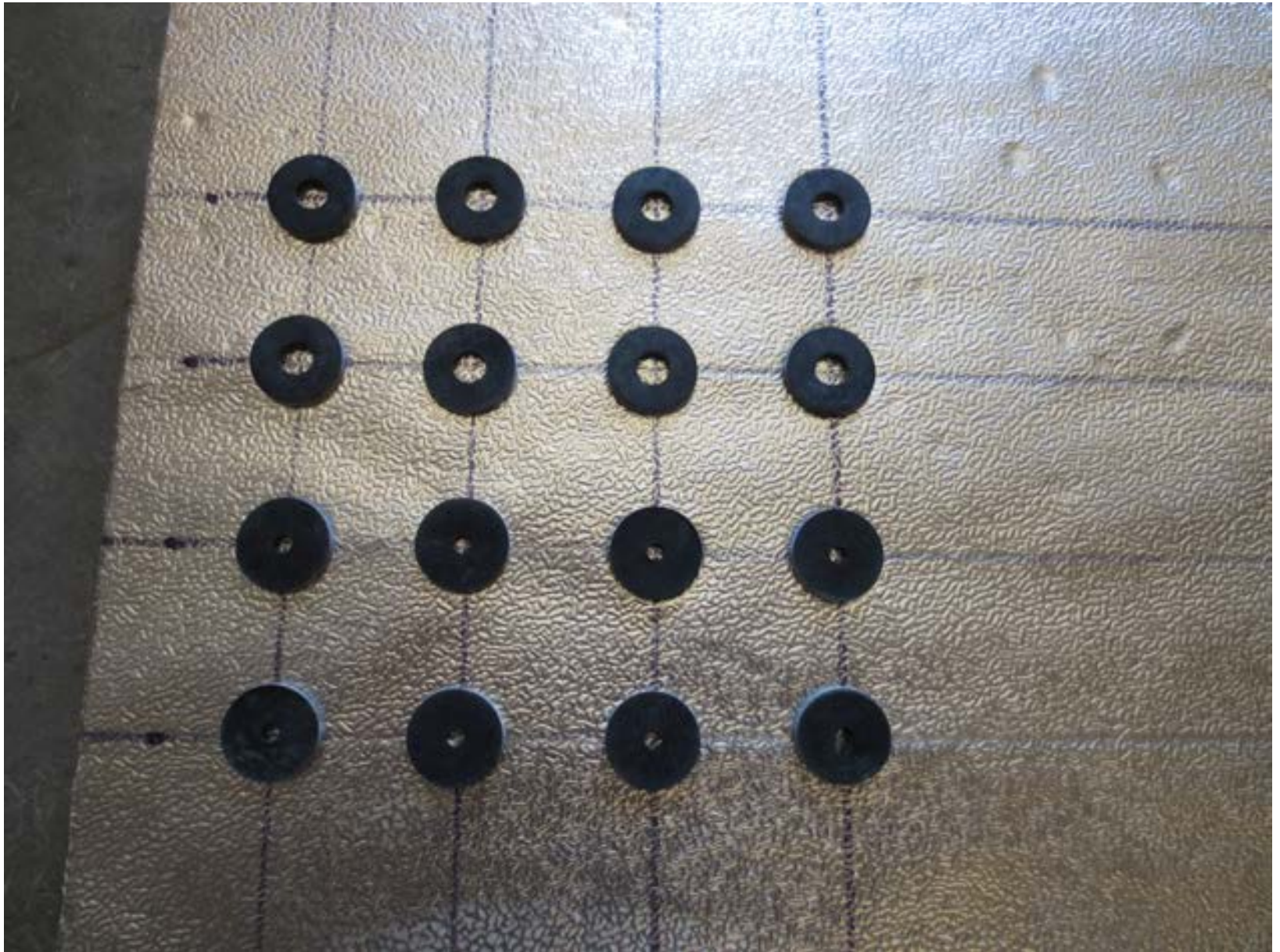




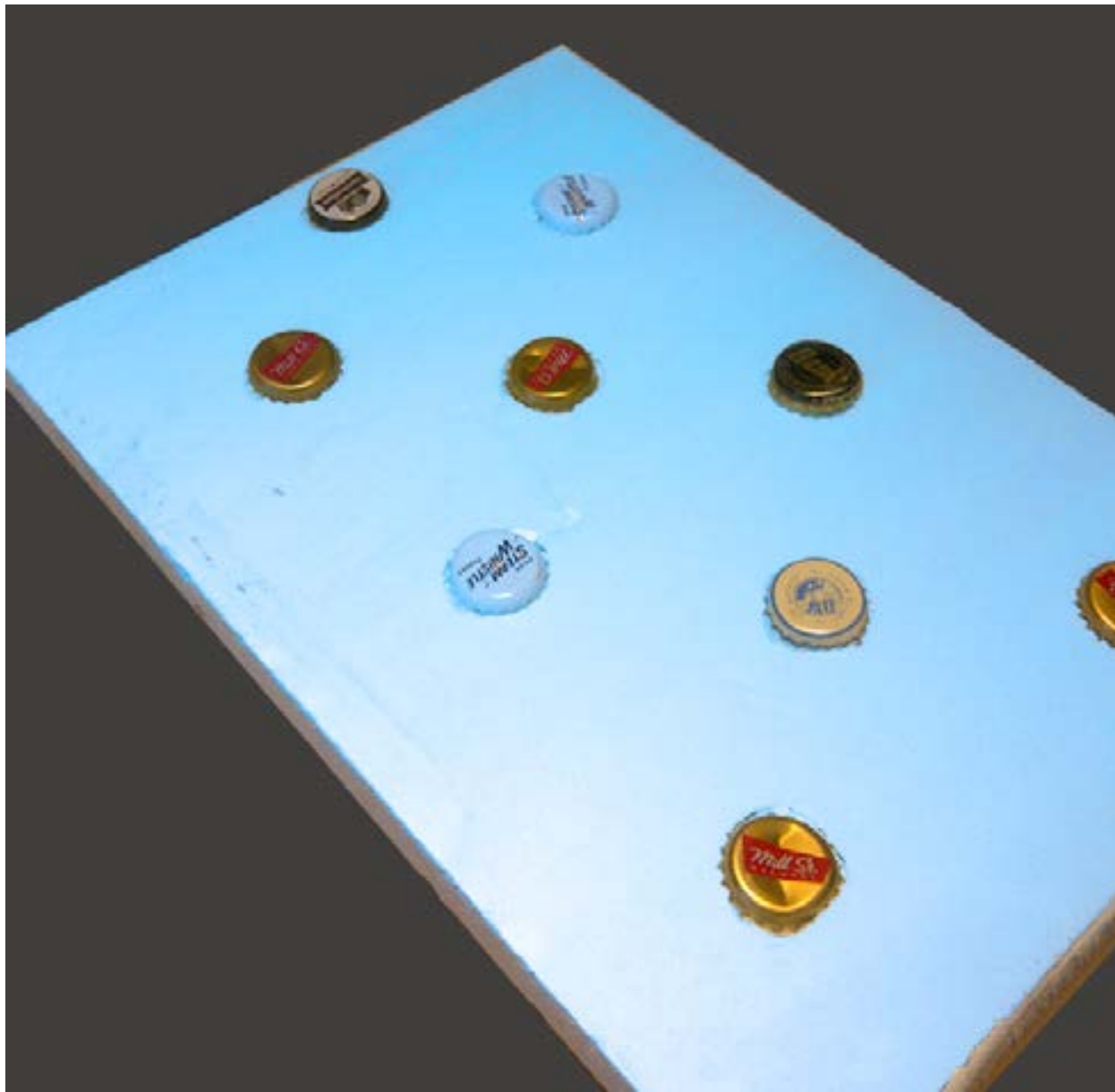




Rain Screen



Beer Screen?



2nd Law of Thermodynamics

In an isolated system, a process can occur only if it increases the total entropy of the system

Rudolf Clausius

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

Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

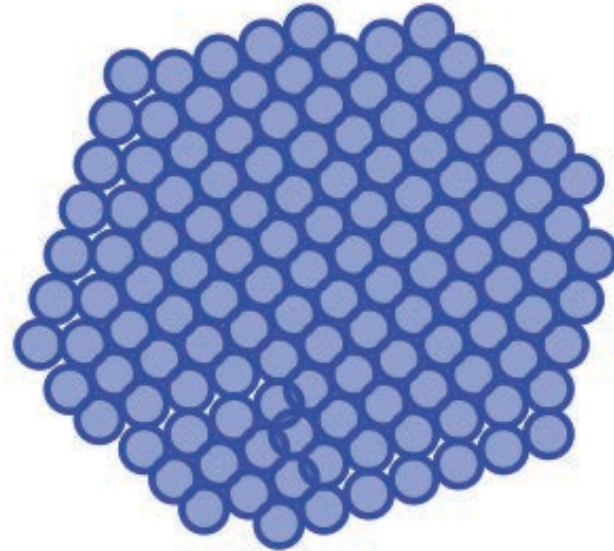
Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion

