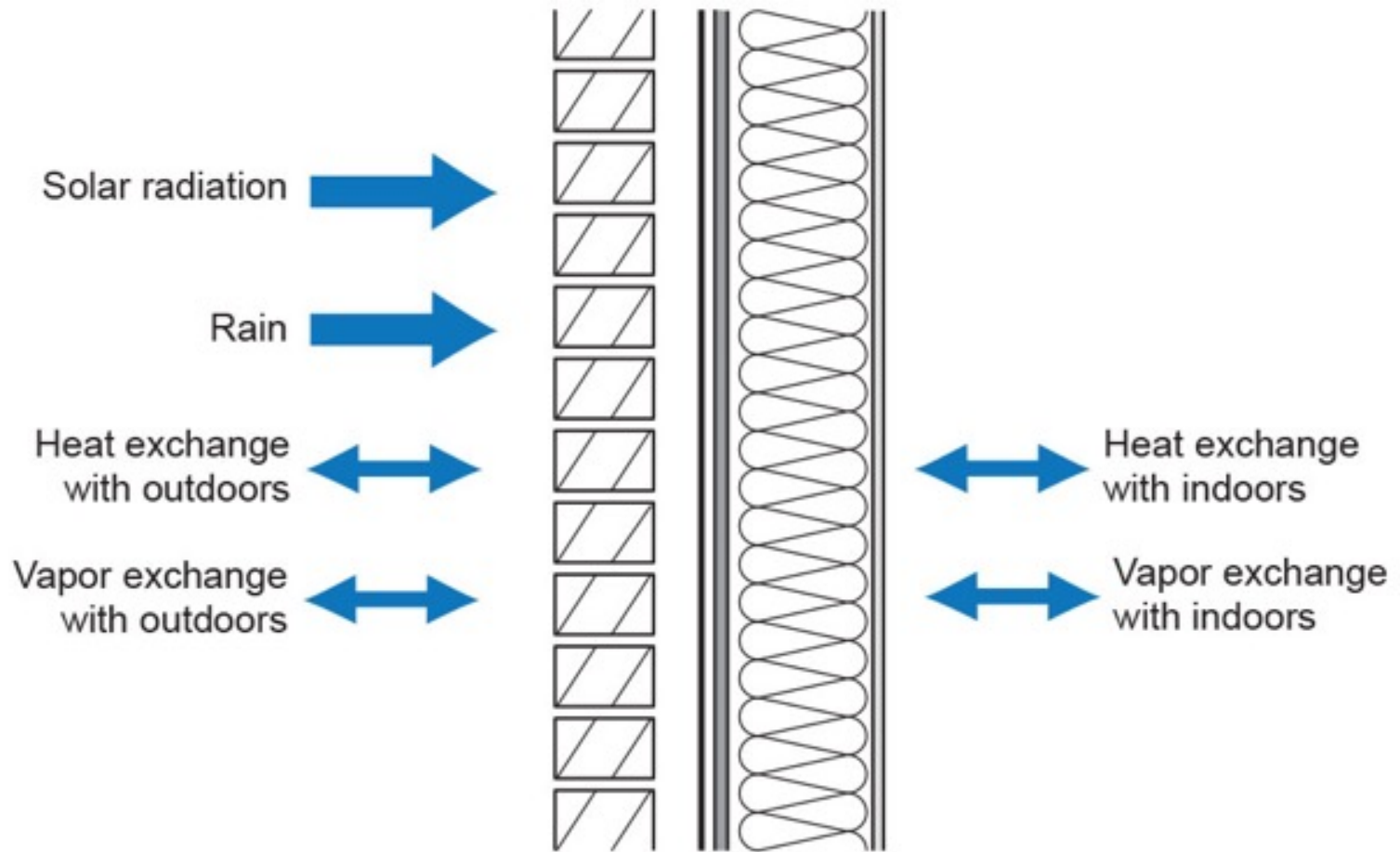


Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

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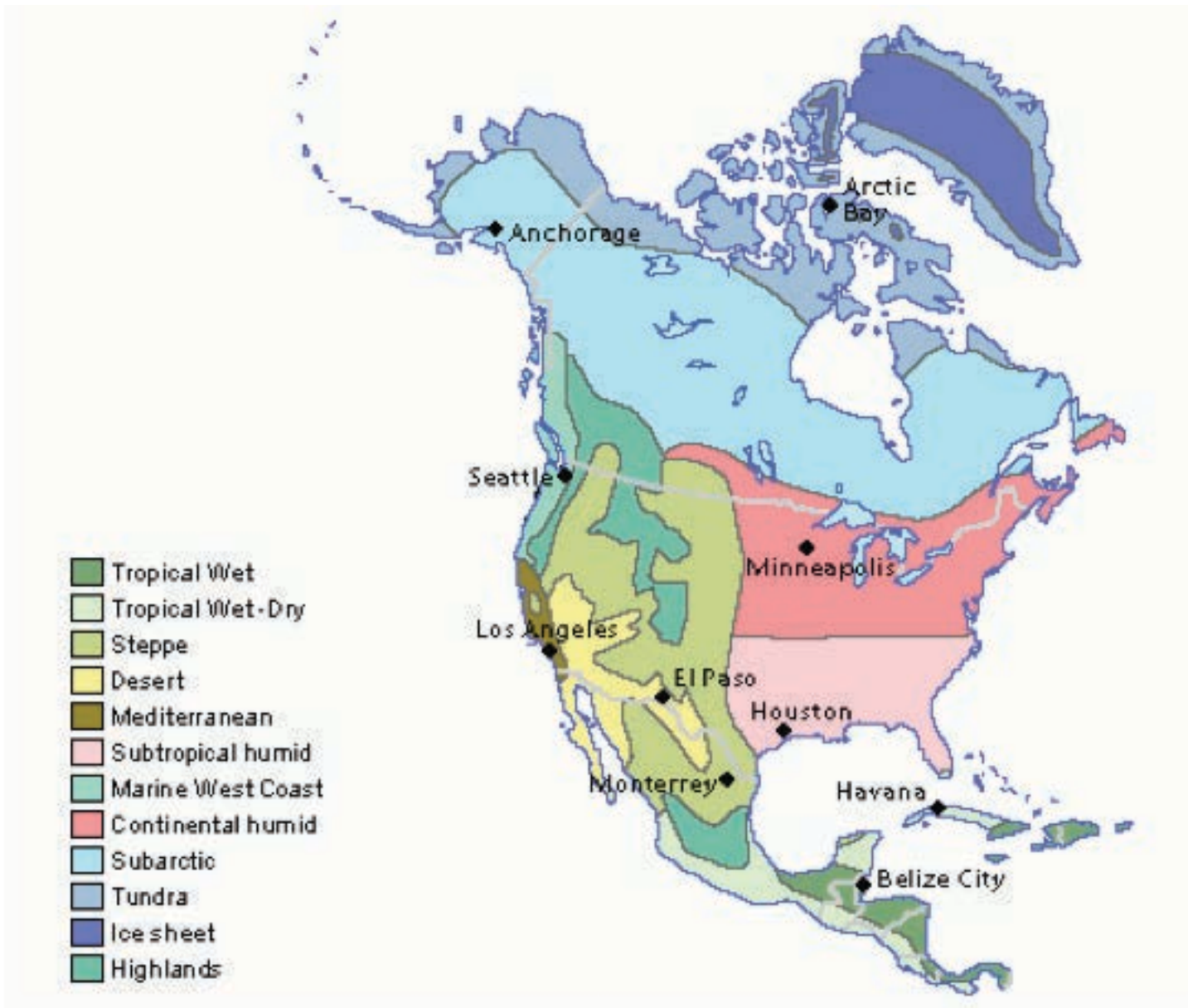
Water control layer

Air control layer

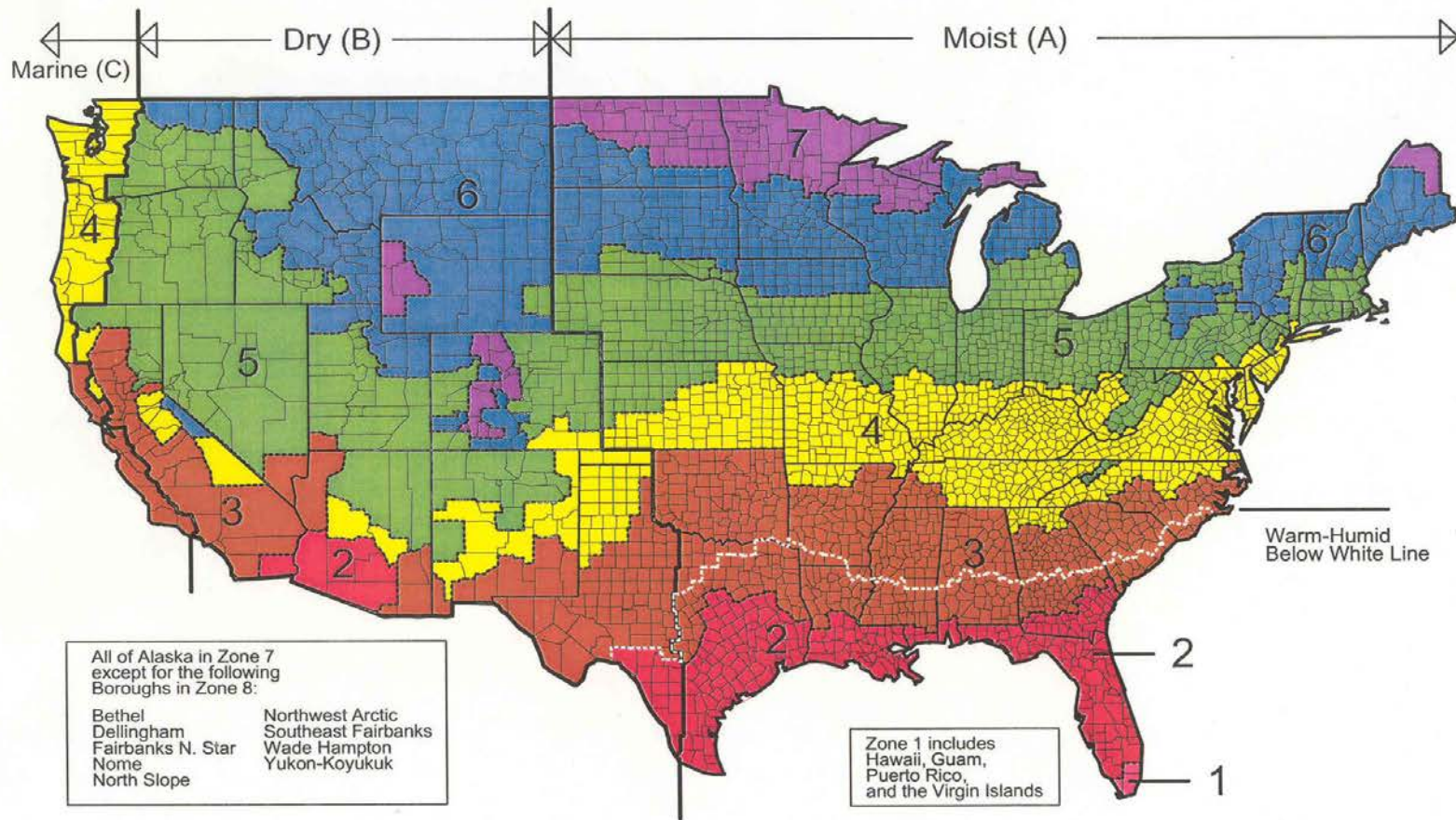
Vapor control layer

Thermal control layer



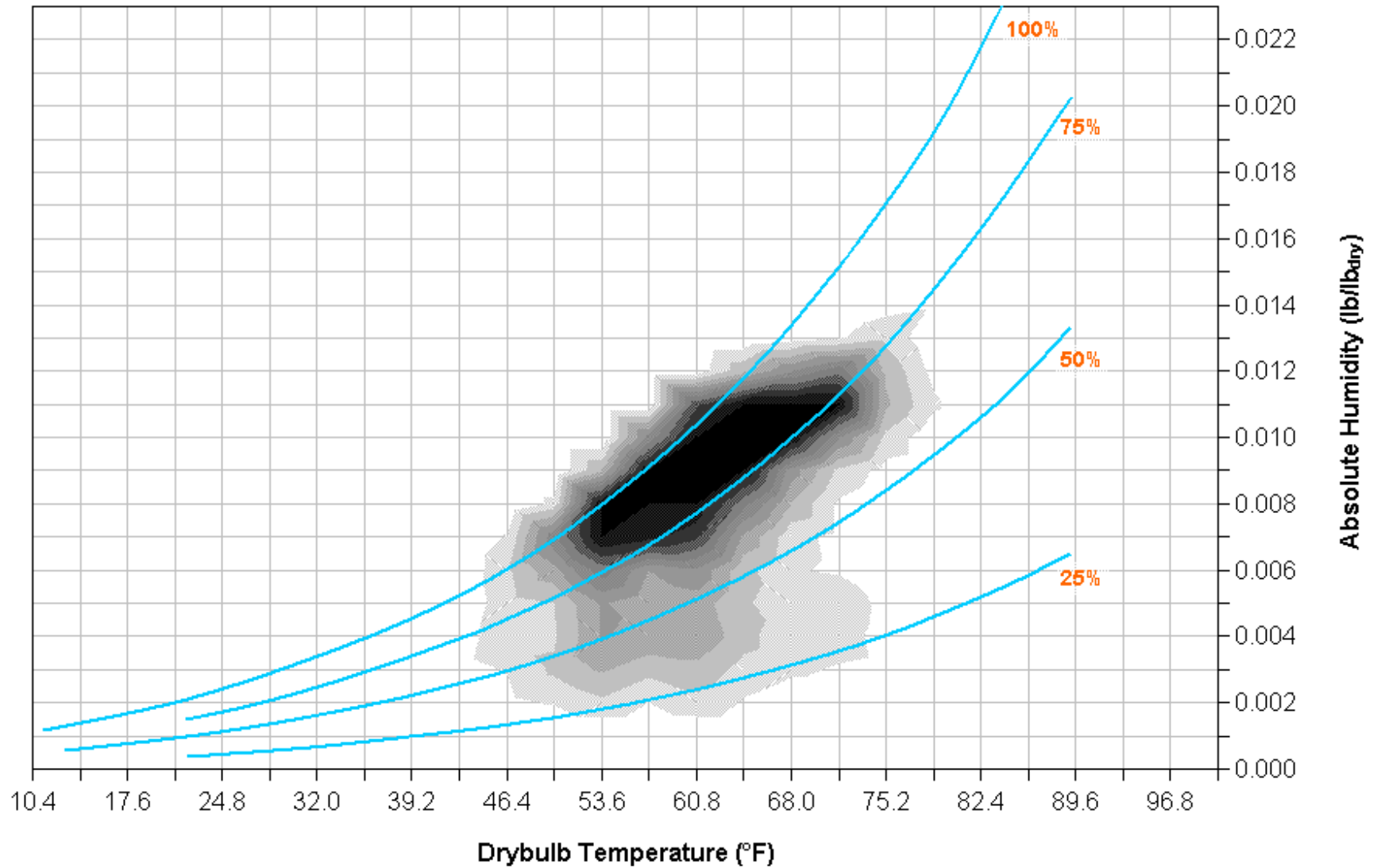


Map of DOE's Proposed Climate Zones

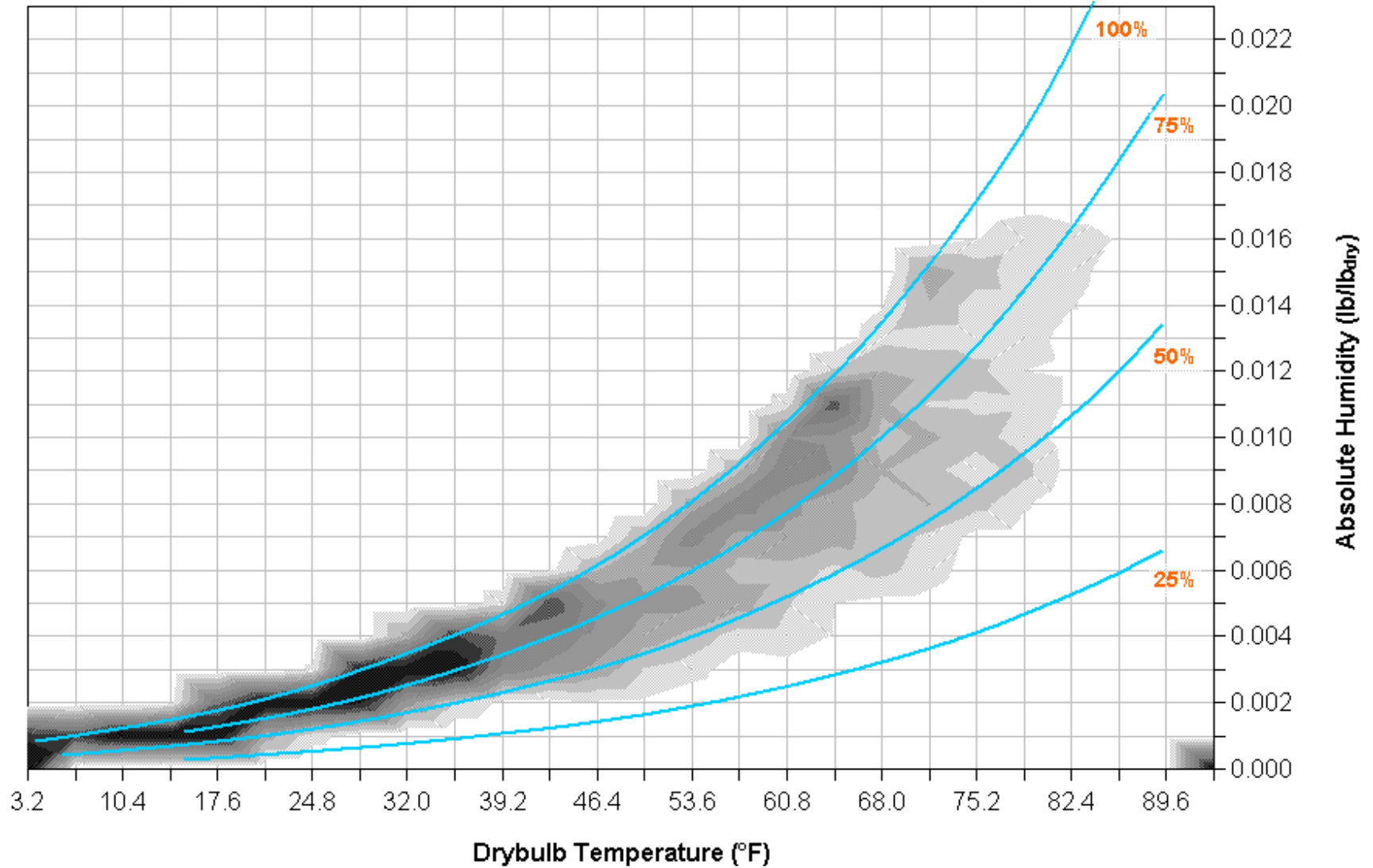


March 24, 2003

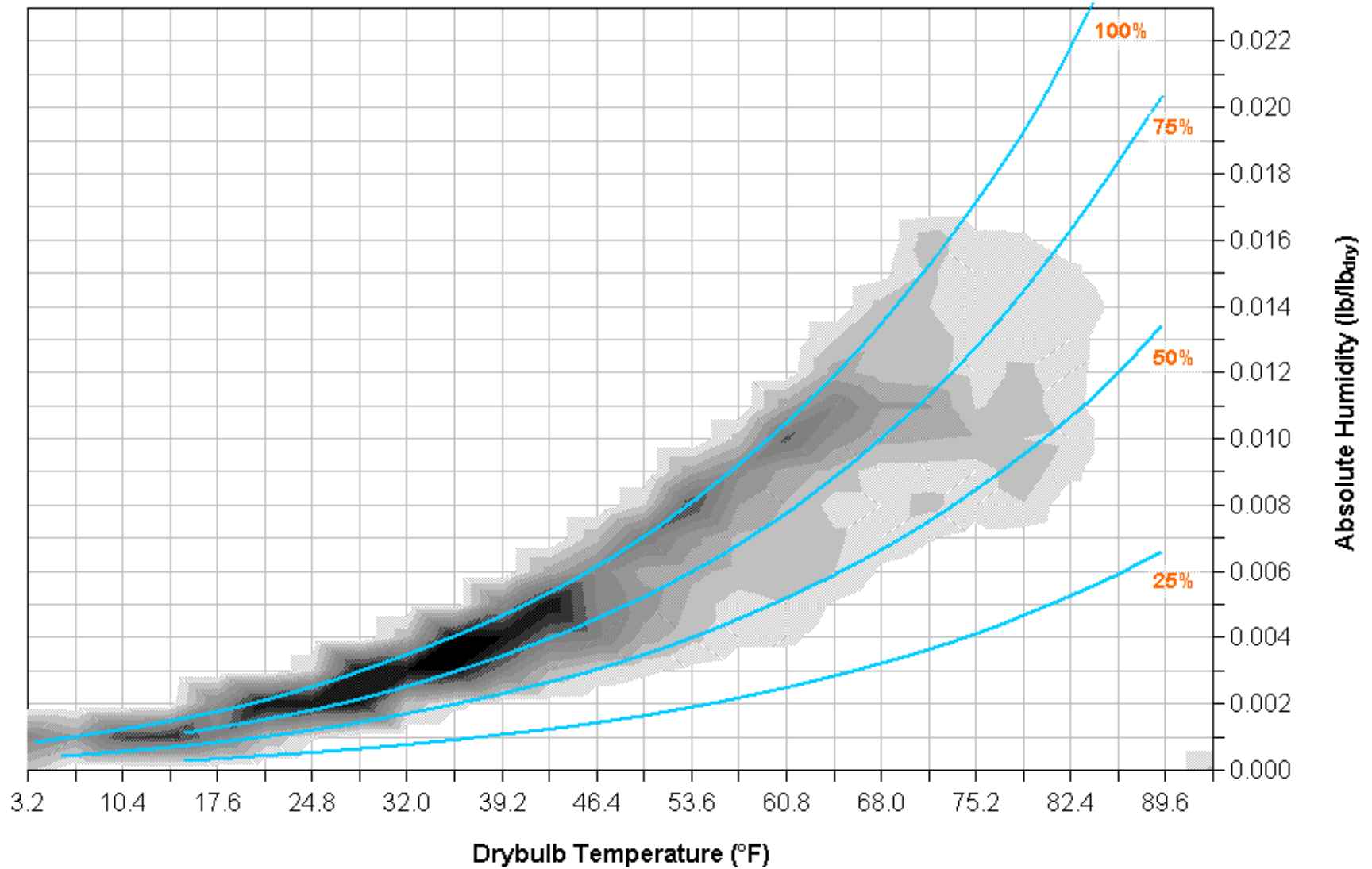
Los Angeles, CA



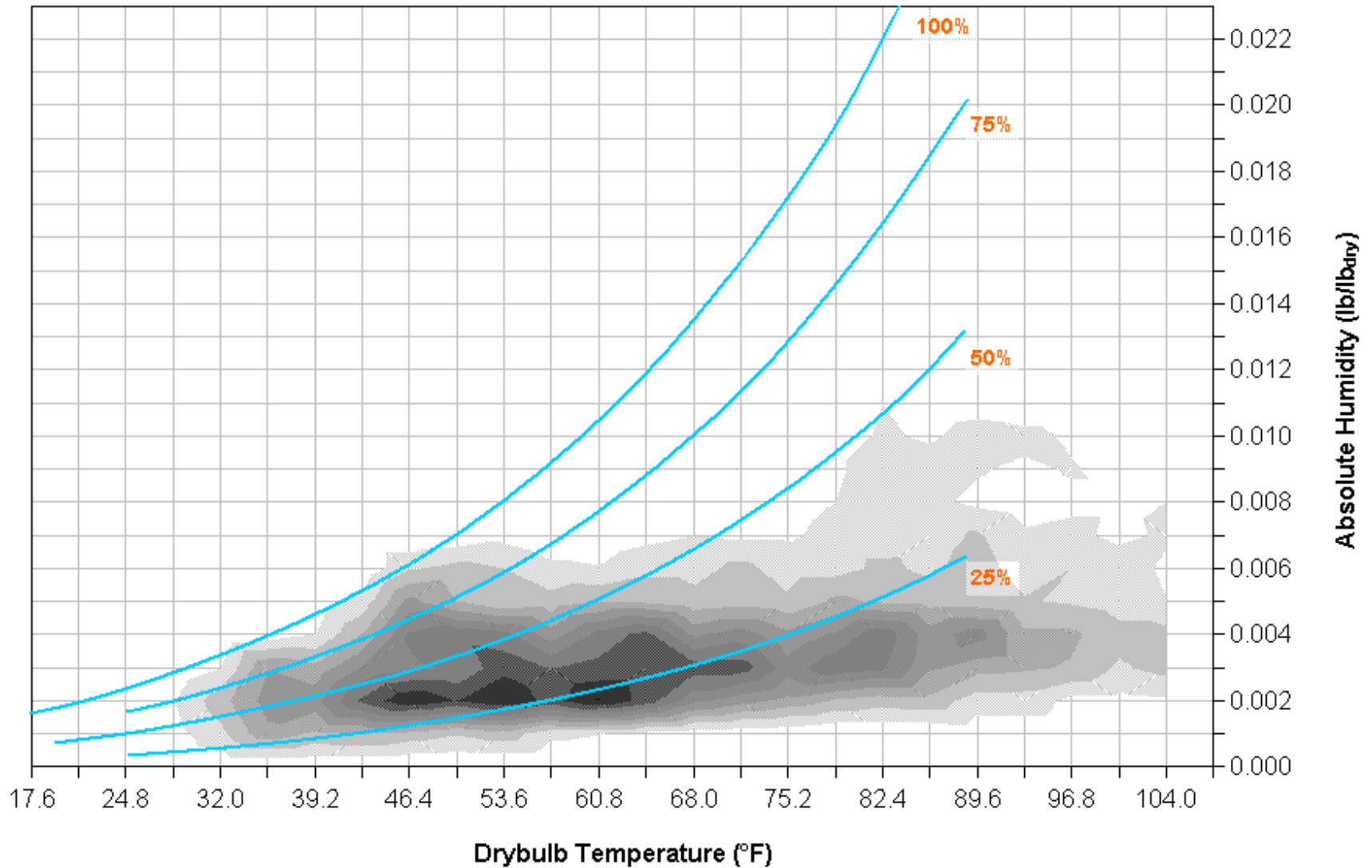
Minneapolis, MN



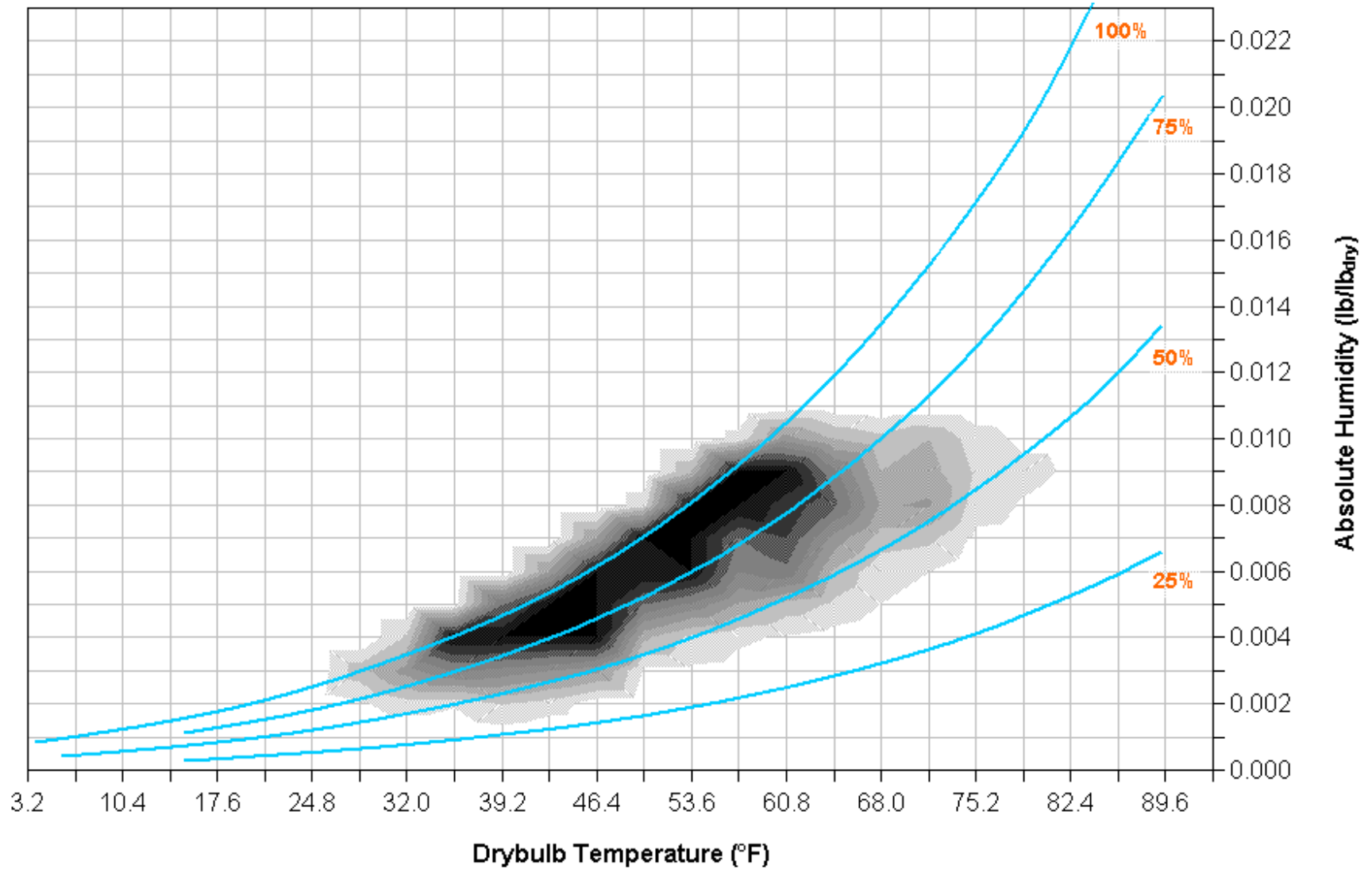
Lansing, MI



Las Vegas, NV



Seattle, WA



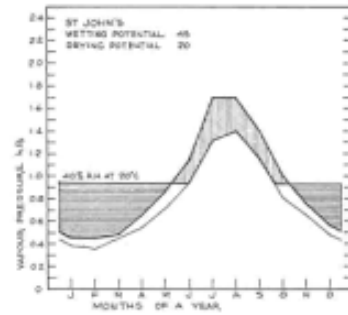


Figure 8-10. Wetting and drying potential for St. John's, Newfoundland.

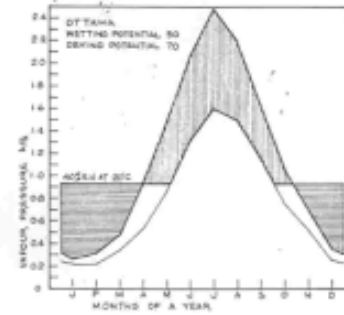


Figure 8-13. Wetting and drying potential for Ottawa, Ontario.

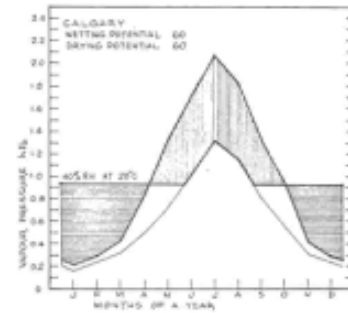


Figure 8-11. Wetting and drying potential for Calgary, Alberta.

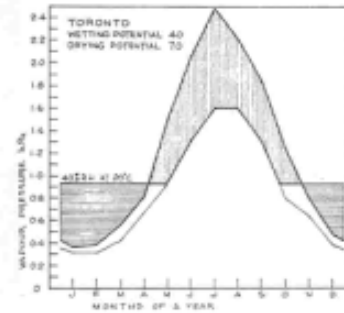


Figure 8-14. Wetting and drying potential for Toronto, Ontario.

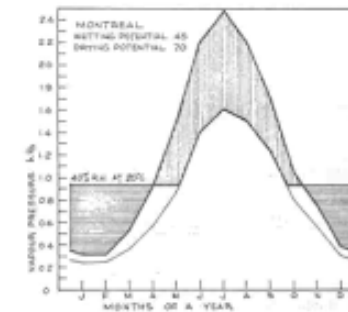


Figure 8-12. Wetting and drying potential for Montreal, Quebec.

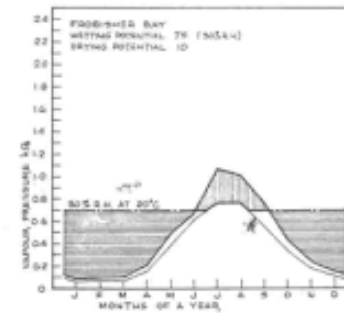


Figure 8-15. Wetting and drying potential for Frobisher Bay, NWT.

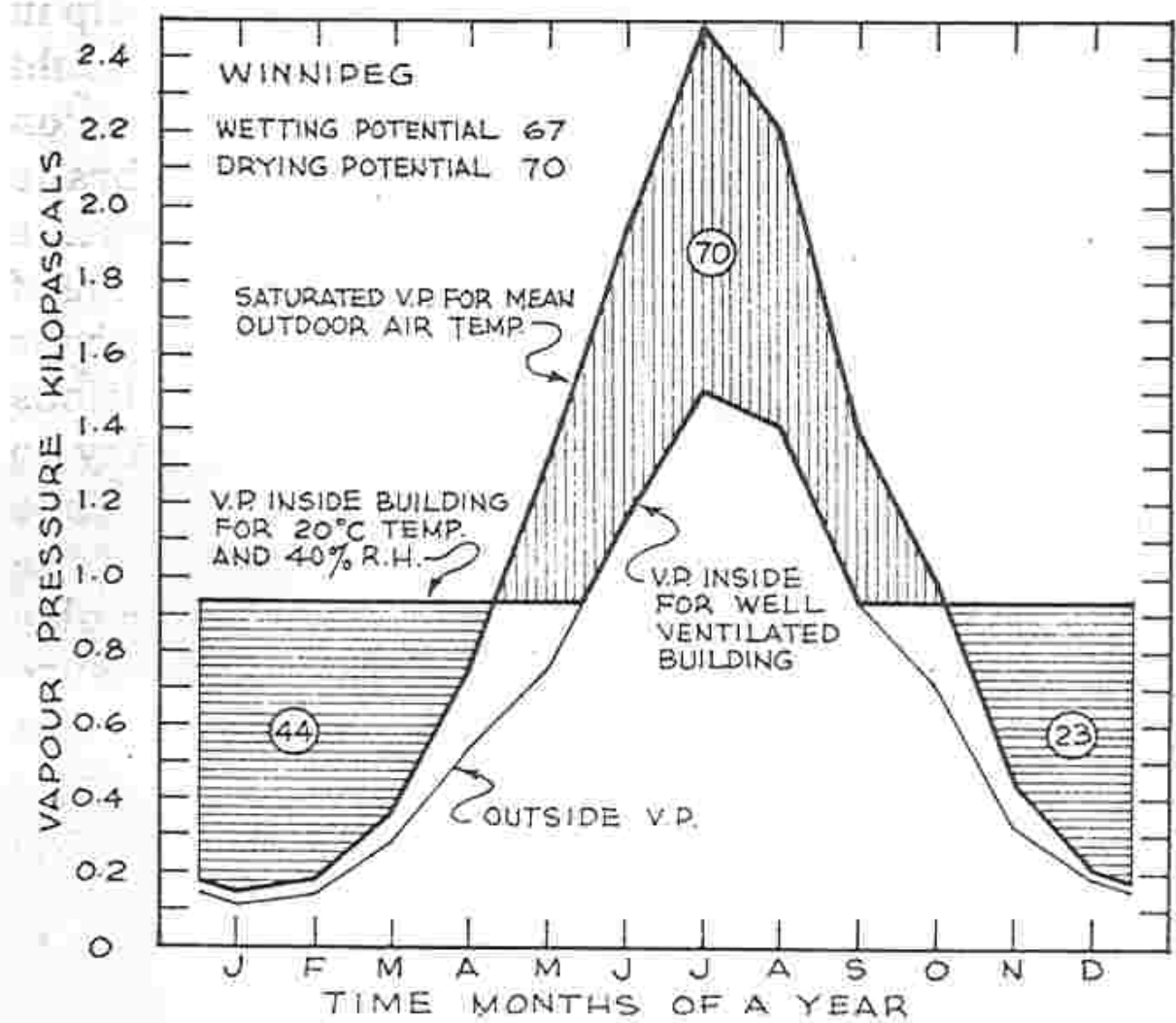
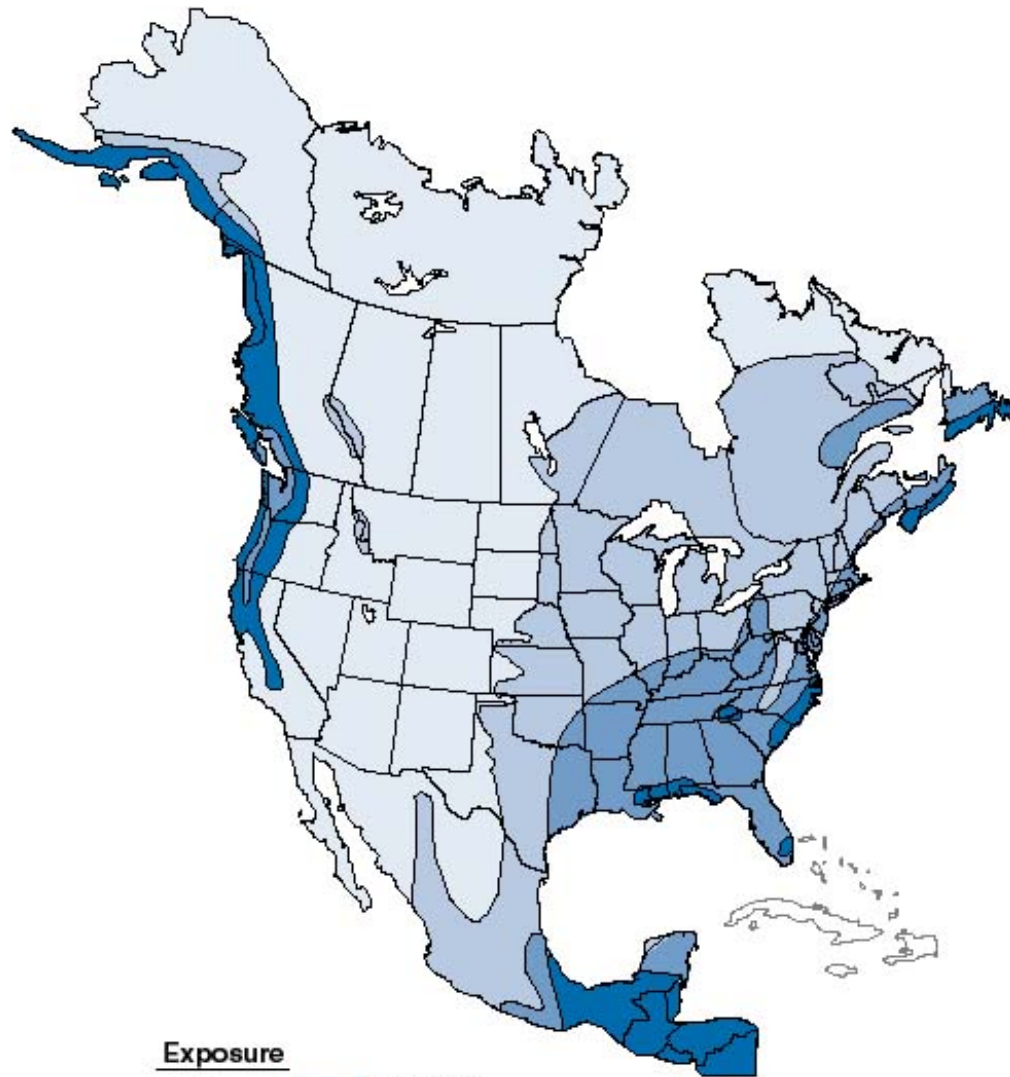


Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.



Exposure

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

Water control layer

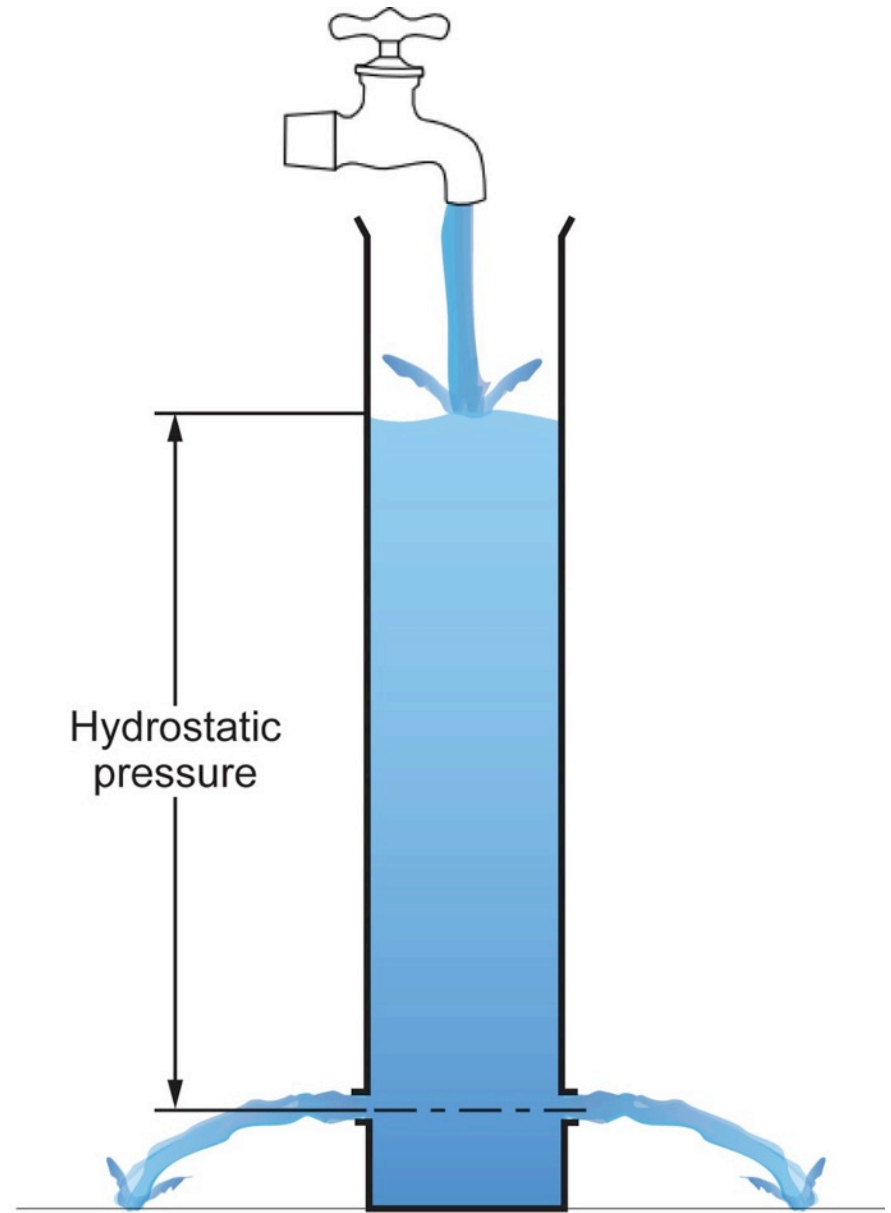
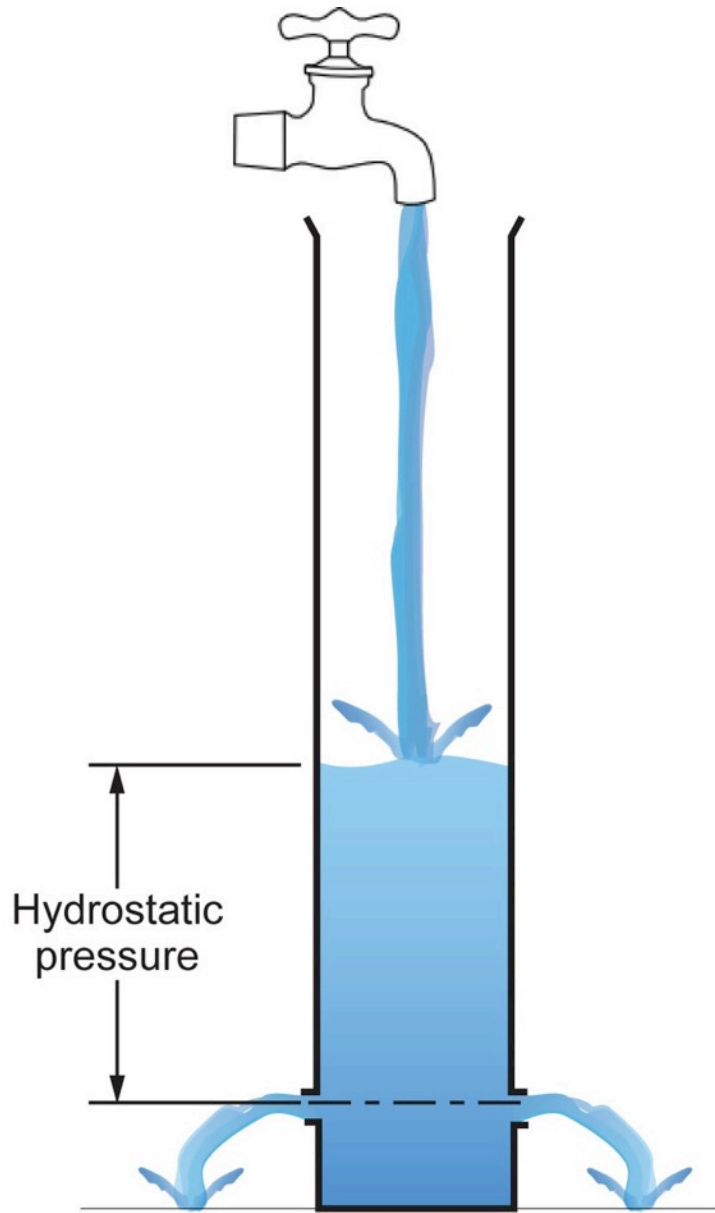
Water control layer

Key is control of hydrostatic pressure

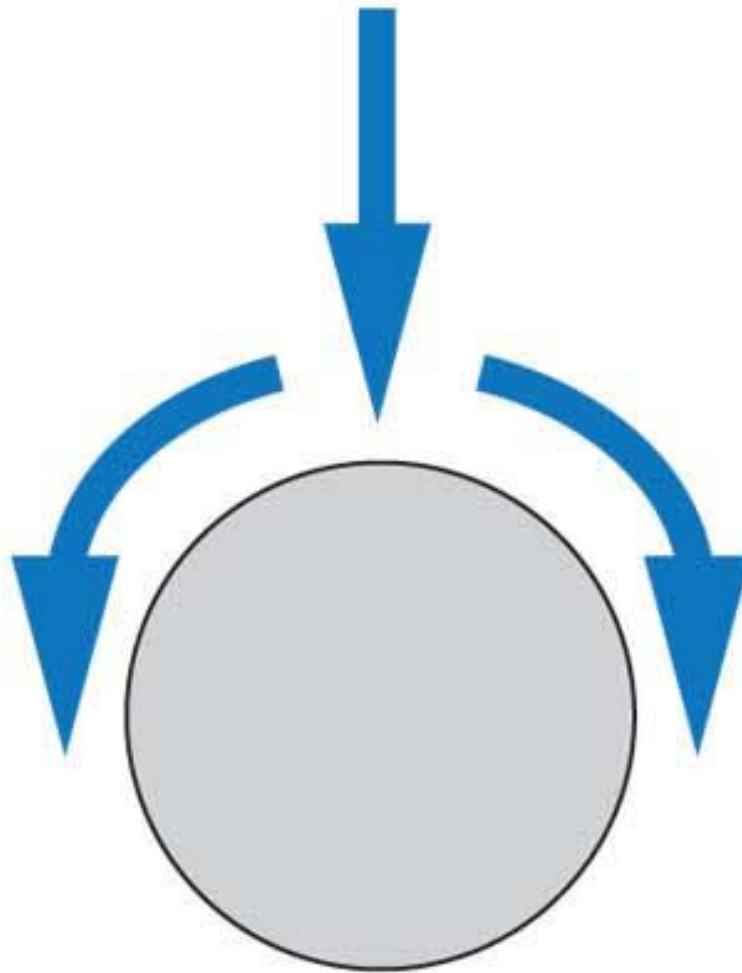
Water control layer

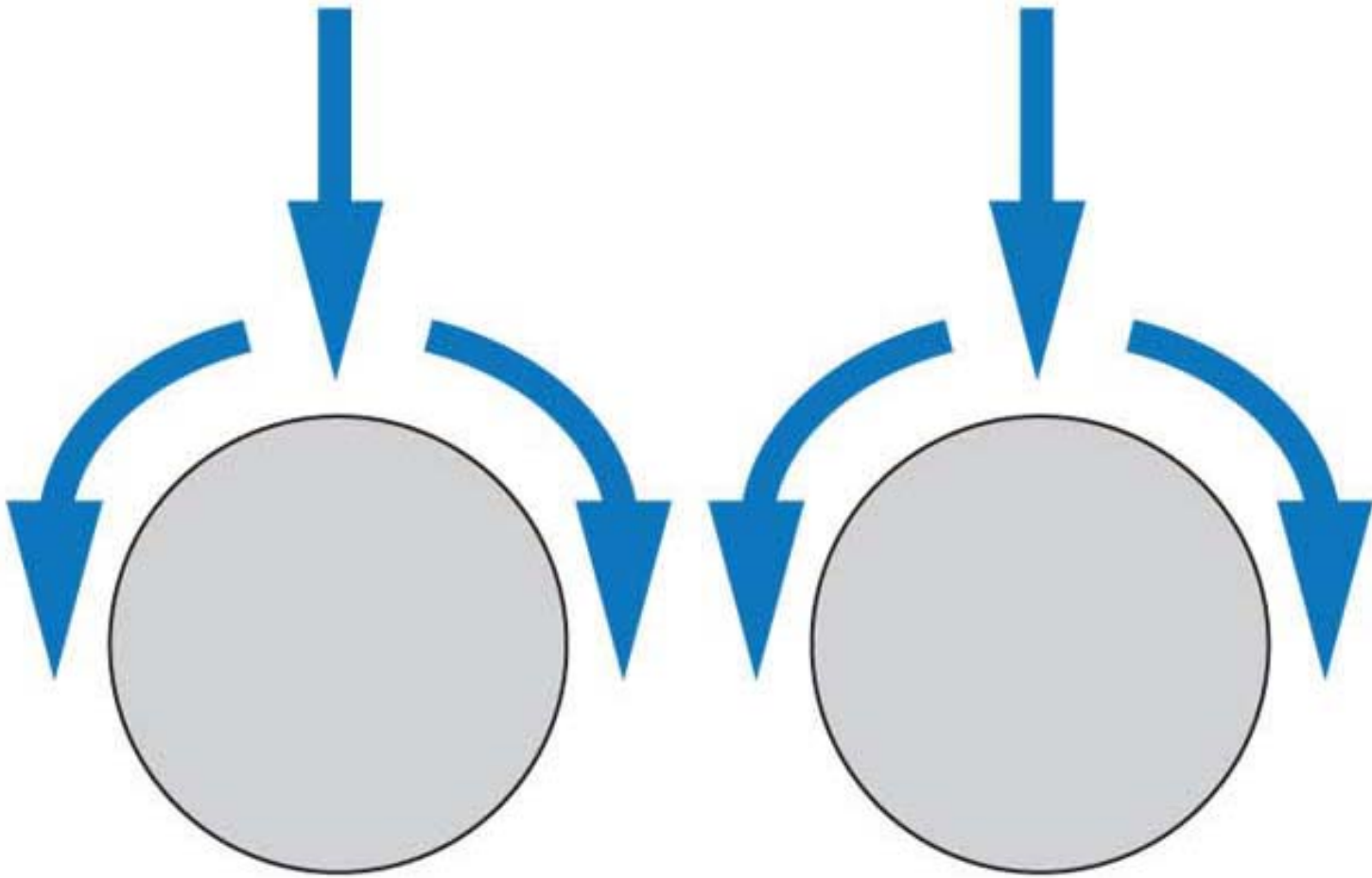
Key is control of hydrostatic pressure

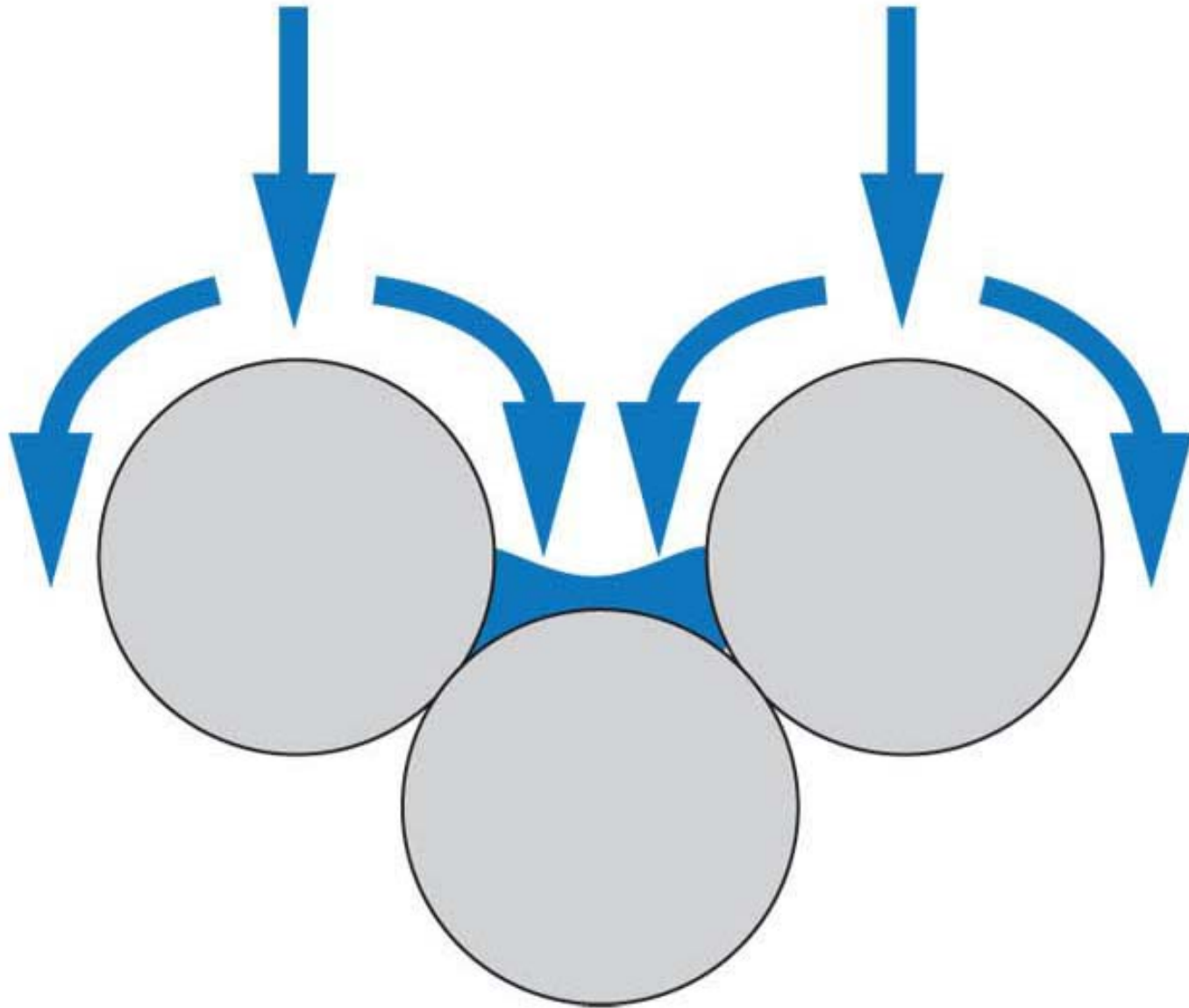
All about “the gap”



