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

Building Science

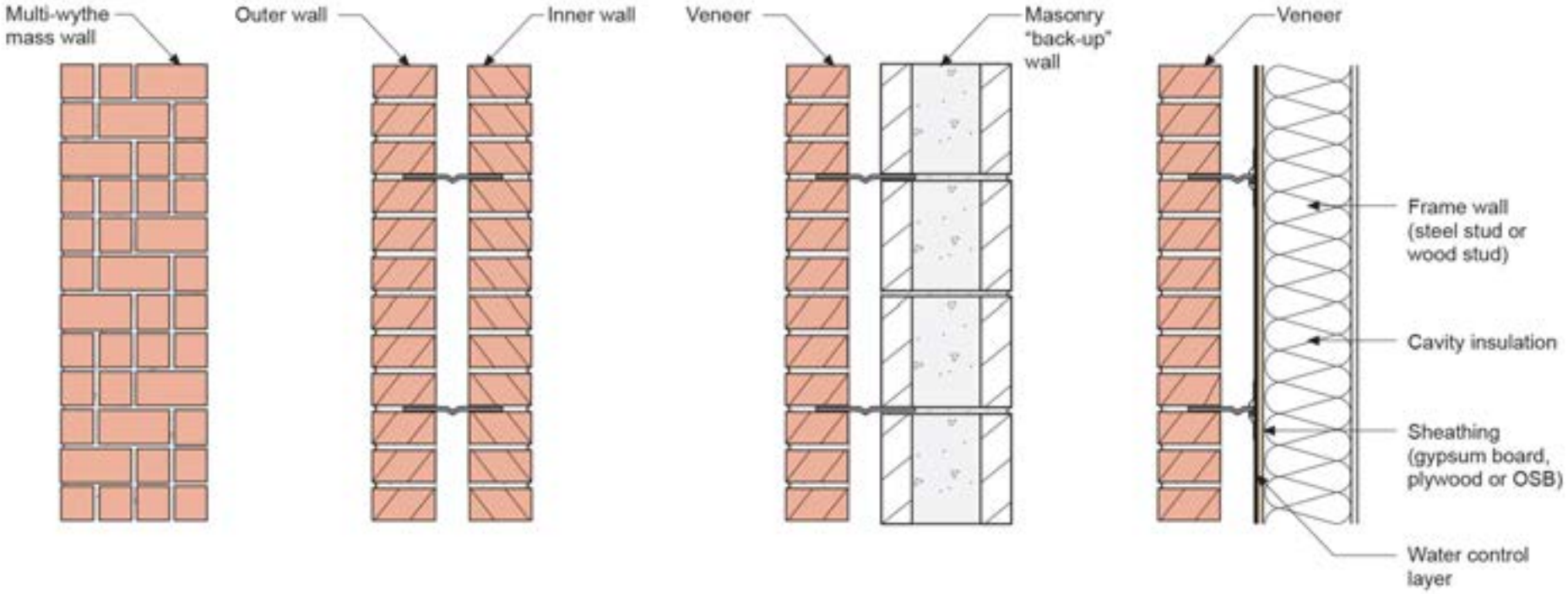
Adventures In Building Science

www.buildingscience.com

What is a Building?

A Building is an Environmental Separator

Evolution of Walls


Multi-wythe mass wall
Outer wall
Inner wall
Veneer
Masonry "back-up" wall
Veneer
Frame wall (steel stud or wood stud)
Cavity insulation
Sheathing (gypsum board, plywood or OSB)
Water control layer

Enclosures

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

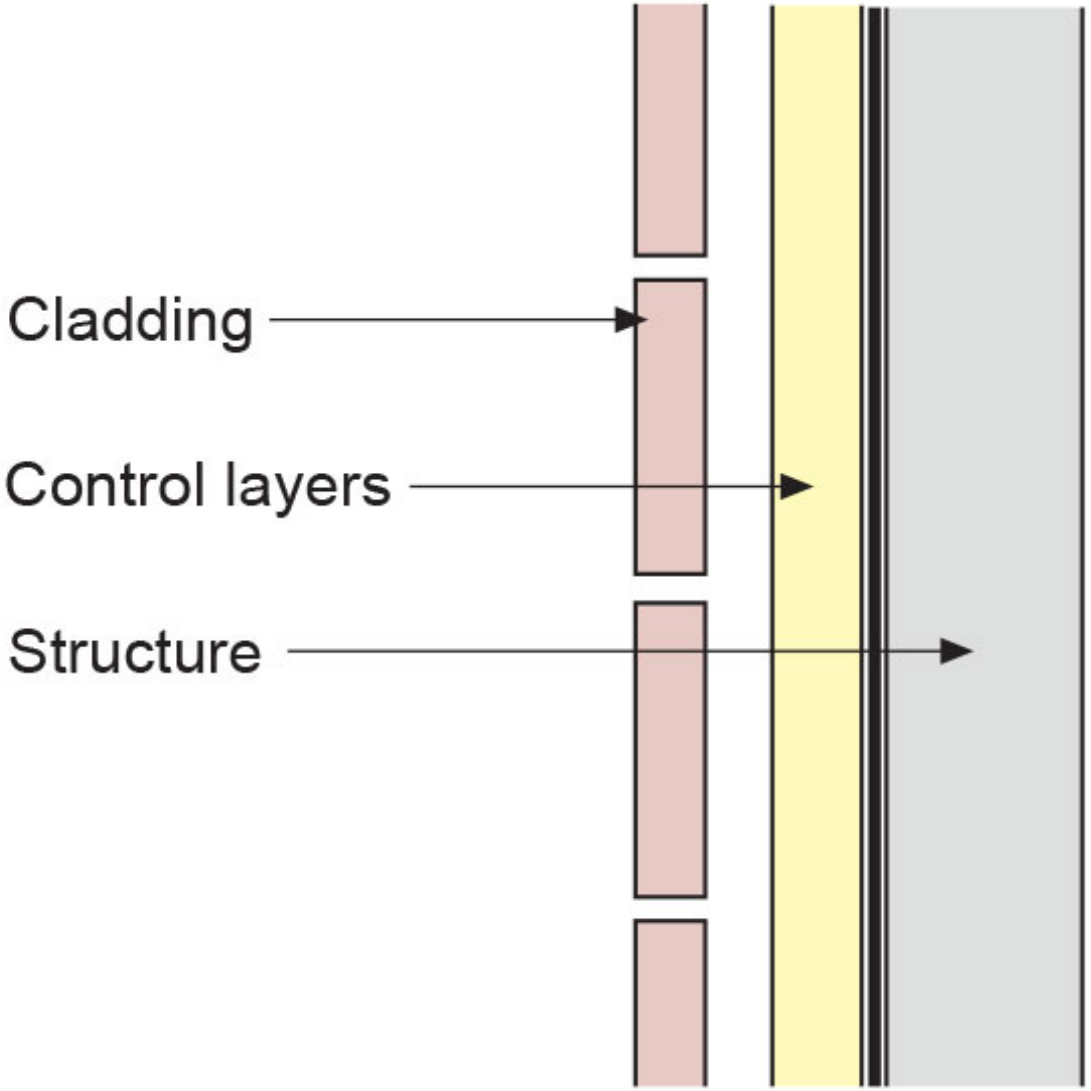
Gravity Acts Down

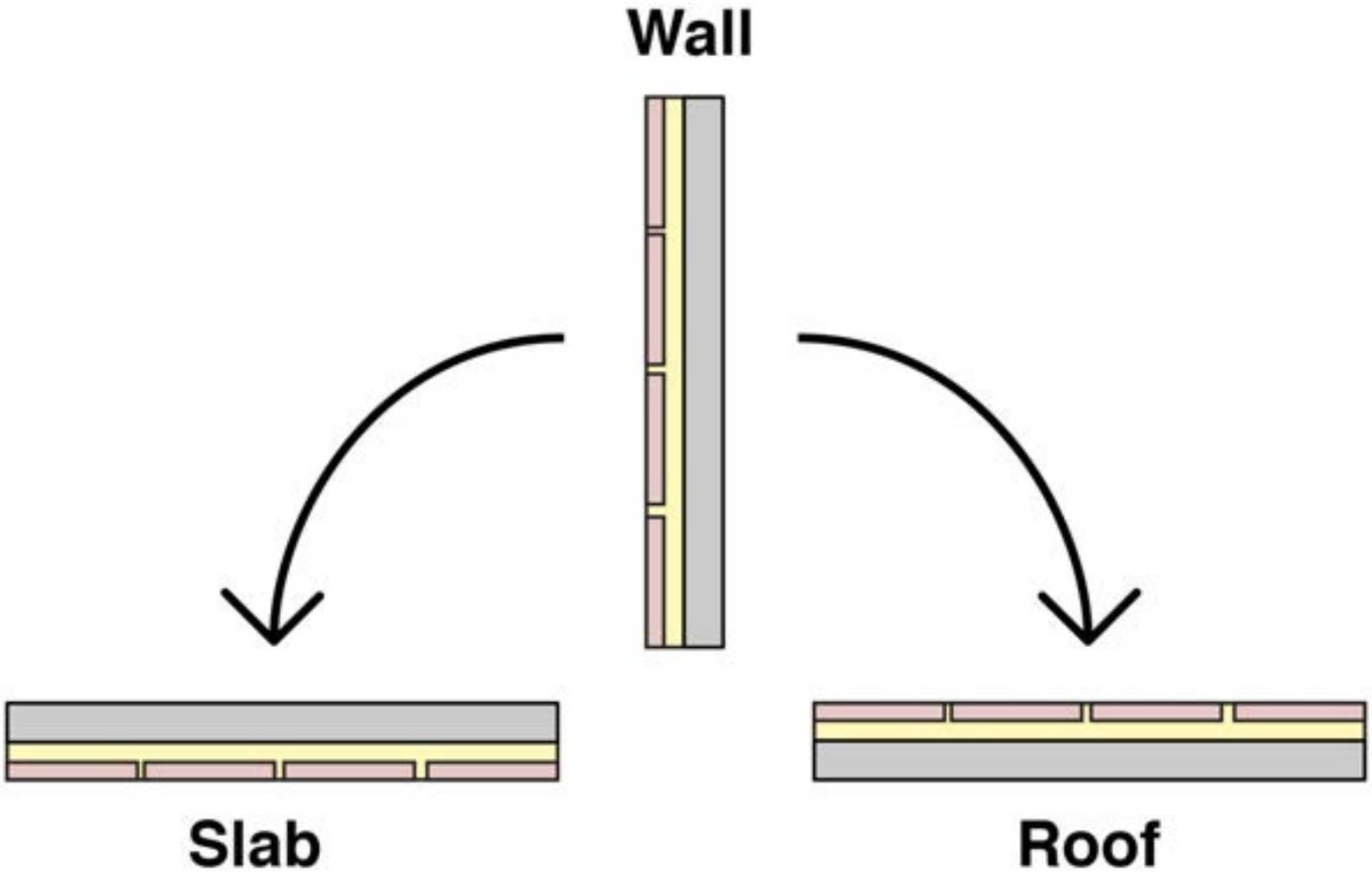
Water Control Layer

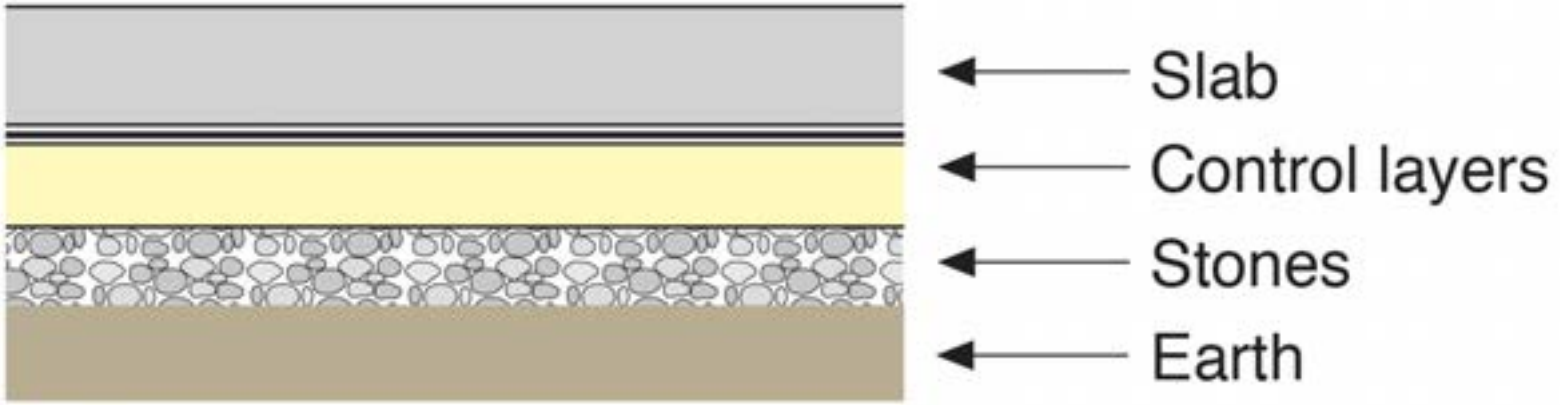
Air Control Layer

Vapor Control Layer

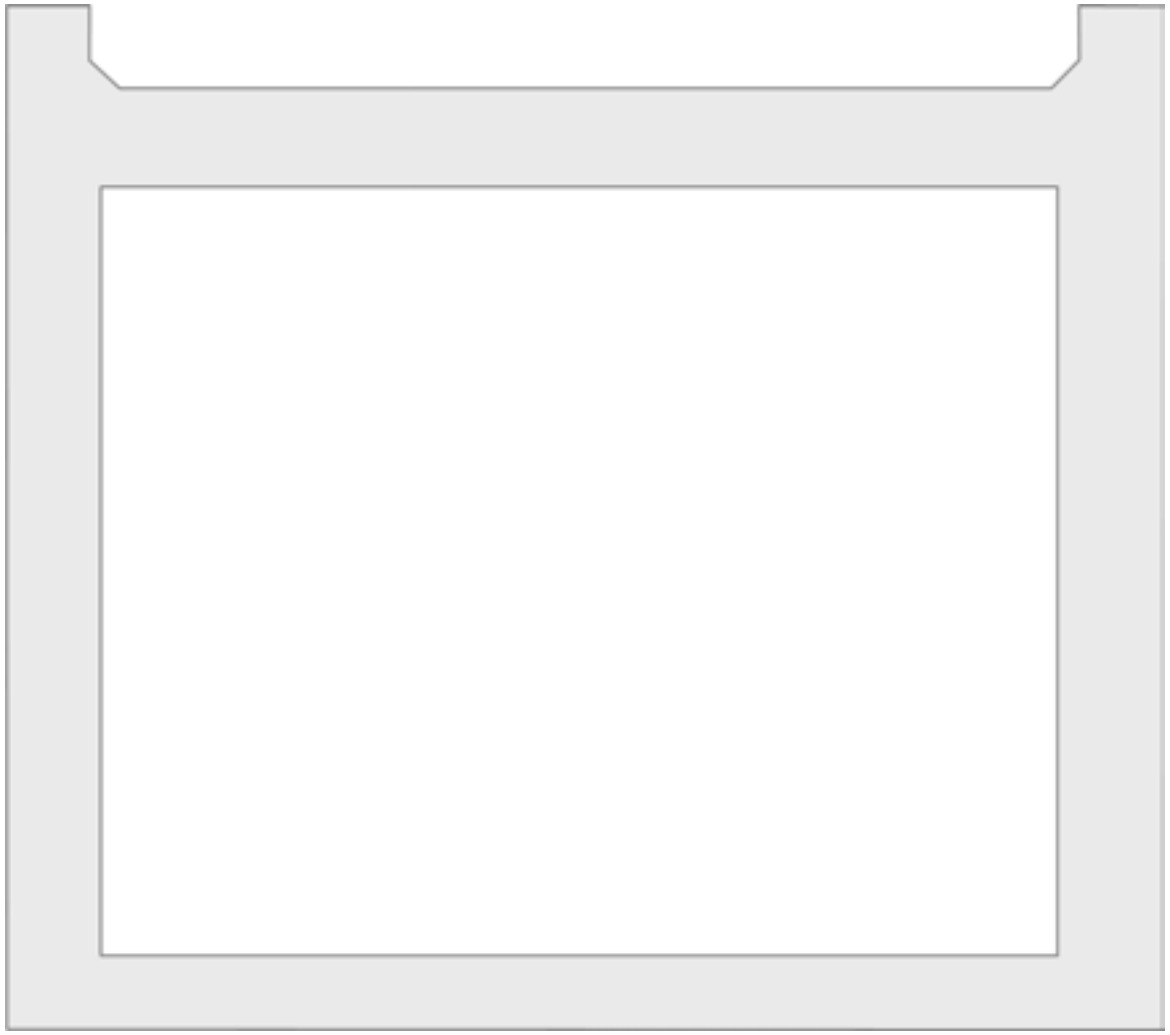
Thermal Control Layer


Cladding
Control layers
Structure

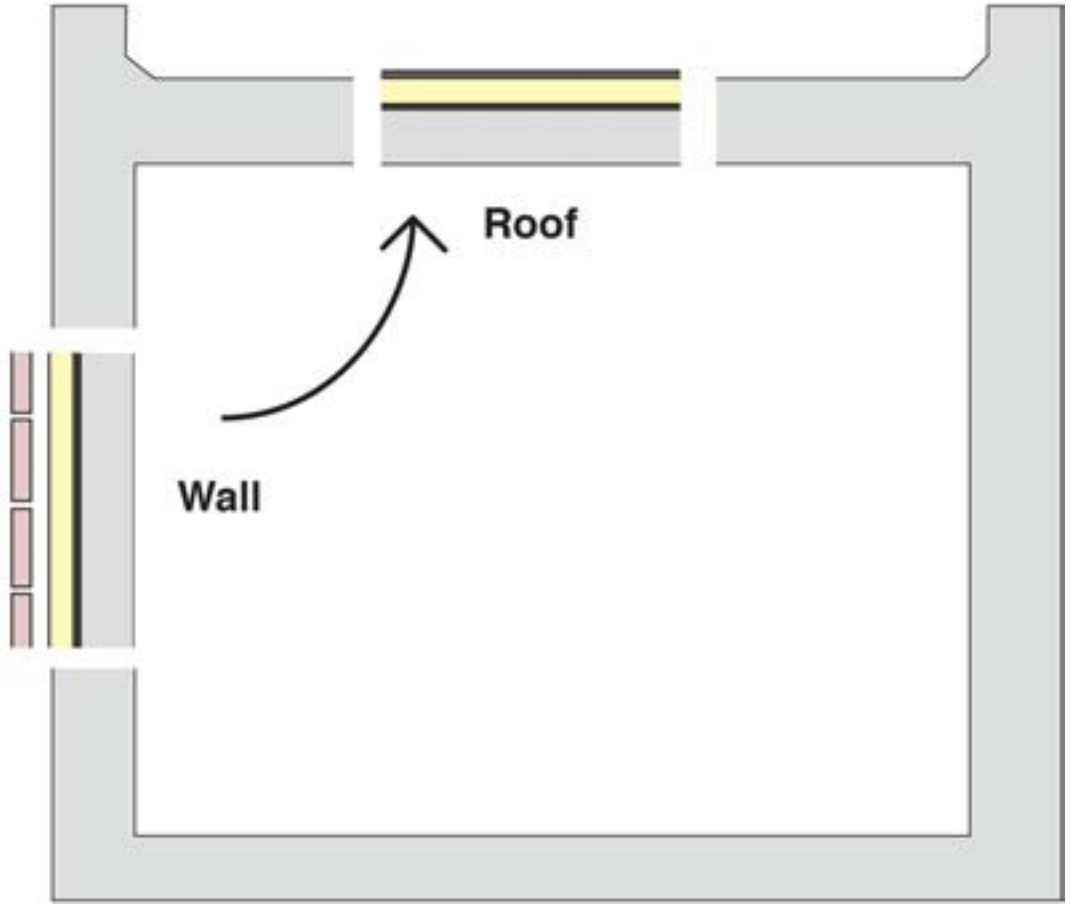

Wall
Slab
Roof

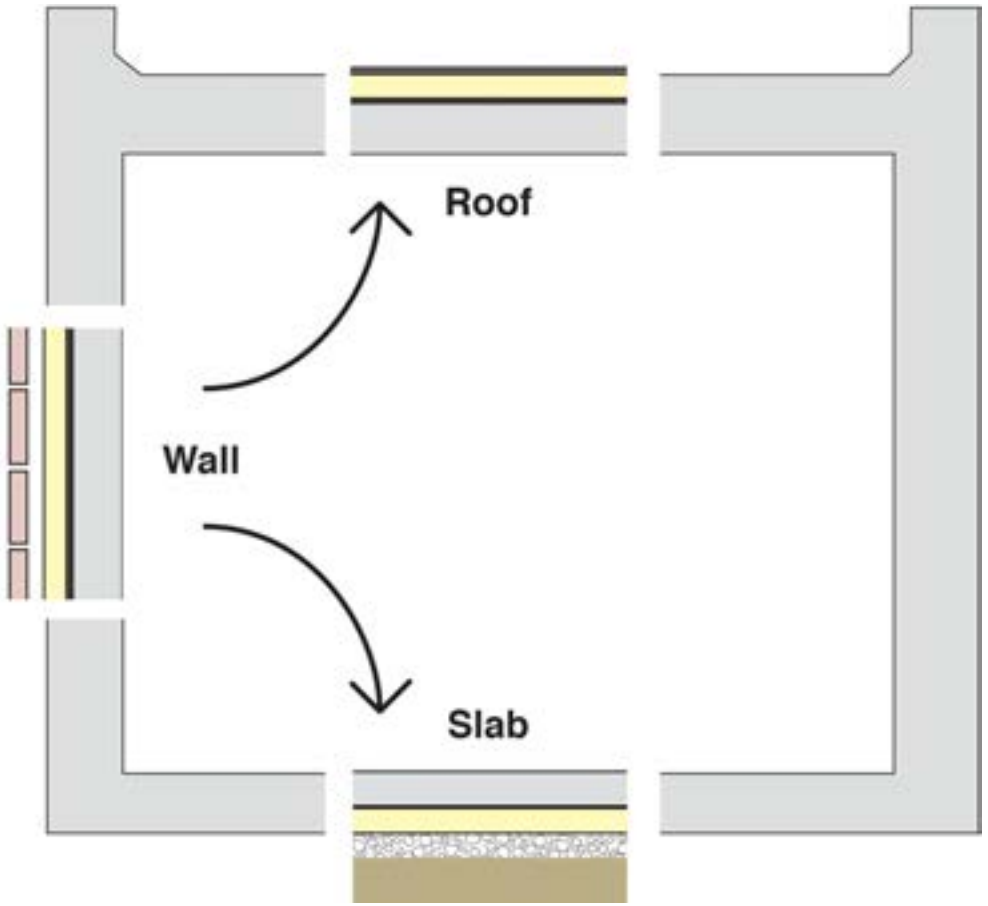

Slab
Control layers
Stones
Earth

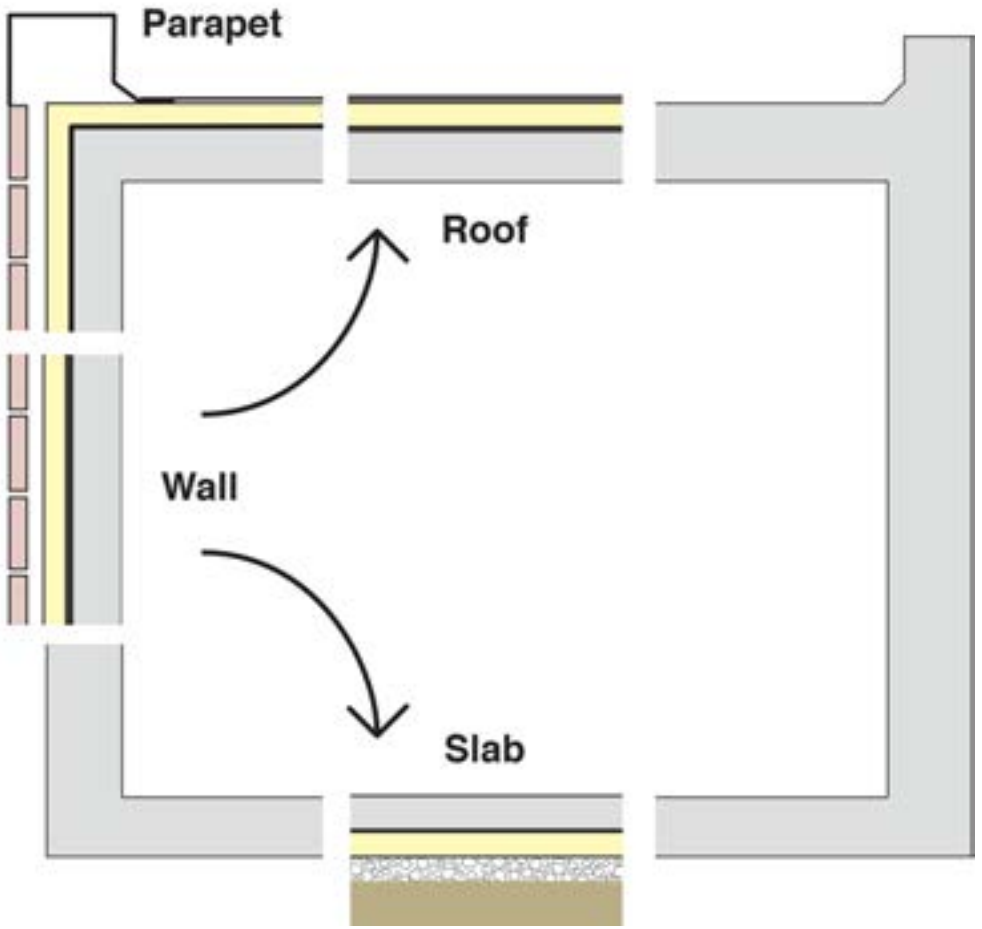

Control layer
Control layer
Roof structure

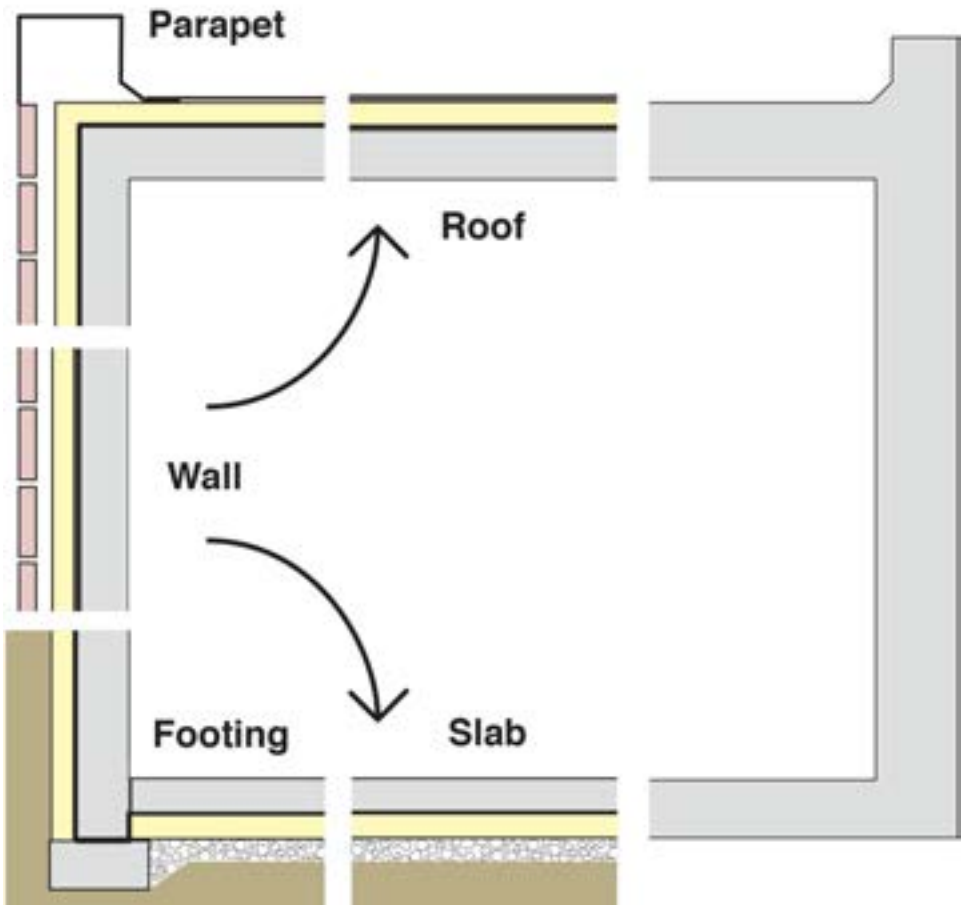


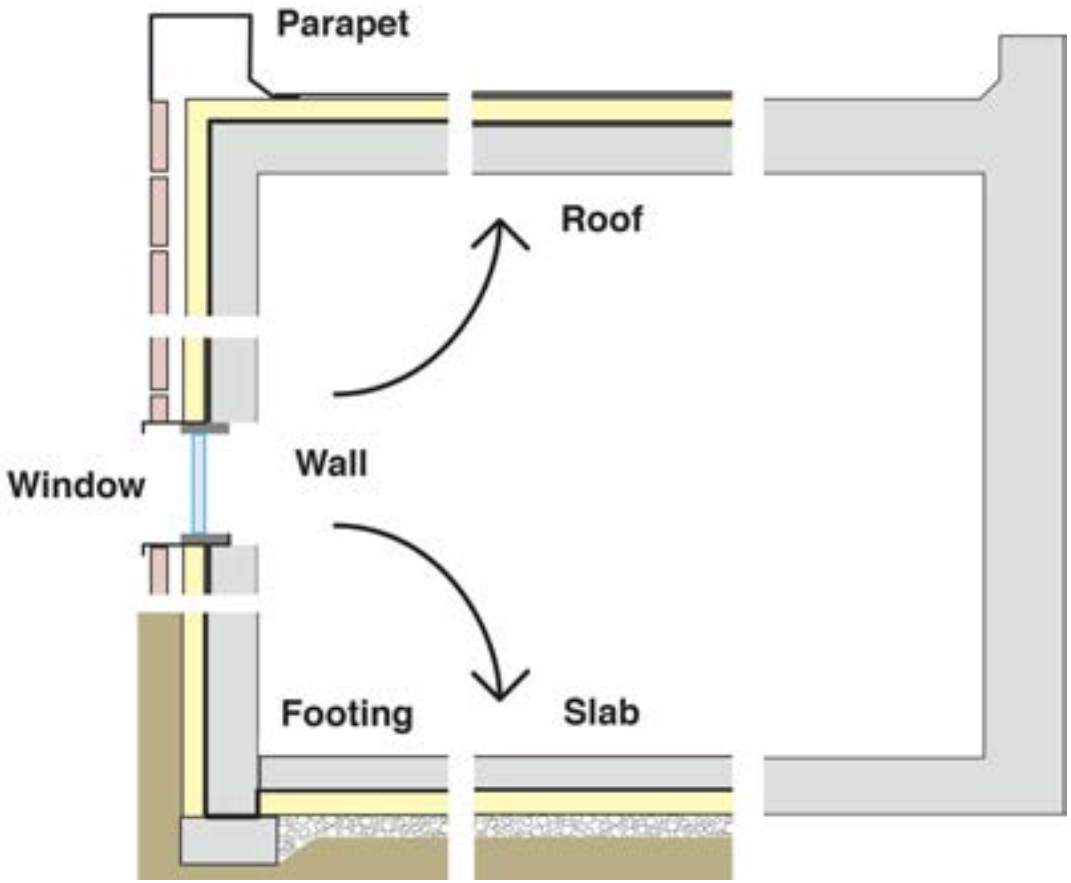

Wall

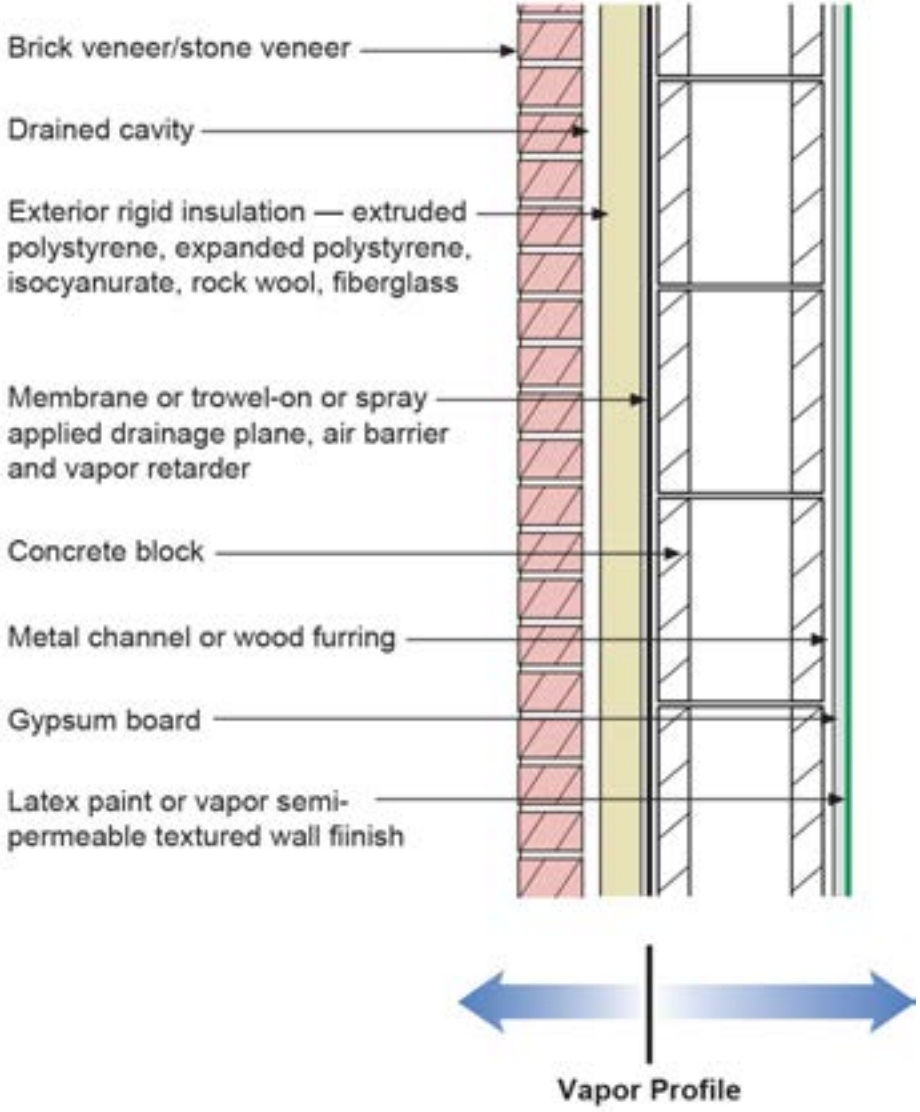

Roof
Wall

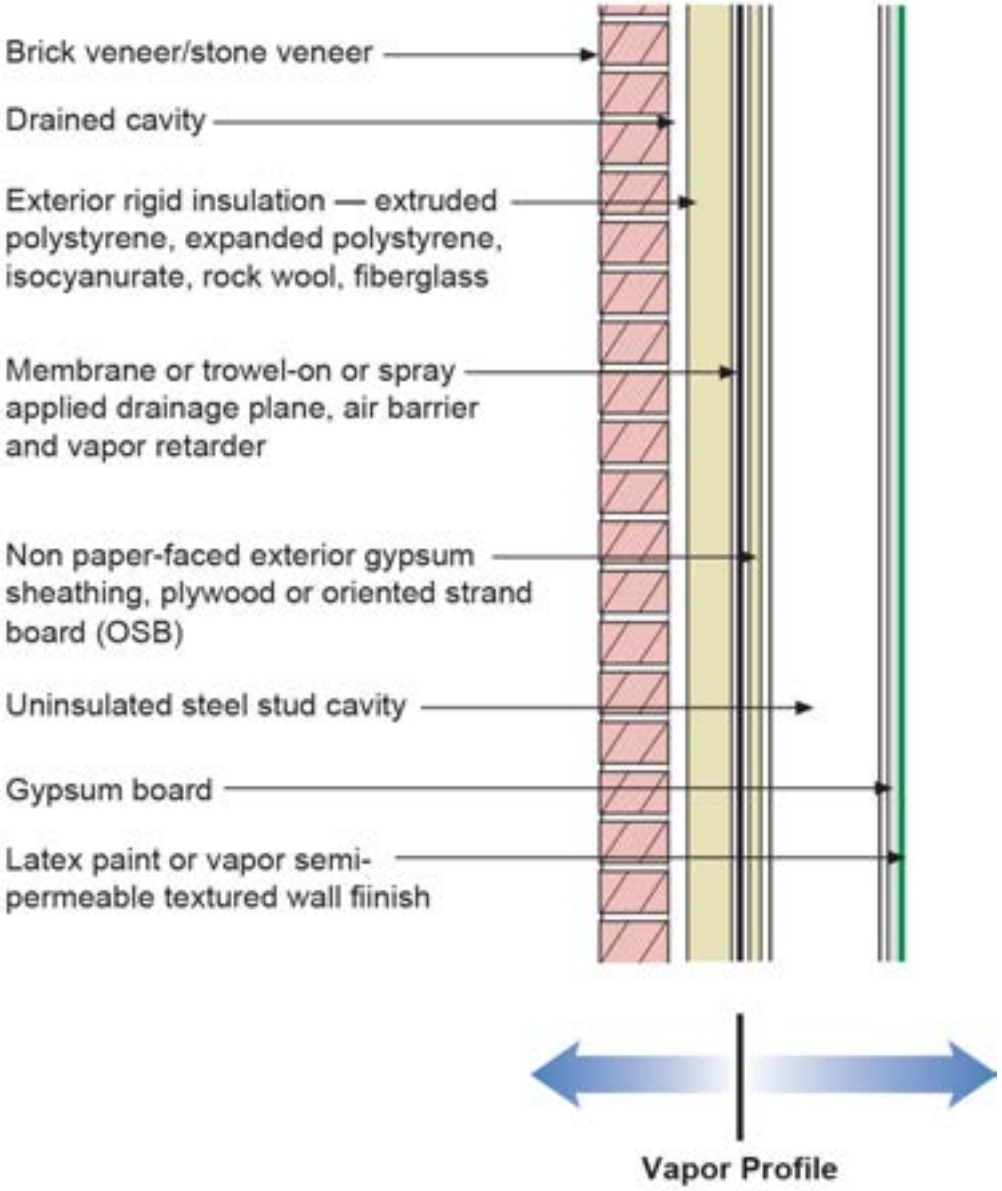

Roof
Wall
Slab

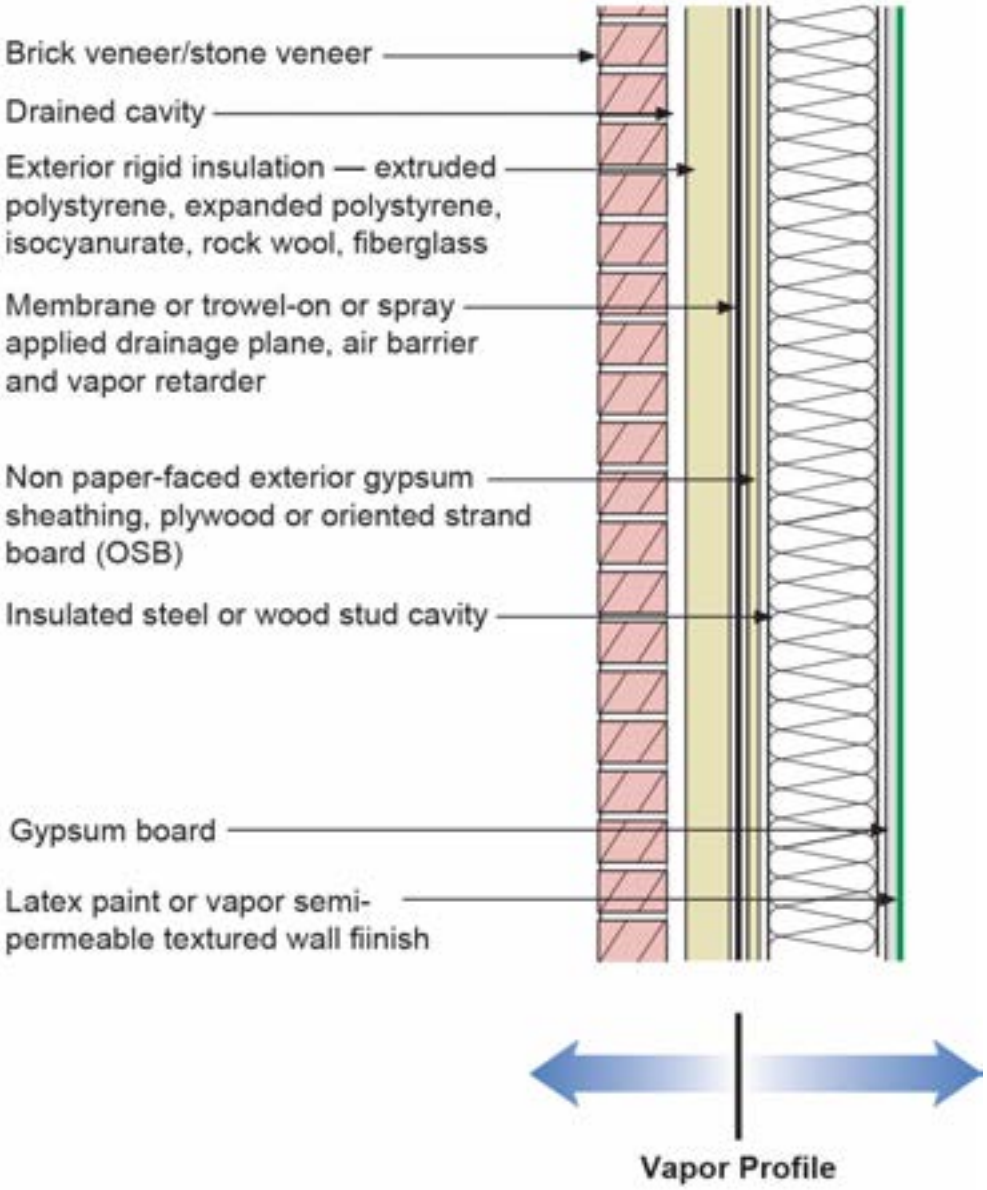

Parapet
Roof
Wall
Slab


Parapet
Roof
Wall
Footing
Slab


Parapet
Roof
Window
Wall
Footing
Slab


Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile


Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile


Brick veneer/stone veneer
Drained cavity
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Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated steel or wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

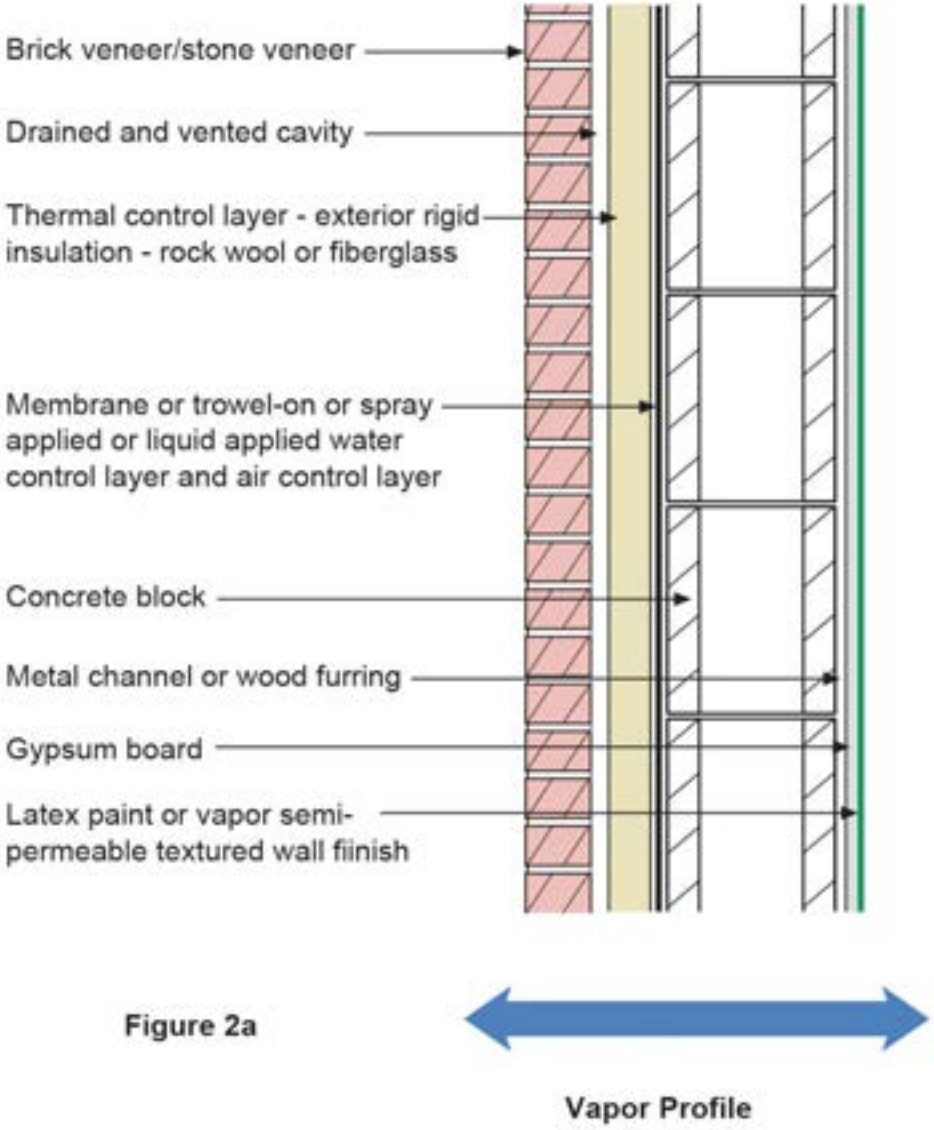

Brick veneer/stone veneer
Drained and vented cavity
Thermal control layer - exterior rigid insulation - rock wool or fiberglass
Membrane or trowel-on or spray applied or liquid applied water control layer and air control layer
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