Thermodynamic Potential



Vapor



Liquid



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**

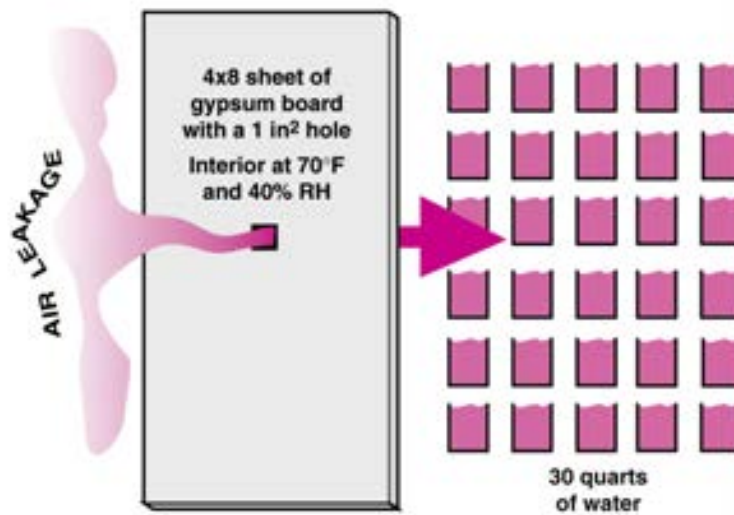
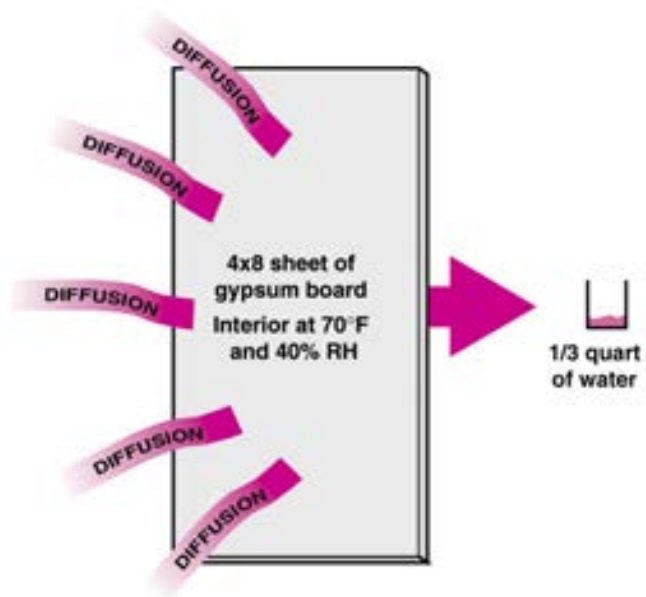


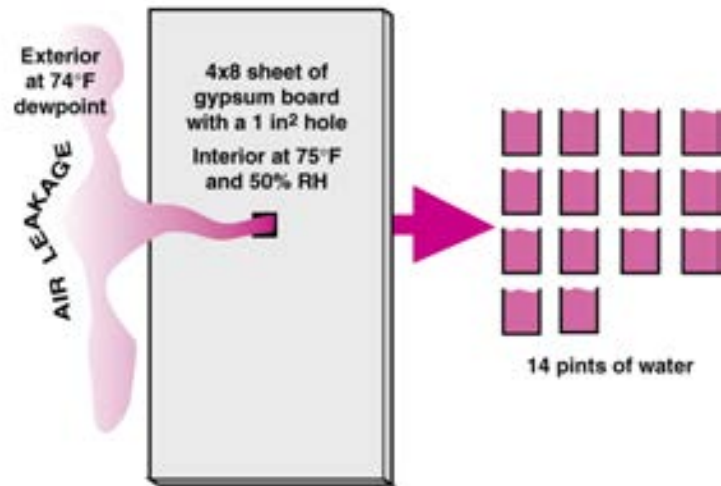
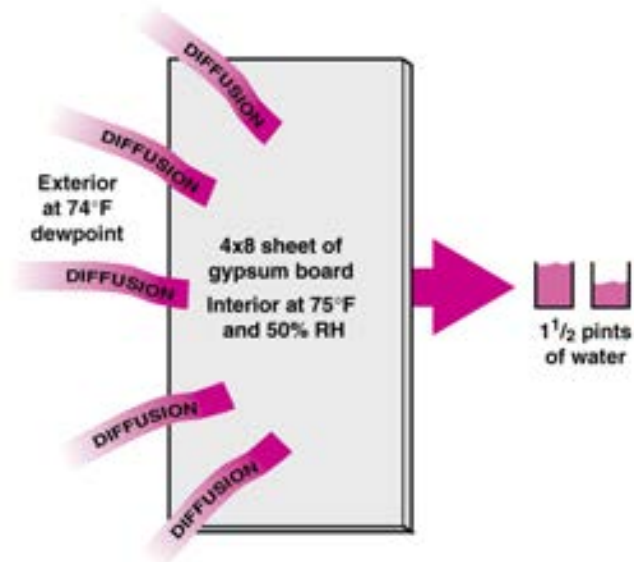
AIR TRANSPORT



**Higher Air
Pressure**

**Lower Air
Pressure**

























































Commercial Enclosure: Simple Layers



- Structure
- Rain/Air/Vapor
- Insulation
- Finish