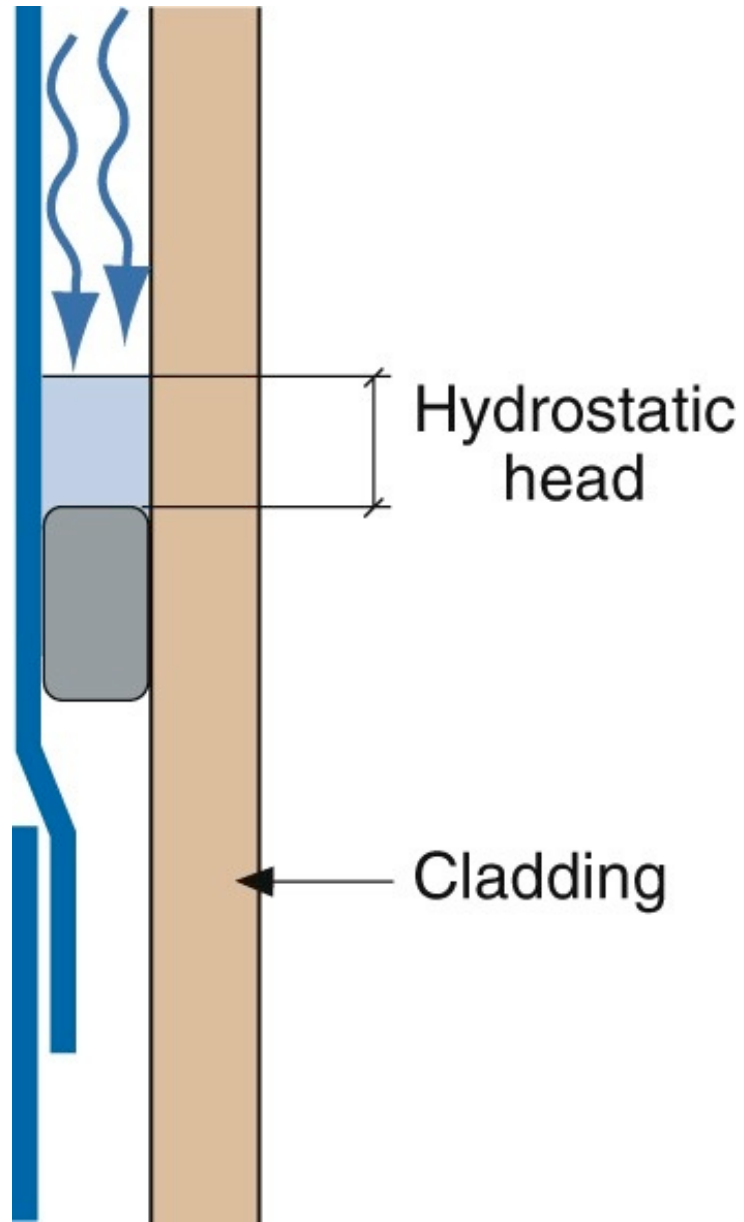


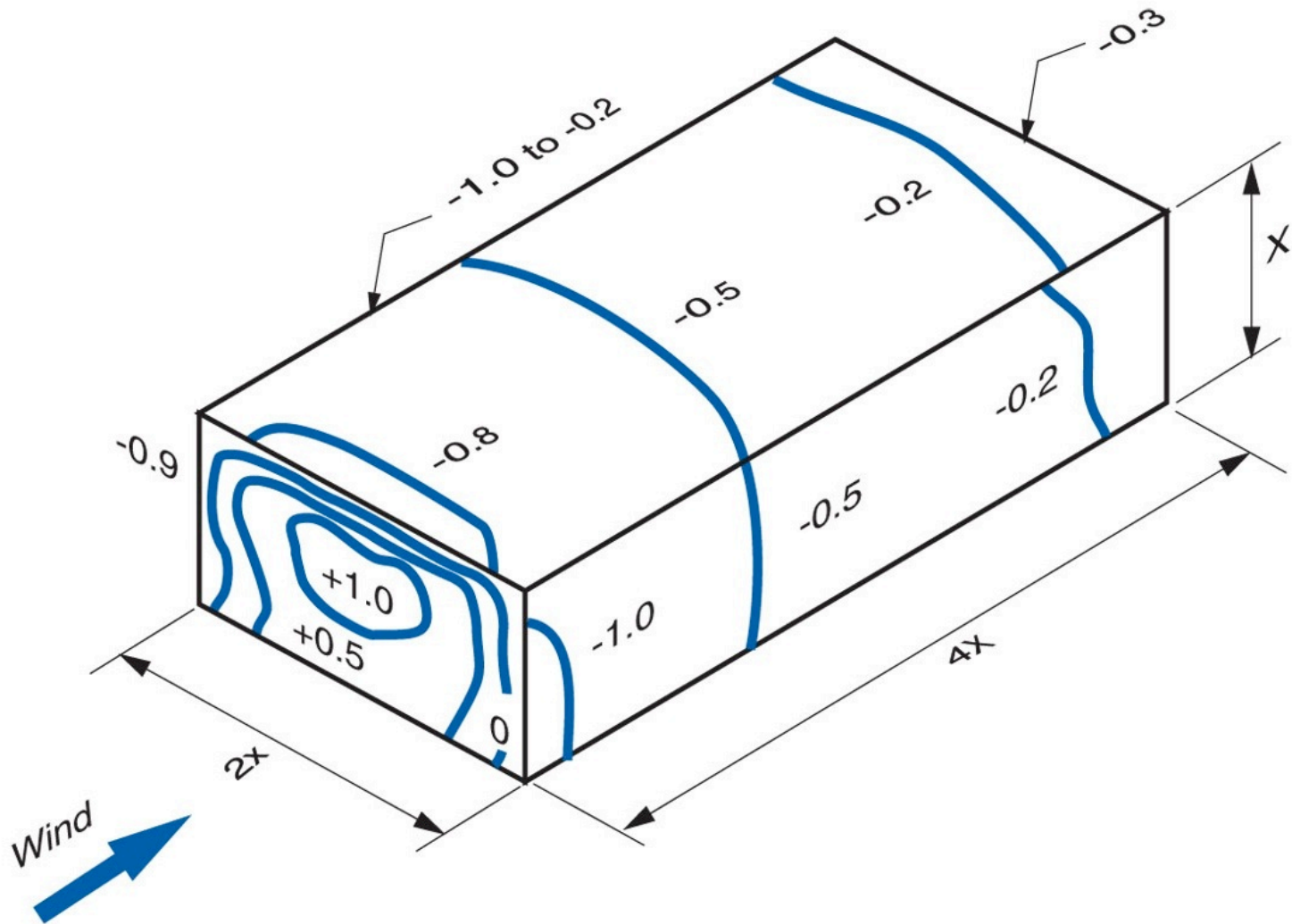


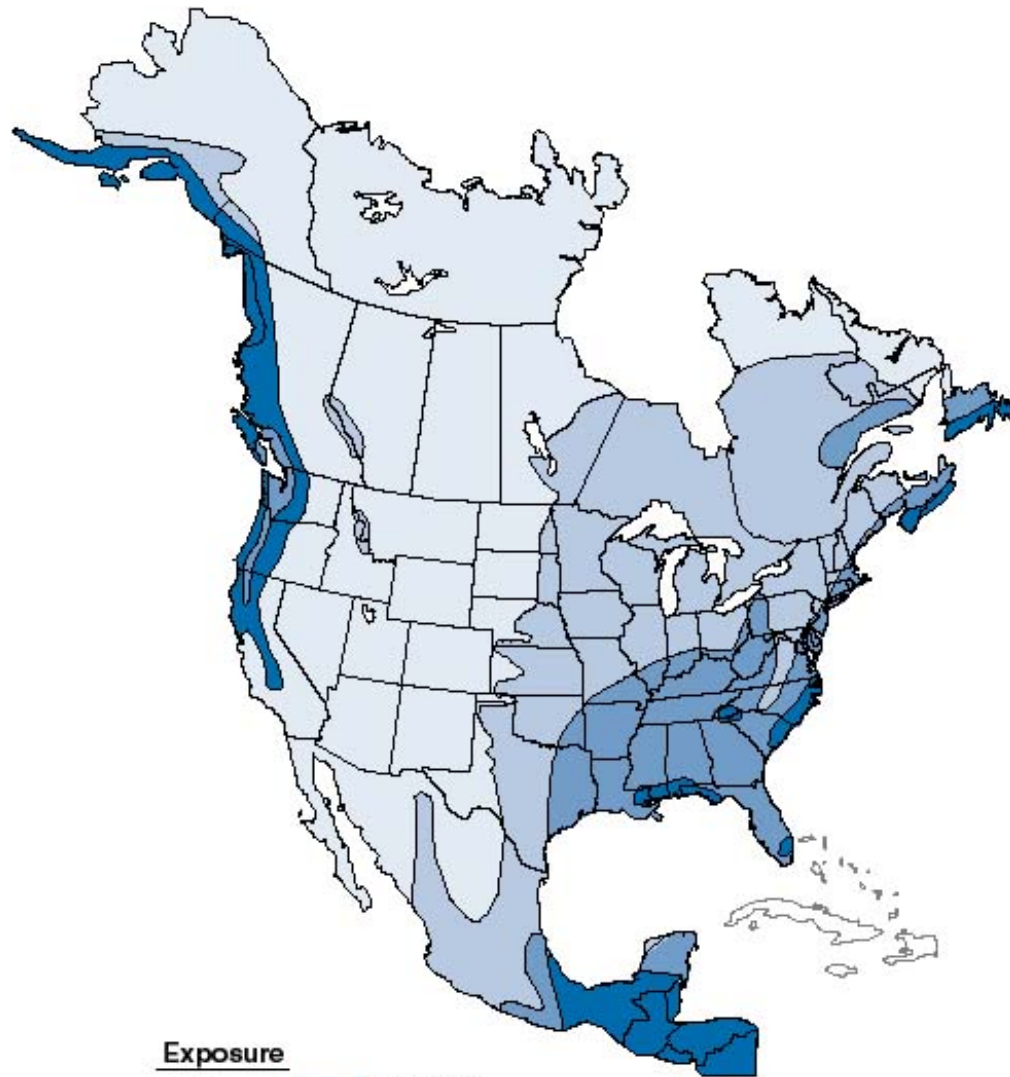












Exposure

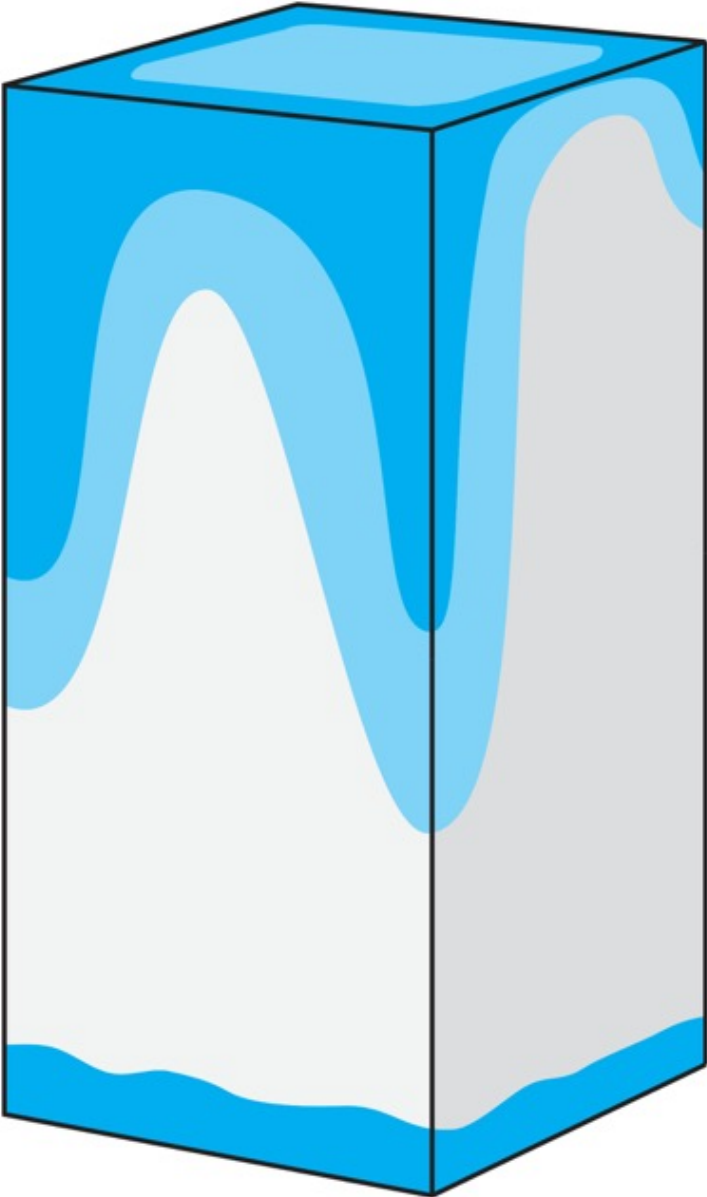
Extreme	Over 60'
High	40' - 60'
Moderate	20' - 40'
Low	Under 20'

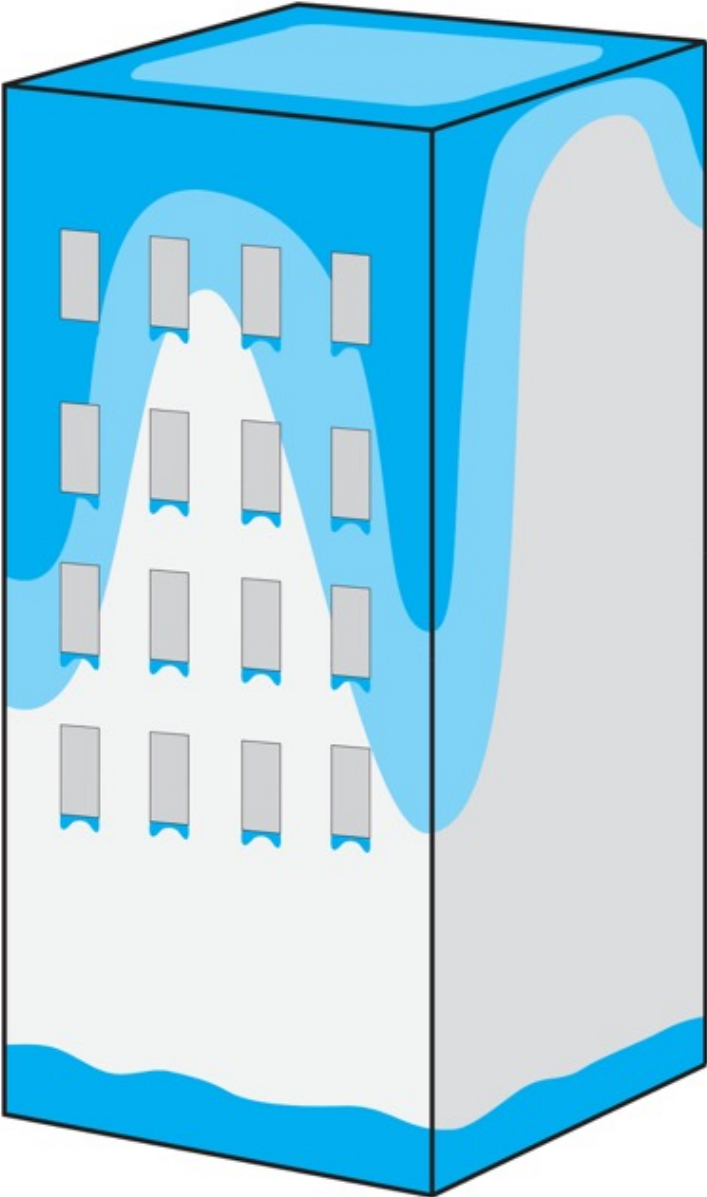
Trick is to figure out how much hits the wall

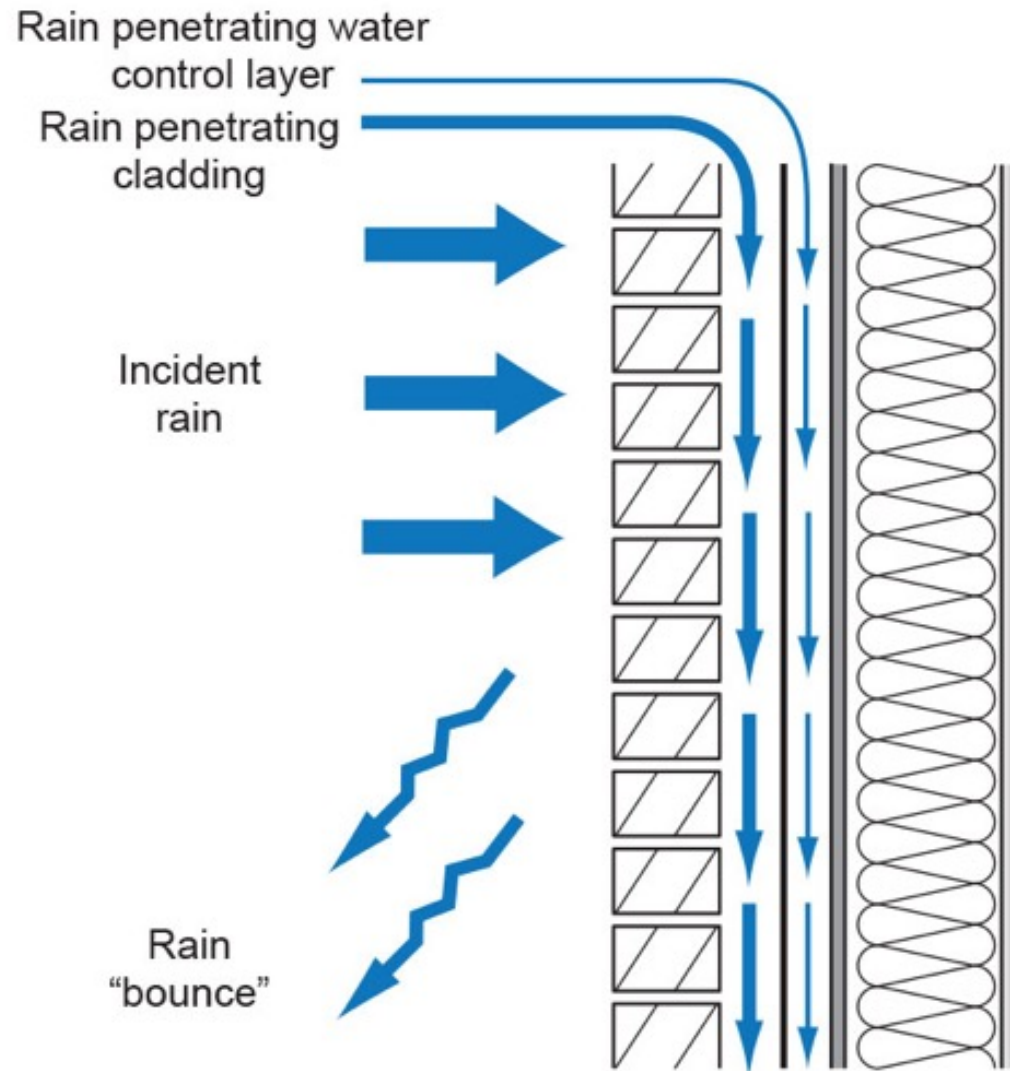
Assume 30 percent bounces off

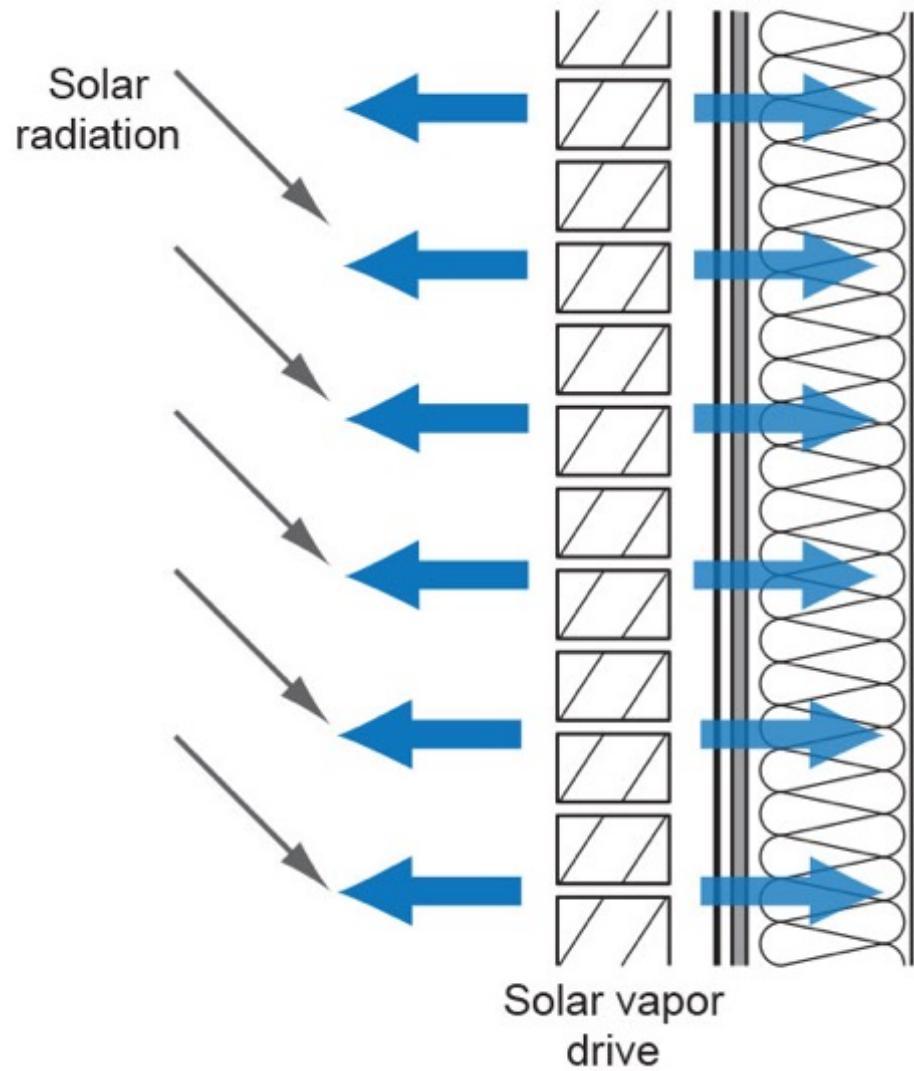
Assume 1 percent that stays on the wall passes through the cladding

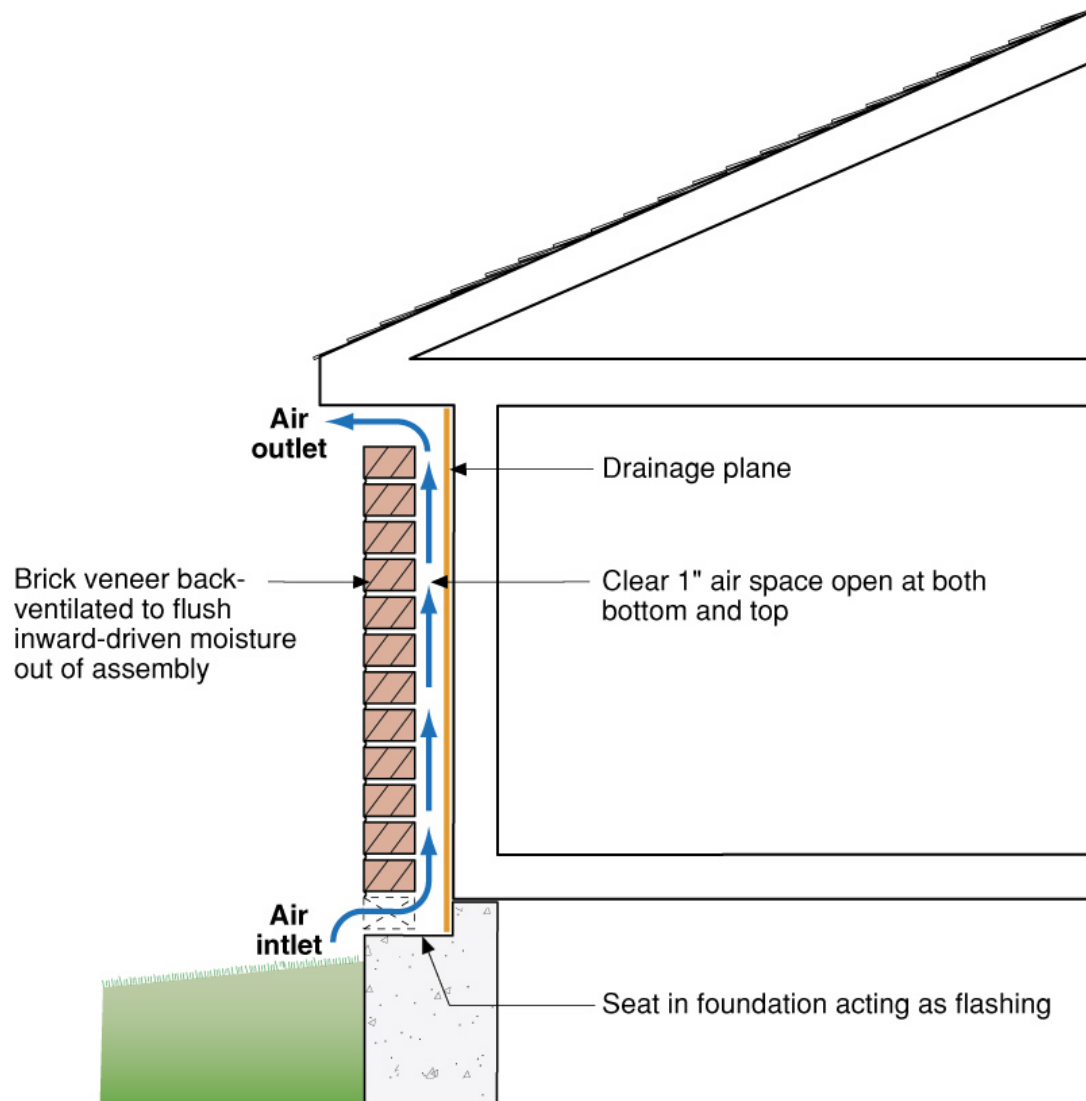
Assume 1 percent of the 1 percent passes through the water control layer into the sheathing



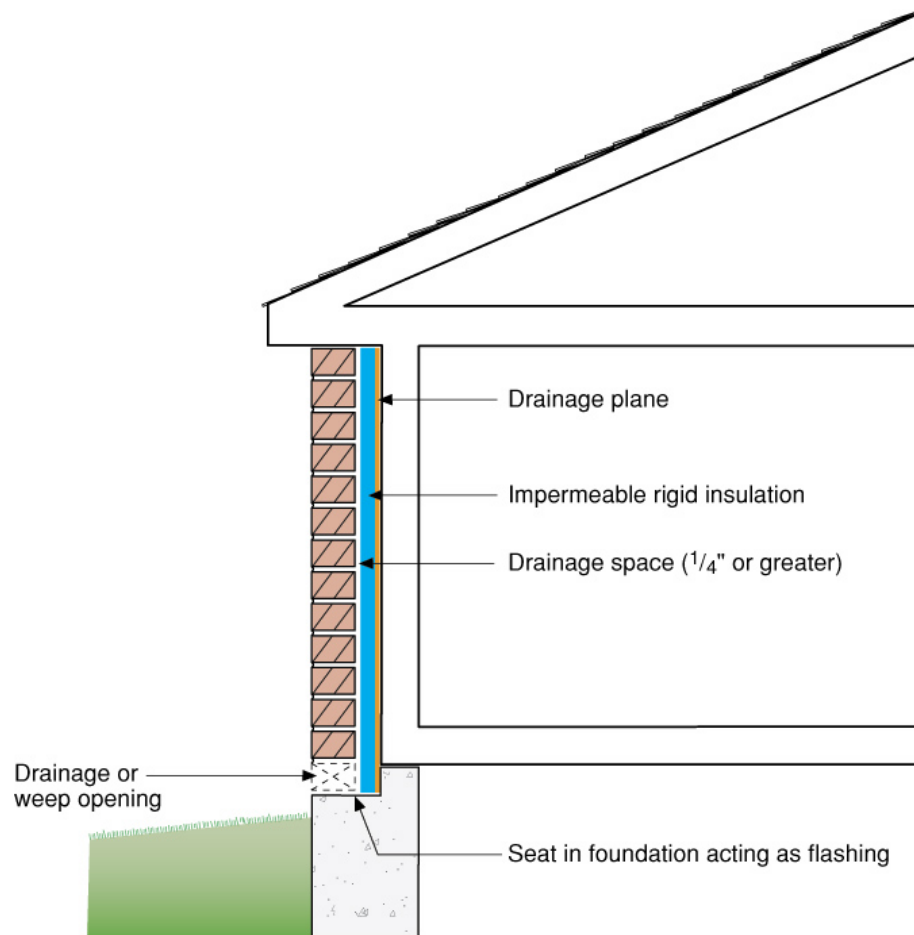






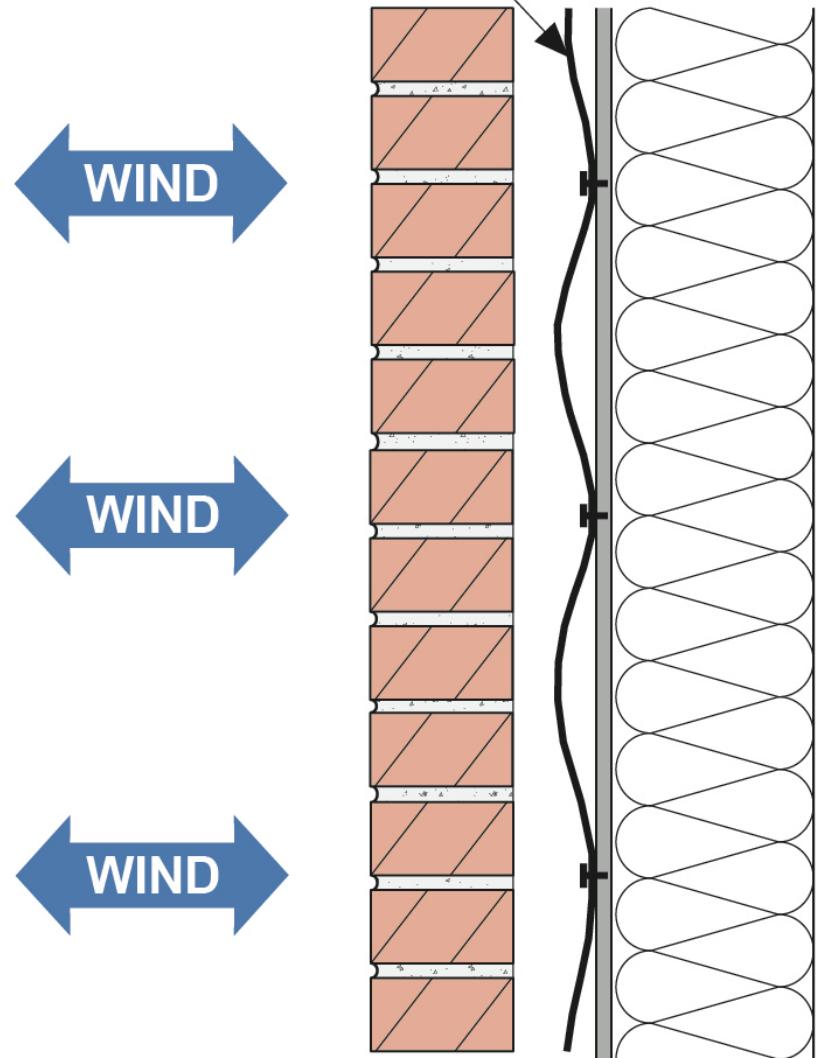


- To effectively uncouple a brick veneer from a wall system by using back ventilation a clear cavity must be provided along with both air inlets at the bottom and air outlets at the top



- To effectively uncouple a brick veneer from a wall system by using a condensing surface the drainage plane must also be a vapor barrier or a vapor impermeable layer (i.e. rigid insulation) must be installed between the drainage plane and the brick veneer. Alternatively, the rigid insulation can be configured to act as a both the drainage plane and vapor impermeable layer.
- When a condensing surface is used to uncouple a brick veneer from a wall system a ventilated air space is no longer necessary. Additionally, the width of the drainage space is almost irrelevant.

Fluctuating Membrane

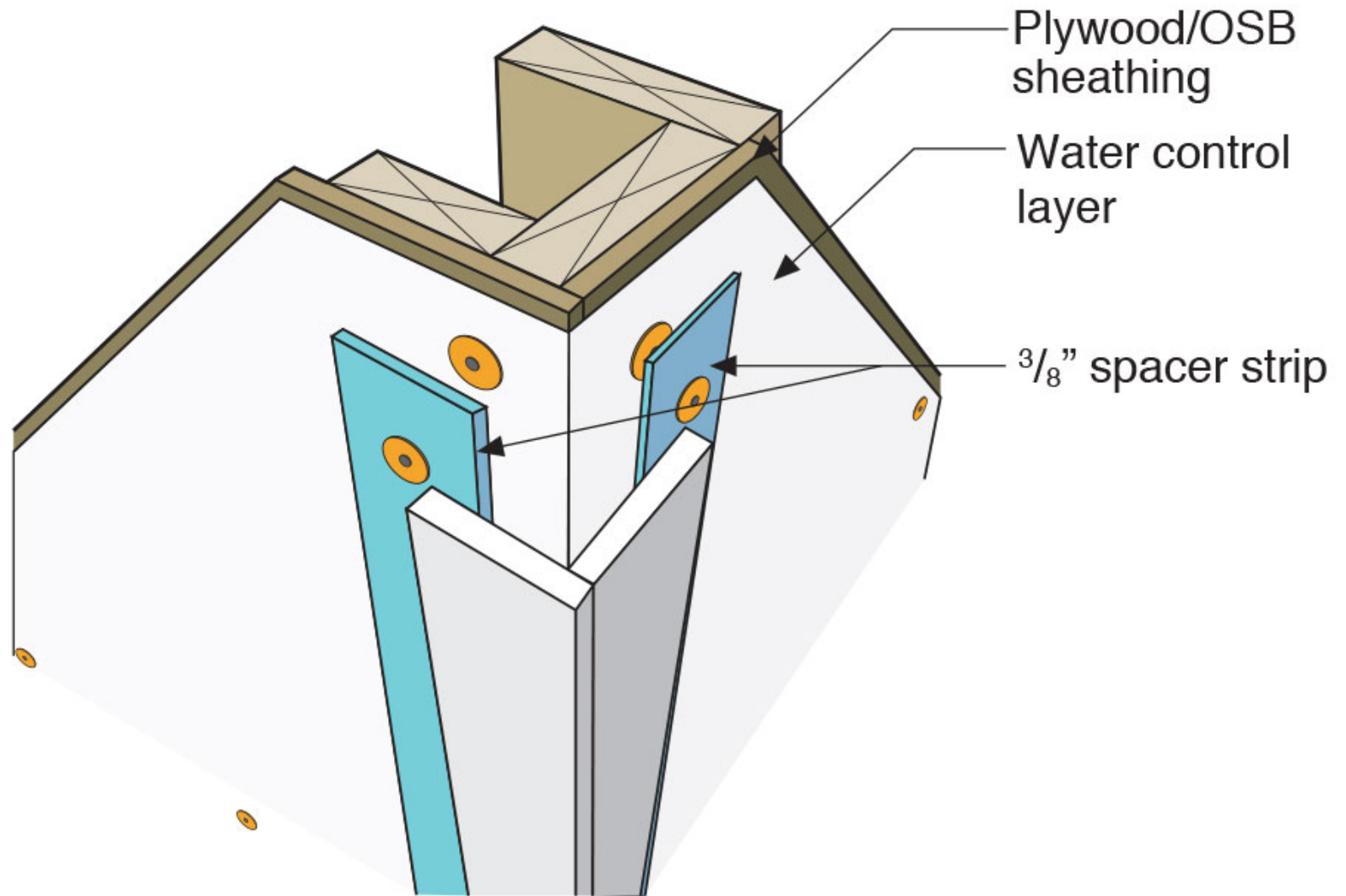


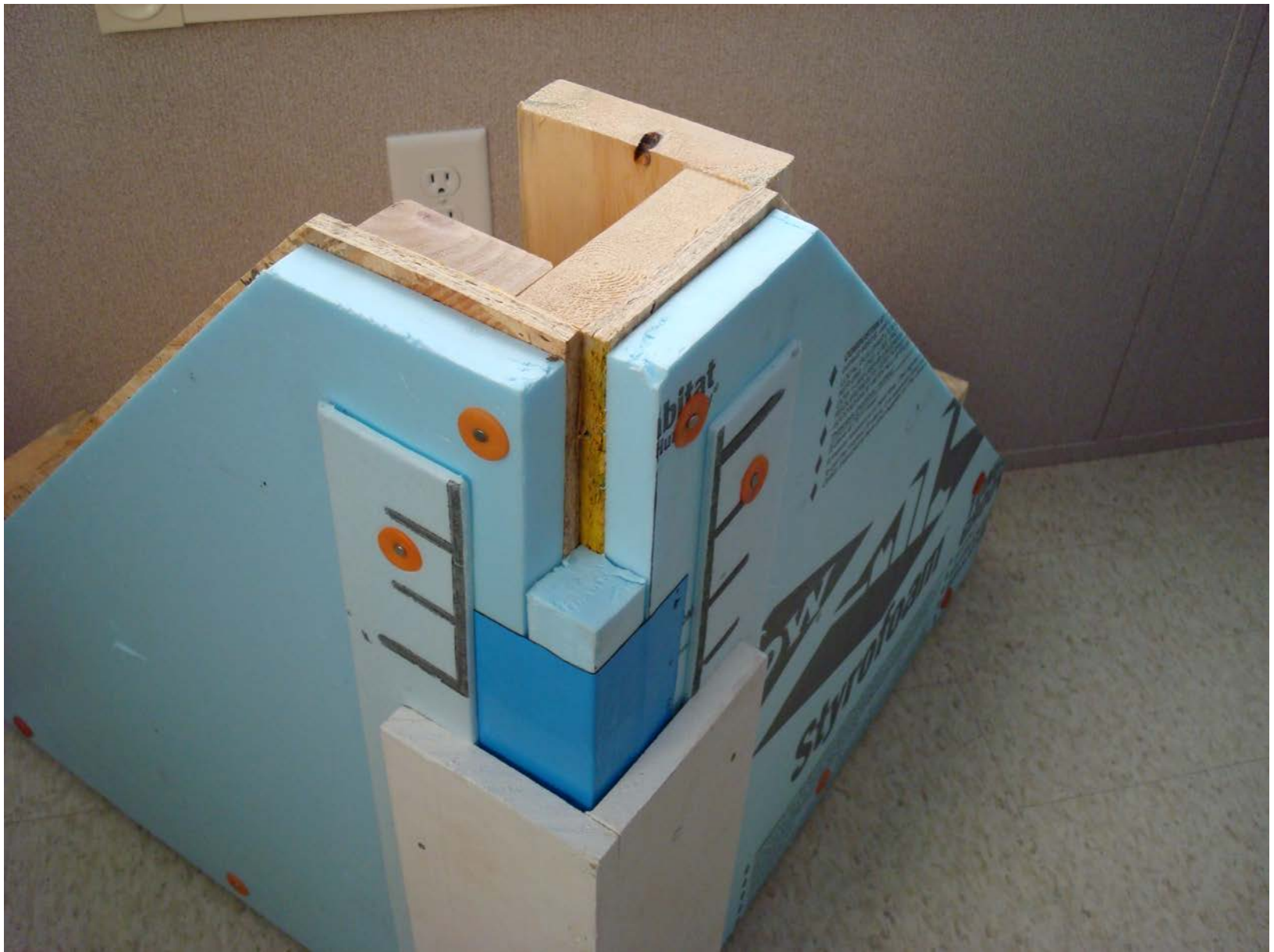




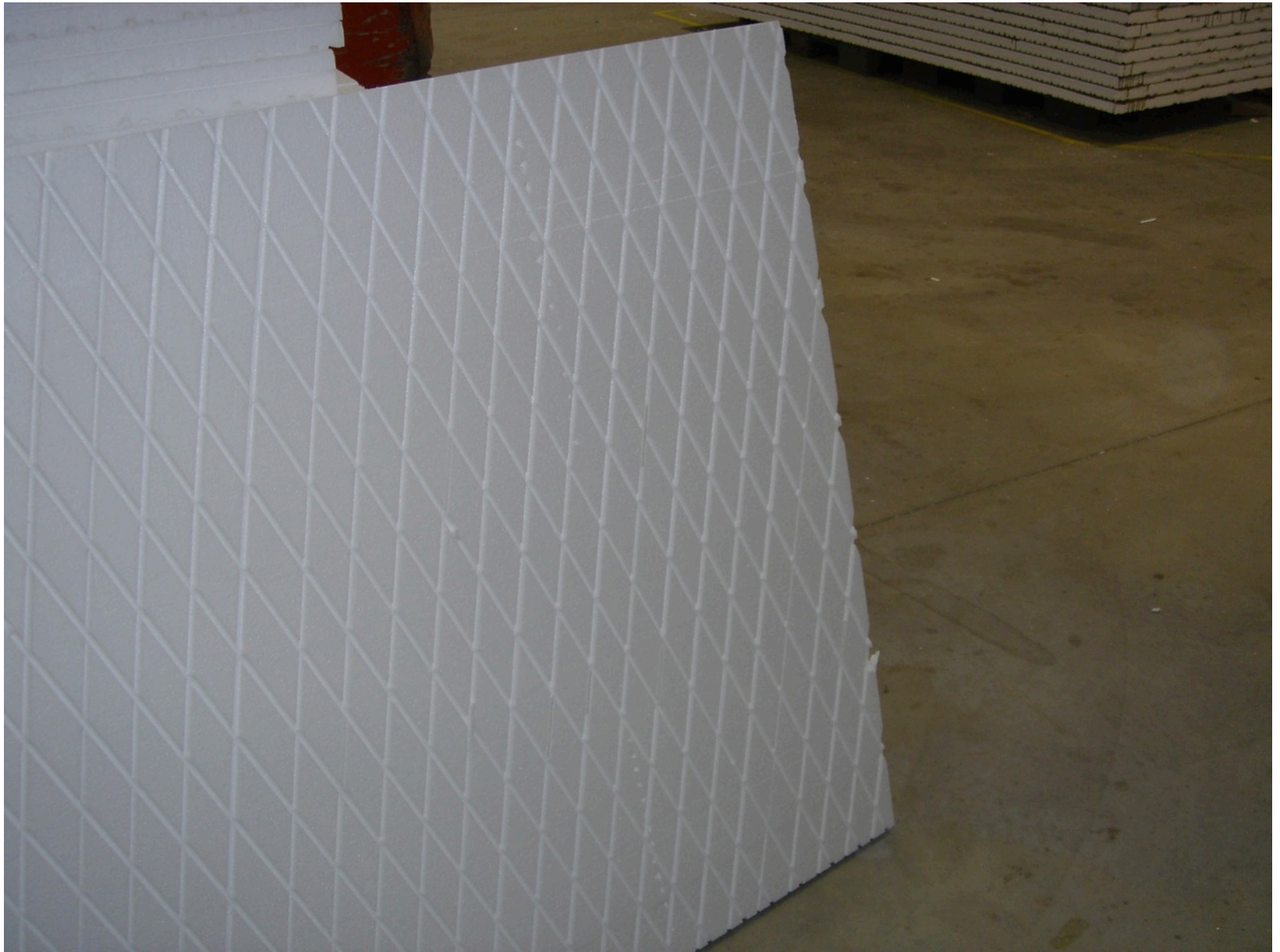




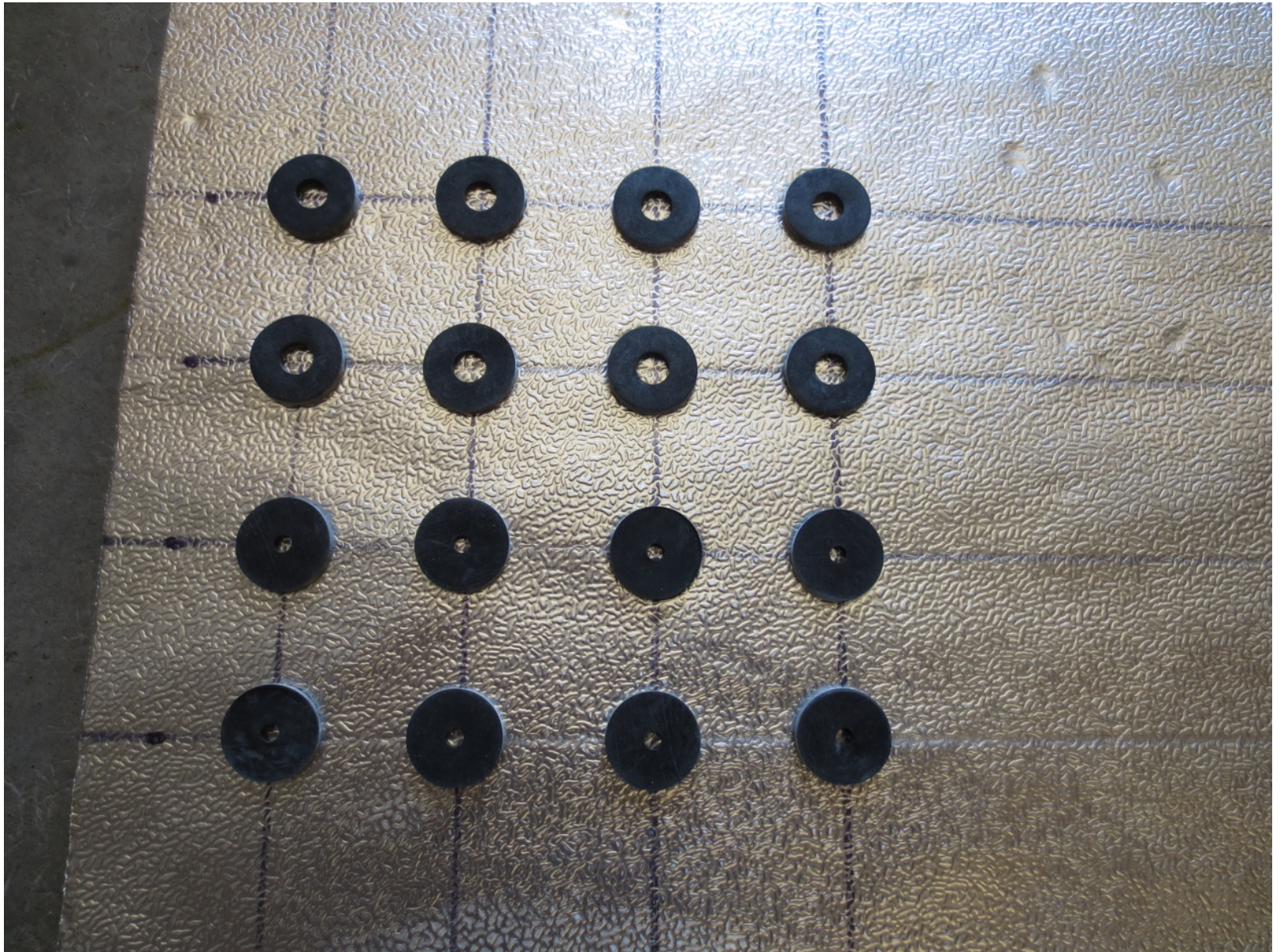




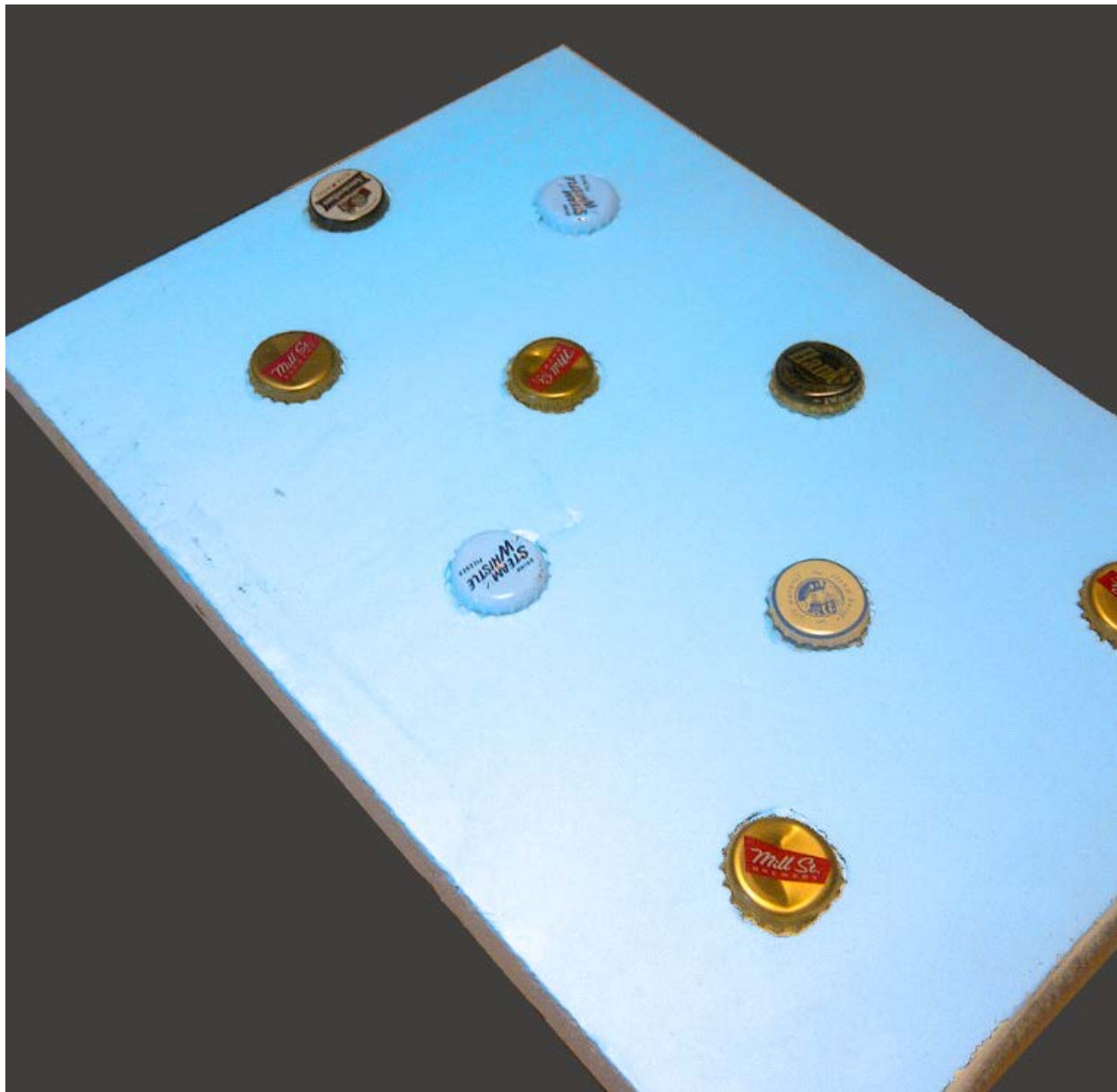




Rain Screen



Beer Screen?



Vapor control layer

Permeance Permeability

Vapor control layer

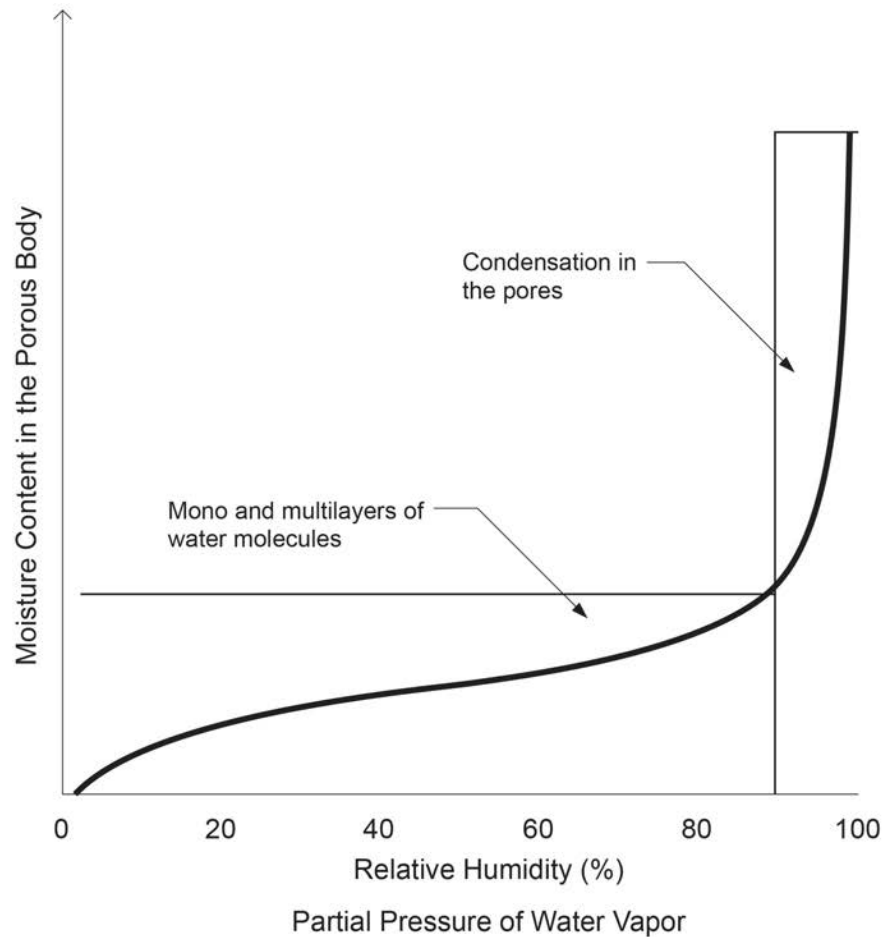
Class I 0.1 perms (“vapor barrier”)

Class II 1.0 perms (“vapor semi impermeable)

Class III 10.0 perms (“vapor semi permeable)

Greater than 10 perms

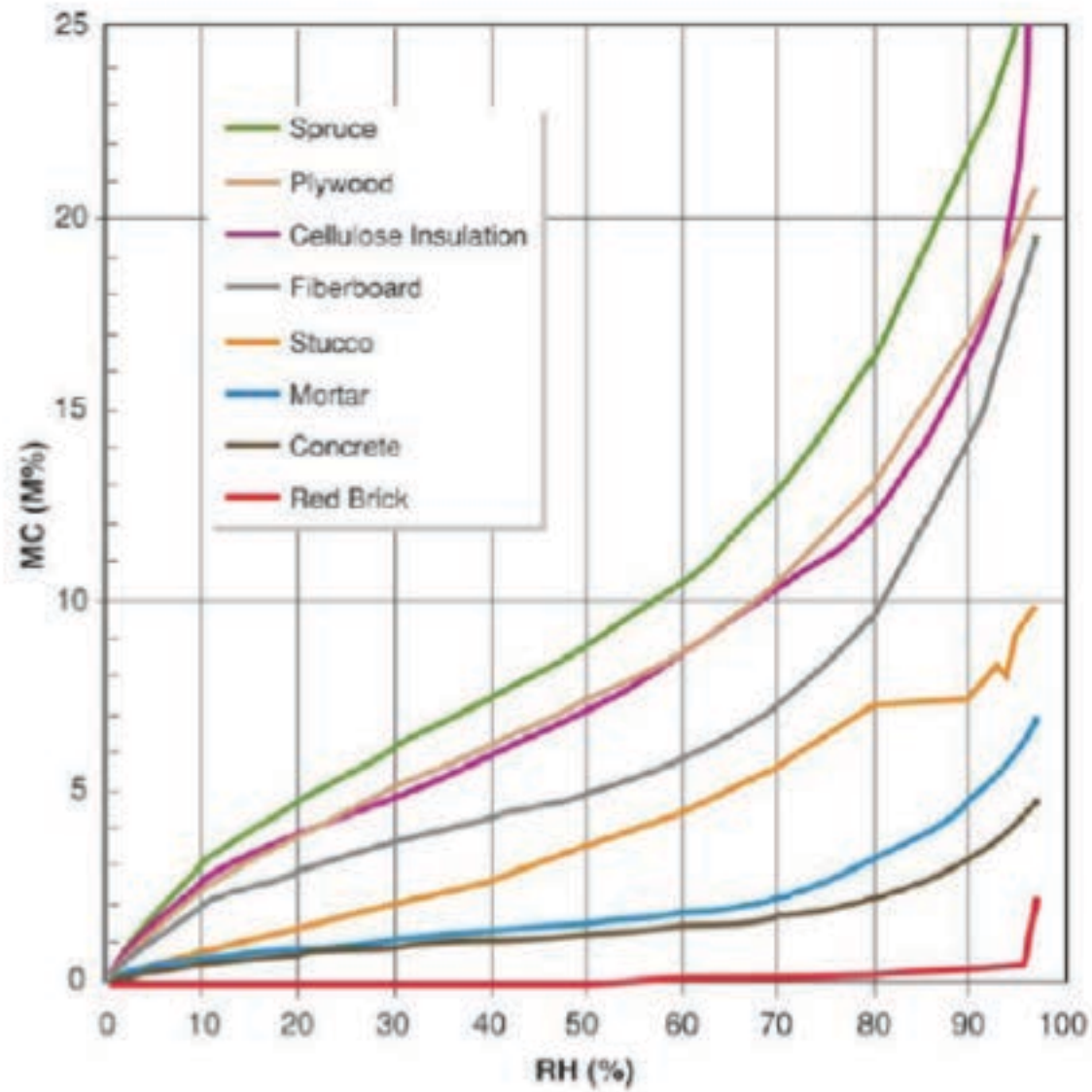
Vapor permeable



Change in the storage of moisture in a porous building material as the partial pressure of water vapor in the ambient air increases from zero to full saturation value at a given temperature.