Figure 2a

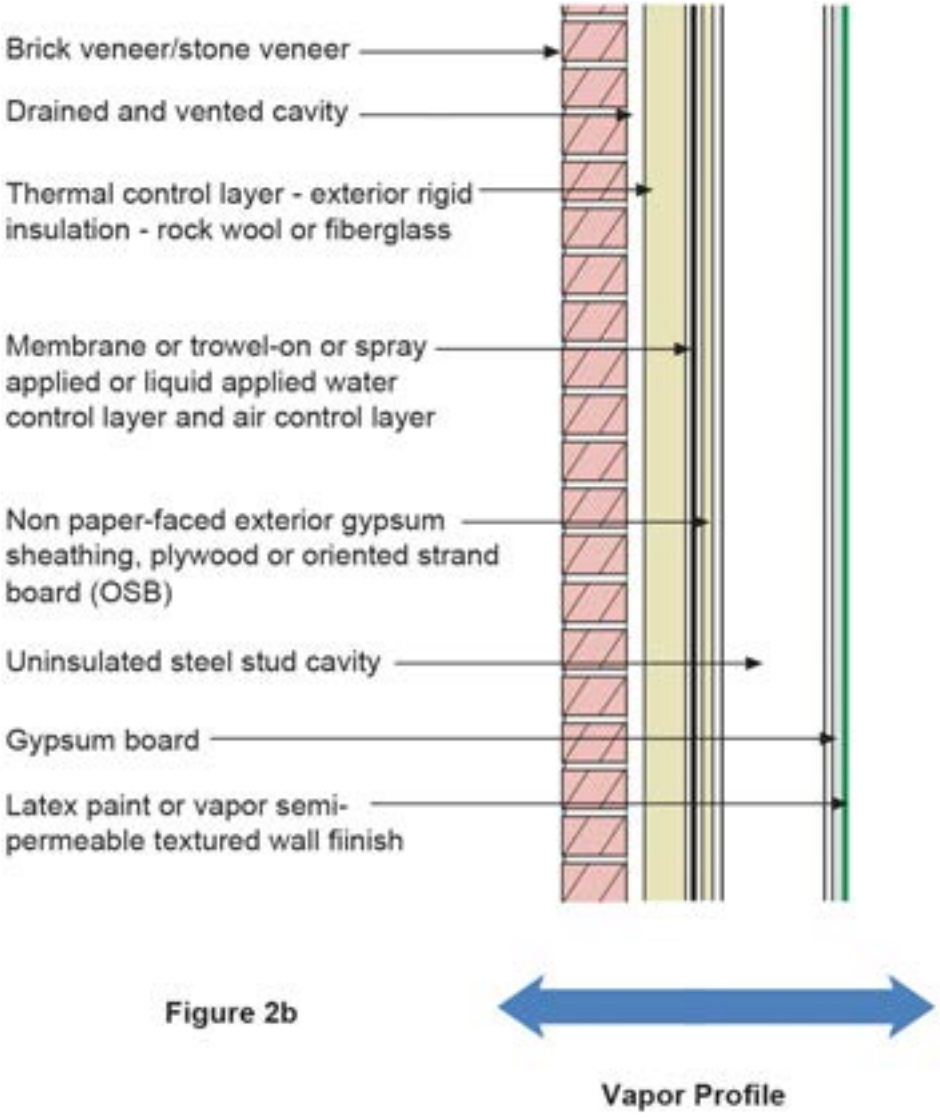

Brick veneer/stone veneer
Drained and vented cavity
Thermal control layer - exterior rigid insulation - rock wool or fiberglass
Membrane or trowel-on or spray applied or liquid applied water control layer and air control layer
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

Figure 2b

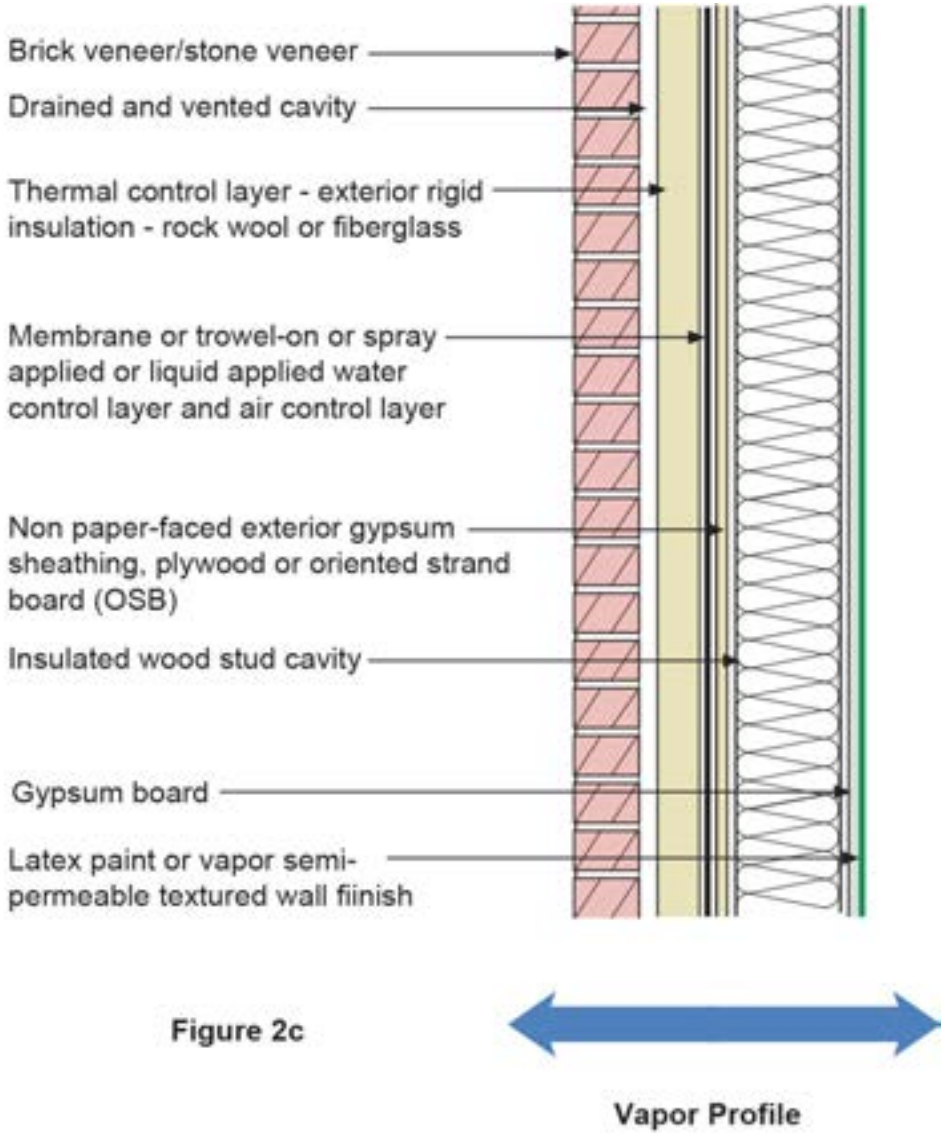
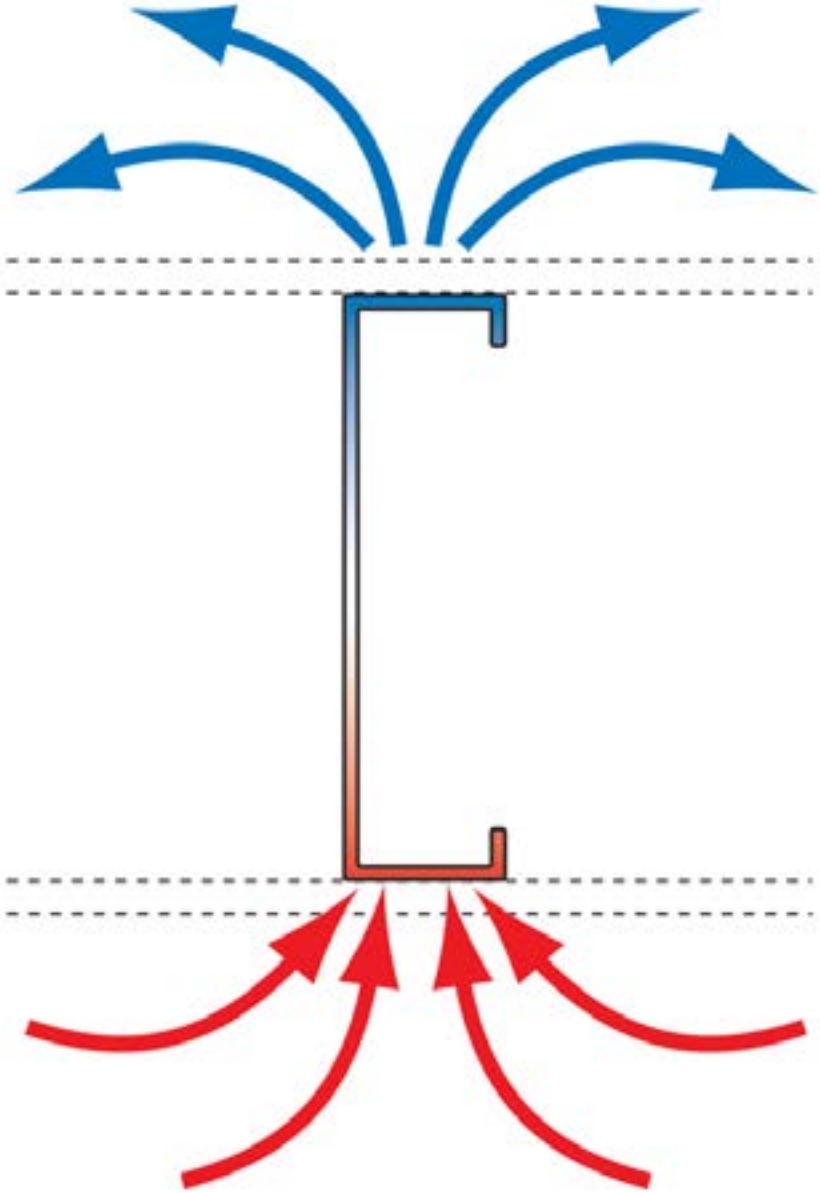
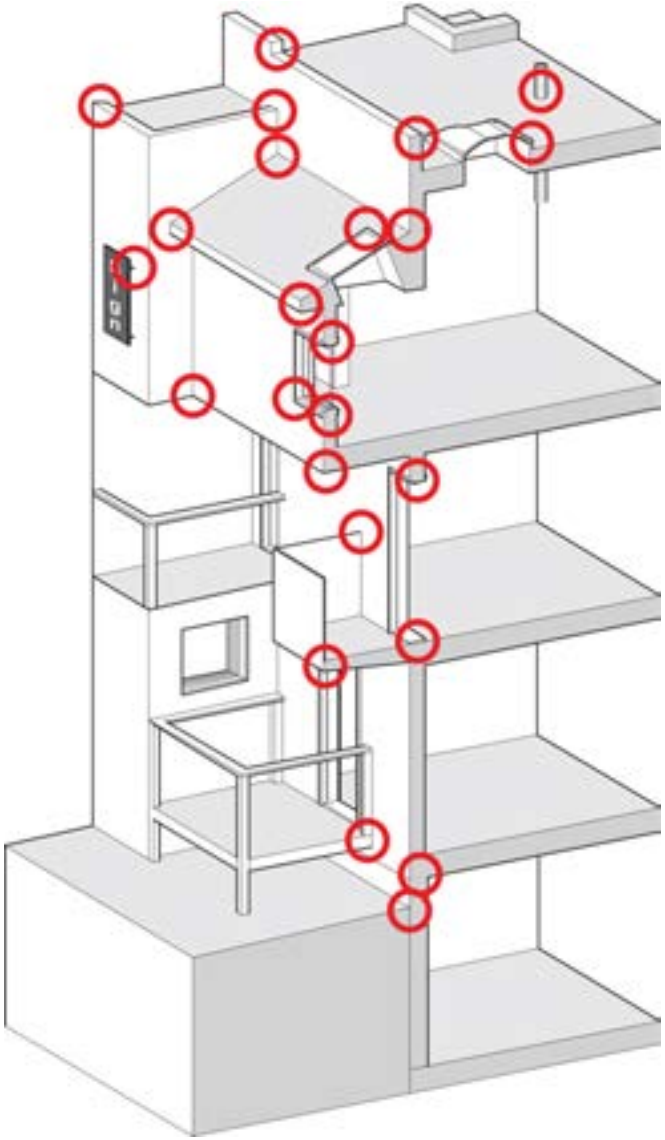

Brick veneer/stone veneer
Drained and vented cavity
Thermal control layer - exterior rigid insulation - rock wool or fiberglass
Membrane or trowel-on or spray applied or liquid applied water control layer and air control layer
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile

Figure 2c



Commercial Enclosure: Simple Layers

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



GP
DensGlass
Sheathing
GP
Polyguard

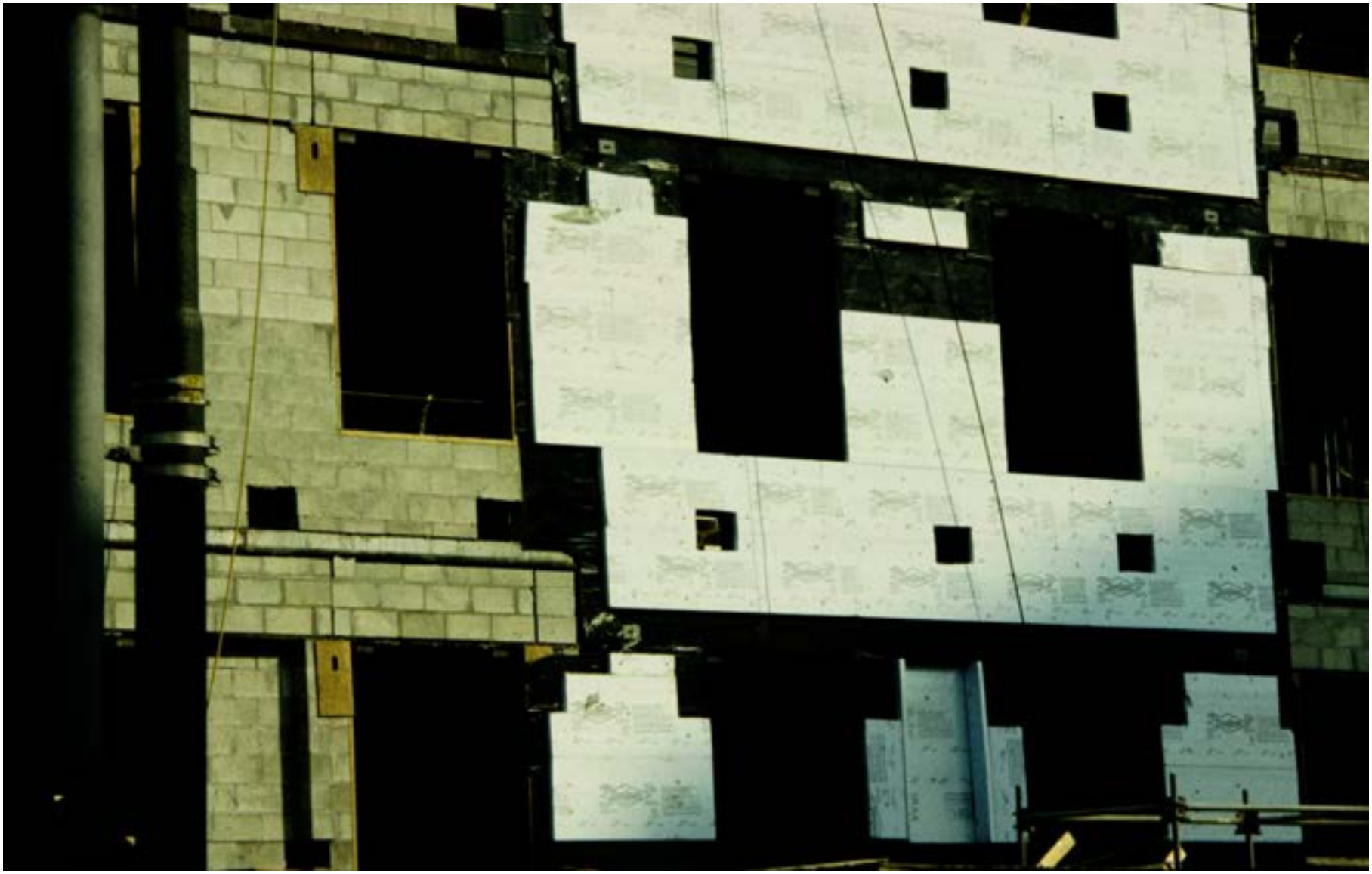

DU PONT


StraightFlash


DUPONT
DUPONT


StraightFlash
StraightFlash


CONGRESS




HARVARD SCHOOL OF PUBLIC HEALTH


CAUTION


GP
GLASS GOLD


GP
DENSGLASS GOLD
Exterior Sheathing
GP
DENSGLASS GOLD
Exterior Sheathing

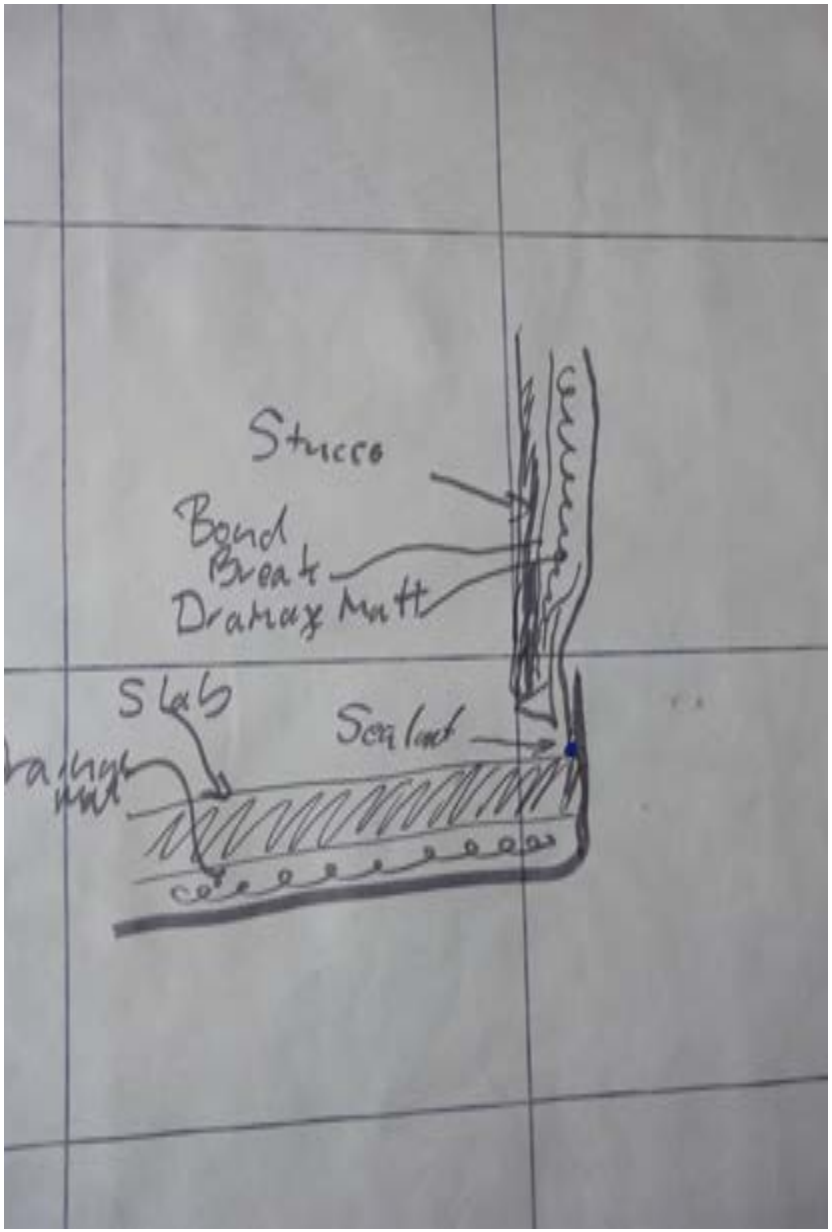

Blueskin


soprasEAL


GS-5390
GP
DensGlass
Sheathing


DensGlass


yvek


Stucco
Bond Break
Dramex Mutt
Slab
Sealant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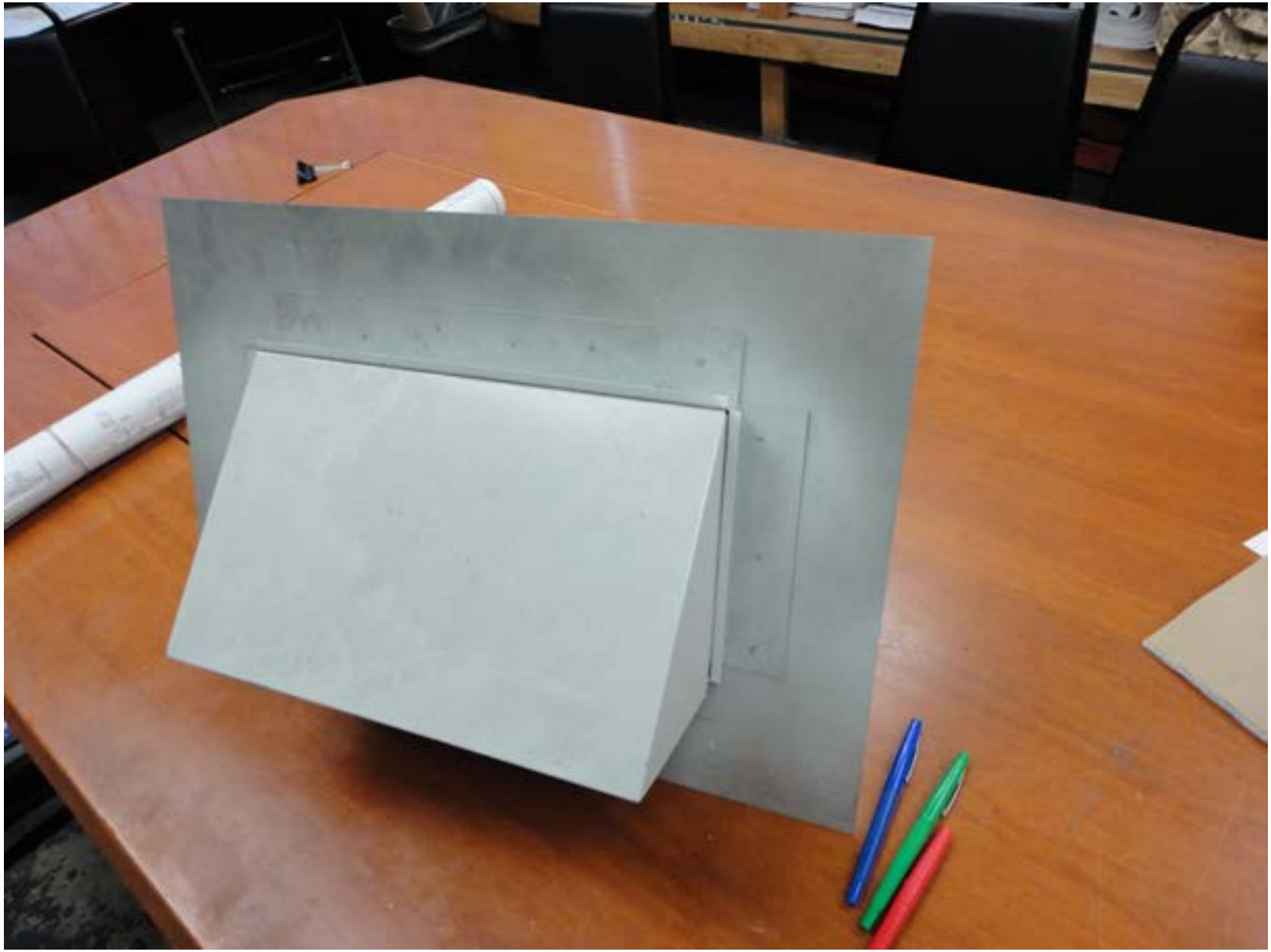
KEEP OUT
LUCIANO


