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

Building Science

Adventures In Building Science

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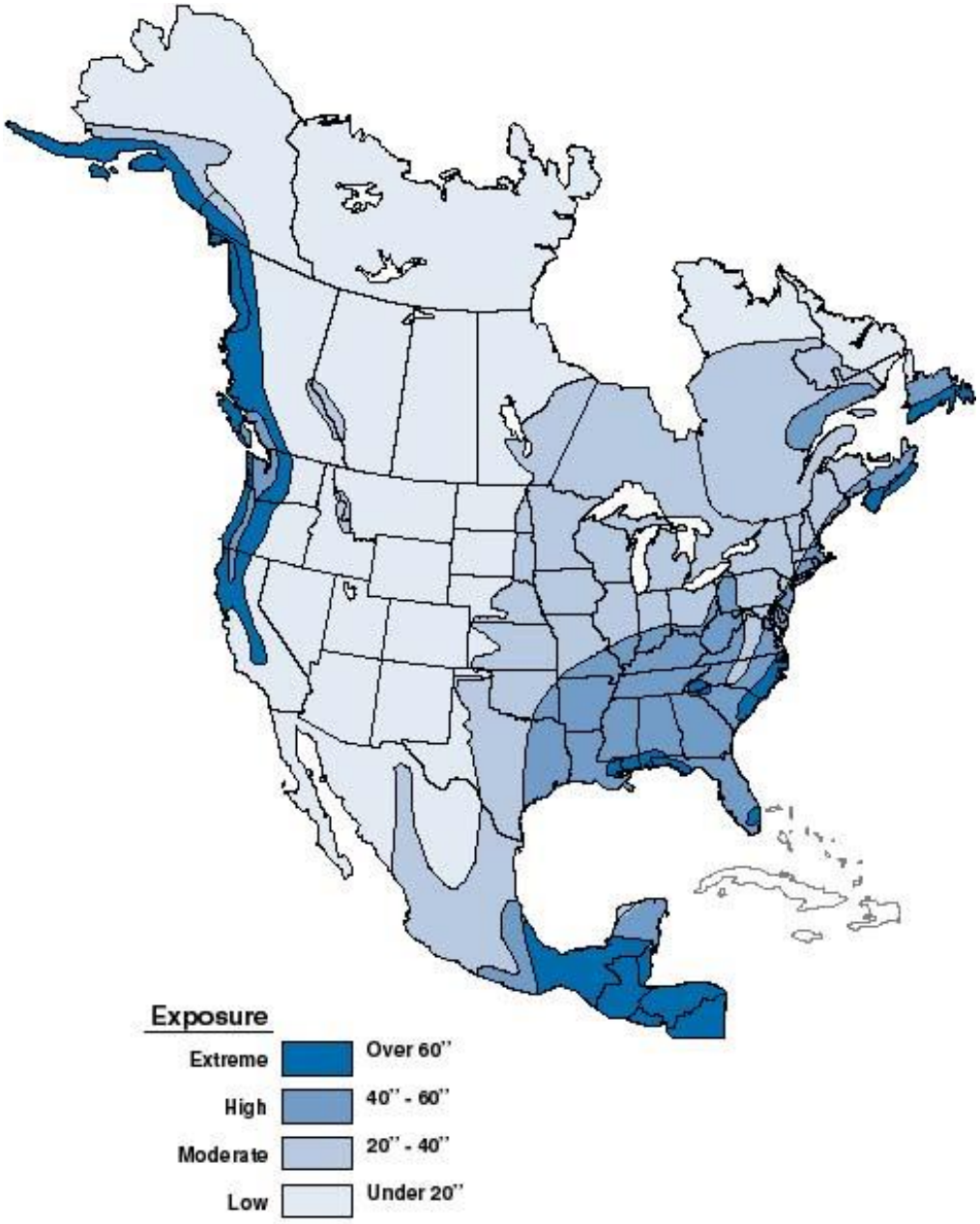
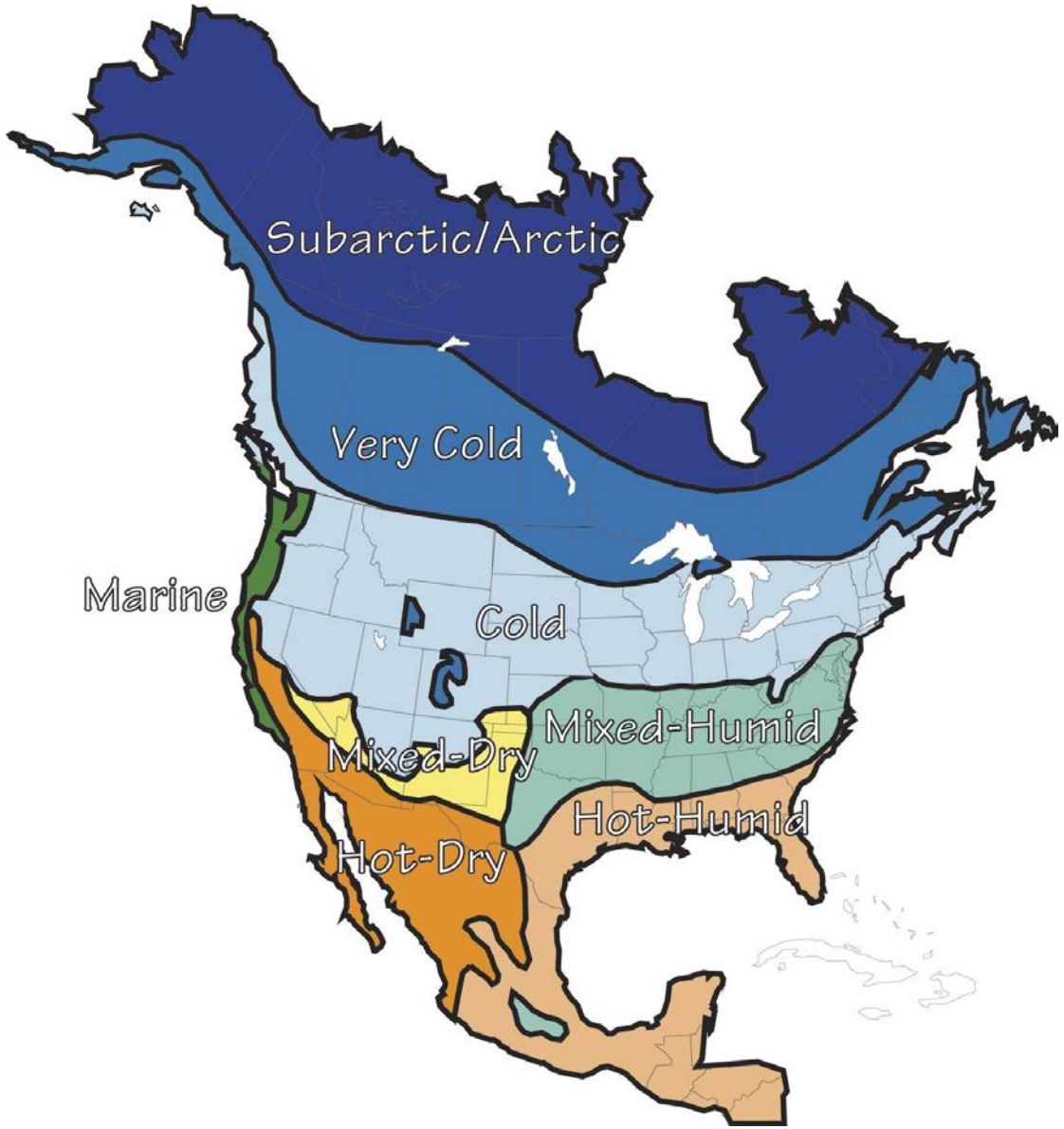
Context