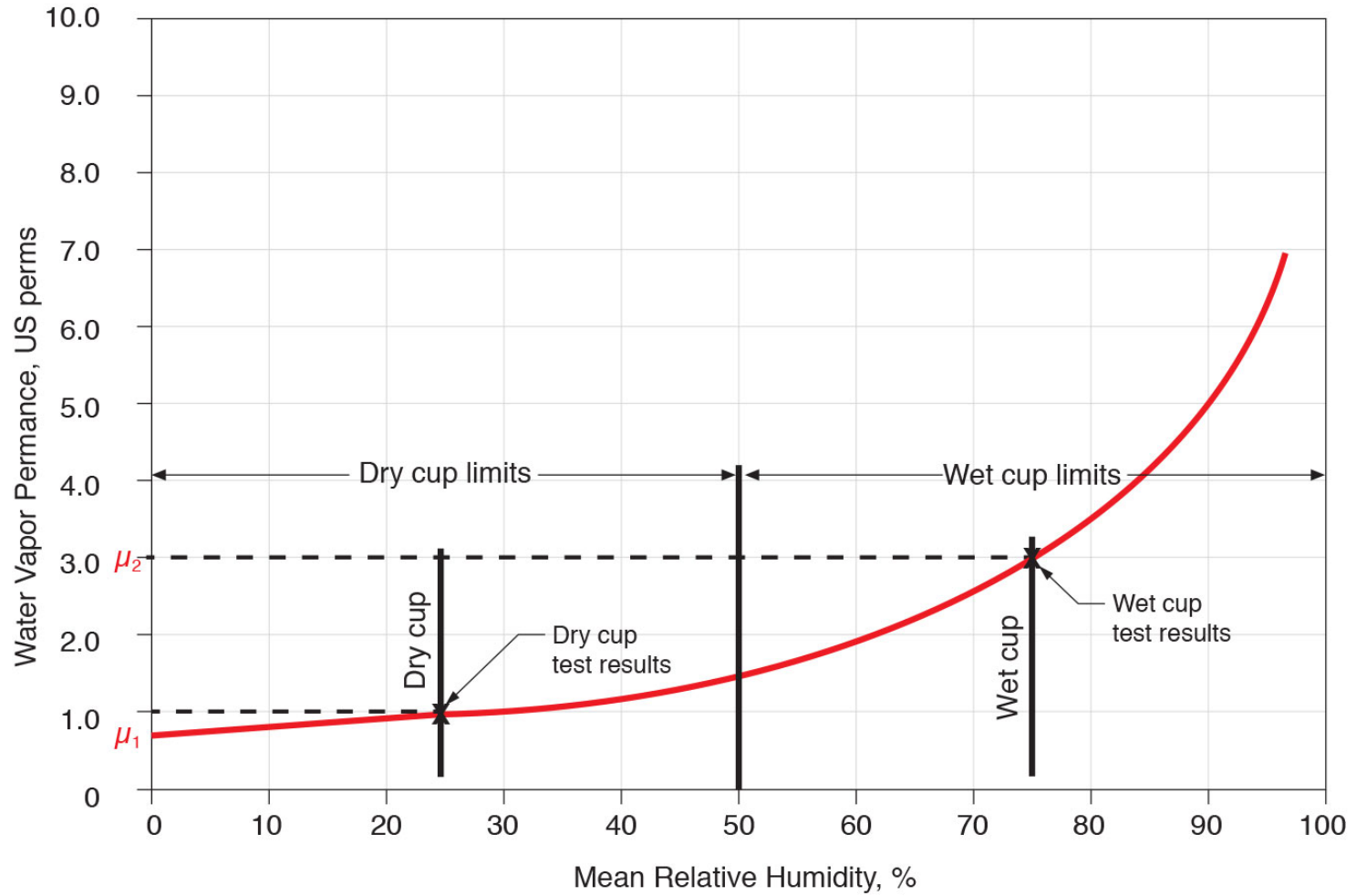
Sorption Curve

From M.K. Kumaran, ASTM MNL 18-2nd Edition,
Moisture Control in Buildings, 2009



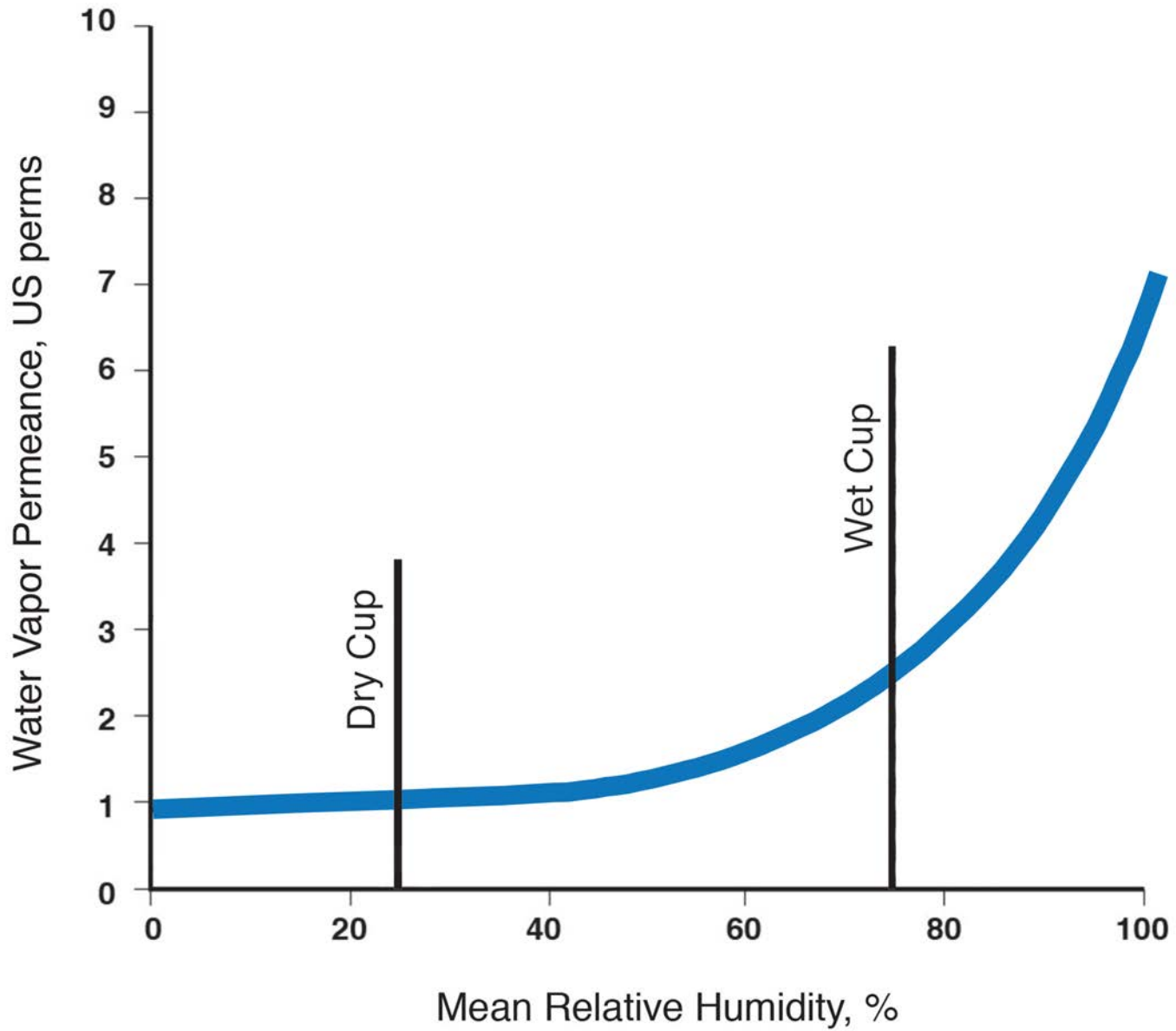


Water Vapor Permeance vs. Relative Humidity

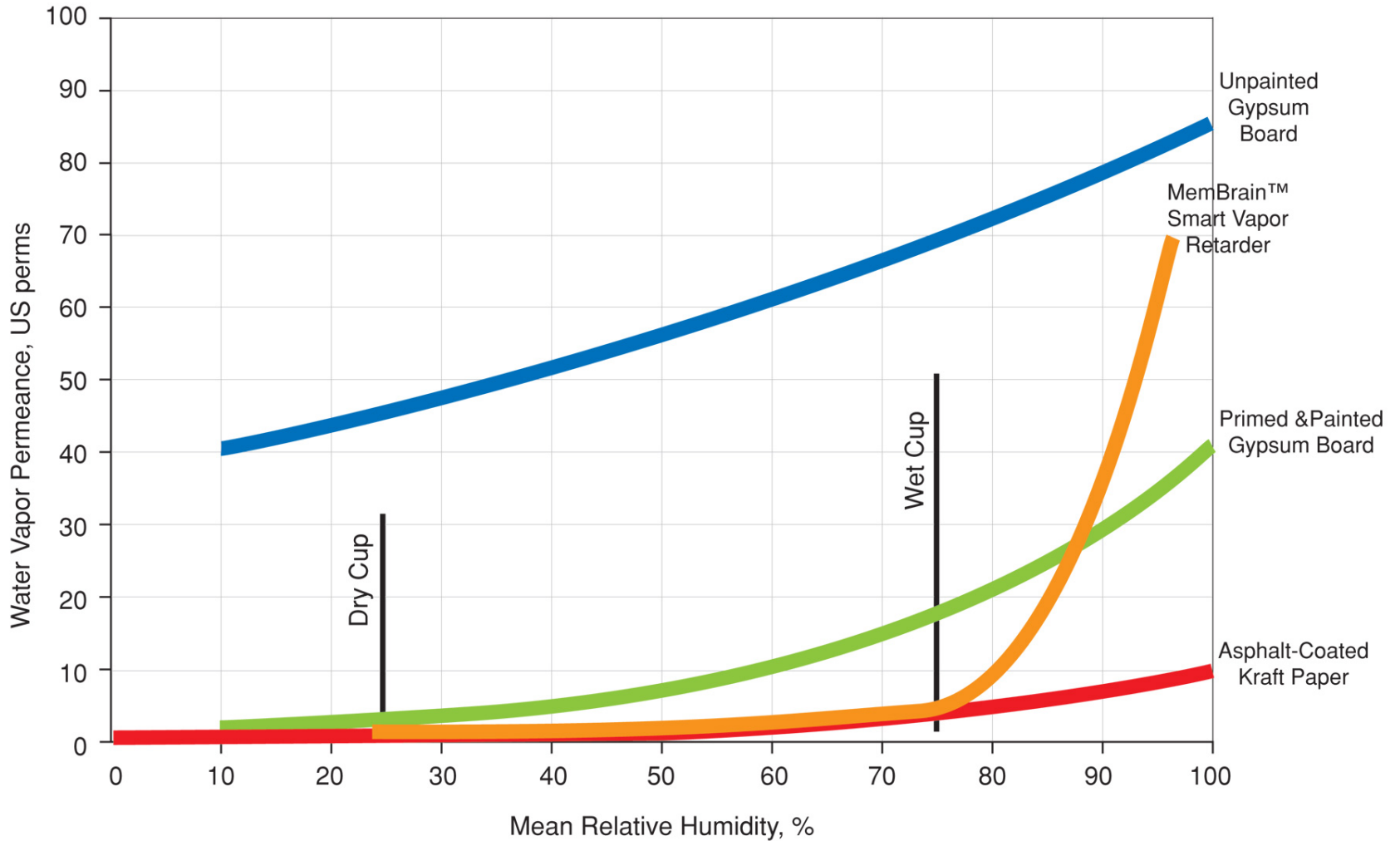


μ_1 = Dry cup permeance
 μ_2 = Wet cup permeance

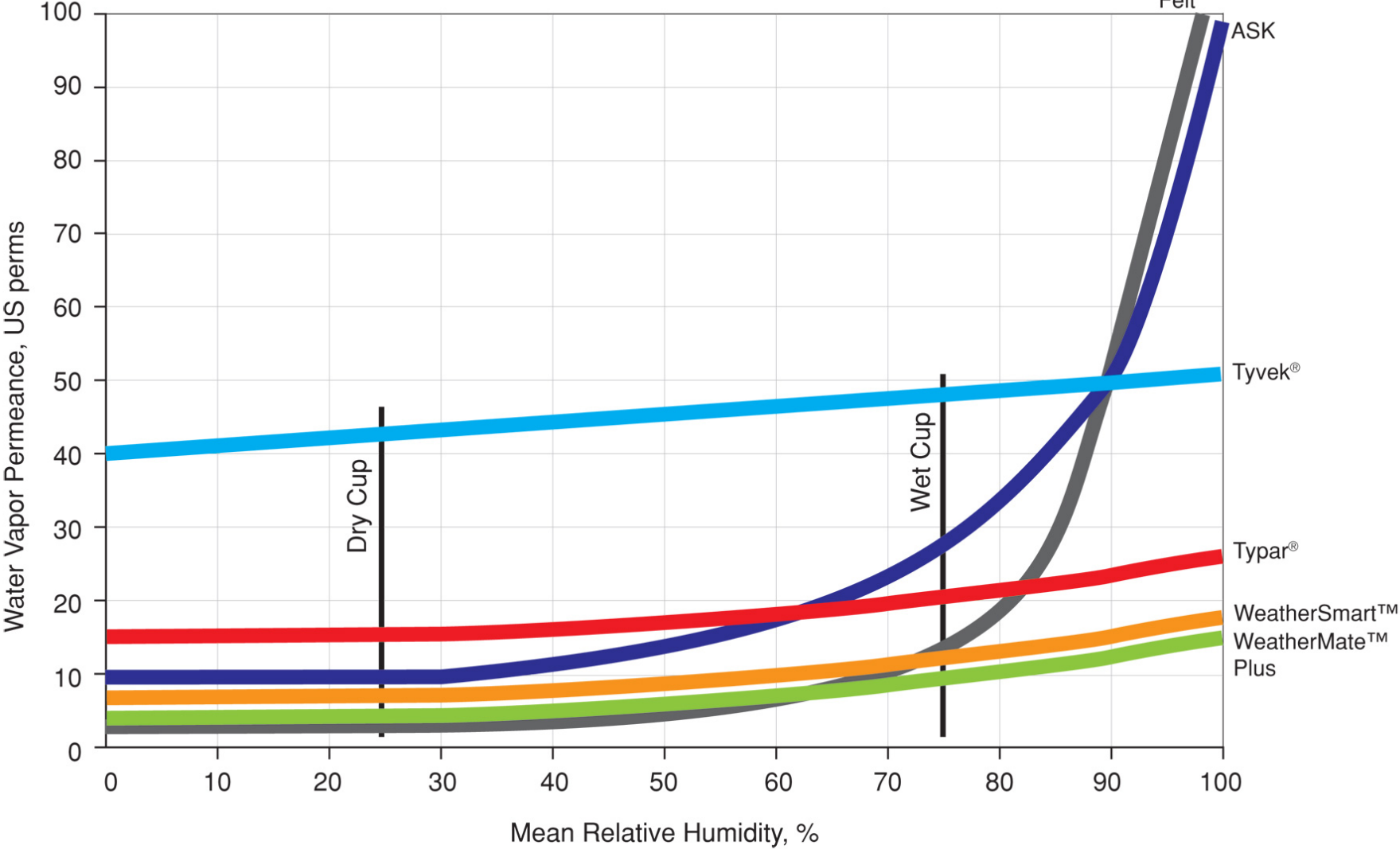




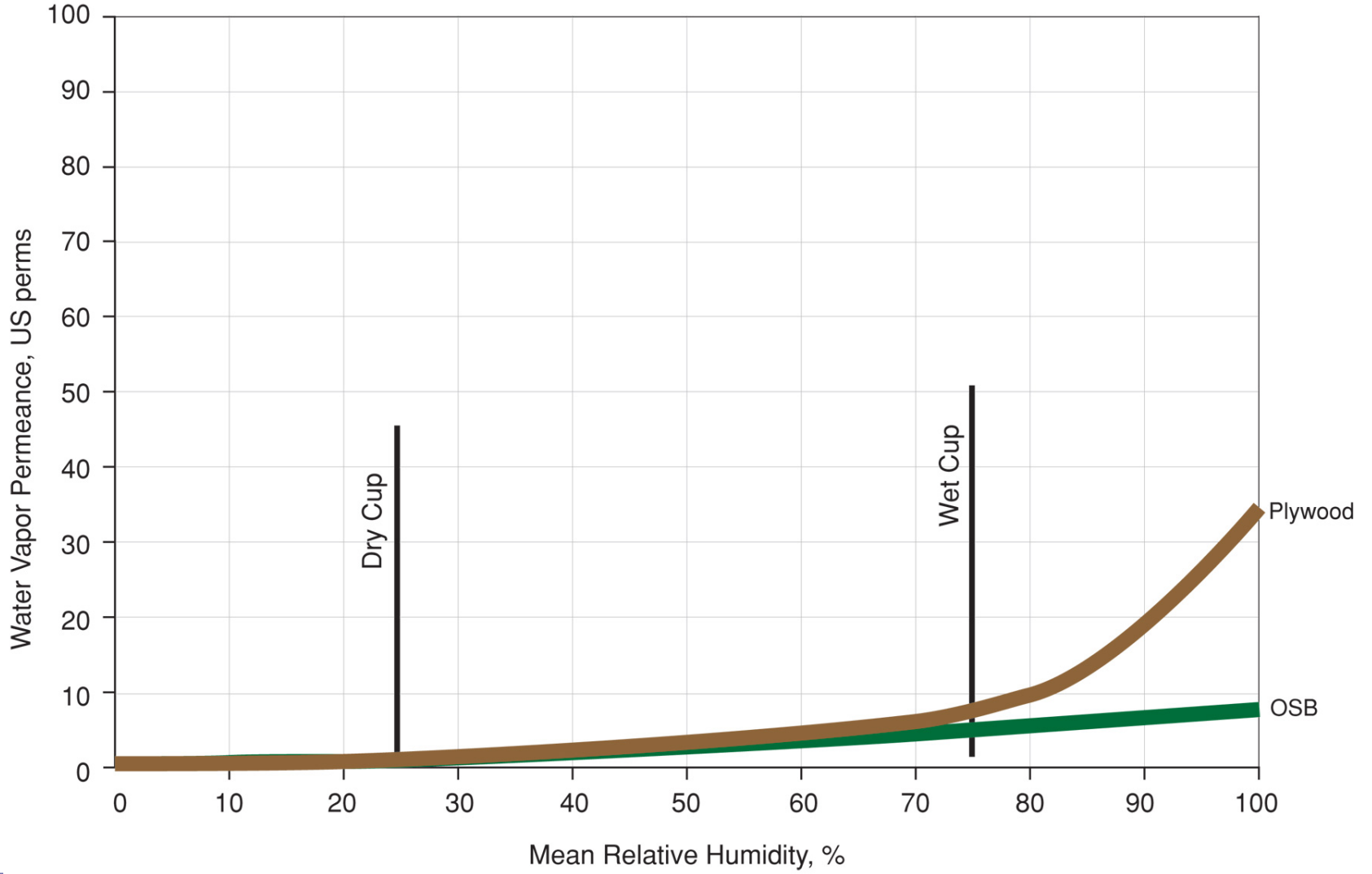
Water Vapor Permeance of MemBrain™ Smart Vapor Retarder, Primed and Painted Gypsum Board, Unpainted Gypsum Board and Asphalt-Coated Kraft Paper

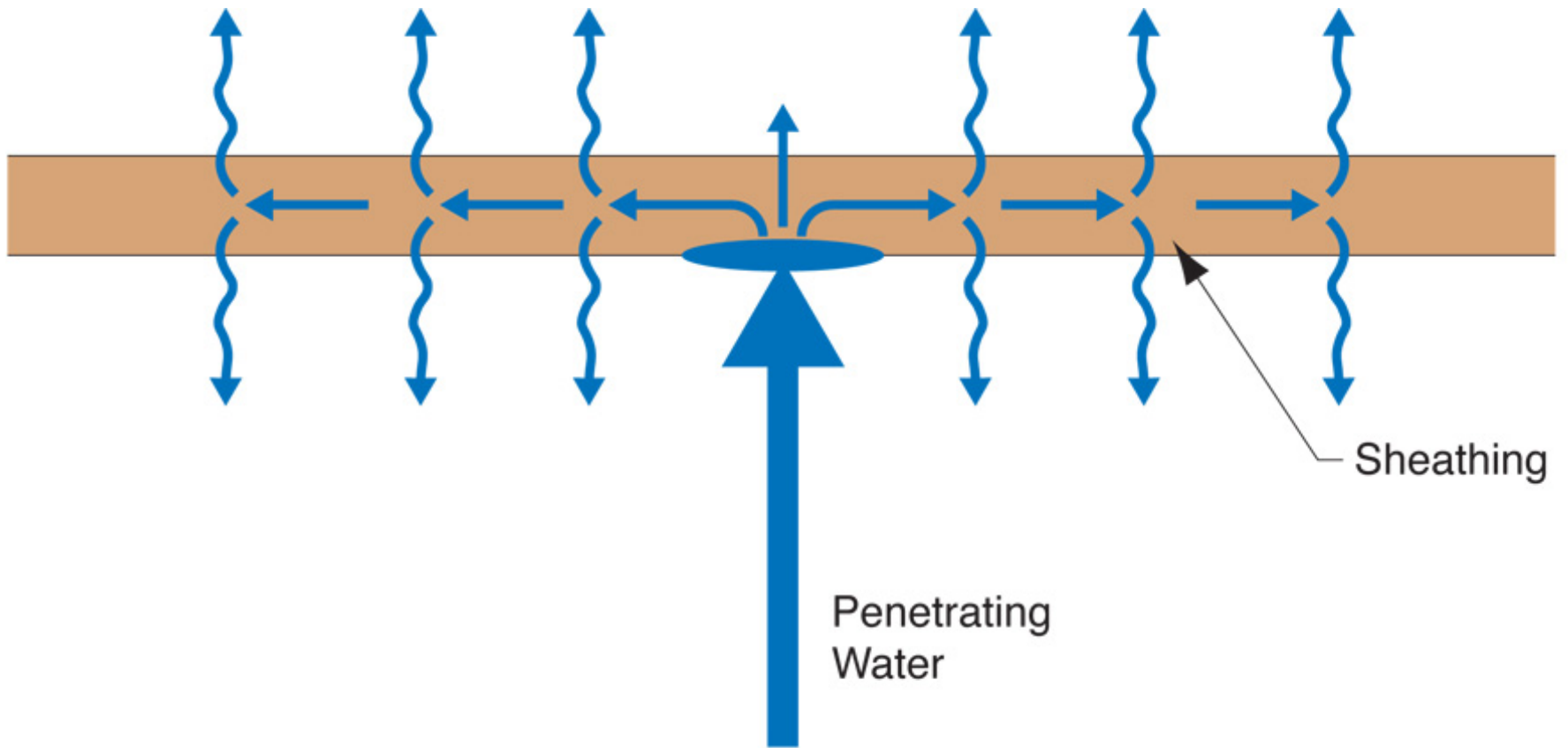


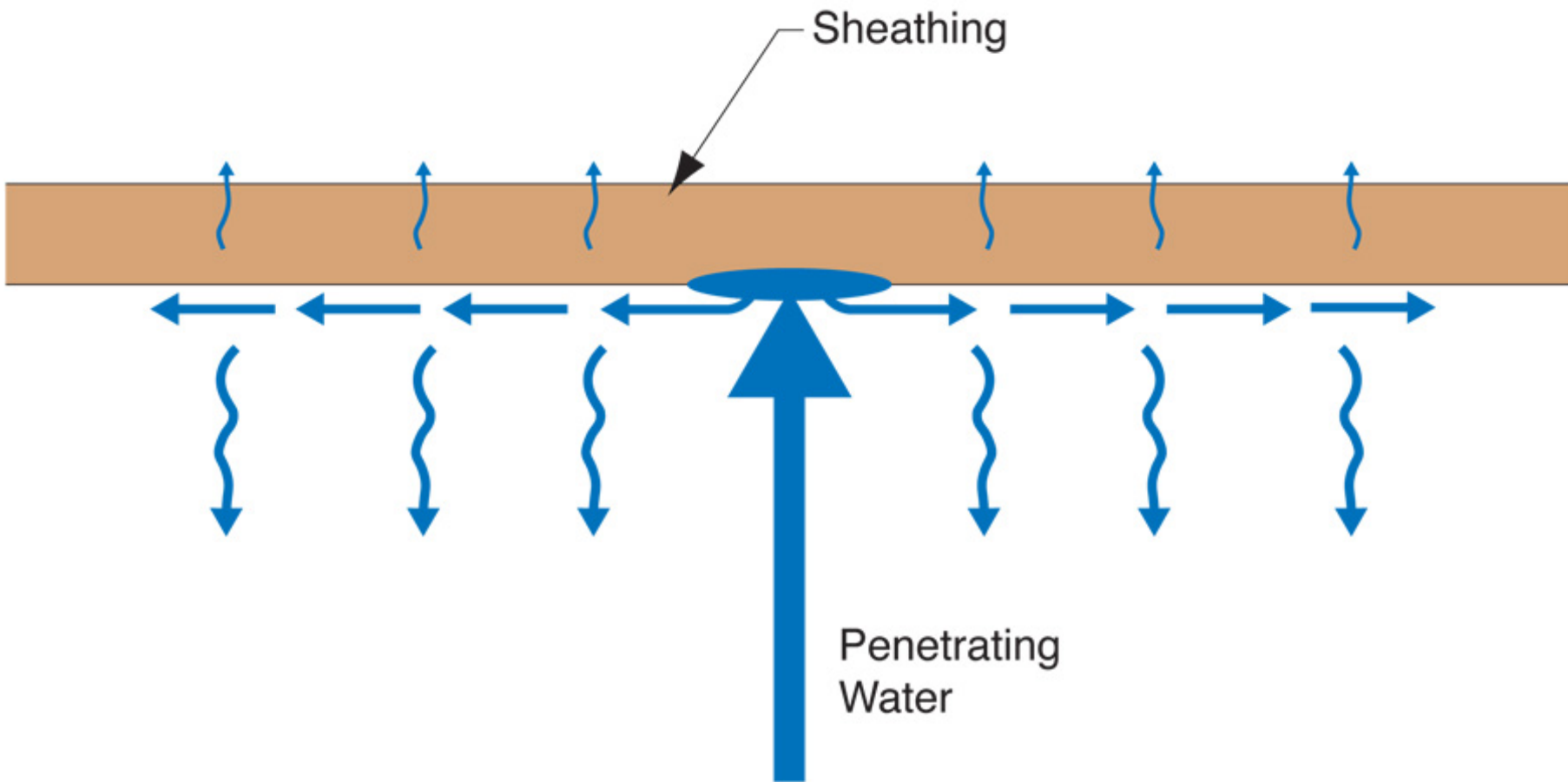
Water Vapor Permeance of WRB's



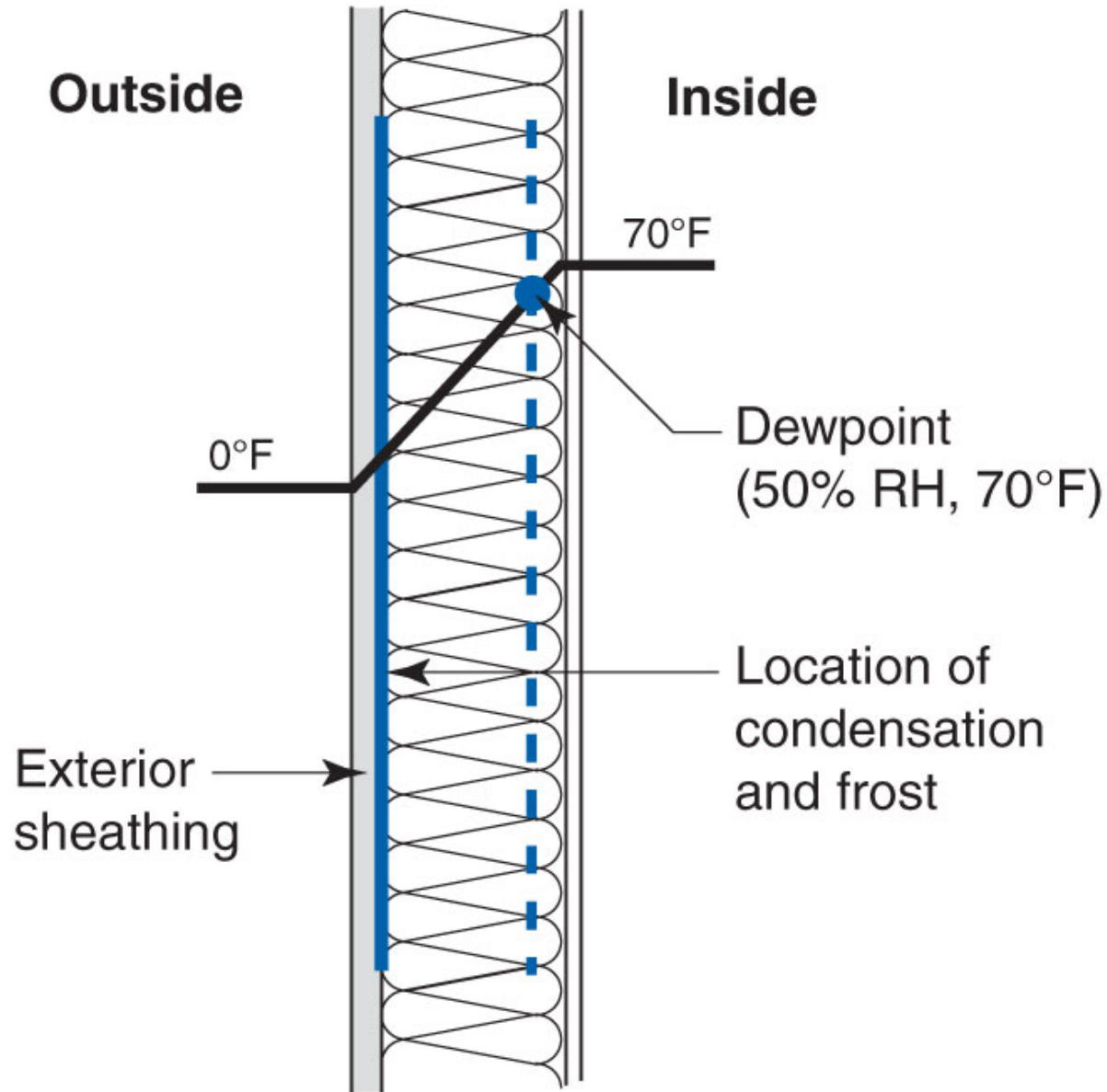
Water Vapor Permeance of Sheathing Materials



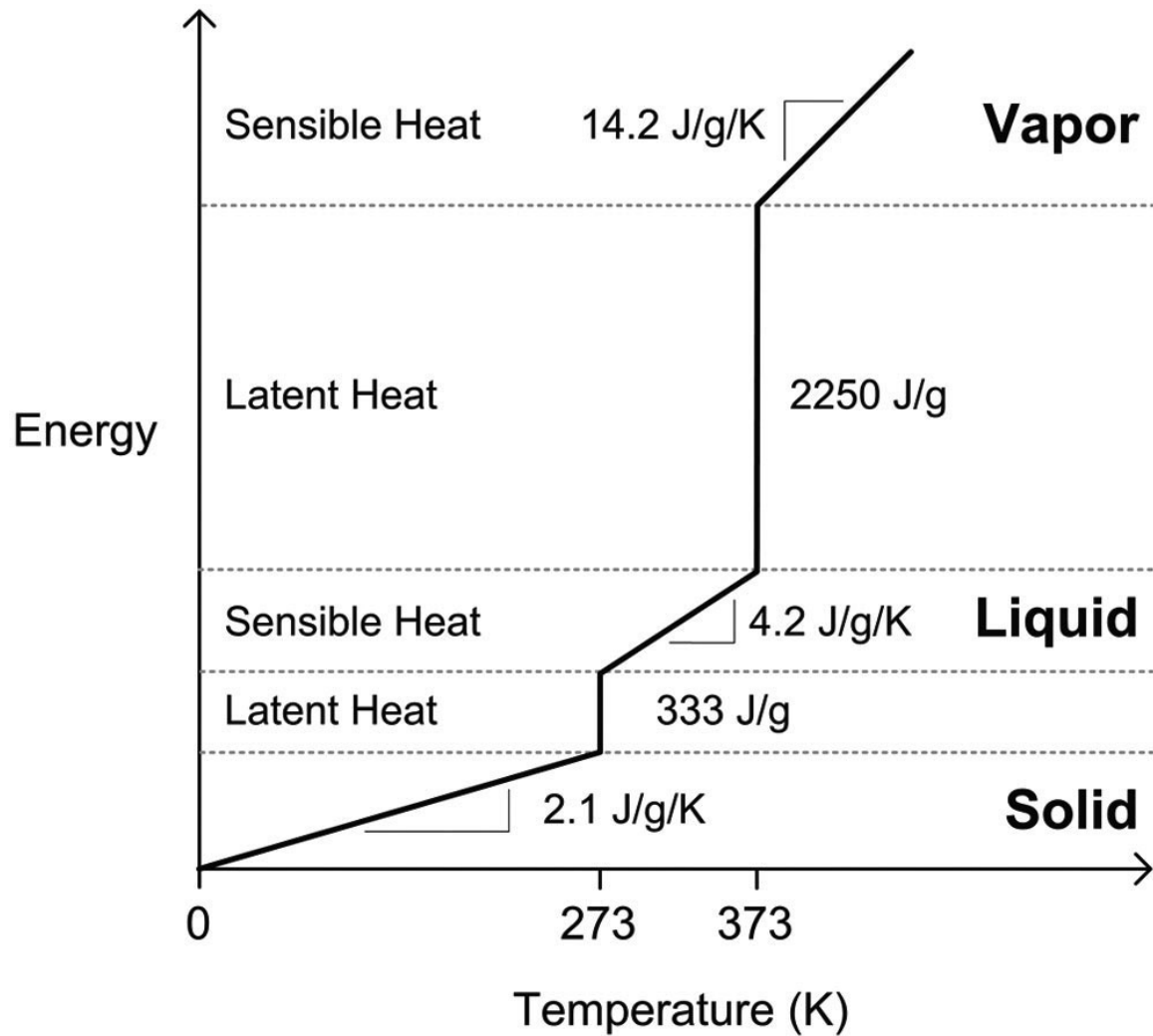




Condensing surfaces





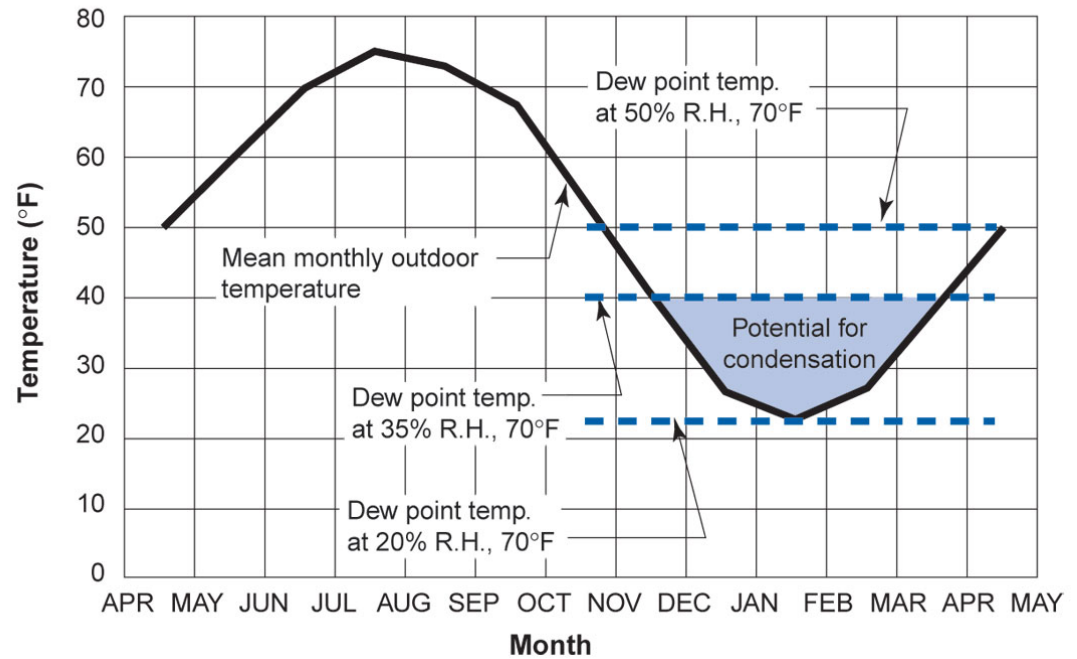
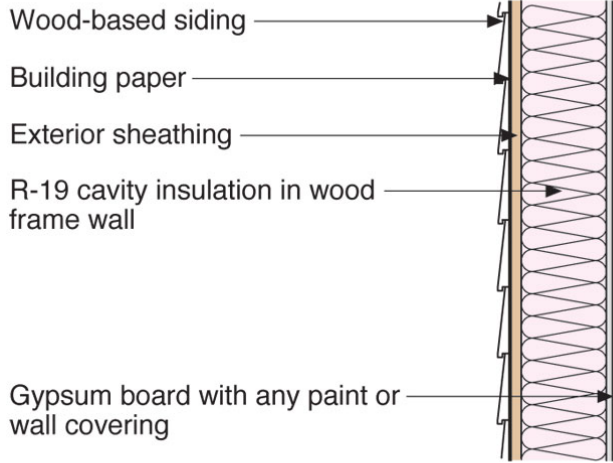


Simple linearized energy-temperature relation for water

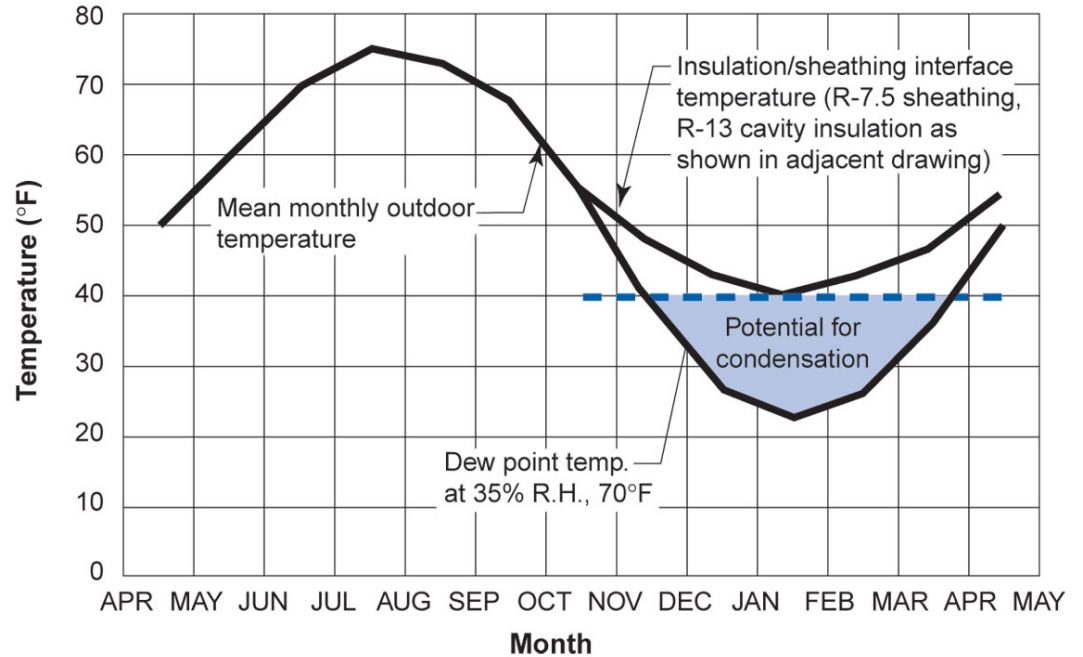
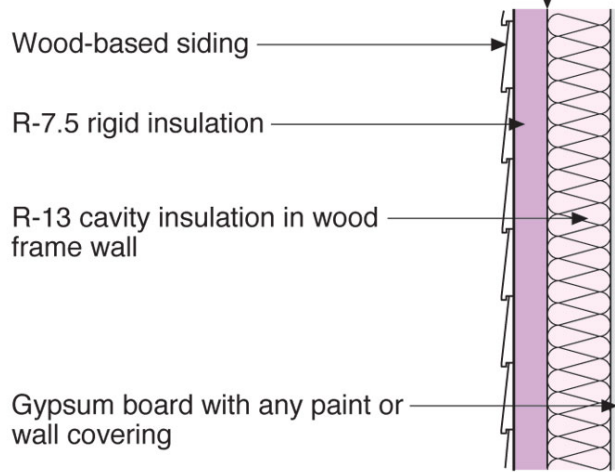
From Straube & Burnett, 2005



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



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



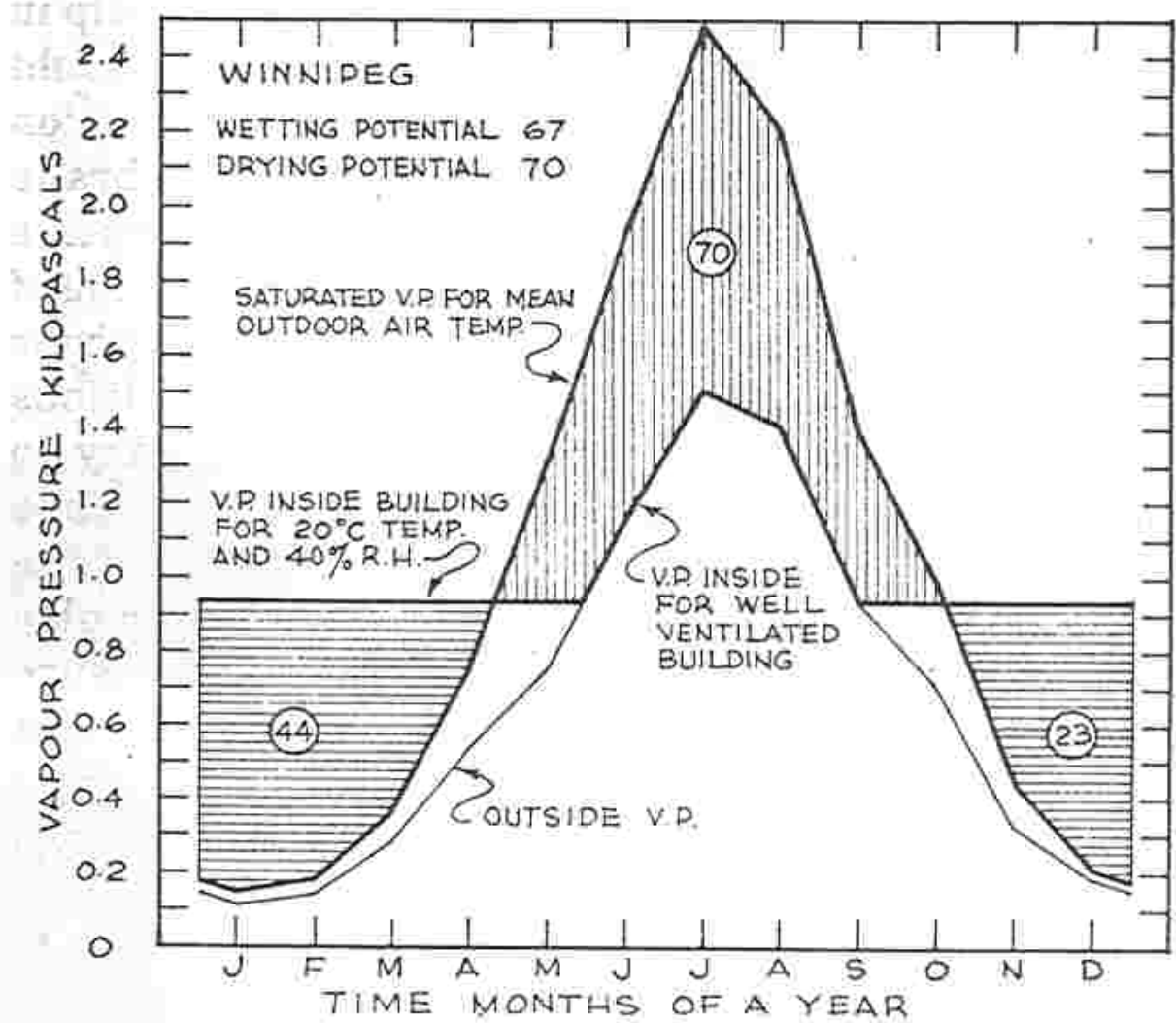
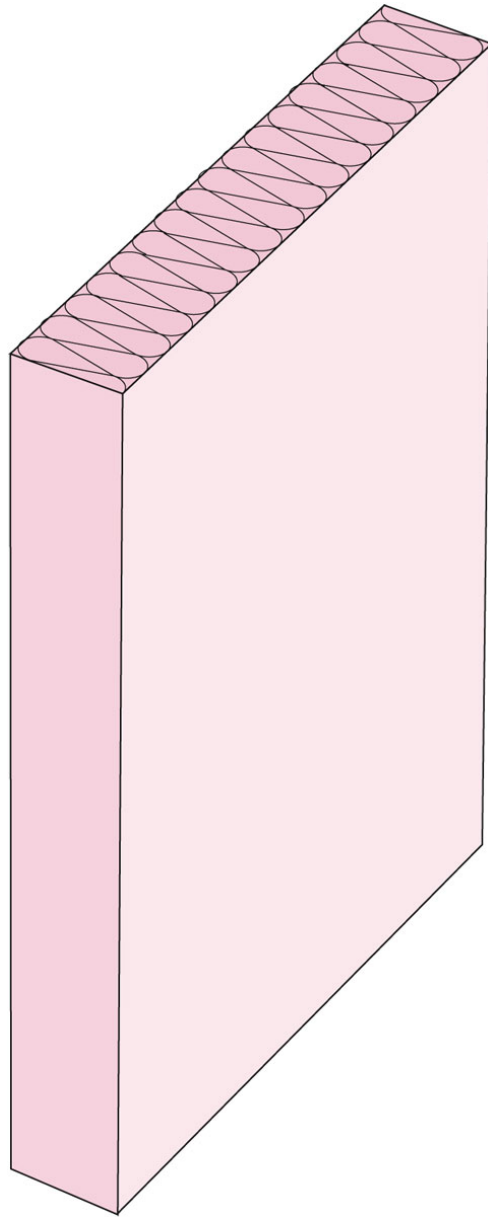


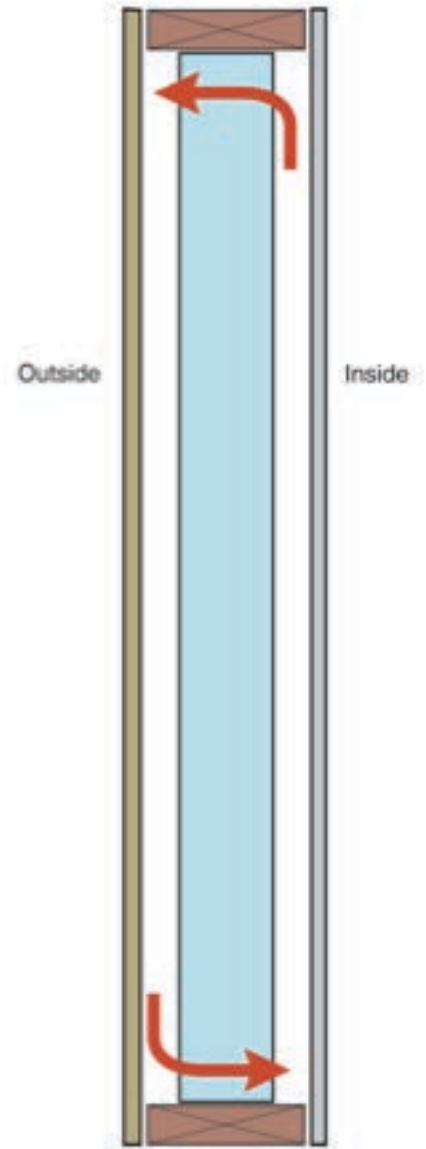
Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.

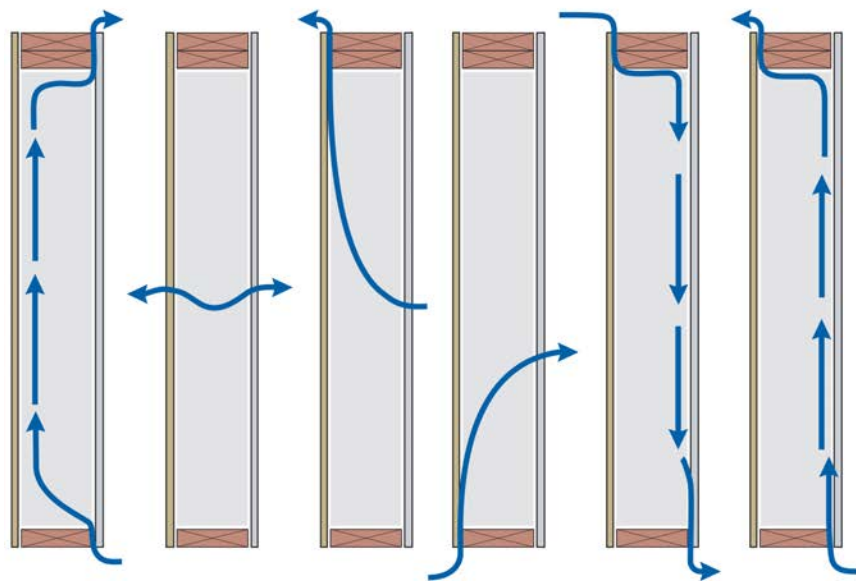
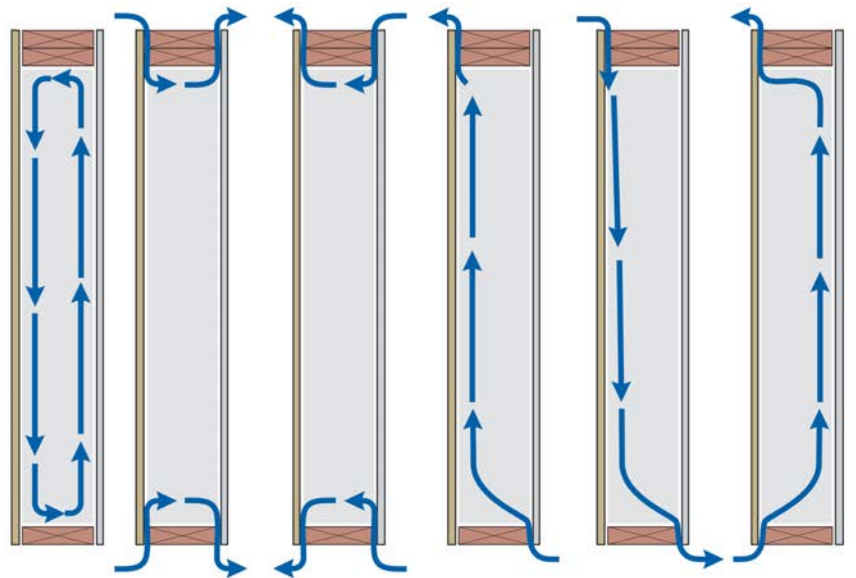
Air control layer

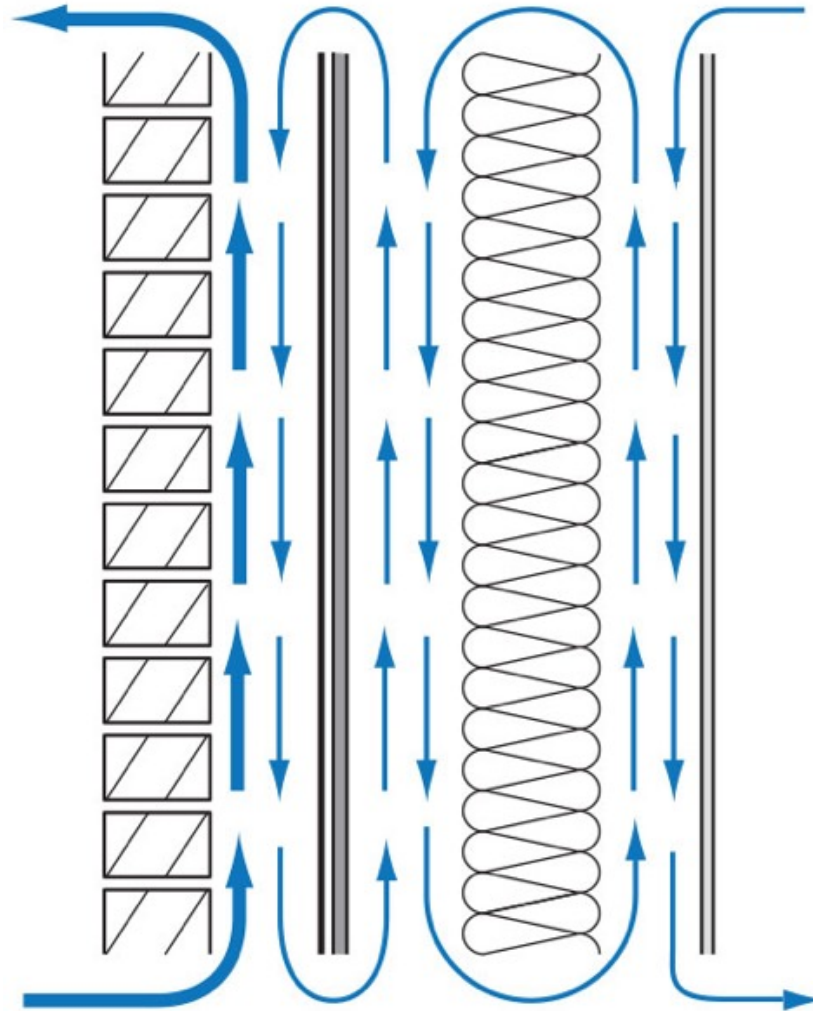
Air Barrier Metrics

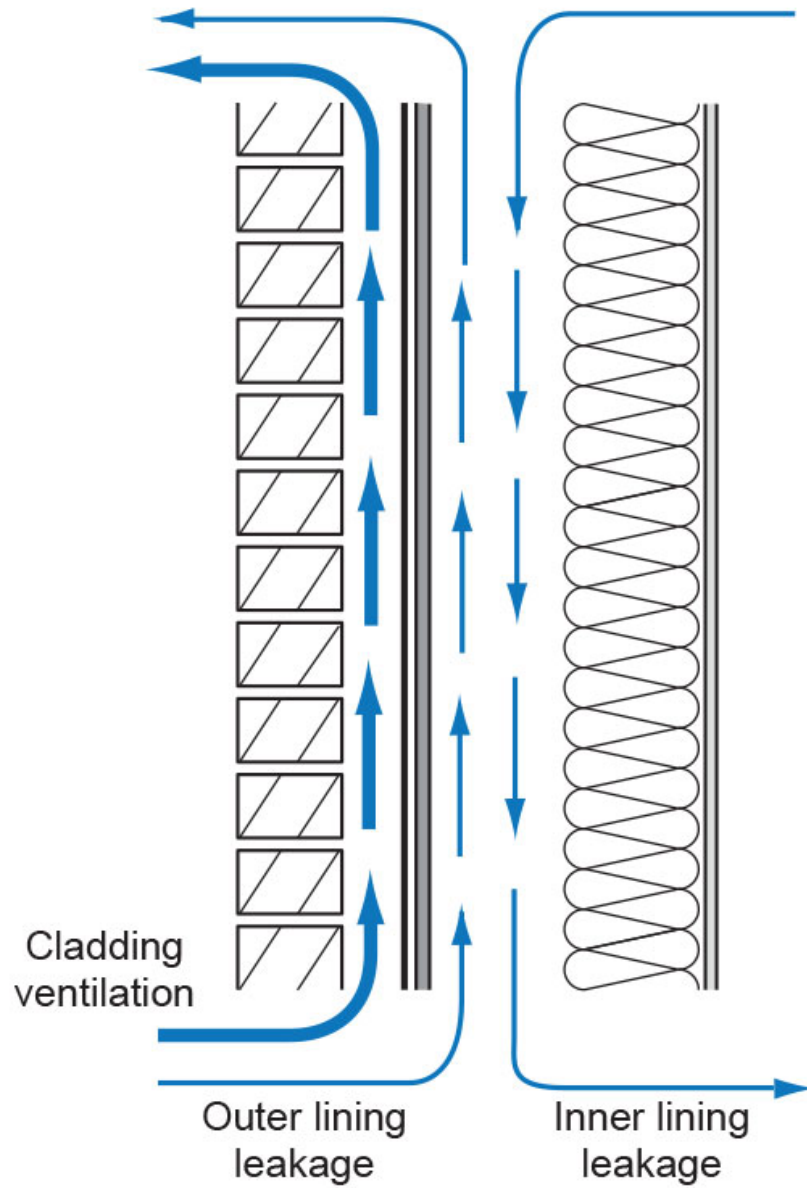
Material	0.02 l/(s-m ²)@75 Pa
Assembly	0.20 l/(s-m ²)@75 Pa
Enclosure	2.00 l/(s-m ²)@75 Pa

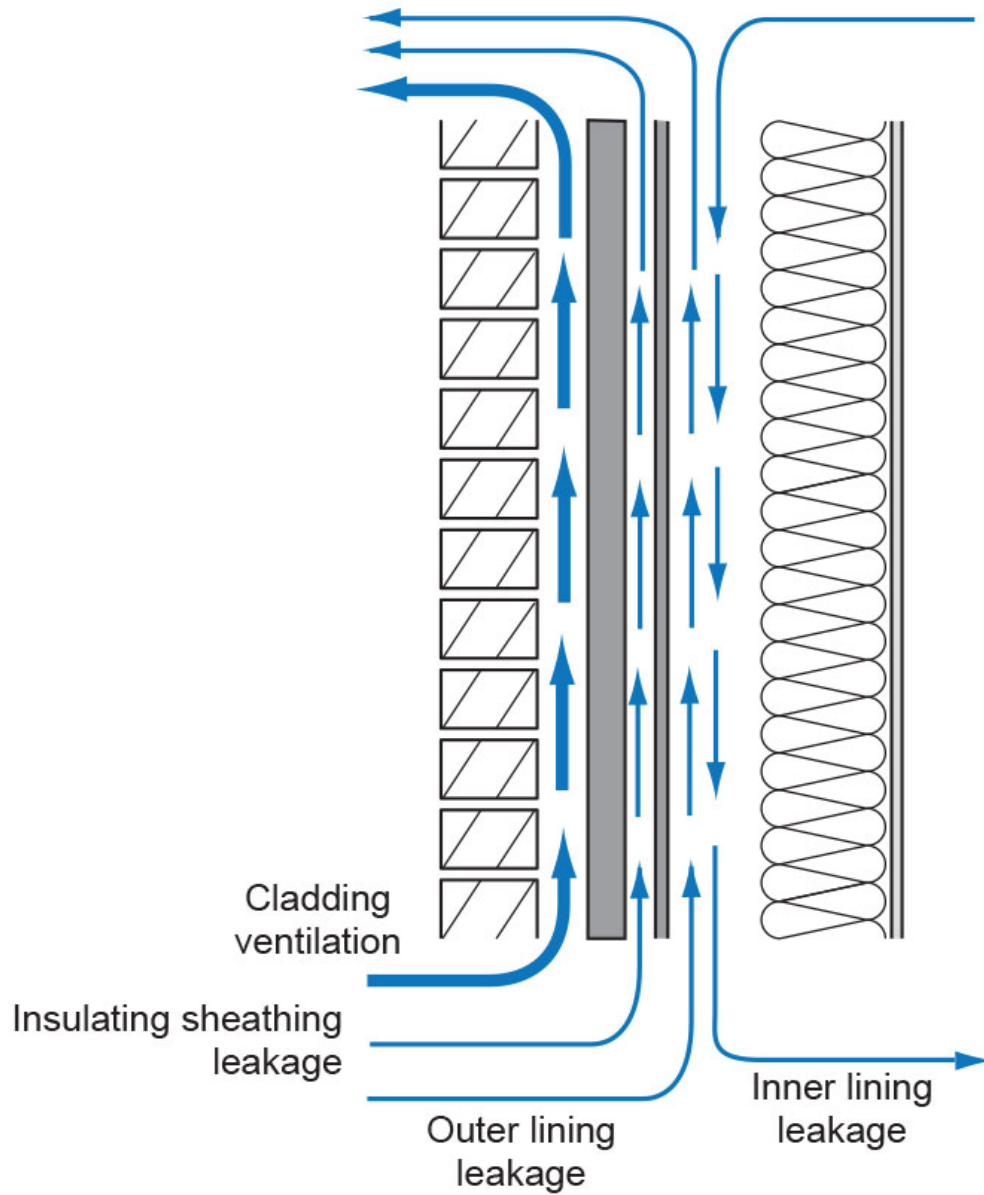






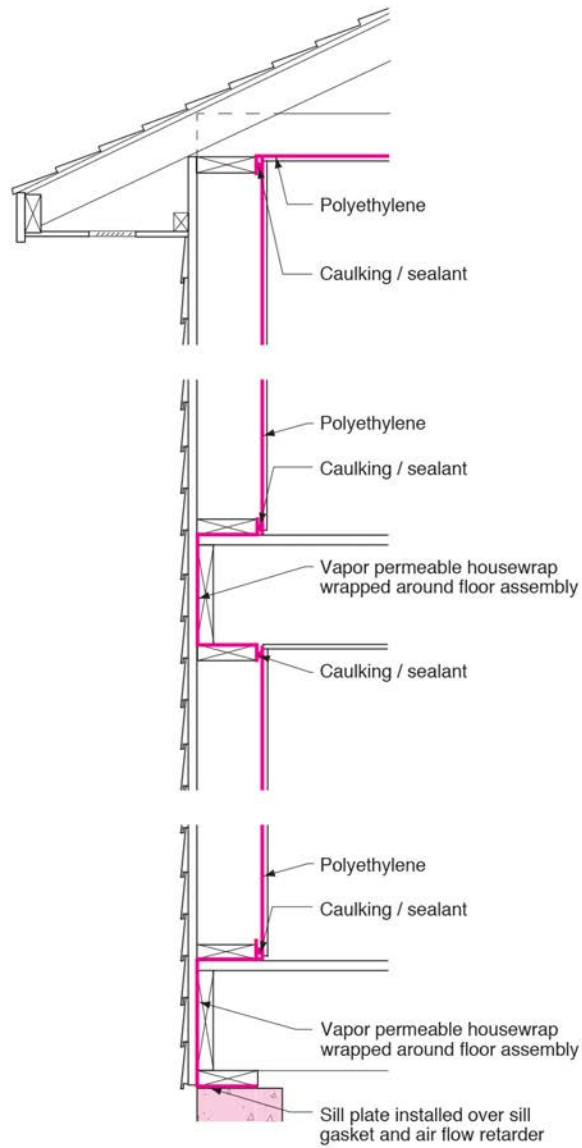




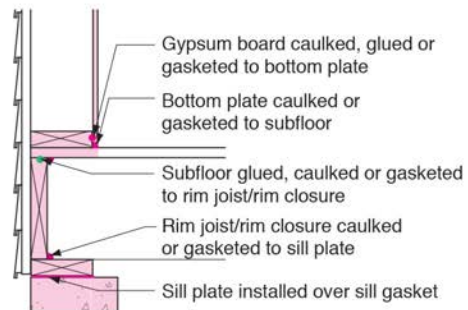
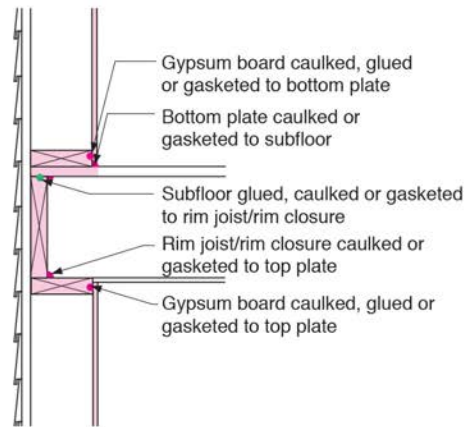
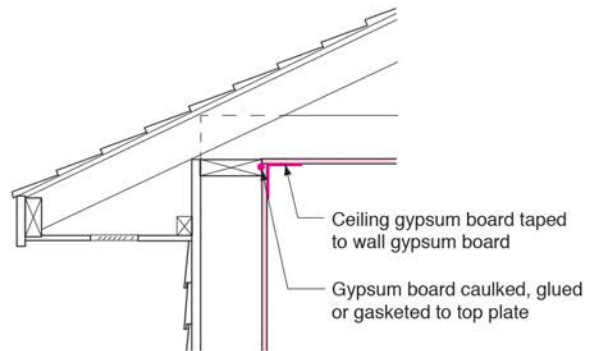


Cladding Ventilation/ Sheathing Ventilation

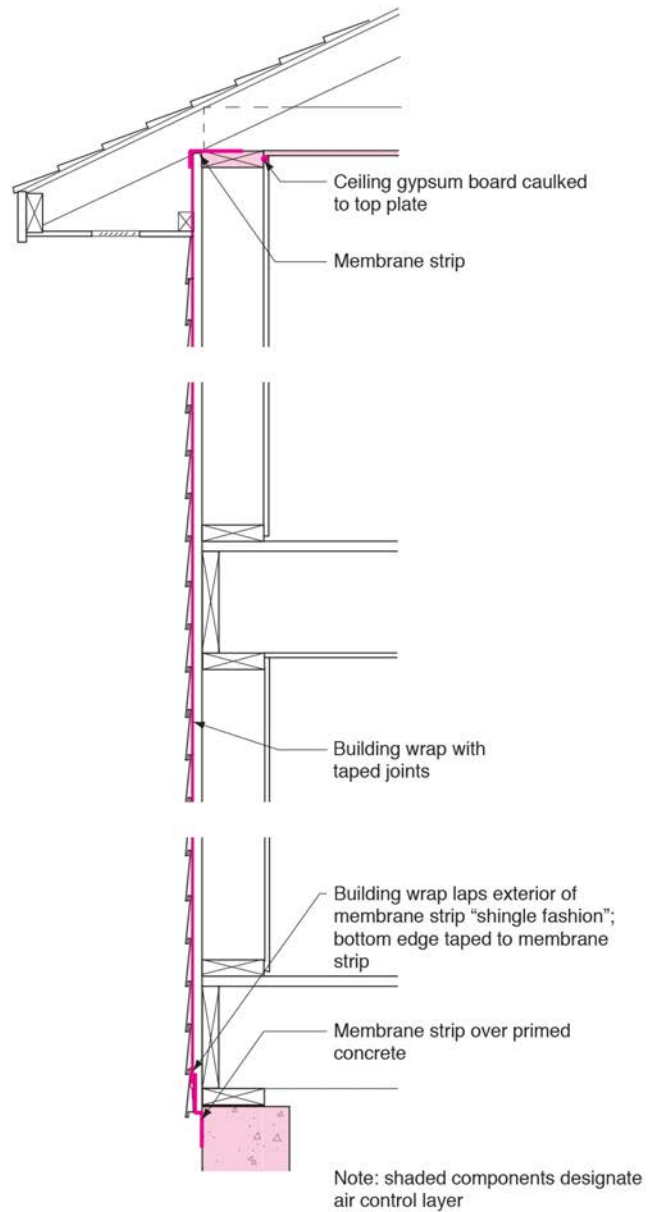
	Flow Rate	Gap	ACH
Wood Siding	0.1 cfm/sf	3/16"	20
Vinyl Siding	0.5 cfm/sf	3/16"	200
Brick Veneer	0.15 cfm/sf	1"	10
Stucco (vented)	0.1 cfm/sf	3/8"	10
Stucco (direct applied)	none	none	0
Sheathing flanking flow	0.05 cfm/sf	3/16"	10