BARRICADE
Pulte Homes


StraightFlash
DU PON
StraightFlash
FlexWrap NF

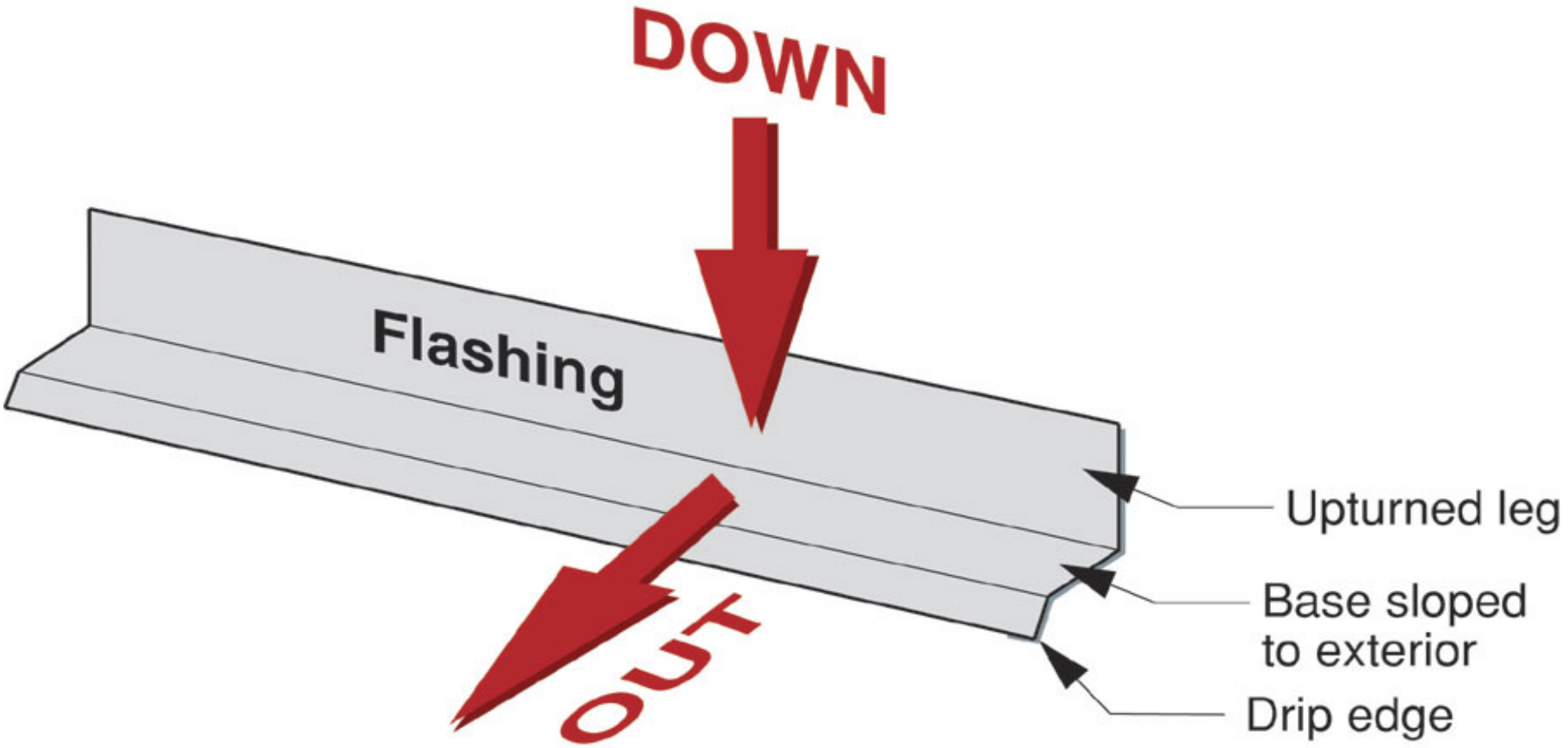

TallWall
TallWall
TallWall
TallWall

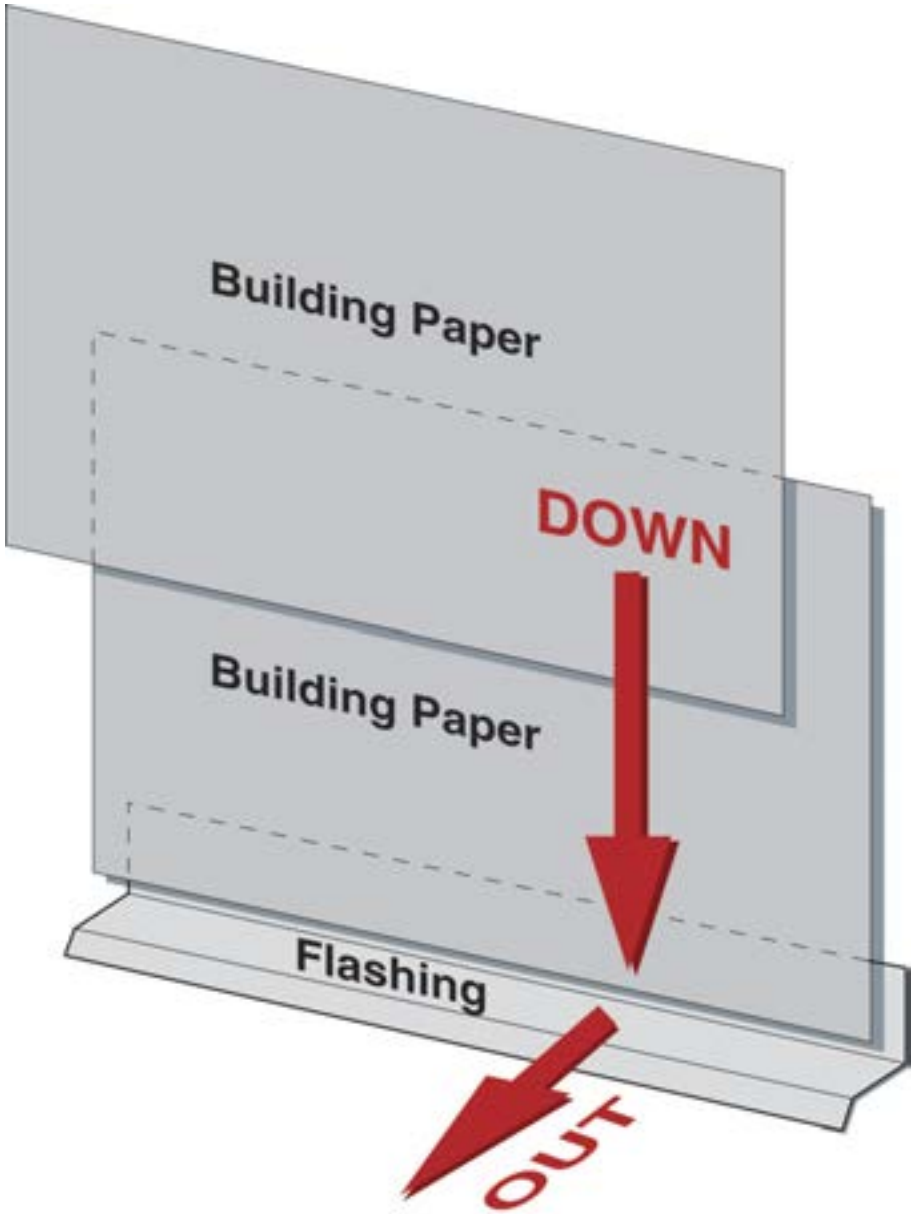


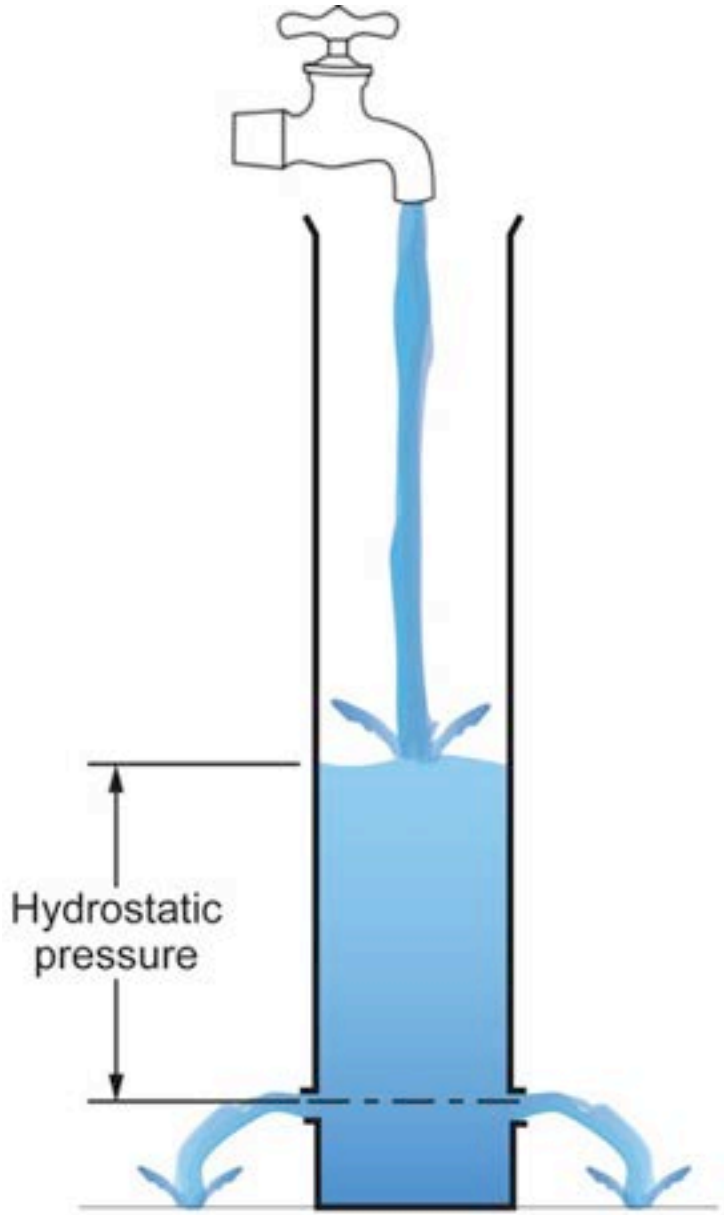

MOISTOP
MOISTOP
alsco
3700

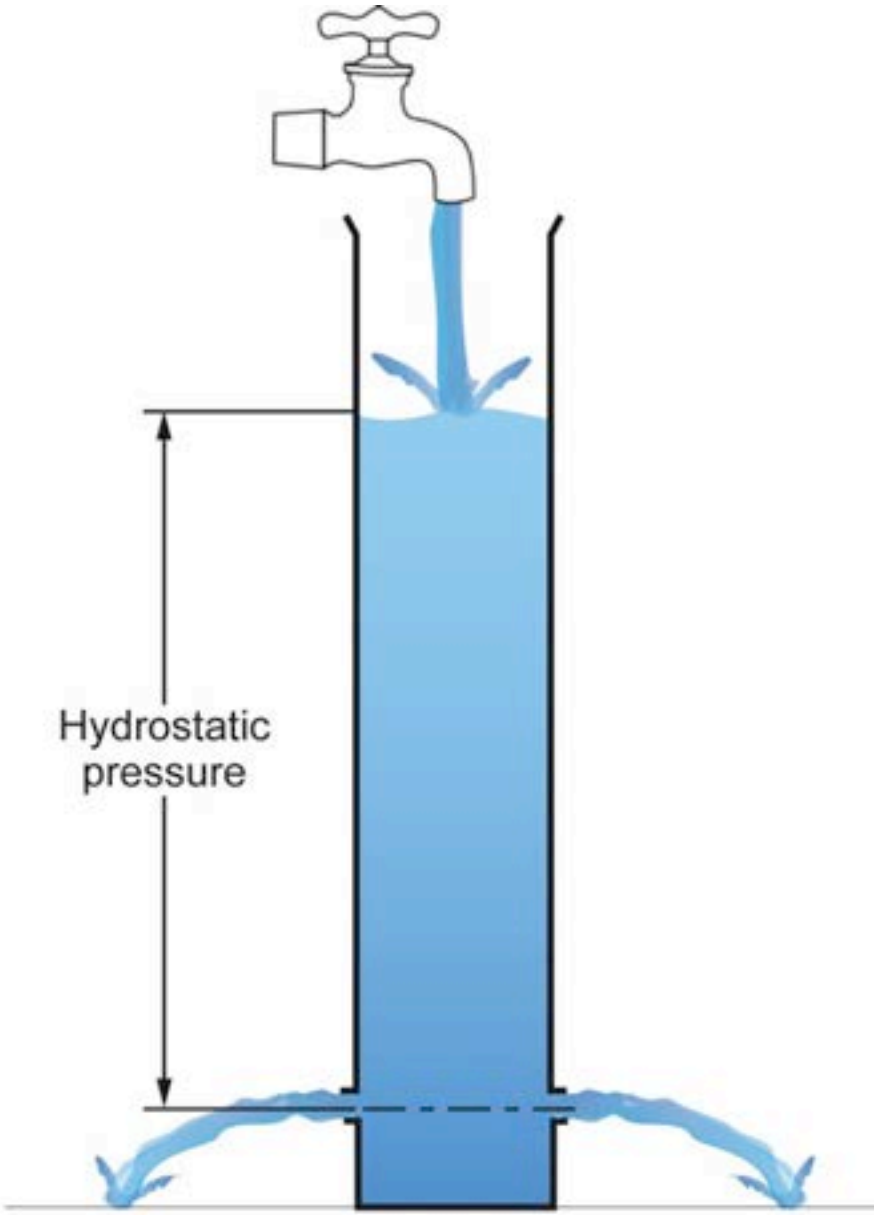

GP
sGlass™
eathing
GP
DensG
Sheathi

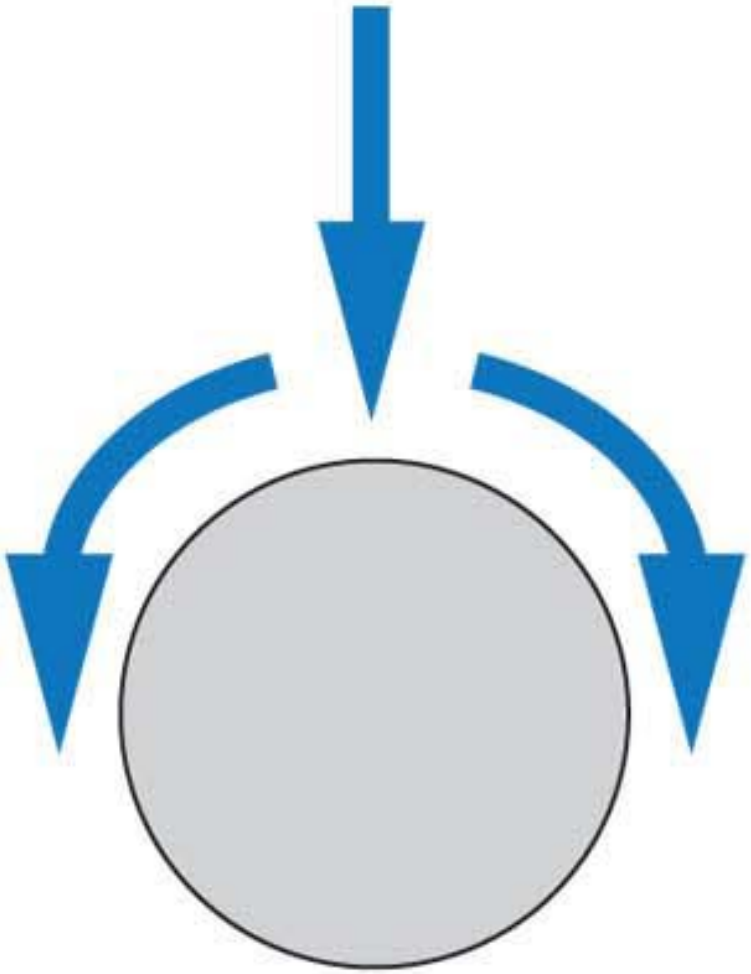

rmax ci
Isolant extérie
Thermax ci
Aislamiento Ext
THERM X ci

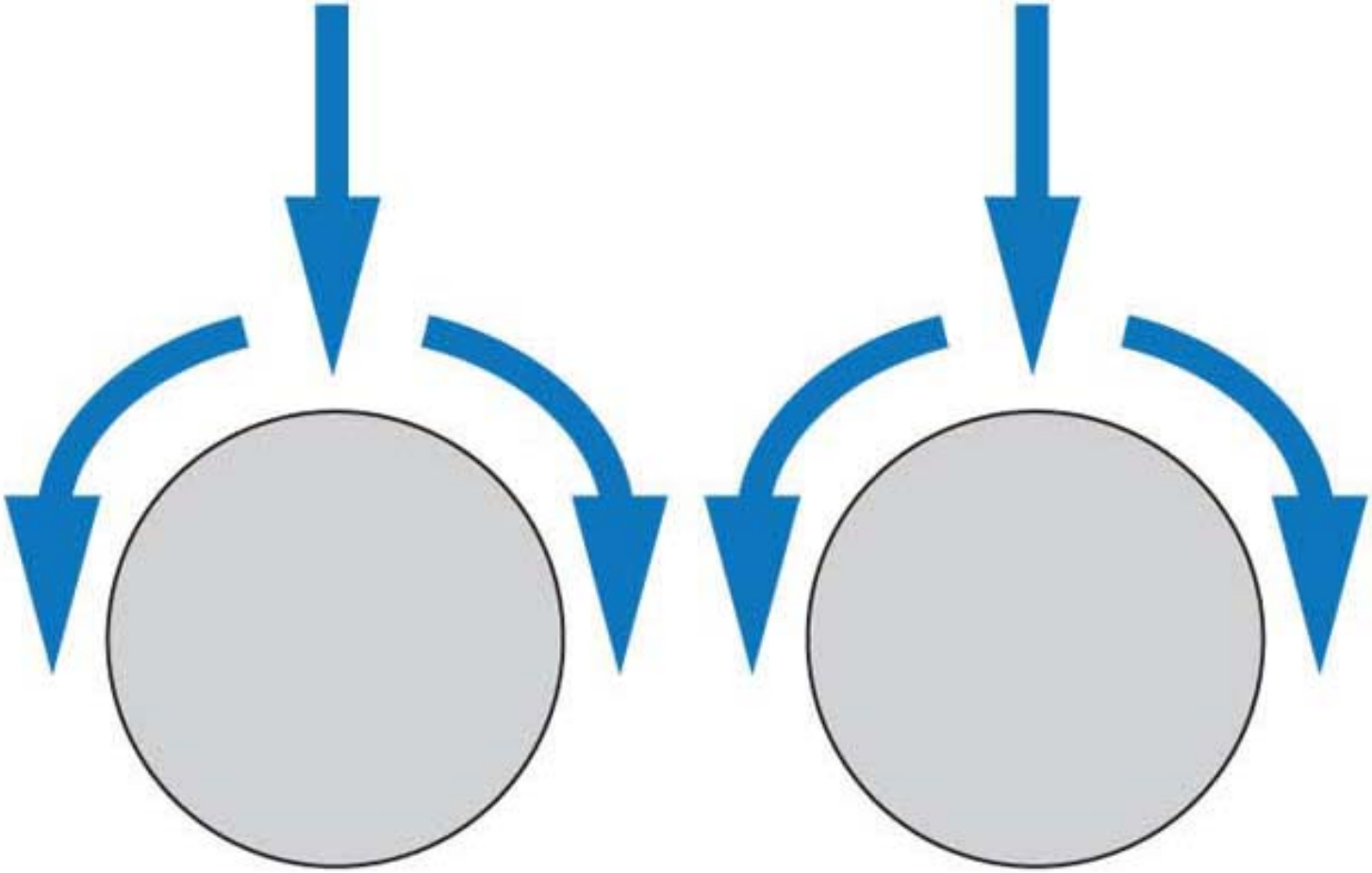

DOWN
Flashing
OUT
Upturned leg
Base sloped
to exterior
Drip edge

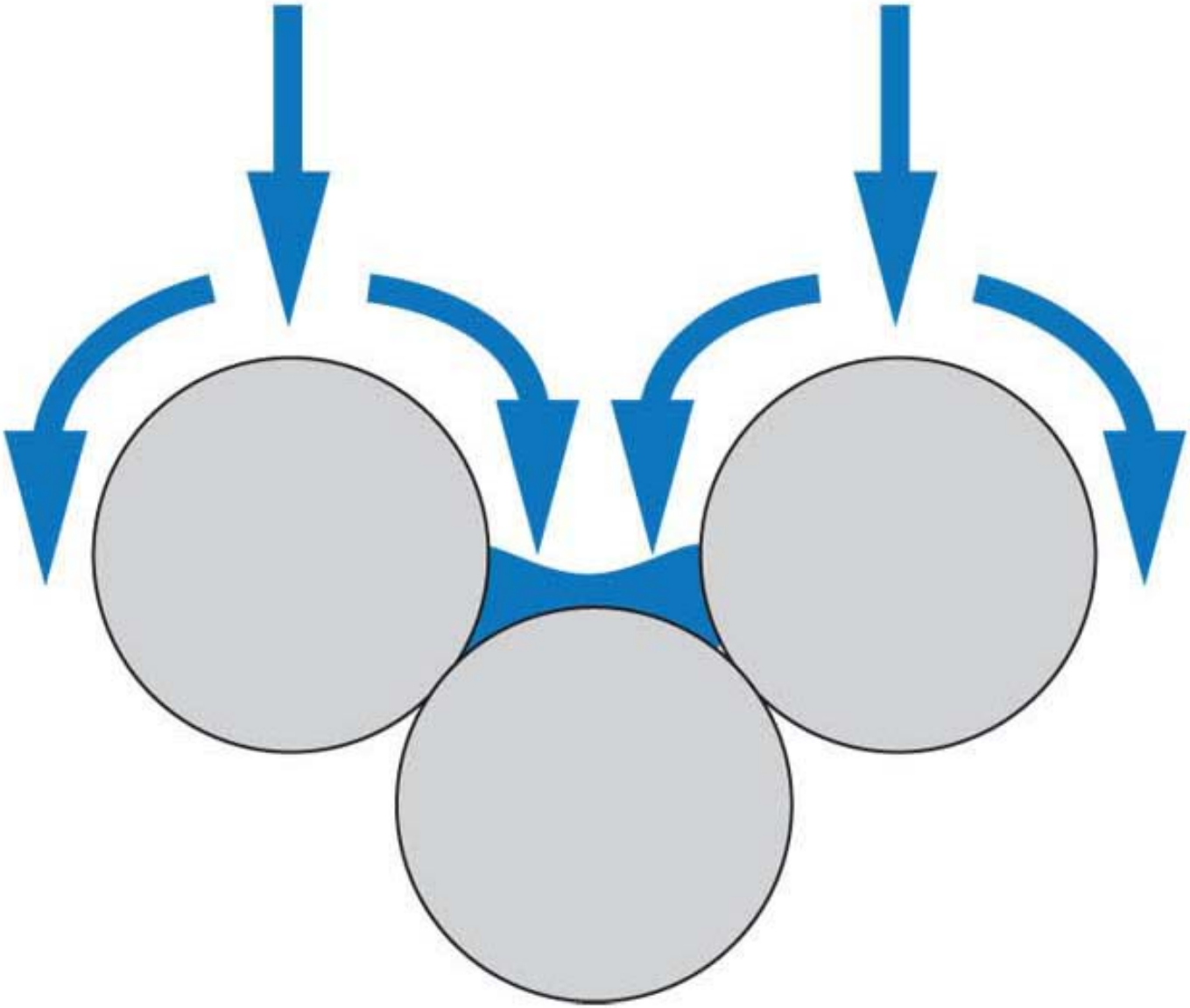

Building Paper
DOWN
Building Paper
Flashing
OUT

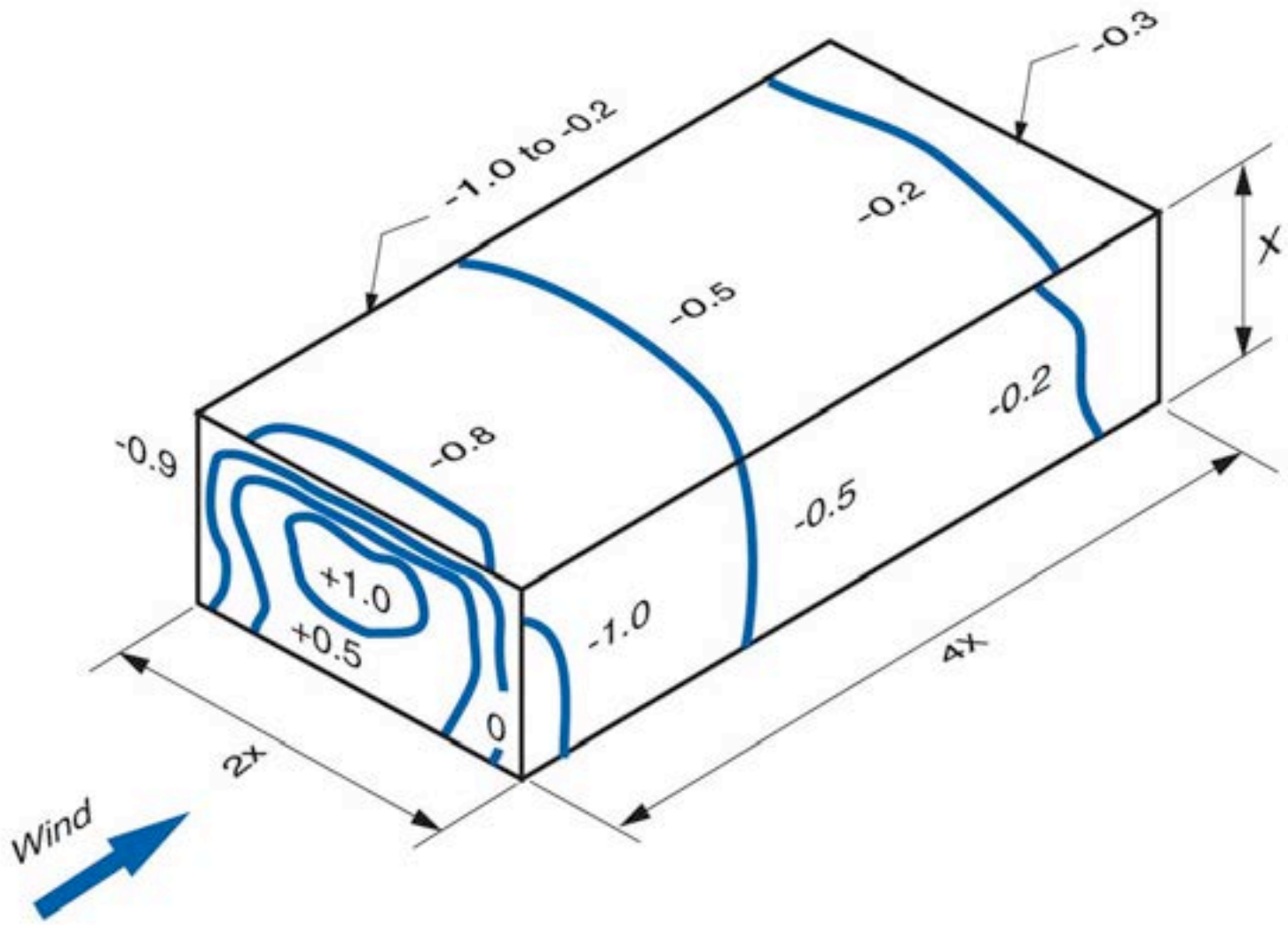

Hydrostatic
pressure


Hydrostatic
pressure

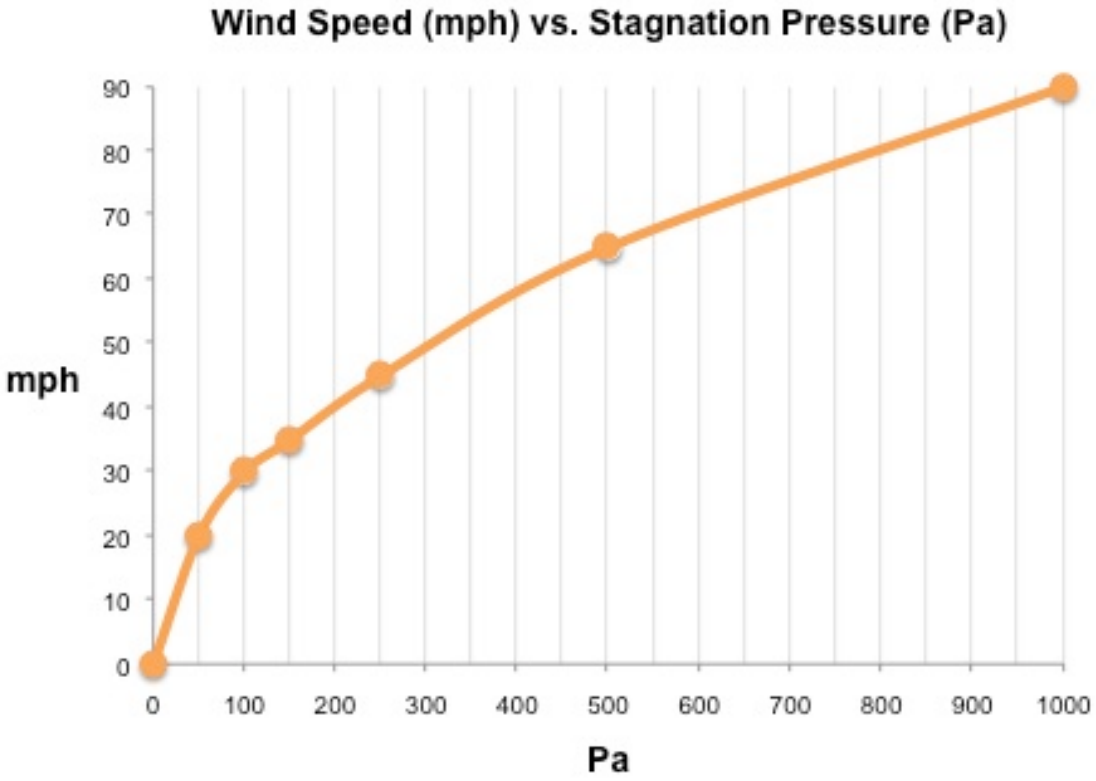







-0.3
-1.0 to -0.2
-0.2
-0.5
-0.2
-0.9
-0.8
-0.5
+1.0
+0.5
-1.0
0
X
2X
4X
Wind

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




DUPONT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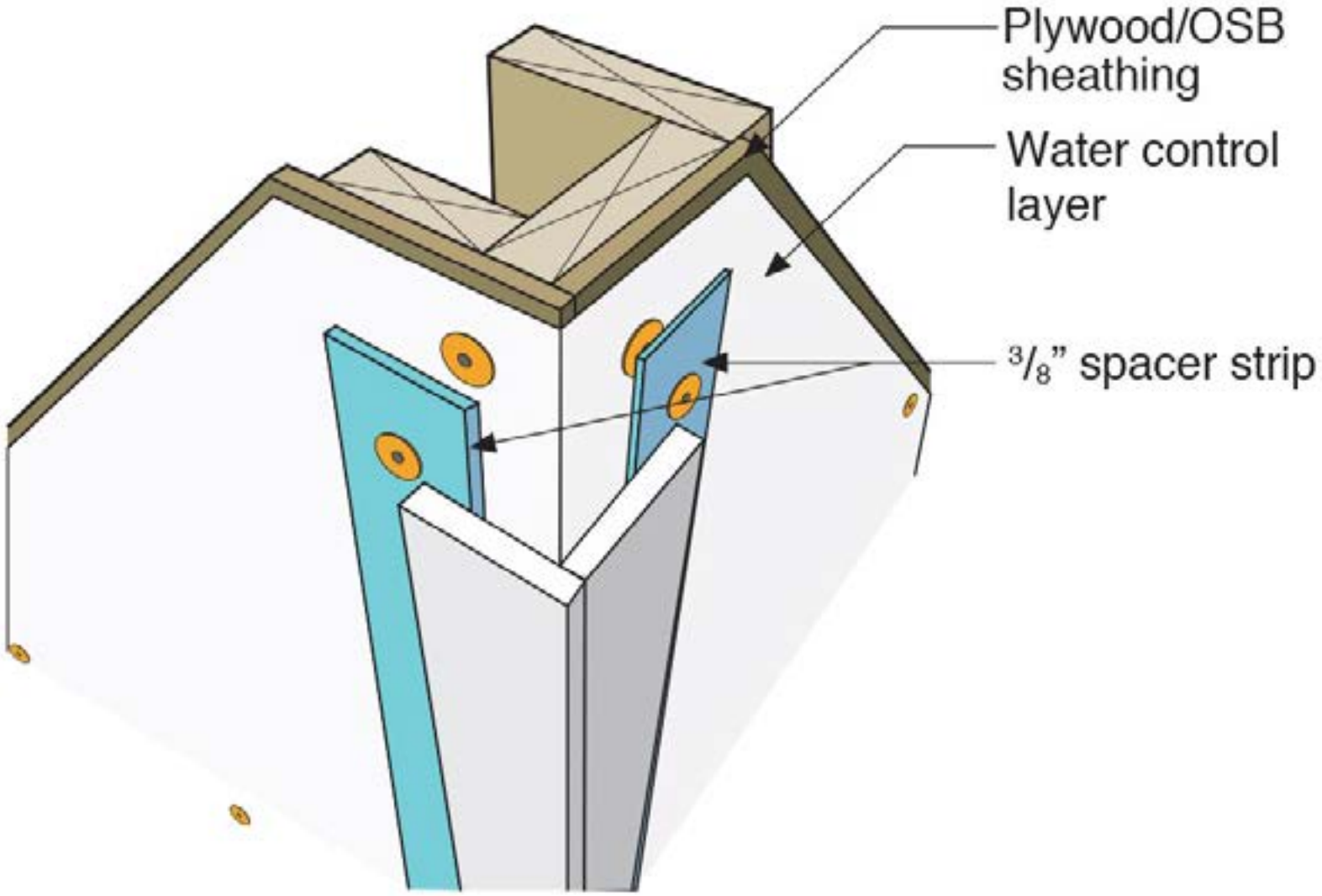
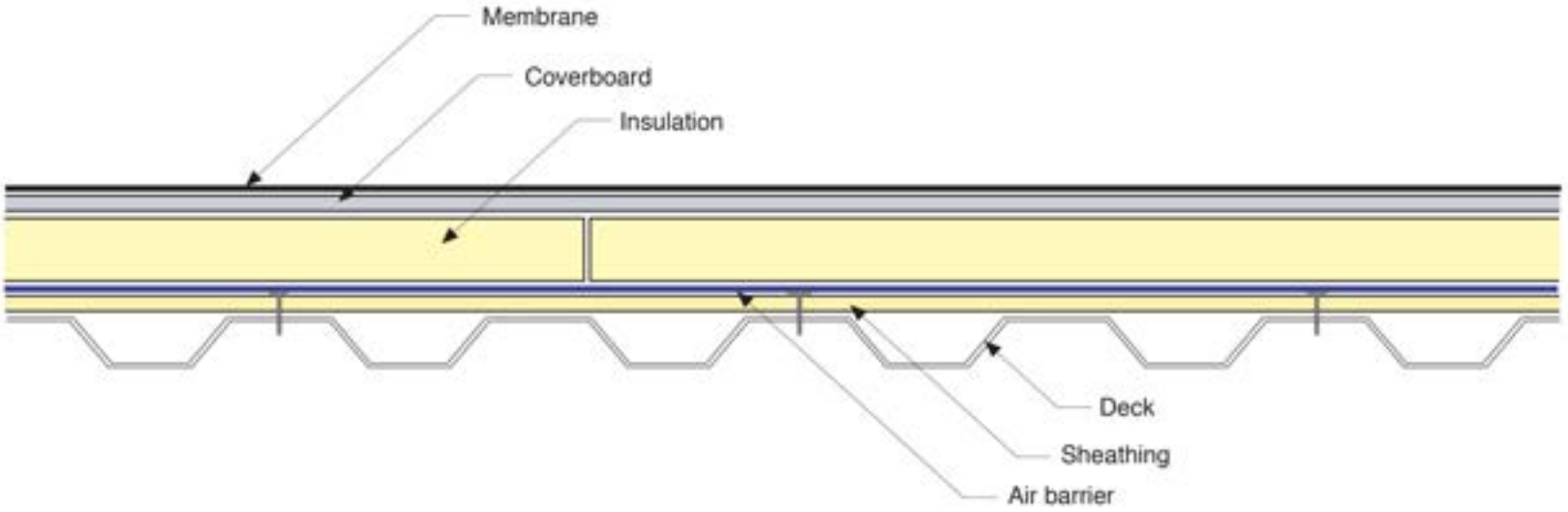
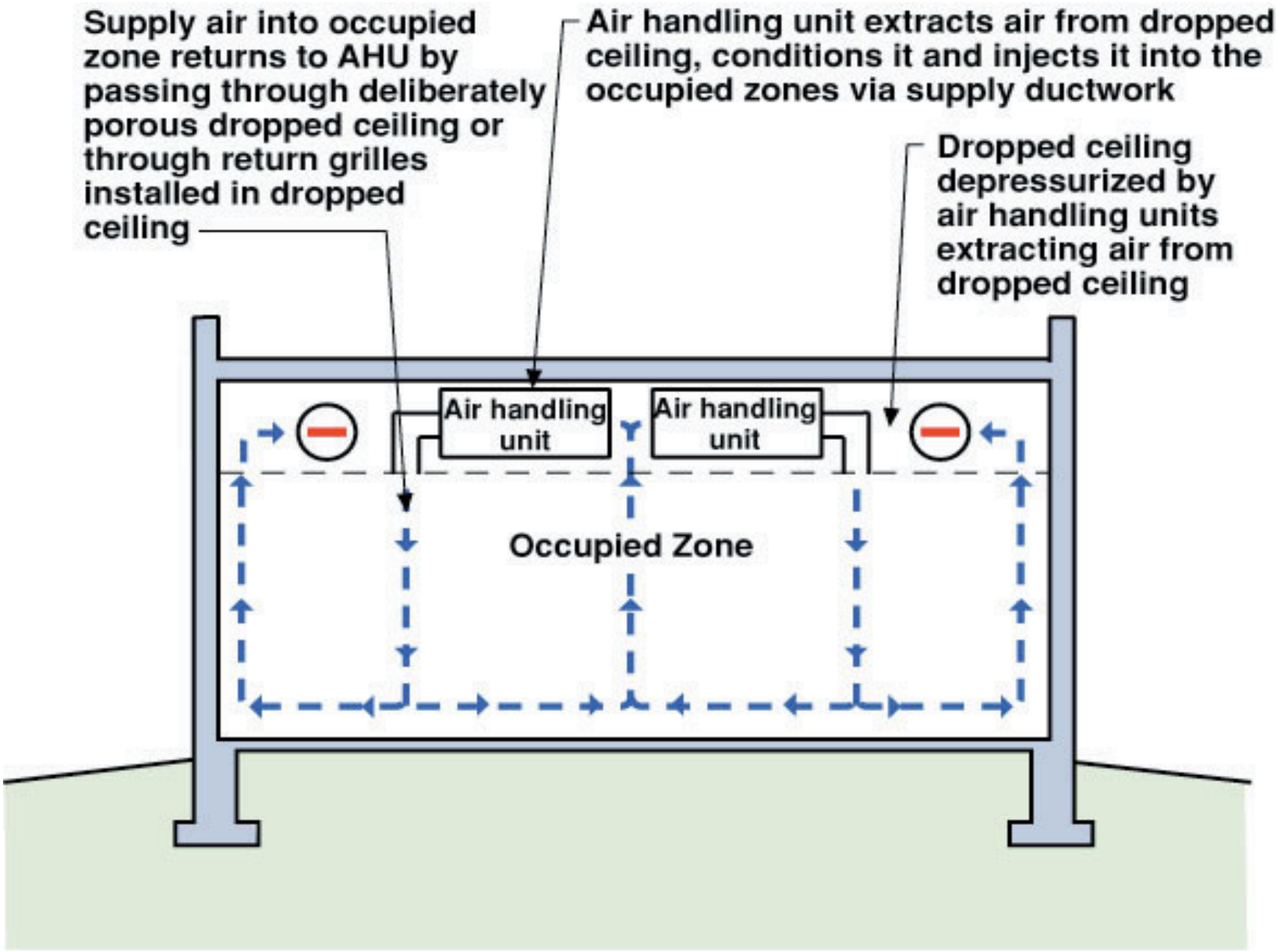
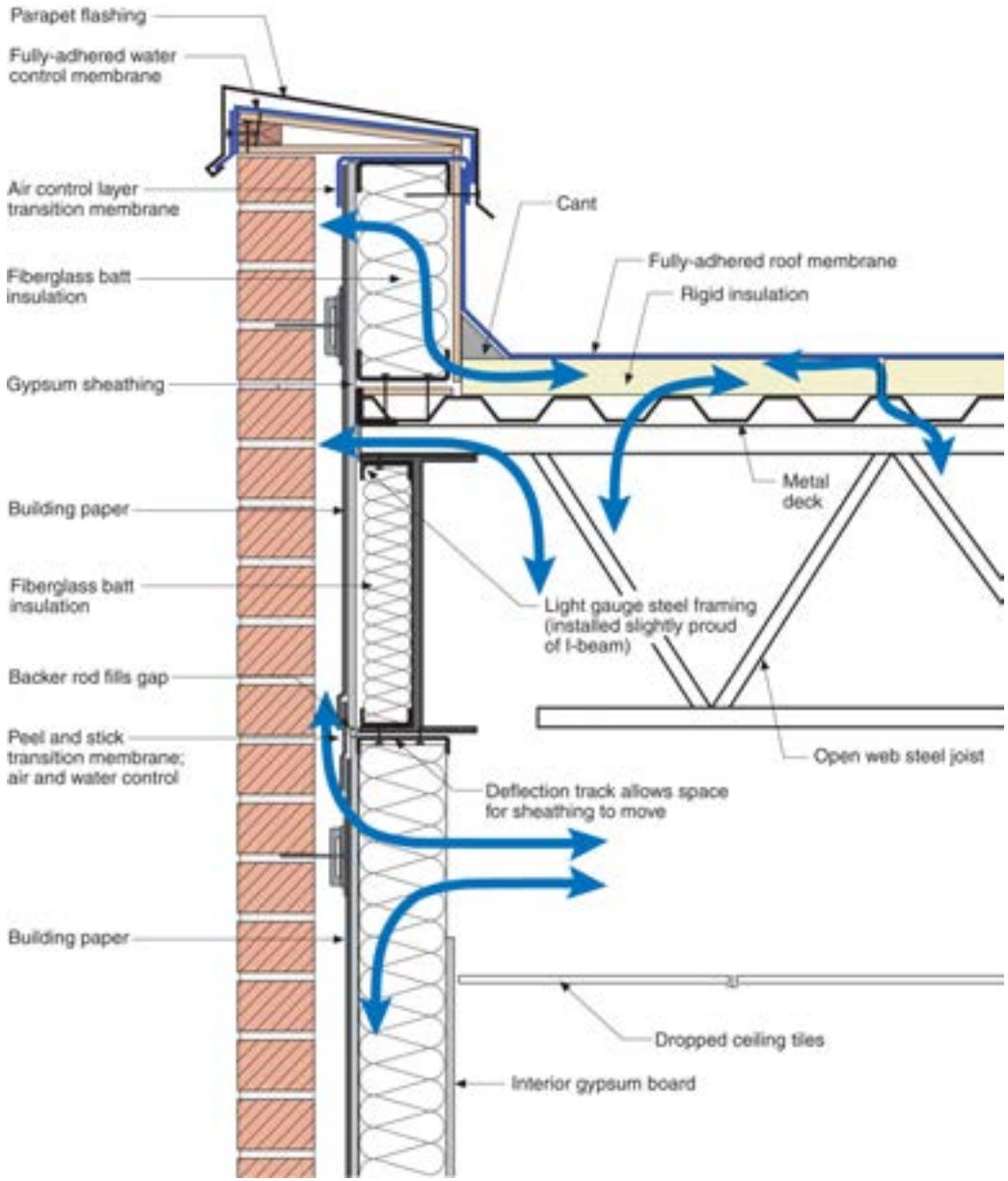
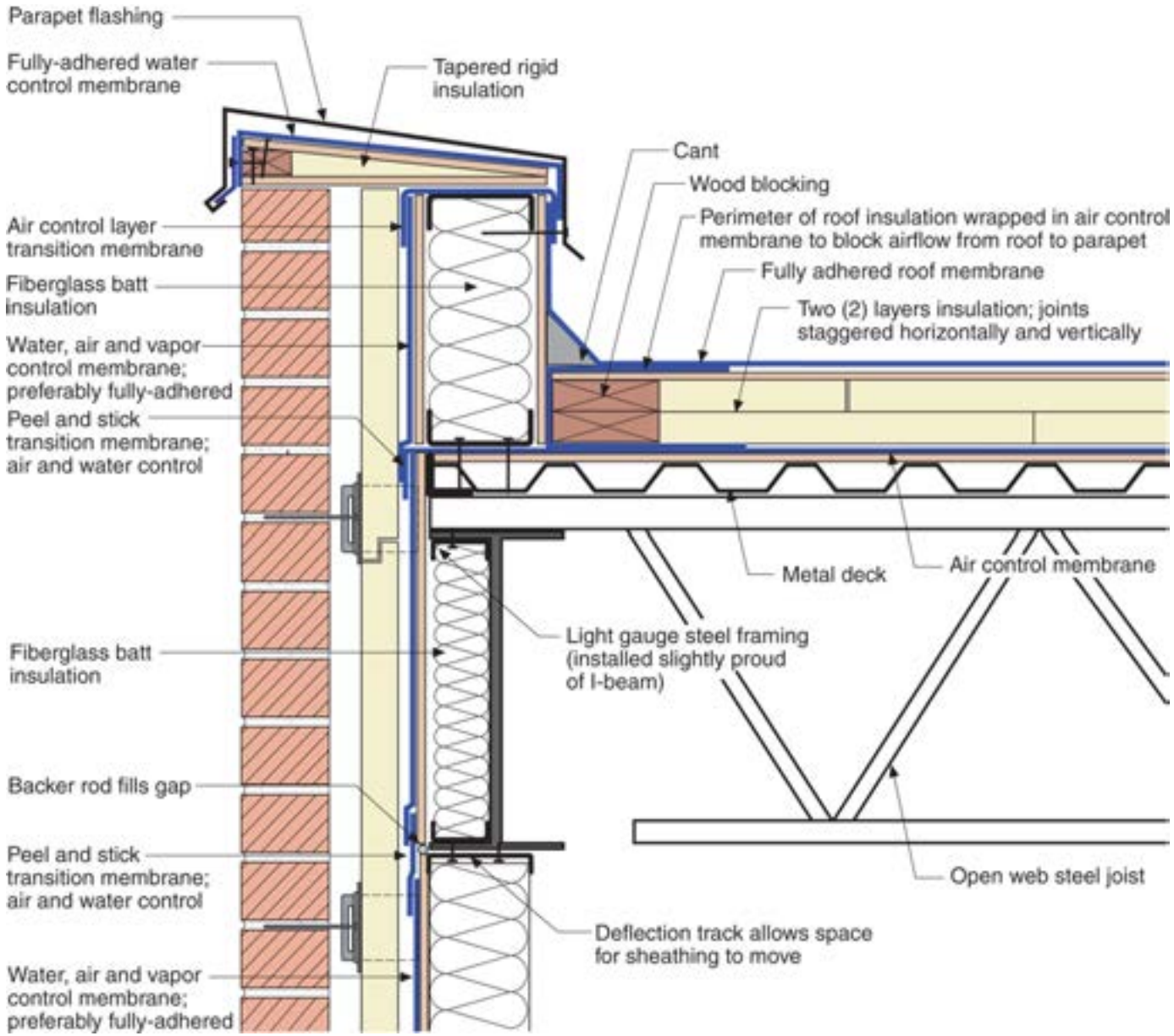

Plywood/OSB sheathing
Water control layer
3/8" spacer strip


Membrane
Coverboard
Insulation
Deck
Sheathing
Air barrier

Air Leakage


Supply air into occupied zone returns to AHU by passing through deliberately porous dropped ceiling or through return grilles installed in dropped ceiling
Air handling unit extracts air from dropped ceiling, conditions it and injects it into the occupied zones via supply ductwork
Dropped ceiling depressurized by air handling units extracting air from dropped ceiling
Air handling unit
Air handling unit
Occupied Zone


Parapet flashing
Fully-adhered water control membrane
Air control layer transition membrane
Fiberglass batt insulation
Gypsum sheathing
Building paper
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Building paper
Cant
Fully-adhered roof membrane
Rigid insulation
Metal deck
Light gauge steel framing (installed slightly proud of I-beam)
Open web steel joist
Deflection track allows space for sheathing to move
Dropped ceiling tiles
Interior gypsum board


Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Cant
Wood blocking
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Air control layer transition membrane
Fiberglass batt insulation
Water, air and vapor control membrane; preferably fully-adhered
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
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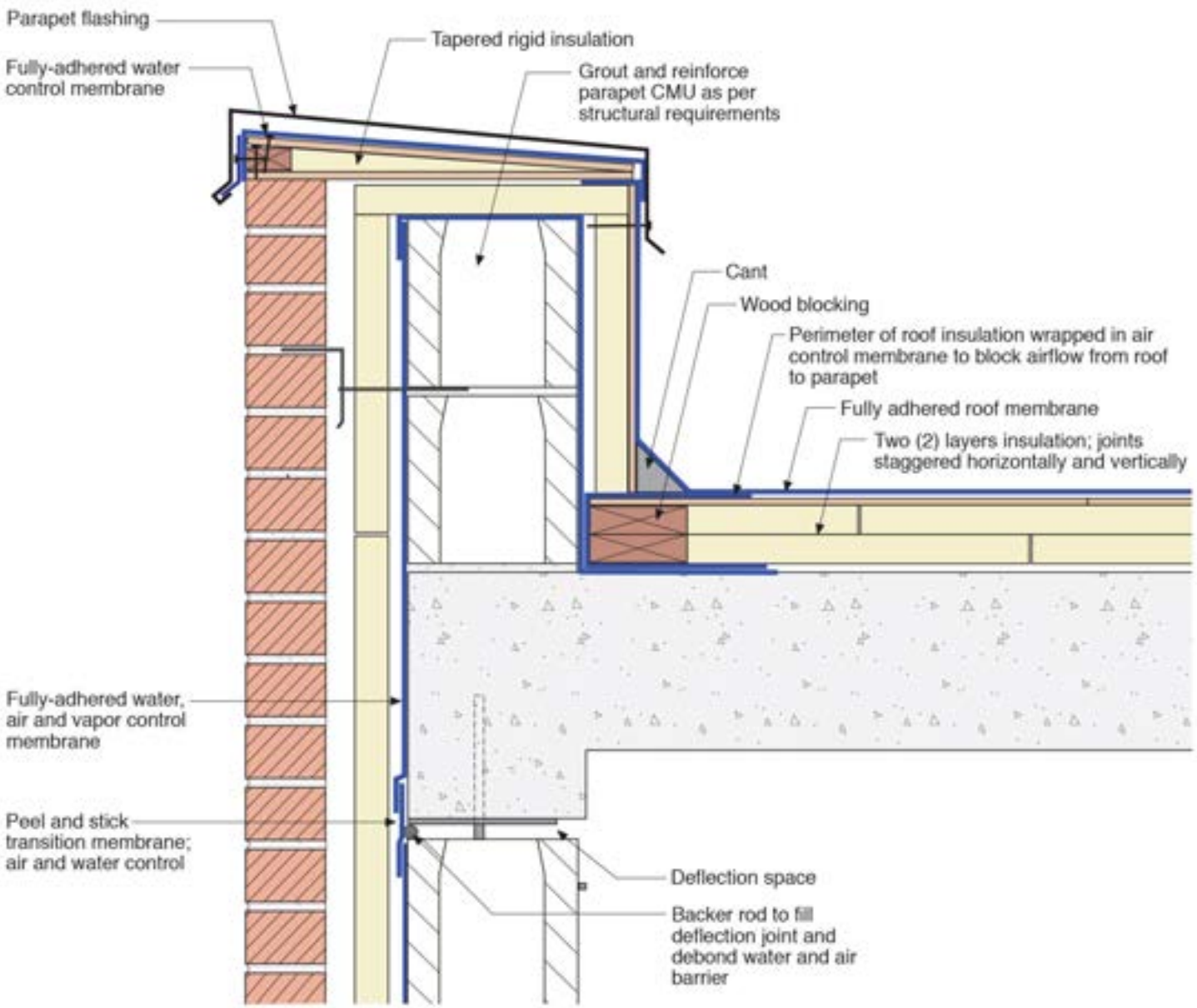
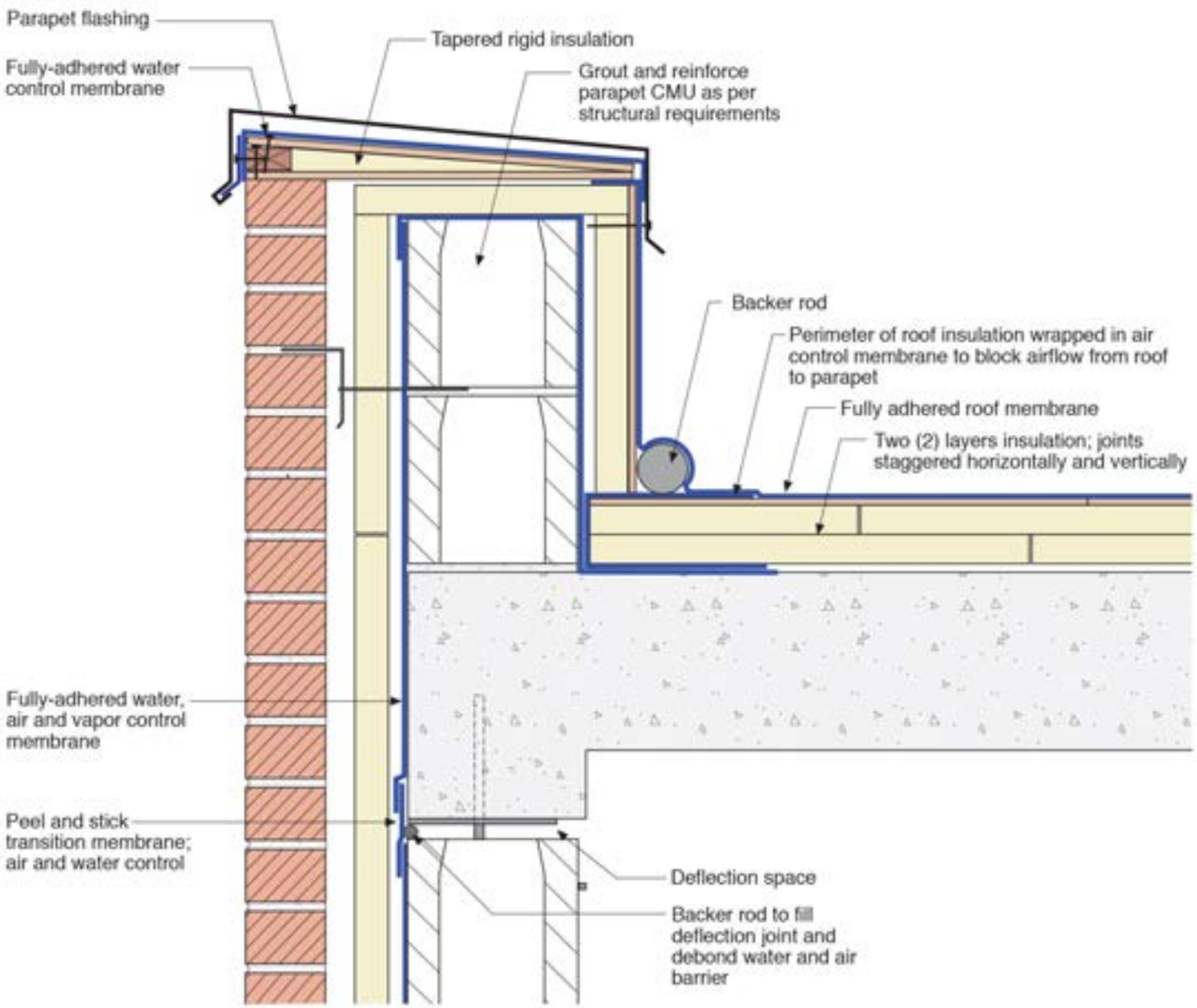

Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Grout and reinforce parapet CMU as per structural requirements
Cant
Wood blocking
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Fully-adhered water, air and vapor control membrane
Peel and stick transition membrane; air and water control
Deflection space
Backer rod to fill deflection joint and debond water and air barrier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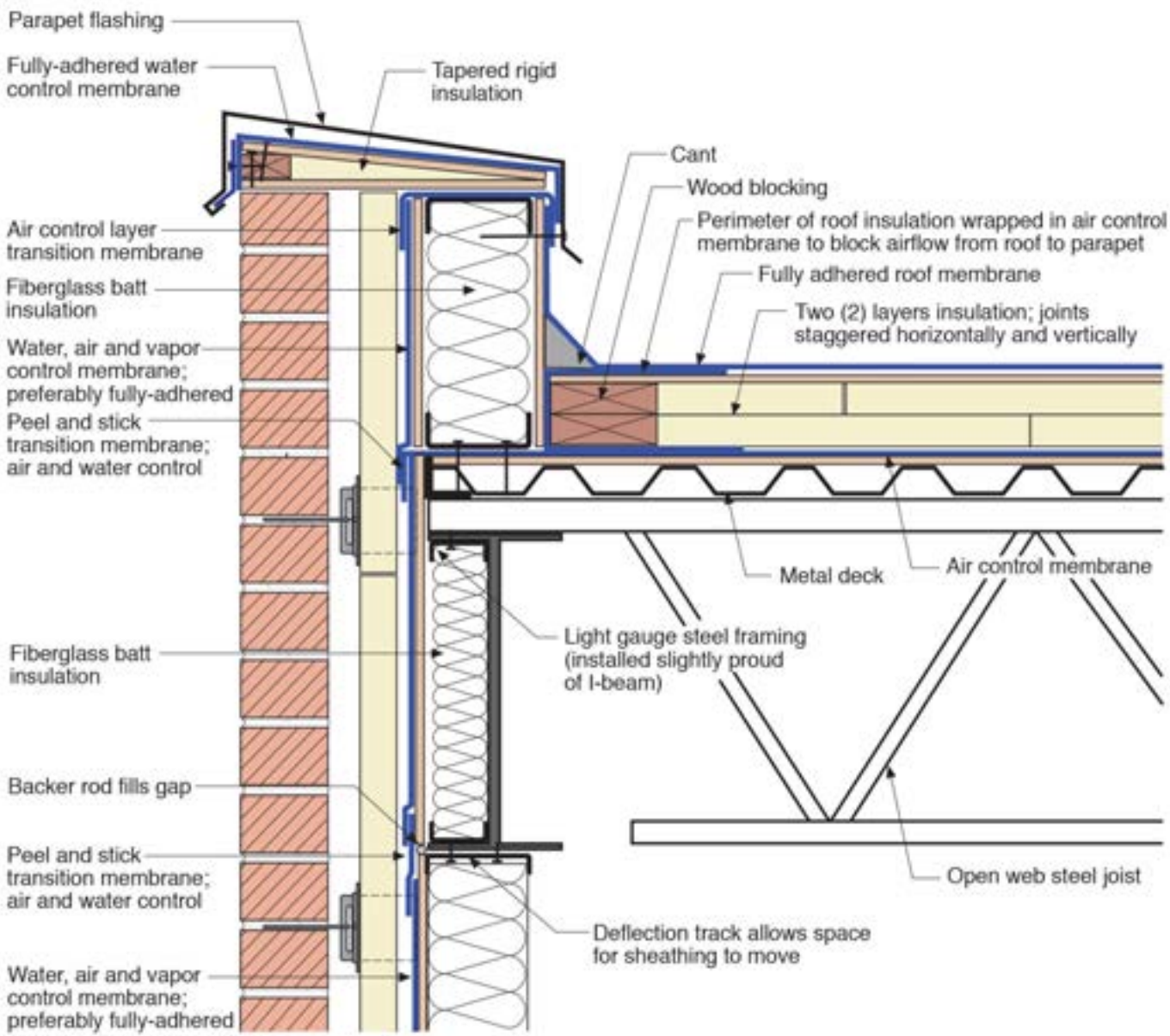
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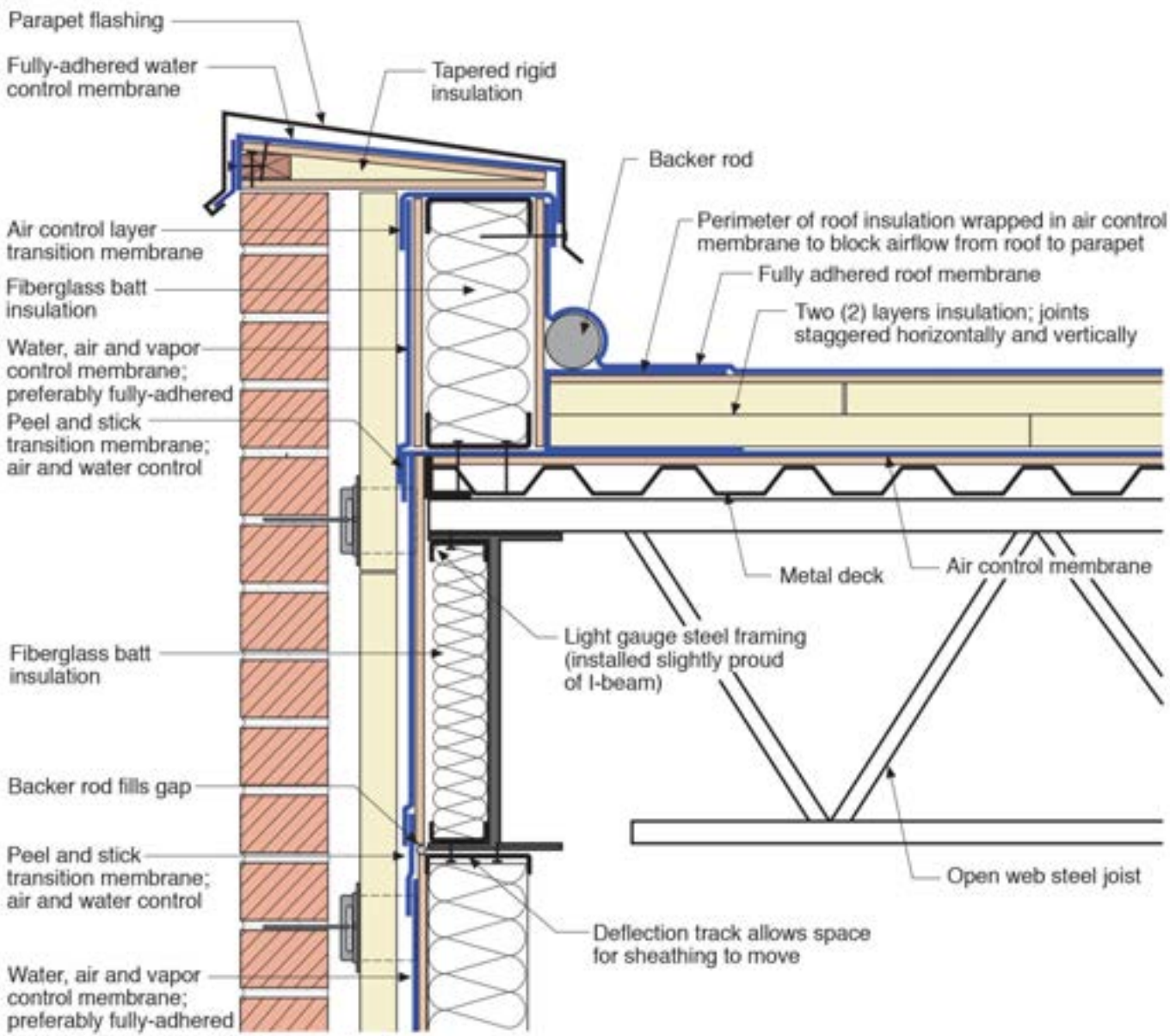
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Water, air and vapor control membrane; preferably fully-adhered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Backer rod
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Air control membrane
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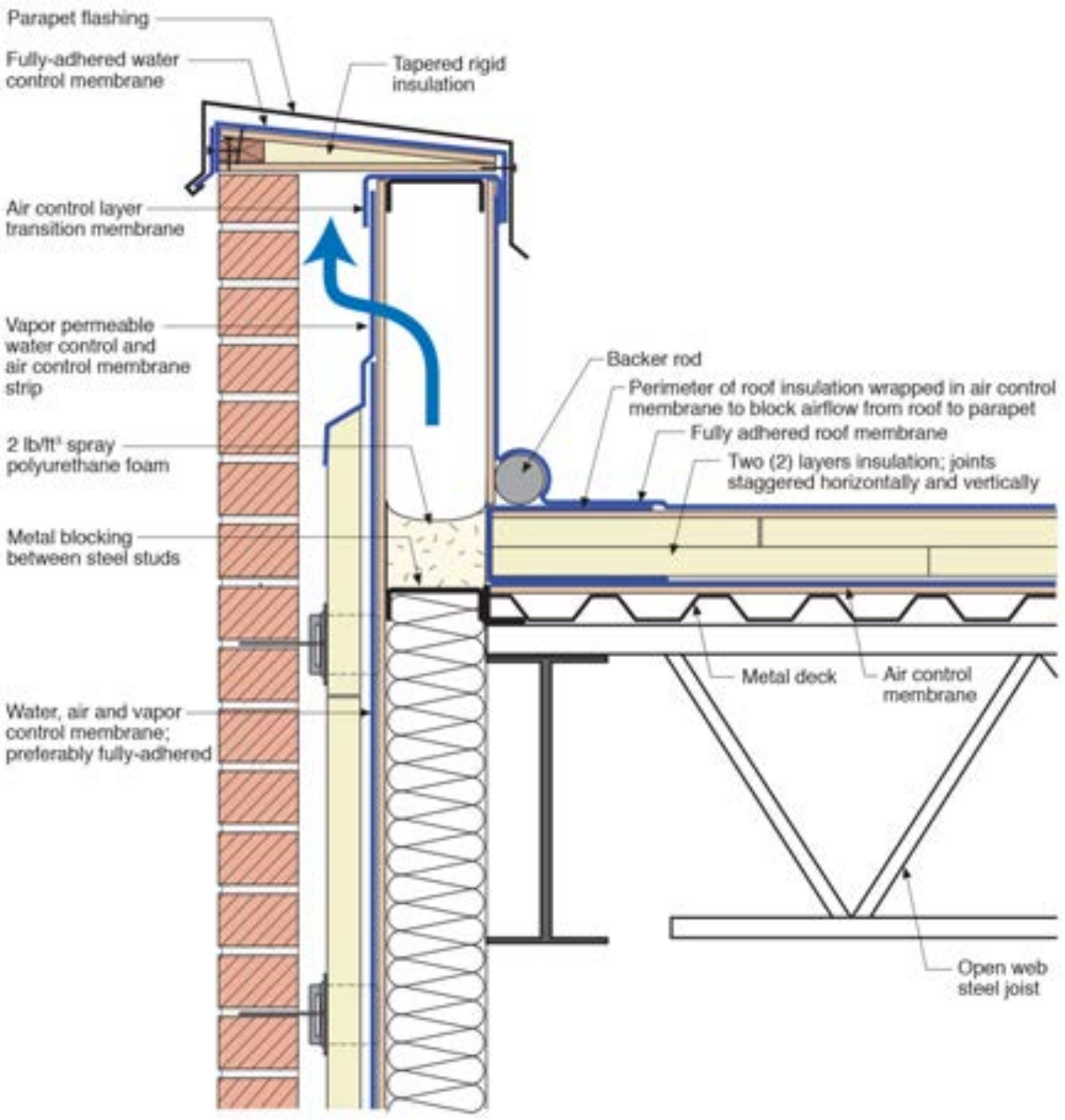
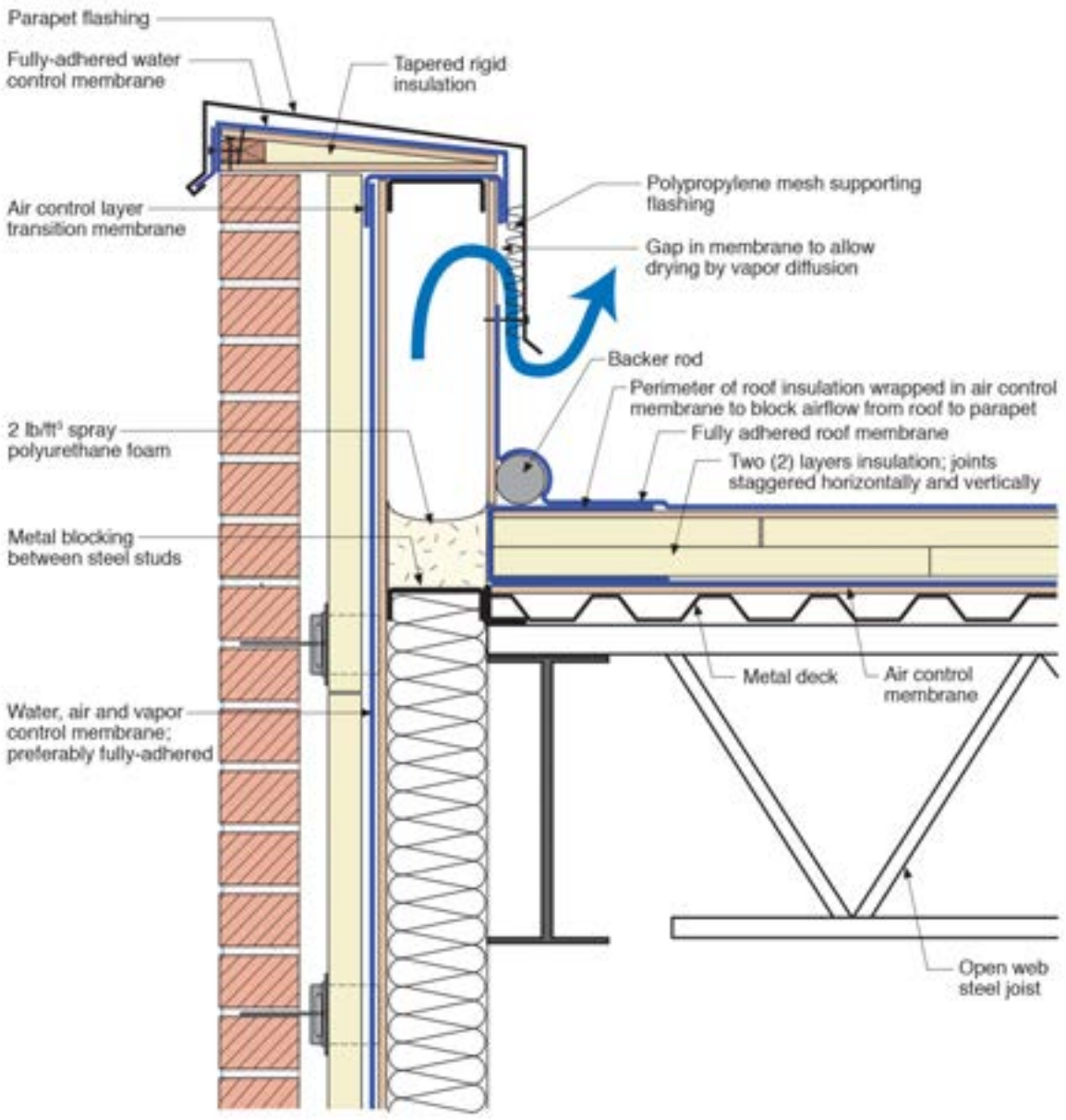
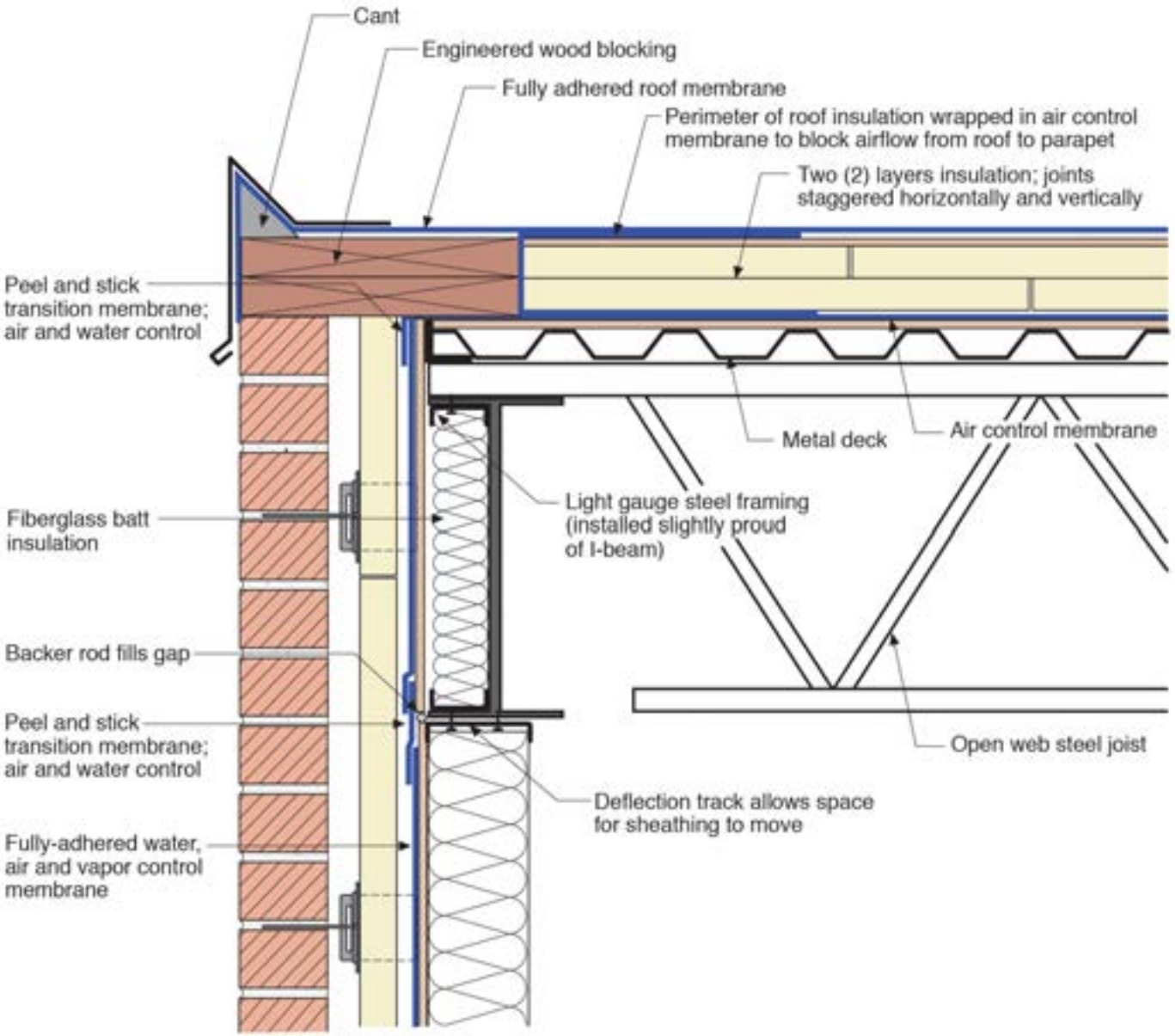
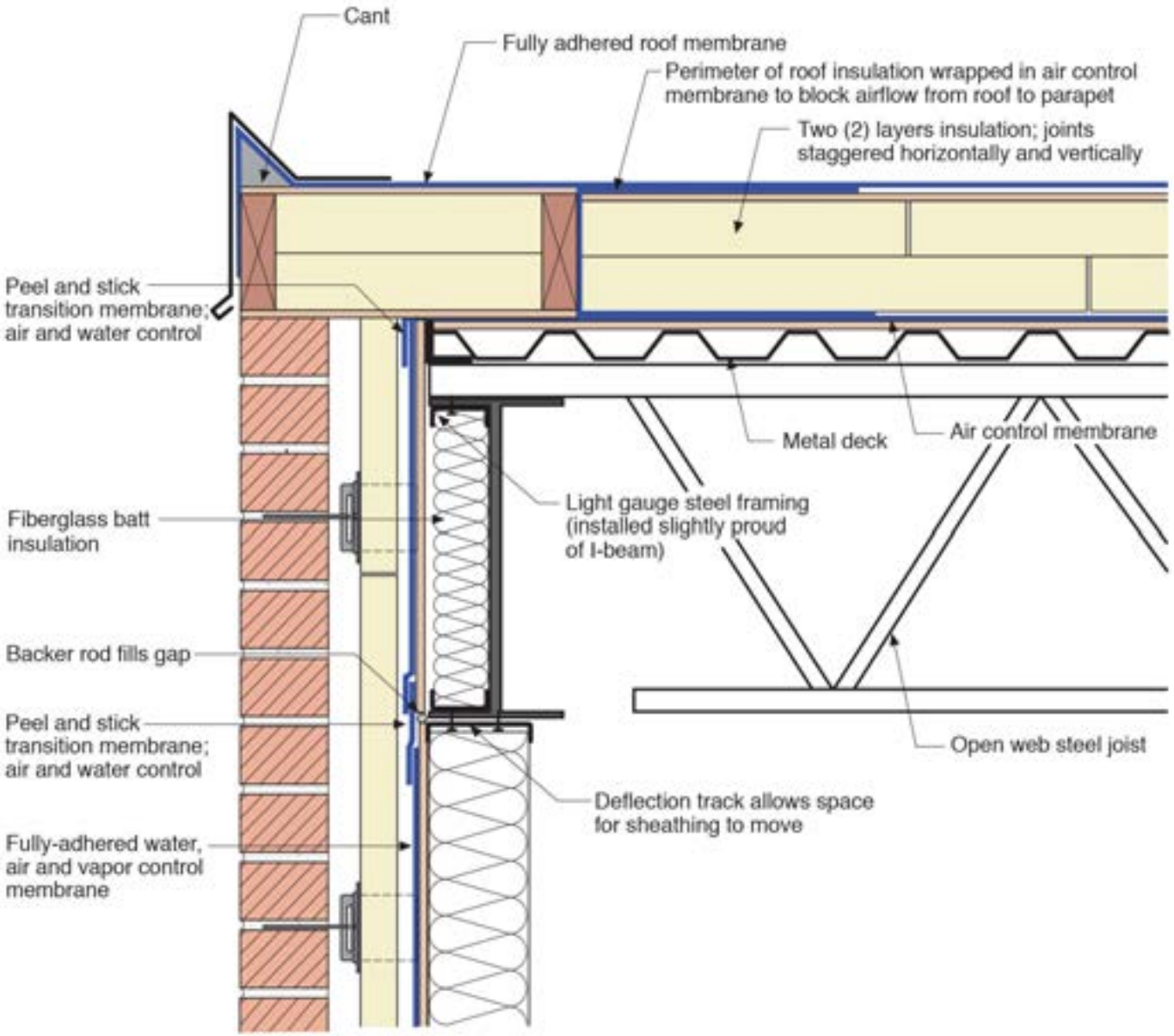
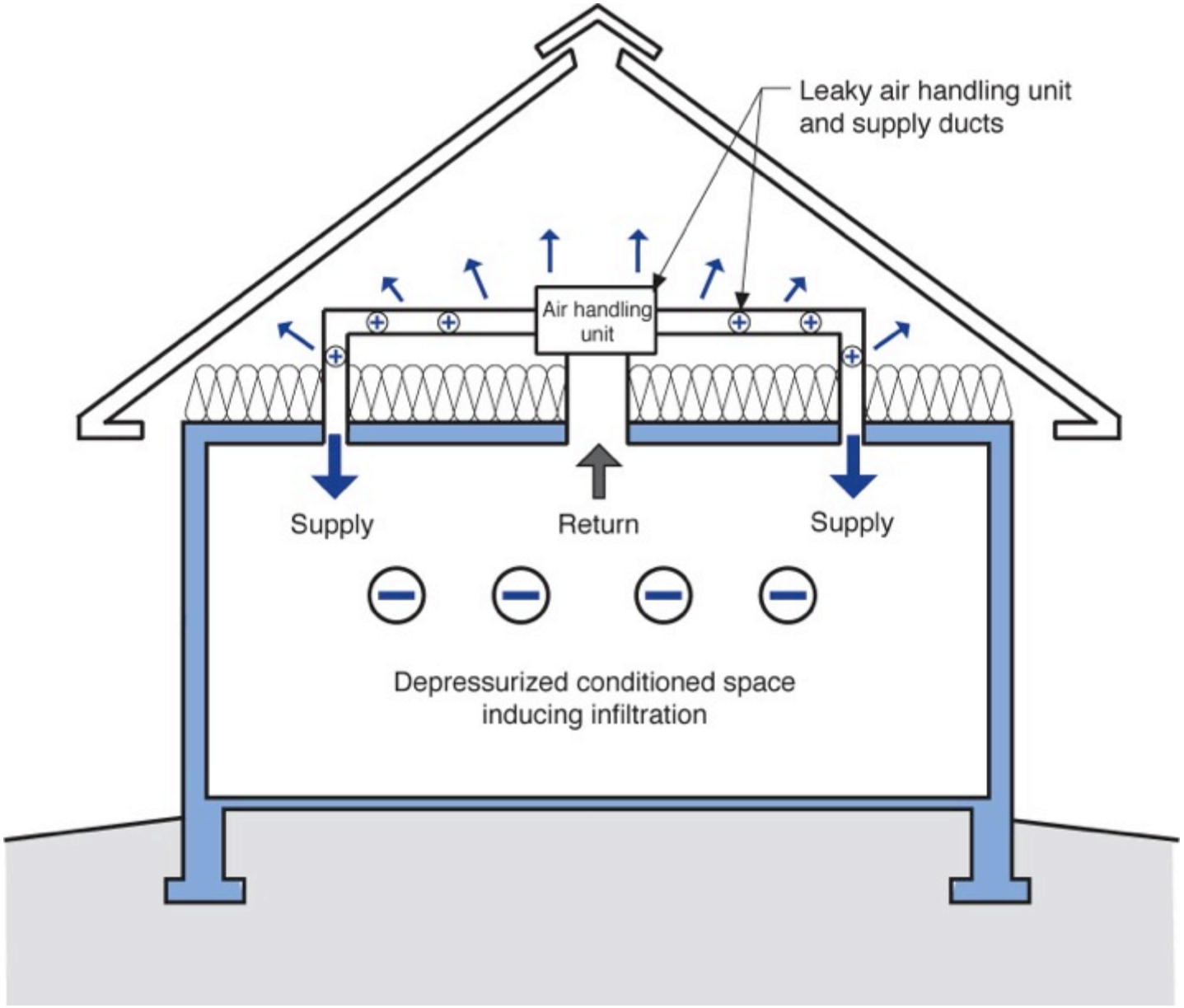
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Water, air and vapor control membrane; preferably fully-adhered


Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Air control layer transition membrane
Vapor permeable water control and air control membrane strip
2 lb/ft³ spray polyurethane foam
Metal blocking between steel studs
Water, air and vapor control membrane; preferably fully-adhered
Backer rod
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
Metal deck
Air control membrane
Open web steel joist


Parapet flashing
Fully-adhered water control membrane
Tapered rigid insulation
Air control layer transition membrane
Polypropylene mesh supporting flashing
Gap in membrane to allow drying by vapor diffusion
Backer rod
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Fully adhered roof membrane
Two (2) layers insulation; joints staggered horizontally and vertically
2 lb/ft³ spray polyurethane foam
Metal blocking between steel studs
Metal deck
Air control membrane
Water, air and vapor control membrane; preferably fully-adhered
Open web steel joist


Cant
Engineered wood blocking
Fully adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Fully-adhered water, air and vapor control membrane

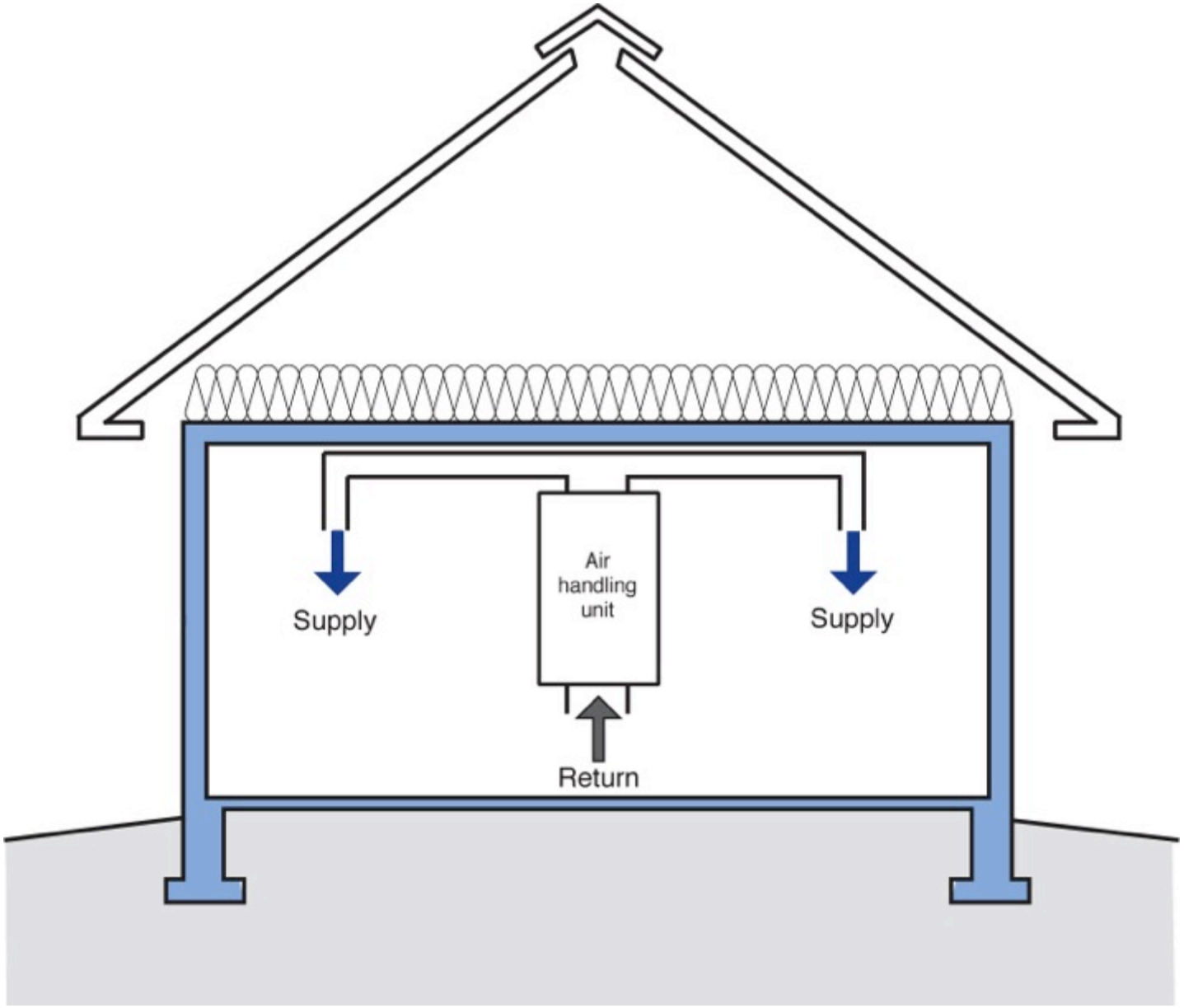

Cant
Fully adhered roof membrane
Perimeter of roof insulation wrapped in air control membrane to block airflow from roof to parapet
Two (2) layers insulation; joints staggered horizontally and vertically
Peel and stick transition membrane; air and water control
Metal deck
Air control membrane
Light gauge steel framing (installed slightly proud of I-beam)
Fiberglass batt insulation
Backer rod fills gap
Peel and stick transition membrane; air and water control
Open web steel joist
Deflection track allows space for sheathing to move
Fully-adhered water, air and vapor control membrane

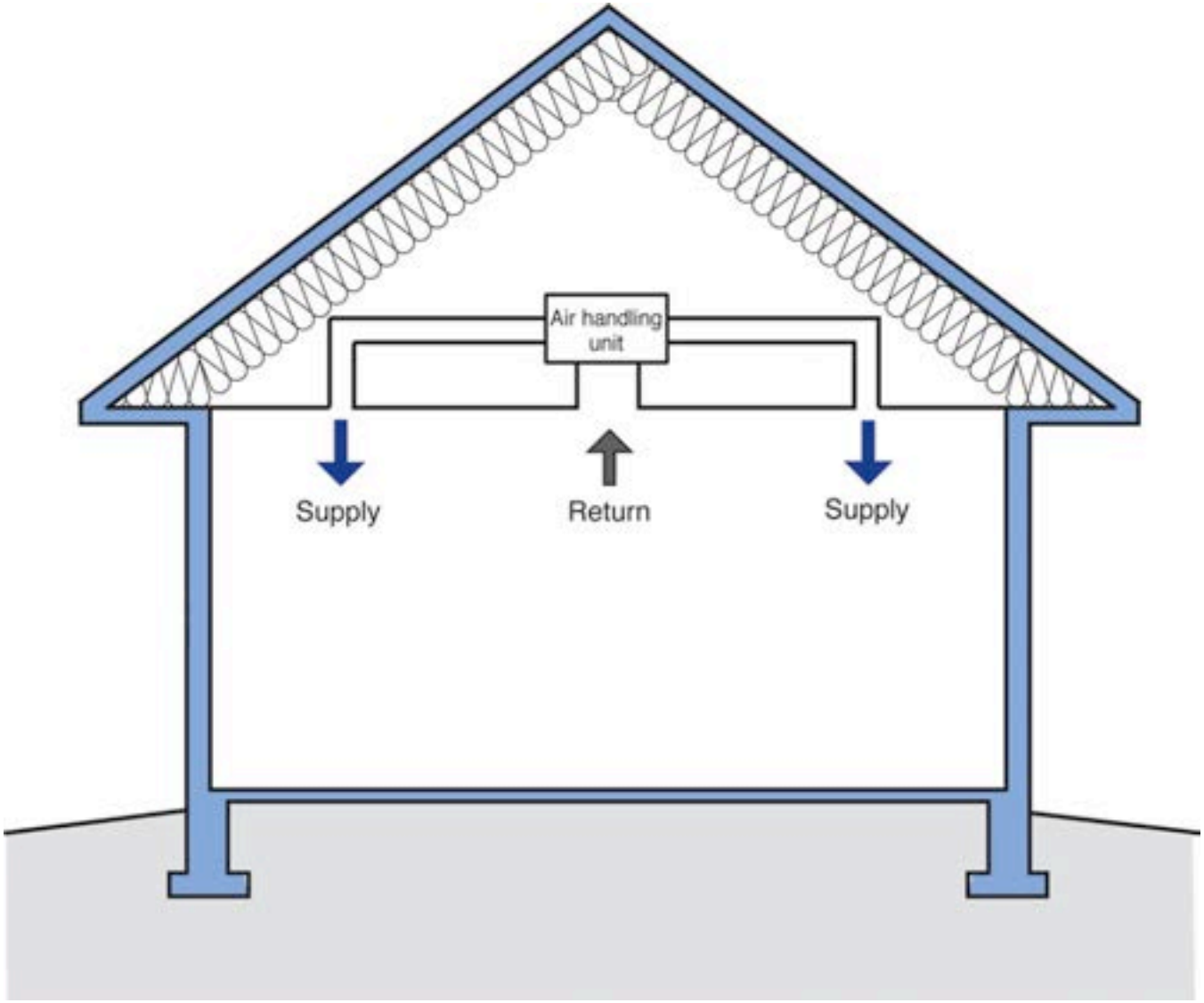

Leaky air handling unit
and supply ducts
Air handling
unit
Supply
Return
Supply
Depressurized conditioned space
inducing infiltration

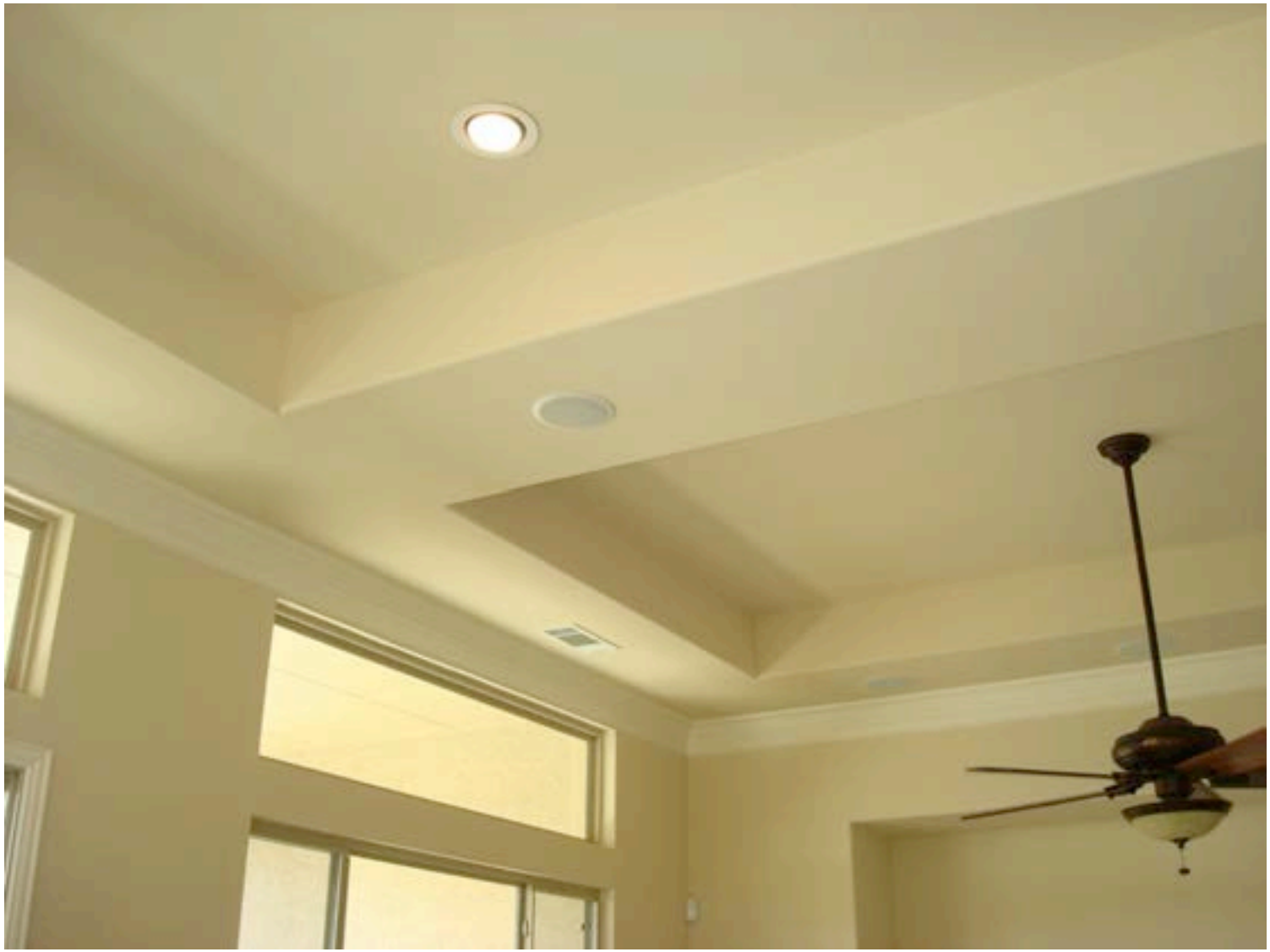
Houses With Vented Attics Suck

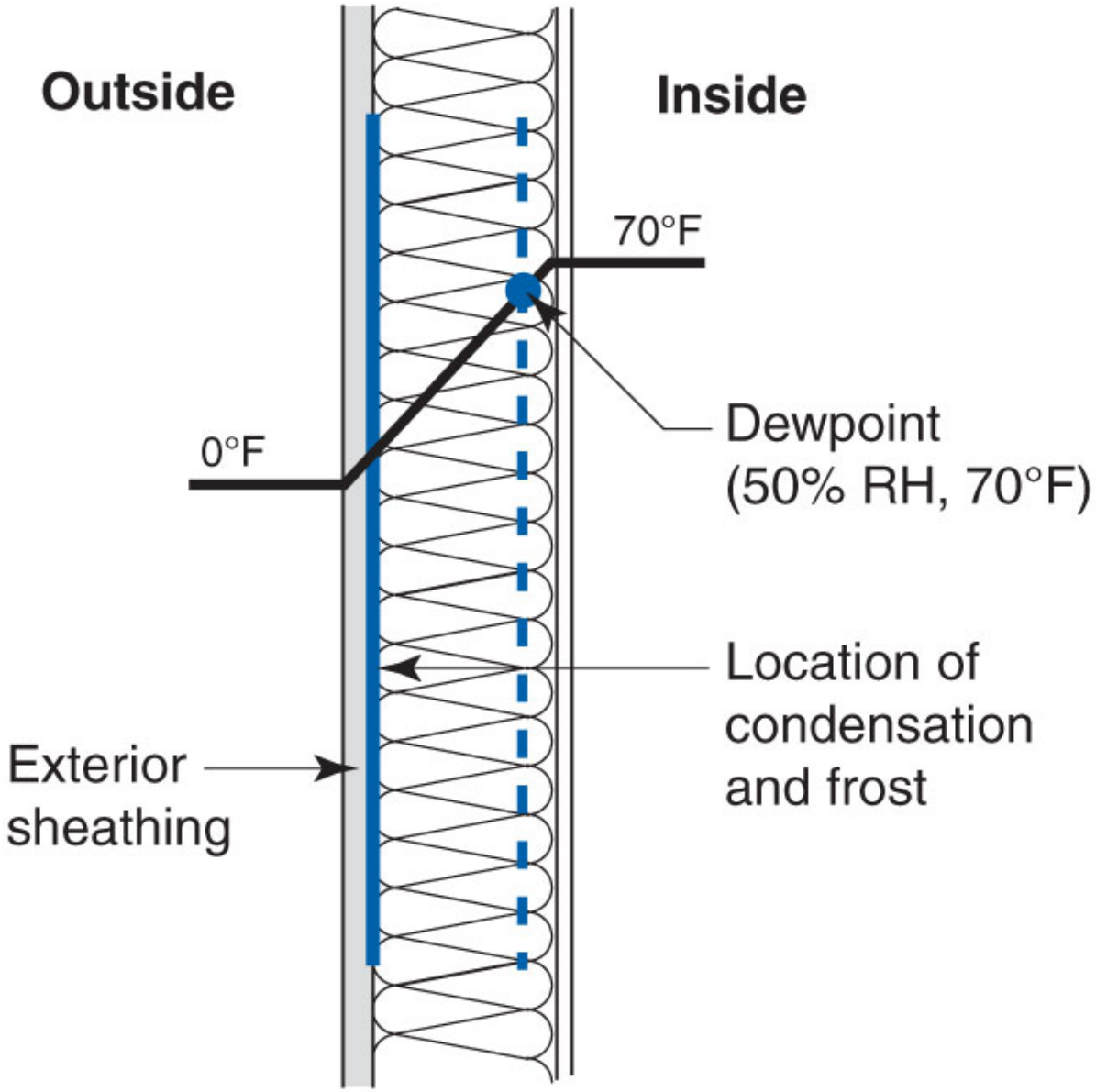
Houses With Vented Attics Suck

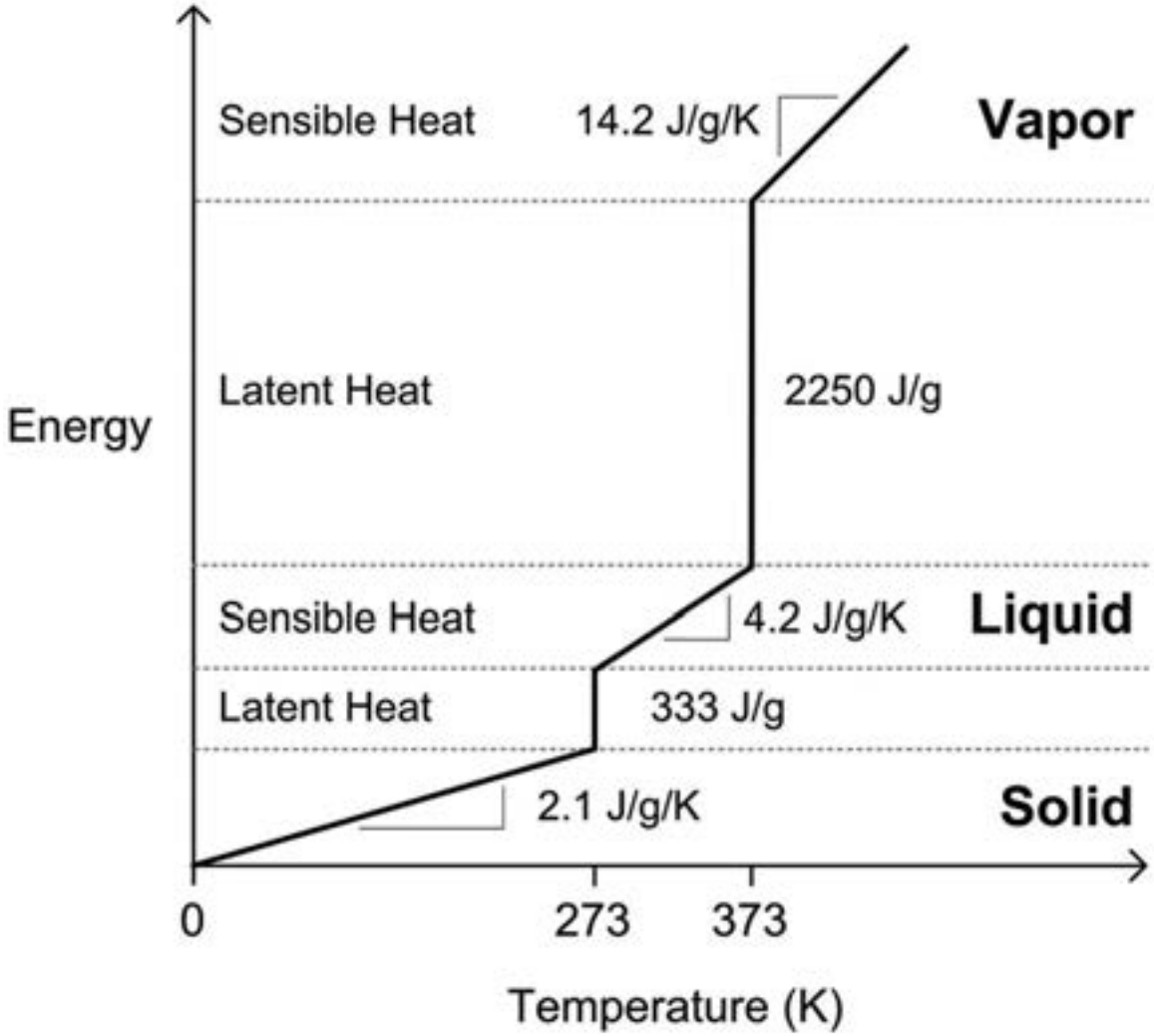
Not all the Time…..but.....


Supply
Air handling unit
Supply
Return

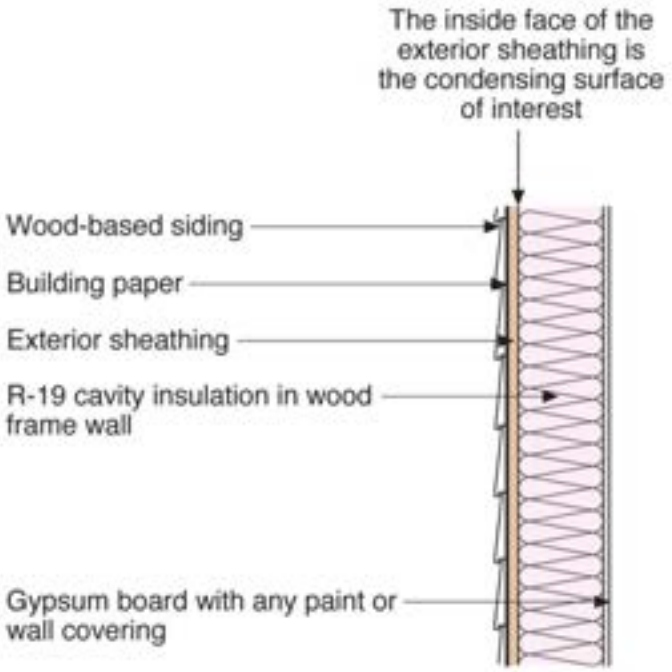

Air handling unit
Supply
Return
Supply

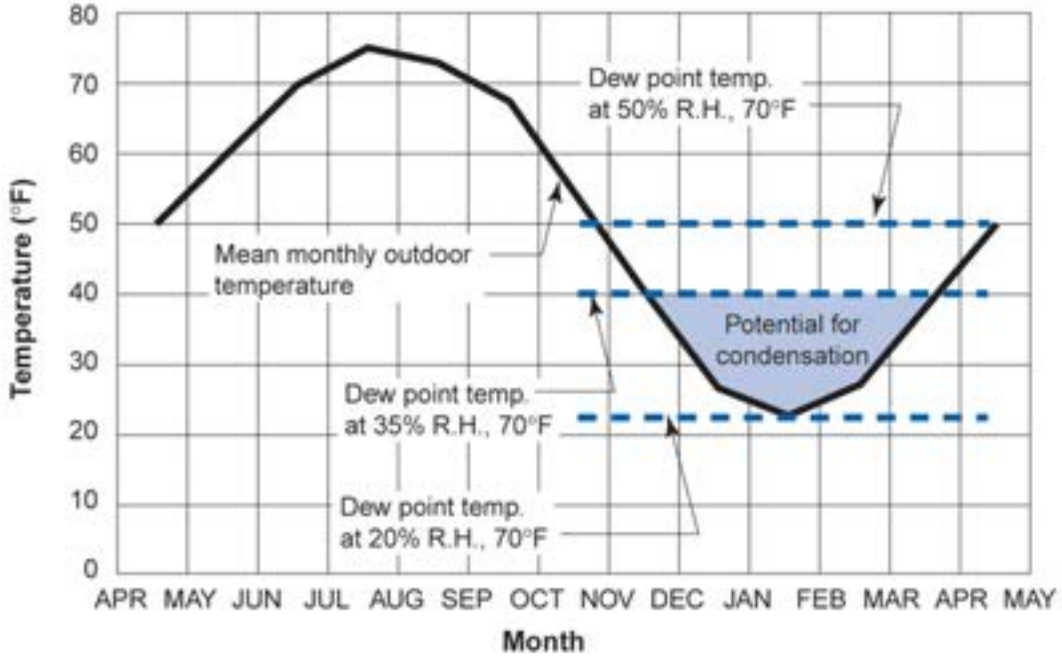


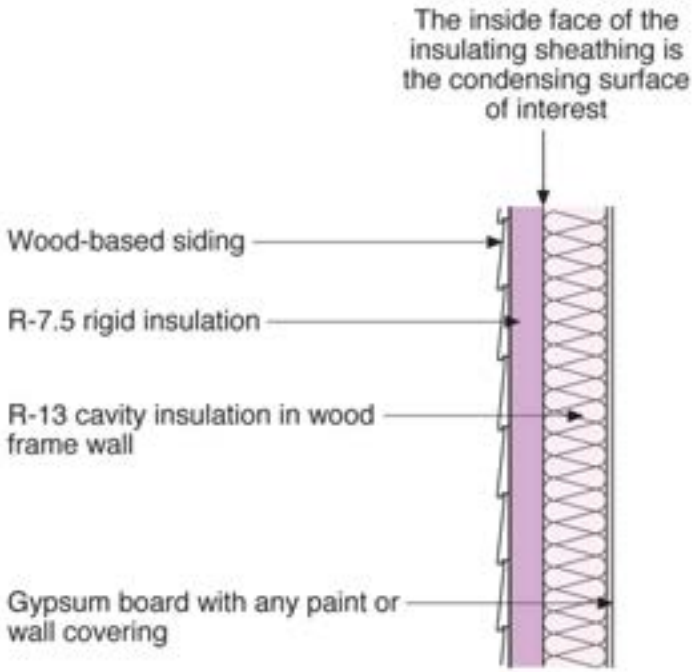

Outside
Inside
70°F
0°F
Dewpoint
(50% RH, 70°F)
Location of
condensation
and frost
Exterior
sheathing

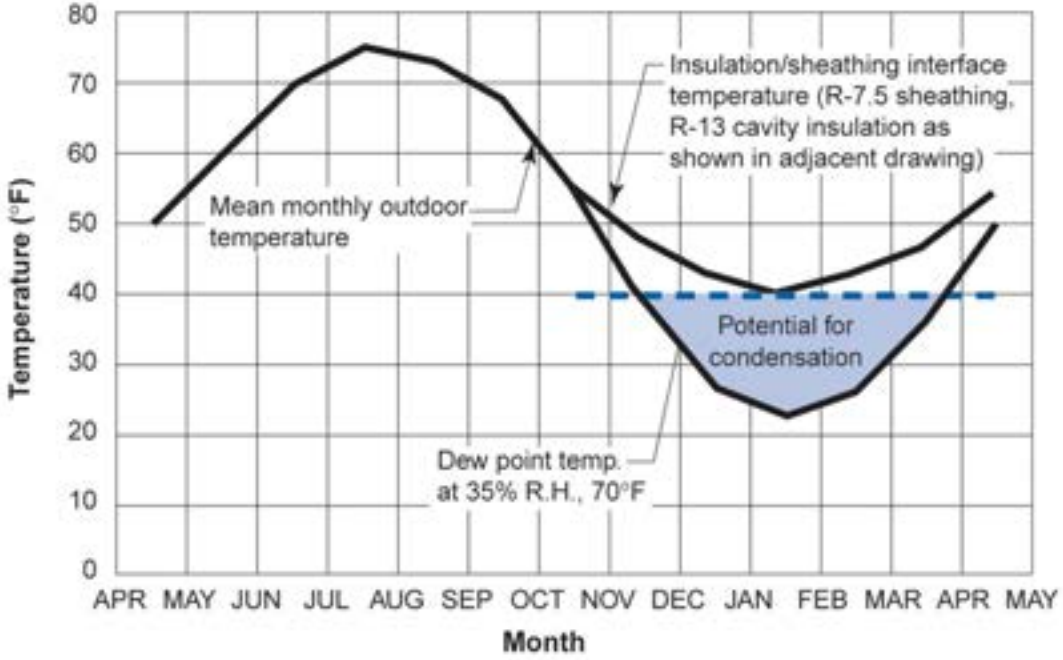


Simple linearized energy-temperature relation for water
From Straube & Burnett, 2005