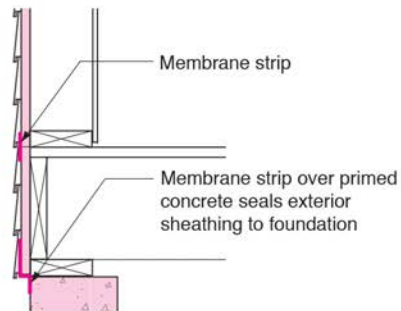
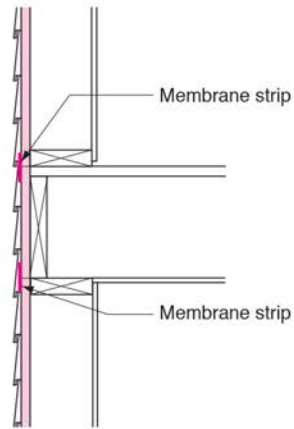
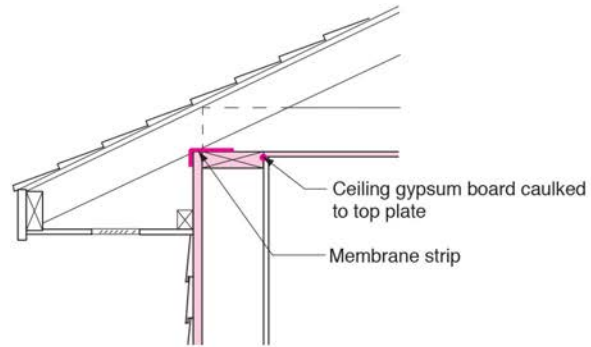


Note: shaded components designate air barrier system

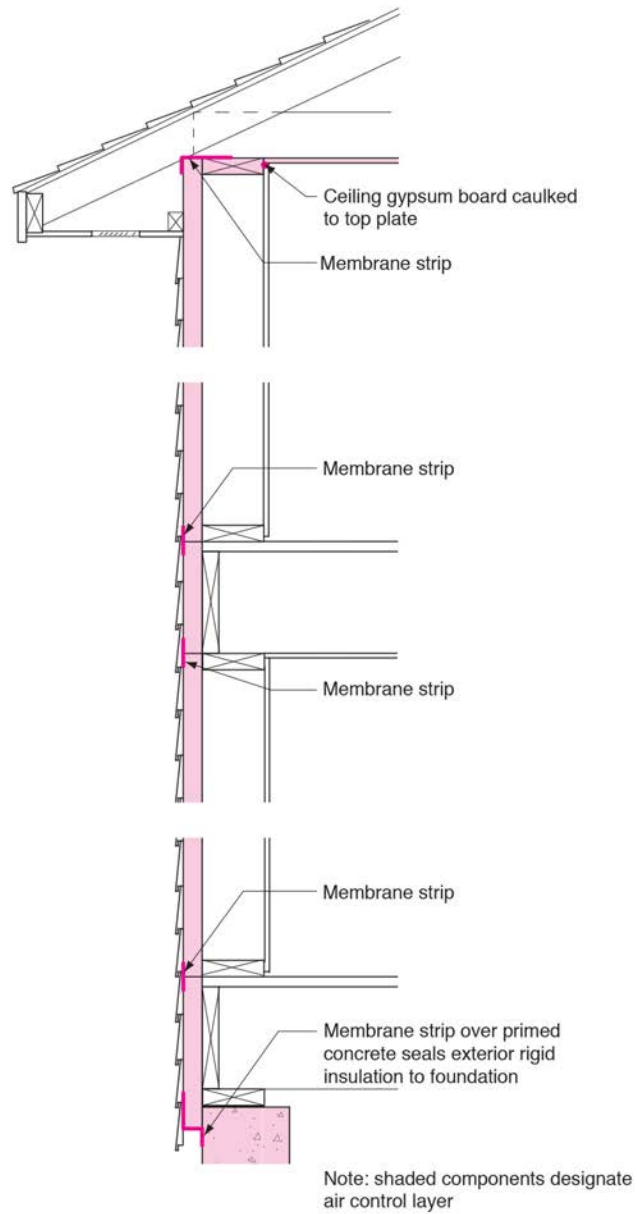


Note: shaded components designate air control layer

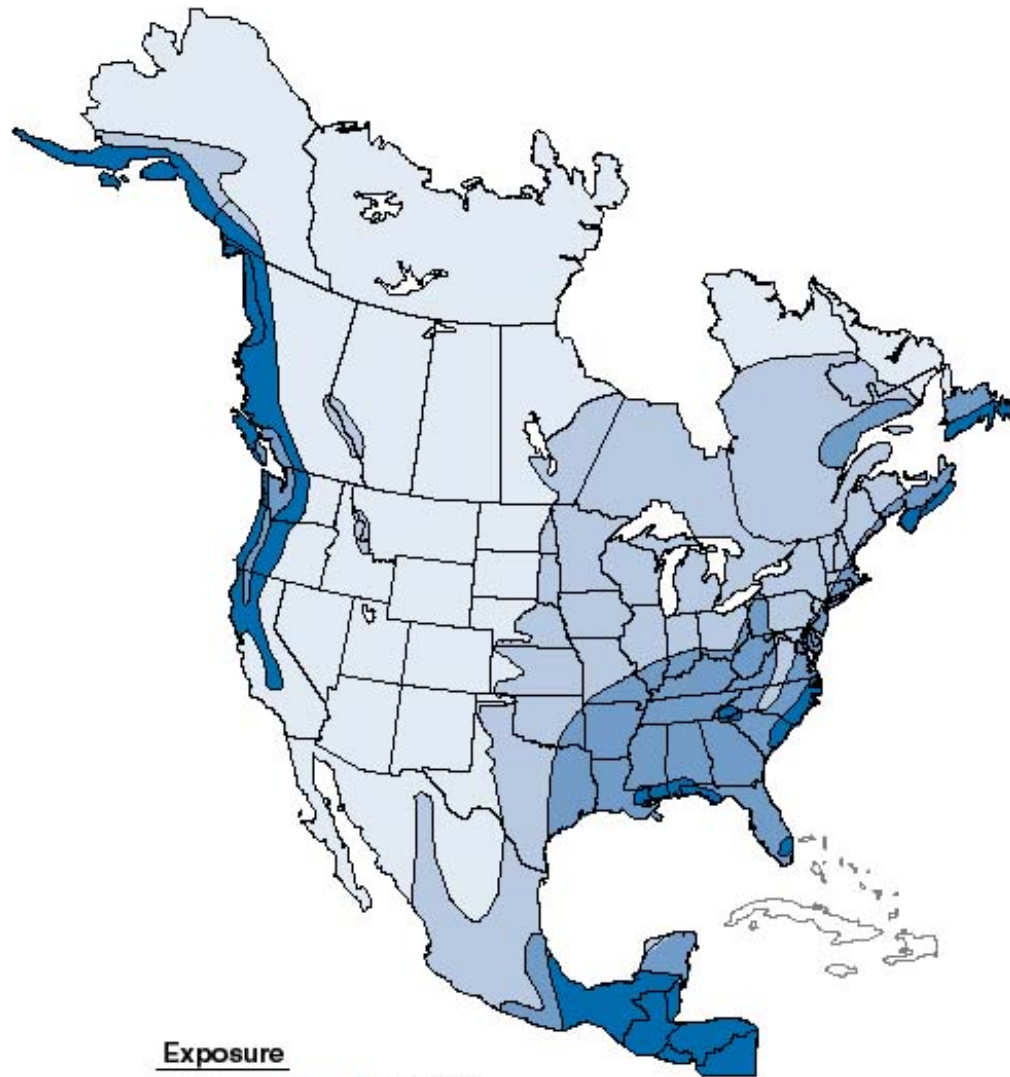








Note: shaded components designate air control layer







Exposure

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













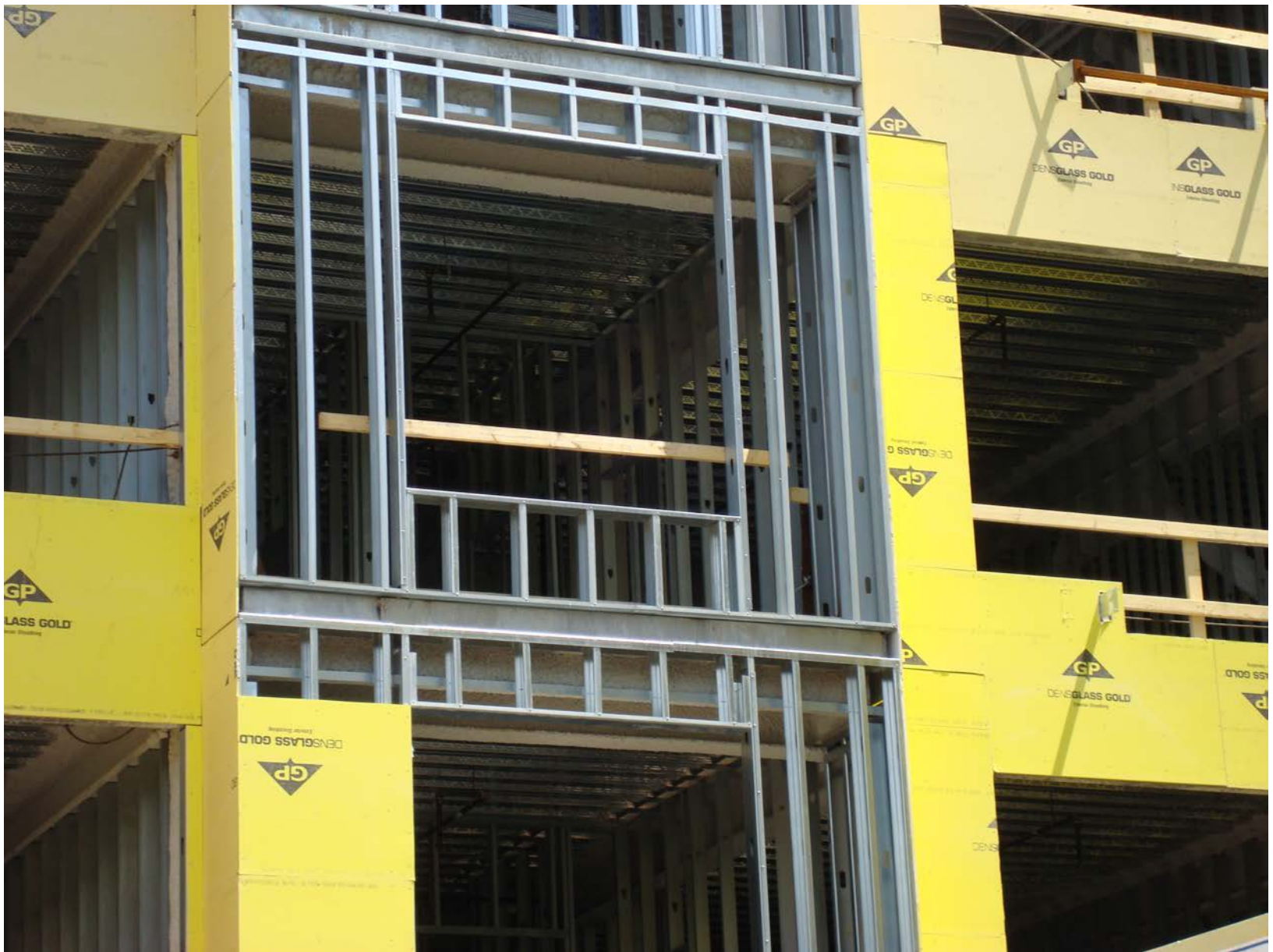














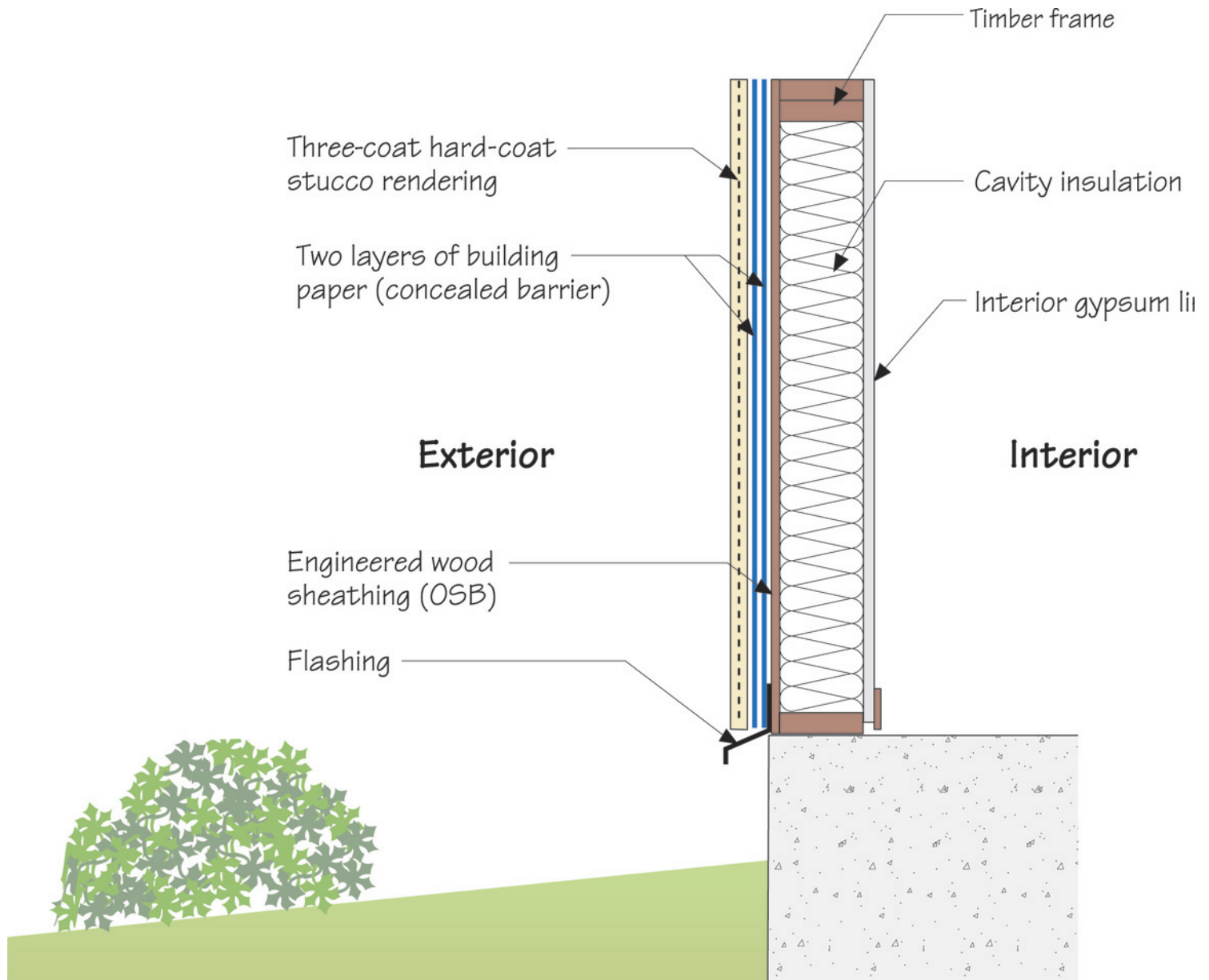






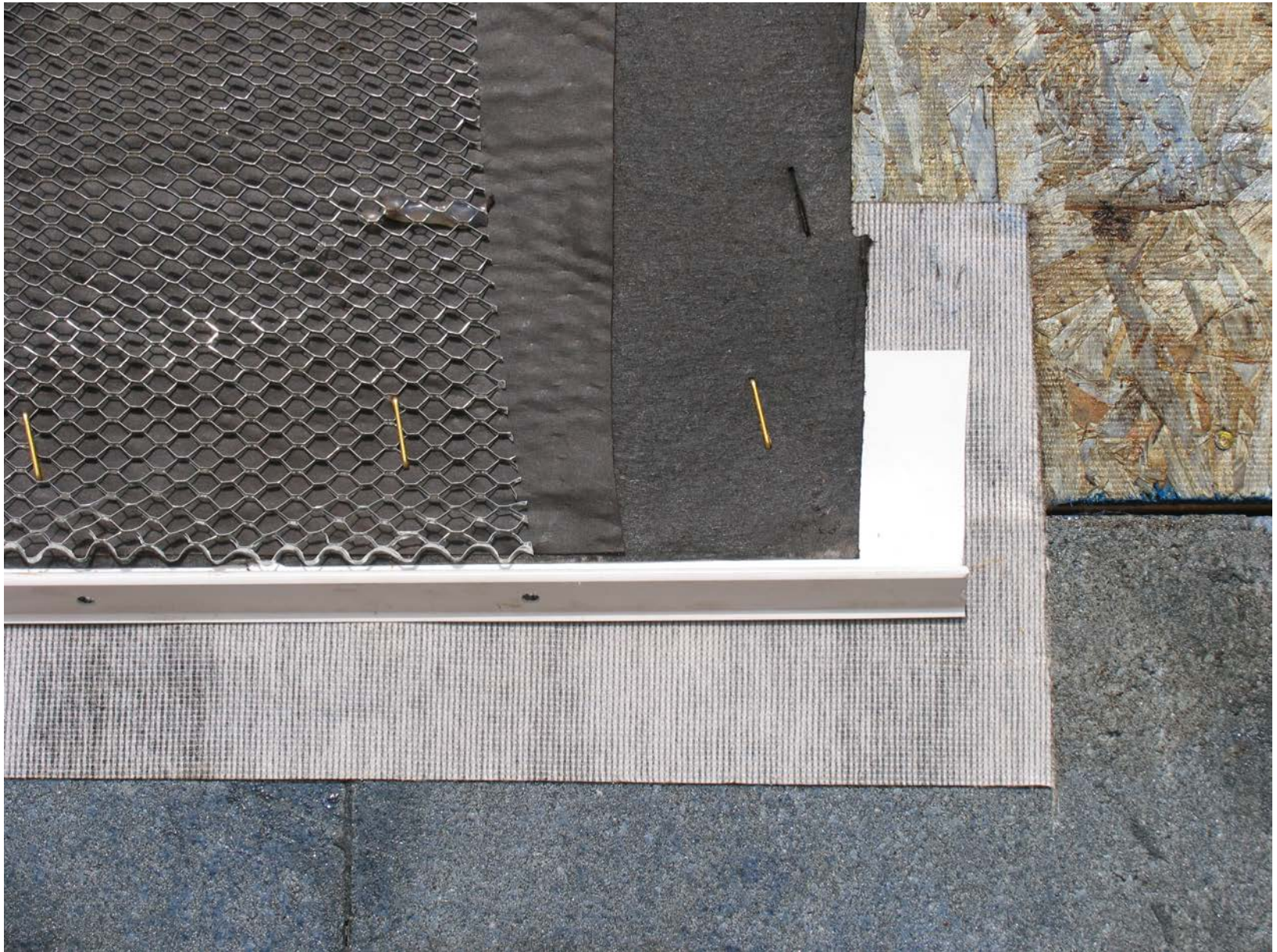


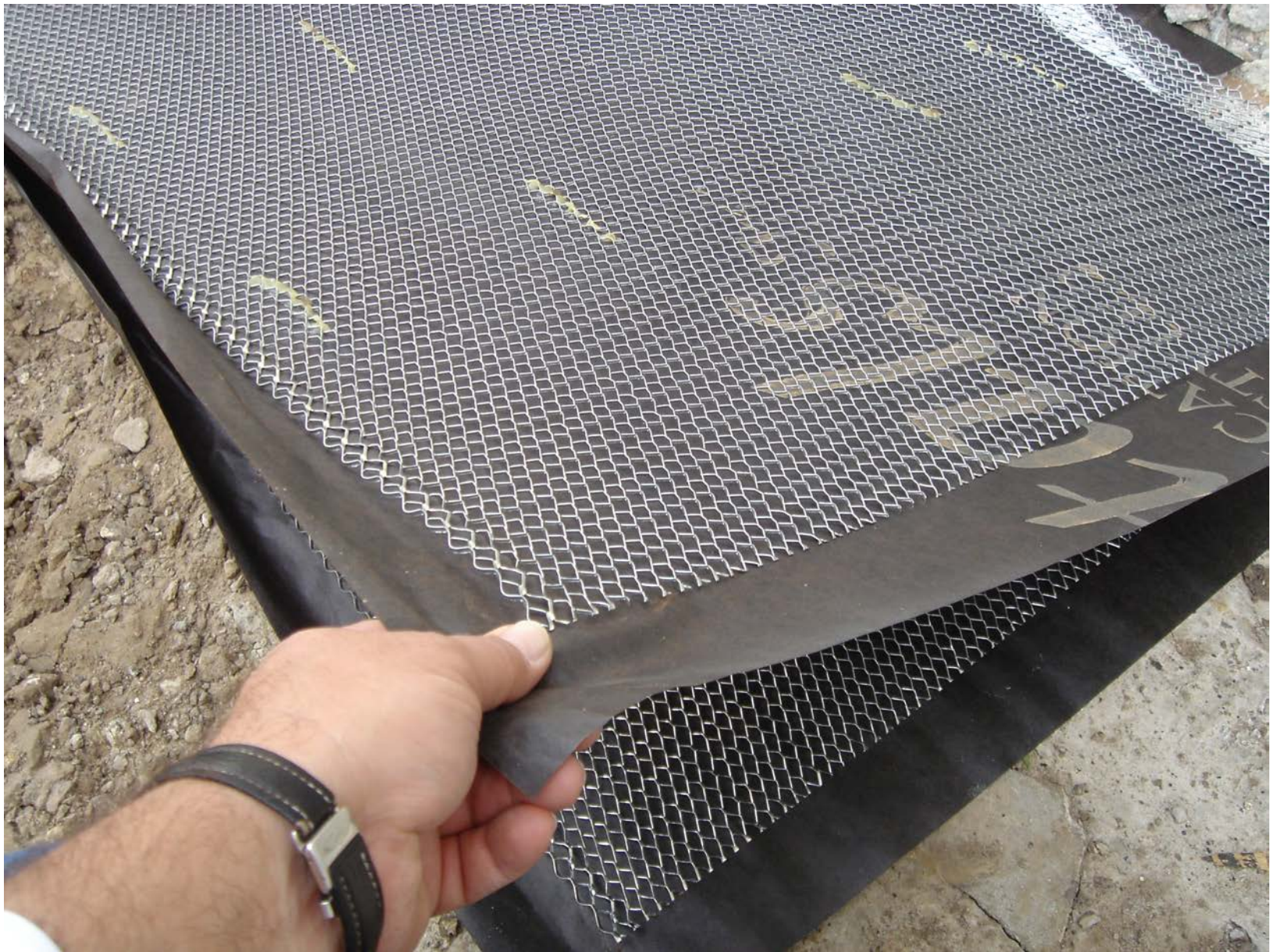
































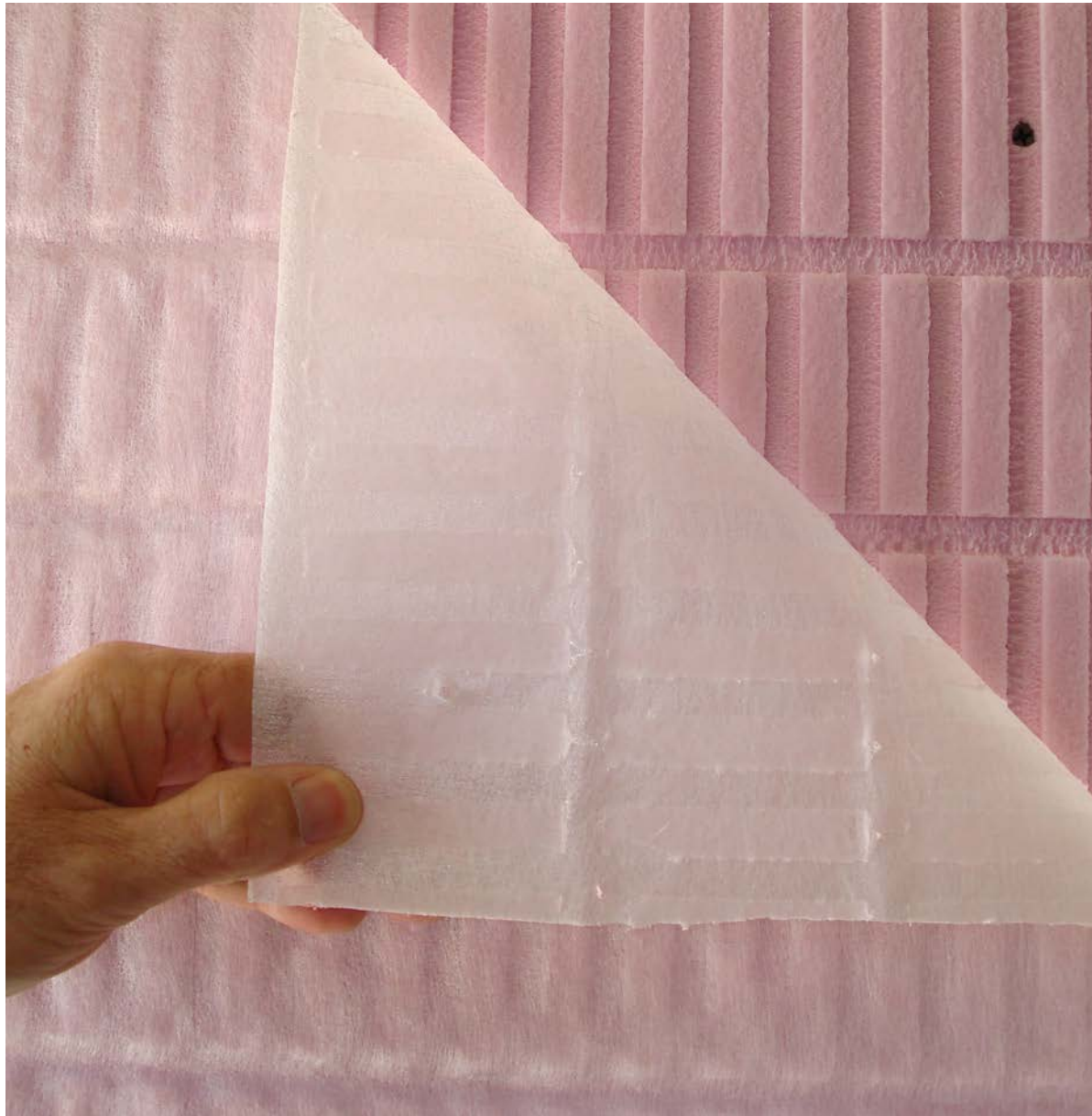


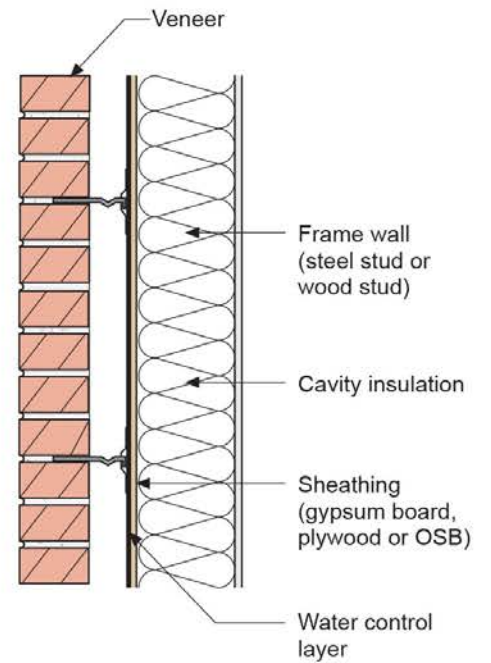
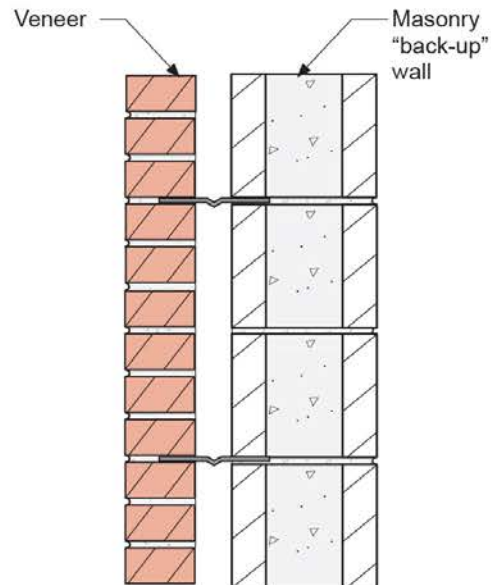
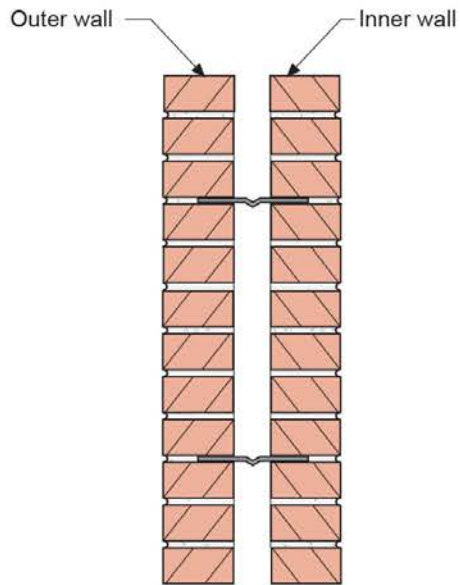
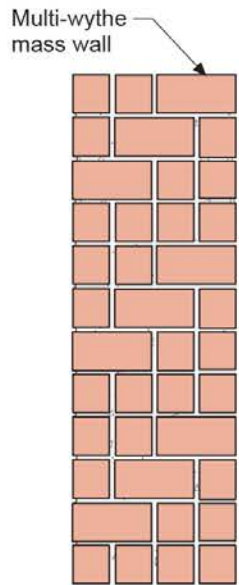


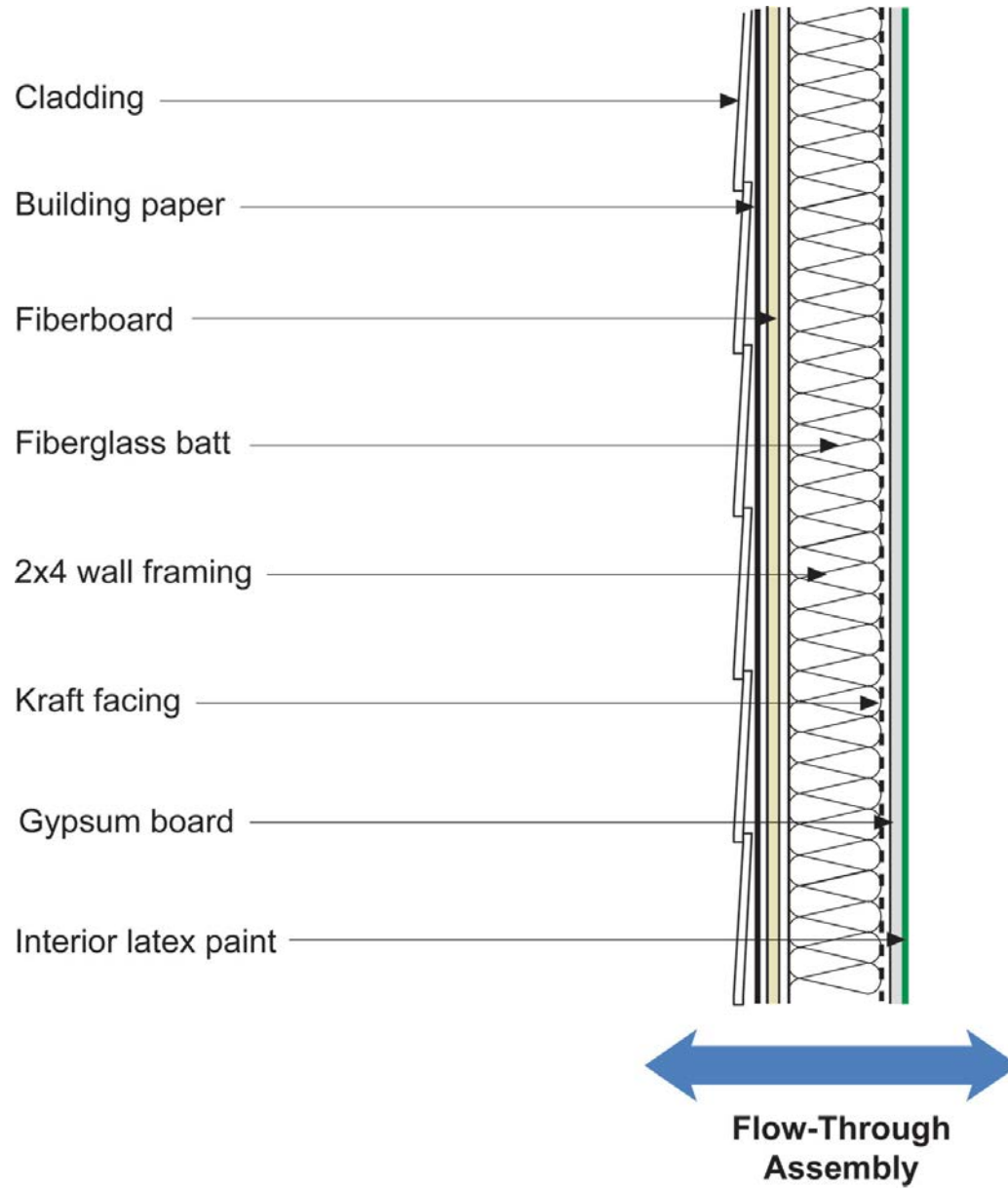


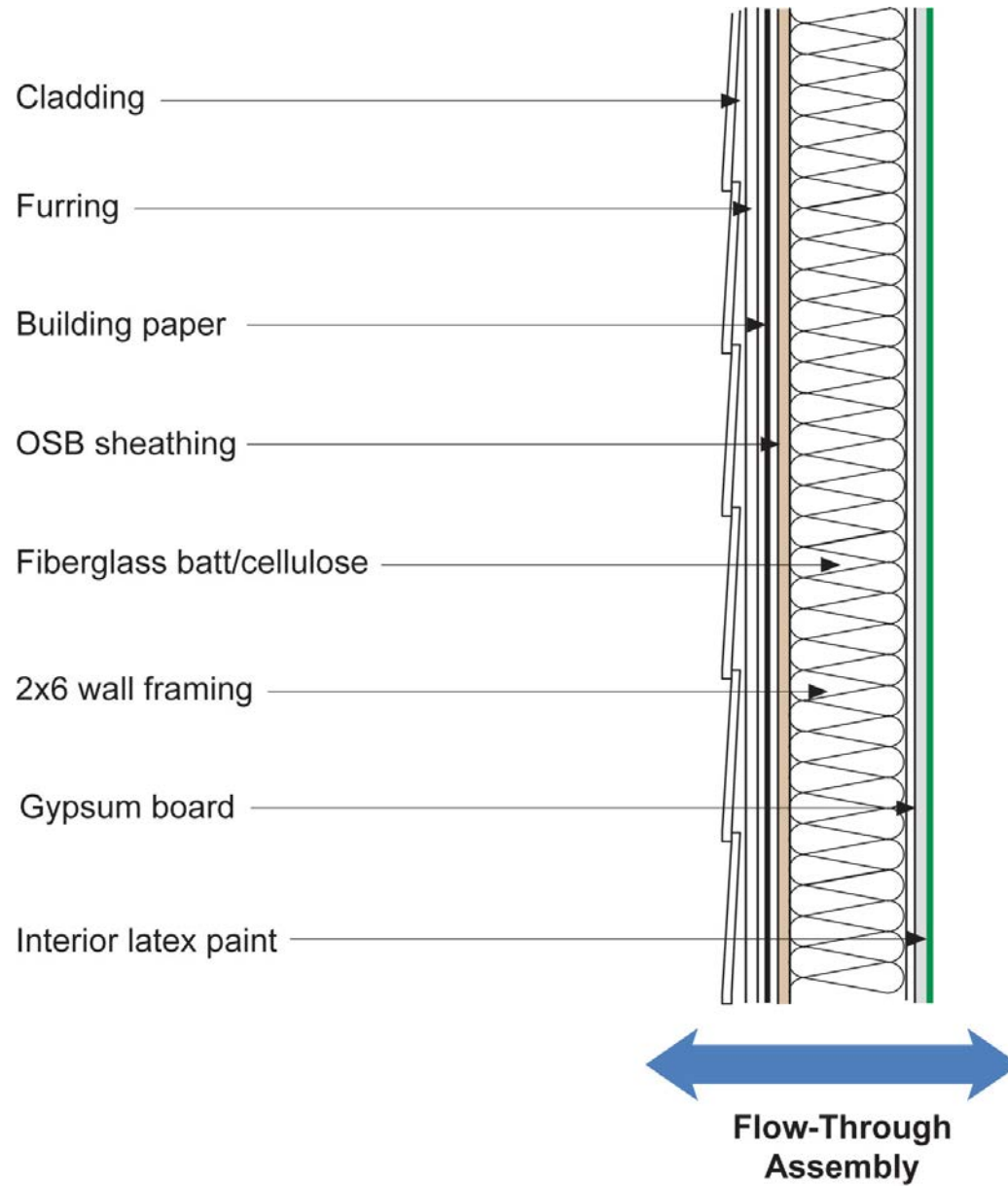


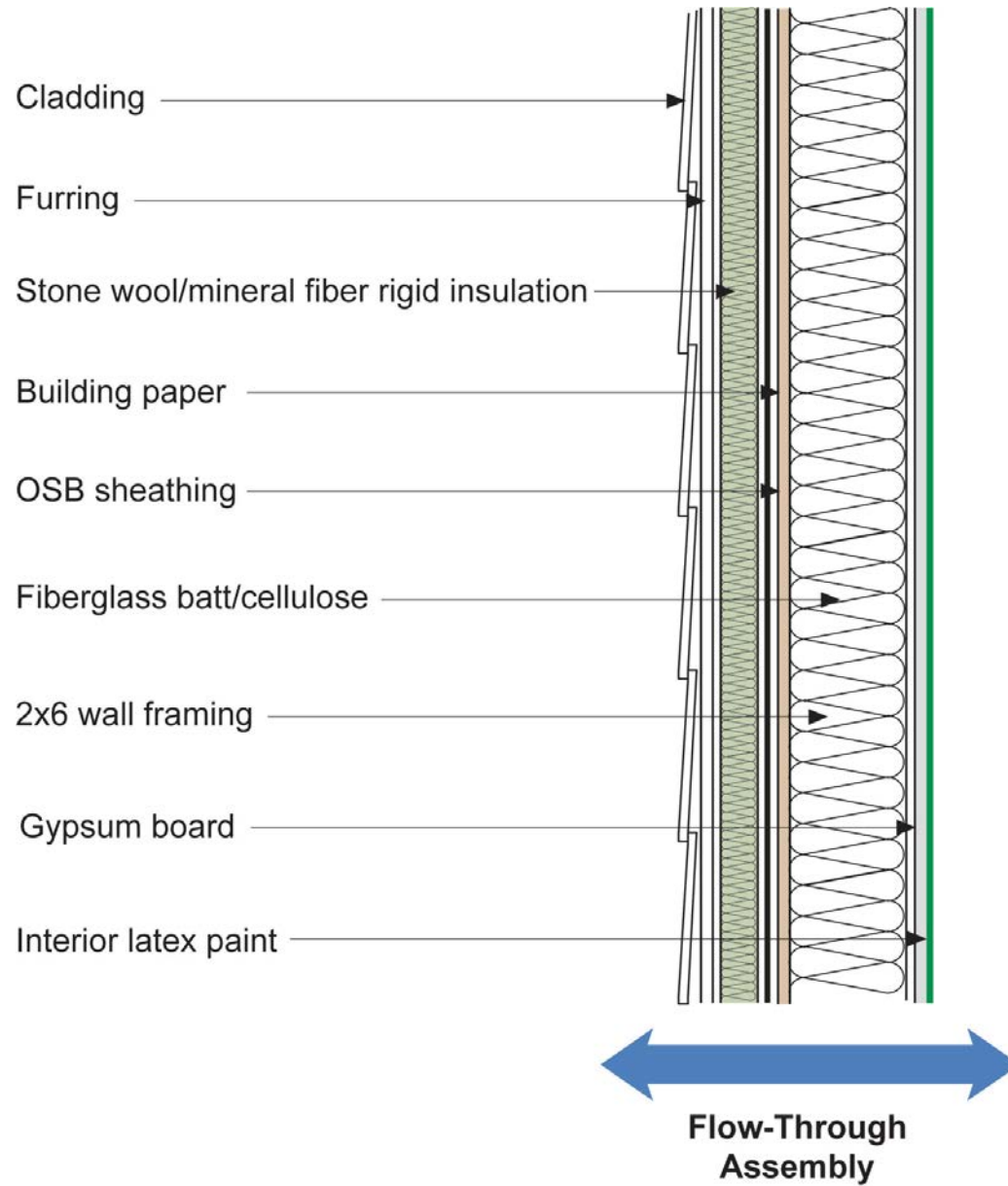


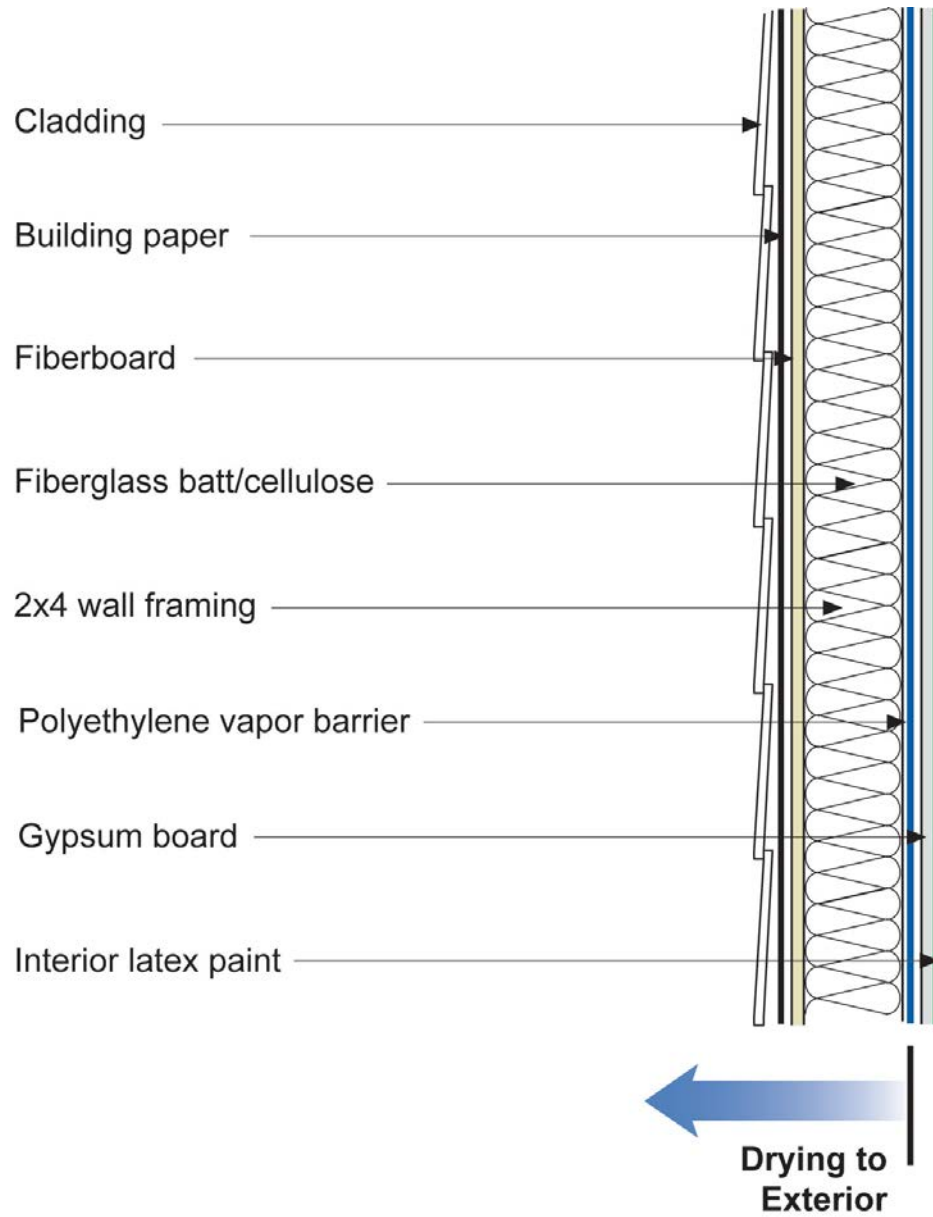


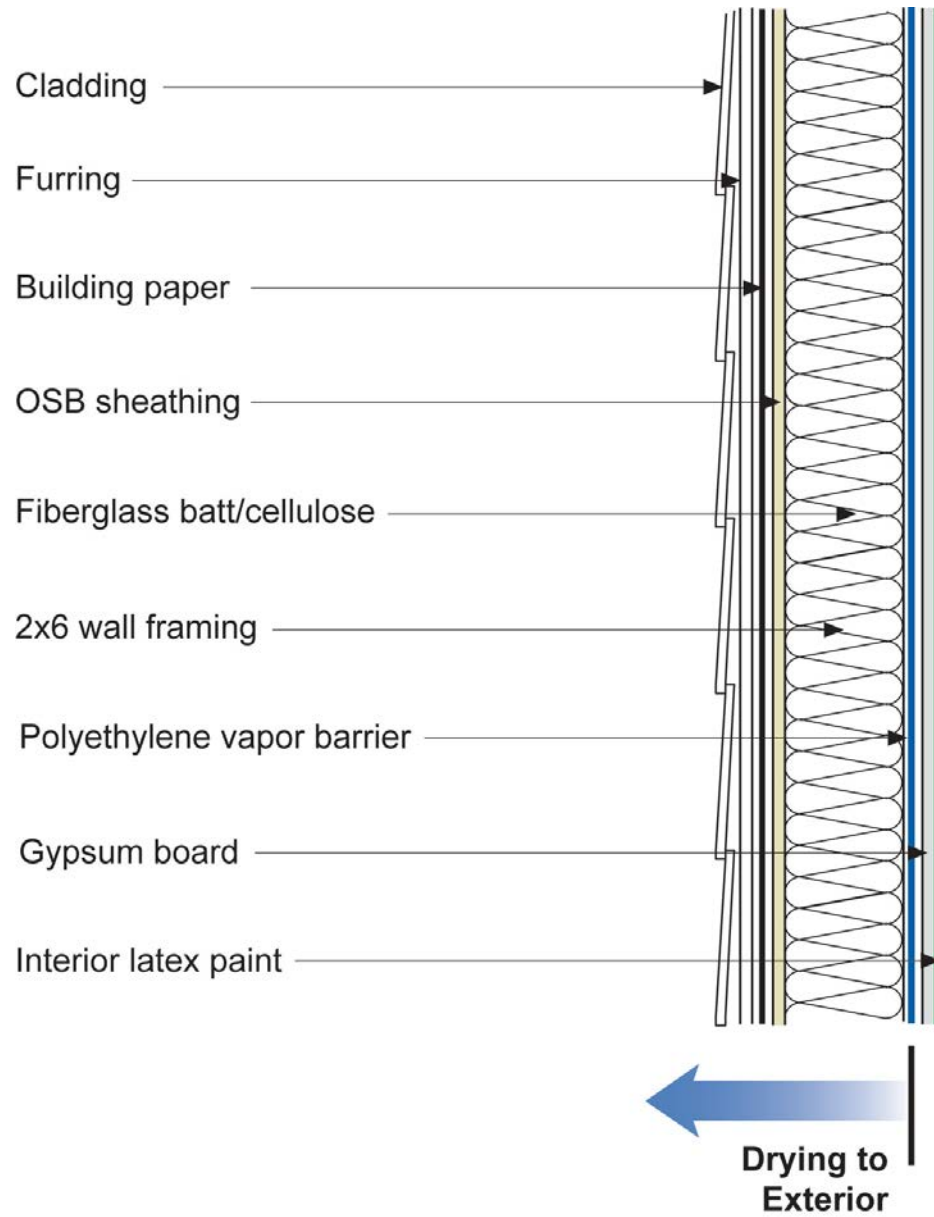


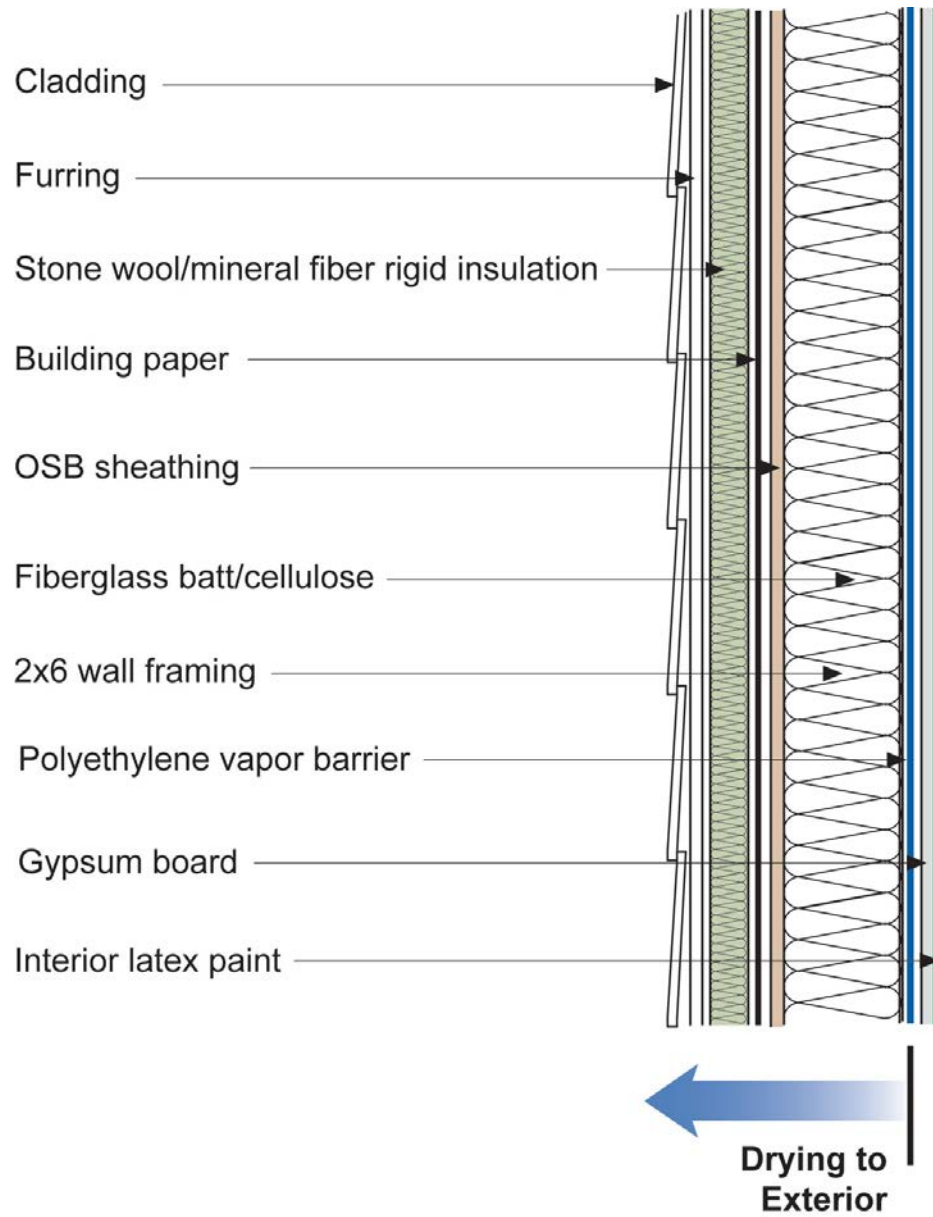


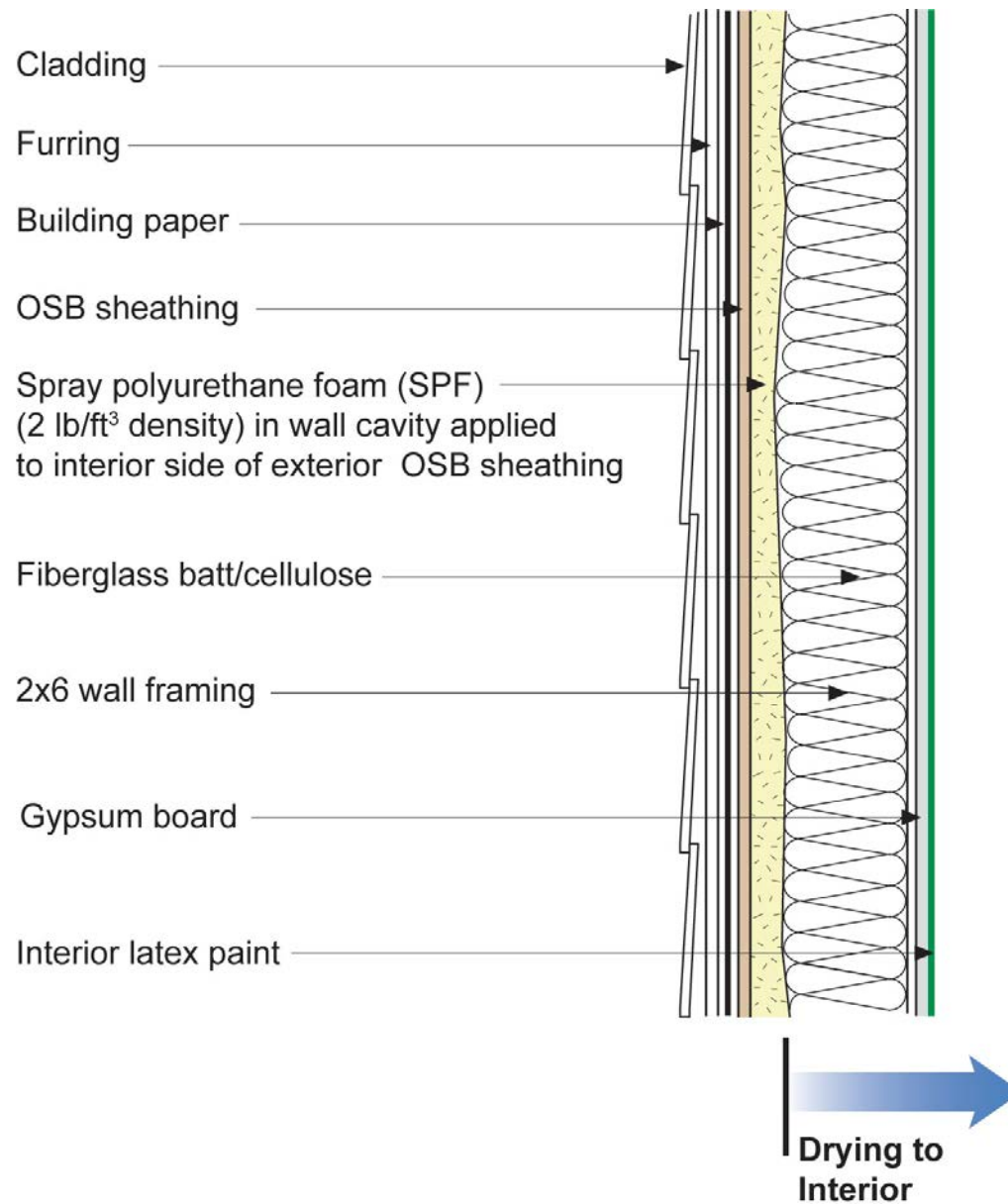


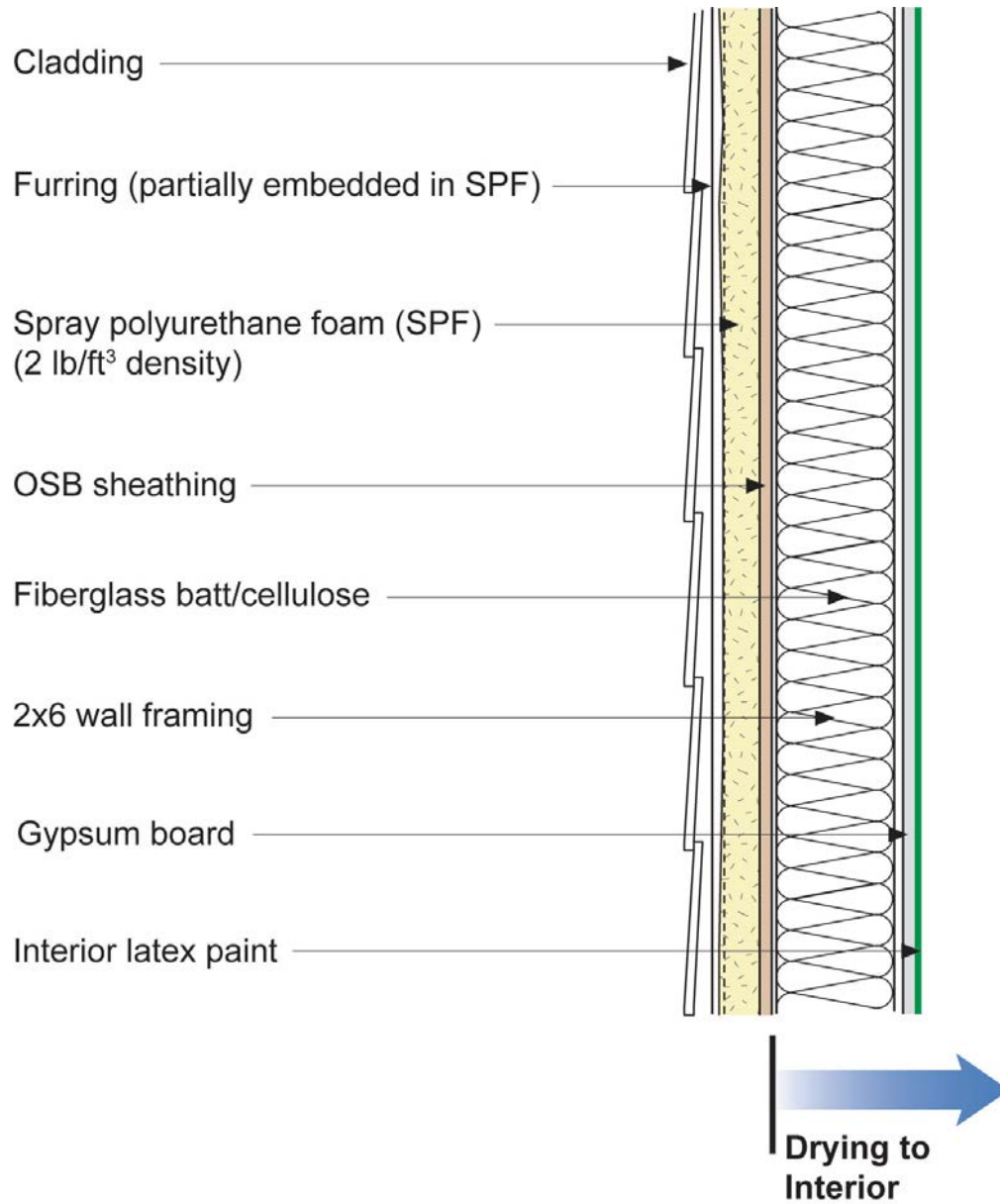












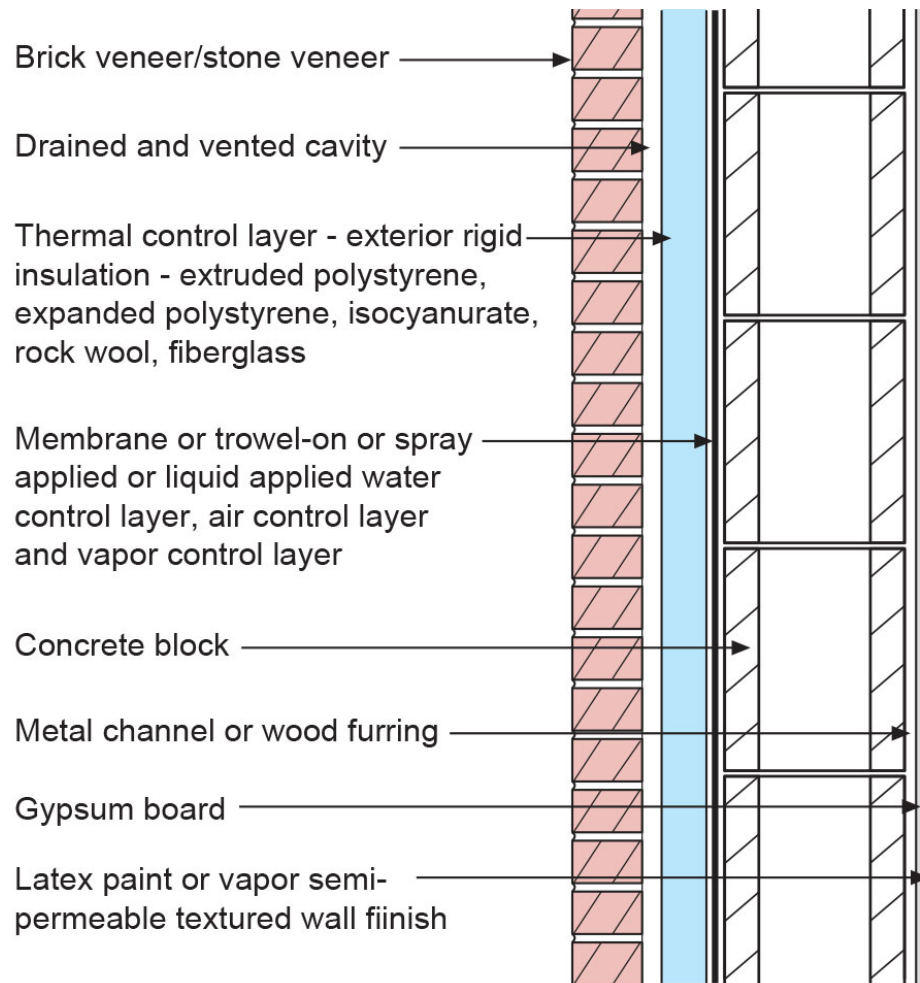


Figure 1a



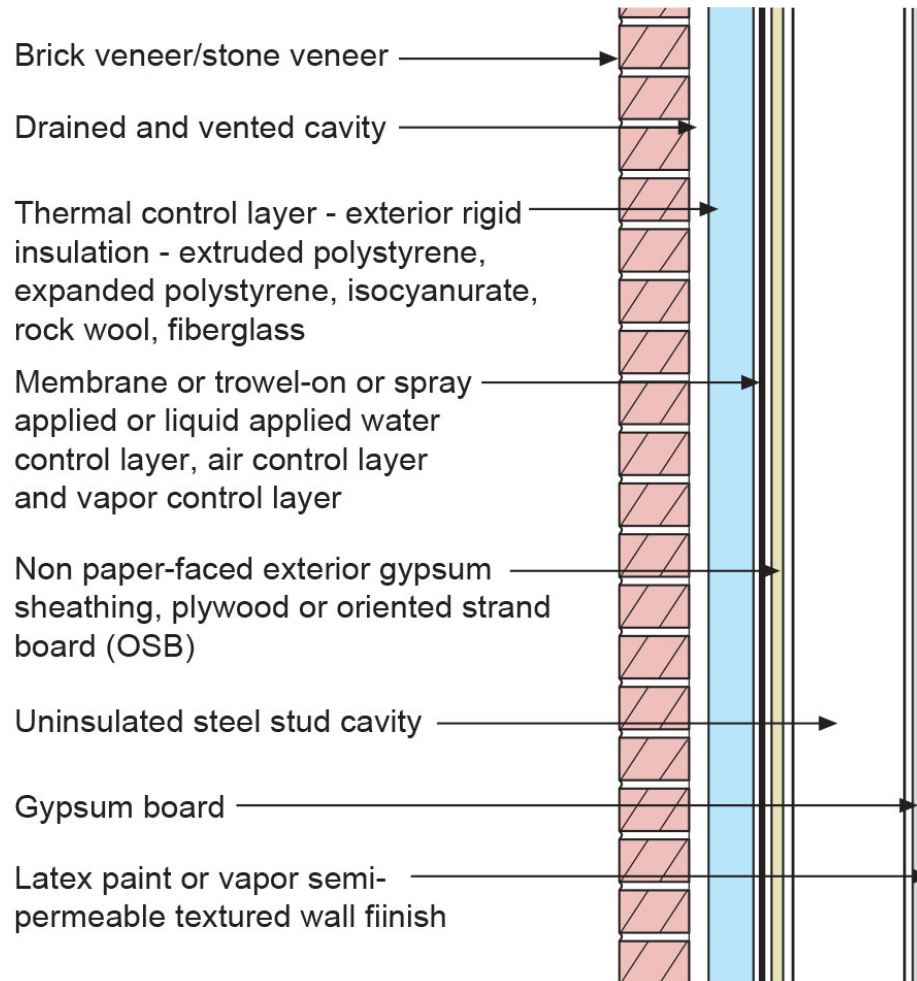


Figure 1b



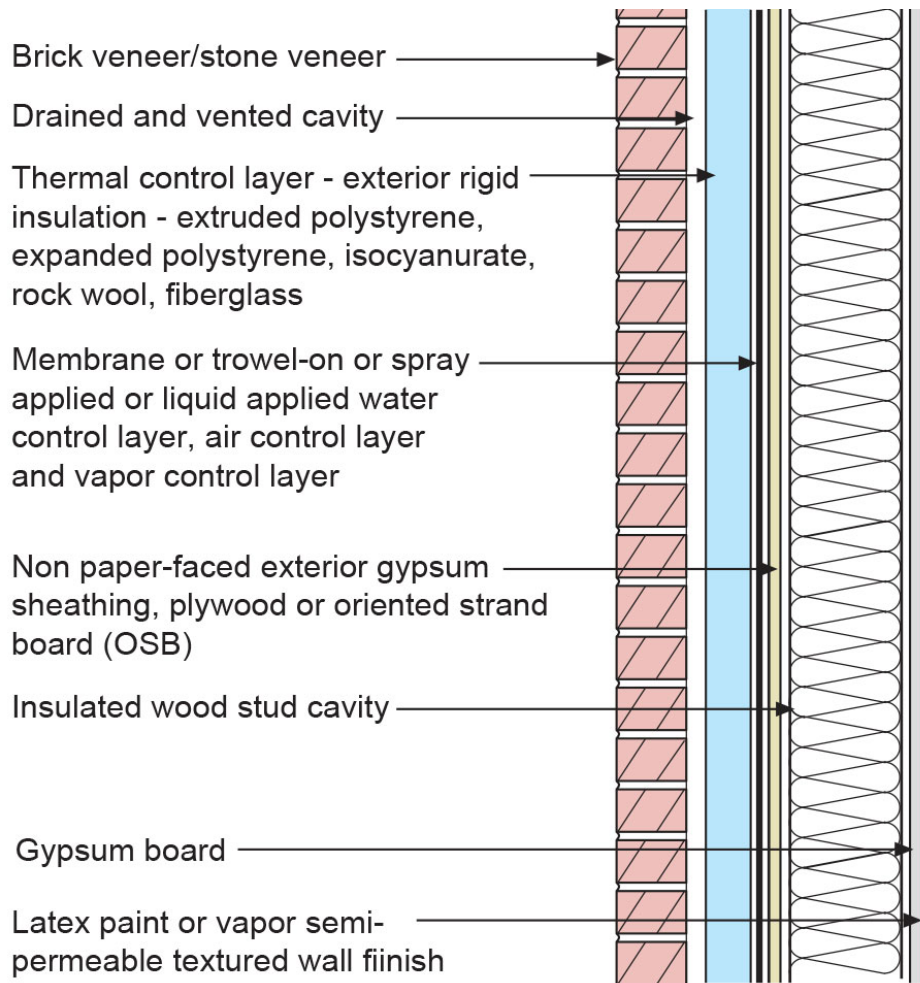
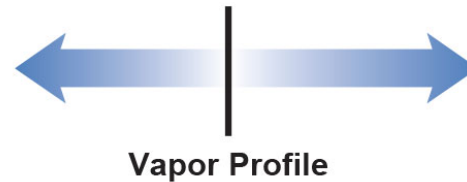


Figure 1c



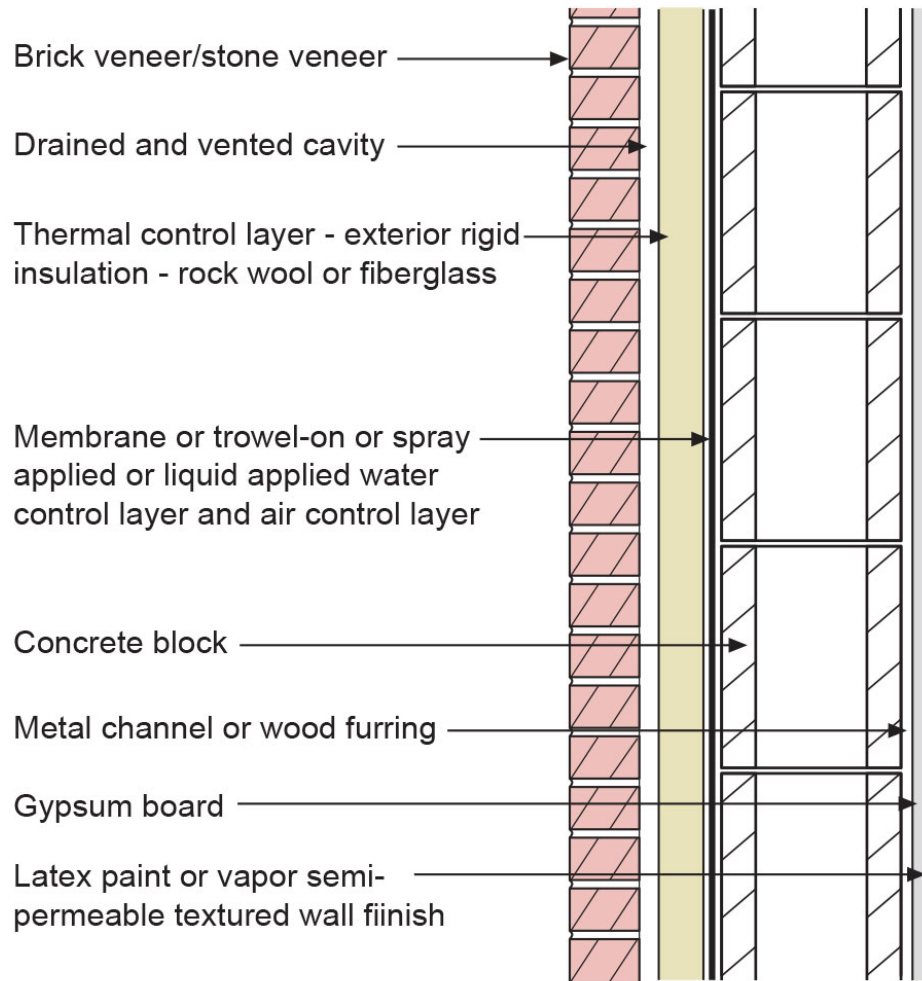


Figure 2a



Vapor Profile

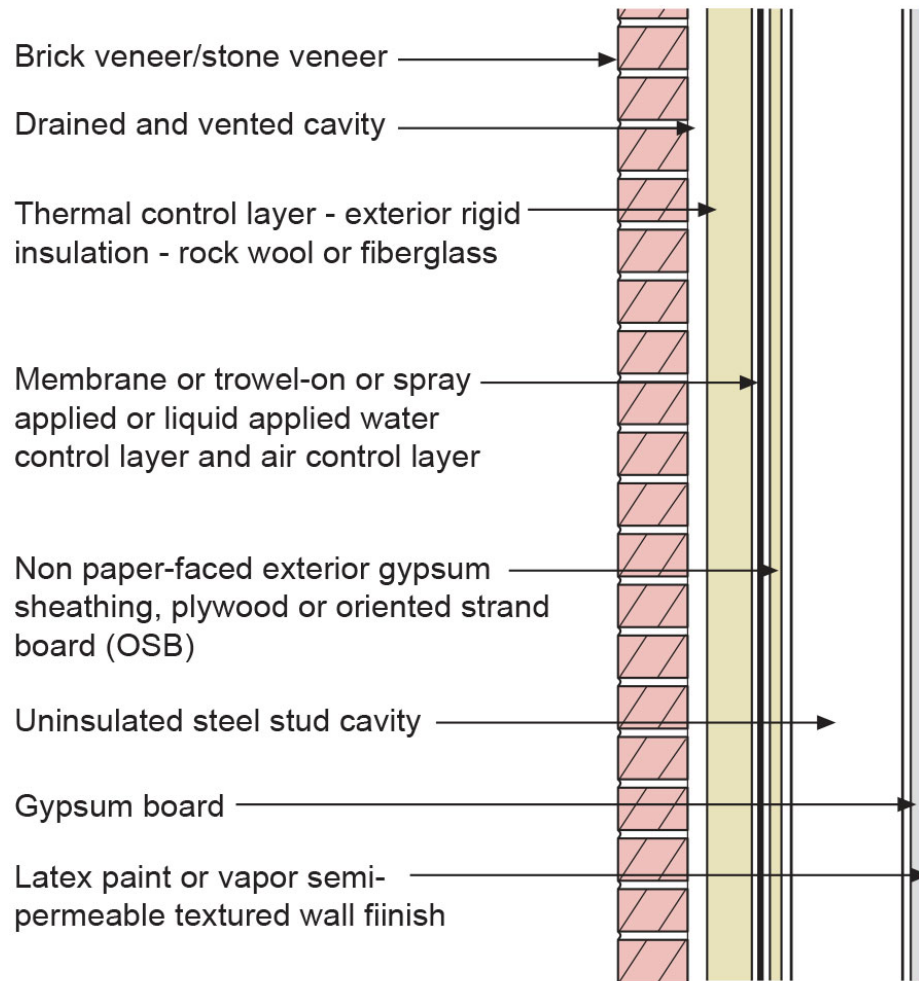


Figure 2b



Vapor Profile

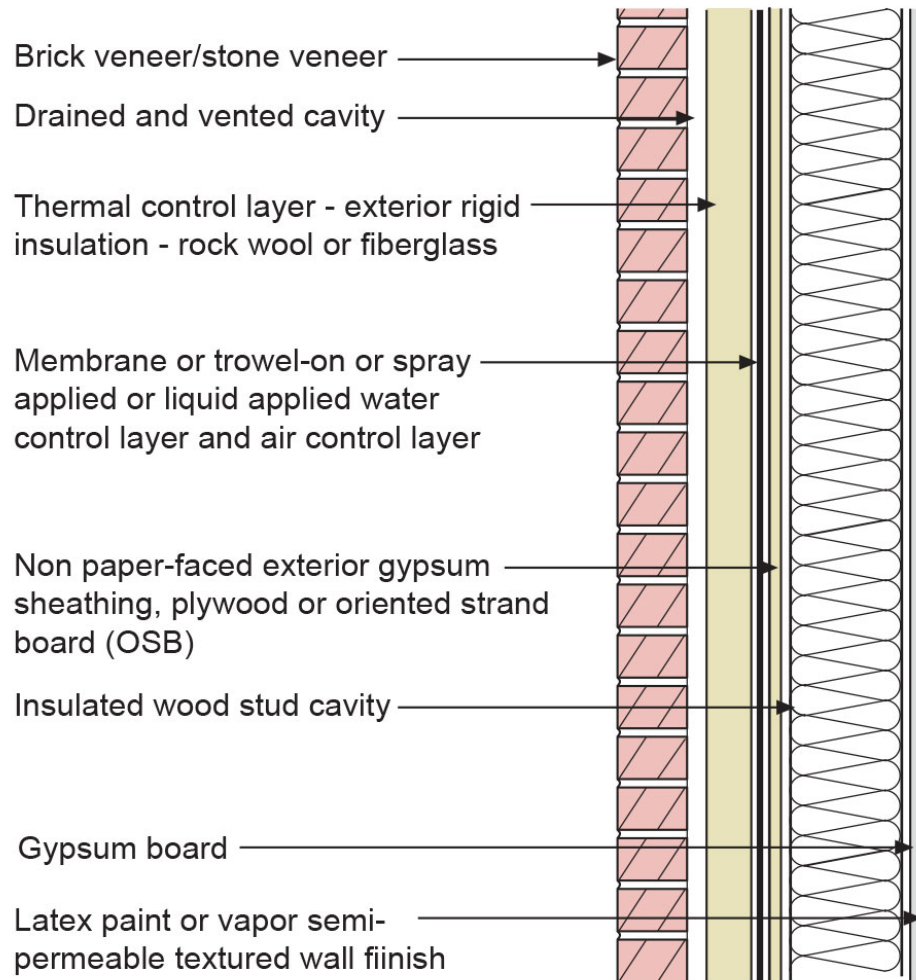
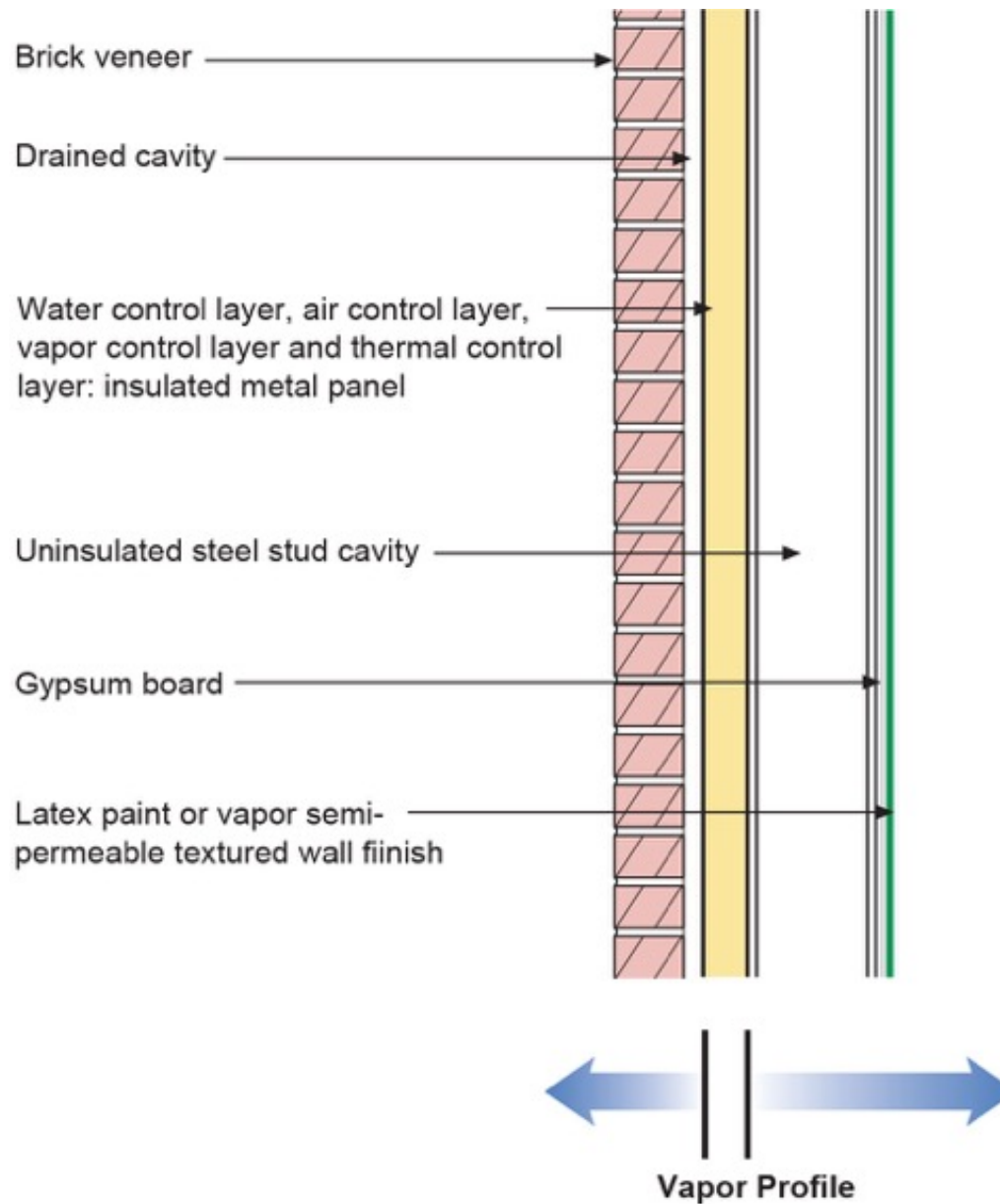
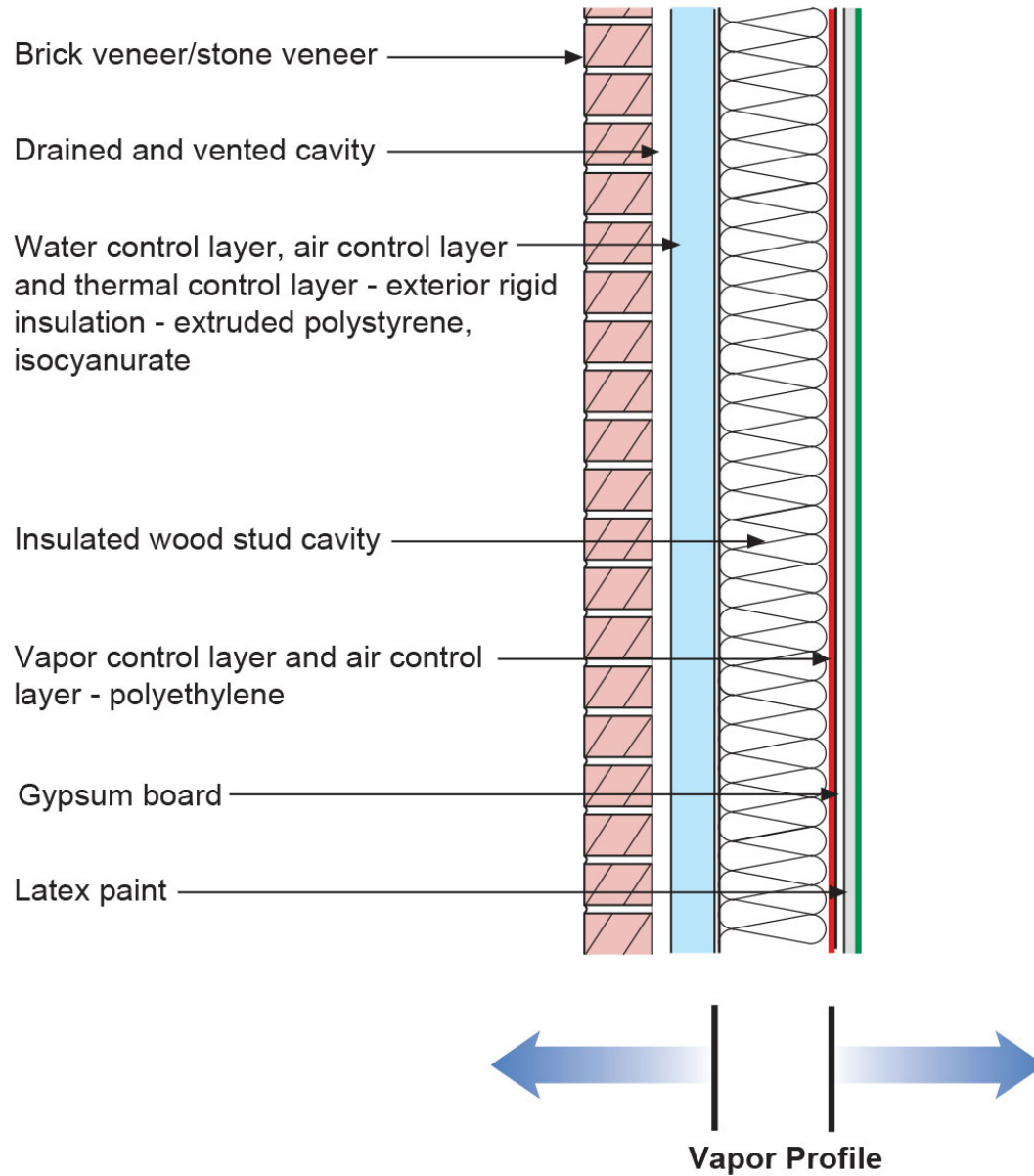