The inside face of the exterior sheathing is the condensing surface of interest
Wood-based siding
Building paper
Exterior sheathing
R-19 cavity insulation in wood frame wall
Gypsum board with any paint or wall covering


Temperature (°F)
80
70
60
50
40
30
20
10
0
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
Month
Dew point temp. at 50% R.H., 70°F
Mean monthly outdoor temperature
Potential for condensation
Dew point temp. at 35% R.H., 70°F
Dew point temp. at 20% R.H., 70°F


The inside face of the insulating sheathing is the condensing surface of interest
Wood-based siding
R-7.5 rigid insulation
R-13 cavity insulation in wood frame wall
Gypsum board with any paint or wall covering


Temperature (°F)
80
70
60
50
40
30
20
10
0
APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
Month
Insulation/sheathing interface temperature (R-7.5 sheathing, R-13 cavity insulation as shown in adjacent drawing)
Mean monthly outdoor temperature
Potential for condensation
Dew point temp. at 35% R.H., 70°F

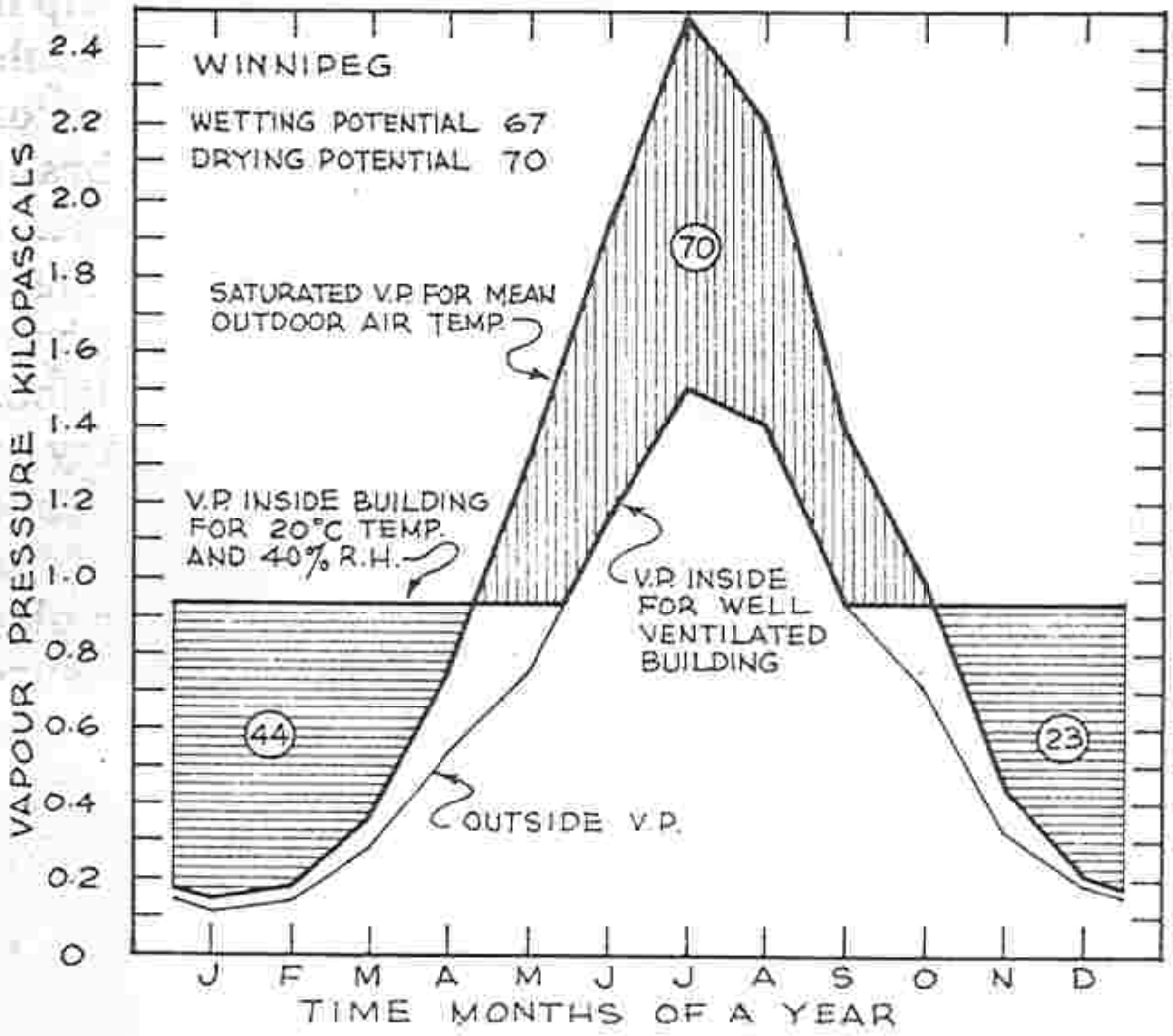
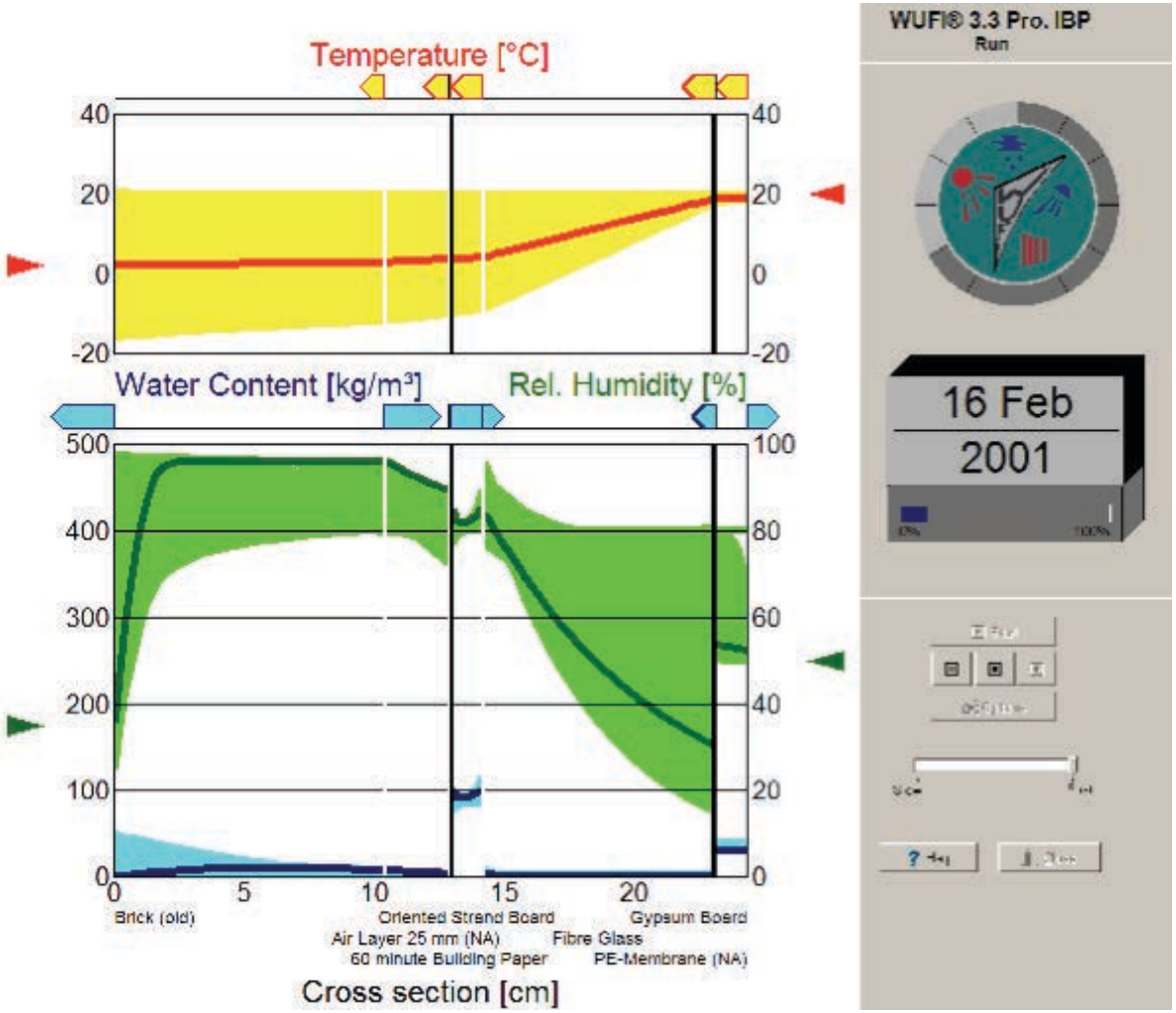
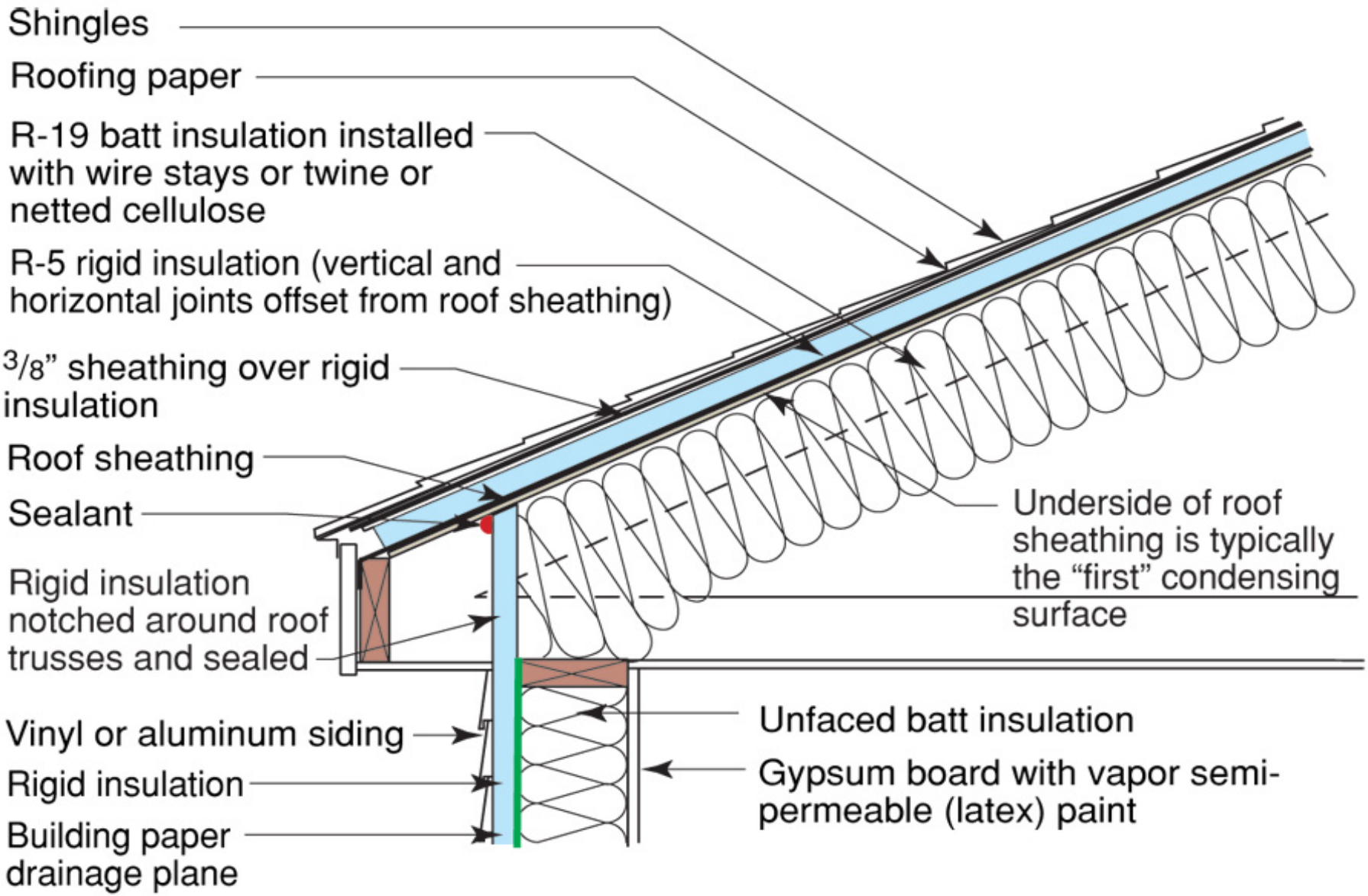
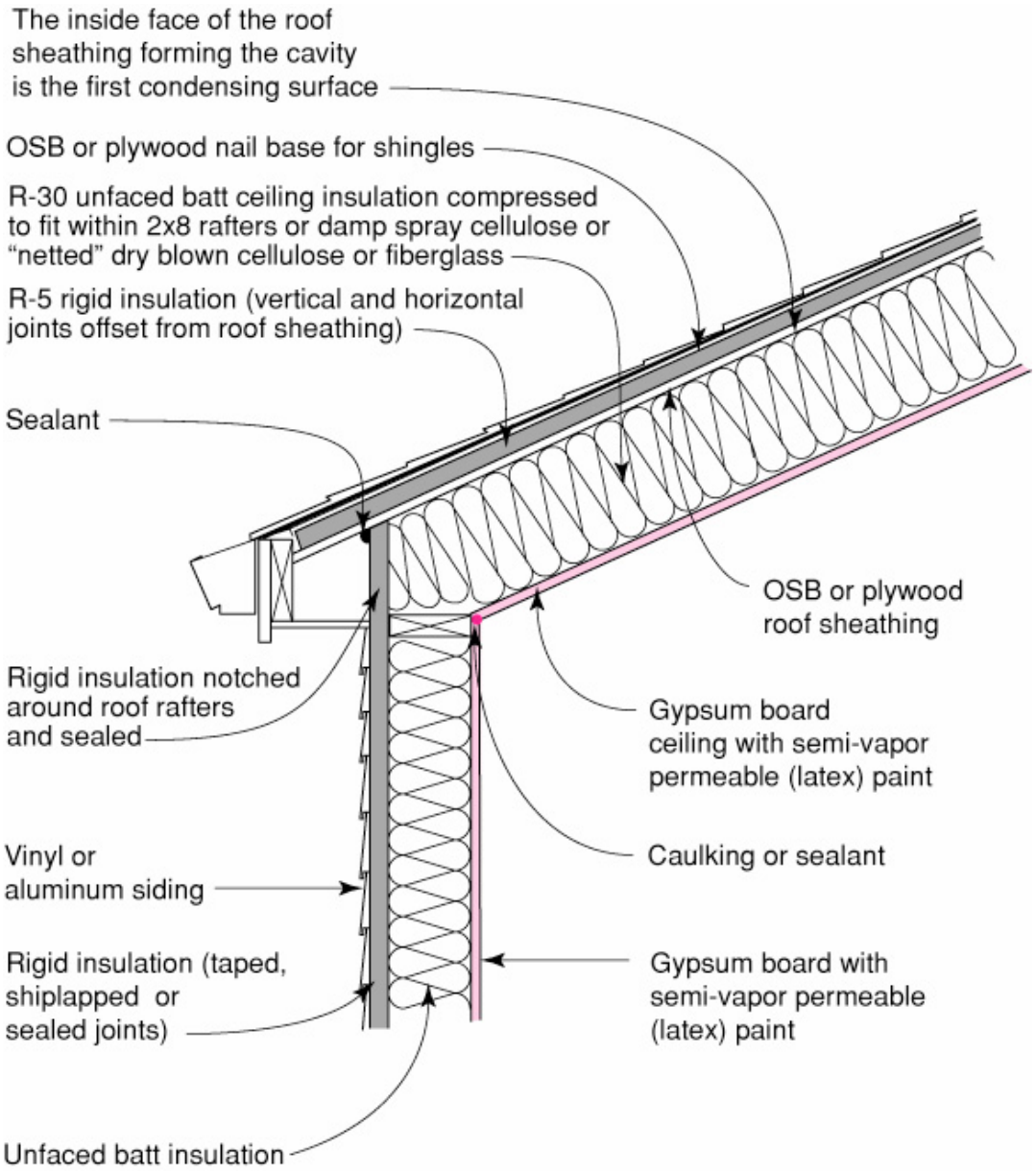
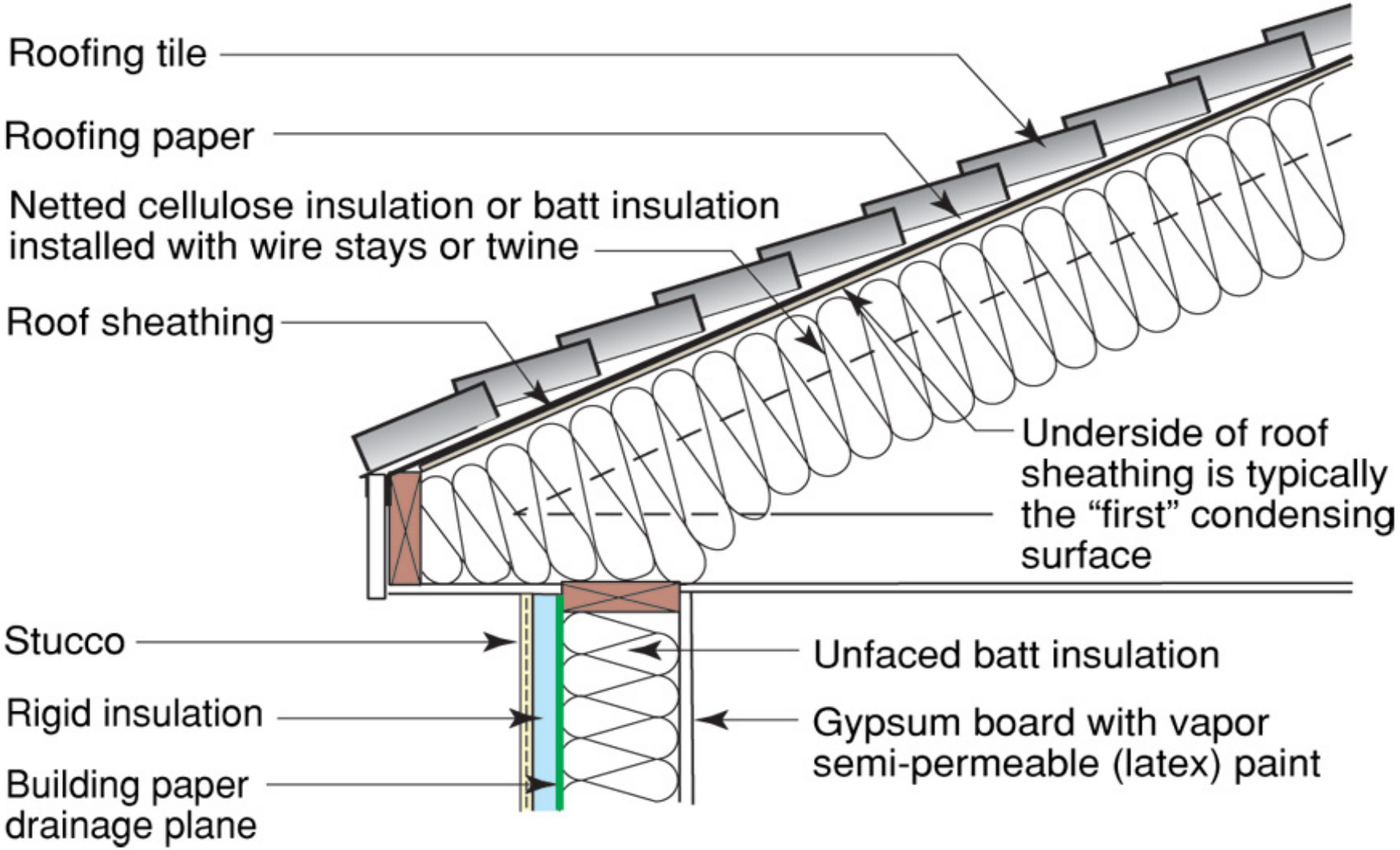


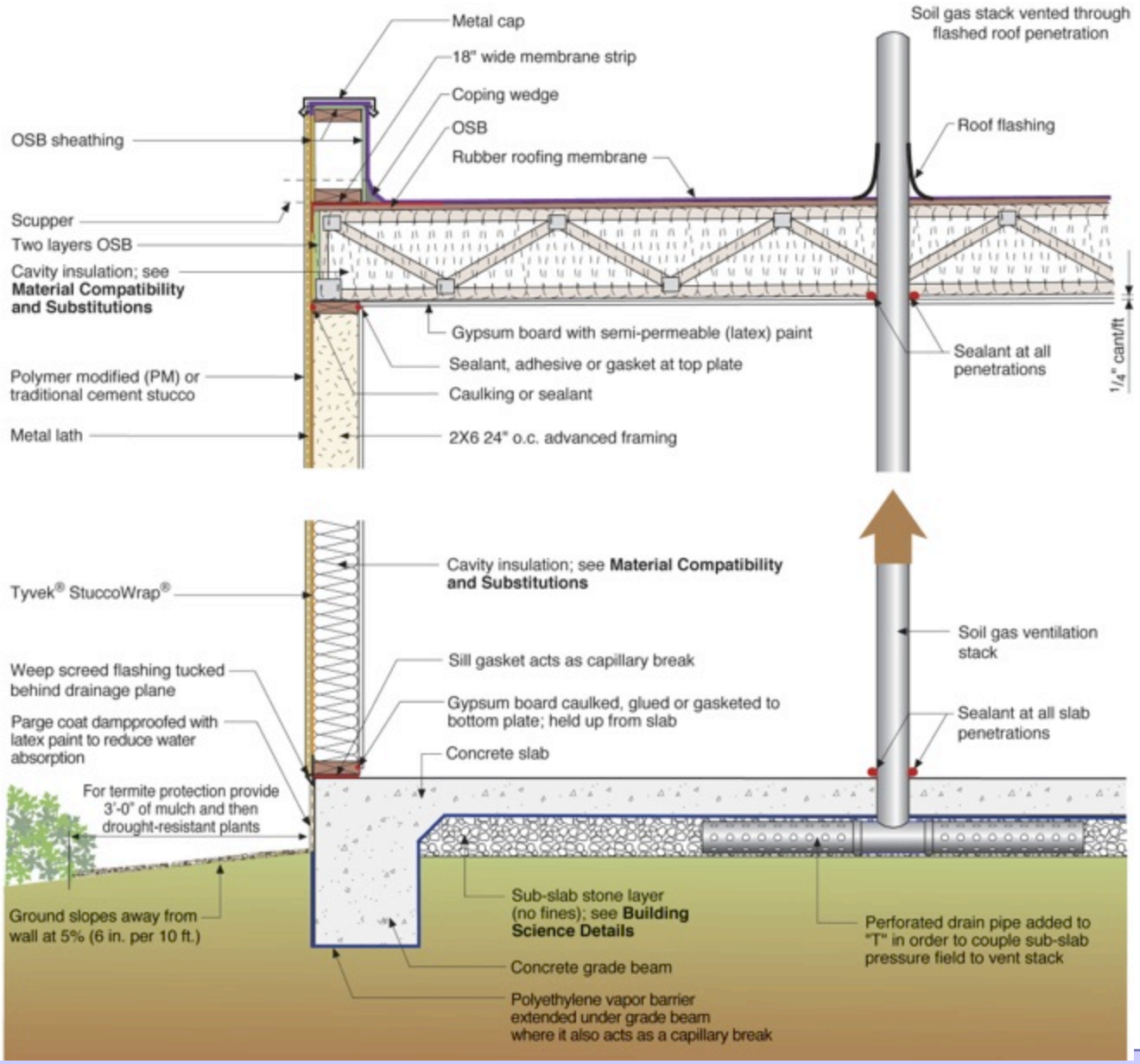
Figure 8-7. Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.

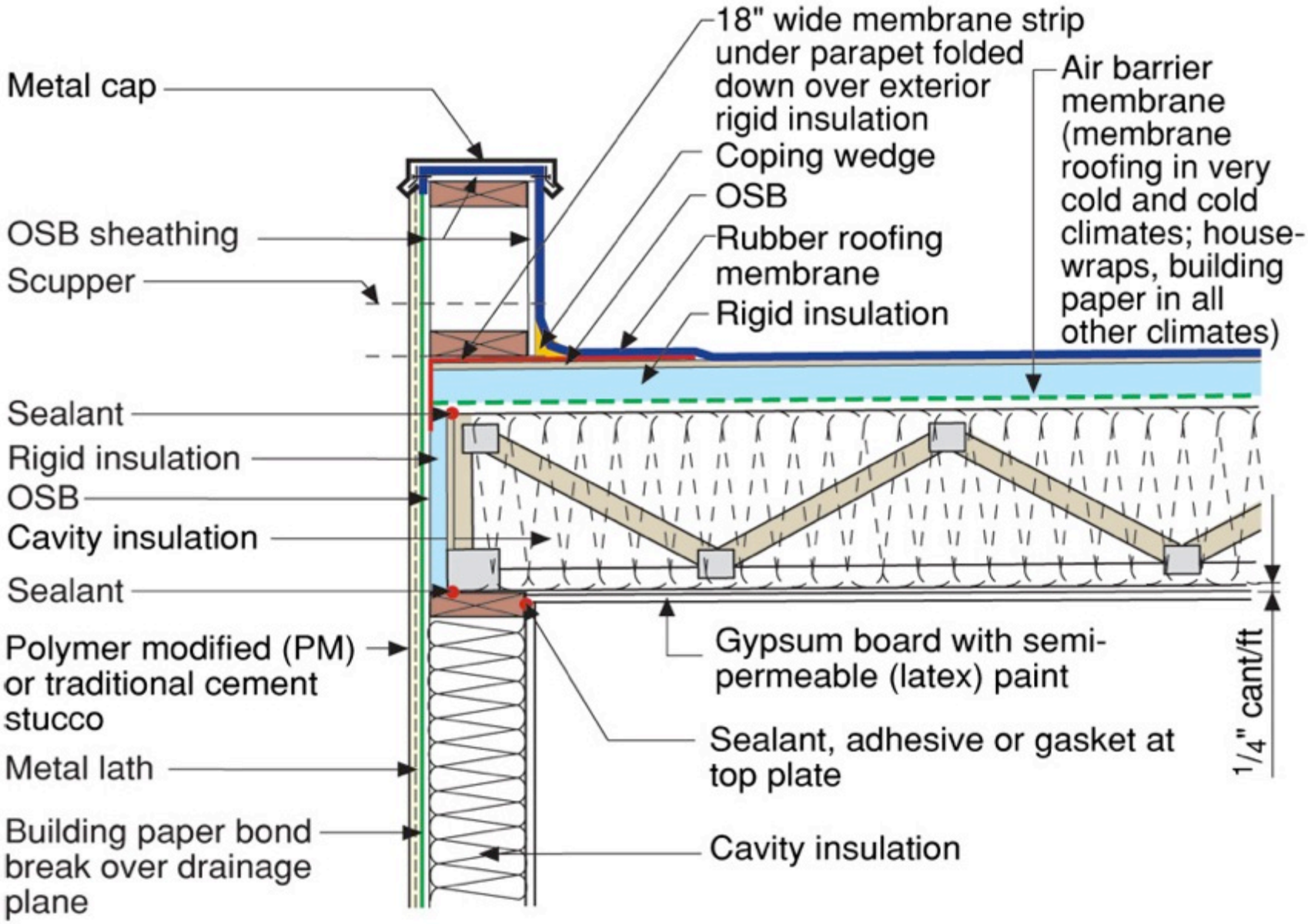

Temperature [°C]
40
20
0
-20
Water Content [kg/m³]
Rel. Humidity [%]
500
400
300
200
100
0
100
80
60
40
20
0
0
5
10
15
20
Brick (old)
Air Layer 25 mm (NA)
60 minute Building Paper
Oriented Strand Board
Fibre Glass
Gypsum Board
PE-Membrane (NA)
Cross section [cm]
WUFI® 3.3 Pro. IBP
Run
16 Feb
2001

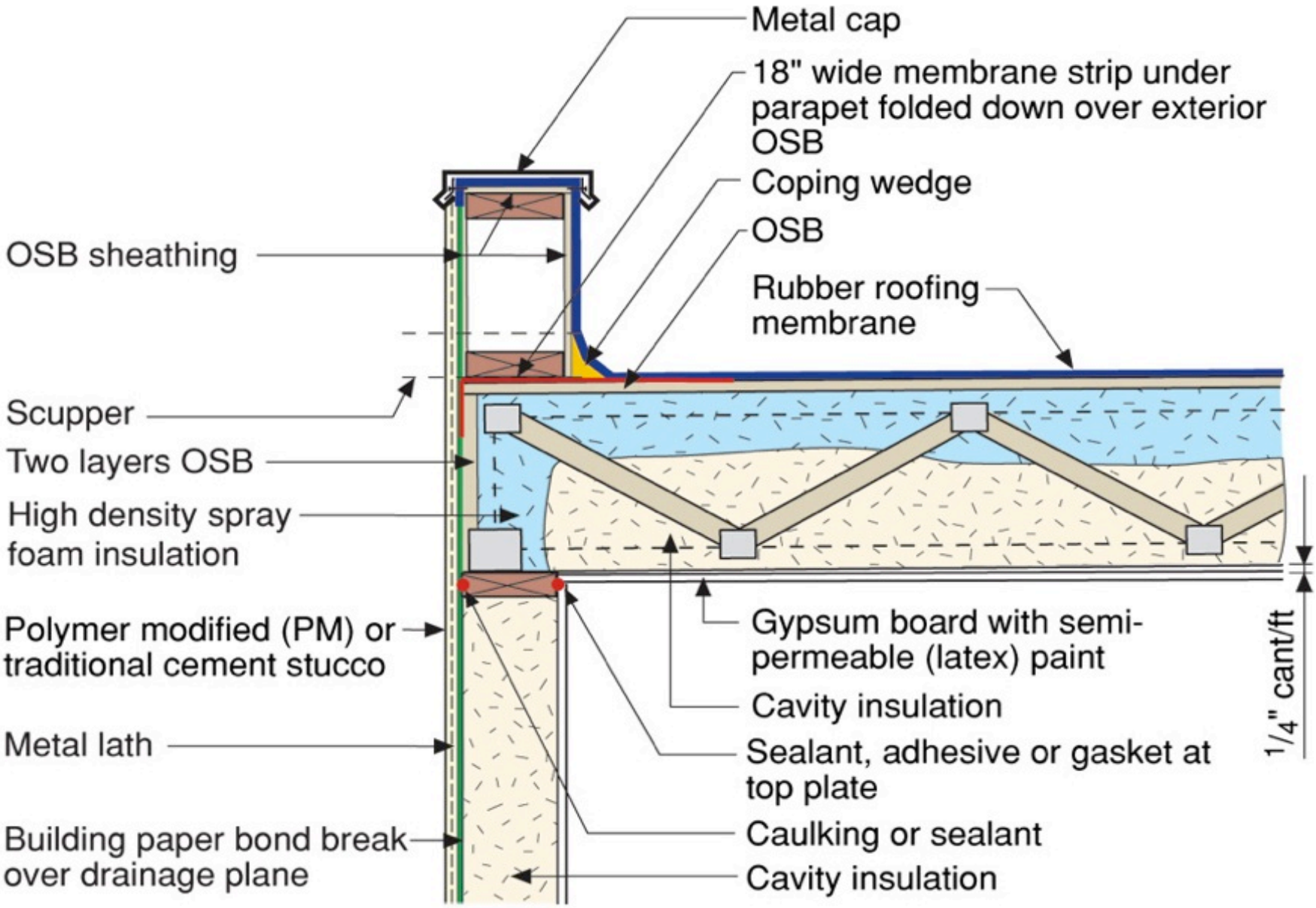

Shingles
Roofing paper
R-19 batt insulation installed with wire stays or twine or netted cellulose
R-5 rigid insulation (vertical and horizontal joints offset from roof sheathing)
3/8" sheathing over rigid insulation
Roof sheathing
Sealant
Rigid insulation notched around roof trusses and sealed
Vinyl or aluminum siding
Rigid insulation
Building paper drainage plane
Underside of roof sheathing is typically the "first" condensing surface
Unfaced batt insulation
Gypsum board with vapor semi-permeable (latex) paint

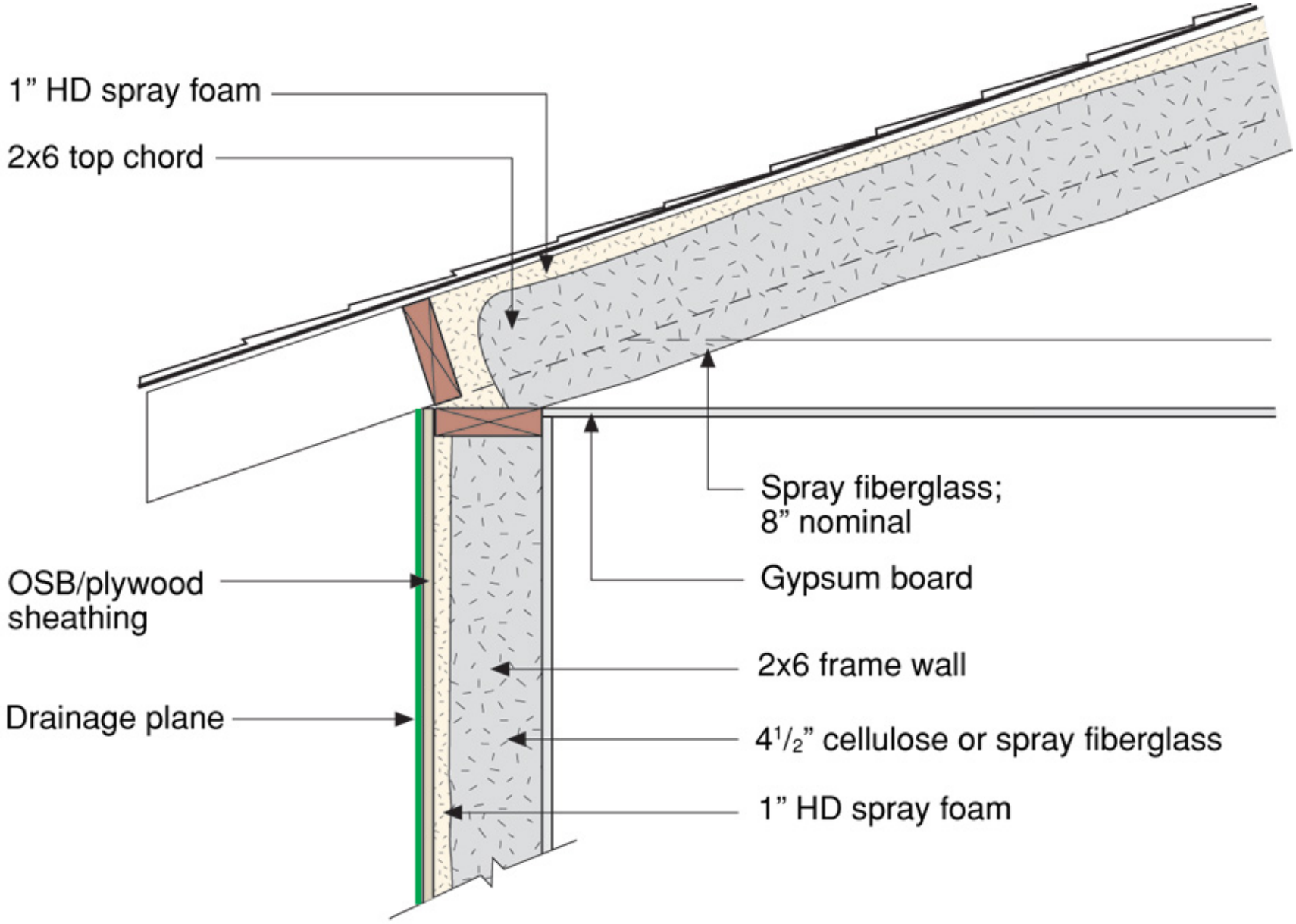

The inside face of the roof sheathing forming the cavity is the first condensing surface
OSB or plywood nail base for shingles
R-30 unfaced batt ceiling insulation compressed to fit within 2x8 rafters or damp spray cellulose or "netted" dry blown cellulose or fiberglass
R-5 rigid insulation (vertical and horizontal joints offset from roof sheathing)
Sealant
OSB or plywood roof sheathing
Rigid insulation notched around roof rafters and sealed
Gypsum board ceiling with semi-vapor permeable (latex) paint
Caulking or sealant
Vinyl or aluminum siding
Rigid insulation (taped, shiplapped or sealed joints)
Gypsum board with semi-vapor permeable (latex) paint
Unfaced batt insulation

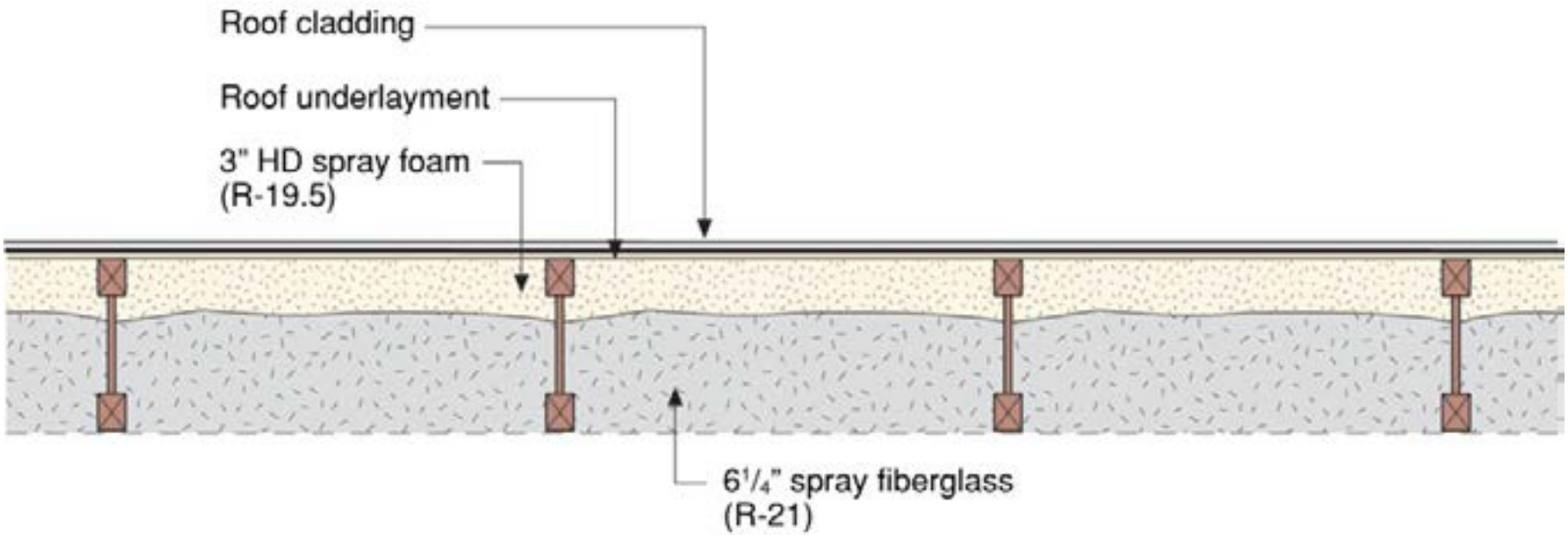

Roofing tile
Roofing paper
Netted cellulose insulation or batt insulation installed with wire stays or twine
Roof sheathing
Underside of roof sheathing is typically the “first” condensing surface
Stucco
Rigid insulation
Building paper drainage plane
Unfaced batt insulation
Gypsum board with vapor semi-permeable (latex) paint

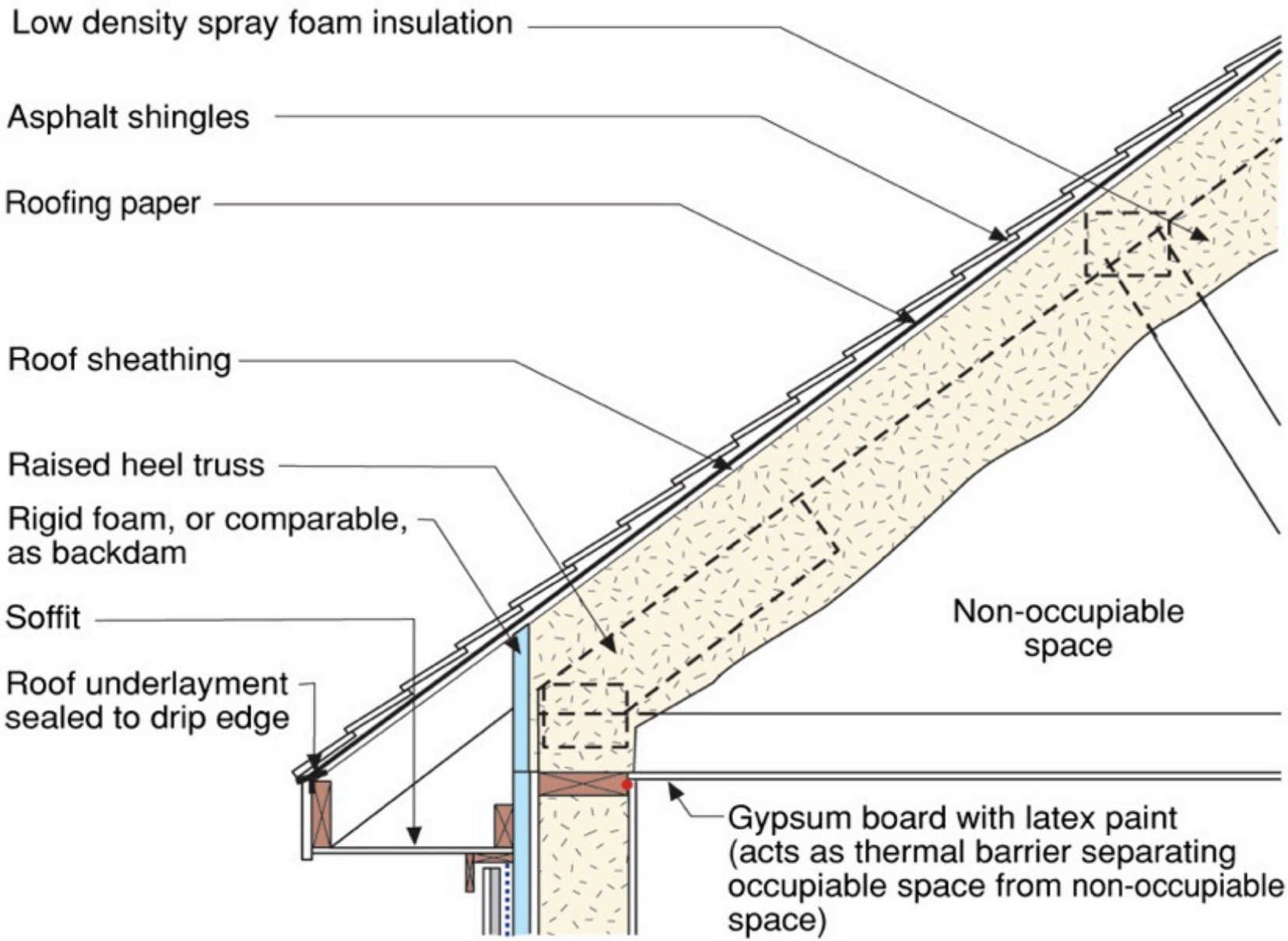

Metal cap
18" wide membrane strip
Coping wedge
OSB
Rubber roofing membrane
Soil gas stack vented through flashed roof penetration
Roof flashing
OSB sheathing
Scupper
Two layers OSB
Cavity insulation; see Material Compatibility and Substitutions
Gypsum board with semi-permeable (latex) paint
Sealant, adhesive or gasket at top plate
Caulking or sealant
2X6 24" o.c. advanced framing
Sealant at all penetrations
1/4" cant/ft
Polymer modified (PM) or traditional cement stucco
Metal lath
Tyvek® StuccoWrap®
Cavity insulation; see Material Compatibility and Substitutions
Soil gas ventilation stack
Weep screed flashing tucked behind drainage plane
Sill gasket acts as capillary break
Gypsum board caulked, glued or gasketed to bottom plate; held up from slab
Sealant at all slab penetrations
Parge coat dampproofed with latex paint to reduce water absorption
Concrete slab
For termite protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Sub-slab stone layer (no fines); see Building Science Details
Perforated drain pipe added to "T" in order to couple sub-slab pressure field to vent stack
Concrete grade beam
Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break