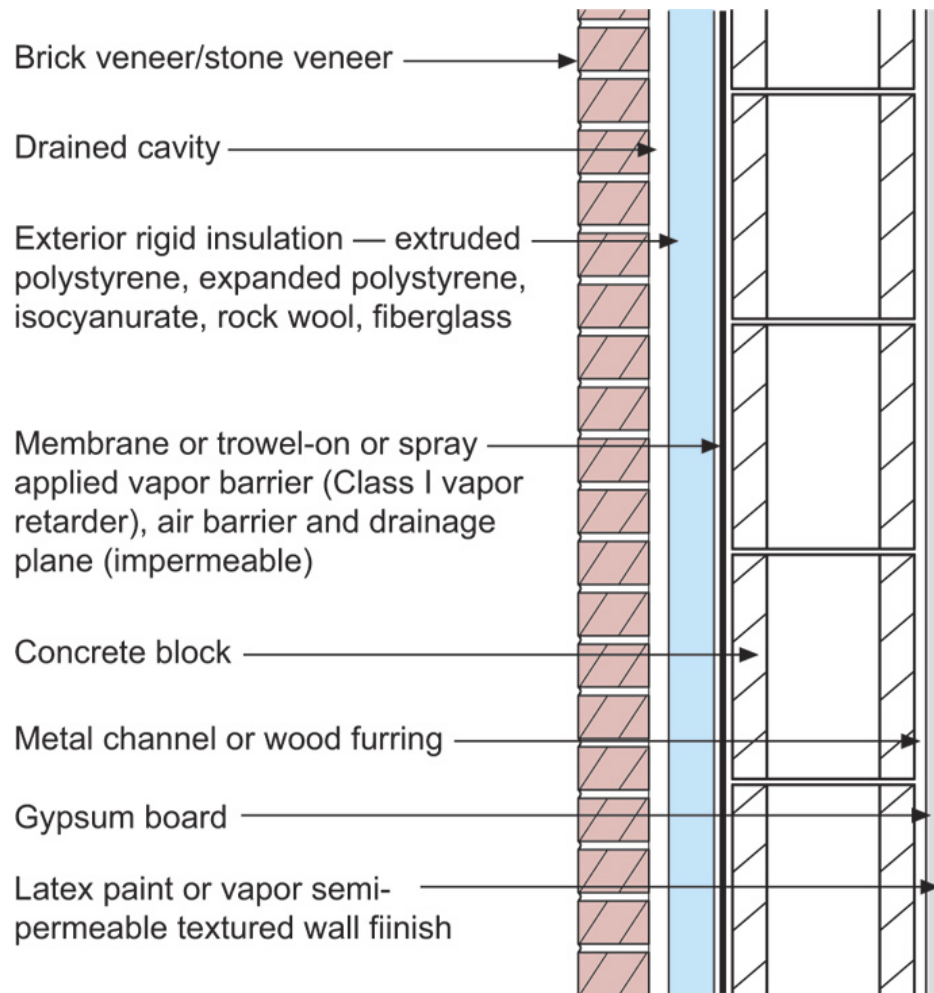
Figure 2c



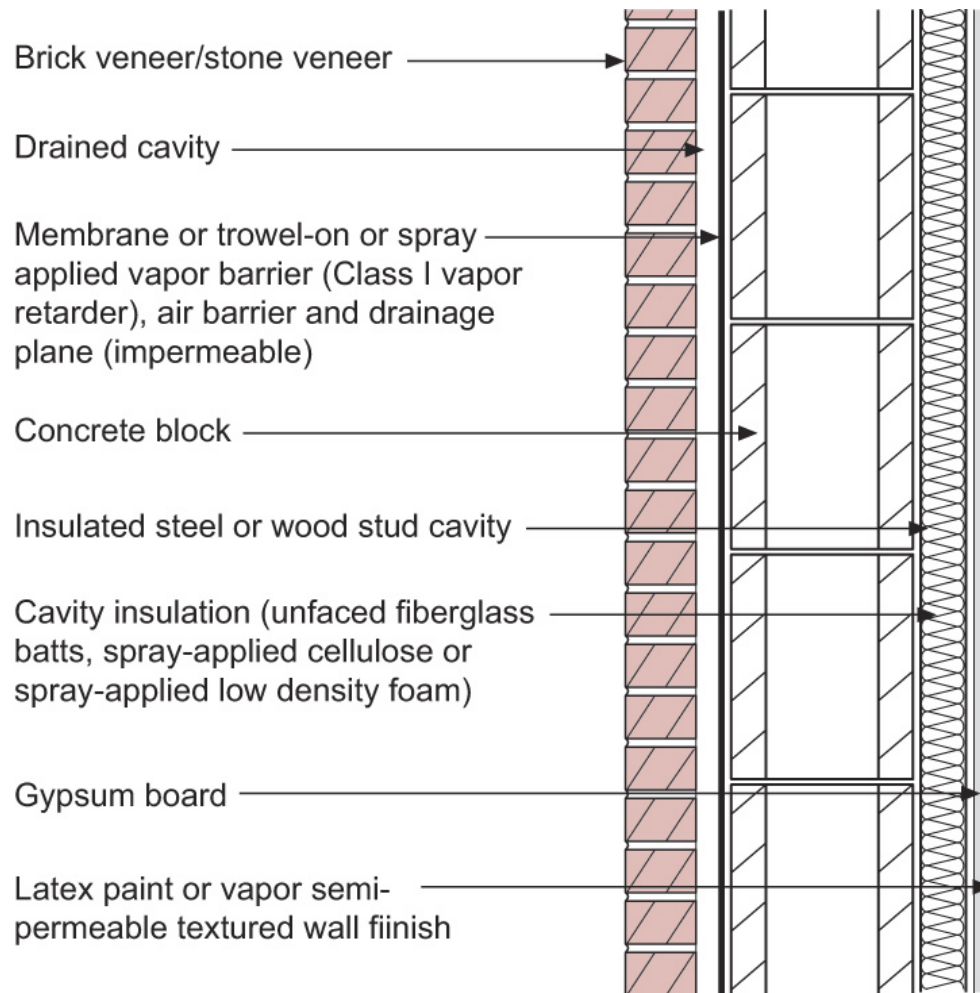
Vapor Profile



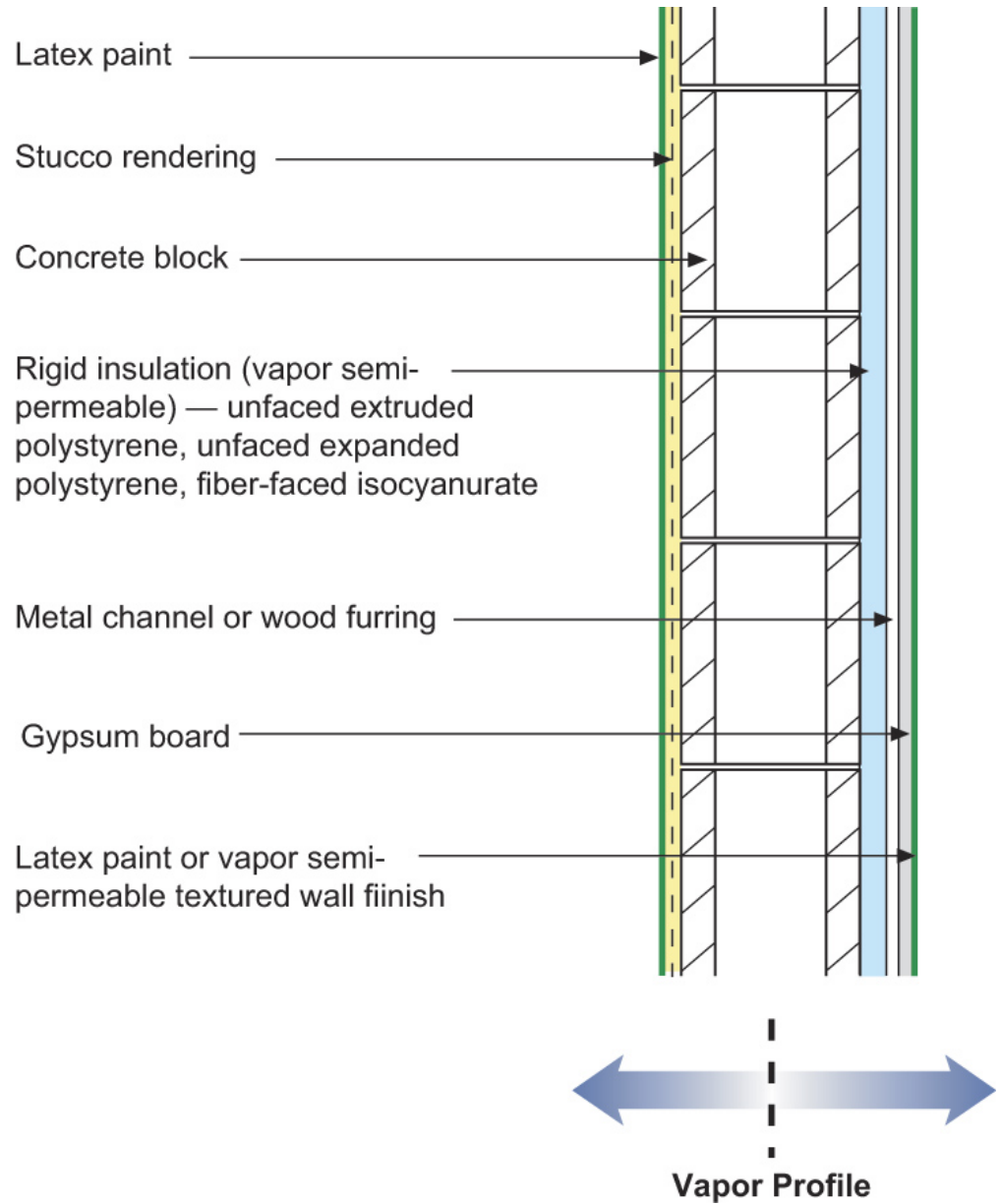


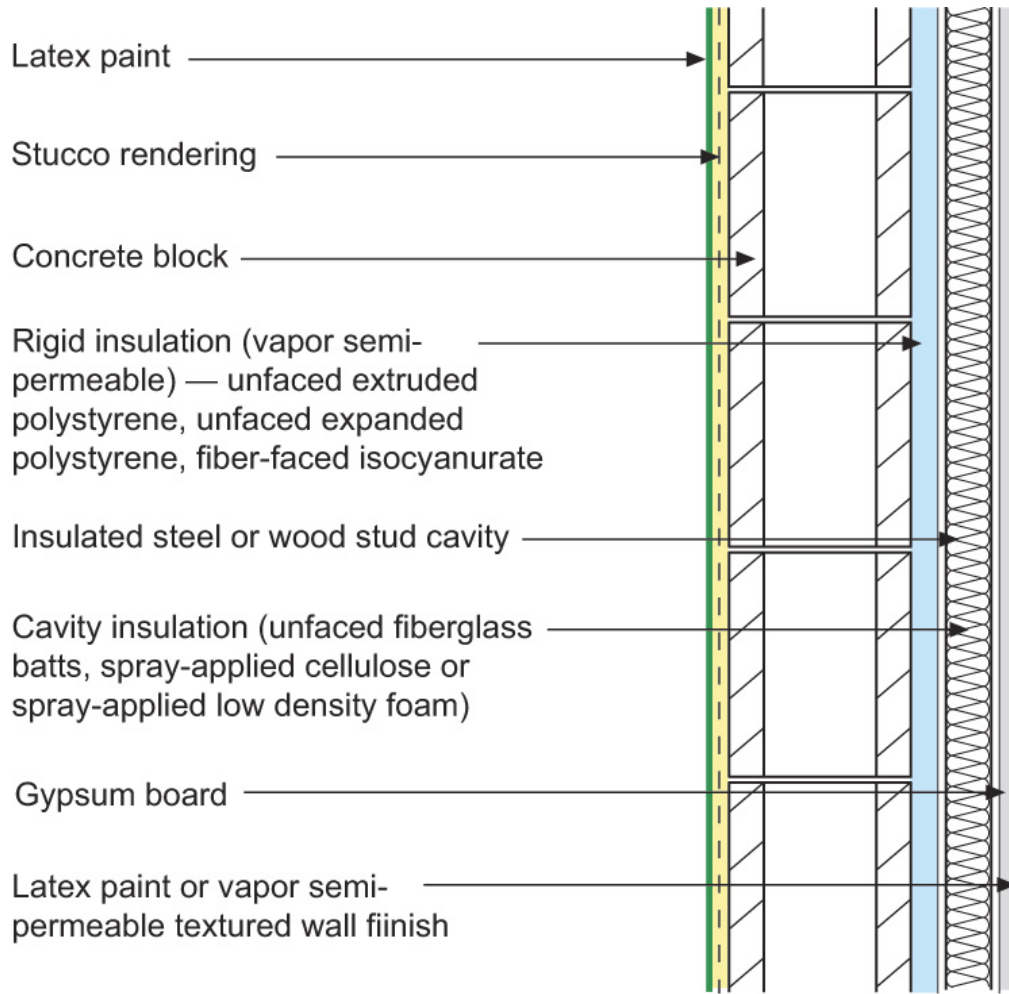


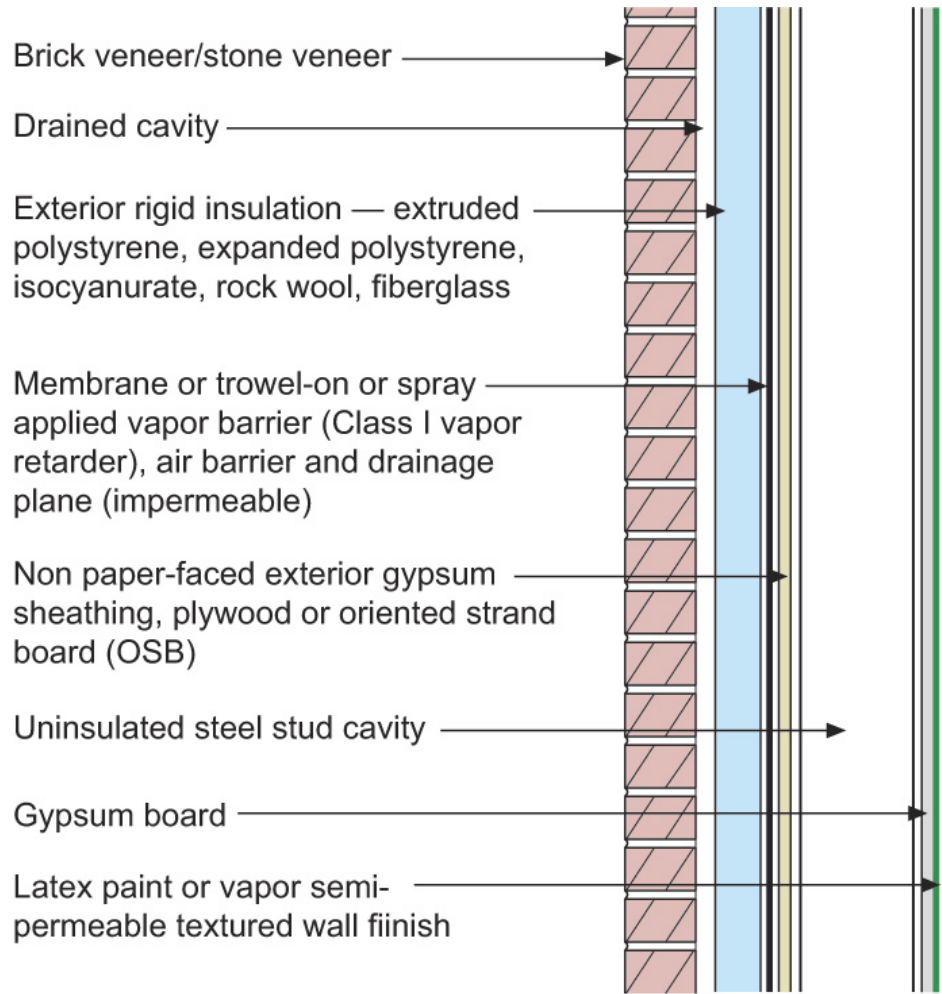
Vapor Profile

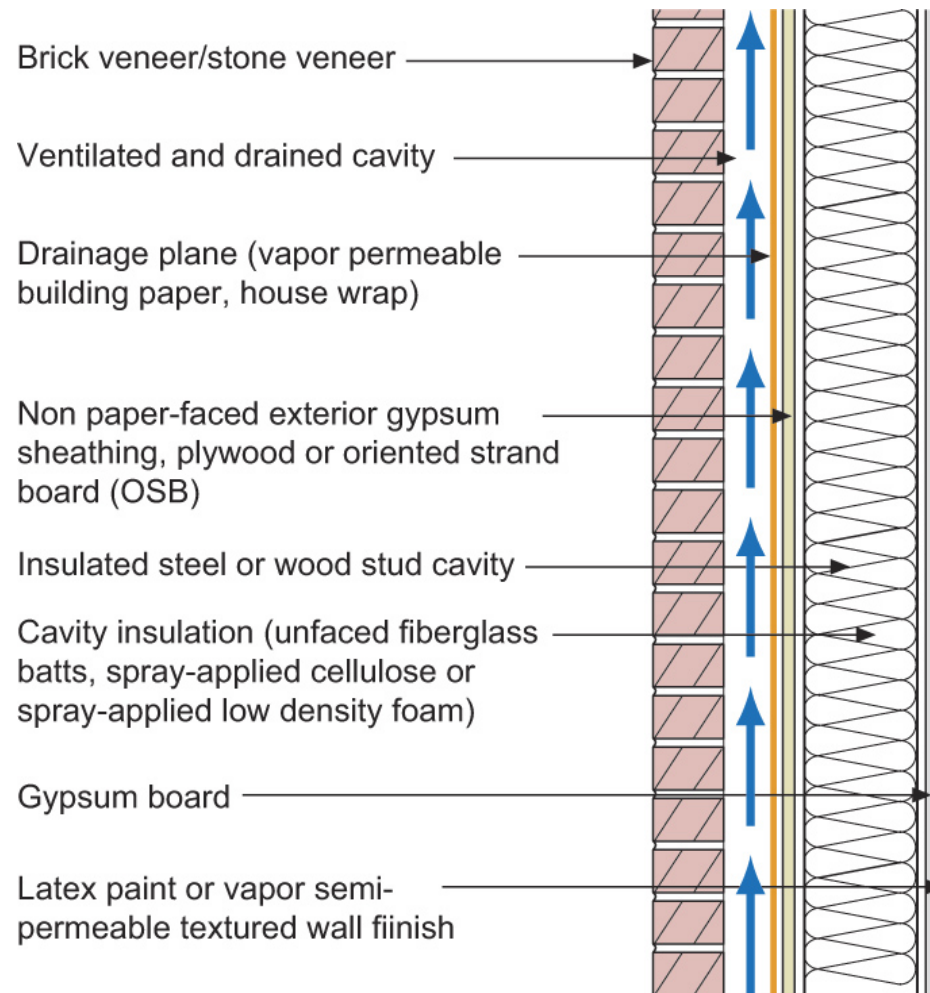


Vapor Profile

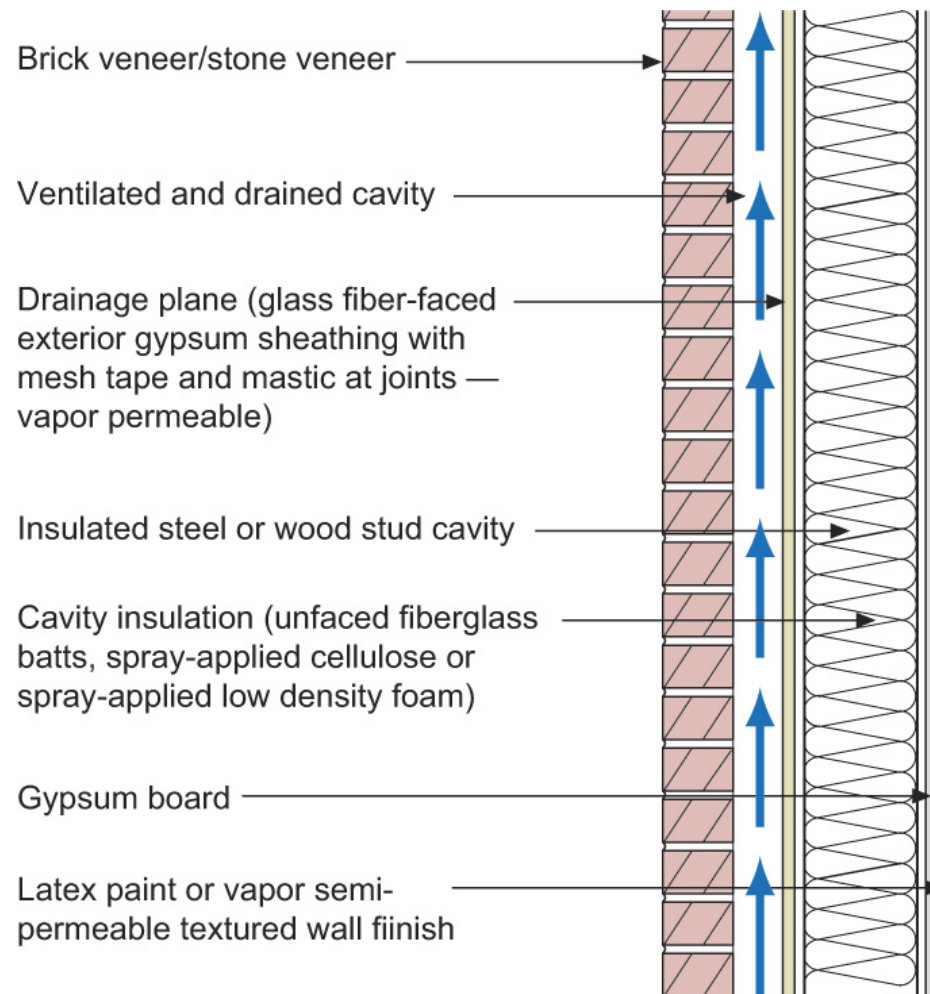




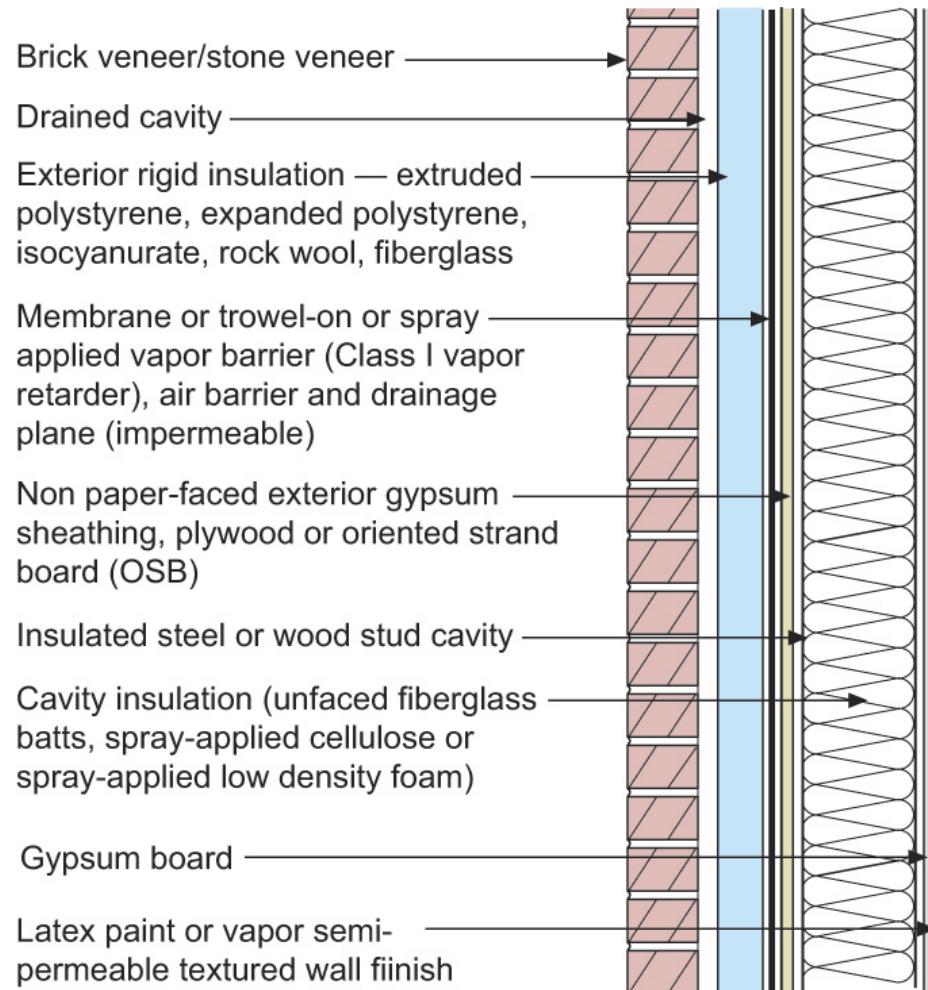


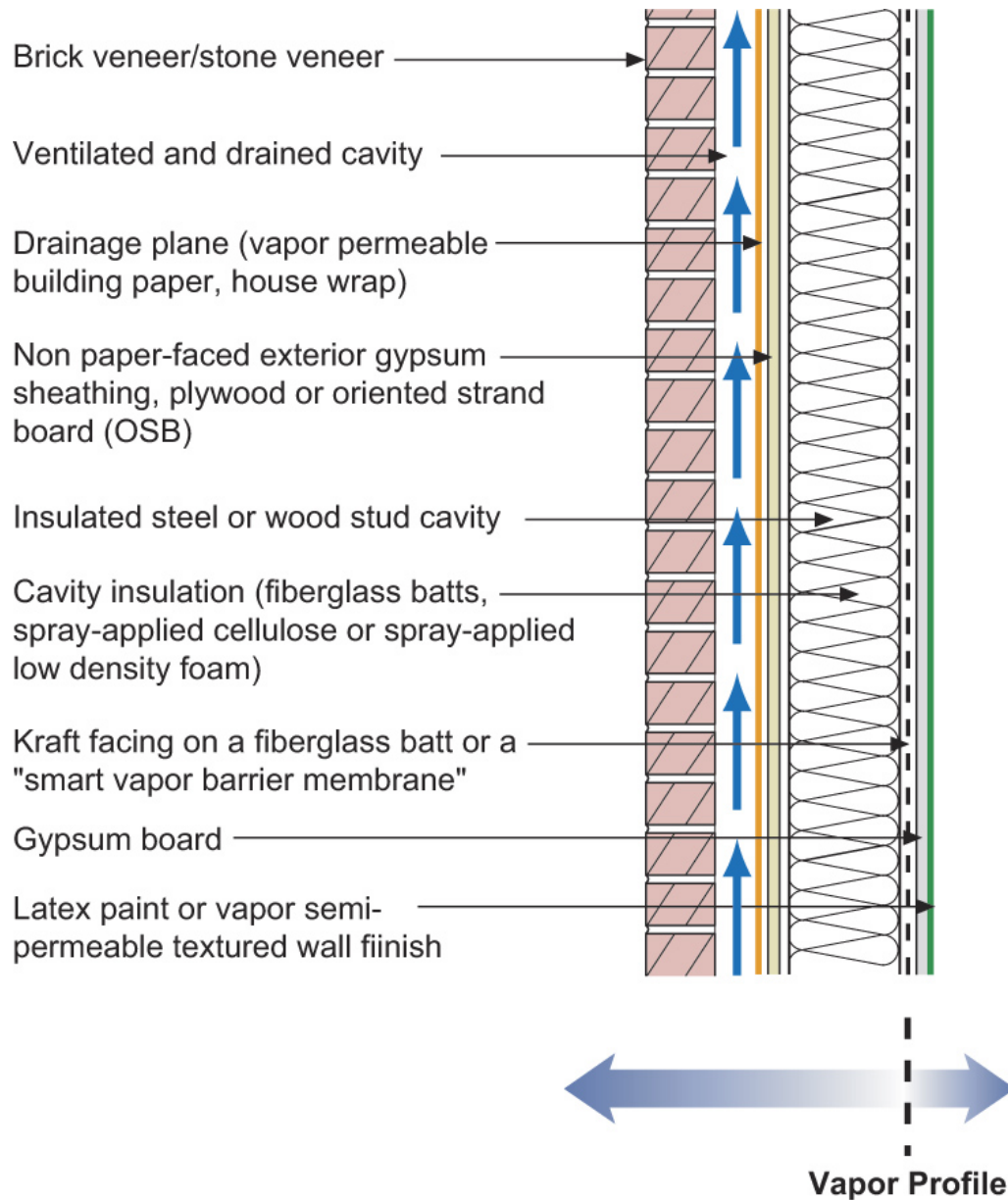


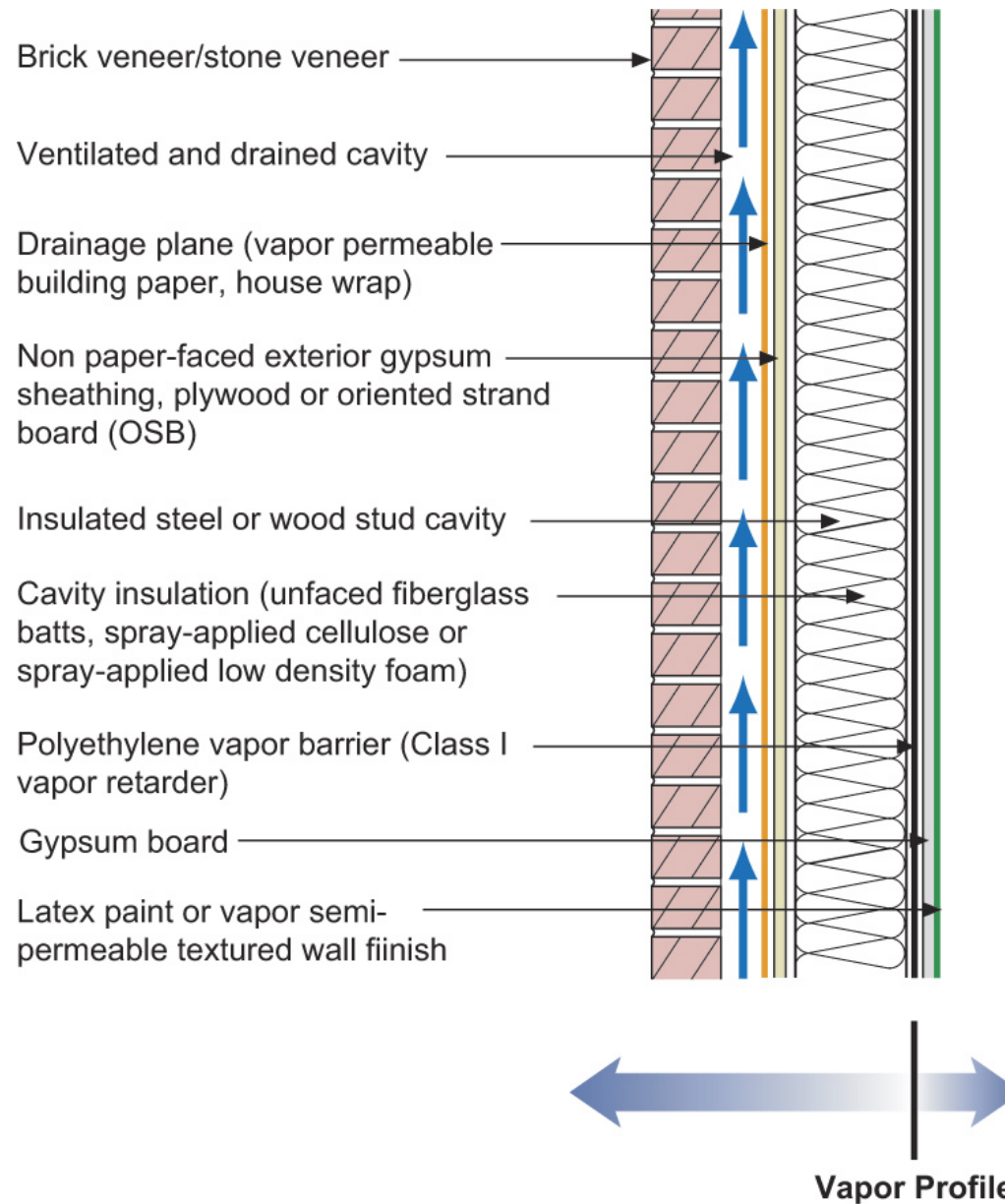
Vapor Profile

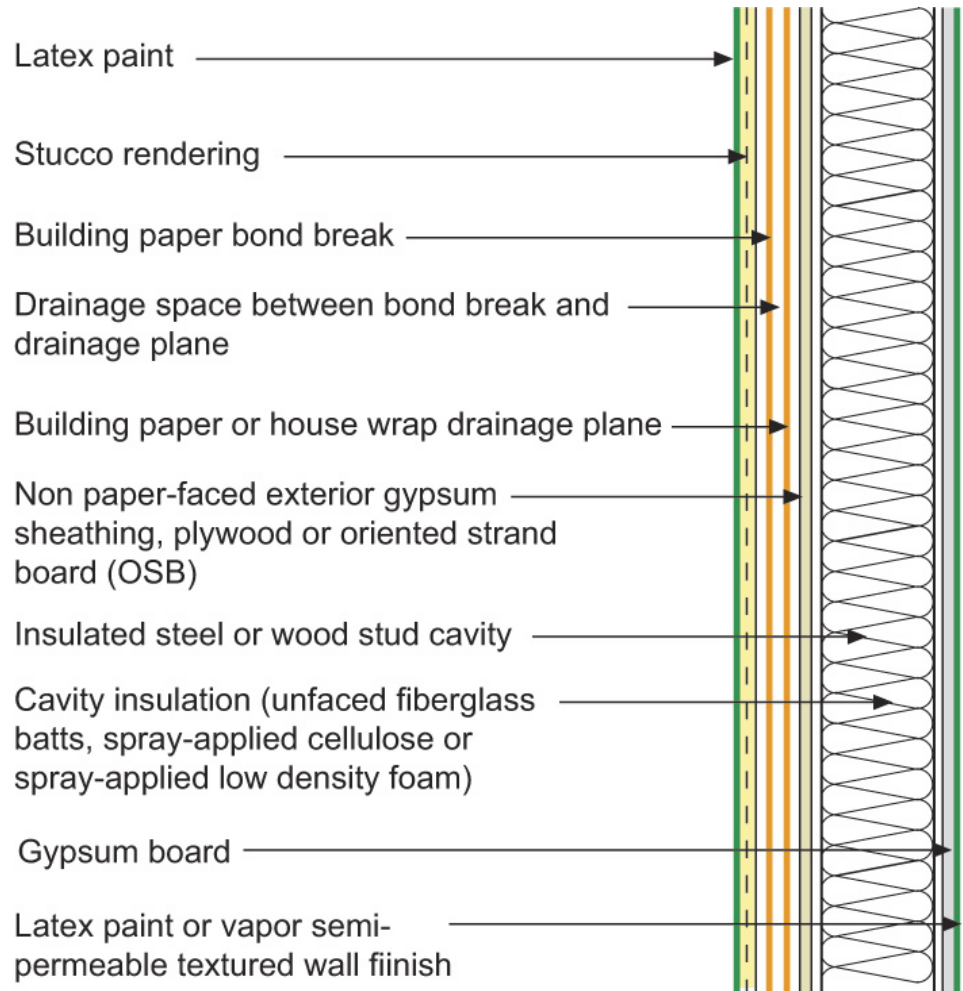


Vapor Profile

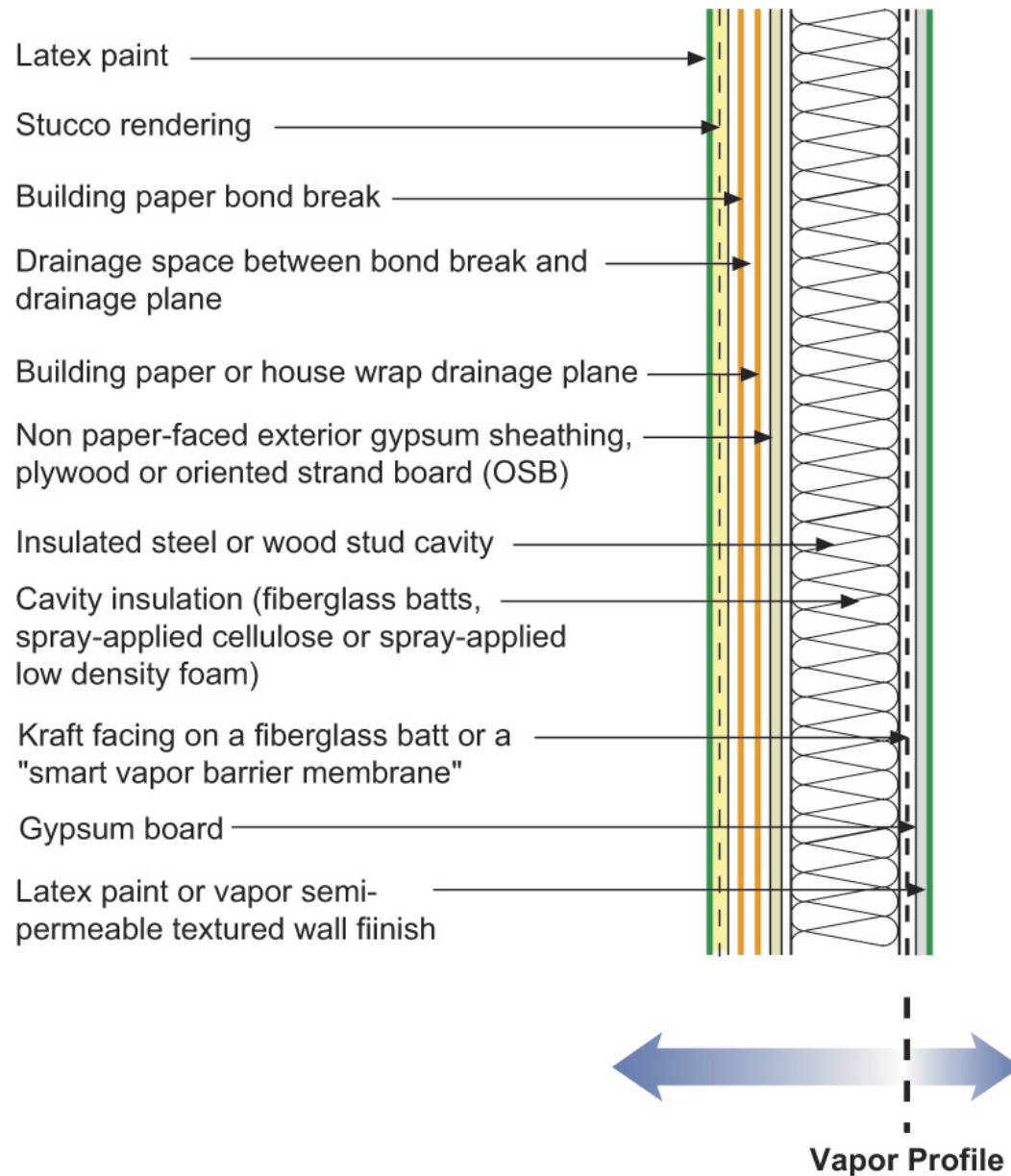


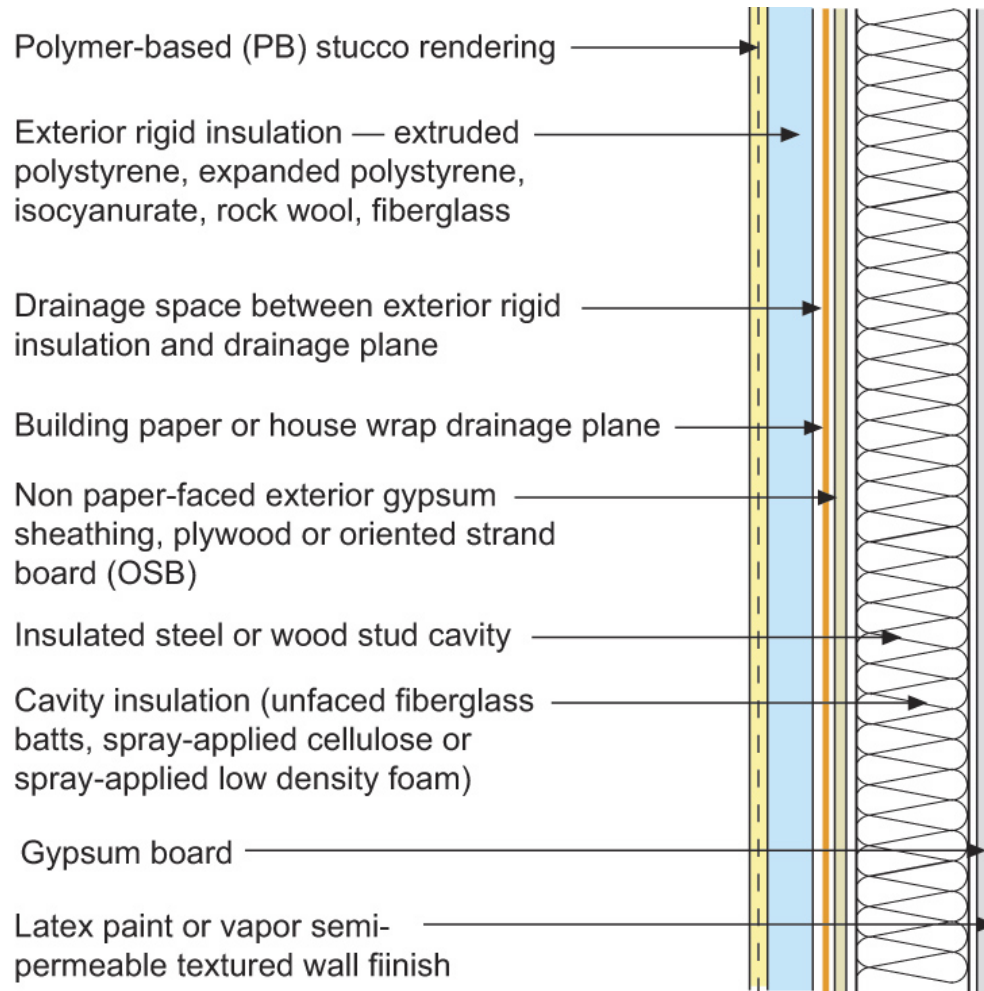




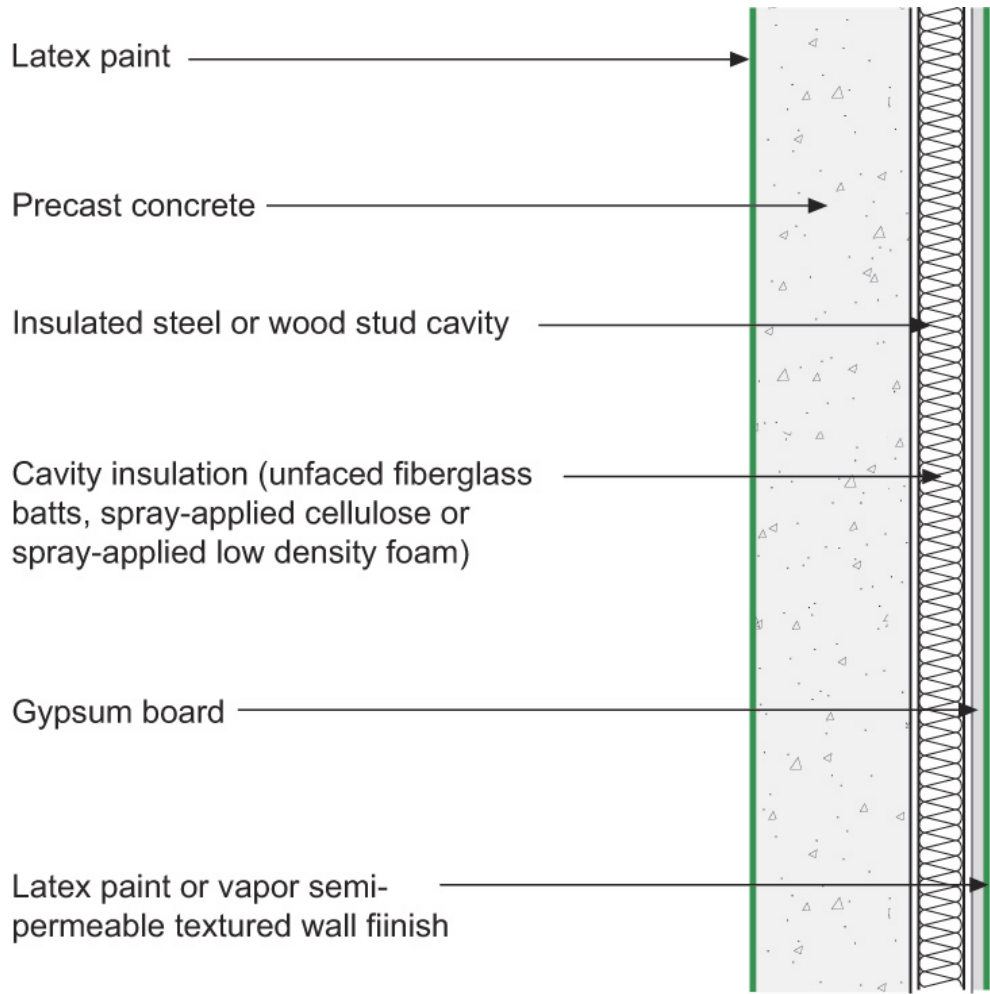


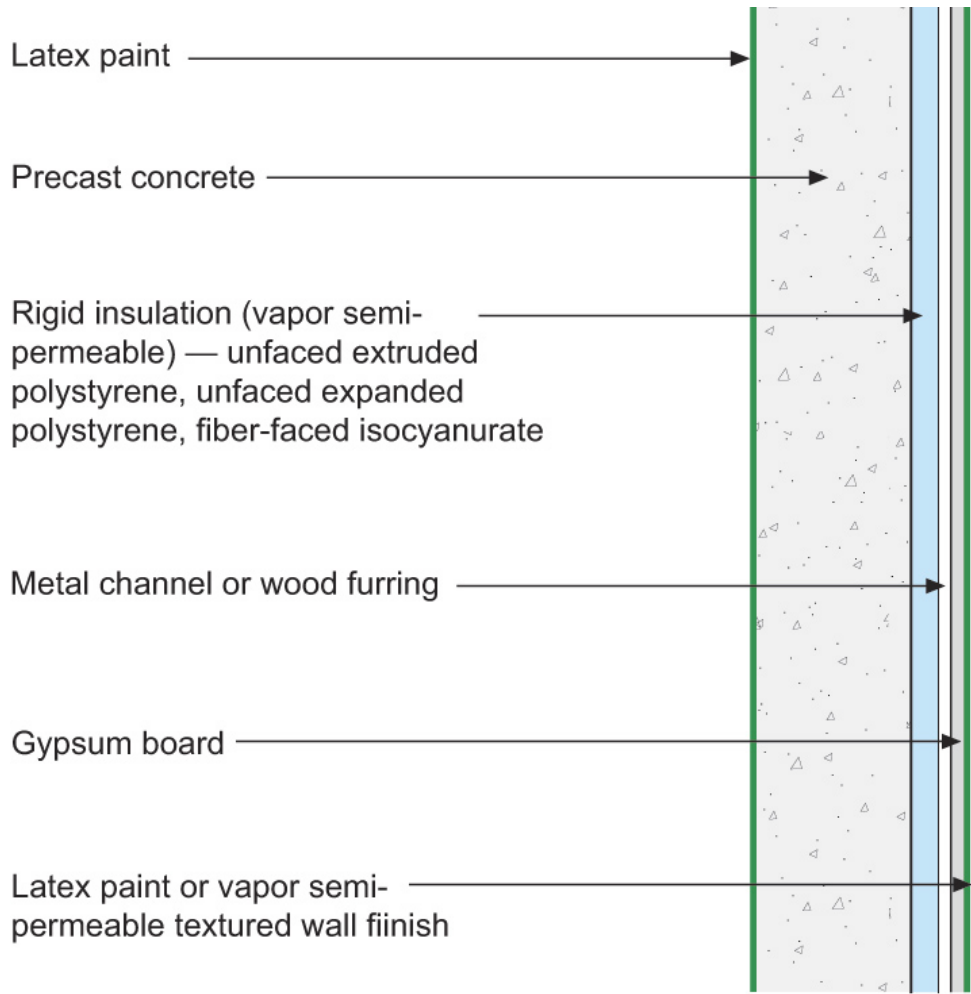
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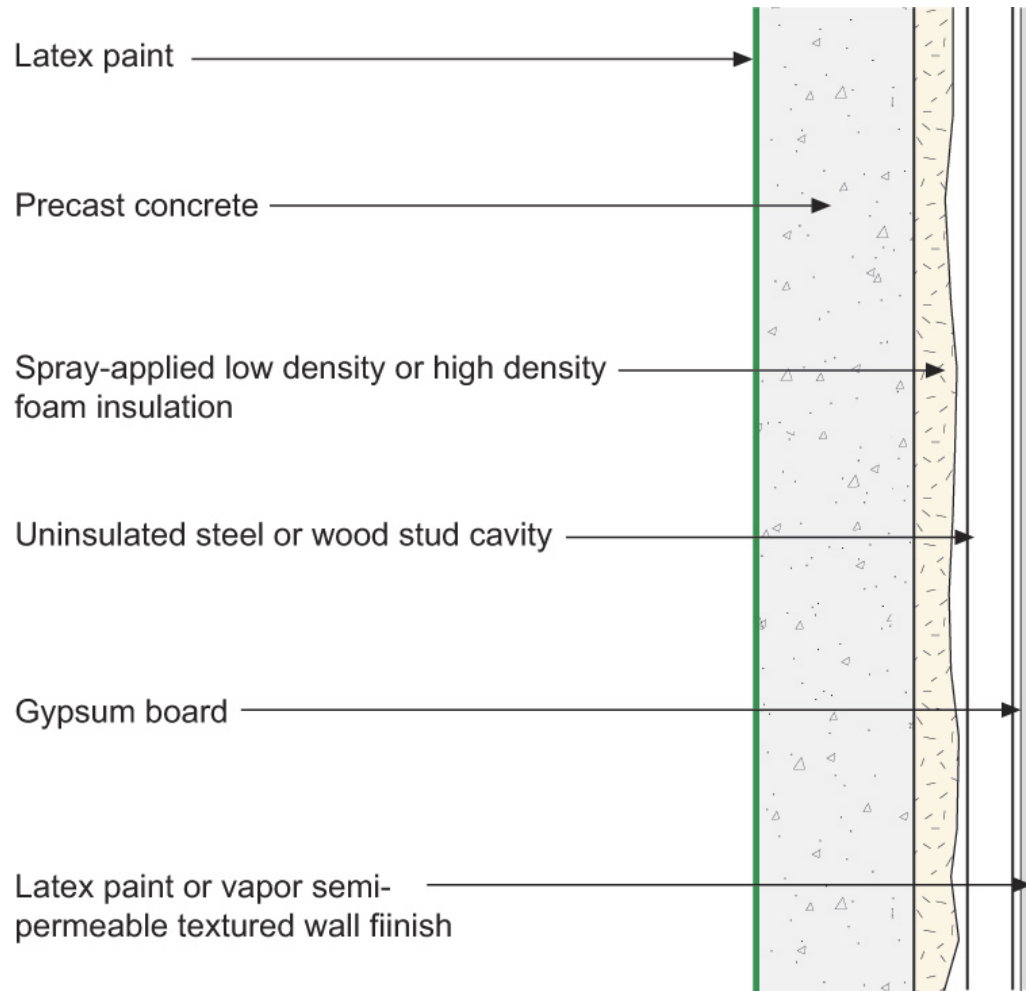




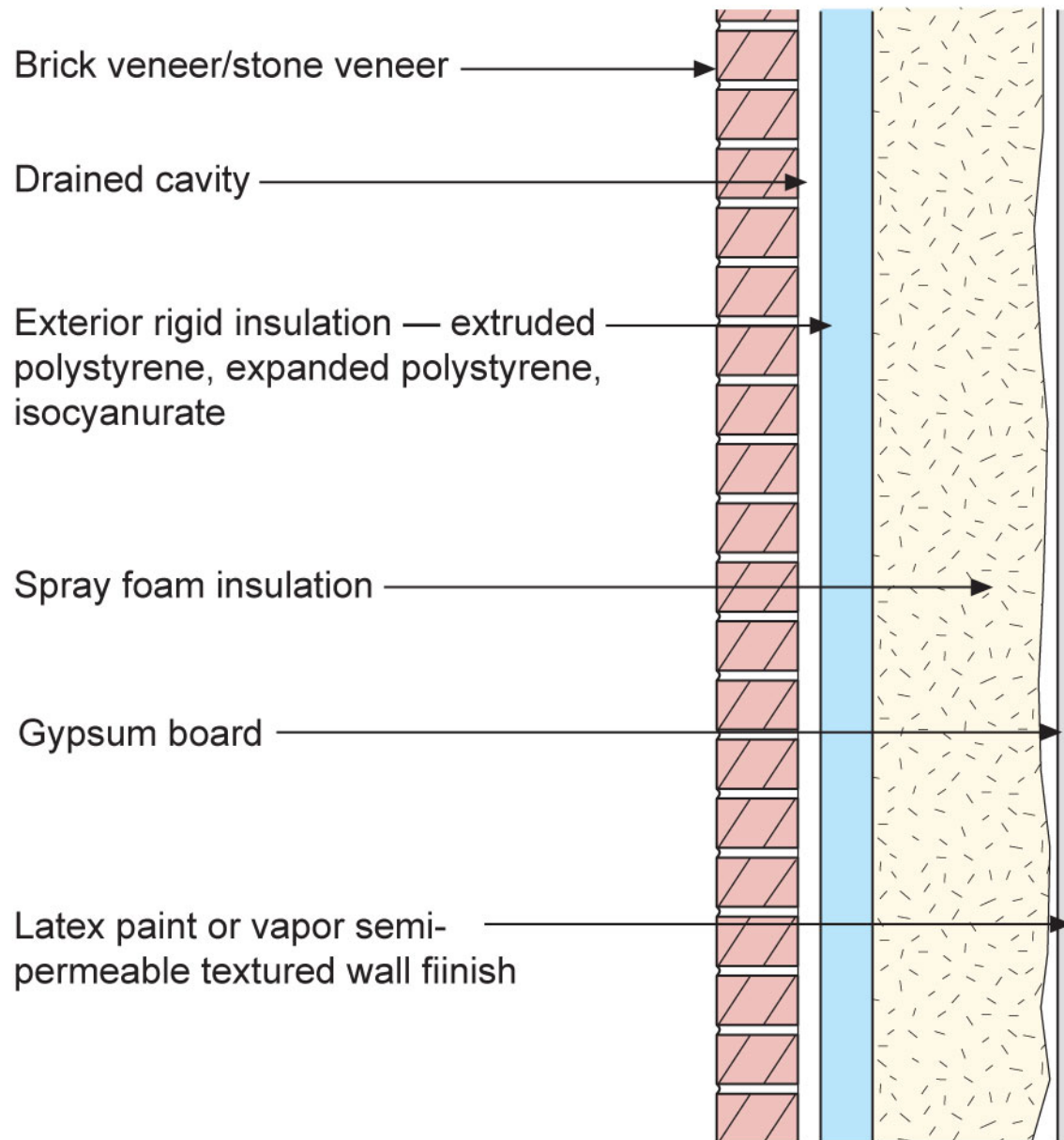
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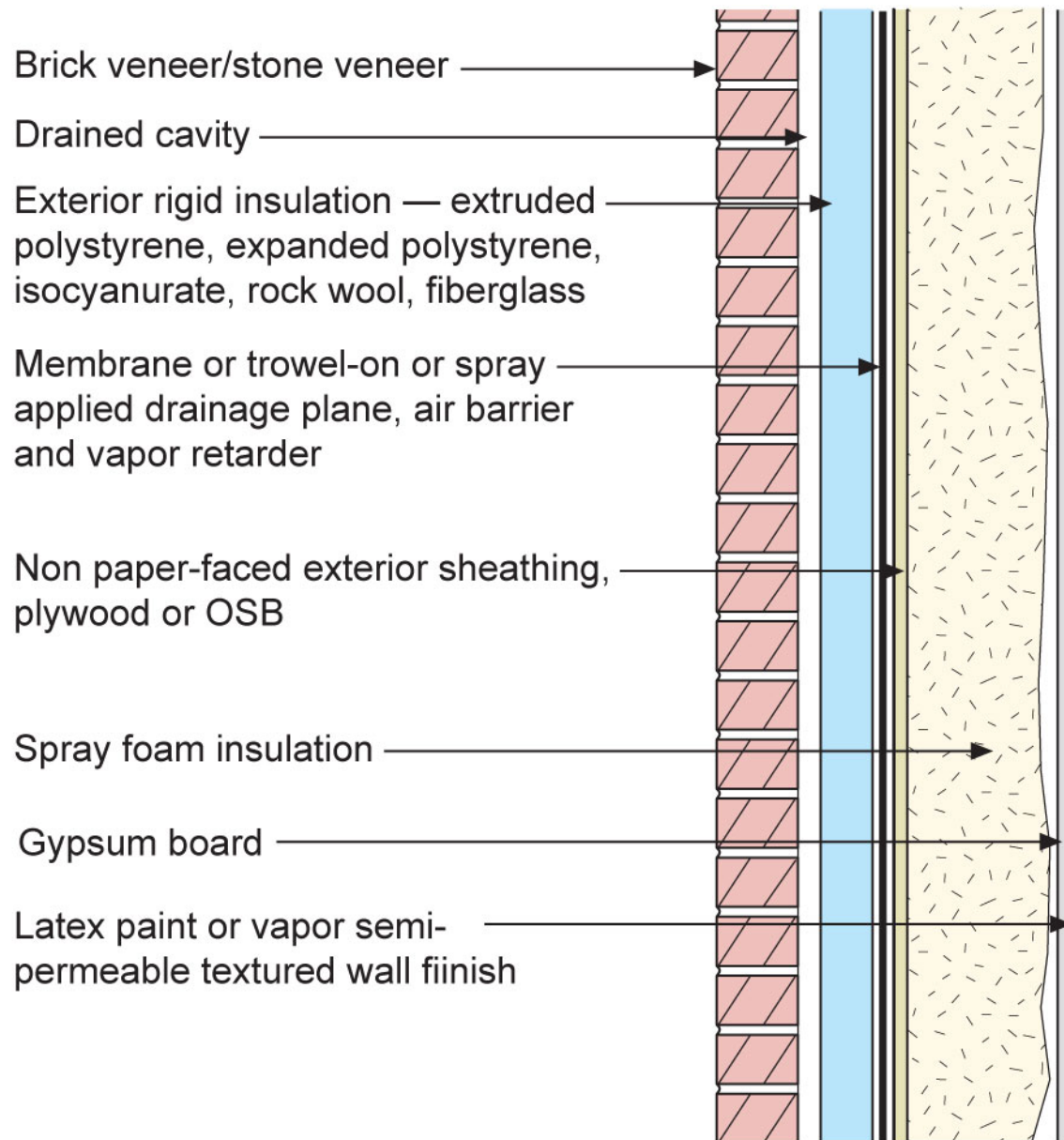