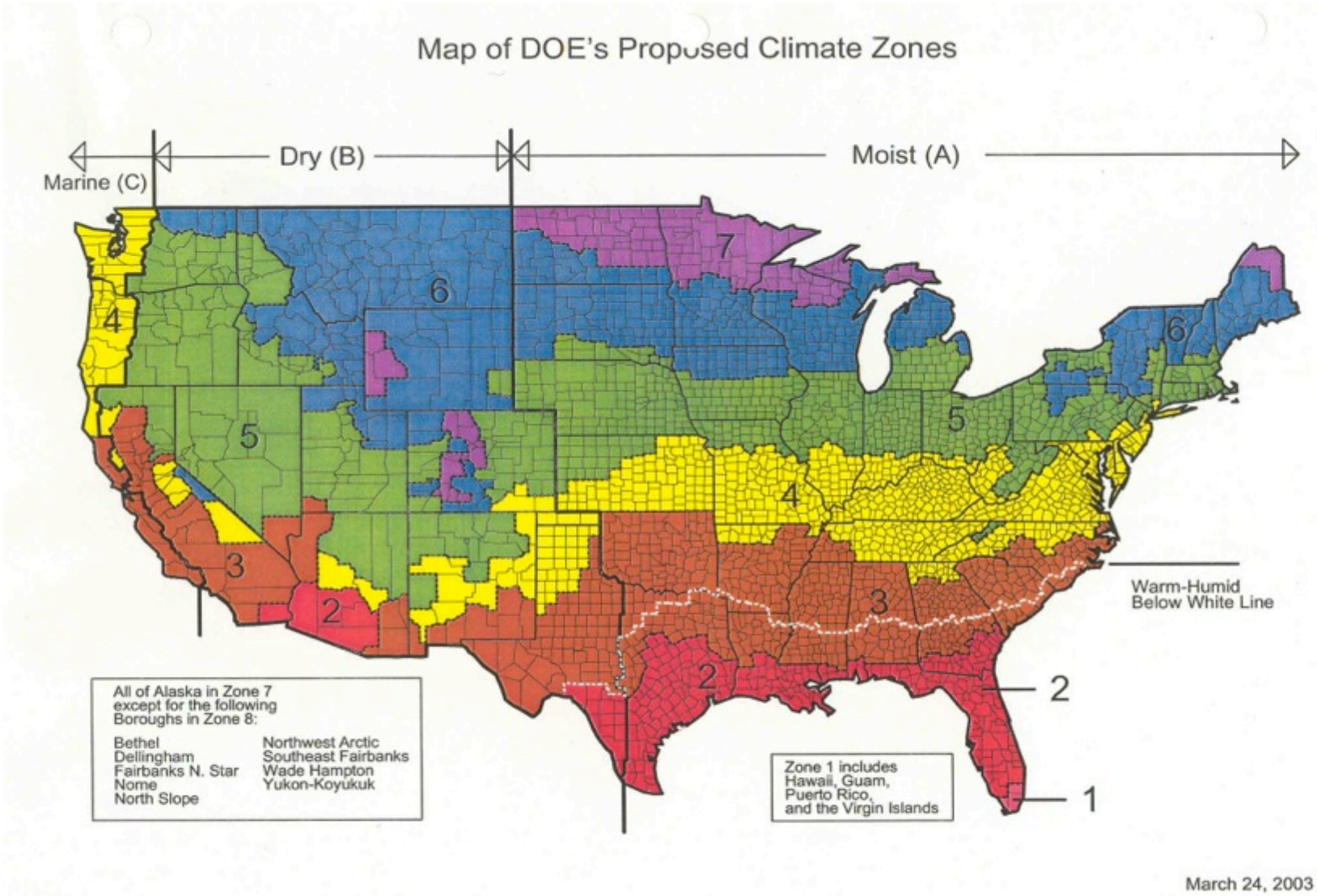

Metal cap
OSB sheathing
Scupper
Sealant
Rigid insulation
OSB
Cavity insulation
Sealant
Polymer modified (PM) or traditional cement stucco
Metal lath
Building paper bond break over drainage plane
18" wide membrane strip under parapet folded down over exterior rigid insulation
Coping wedge
OSB
Rubber roofing membrane
Rigid insulation
Air barrier membrane (membrane roofing in very cold and cold climates; house-wraps, building paper in all other climates)
Gypsum board with semi-permeable (latex) paint
Sealant, adhesive or gasket at top plate
Cavity insulation
1/4" cant/ft


Metal cap
18" wide membrane strip under parapet folded down over exterior OSB
Coping wedge
OSB
OSB sheathing
Rubber roofing membrane
Scupper
Two layers OSB
High density spray foam insulation
Polymer modified (PM) or traditional cement stucco
Metal lath
Building paper bond break over drainage plane
Gypsum board with semi-permeable (latex) paint
Cavity insulation
Sealant, adhesive or gasket at top plate
Caulking or sealant
Cavity insulation
1/4" cant/ft


1” HD spray foam
2x6 top chord
Spray fiberglass;
8” nominal
Gypsum board
OSB/plywood
sheathing
2x6 frame wall
Drainage plane
4 1/2” cellulose or spray fiberglass
1” HD spray foam


Roof cladding
Roof underlayment
3" HD spray foam
(R-19.5)
6¼" spray fiberglass
(R-21)


Low density spray foam insulation
Asphalt shingles
Roofing paper
Roof sheathing
Raised heel truss
Rigid foam, or comparable, as backdam
Soffit
Roof underlayment sealed to drip edge
Non-occupiable space
Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)

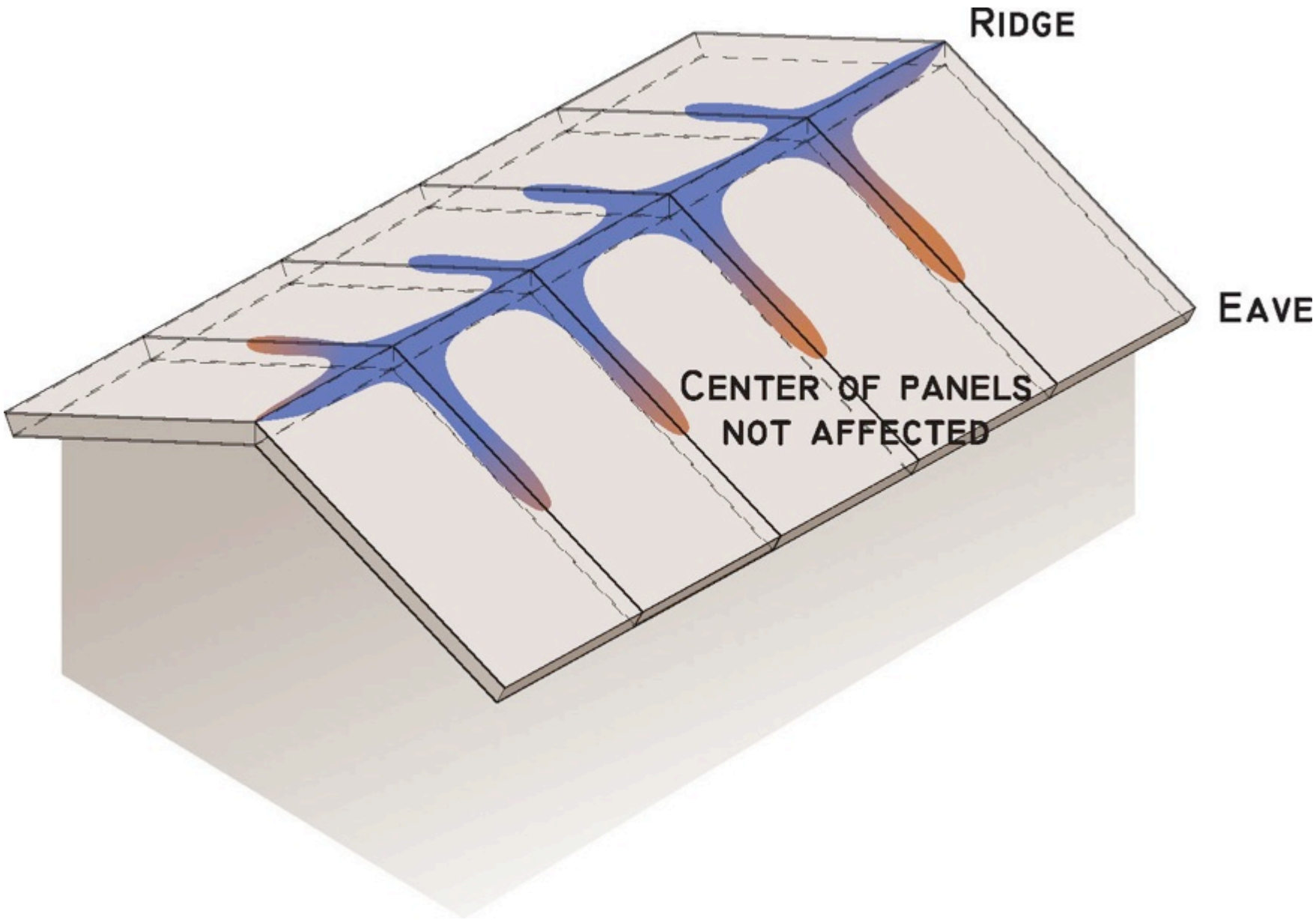

Map of DOE's Proposed Climate Zones
Marine (C)
Dry (B)
Moist (A)
Warm-Humid
Below White Line
All of Alaska in Zone 7
except for the following
Boroughs in Zone 8:
Bethel
Dellingham
Fairbanks N. Star
Nome
North Slope
Northwest Arctic
Southeast Fairbanks
Wade Hampton
Yukon-Koyukuk
Zone 1 includes
Hawaii, Guam,
Puerto Rico,
and the Virgin Islands
March 24, 2003


GRACE
Ice & Water Shield
TRI-FLEX 30
APR 20 2004

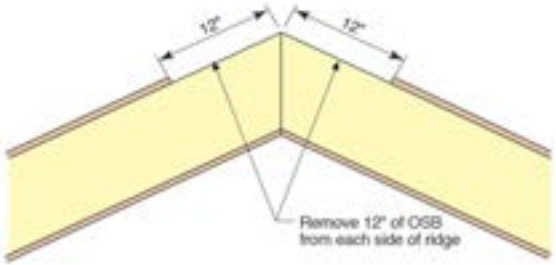

APR 20 2004

Conditioned Attics Not Unvented Attics

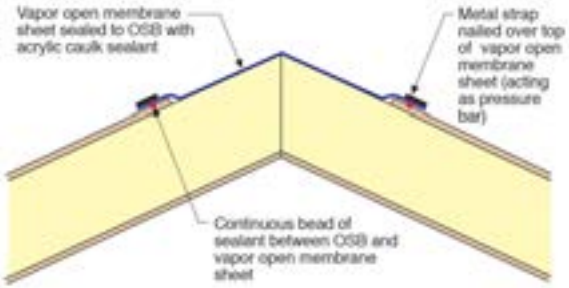

8/22/01 09:32


RIDGE
EAVE
CENTER OF PANELS
NOT AFFECTED

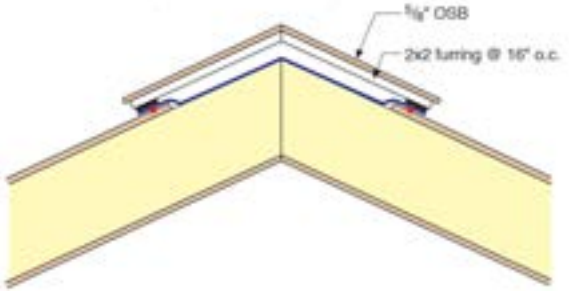
Step 1
- Remove strip of OSB from each side of ridge



Step 2
- Create air seal with strip of vapor open membrane (tape seams)
- Vapor open membrane sheet sealed to OSB with acrylic caulk sealant
- Hold vapor open membrane sheet in place with metal strapping



Step 3
- Construct wood ridge vent with 2x2 furring



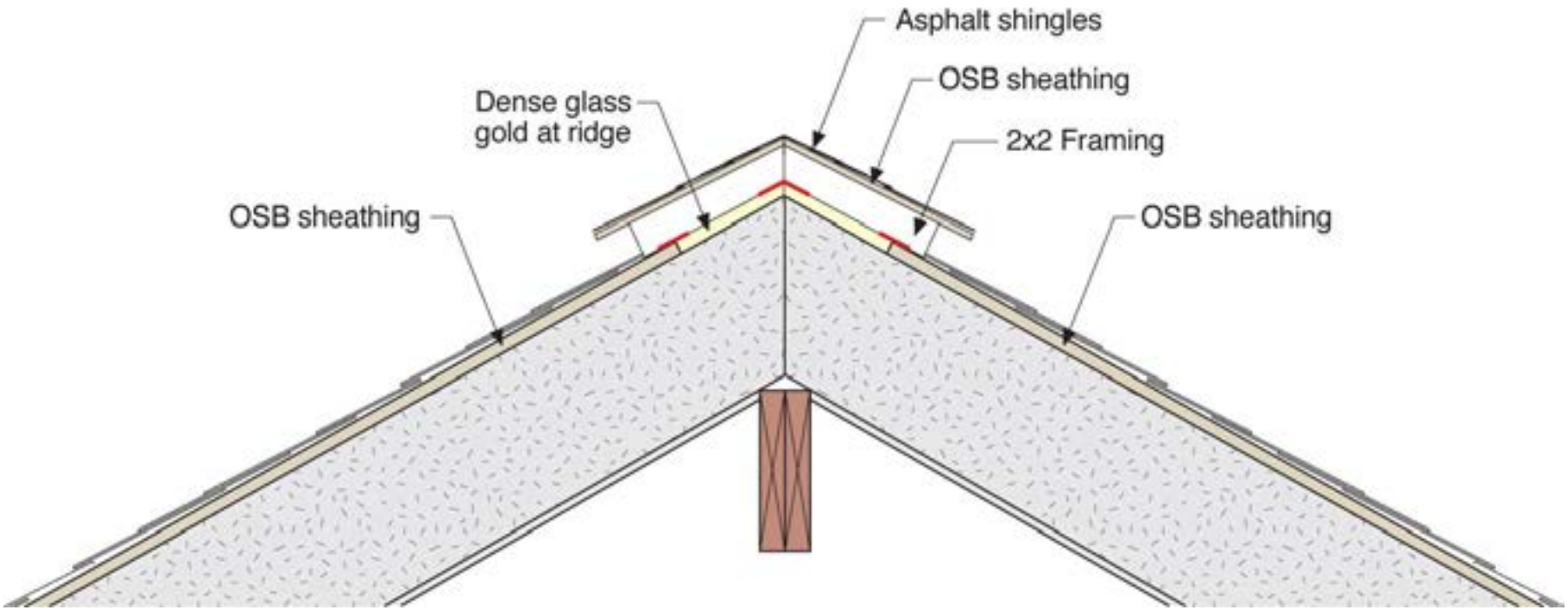

GRACE
Ice & Water Shield
Tyvek
Attic Wrap
DUPONT

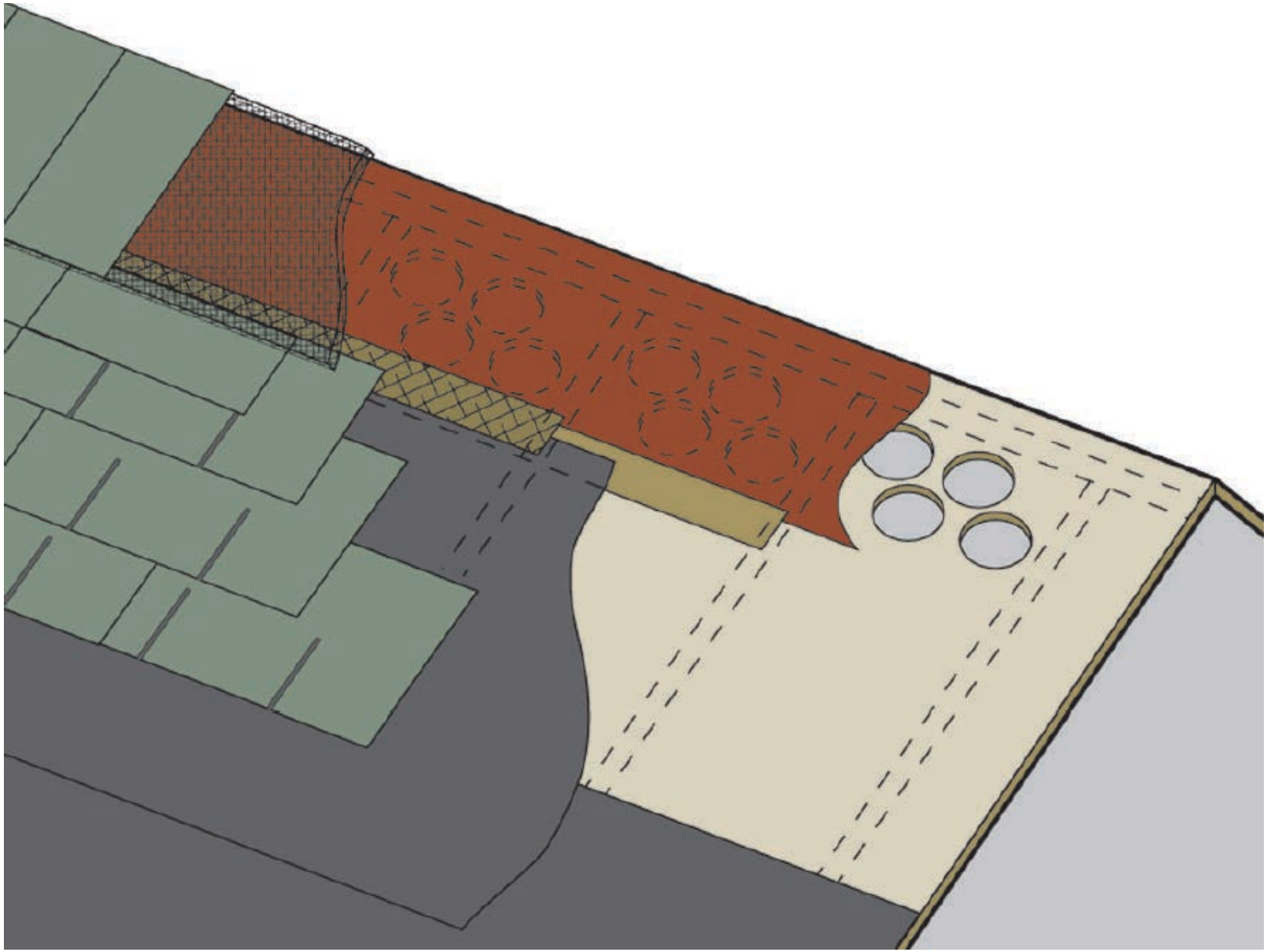

Tyvek
AtticWrap

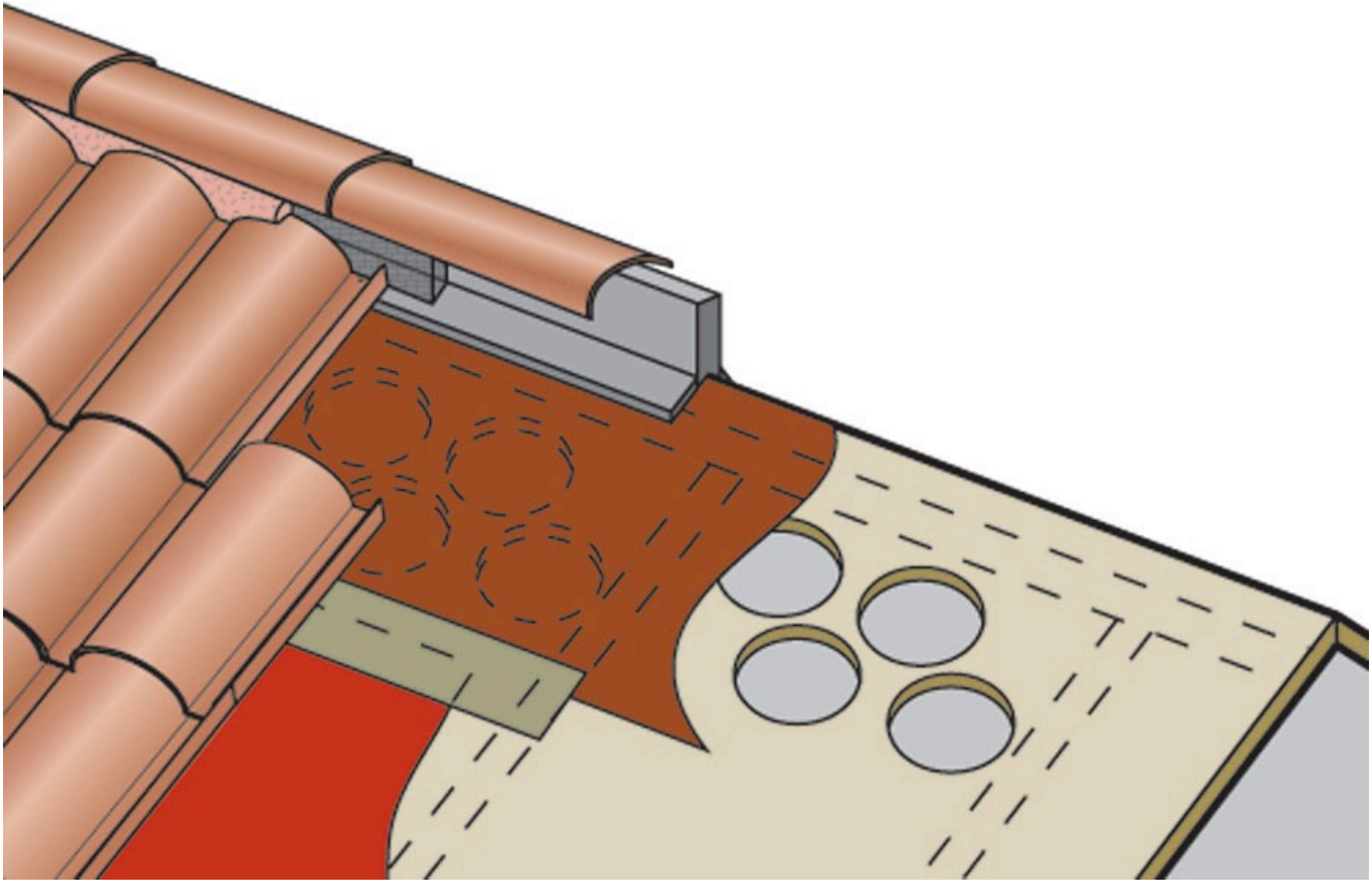

ek
ek

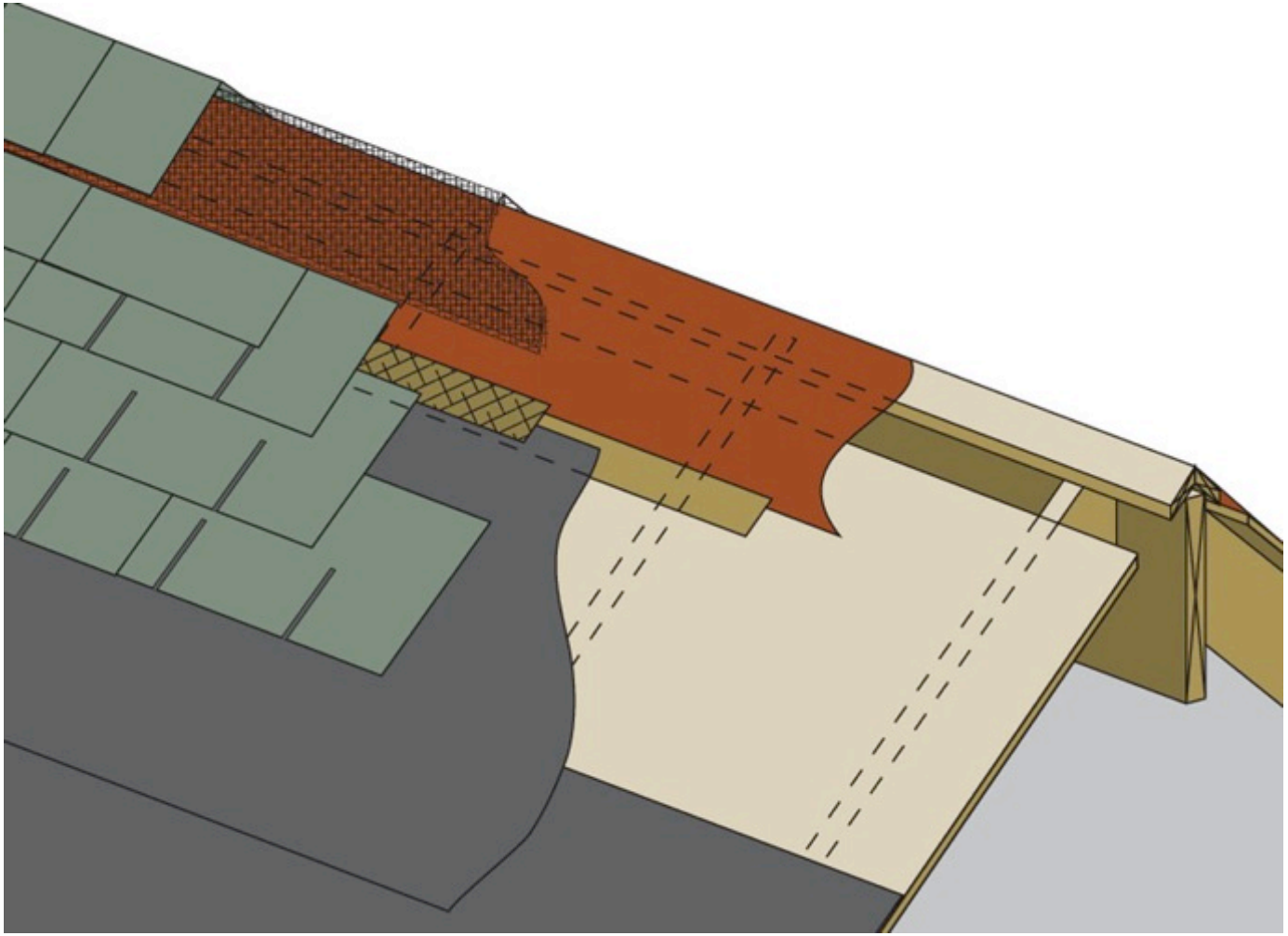

GRACE
Ice & Water Shield®

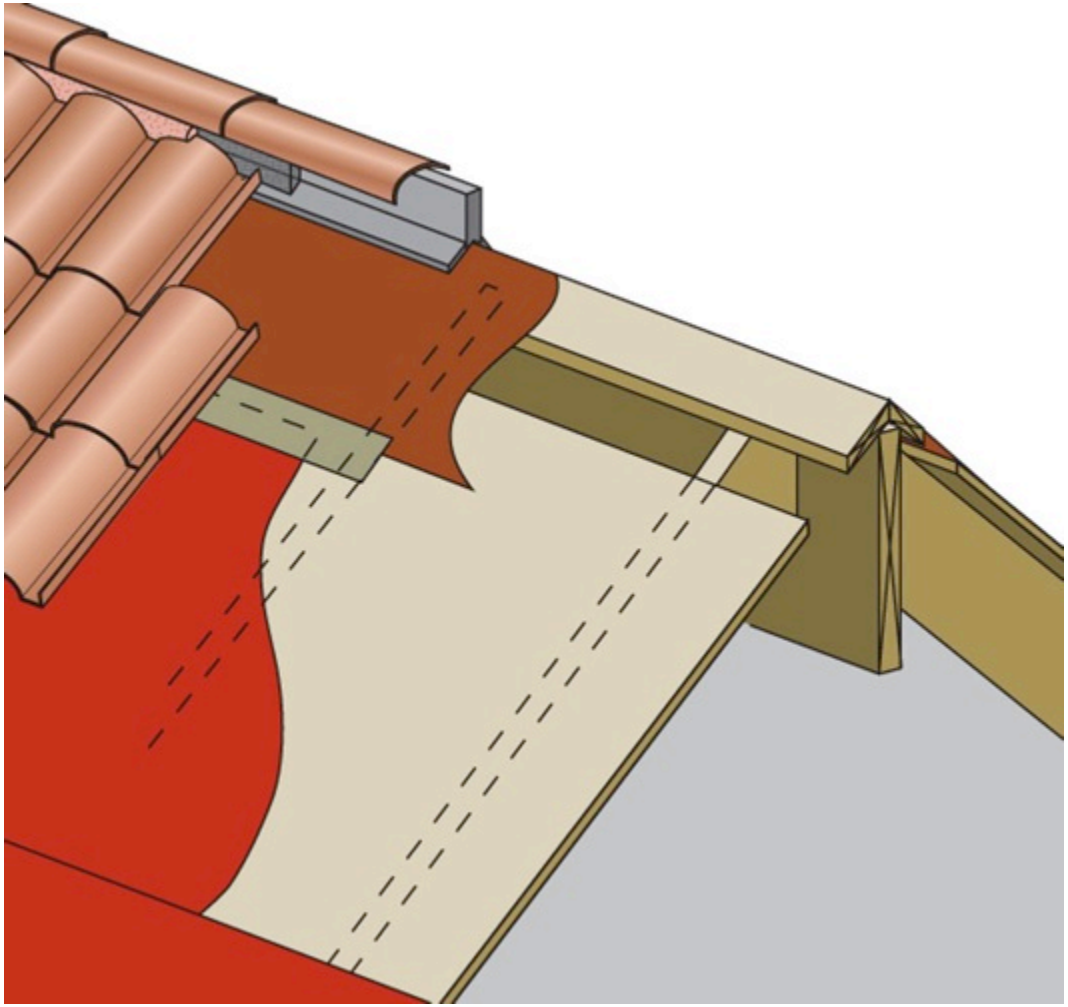

JUL 9 2006


Asphalt shingles
OSB sheathing
Dense glass
gold at ridge
2x2 Framing
OSB sheathing
OSB sheathing



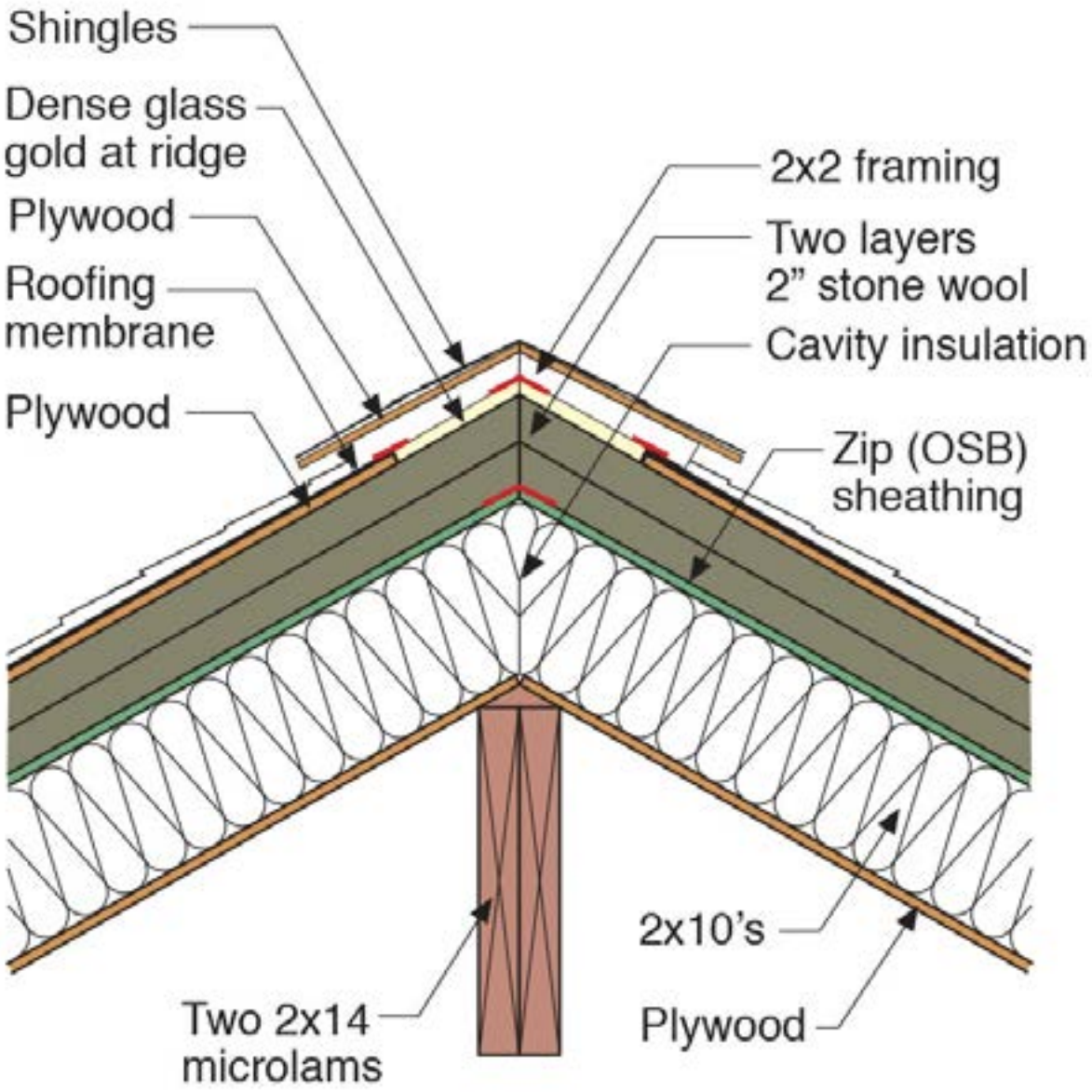




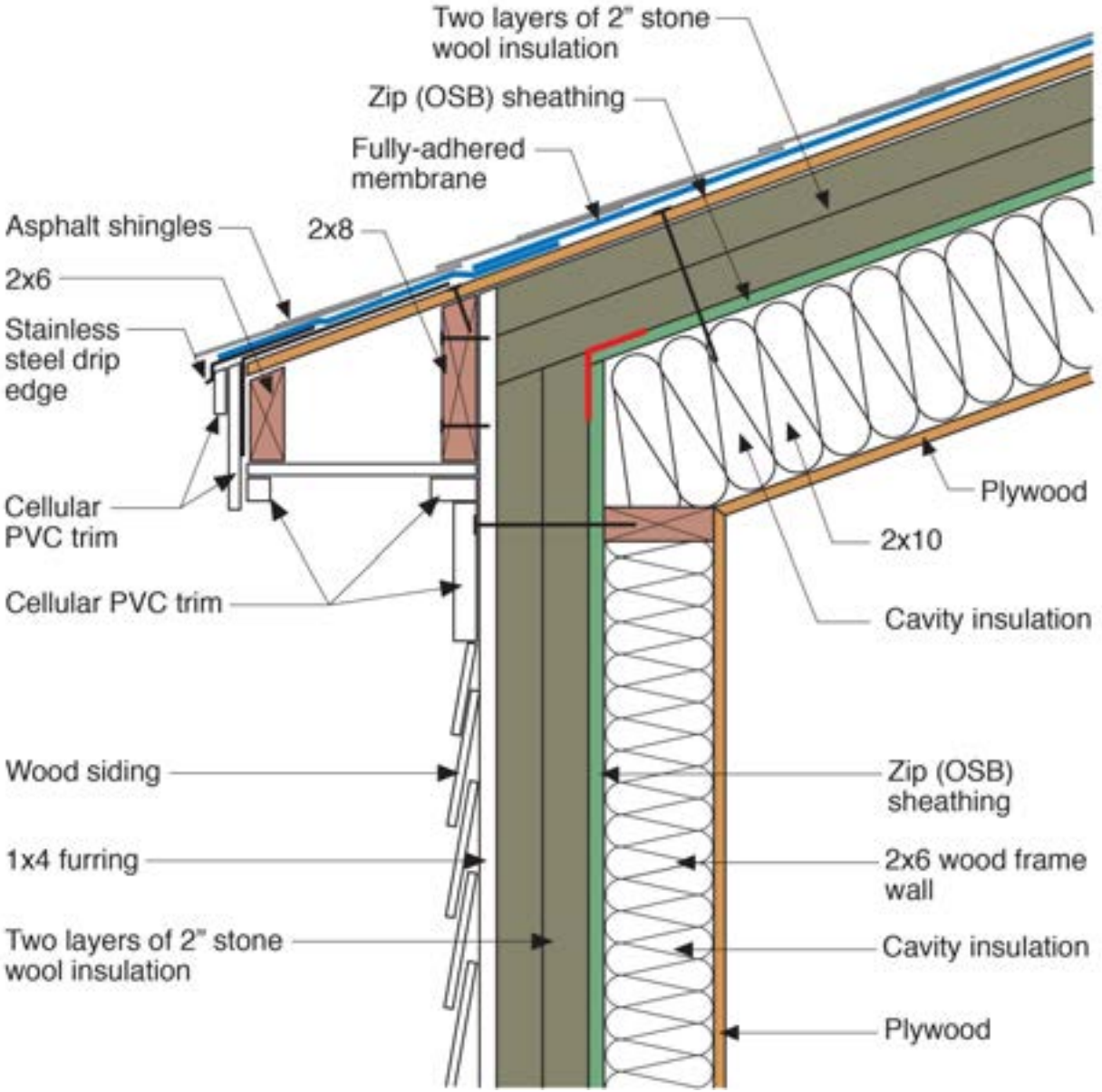


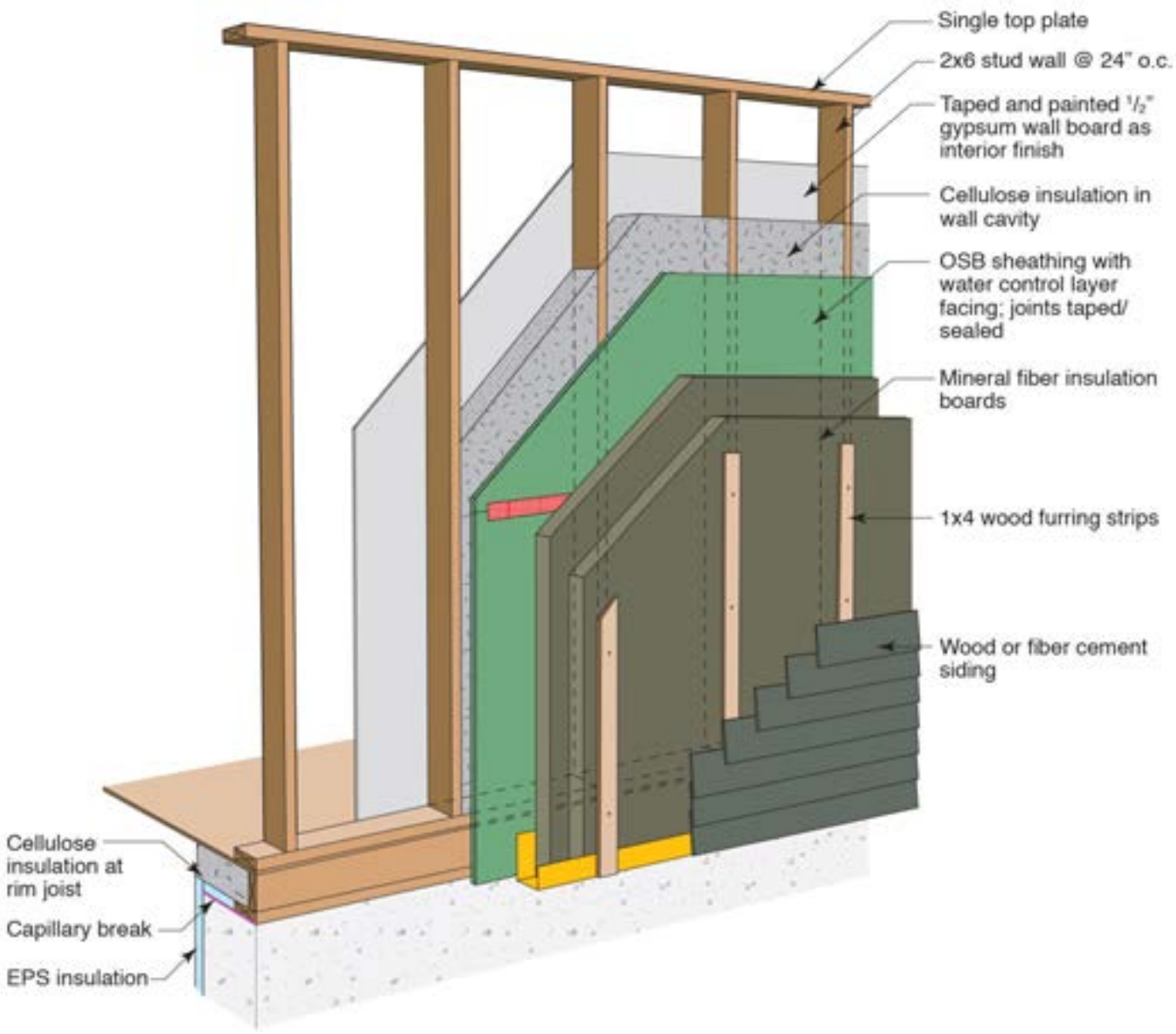

3M

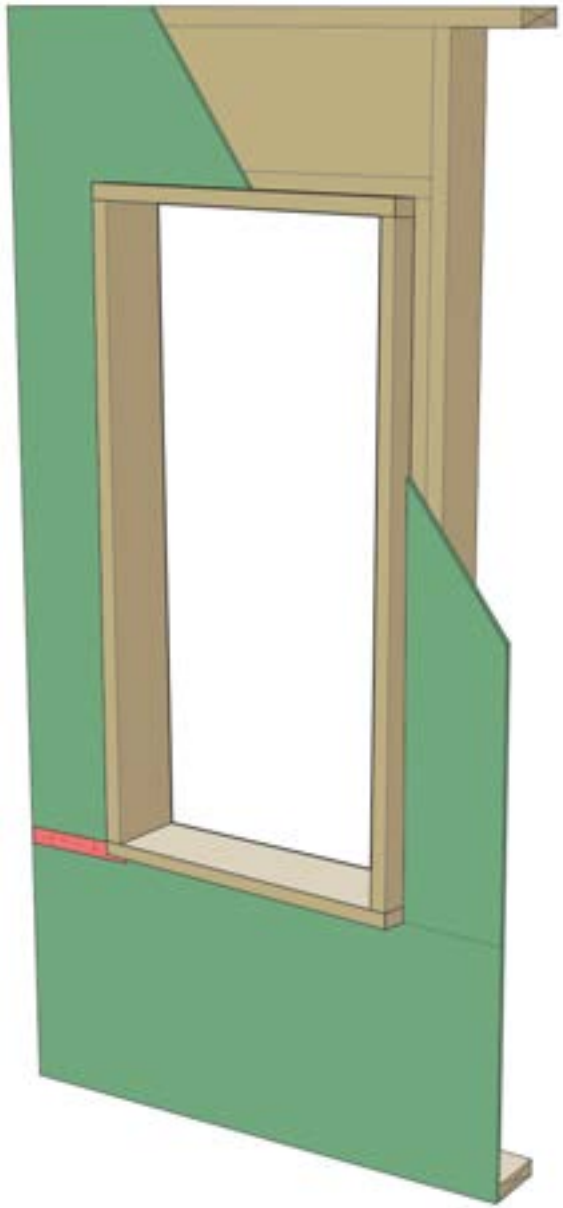

DELTA DELTA DELTA

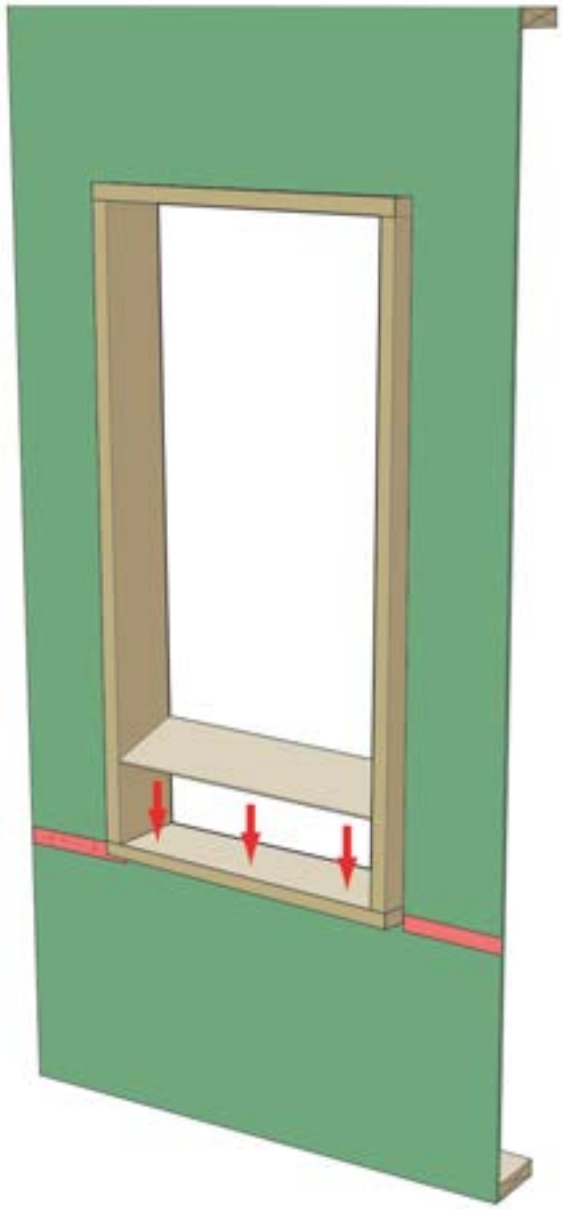

Shingles
Dense glass gold at ridge
Plywood
Roofing membrane
Plywood
2x2 framing
Two layers 2" stone wool
Cavity insulation
Zip (OSB) sheathing
2x10's
Plywood
Two 2x14 microlams