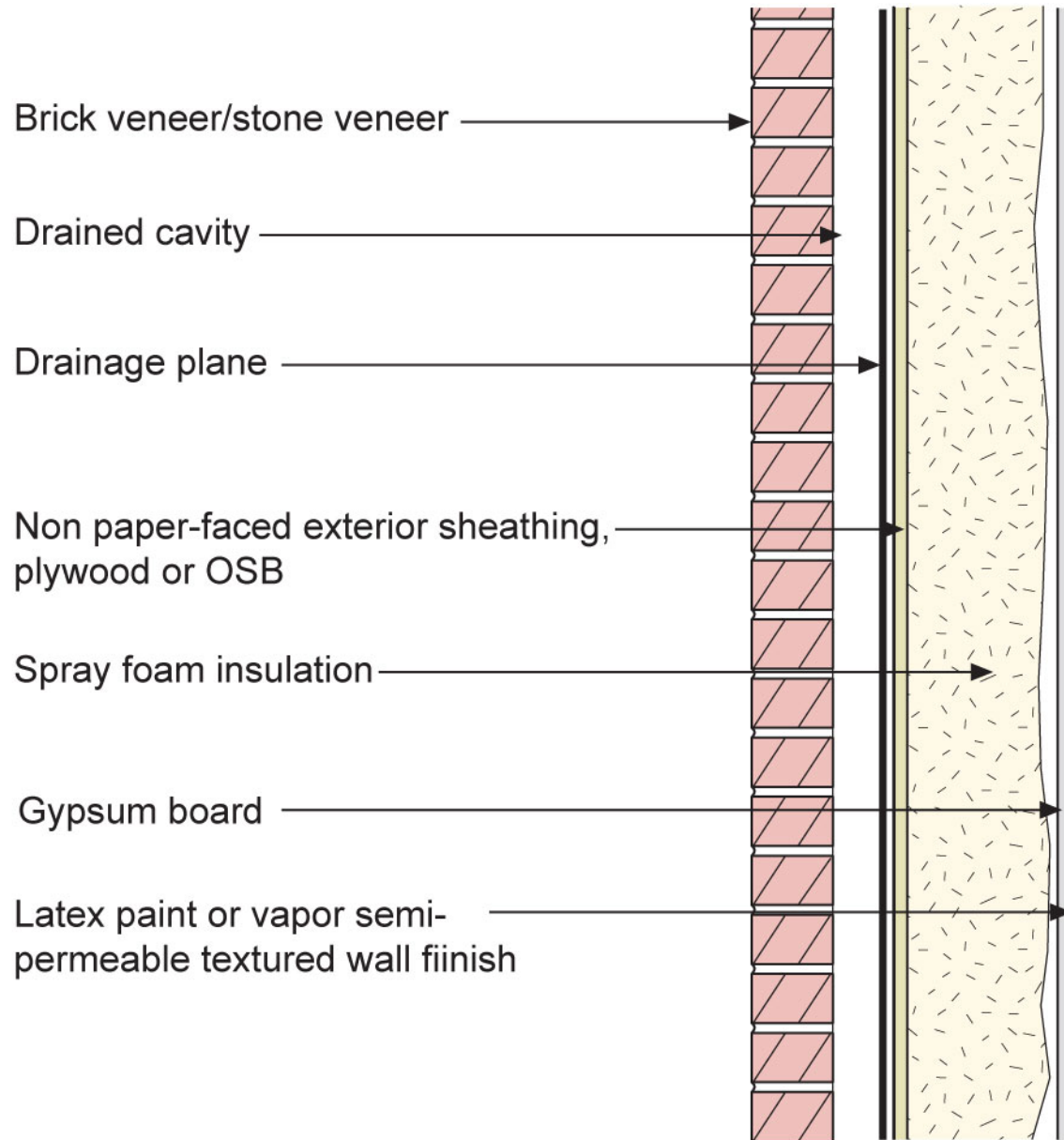


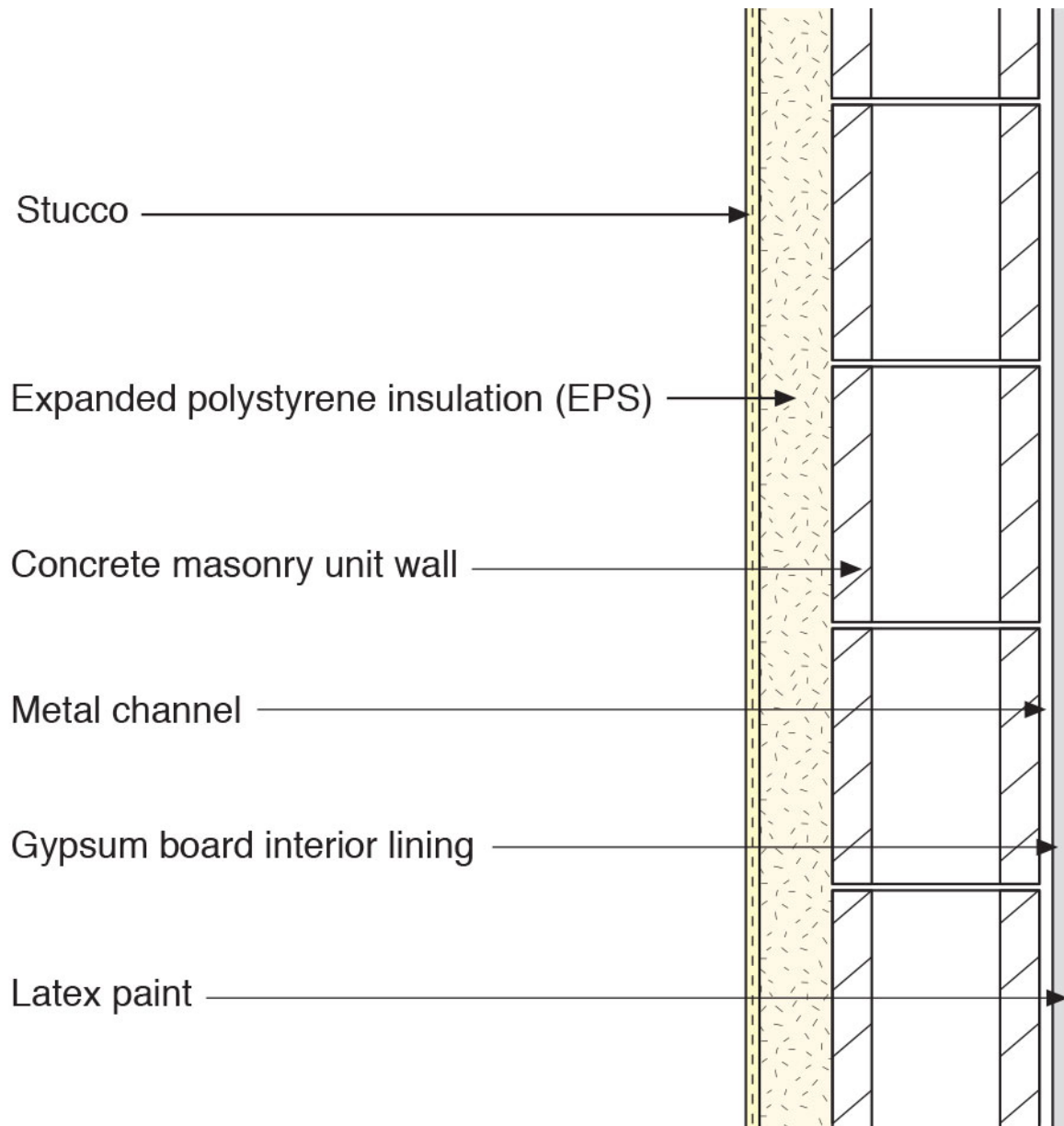


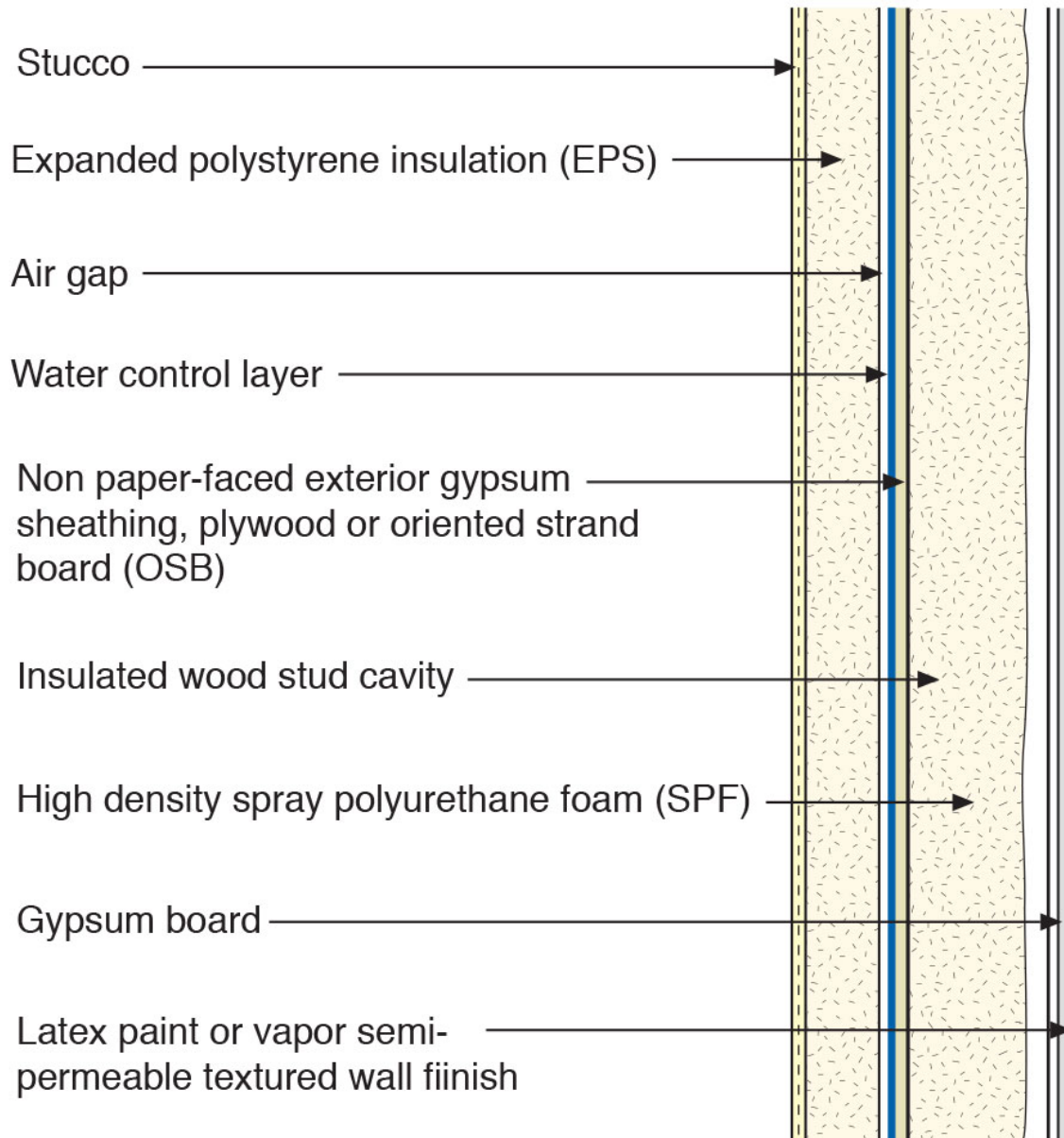
Vapor Profile

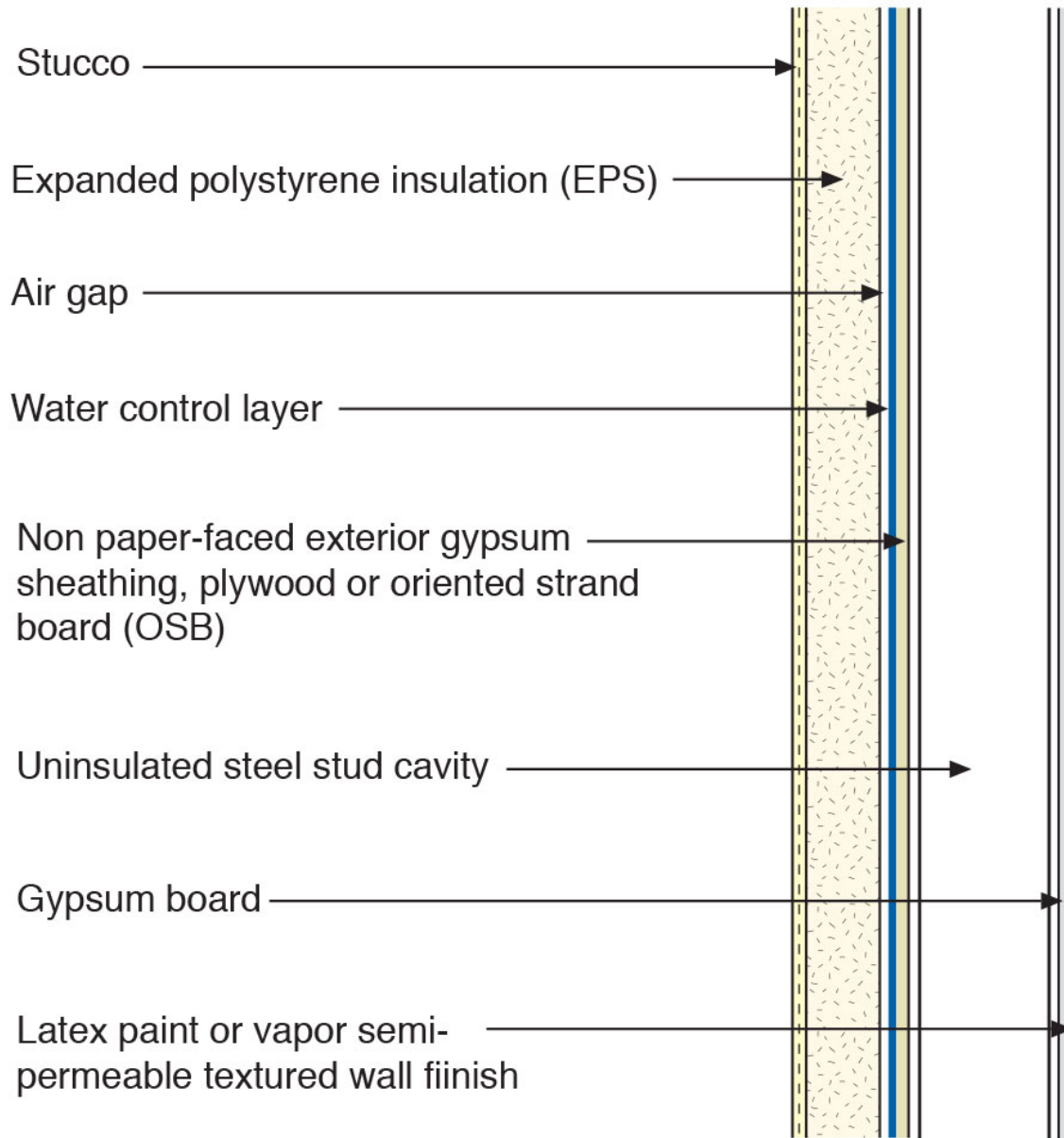


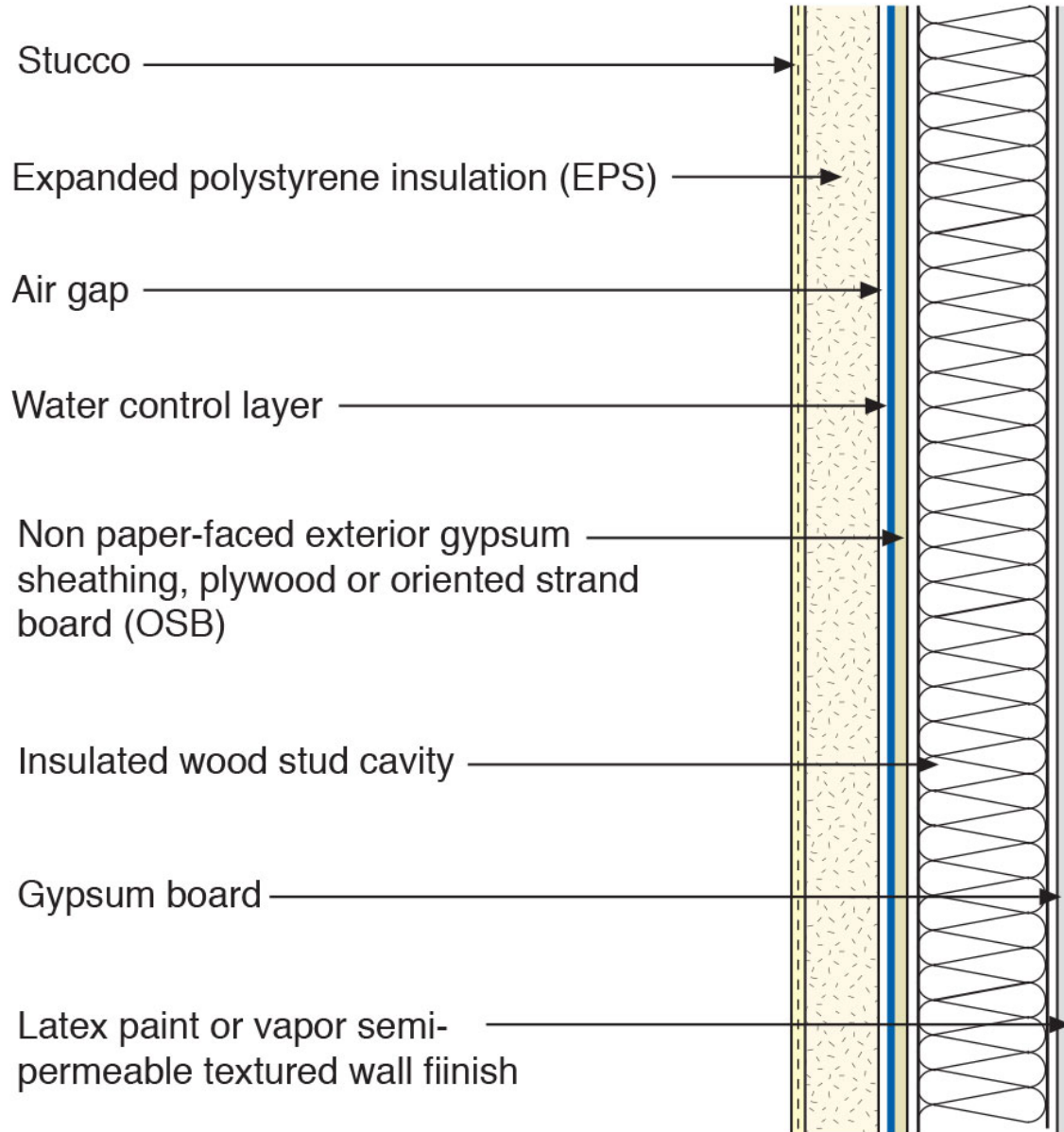


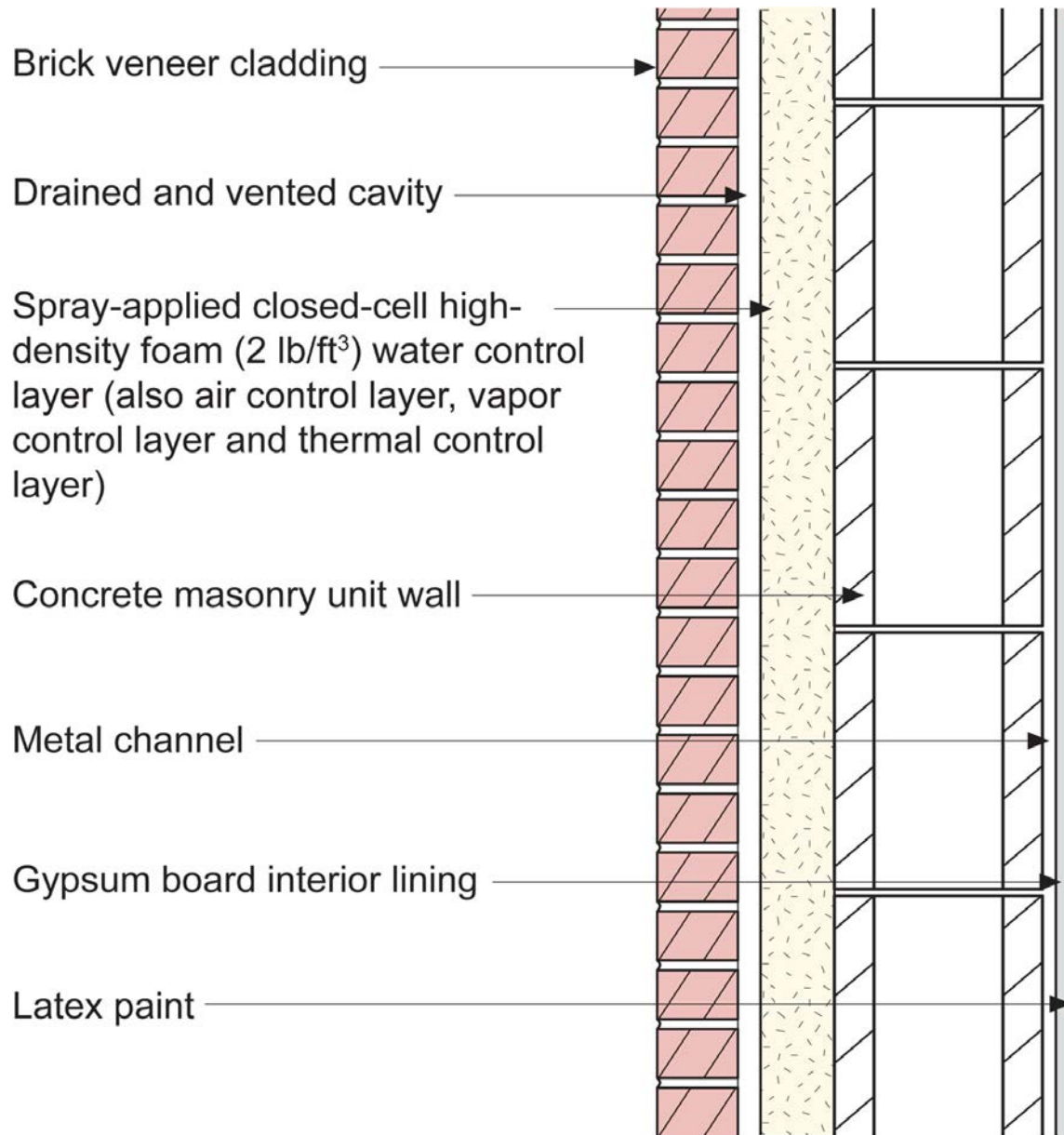


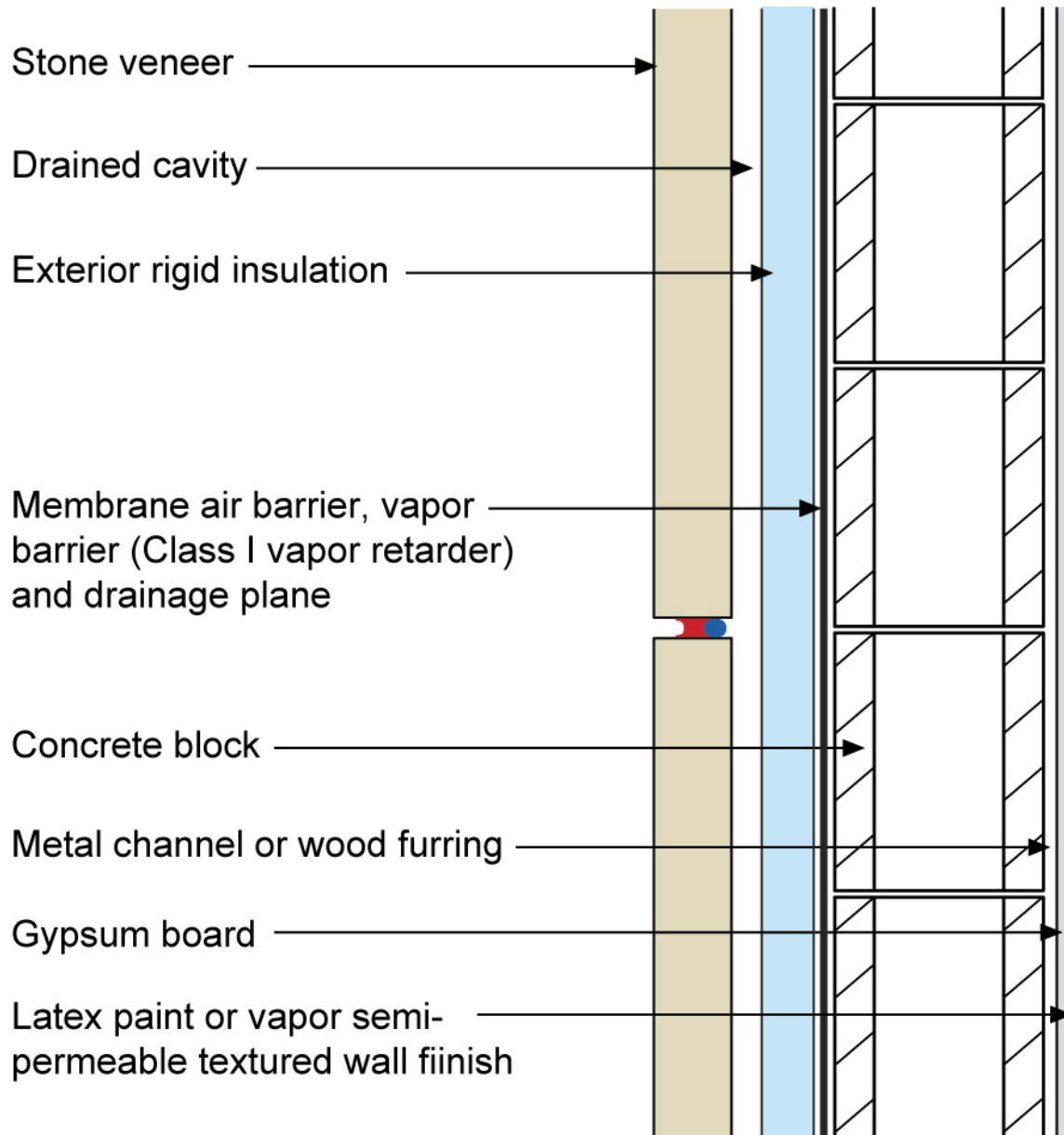


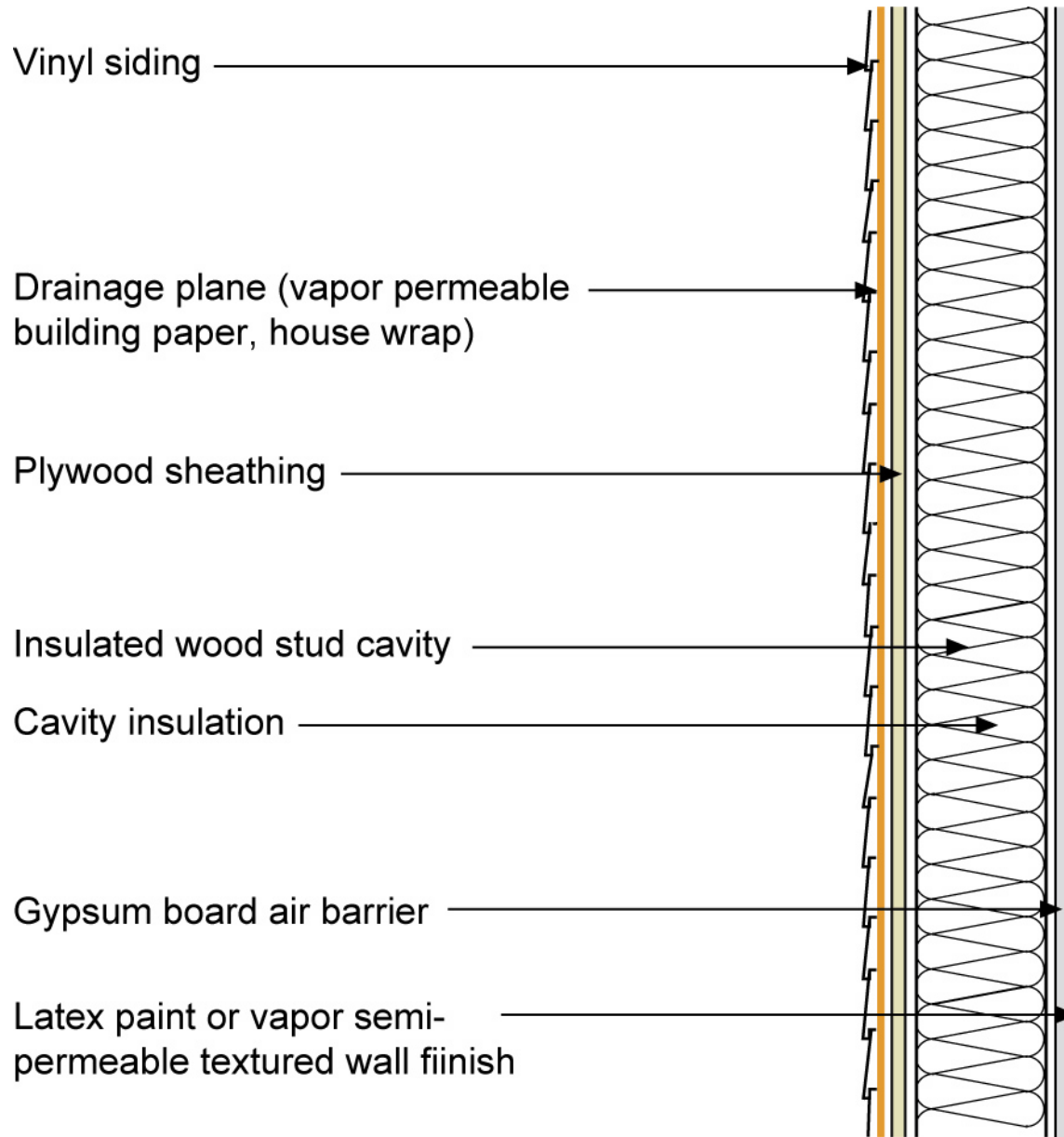


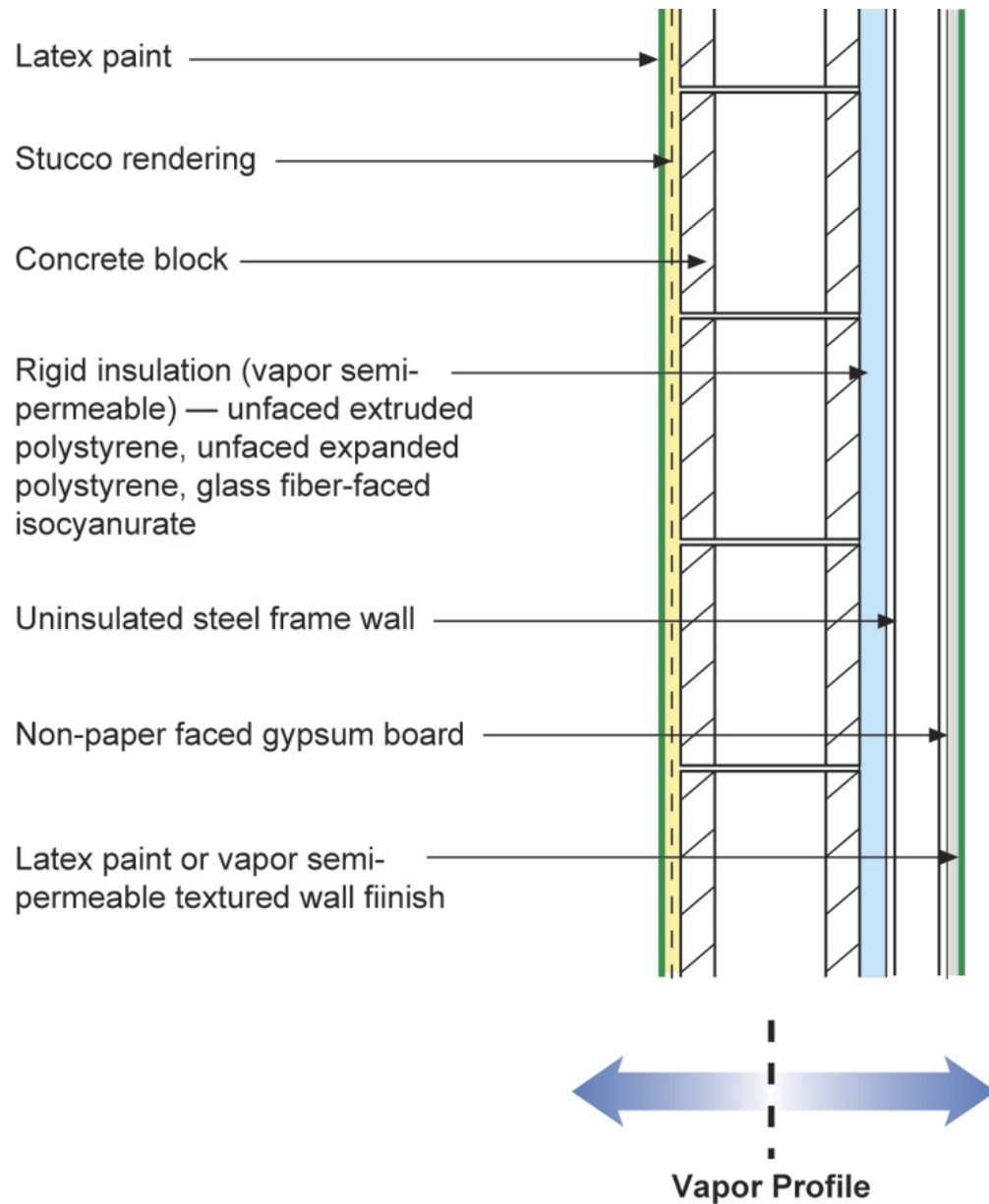


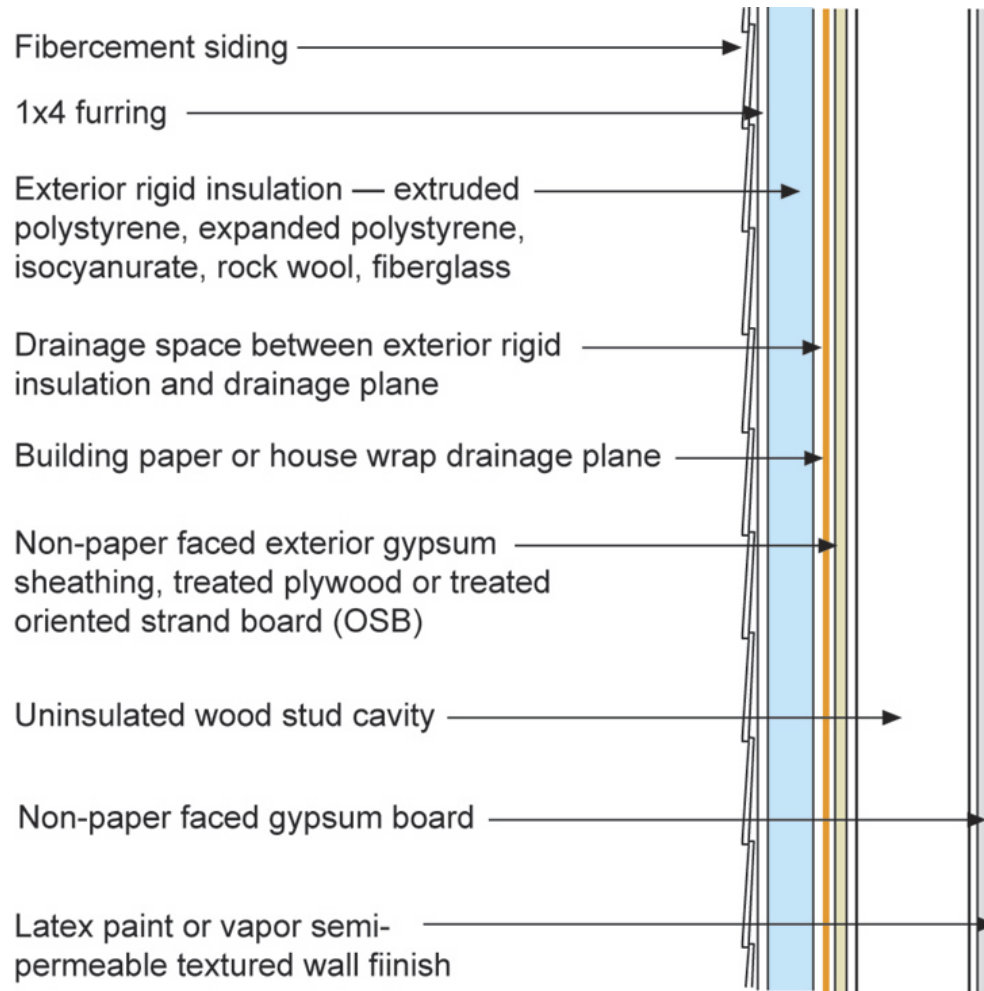




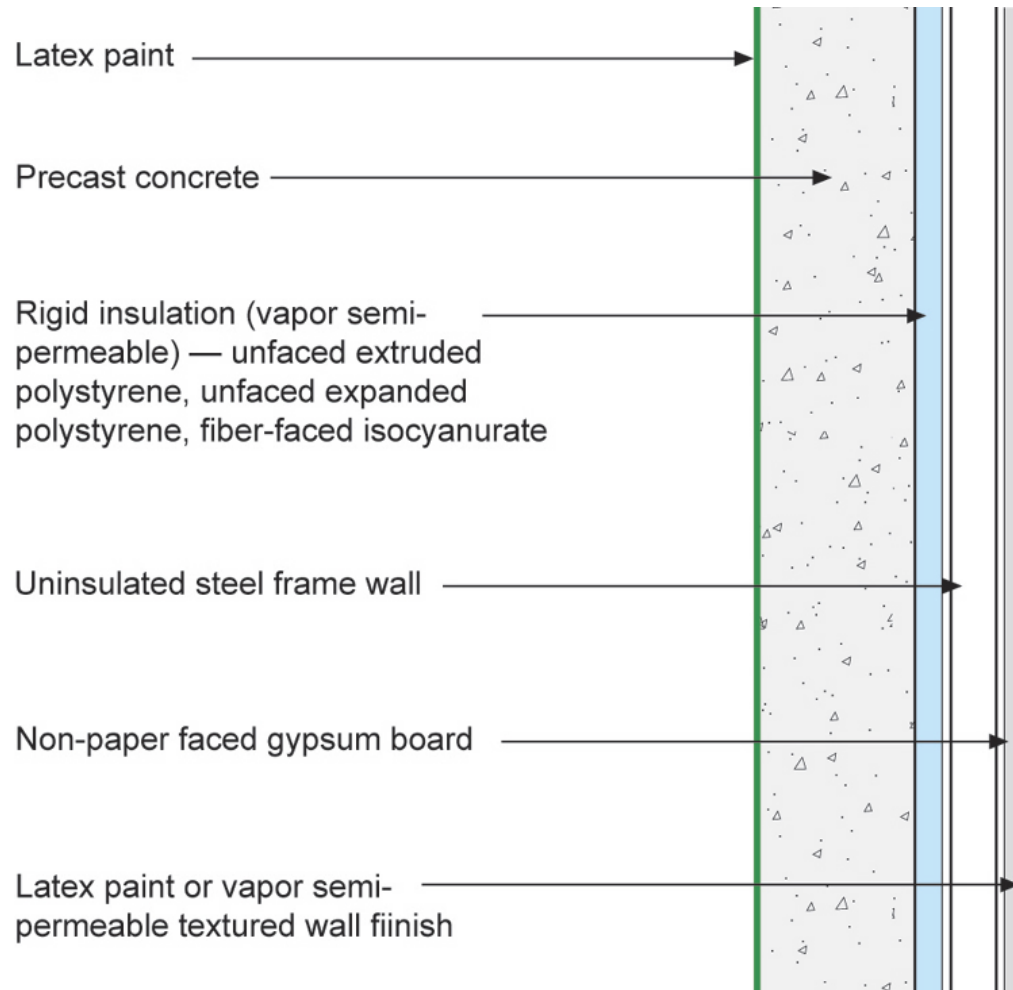




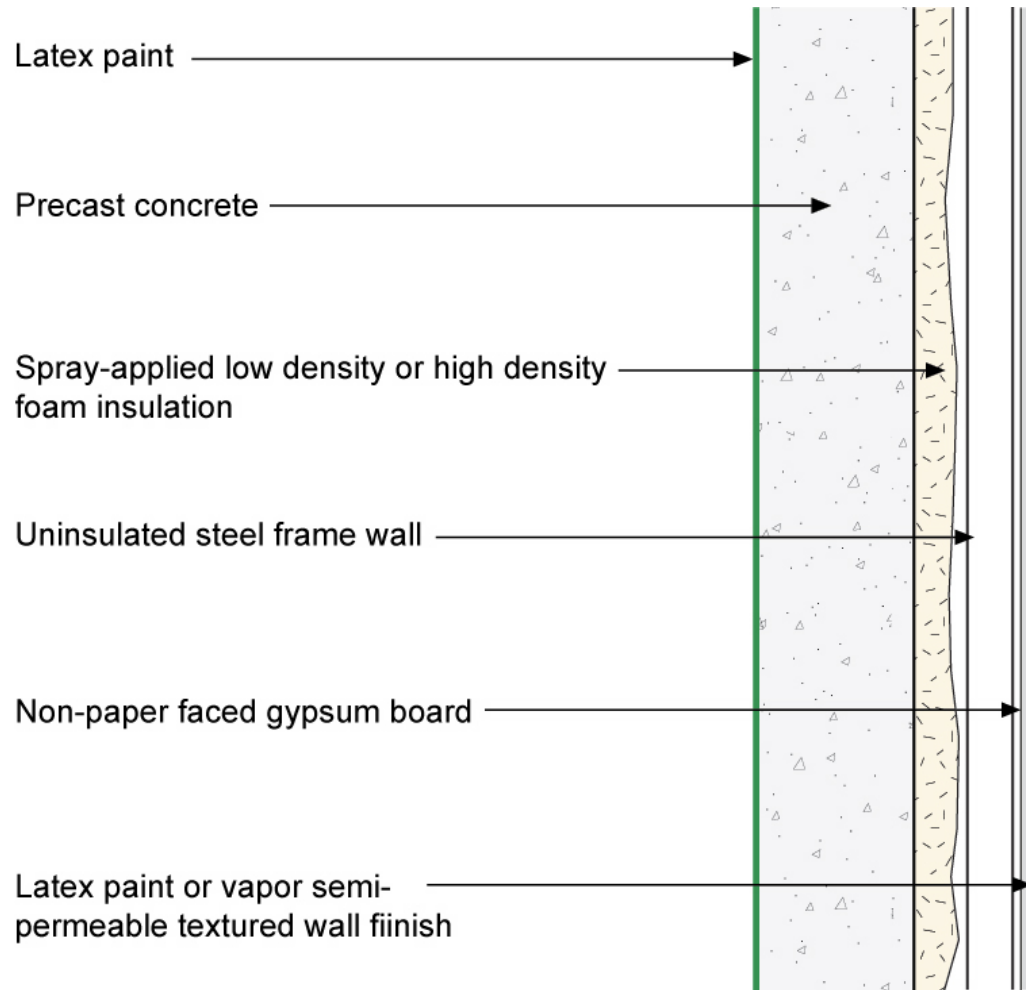




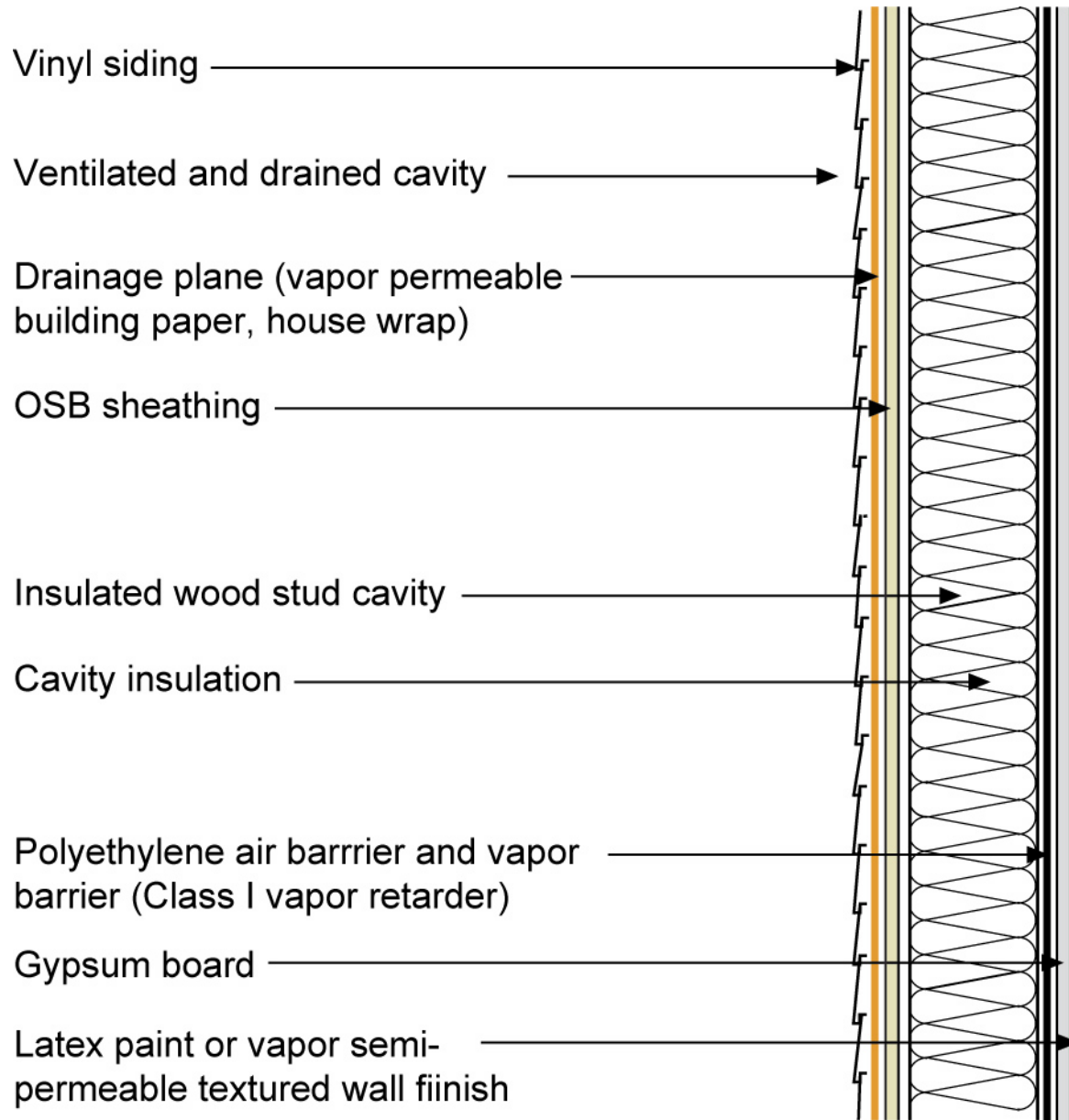
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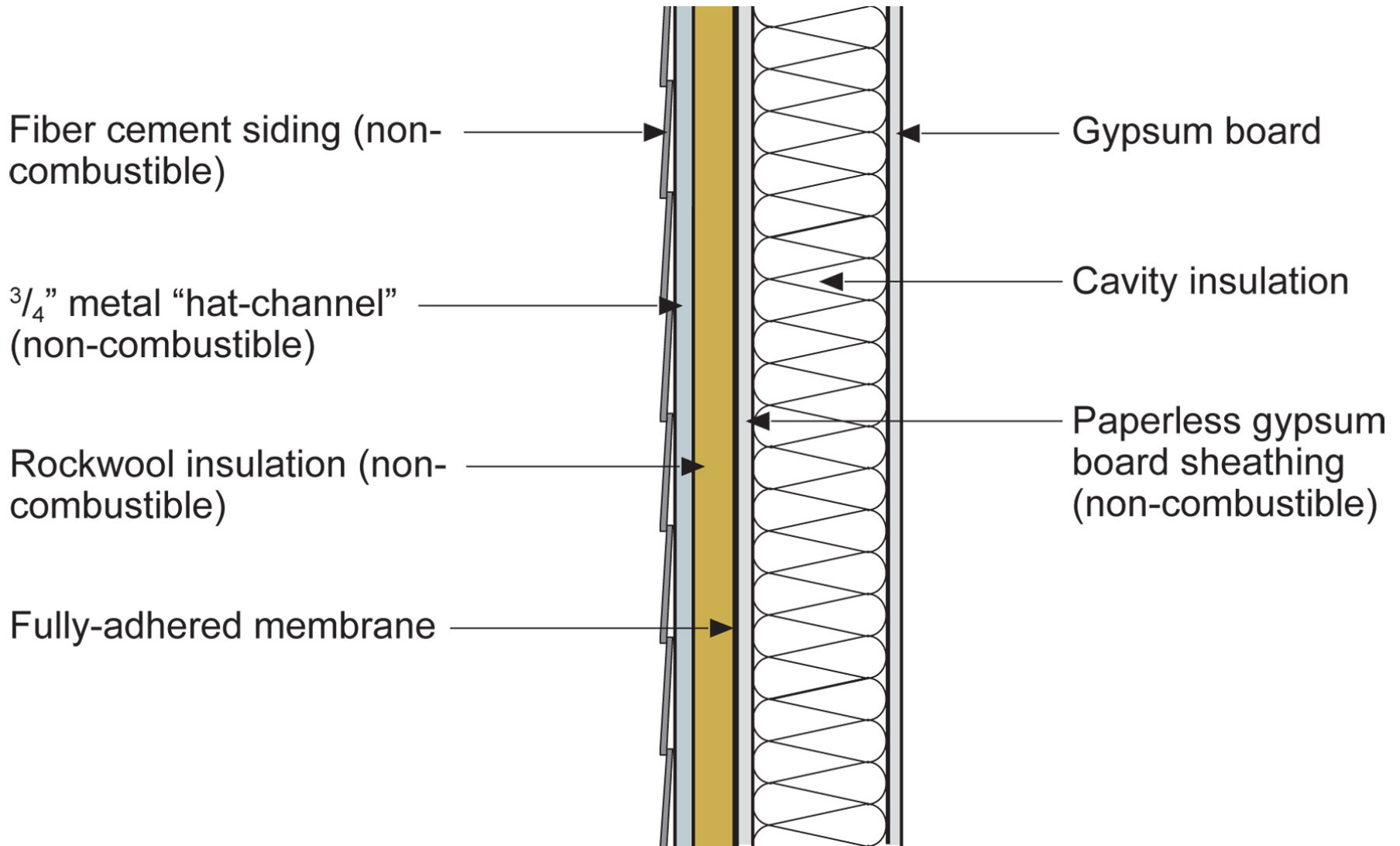


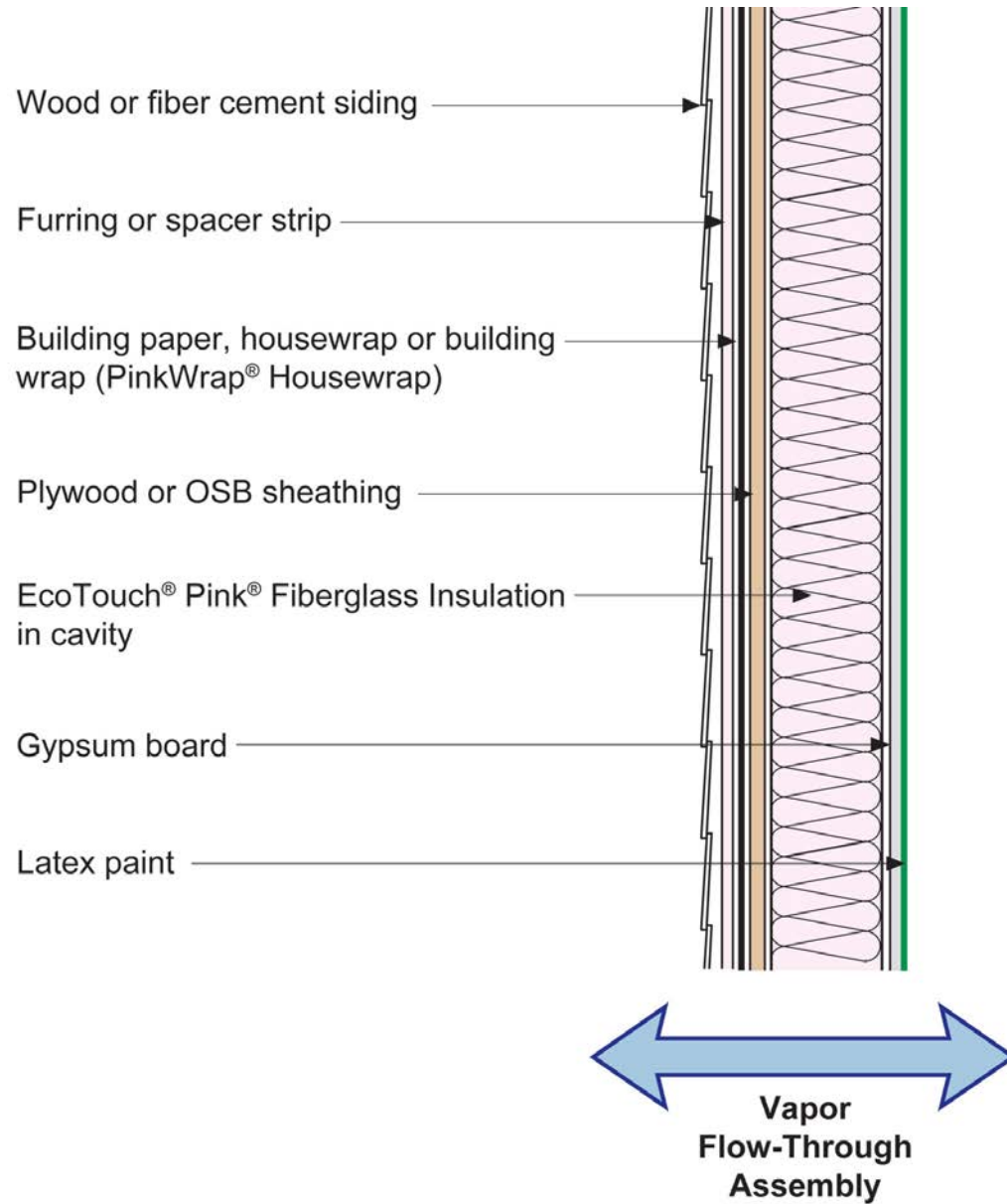
Vapor Profile

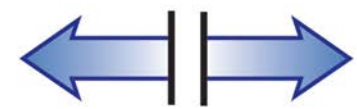
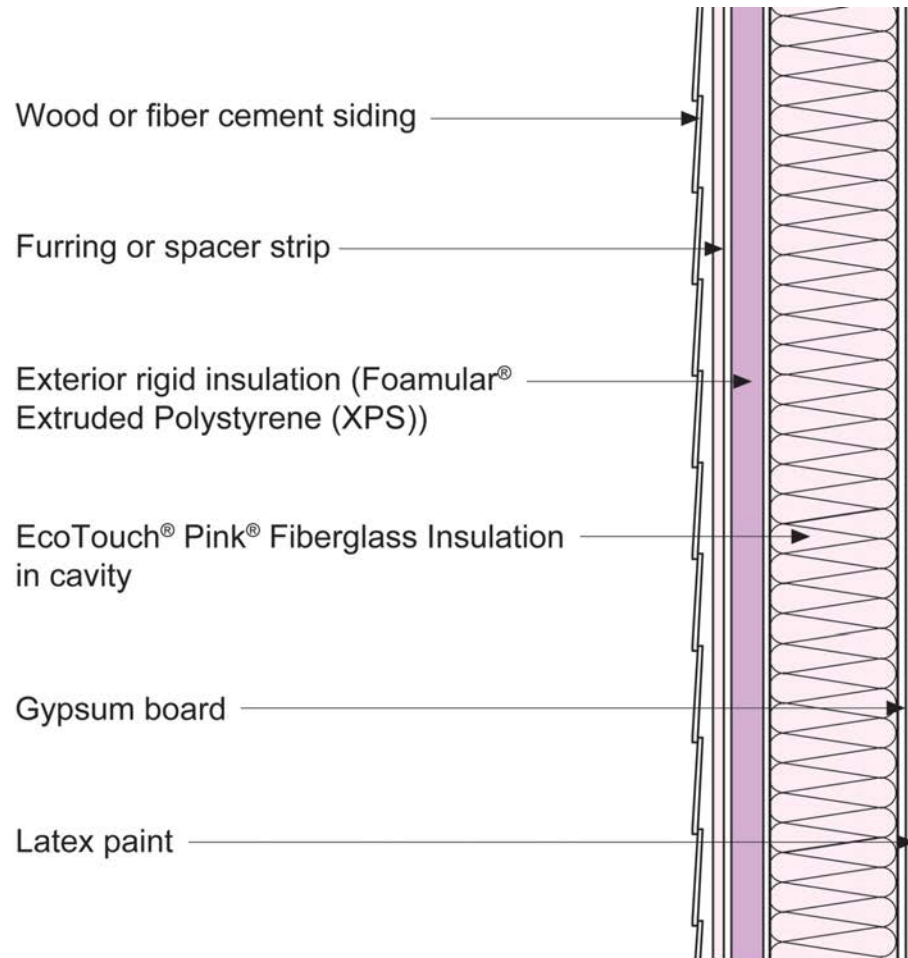


Vapor Profile

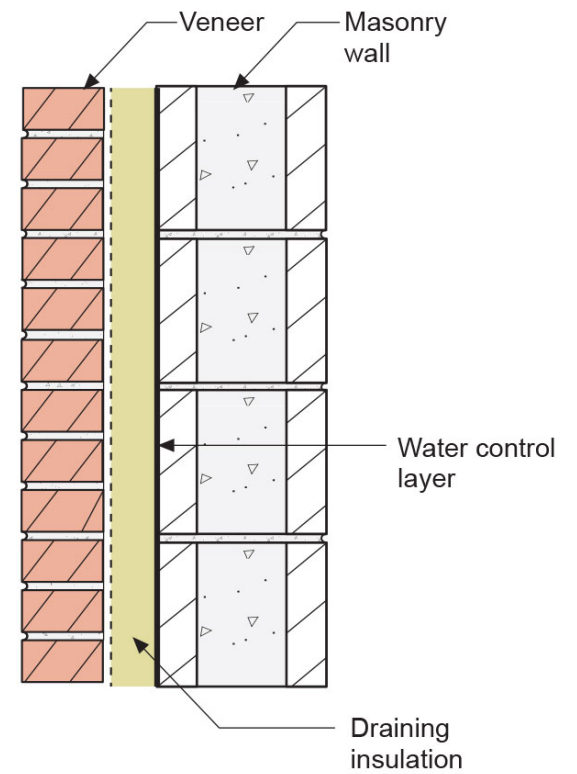
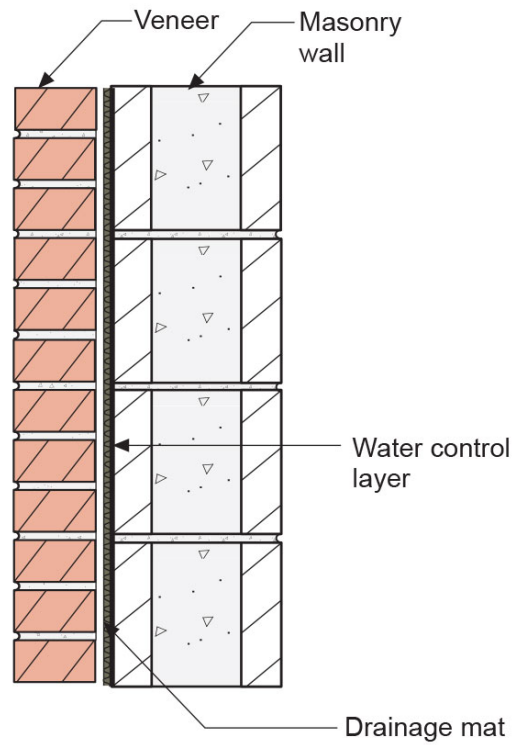
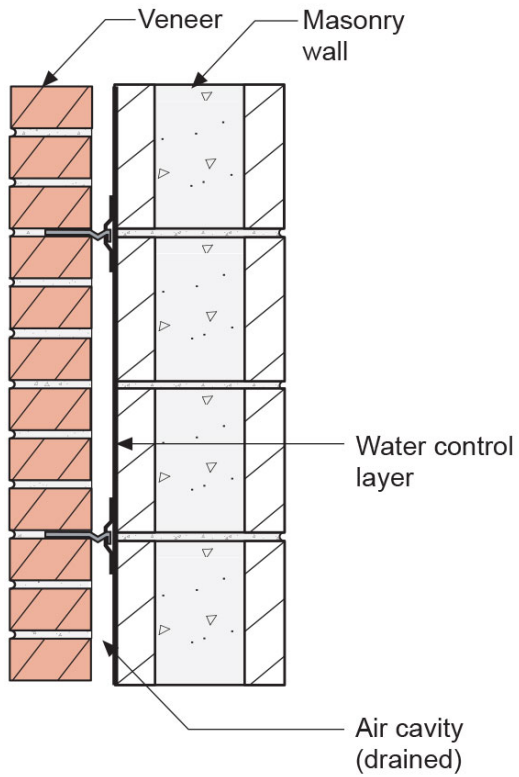


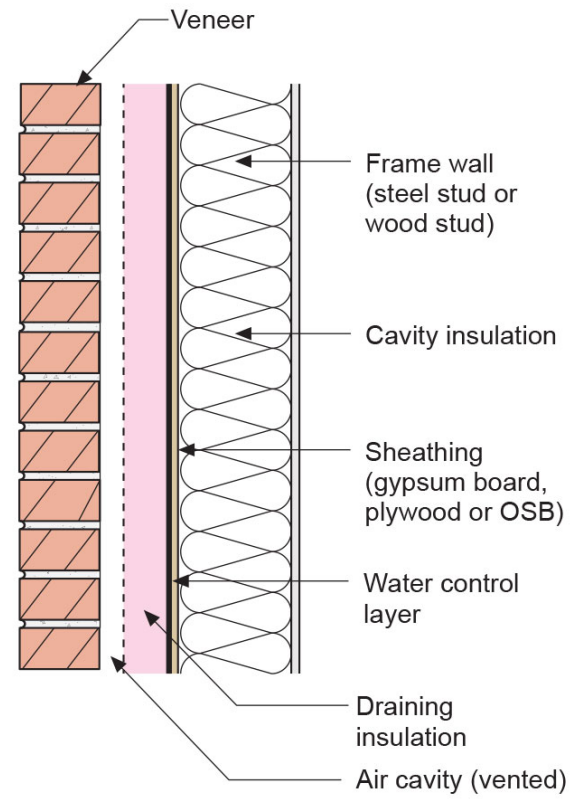
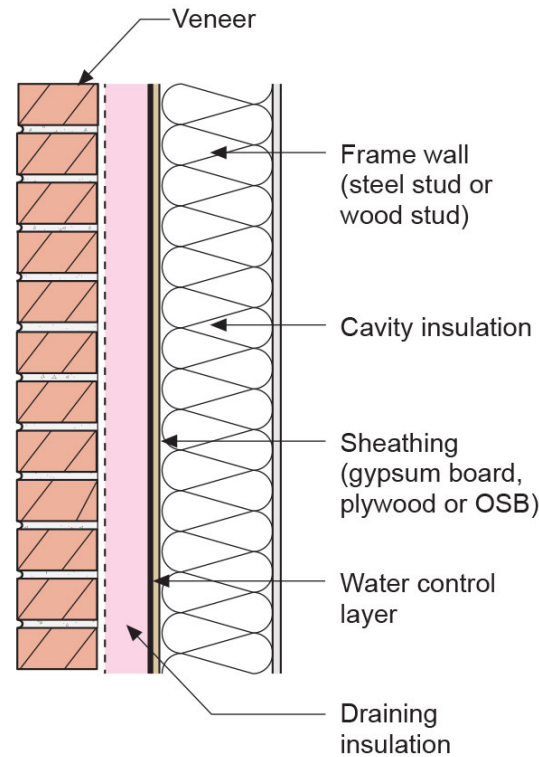
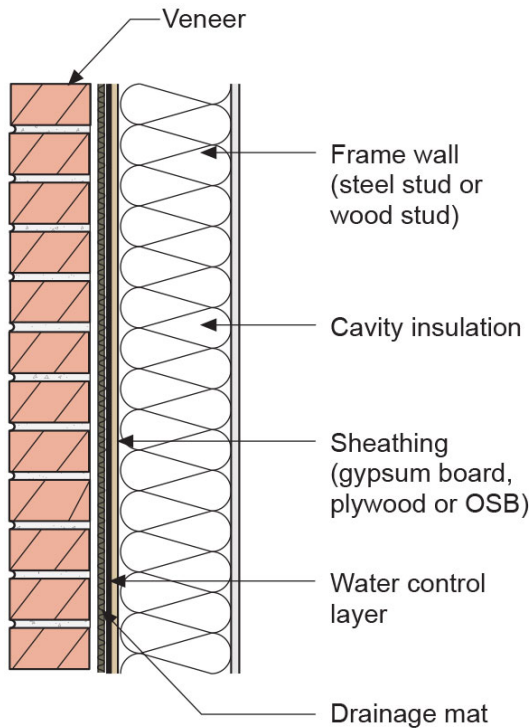


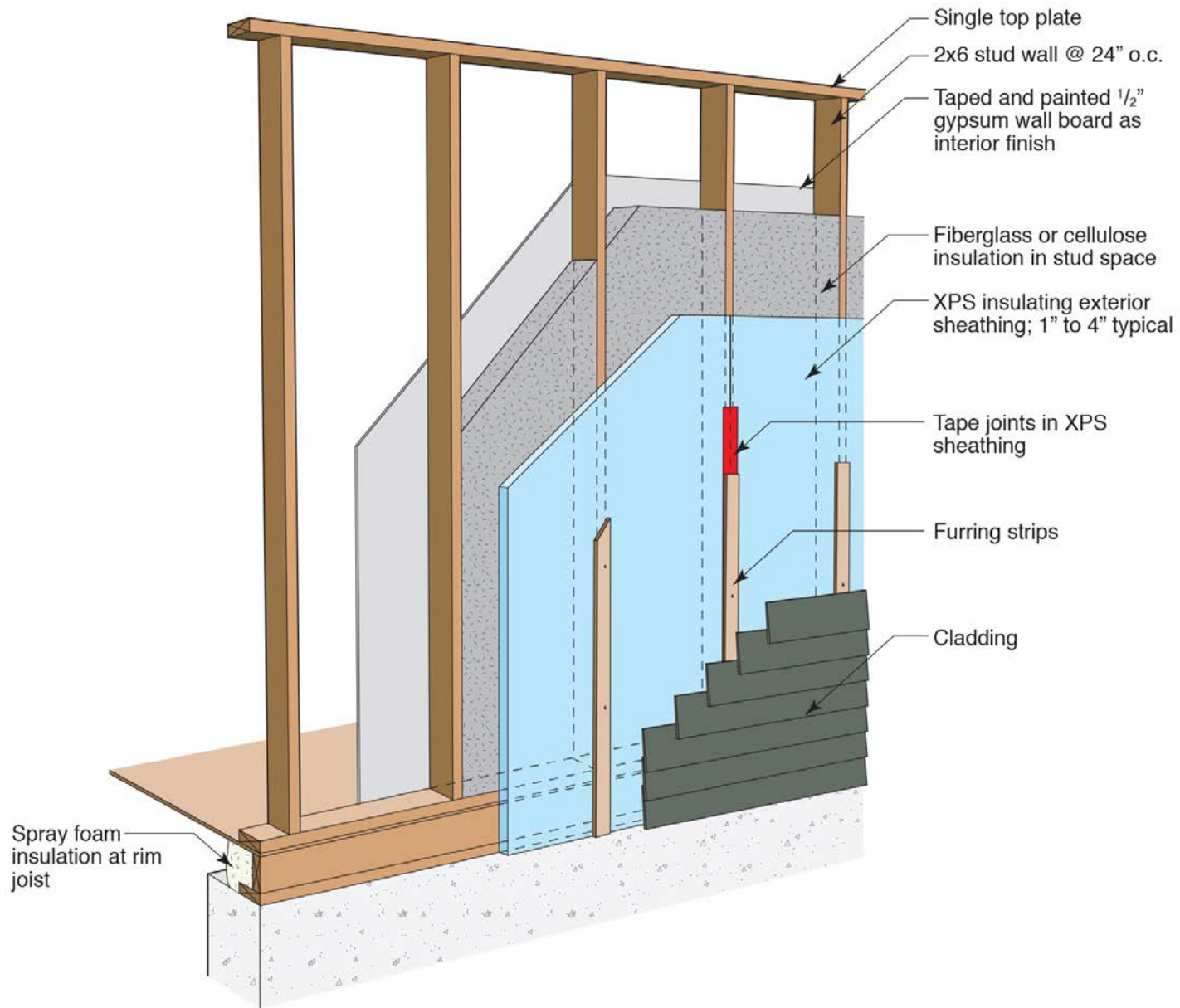


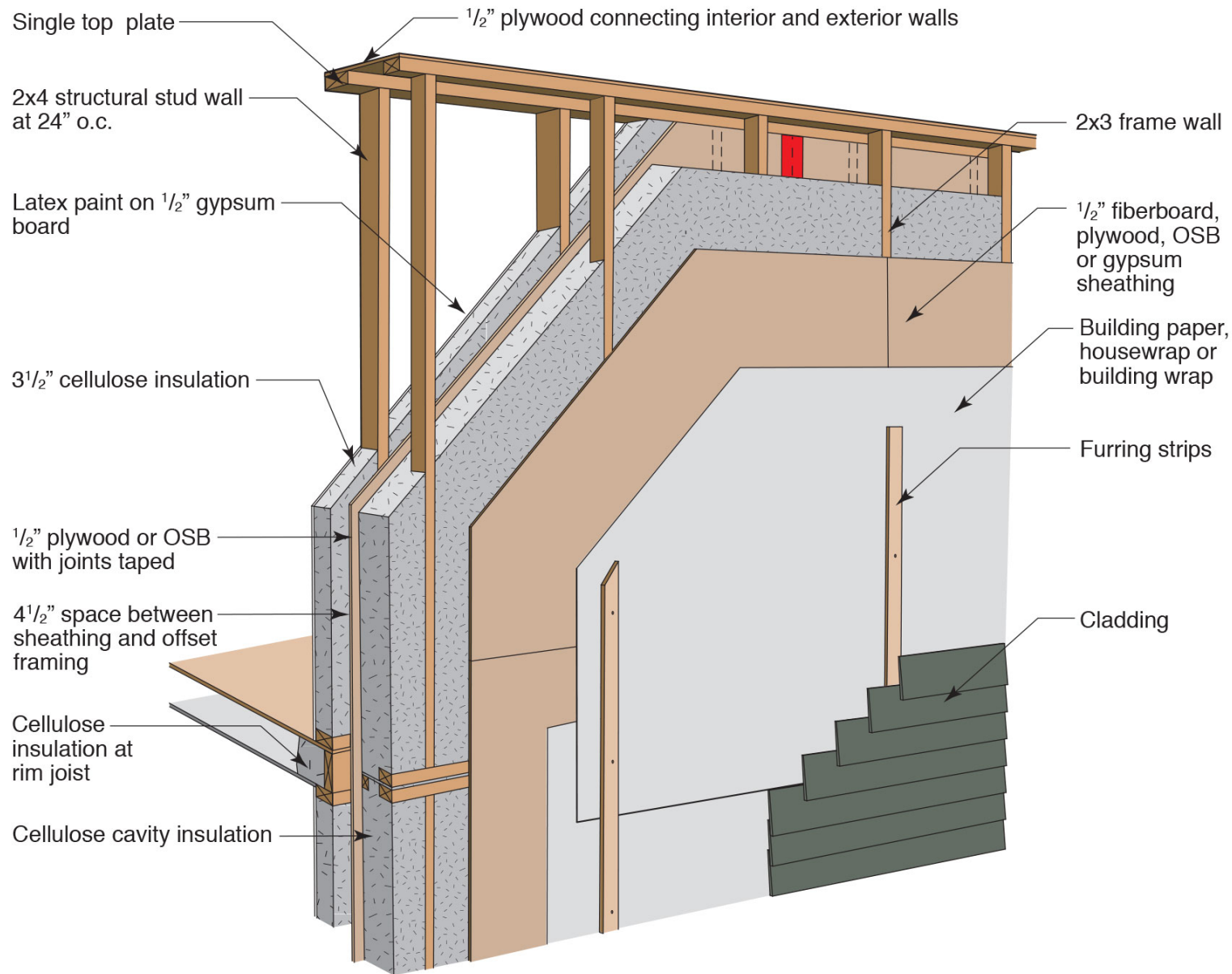


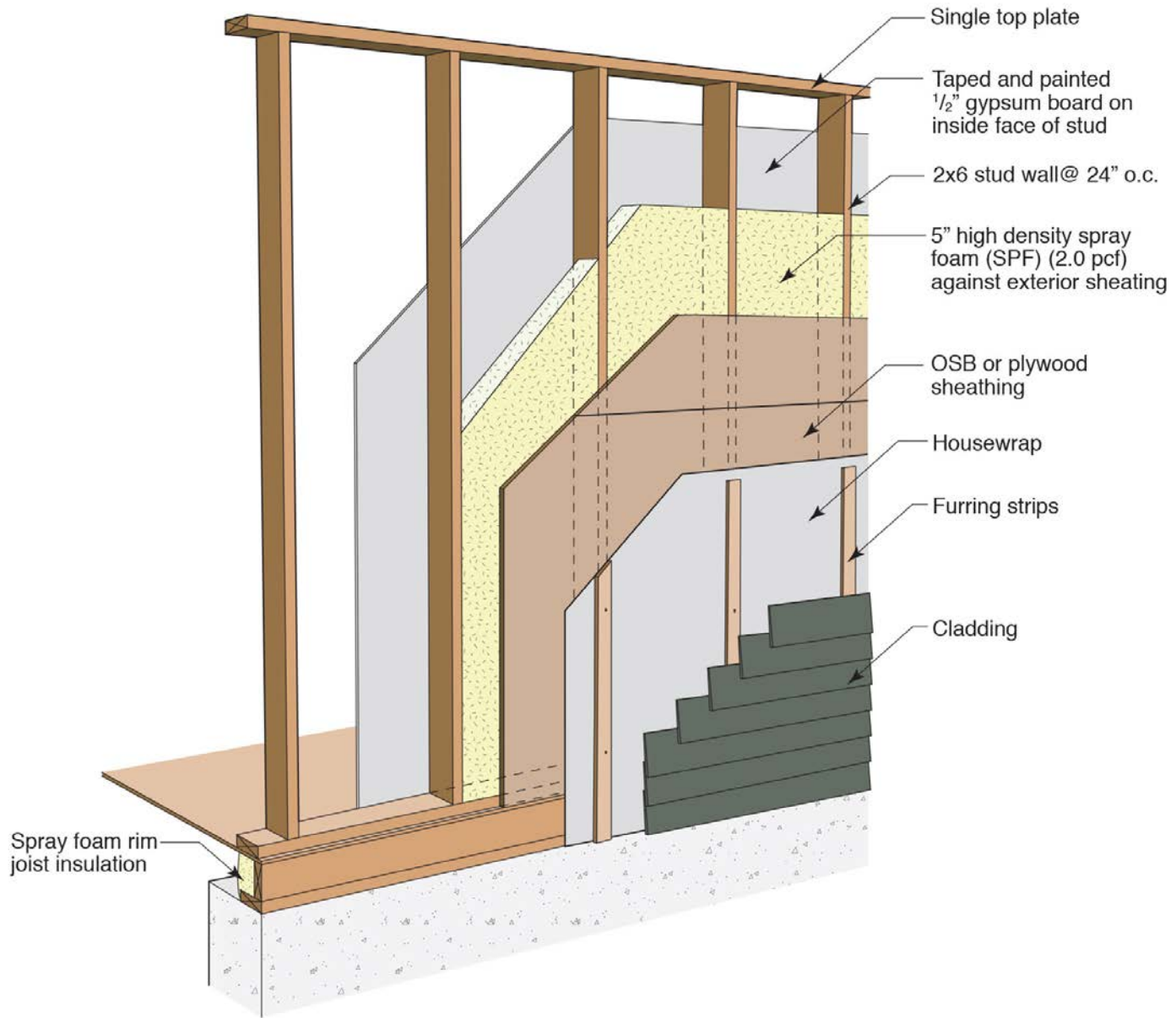
**Control of Condensing
Surface Temperature
Assembly**