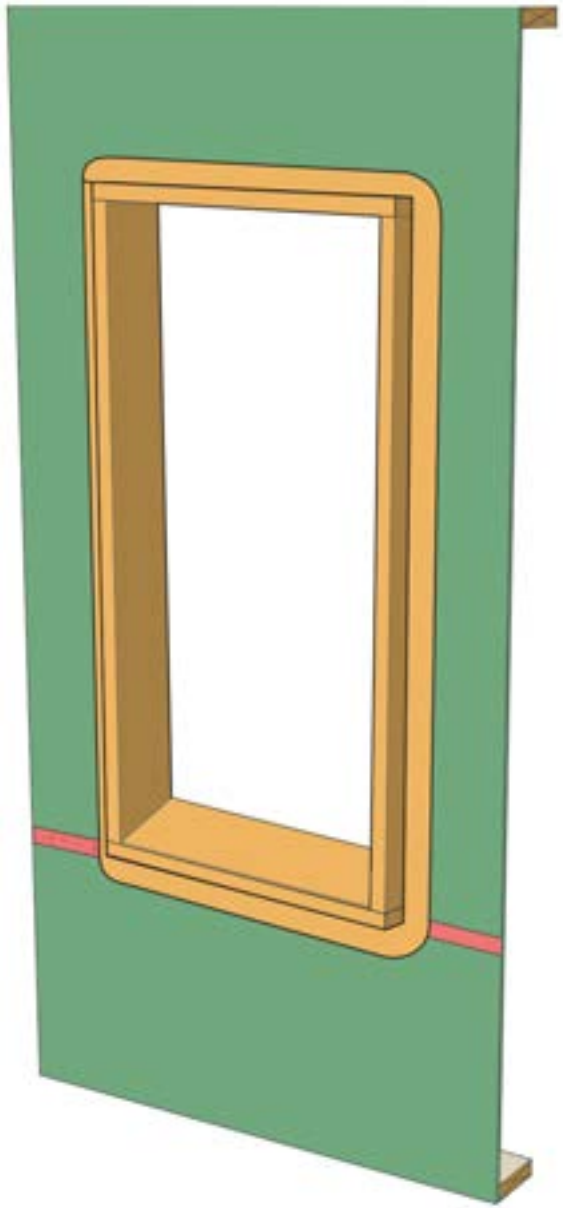

GRACE
Ice & Water Shield
Ice & Water Shield

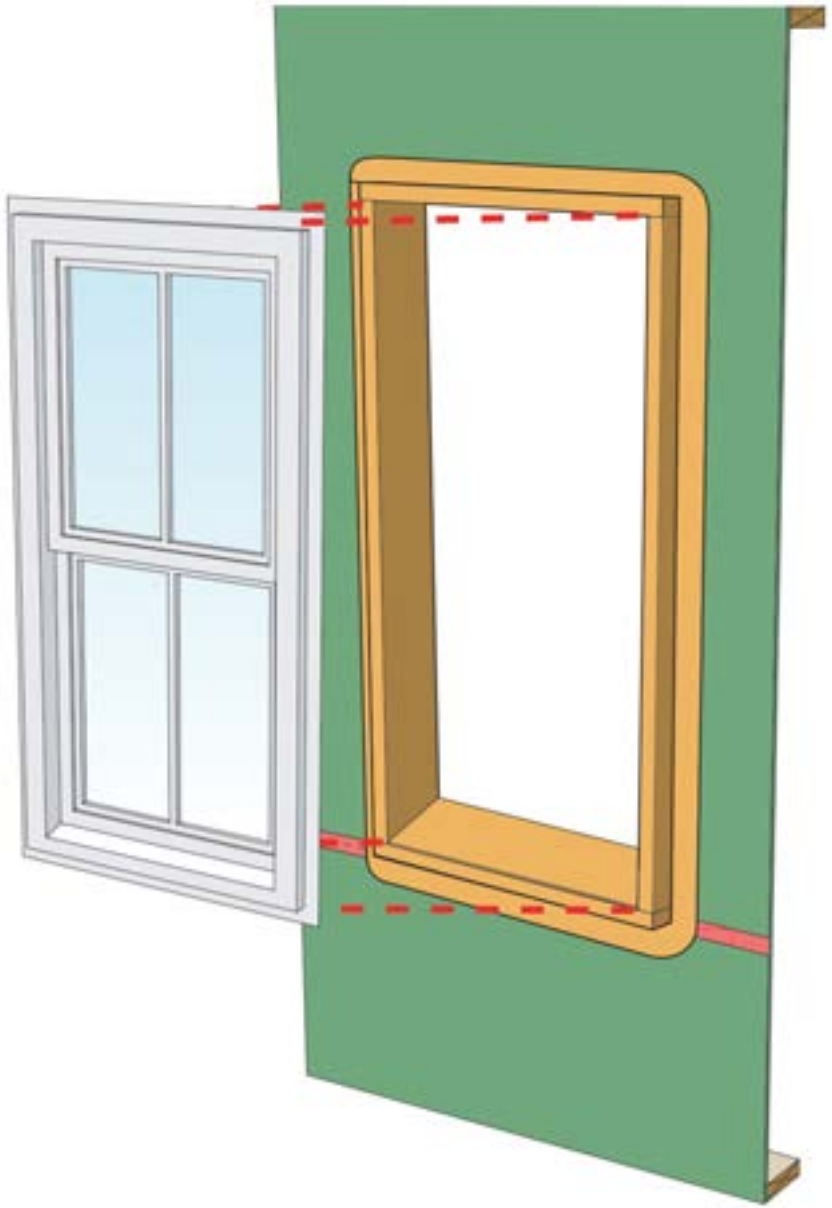

Two layers of 2" stone wool insulation
Zip (OSB) sheathing
Fully-adhered membrane
Asphalt shingles
2x8
2x6
Stainless steel drip edge
Cellular PVC trim
Cellular PVC trim
Plywood
2x10
Cavity insulation
Wood siding
1x4 furring
Two layers of 2" stone wool insulation
Zip (OSB) sheathing
2x6 wood frame wall
Cavity insulation
Plywood

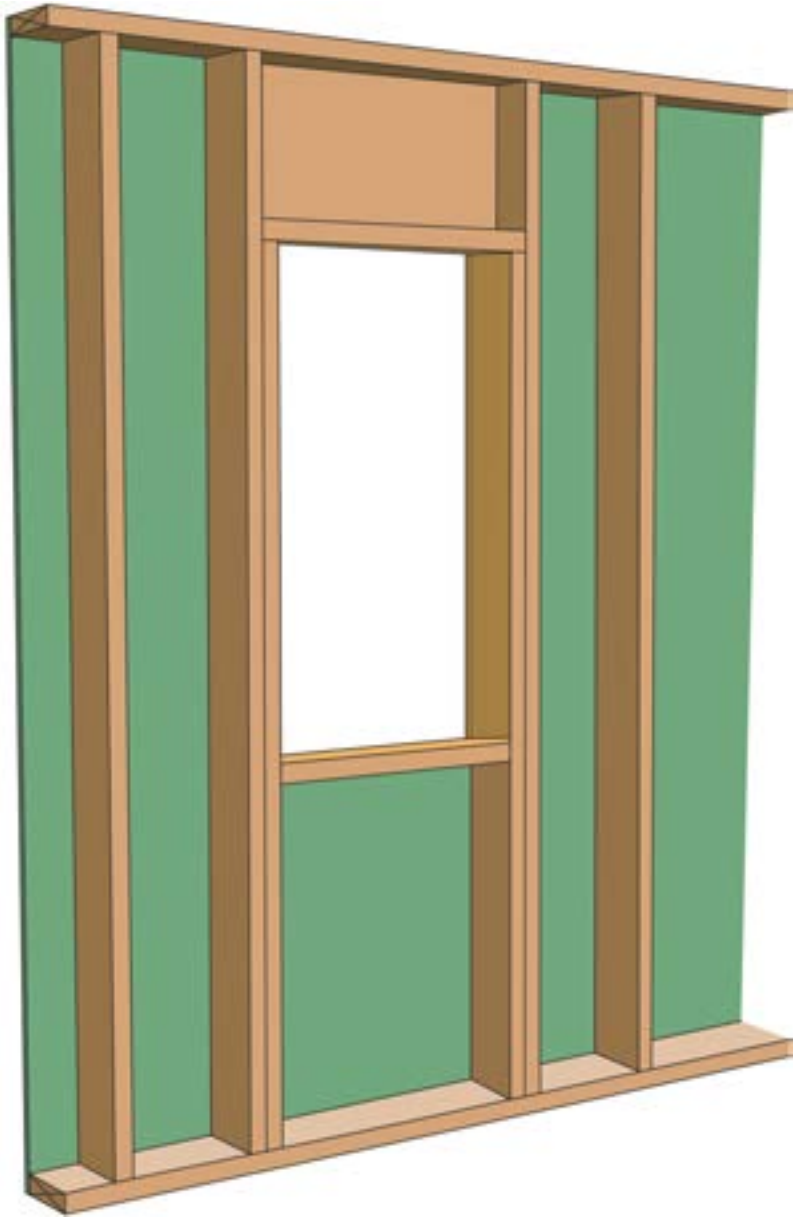

Single top plate
2x6 stud wall @ 24" o.c.
Taped and painted ½" gypsum wall board as interior finish
Cellulose insulation in wall cavity
OSB sheathing with water control layer facing; joints taped/ sealed
Mineral fiber insulation boards
1x4 wood furring strips
Wood or fiber cement siding
Cellulose insulation at rim joist
Capillary break
EPS insulation

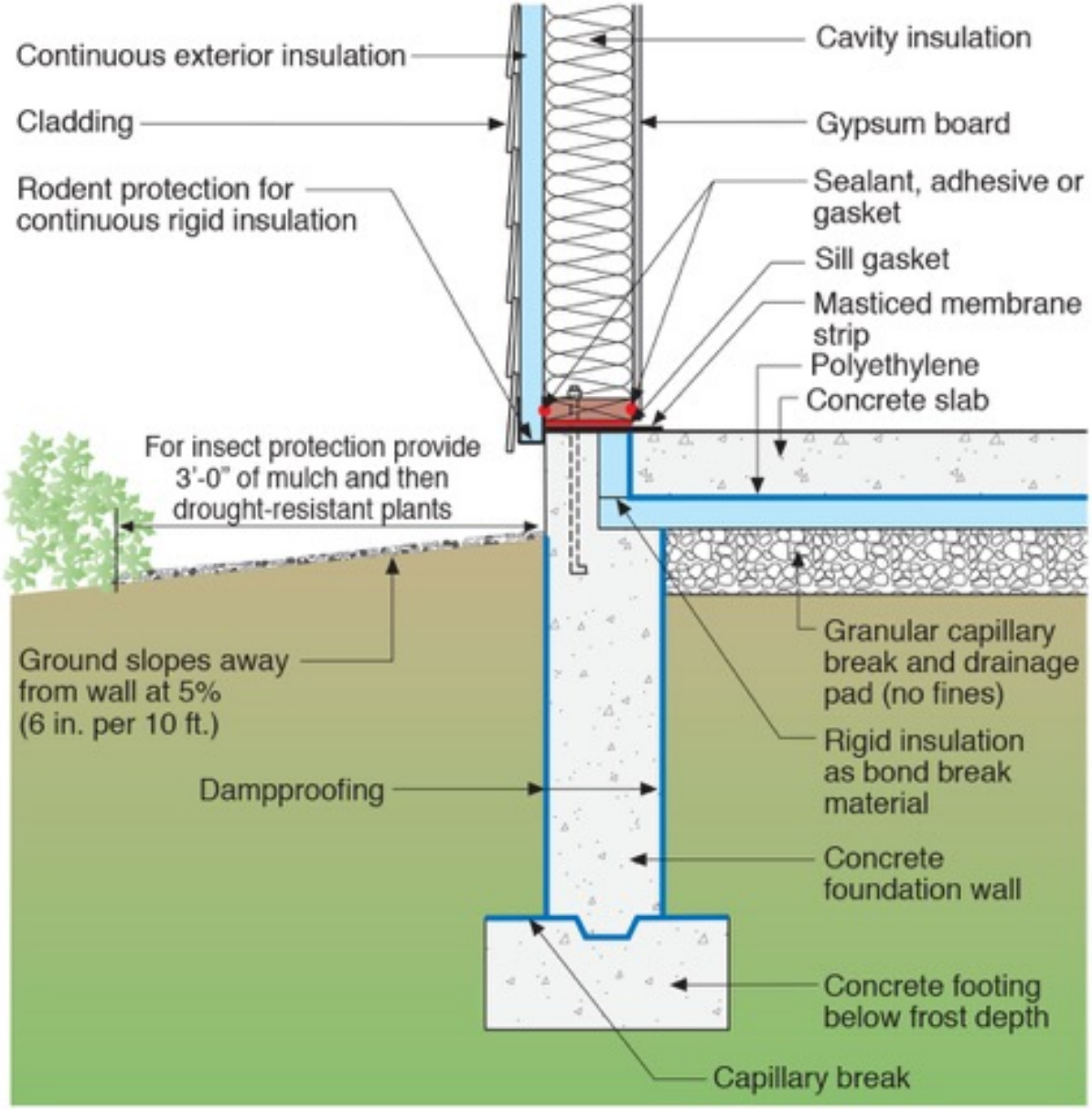


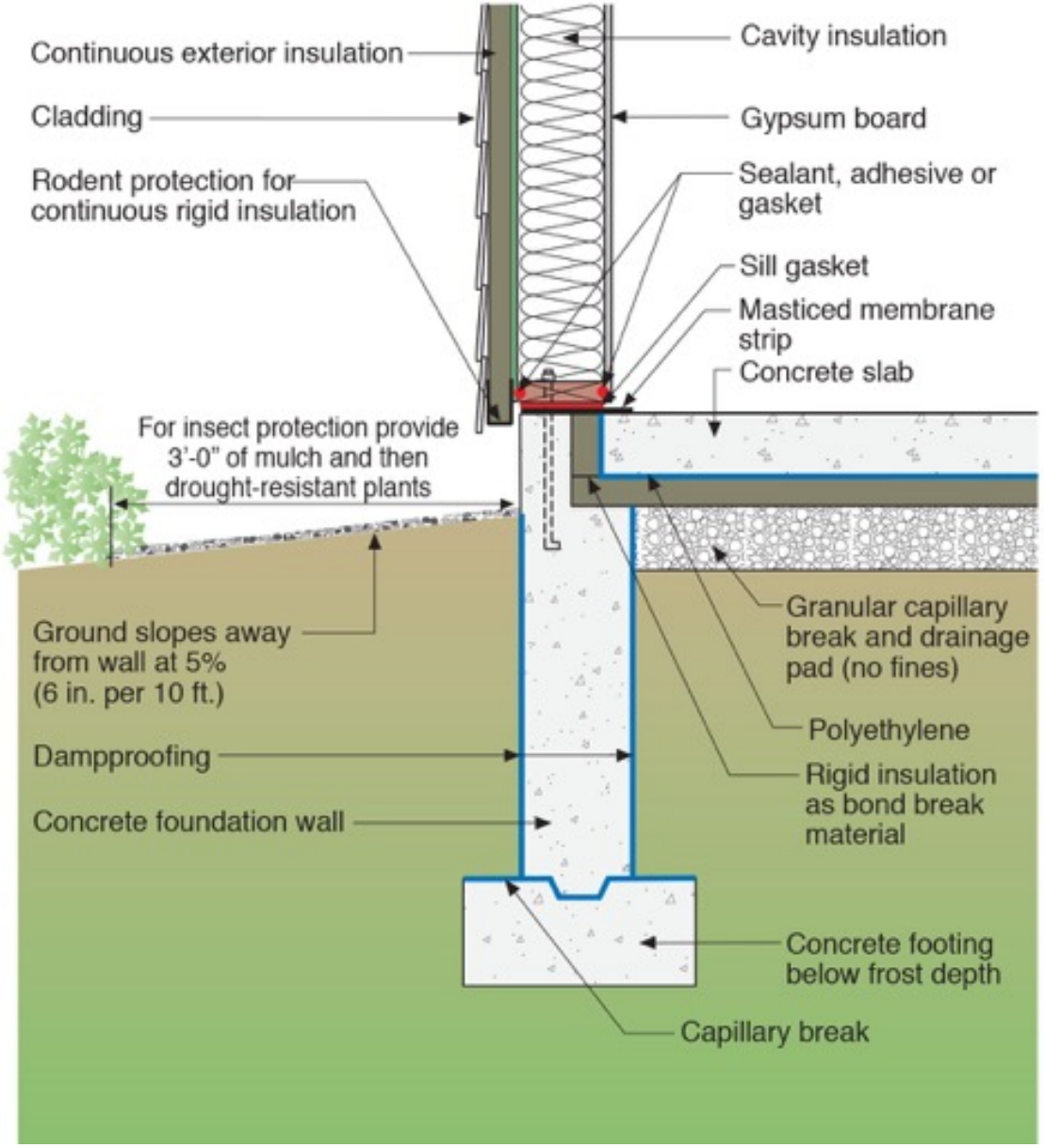


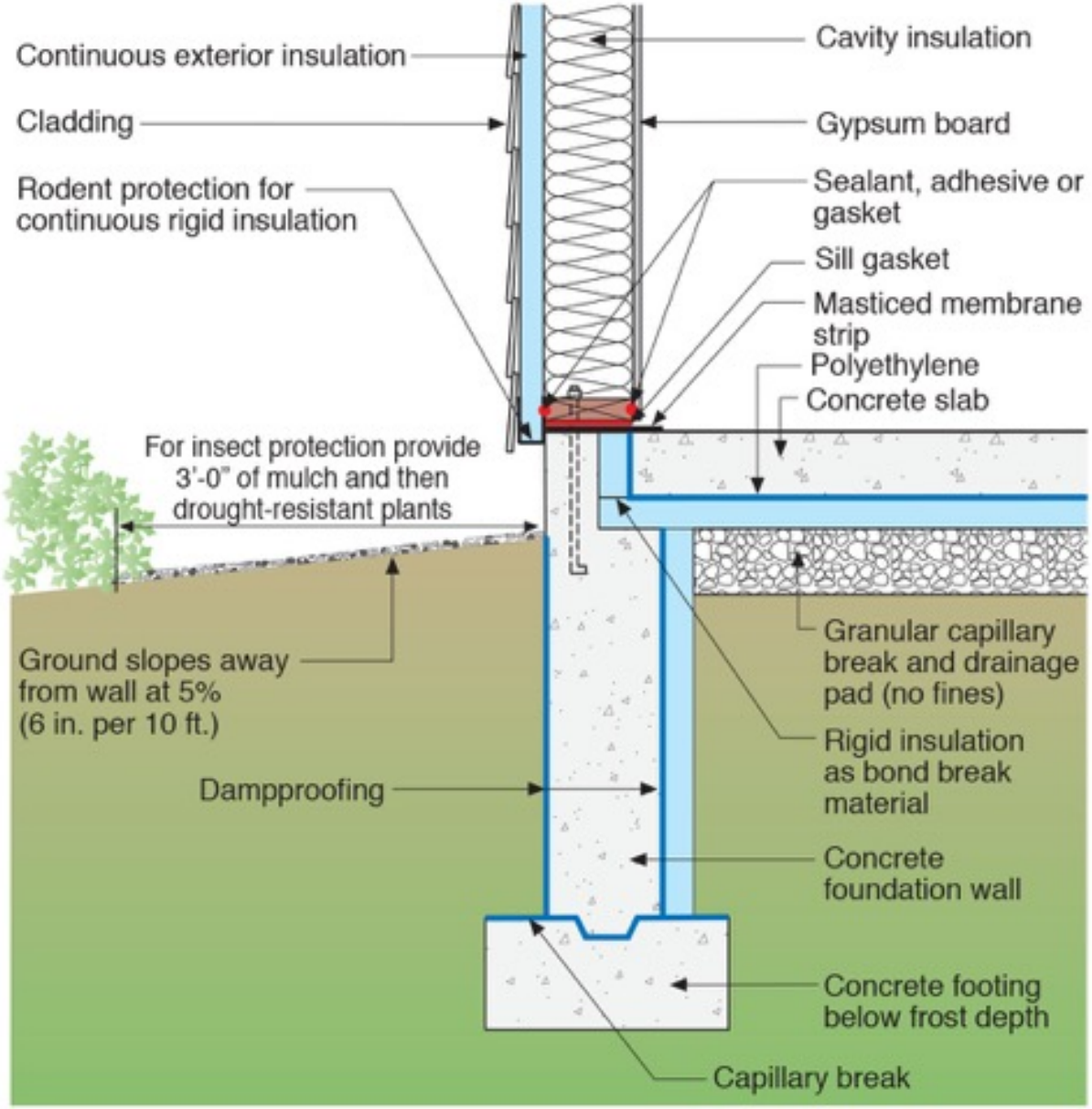


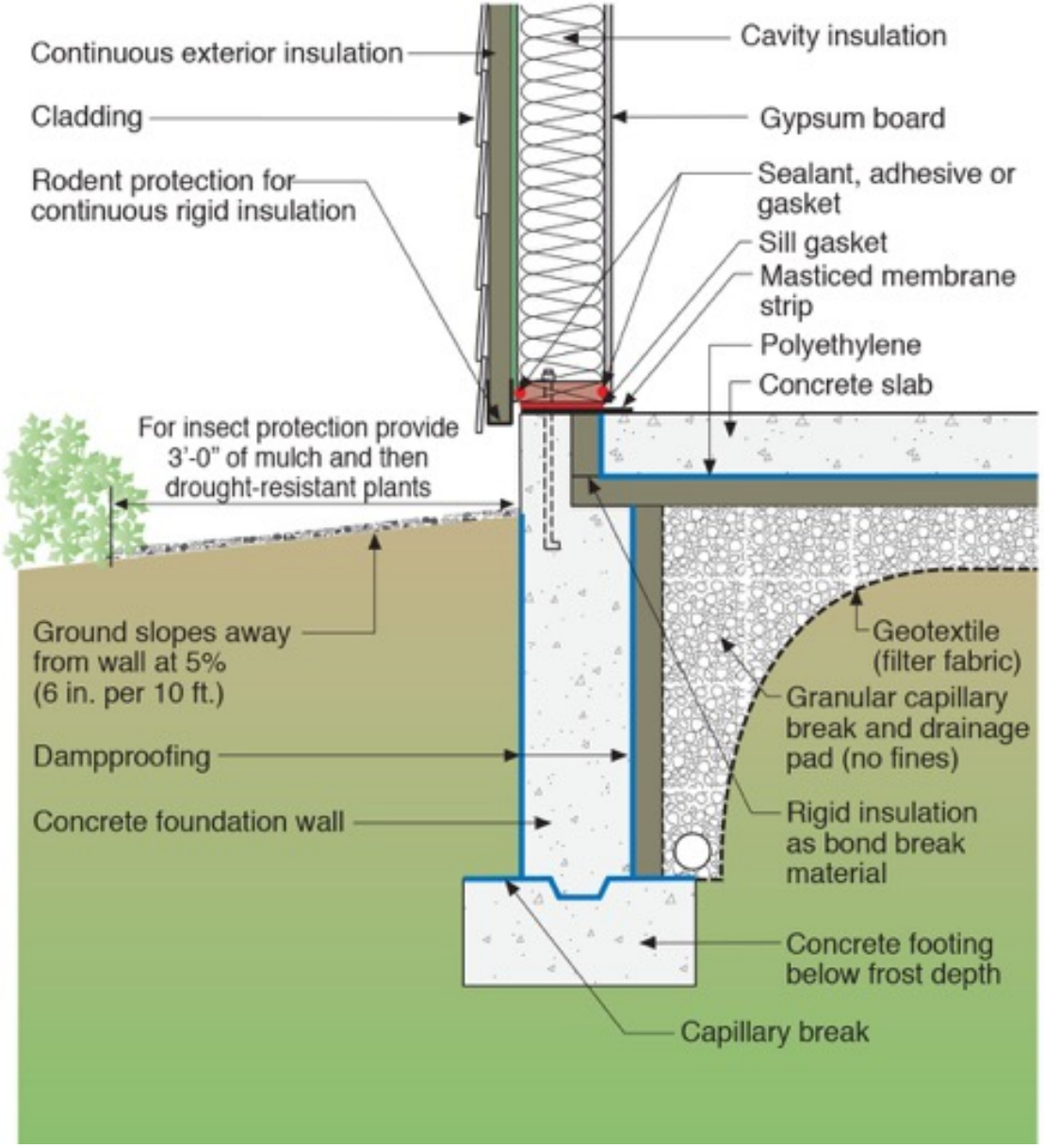


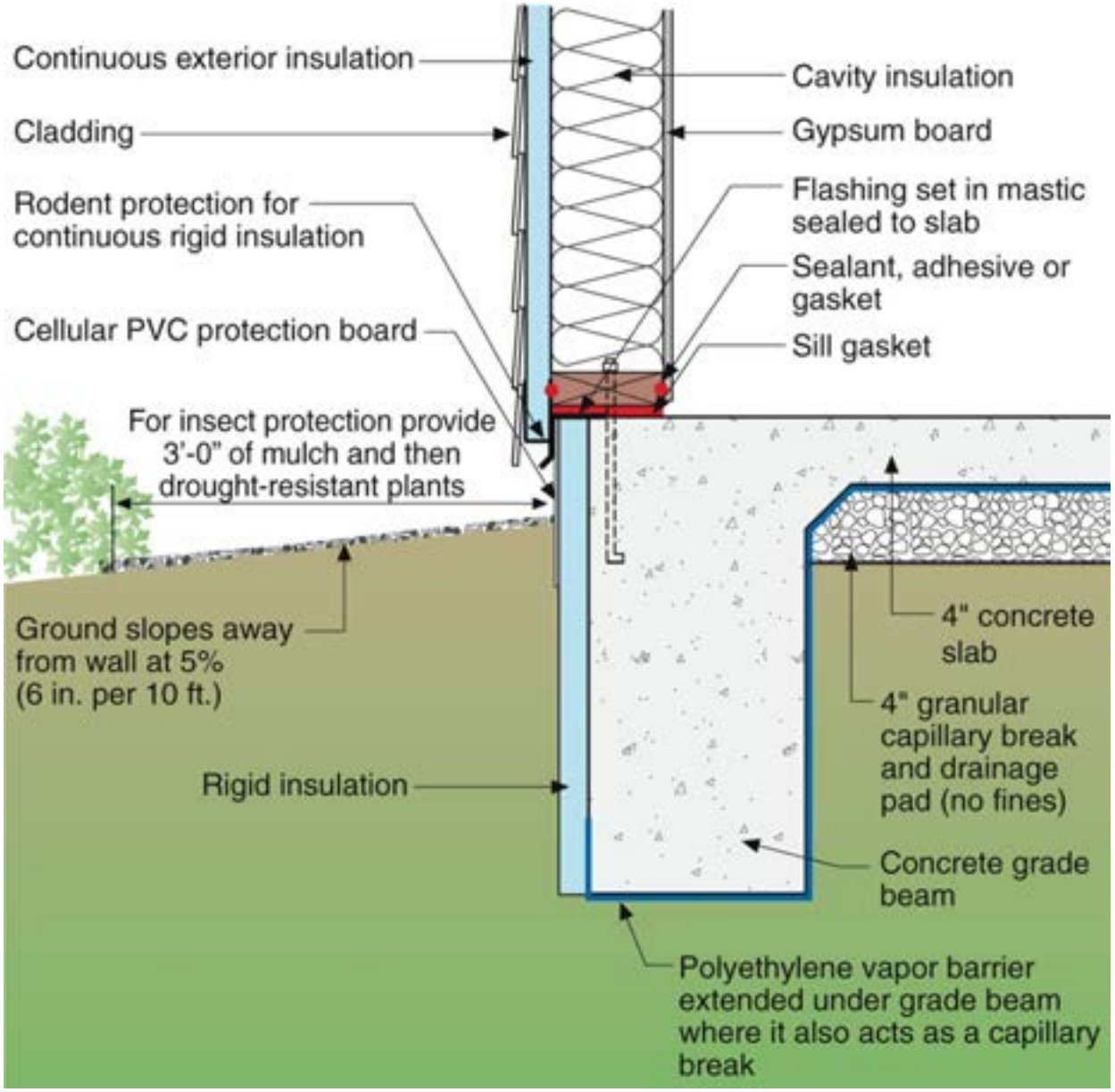


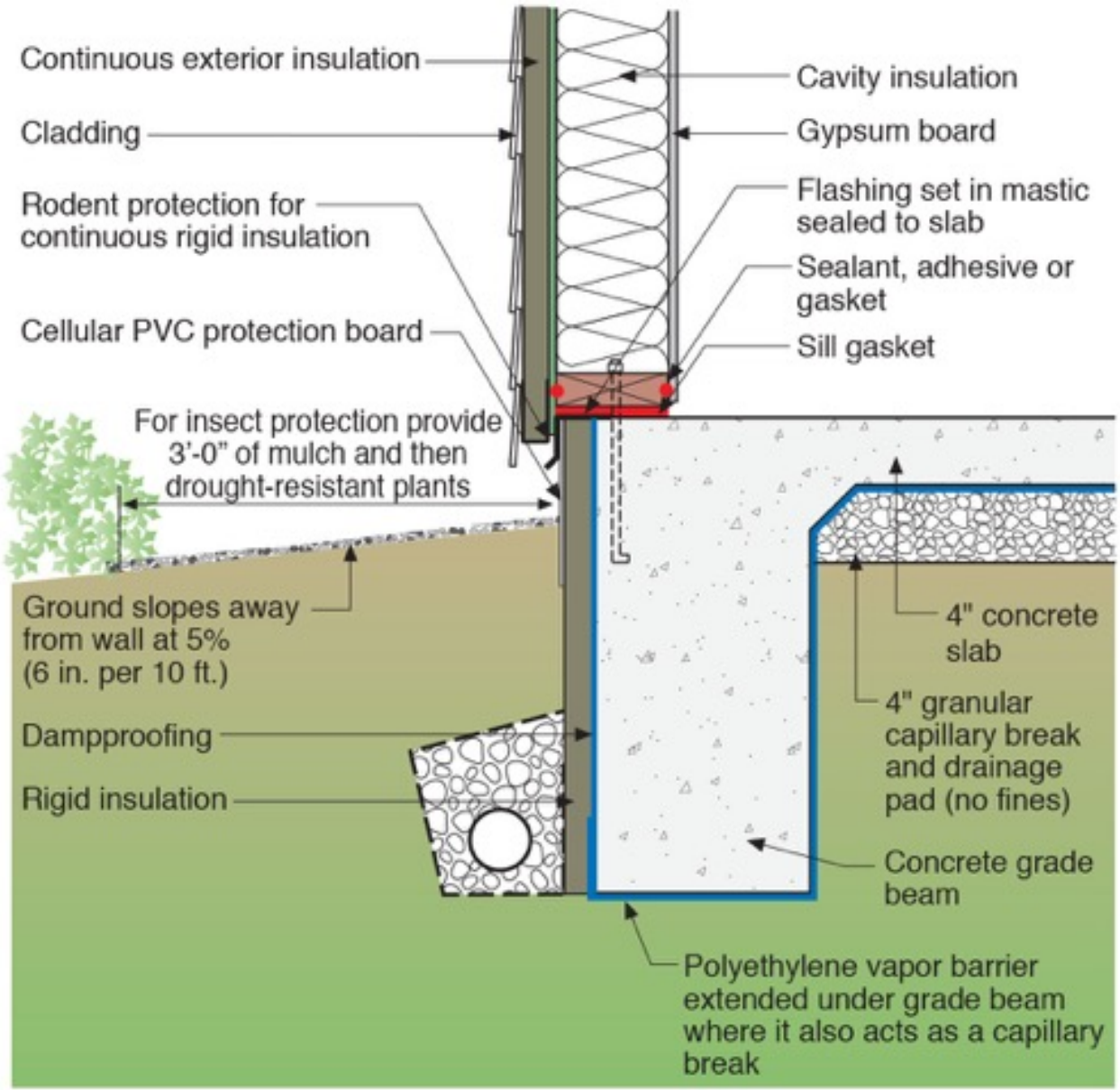

Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cavity insulation
Gypsum board
Sealant, adhesive or gasket
Sill gasket
Masticed membrane strip
Polyethylene
Concrete slab
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Dampproofing
Granular capillary break and drainage pad (no fines)
Rigid insulation as bond break material
Concrete foundation wall
Concrete footing below frost depth
Capillary break

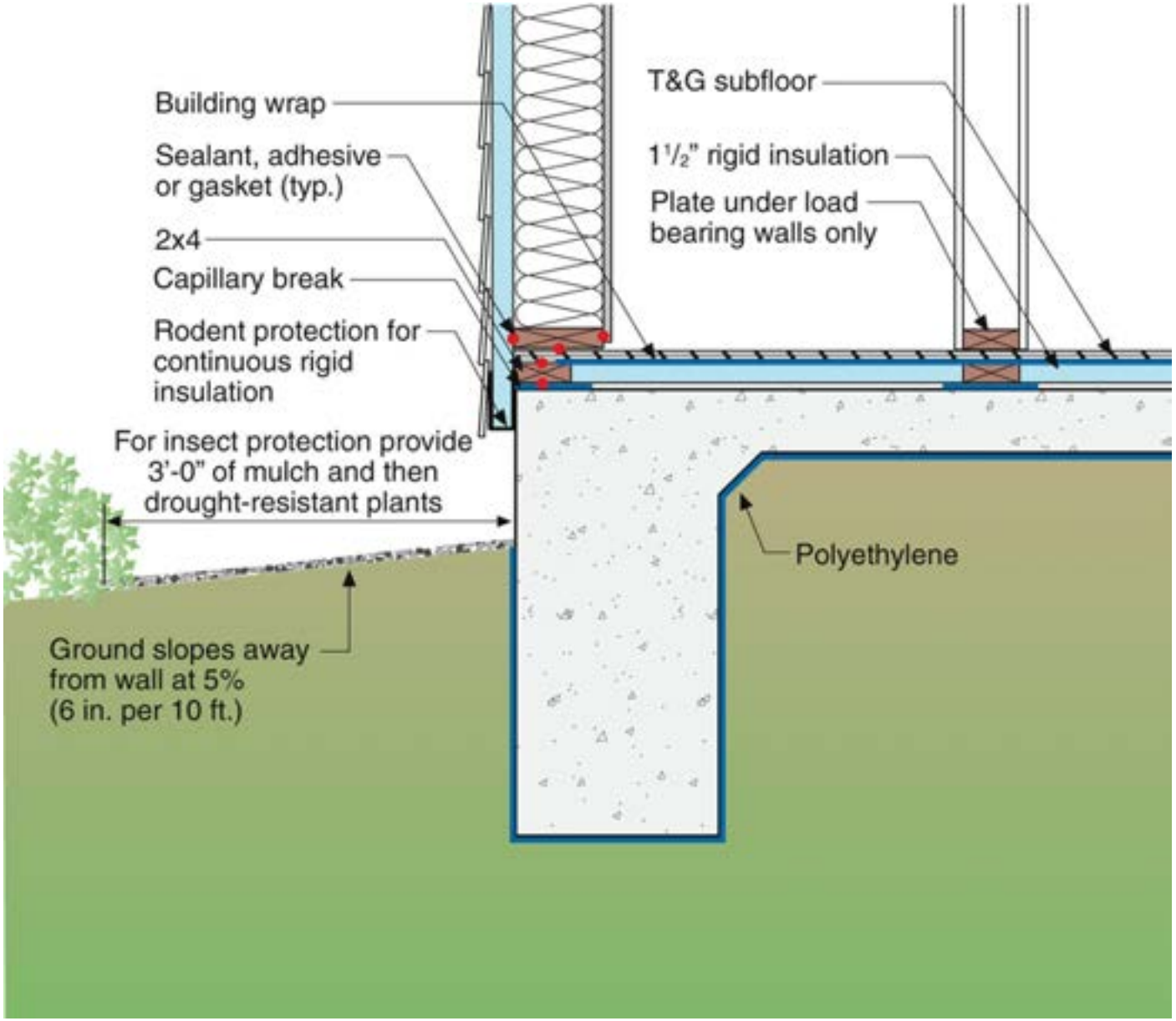

Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cavity insulation
Gypsum board
Sealant, adhesive or gasket
Sill gasket
Masticed membrane strip
Concrete slab
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Dampproofing
Concrete foundation wall
Granular capillary break and drainage pad (no fines)
Polyethylene
Rigid insulation as bond break material
Concrete footing below frost depth
Capillary break

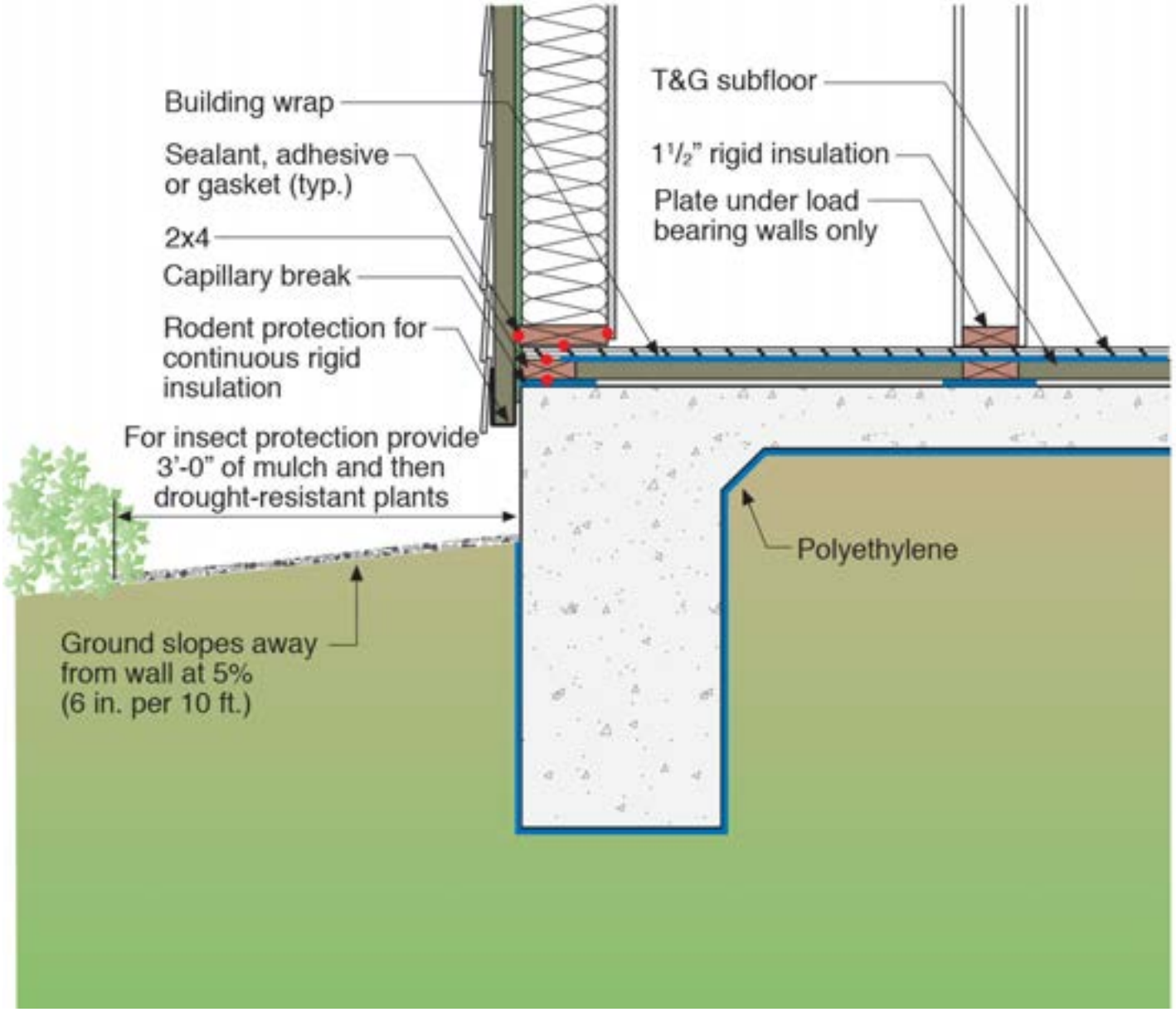

Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cavity insulation
Gypsum board
Sealant, adhesive or gasket
Sill gasket
Masticed membrane strip
Polyethylene
Concrete slab
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Dampproofing
Granular capillary break and drainage pad (no fines)
Rigid insulation as bond break material
Concrete foundation wall
Concrete footing below frost depth
Capillary break


Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cavity insulation
Gypsum board
Sealant, adhesive or gasket
Sill gasket
Masticed membrane strip
Polyethylene
Concrete slab
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Dampproofing
Concrete foundation wall
Geotextile (filter fabric)
Granular capillary break and drainage pad (no fines)
Rigid insulation as bond break material
Concrete footing below frost depth
Capillary break


Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cellular PVC protection board
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Rigid insulation
Cavity insulation
Gypsum board
Flashing set in mastic sealed to slab
Sealant, adhesive or gasket
Sill gasket
4" concrete slab
4" granular capillary break and drainage pad (no fines)
Concrete grade beam
Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break


Continuous exterior insulation
Cladding
Rodent protection for continuous rigid insulation
Cellular PVC protection board
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Dampproofing
Rigid insulation
Cavity insulation
Gypsum board
Flashing set in mastic sealed to slab
Sealant, adhesive or gasket
Sill gasket
4" concrete slab
4" granular capillary break and drainage pad (no fines)
Concrete grade beam
Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break


Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
Rodent protection for continuous rigid insulation
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
T&G subfloor
1½" rigid insulation
Plate under load bearing walls only
Polyethylene


Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
Rodent protection for continuous rigid insulation
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Ground slopes away from wall at 5% (6 in. per 10 ft.)
T&G subfloor
1½" rigid insulation
Plate under load bearing walls only
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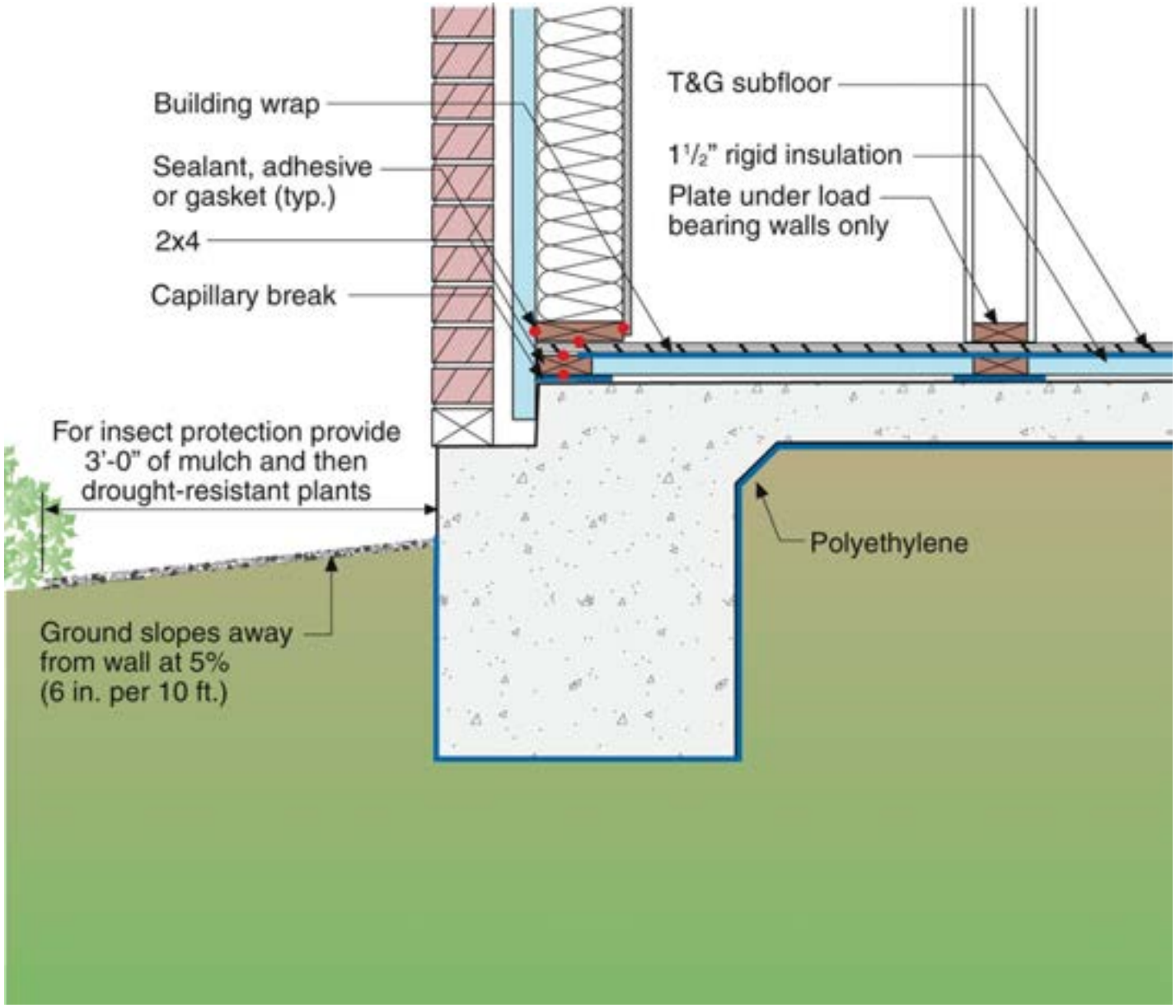
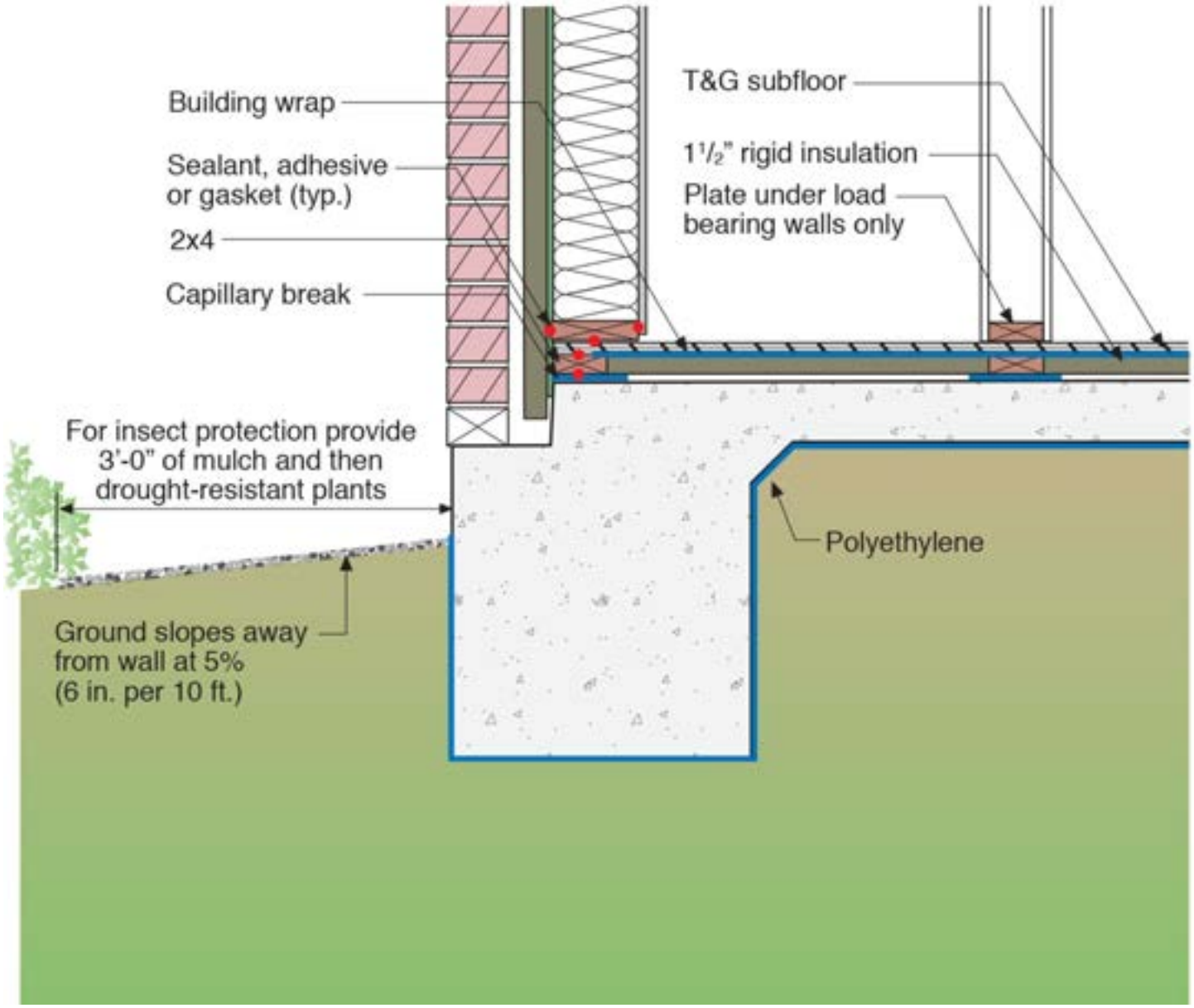
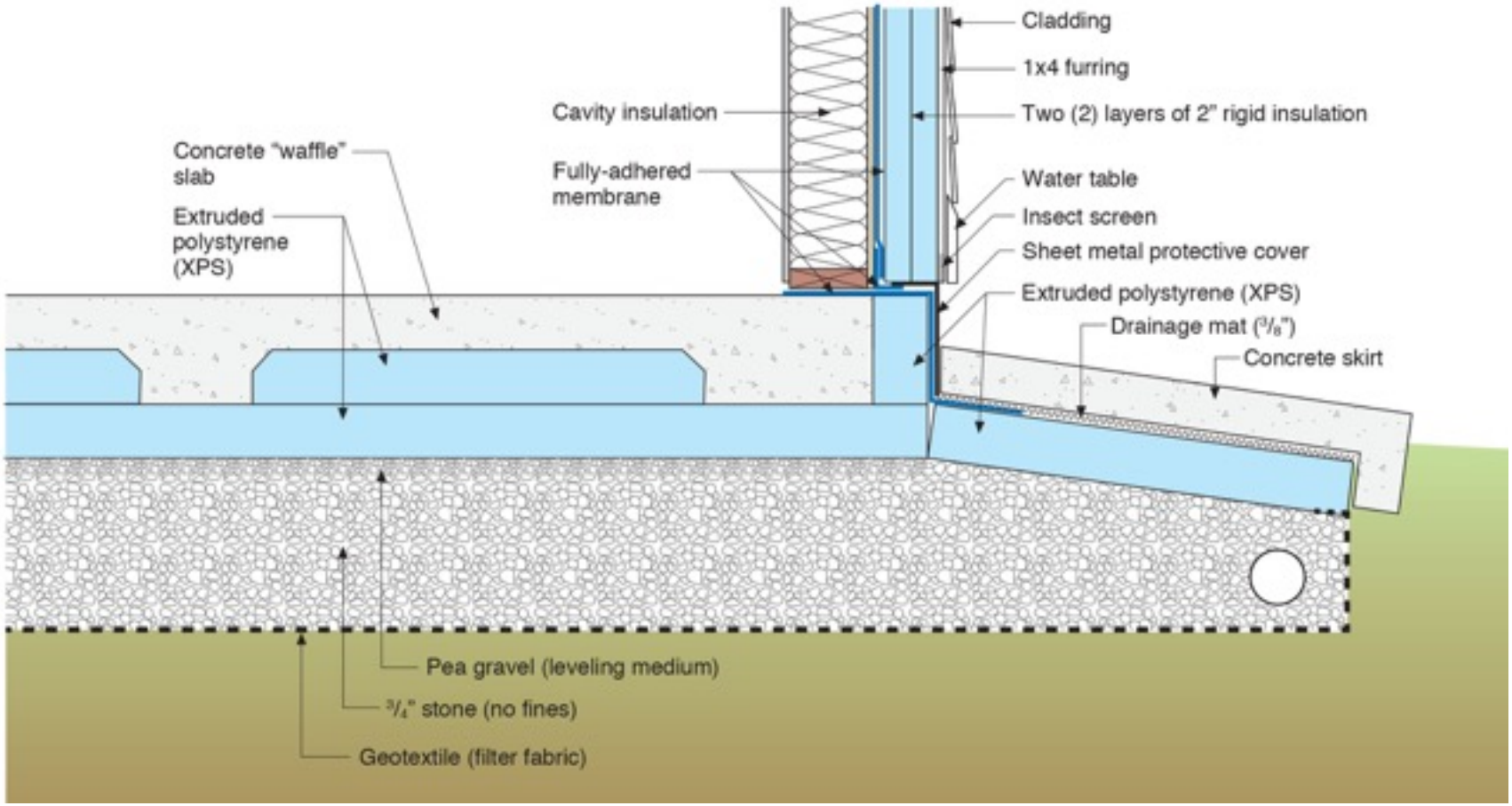
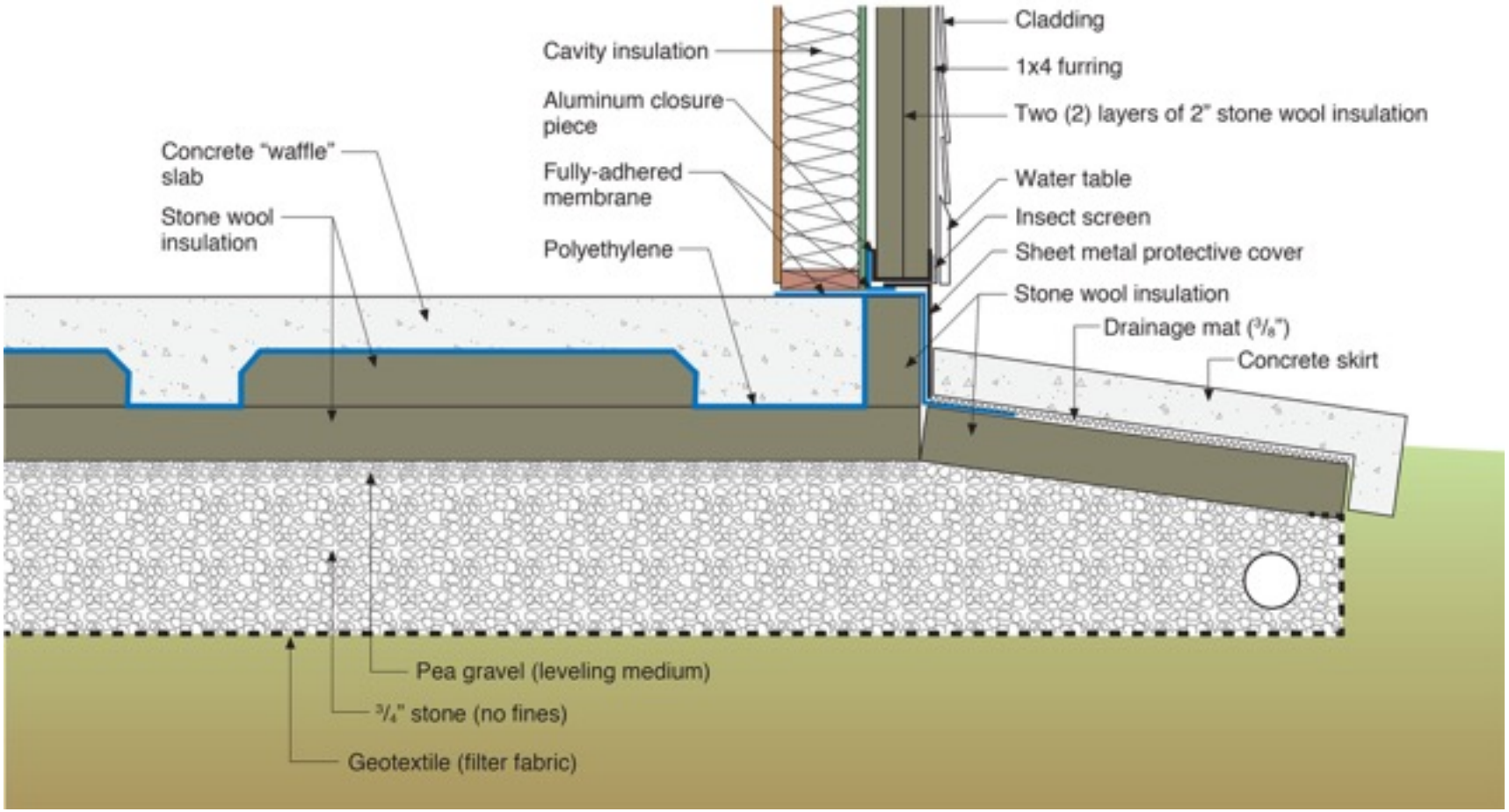
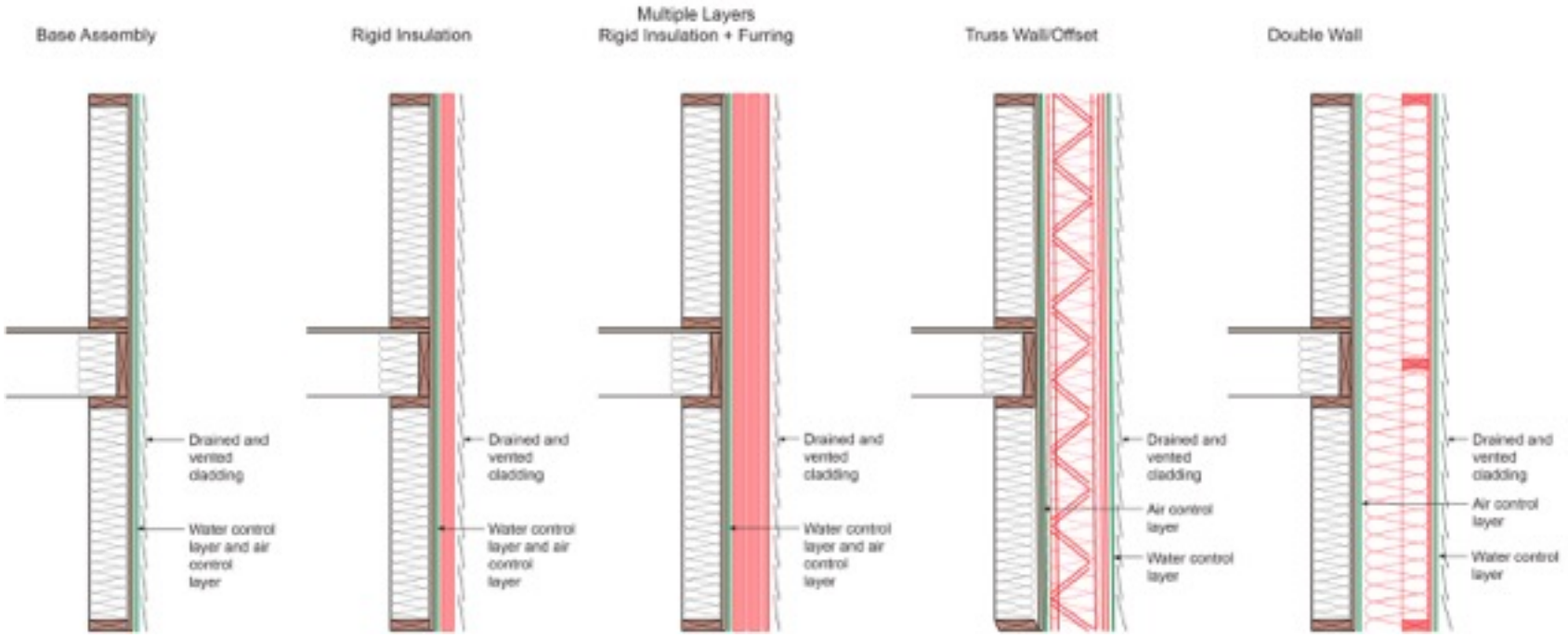

Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
T&G subfloor
1½" rigid insulation
Plate under load bearing walls only
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Polyethylene
Ground slopes away from wall at 5% (6 in. per 10 ft.)


Building wrap
Sealant, adhesive or gasket (typ.)
2x4
Capillary break
T&G subfloor
1½" rigid insulation
Plate under load bearing walls only
For insect protection provide 3'-0" of mulch and then drought-resistant plants
Polyethylene
Ground slopes away from wall at 5% (6 in. per 10 ft.)


Cladding
1x4 furring
Two (2) layers of 2" rigid insulation
Cavity insulation
Fully-adhered membrane
Concrete "waffle" slab
Extruded polystyrene (XPS)
Water table
Insect screen
Sheet metal protective cover
Extruded polystyrene (XPS)
Drainage mat (3/8")
Concrete skirt
Pea gravel (leveling medium)
3/4" stone (no fines)
Geotextile (filter fabric)


Cavity insulation
Aluminum closure piece
Fully-adhered membrane
Polyethylene
Concrete "waffle" slab
Stone wool insulation
Cladding
1x4 furring
Two (2) layers of 2" stone wool insulation
Water table
Insect screen
Sheet metal protective cover
Stone wool insulation
Drainage mat (3/8")
Concrete skirt
Pea gravel (leveling medium)
3/4" stone (no fines)
Geotextile (filter fabric)

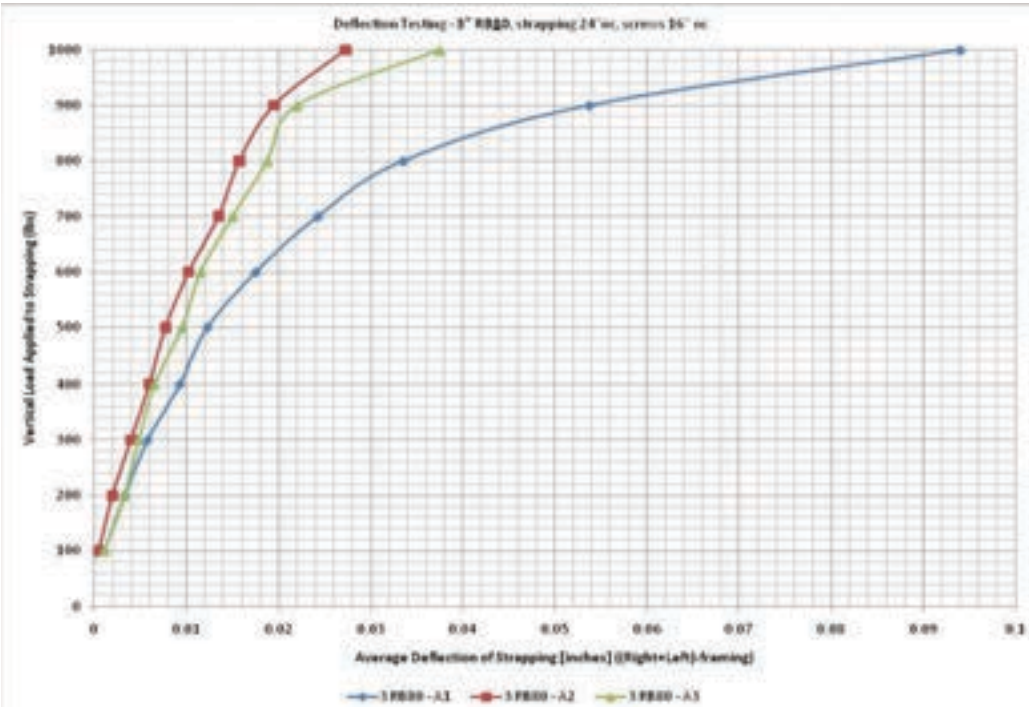

ROXUL
ROXUL
ROXUL

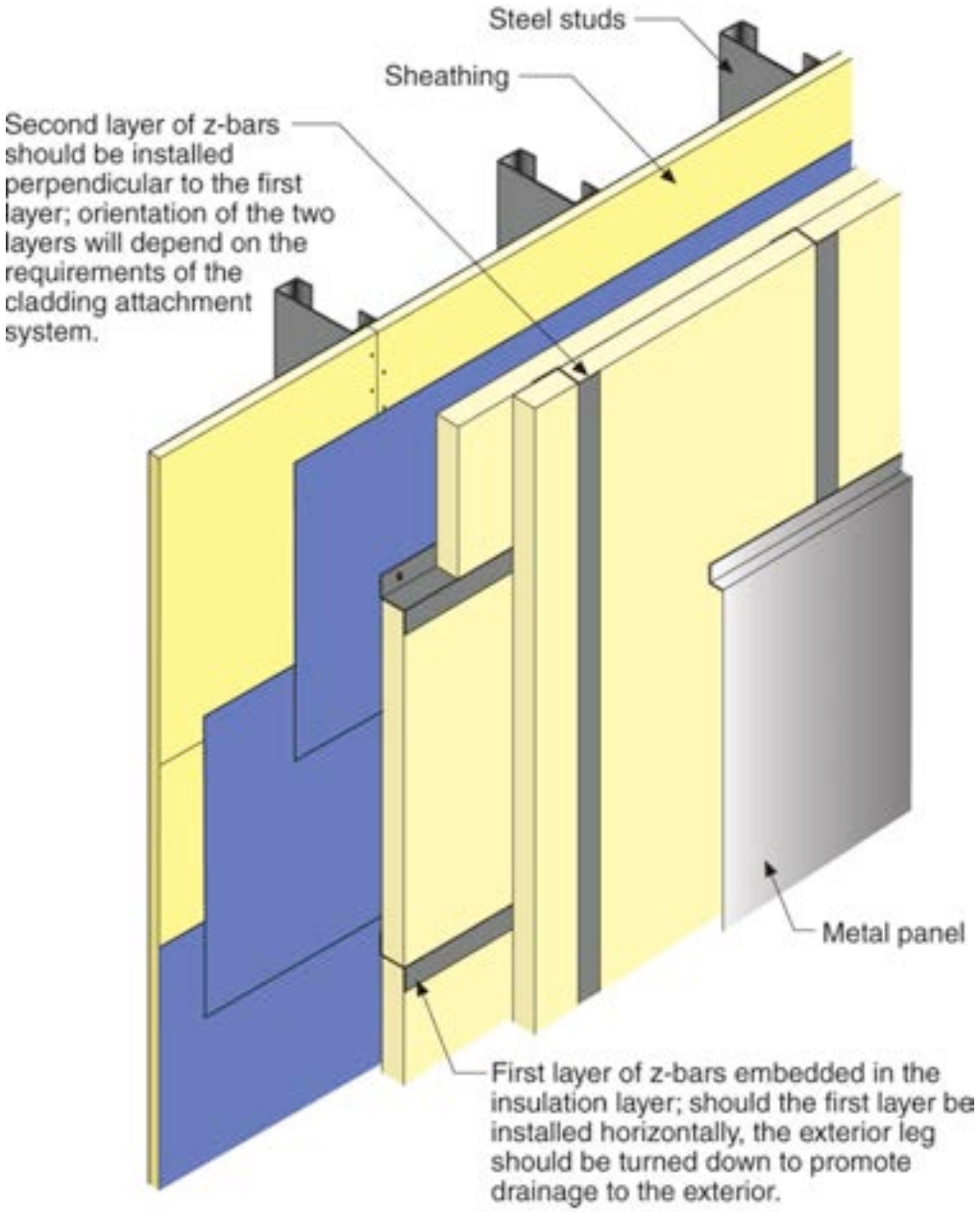

Base Assembly
Drained and vented cladding
Water control layer and air control layer
Rigid Insulation
Drained and vented cladding
Water control layer and air control layer
Multiple Layers
Rigid Insulation + Furring
Drained and vented cladding
Water control layer and air control layer
Truss Wall/Offset
Drained and vented cladding
Air control layer
Water control layer
Double Wall
Drained and vented cladding
Air control layer
Water control layer

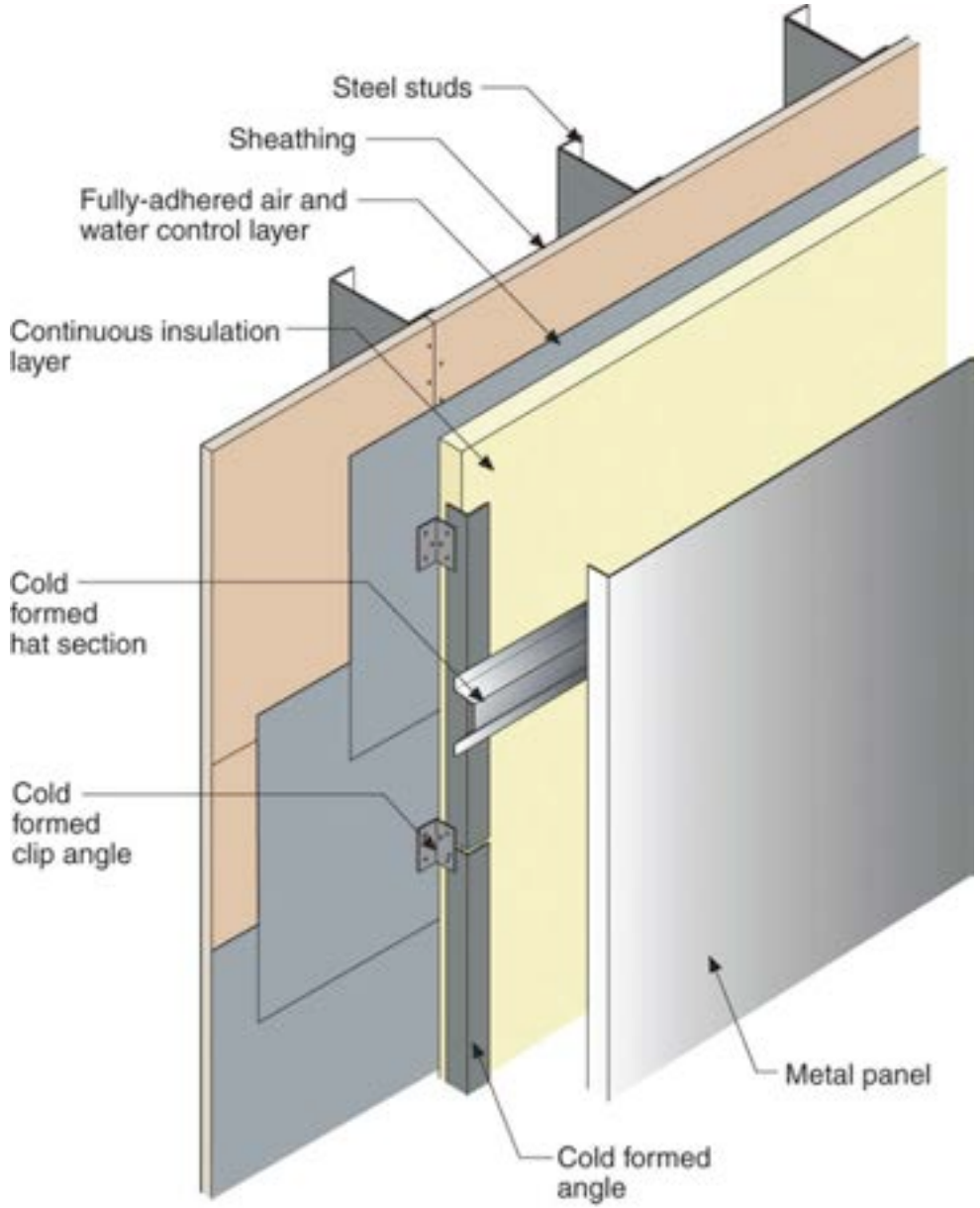

PlastiSpan HD
R8
PlastiSpan HD
R8
PlastiSpan HD
PlastiSpan HD

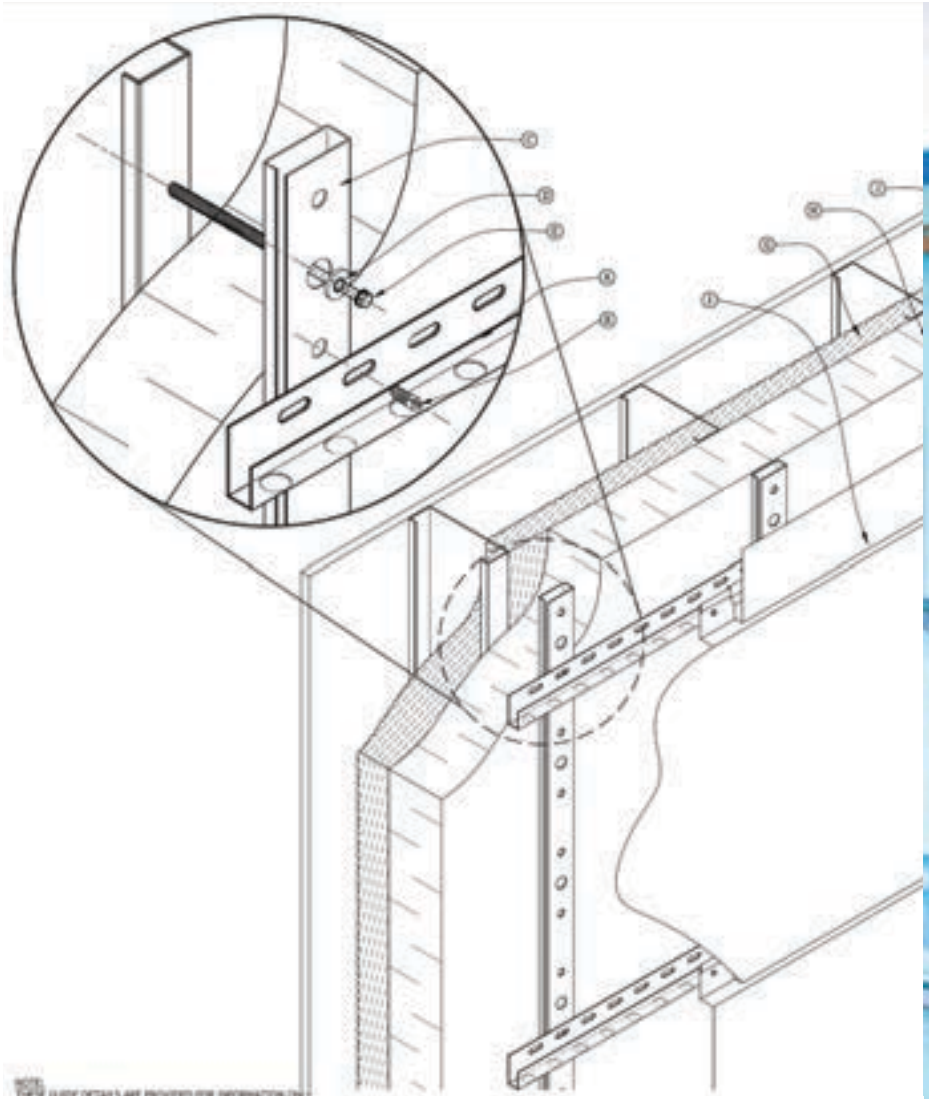
Rockwool

1x3 furring @ 24” o.c.
#10 screws @ 16” o.c. vertically
Result: 20 psf cladding weight
with < 2/100” deflection

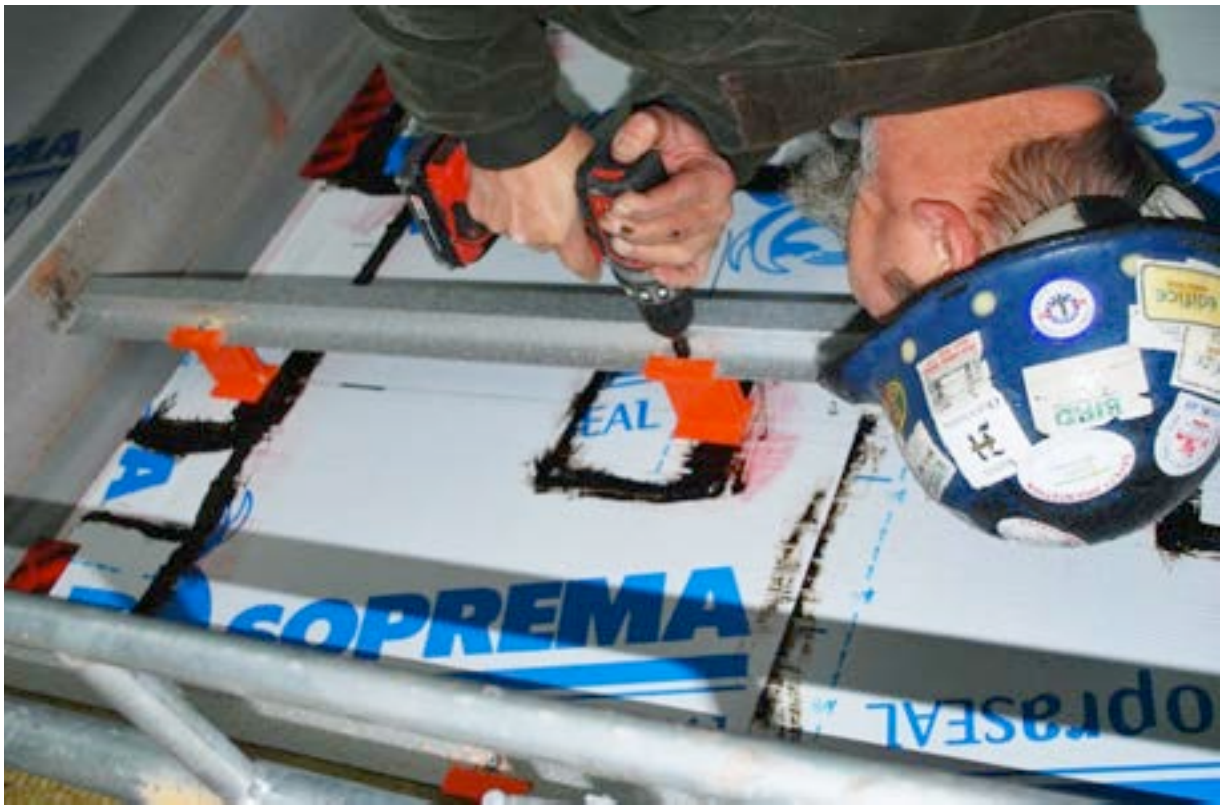



Steel studs
Sheathing
Second layer of z-bars should be installed perpendicular to the first layer; orientation of the two layers will depend on the requirements of the cladding attachment system.
Metal panel
First layer of z-bars embedded in the insulation layer; should the first layer be installed horizontally, the exterior leg should be turned down to promote drainage to the exterior.

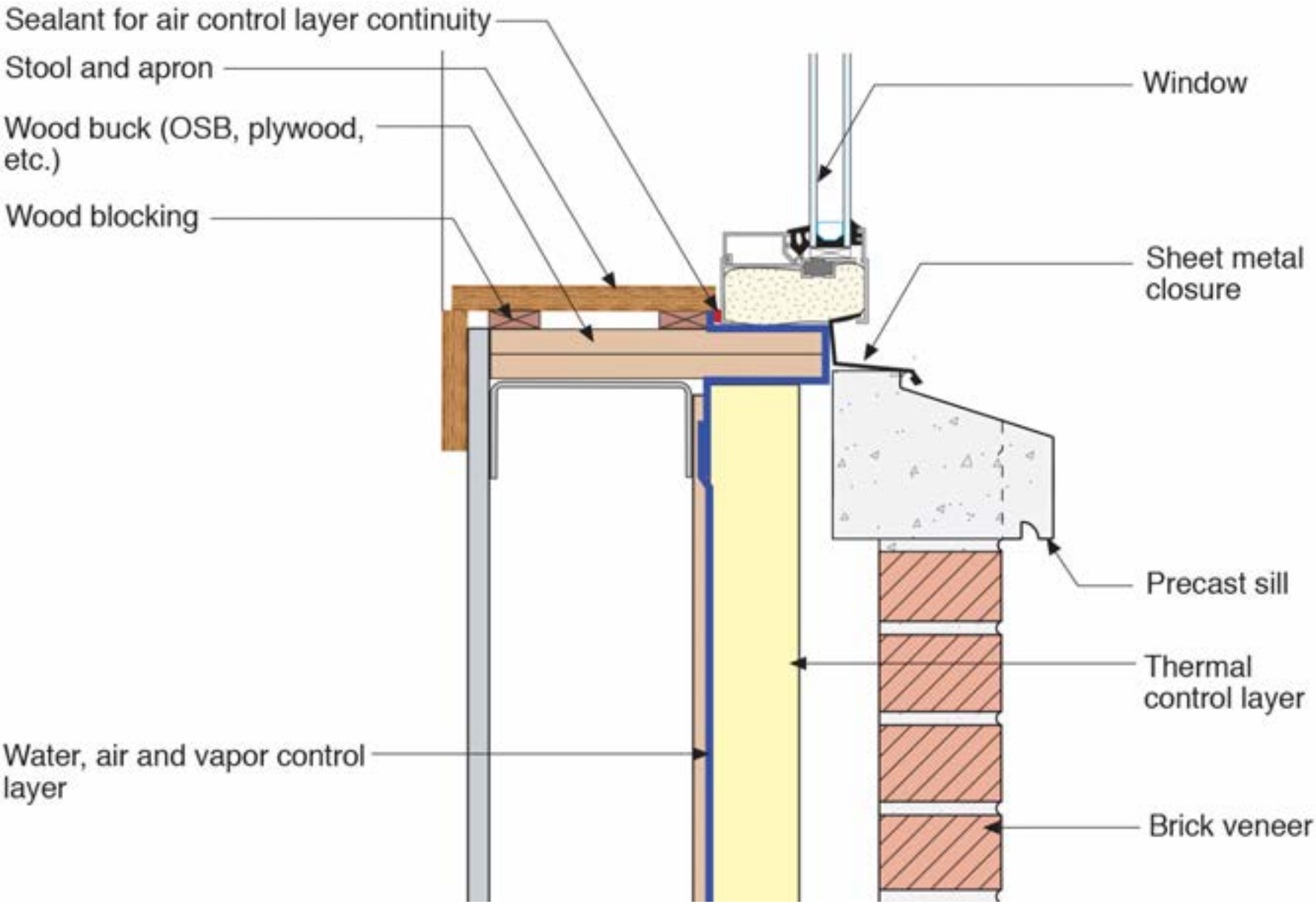

Steel studs
Sheathing
Fully-adhered air and water control layer
Continuous insulation layer
Cold formed hat section
Cold formed clip angle
Metal panel
Cold formed angle

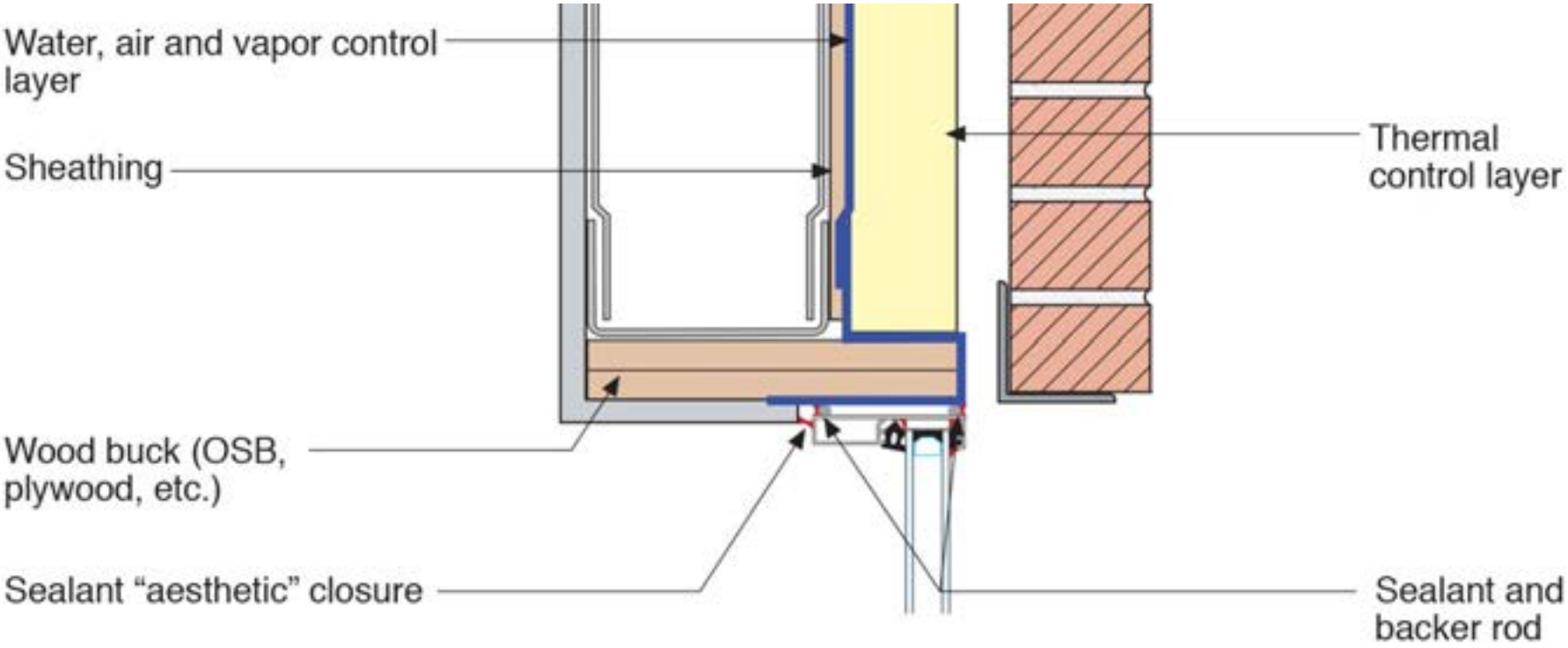


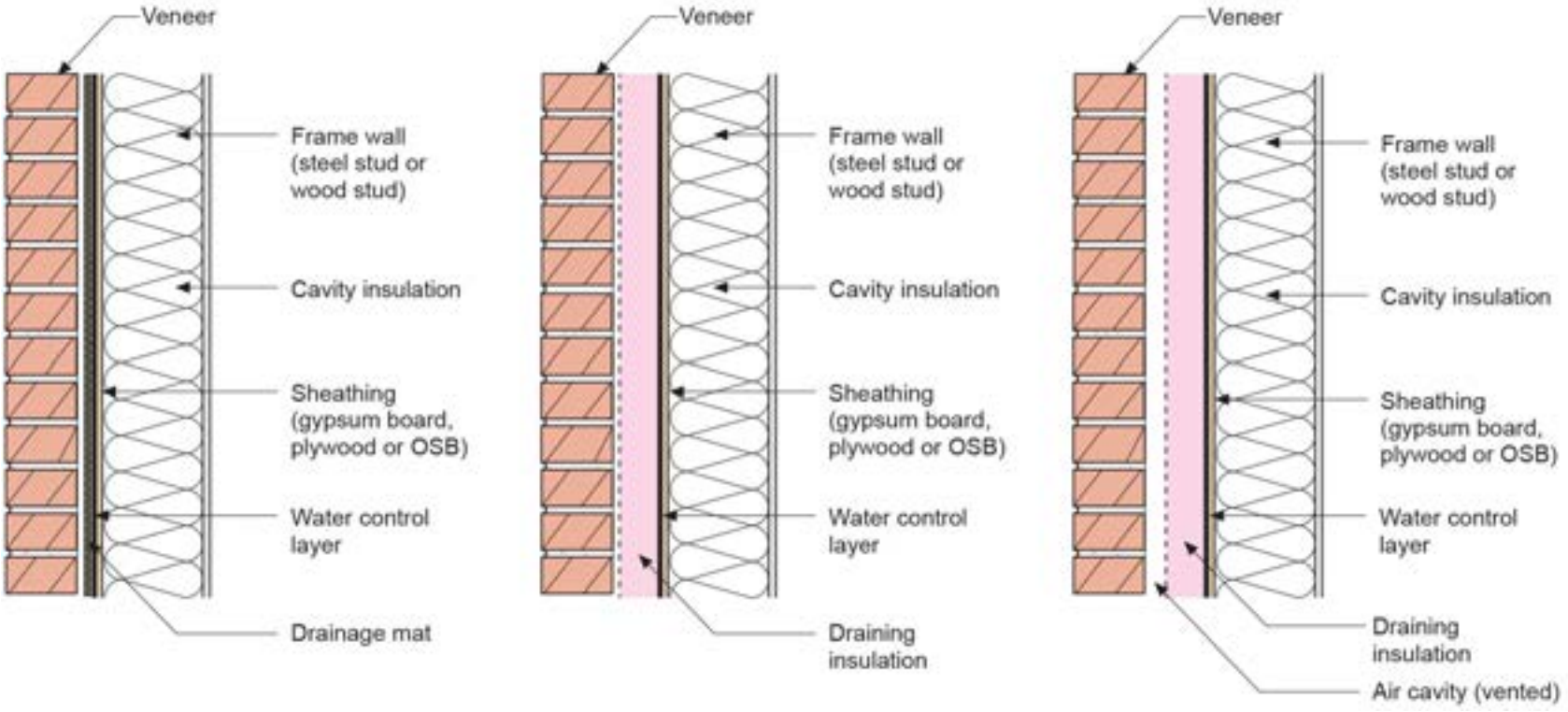

DOW
Thermax ci
Exterior Insulation


SOPREMA


THIS SIDE
UT THIS SIDE
UT THIS SIDE


Sealant for air control layer continuity
Stool and apron
Wood buck (OSB, plywood, etc.)
Wood blocking
Window
Sheet metal closure
Precast sill
Thermal control layer
Water, air and vapor control layer
Brick veneer


Water, air and vapor control layer
Sheathing
Wood buck (OSB, plywood, etc.)
Sealant “aesthetic” closure
Thermal control layer
Sealant and backer rod


Veneer
Frame wall (steel stud or wood stud)
Cavity insulation
Sheathing (gypsum board, plywood or OSB)
Water control layer
Drainage mat
Veneer
Frame wall (steel stud or wood stud)
Cavity insulation
Sheathing (gypsum board, plywood or OSB)
Water control layer
Draining insulation
Veneer
Frame wall (steel stud or wood stud)
Cavity insulation
Sheathing (gypsum board, plywood or OSB)
Water control layer
Draining insulation
Air cavity (vented)