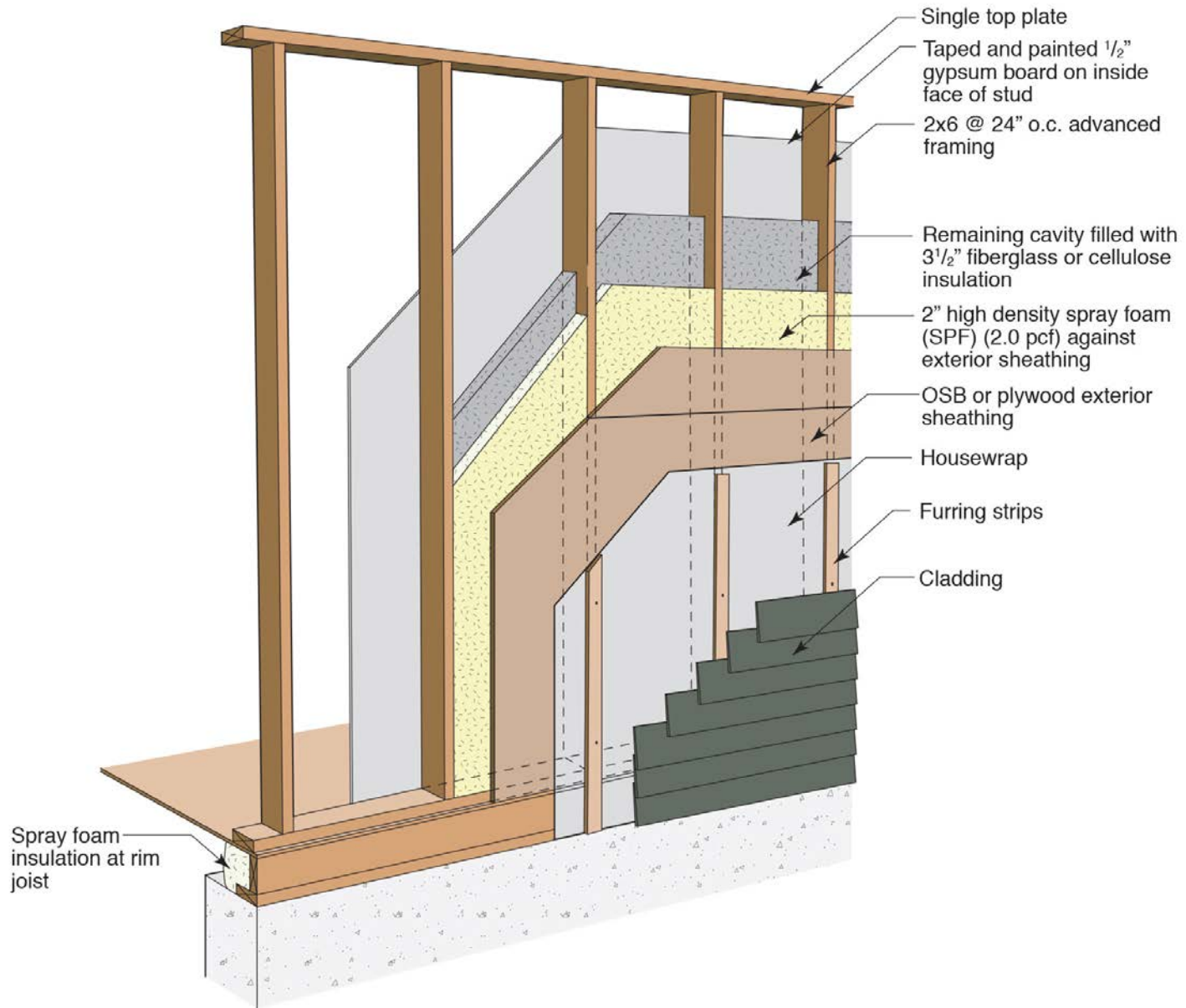


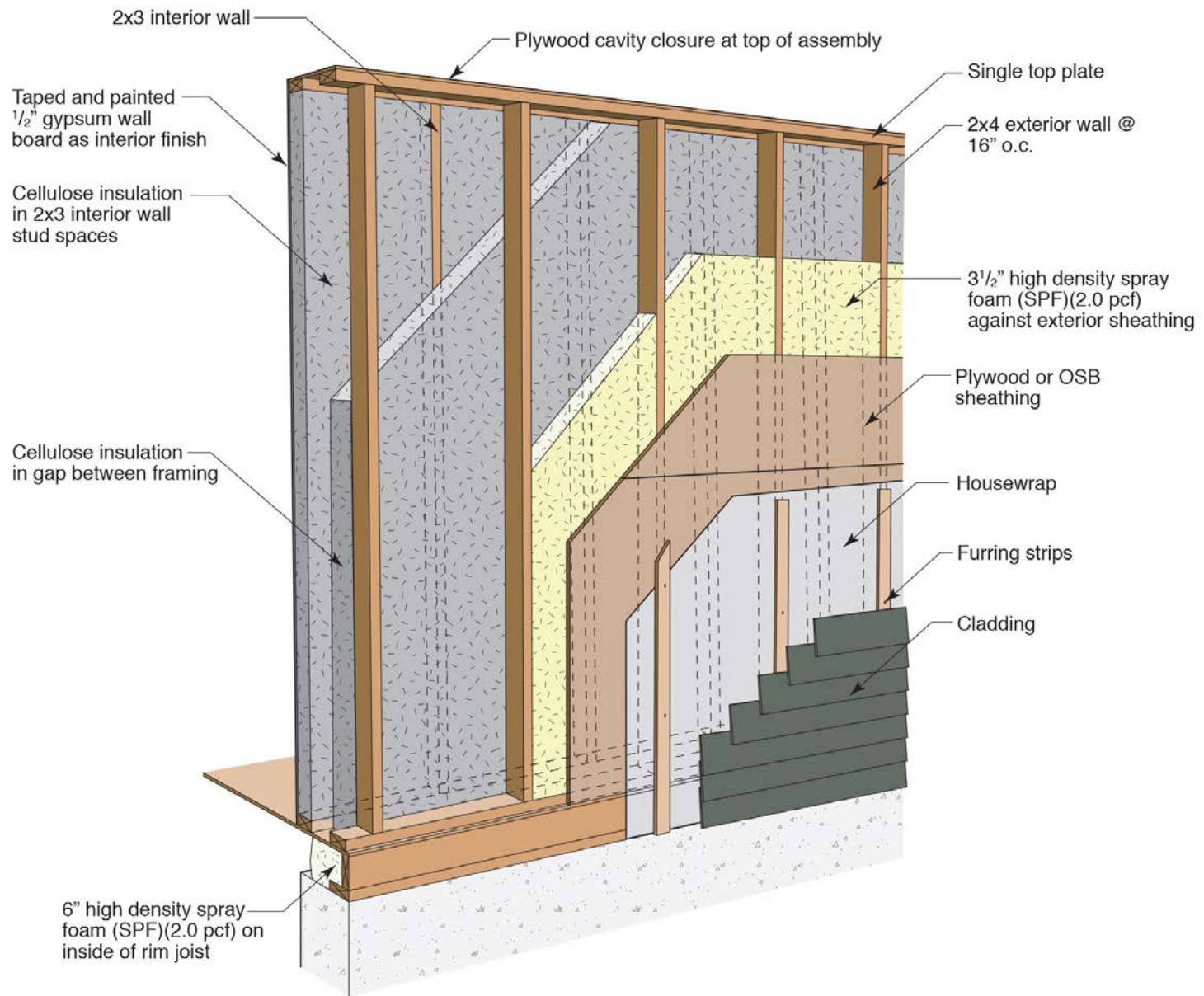


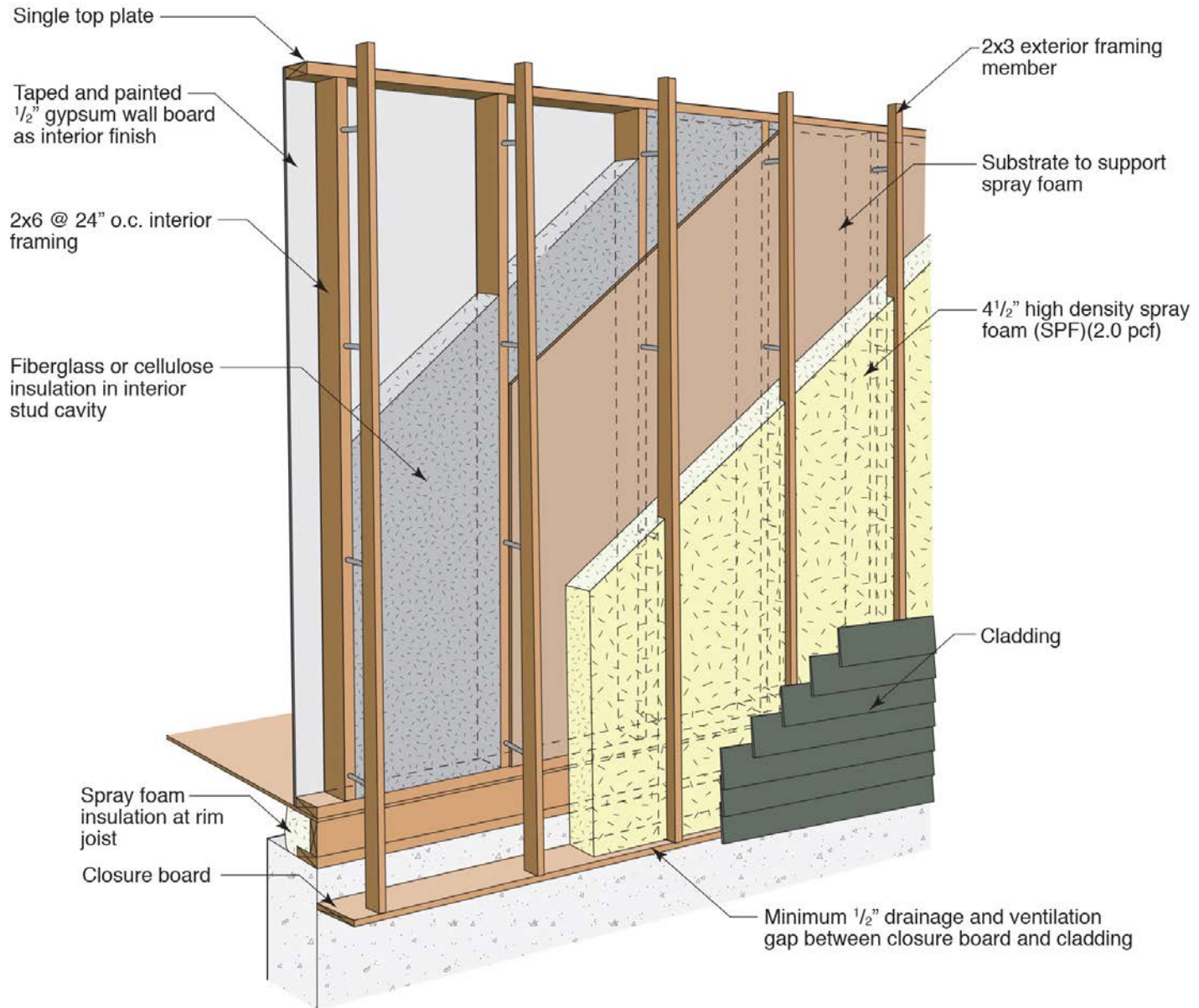


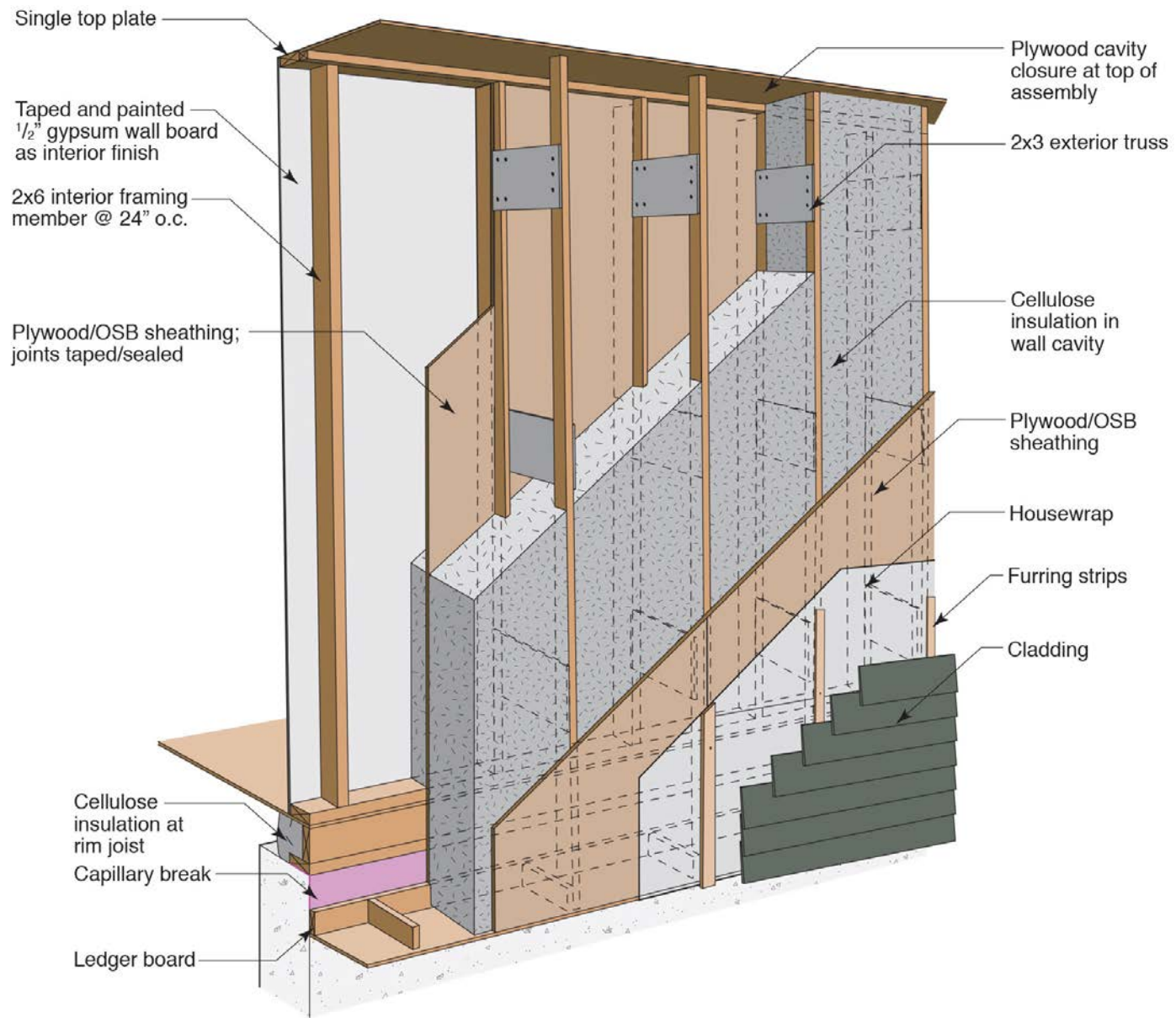


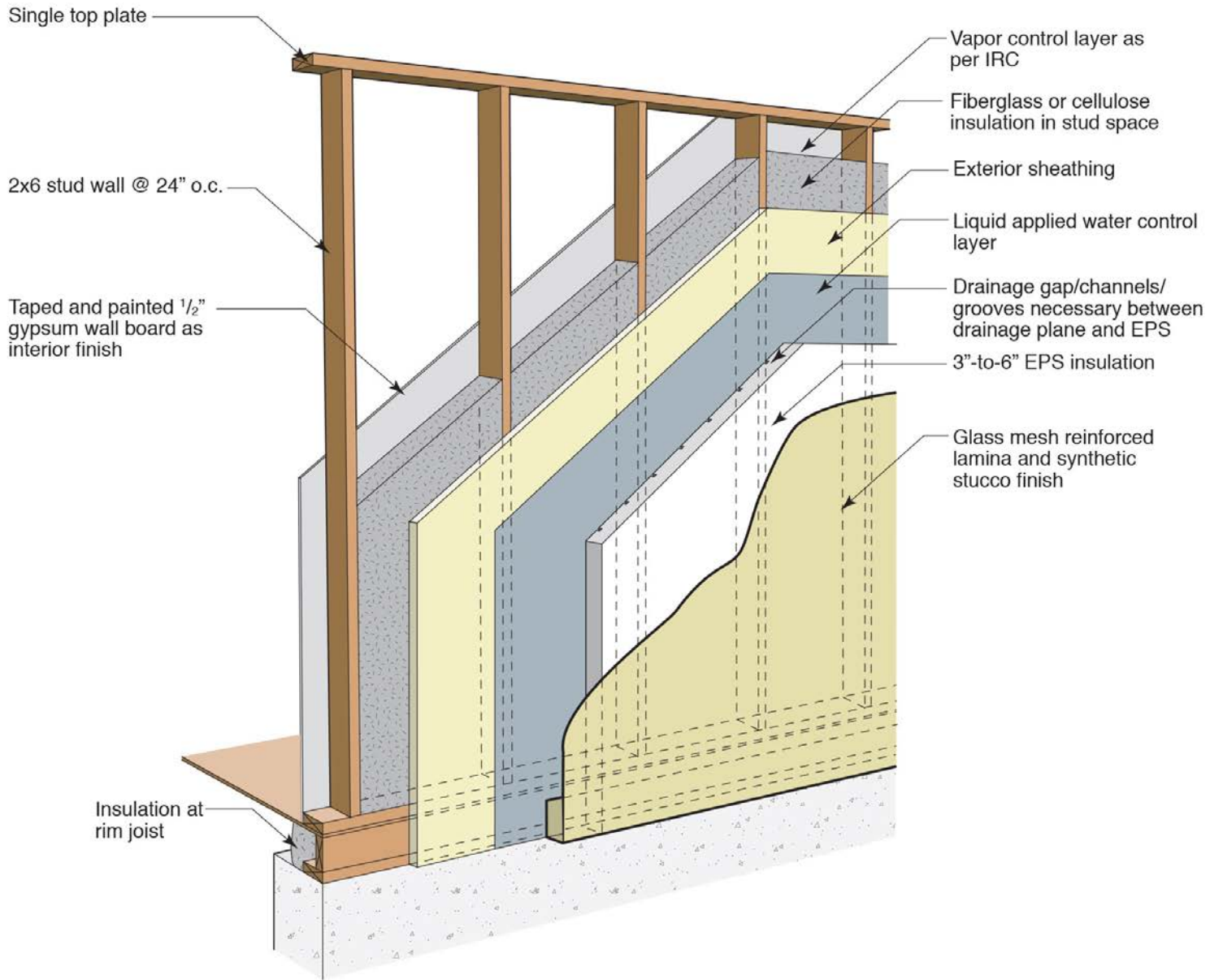


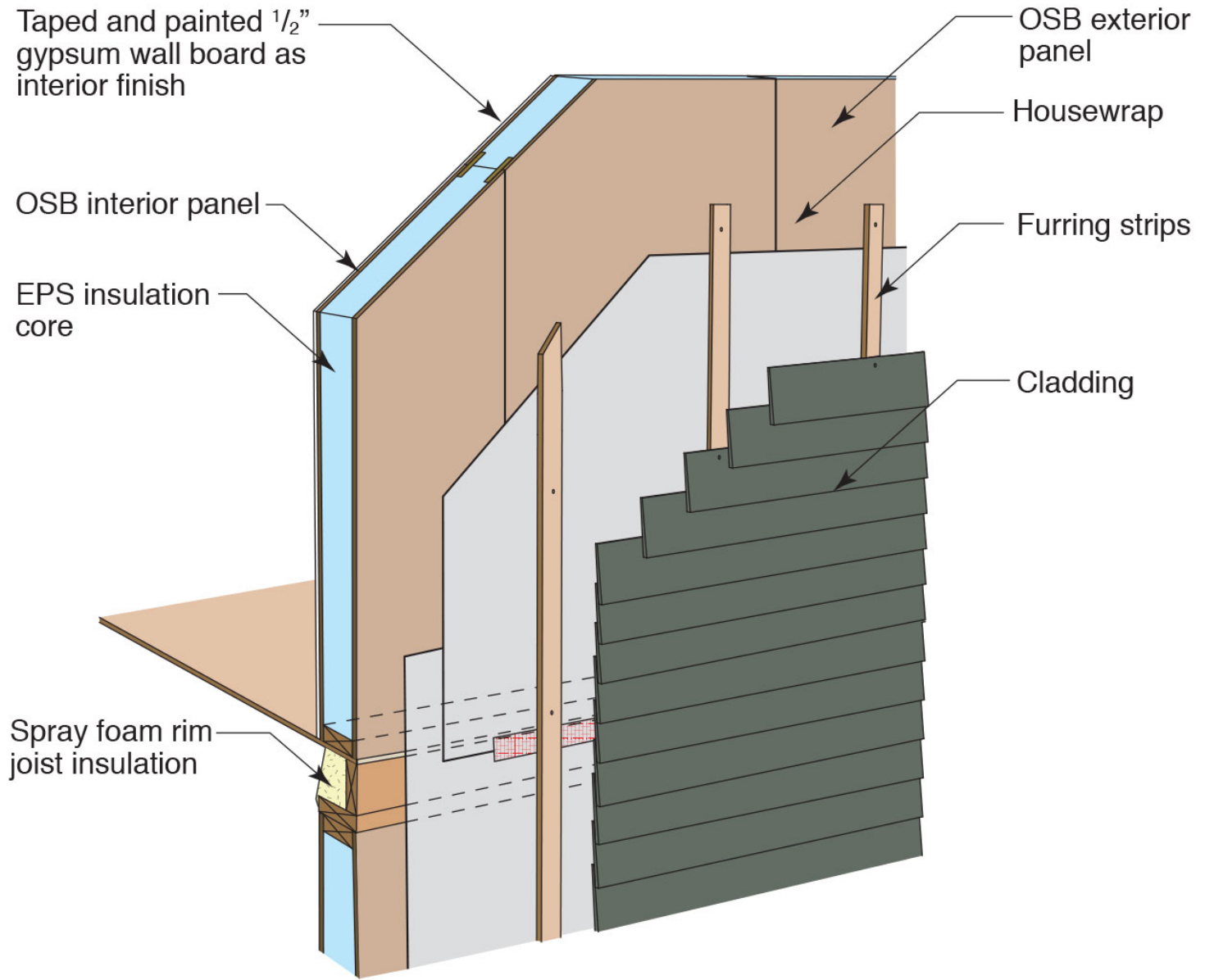








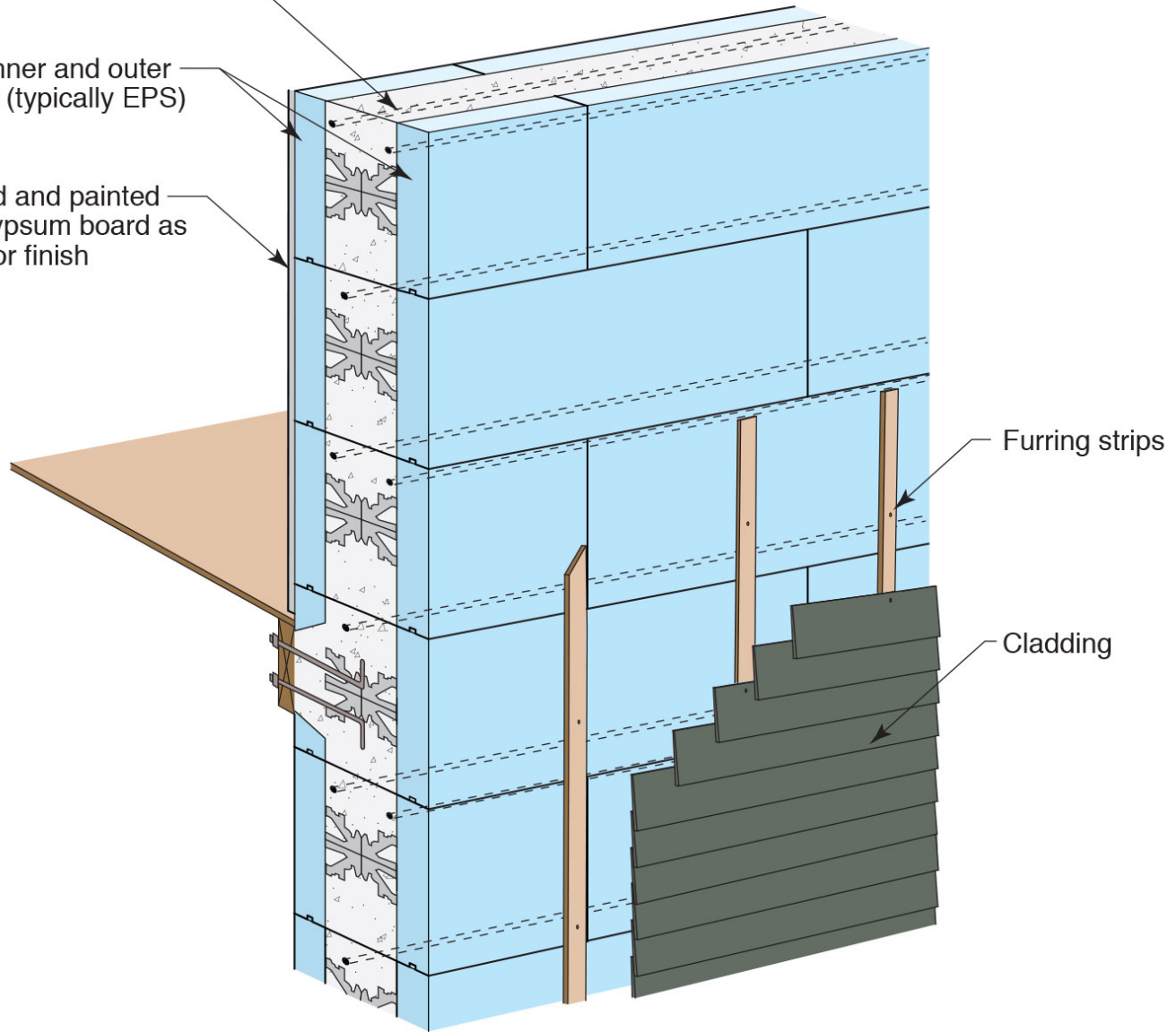


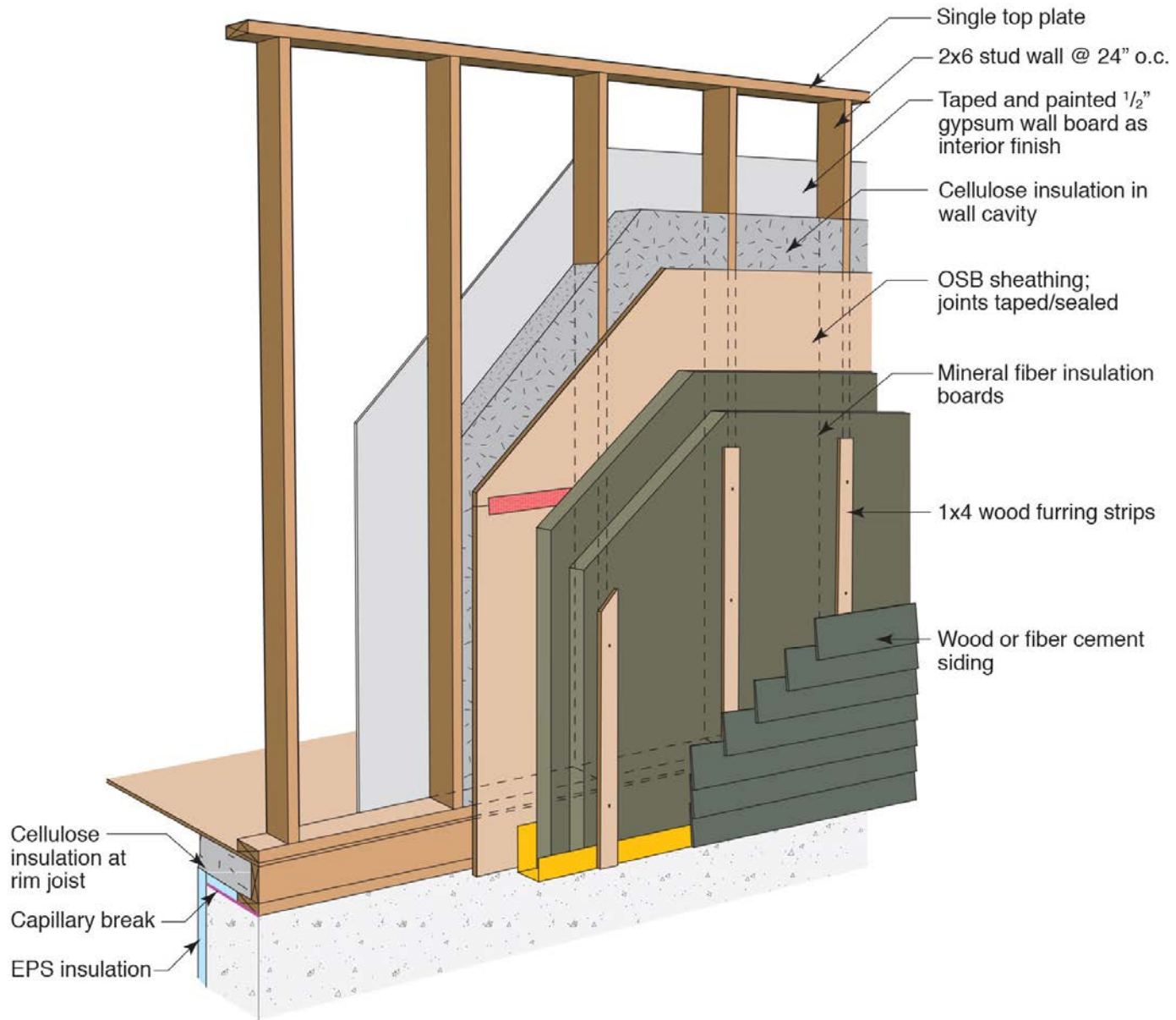


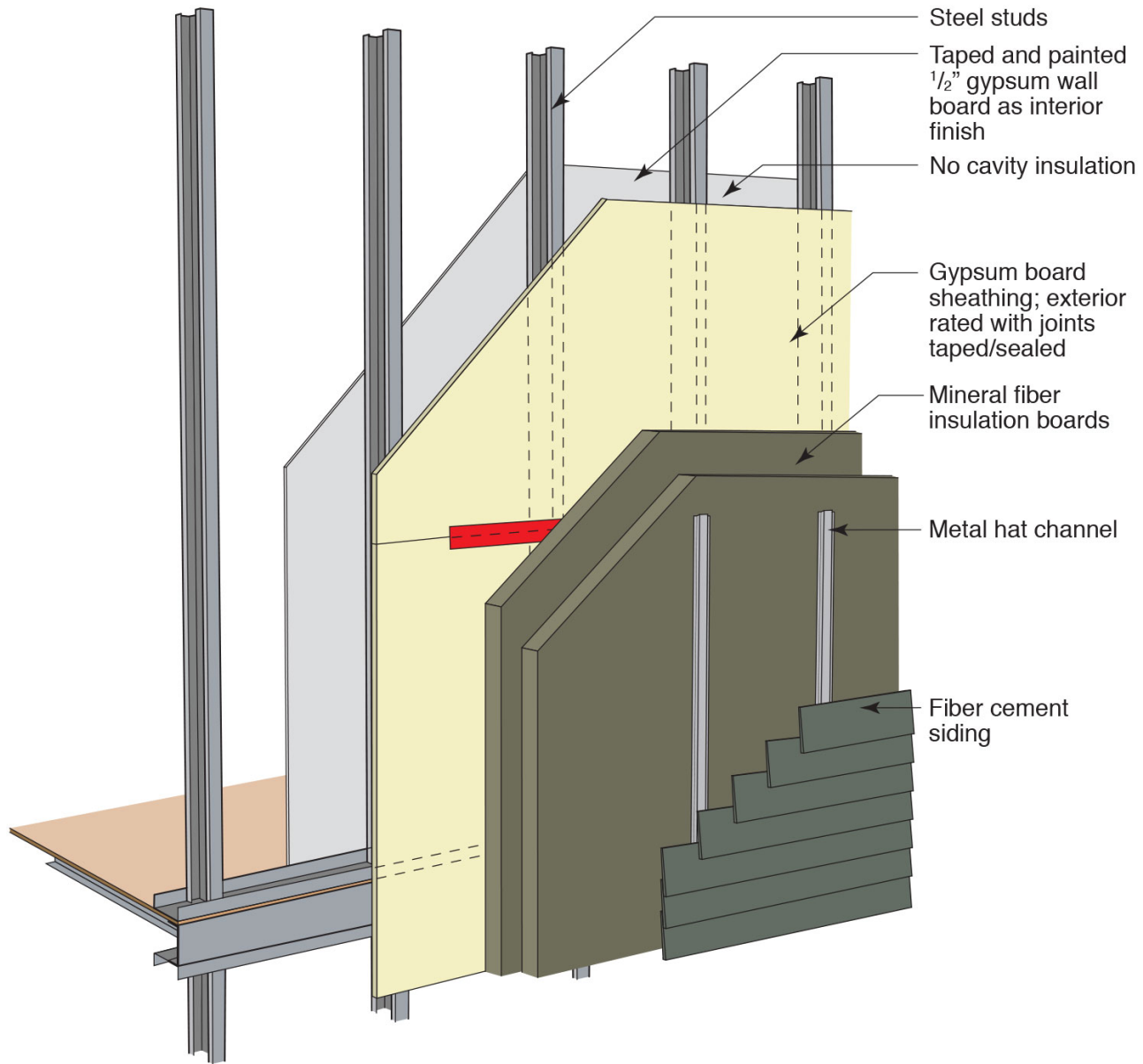
Cast-in-place concrete core

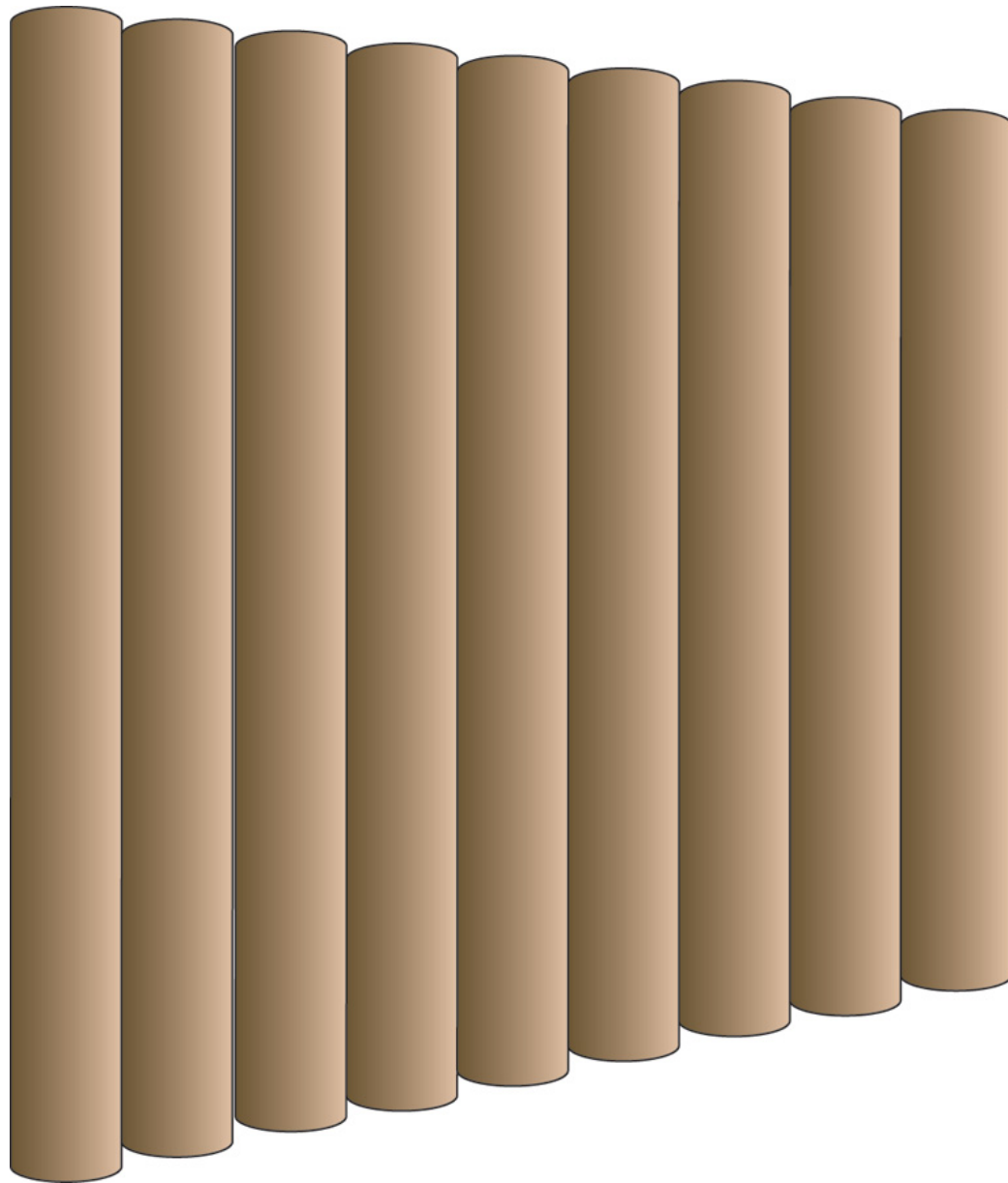
ICF inner and outer faces (typically EPS)

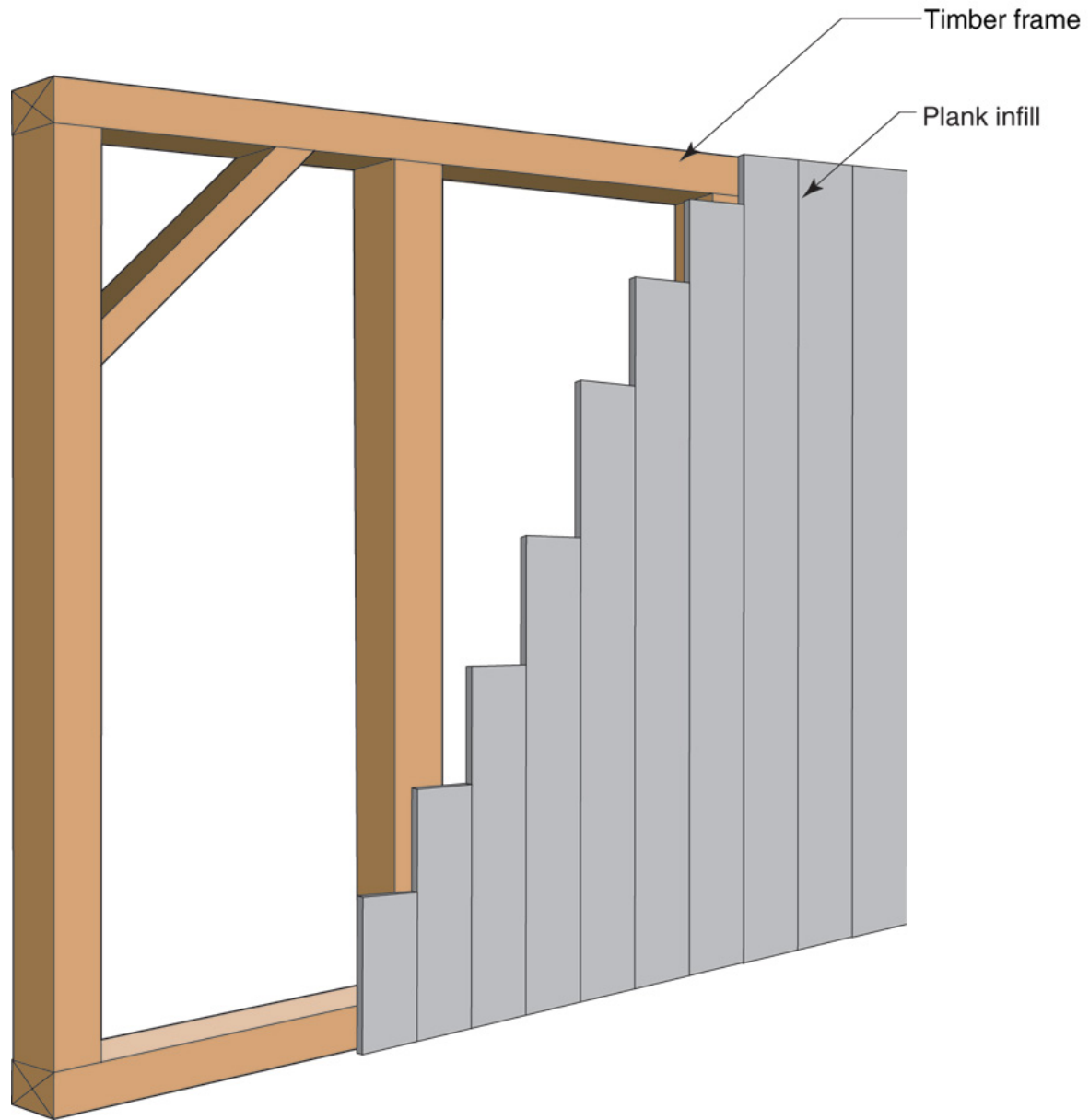
Taped and painted 1/2" gypsum board as interior finish

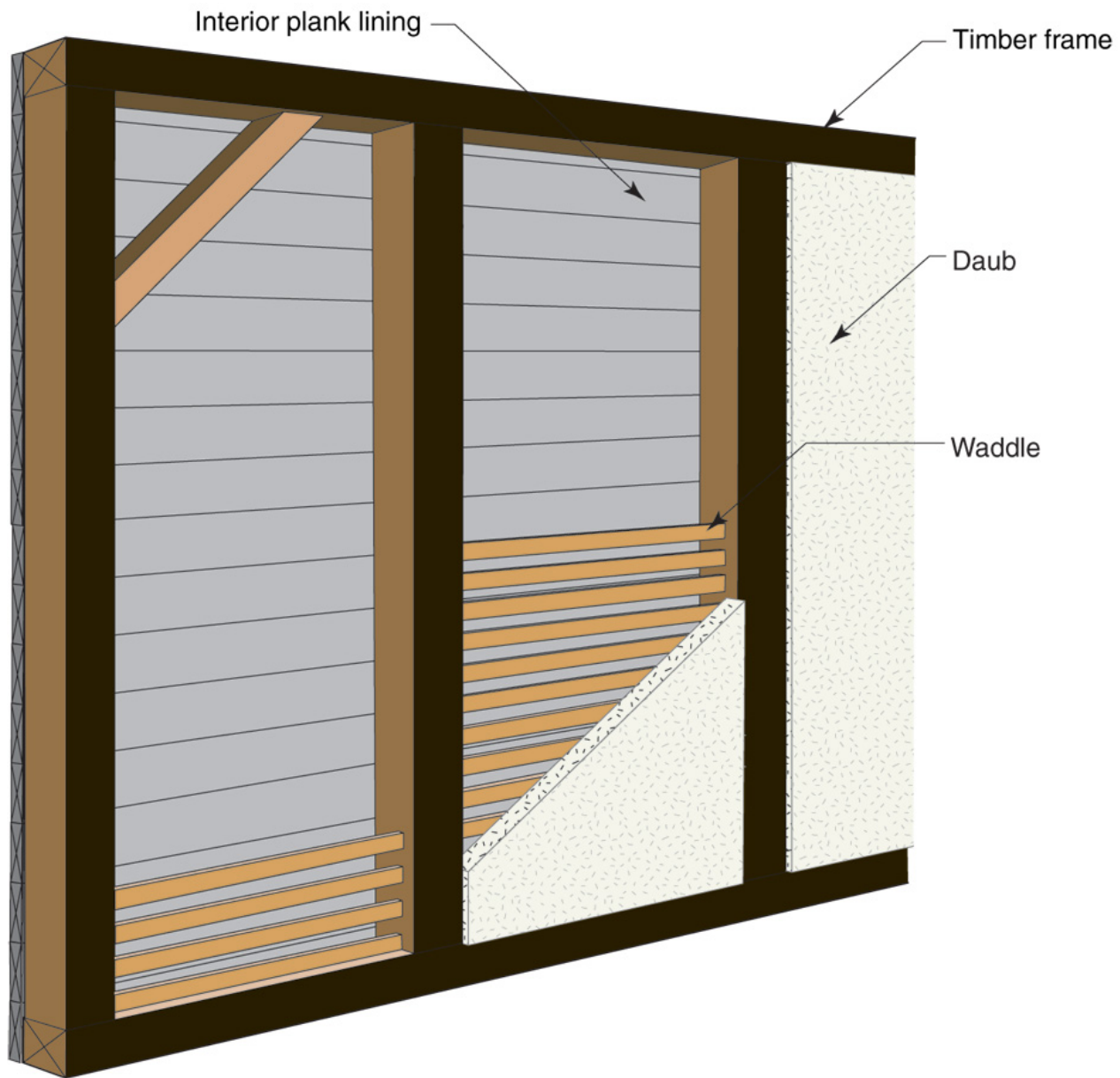


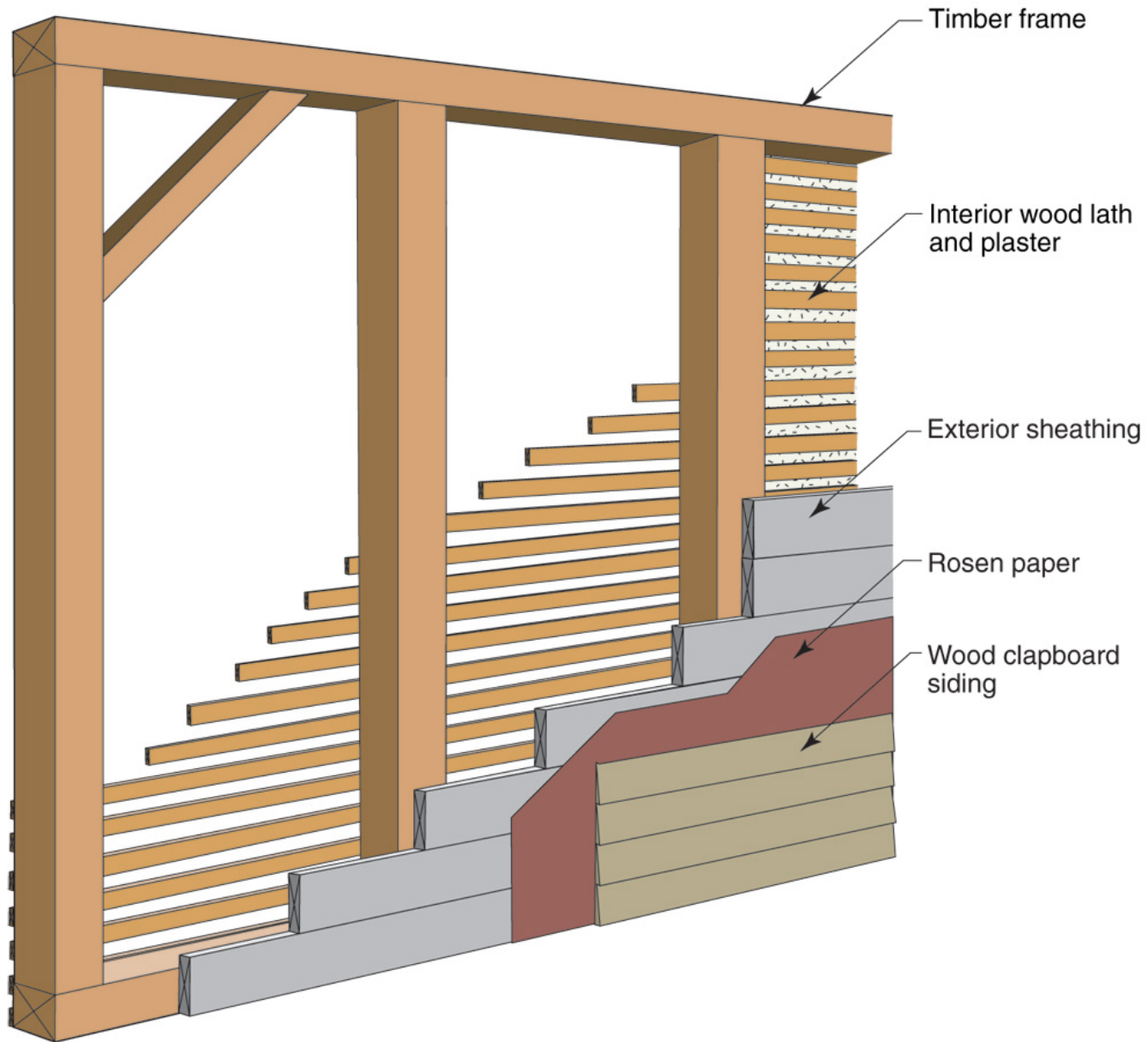


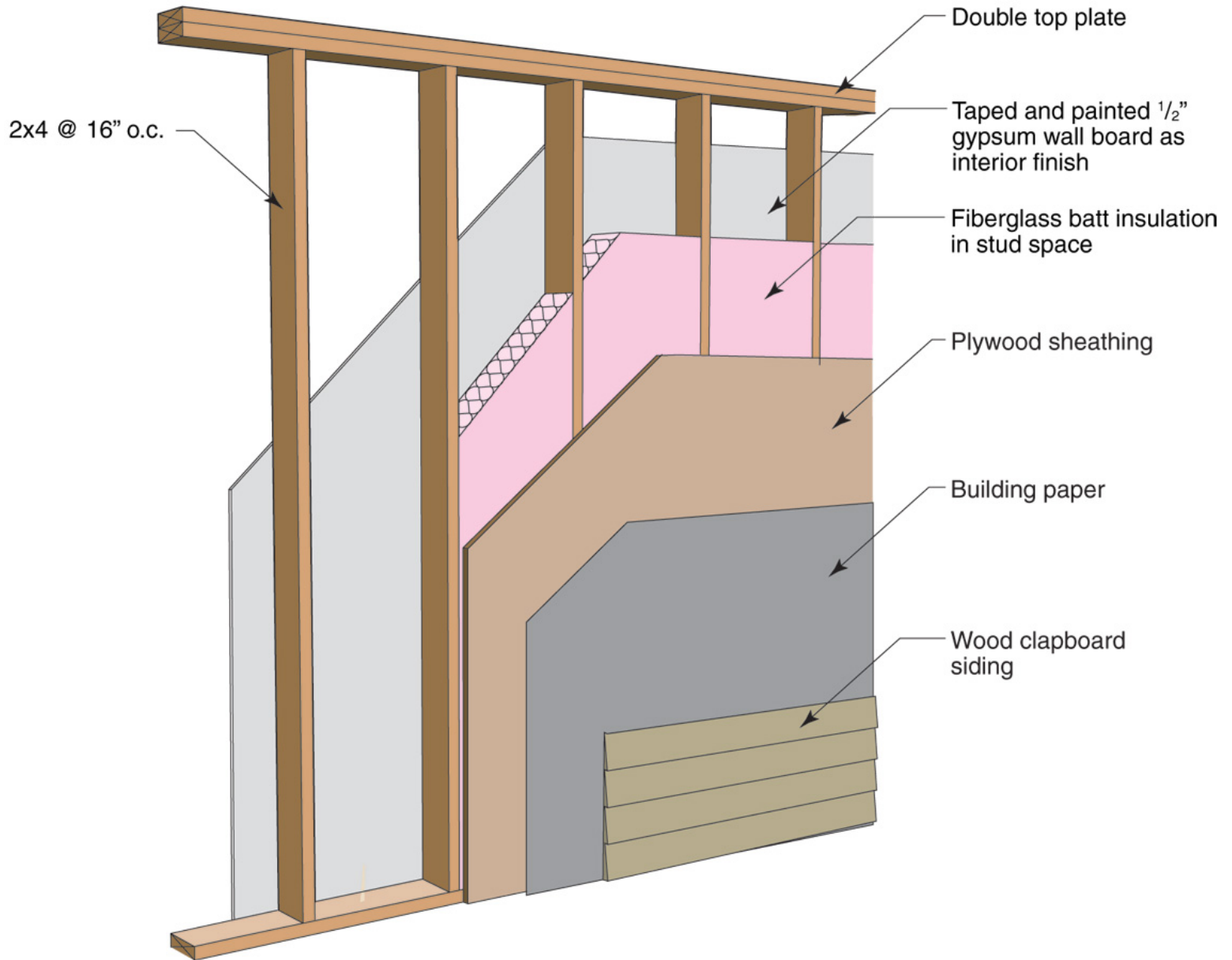


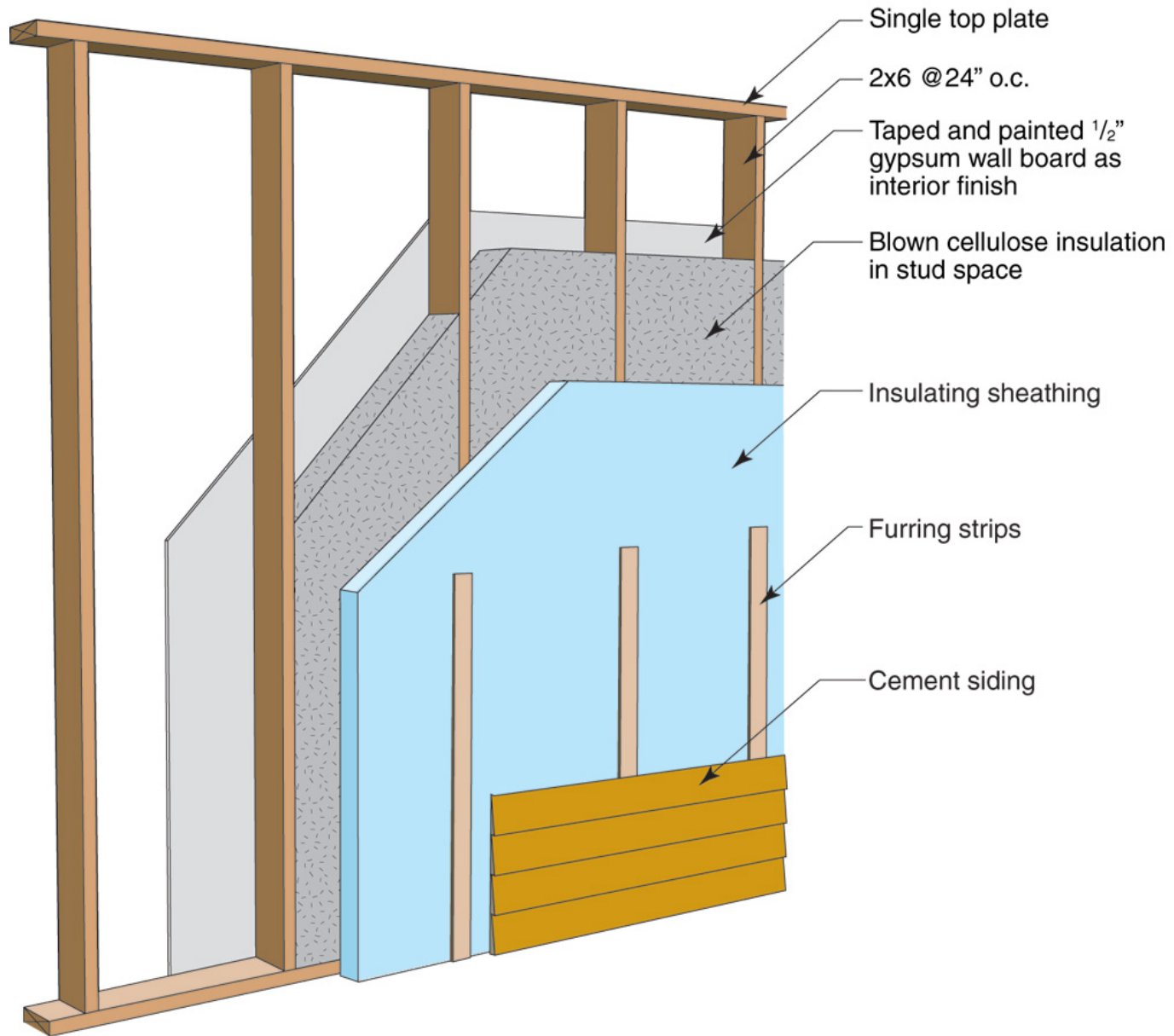








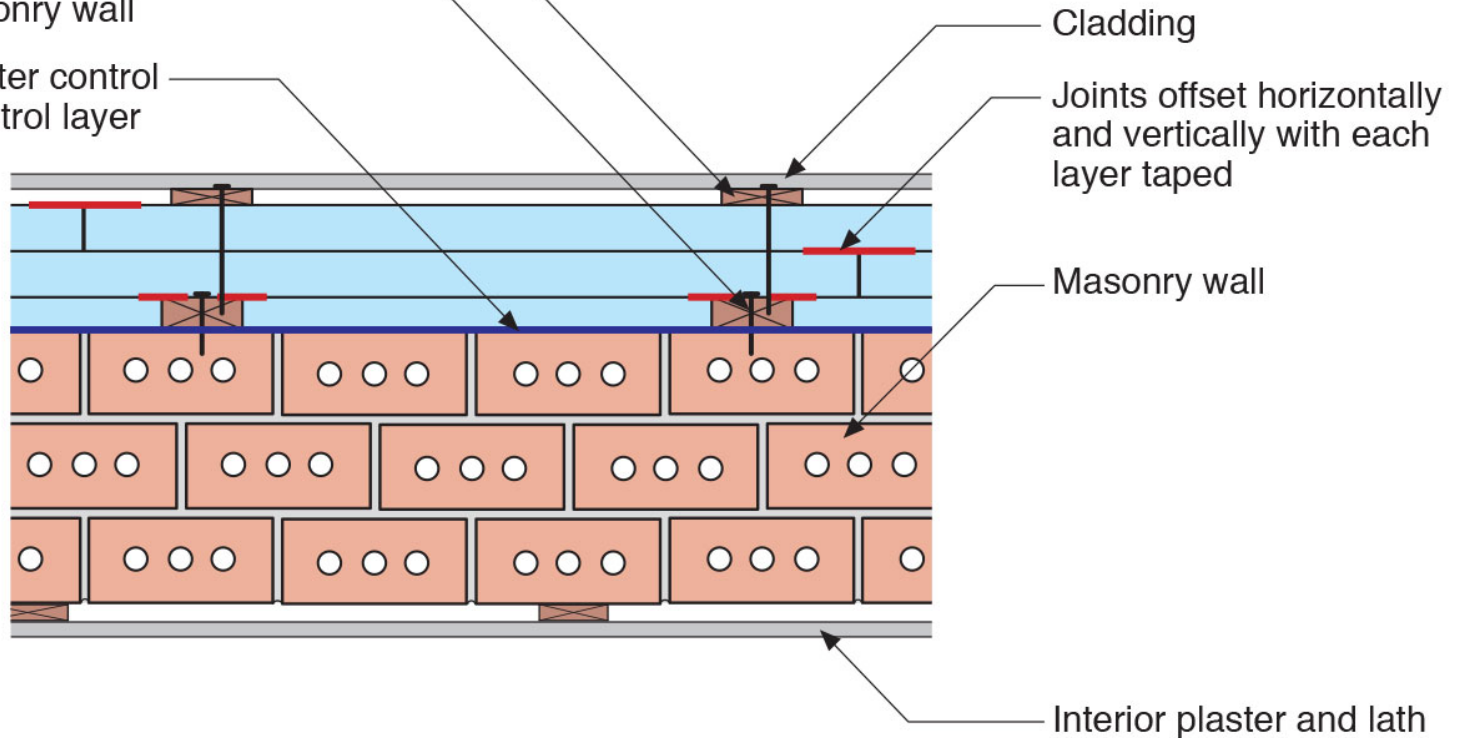




1x4 wood furring attached through rigid insulation to 2x4 wood furring

2x4 wood furring mechanically attached to masonry wall

Fluid-applied water control layer and air control layer

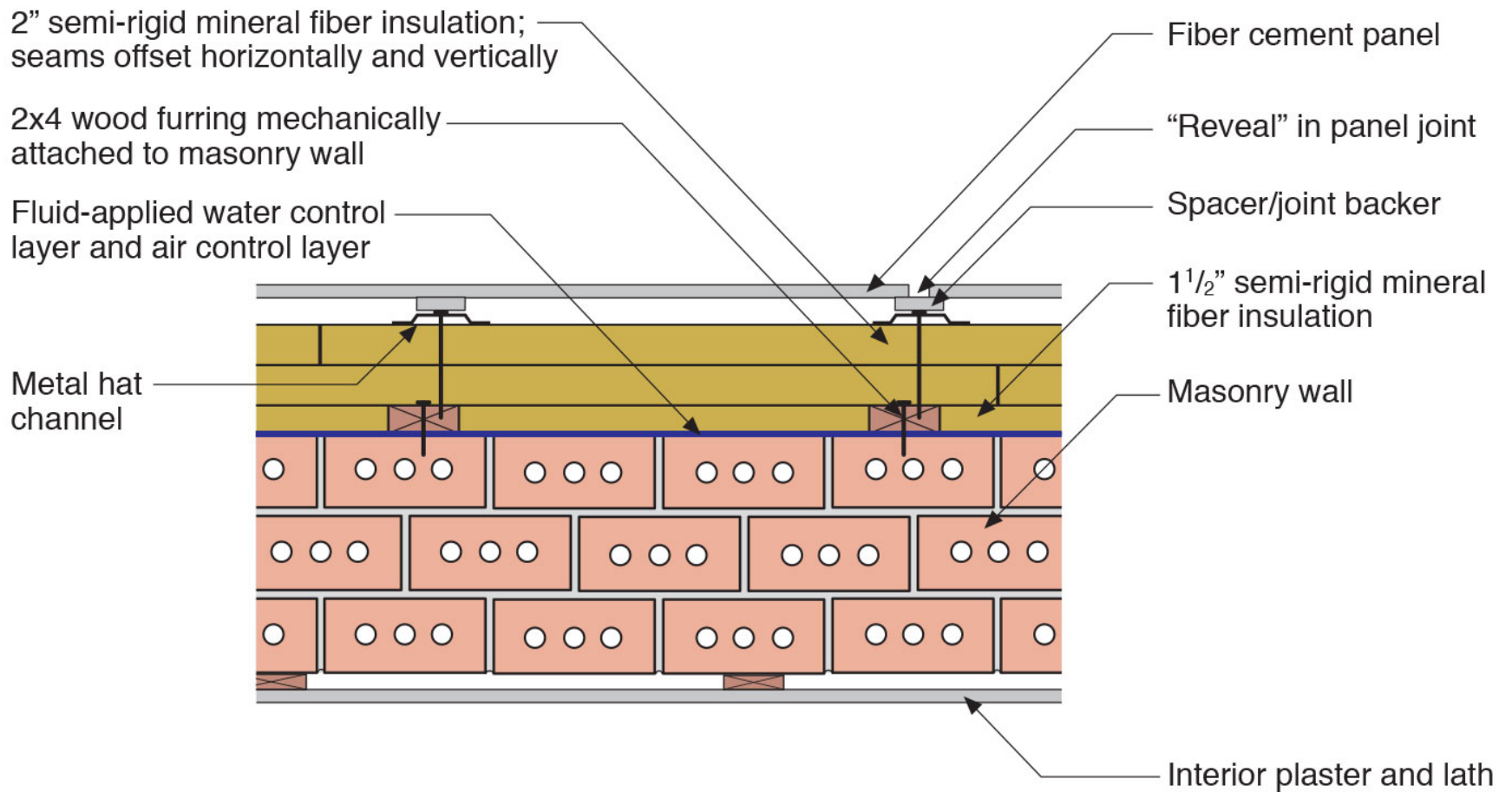


Cladding

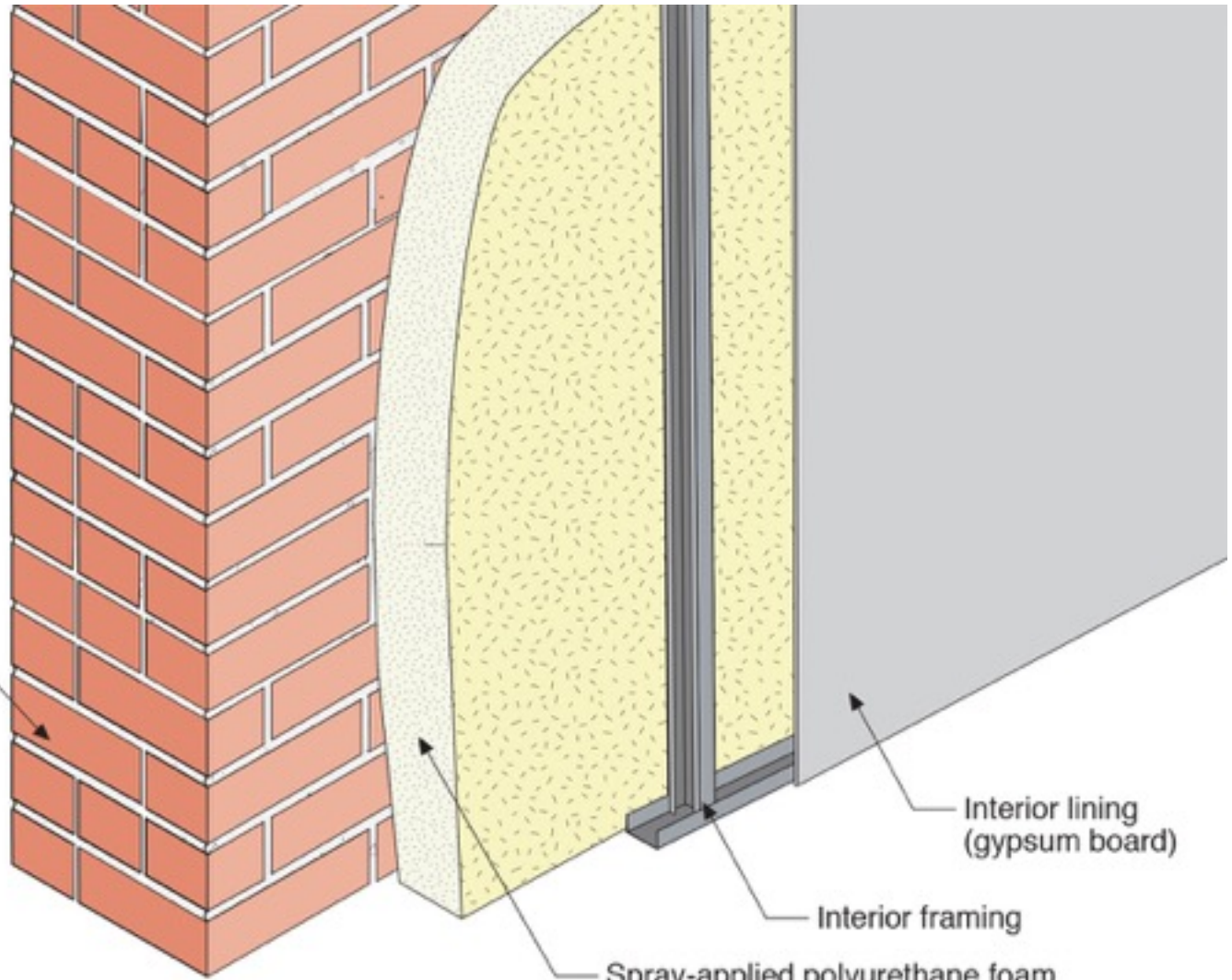
Joints offset horizontally and vertically with each layer taped

Masonry wall

Interior plaster and lath



Multi-wythe mass wall

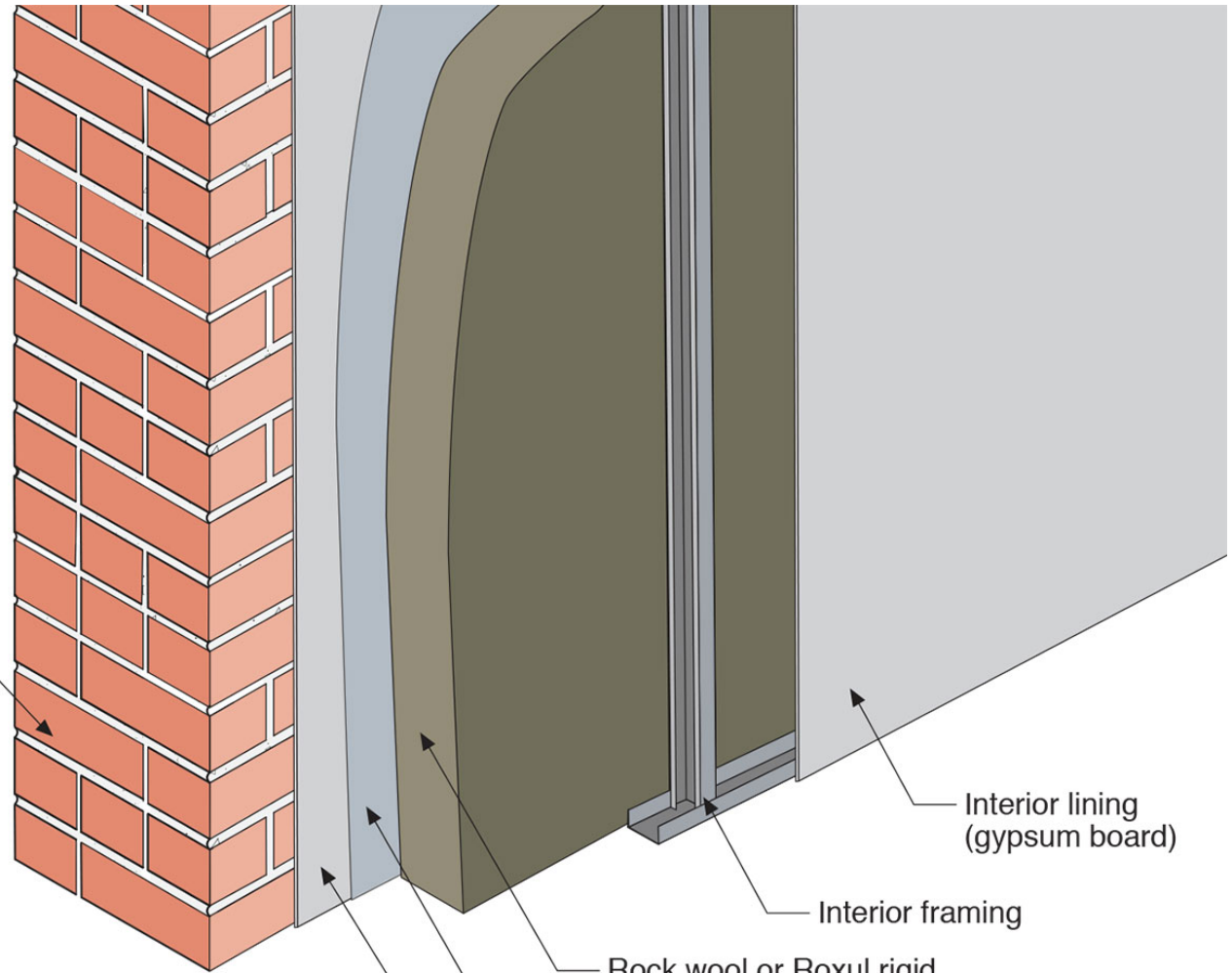


Interior lining
(gypsum board)

Interior framing

Spray-applied polyurethane foam
(2 lb/ft³ density)

Multi-wythe mass wall



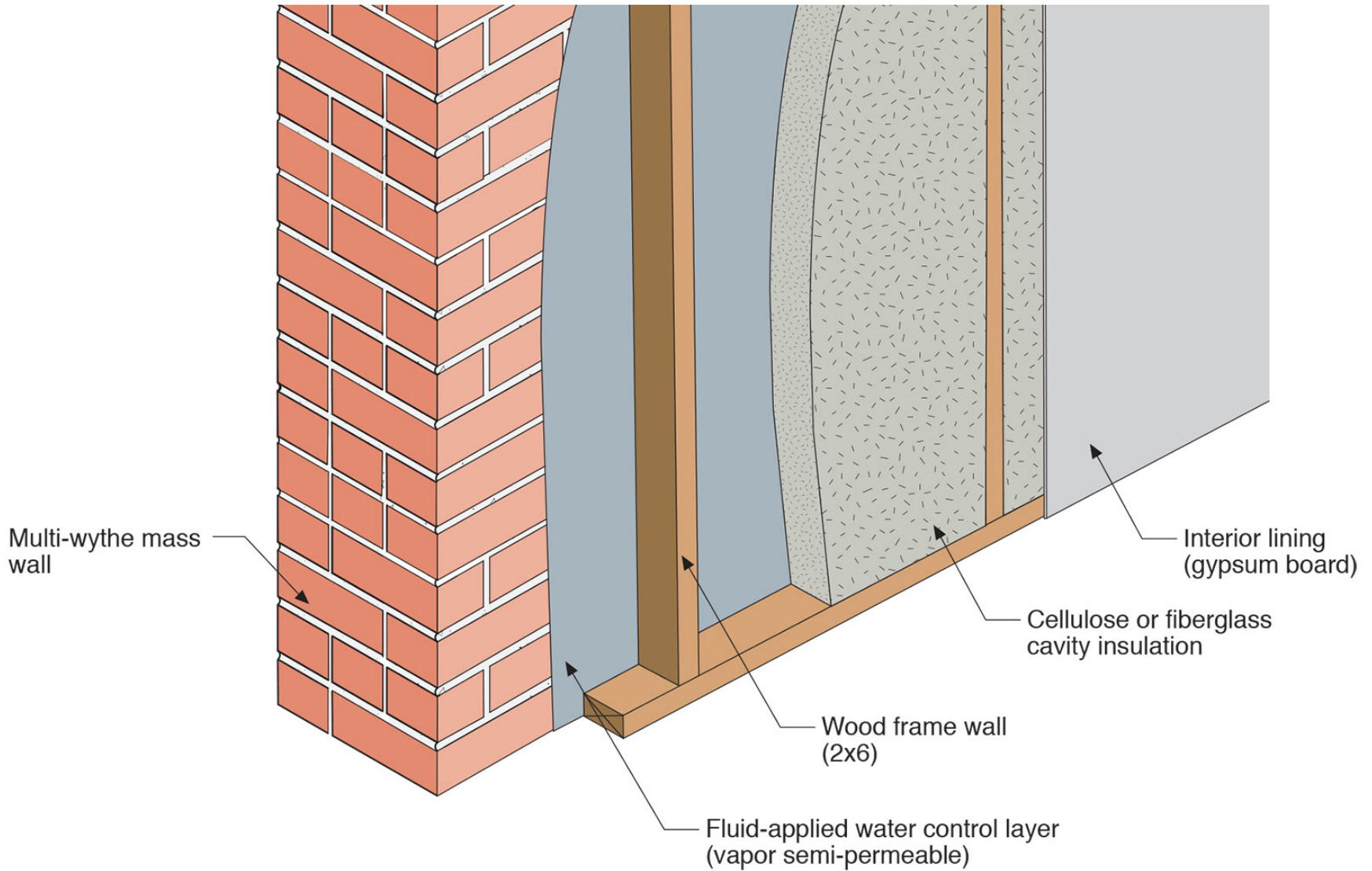
Interior lining (gypsum board)

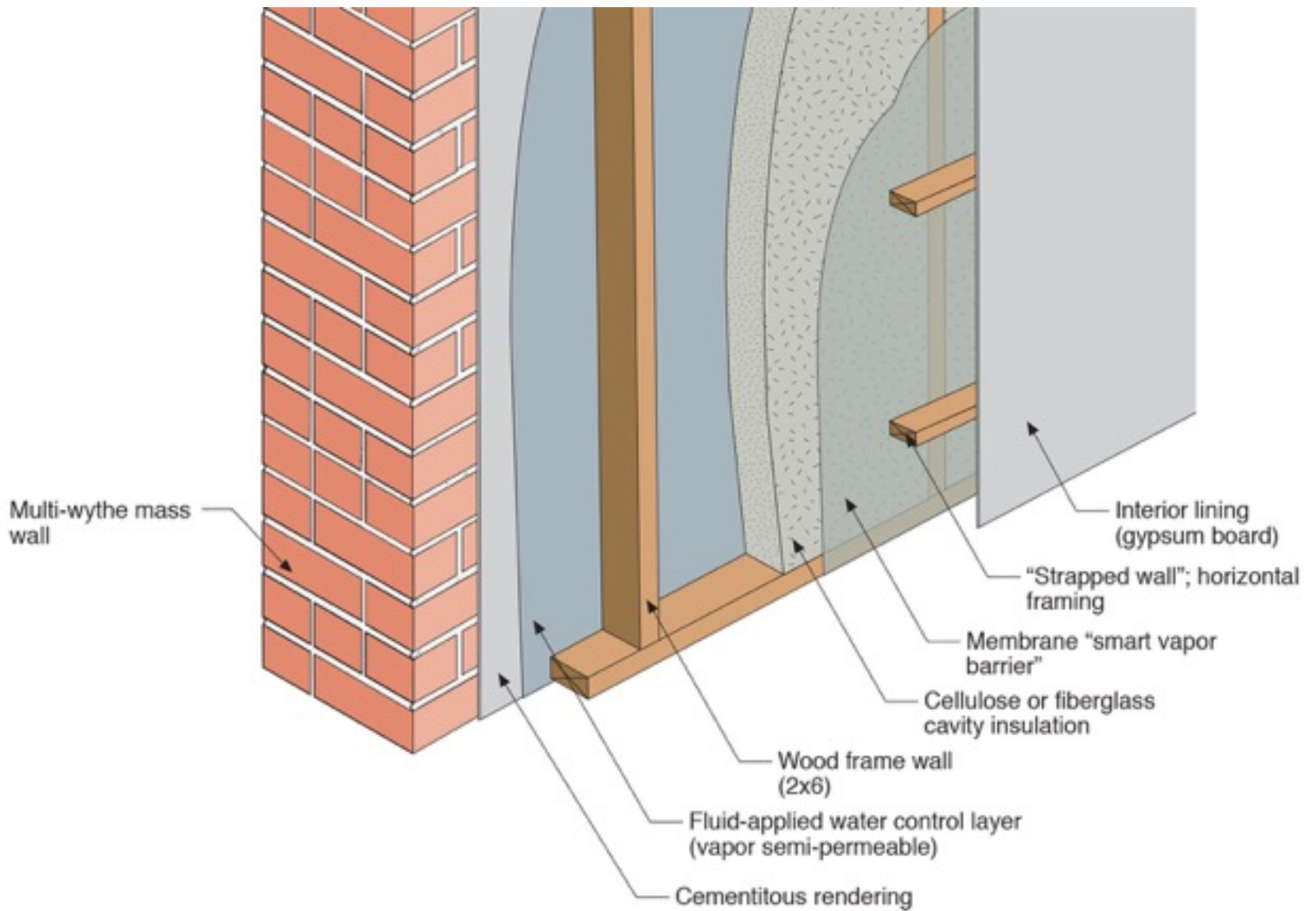
Interior framing

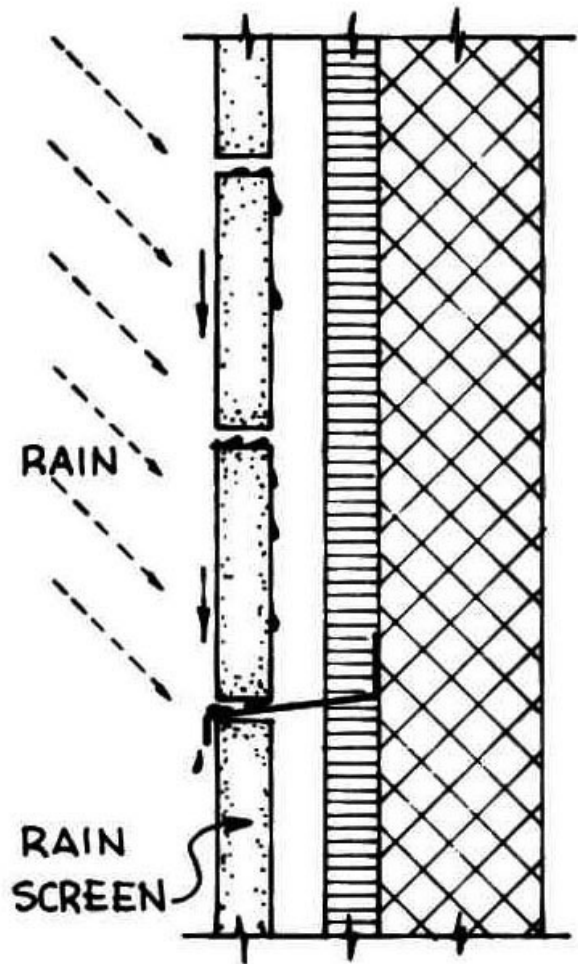
Rock wool or Roxul rigid mineral wool insulation

Fluid-applied water control layer (vapor semi-permeable)

Cementitious rendering







WATER THAT PENETRATES IS DIVERTED OUTWARD BY FLASHINGS