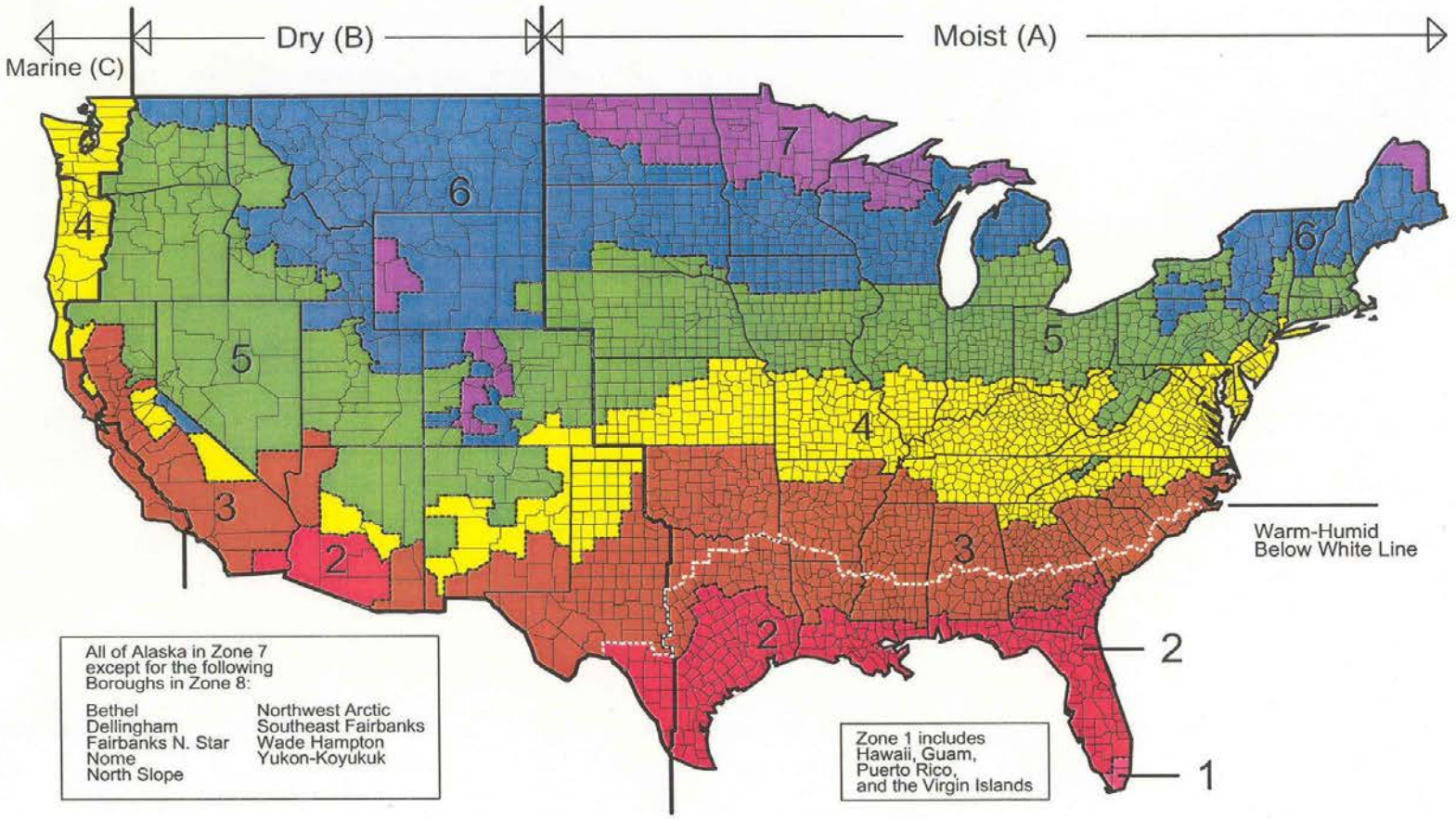
Stucco Evolved As A Barrier System


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


Subarctic/Arctic
Very Cold
Marine
Cold
Mixed-Humid
Mixed-Dry
Hot-Humid
Hot-Dry


Arctic Bay
Anchorage
Seattle
Minneapolis
Los Angeles
El Paso
Houston
Monterrey
Havana
Belize City
Tropical Wet
Tropical Wet-Dry
Steppe
Desert
Mediterranean
Subtropical humid
Marine West Coast
Continental humid
Subarctic
Tundra
Ice sheet
Highlands

Map of DOE's Proposed Climate Zones



March 24, 2003

Exterior Insulation Finish Systems

EIFS

Exterior Insulation Finish Systems

EIFS

Barrier System

Face-Sealed Not Water Managed

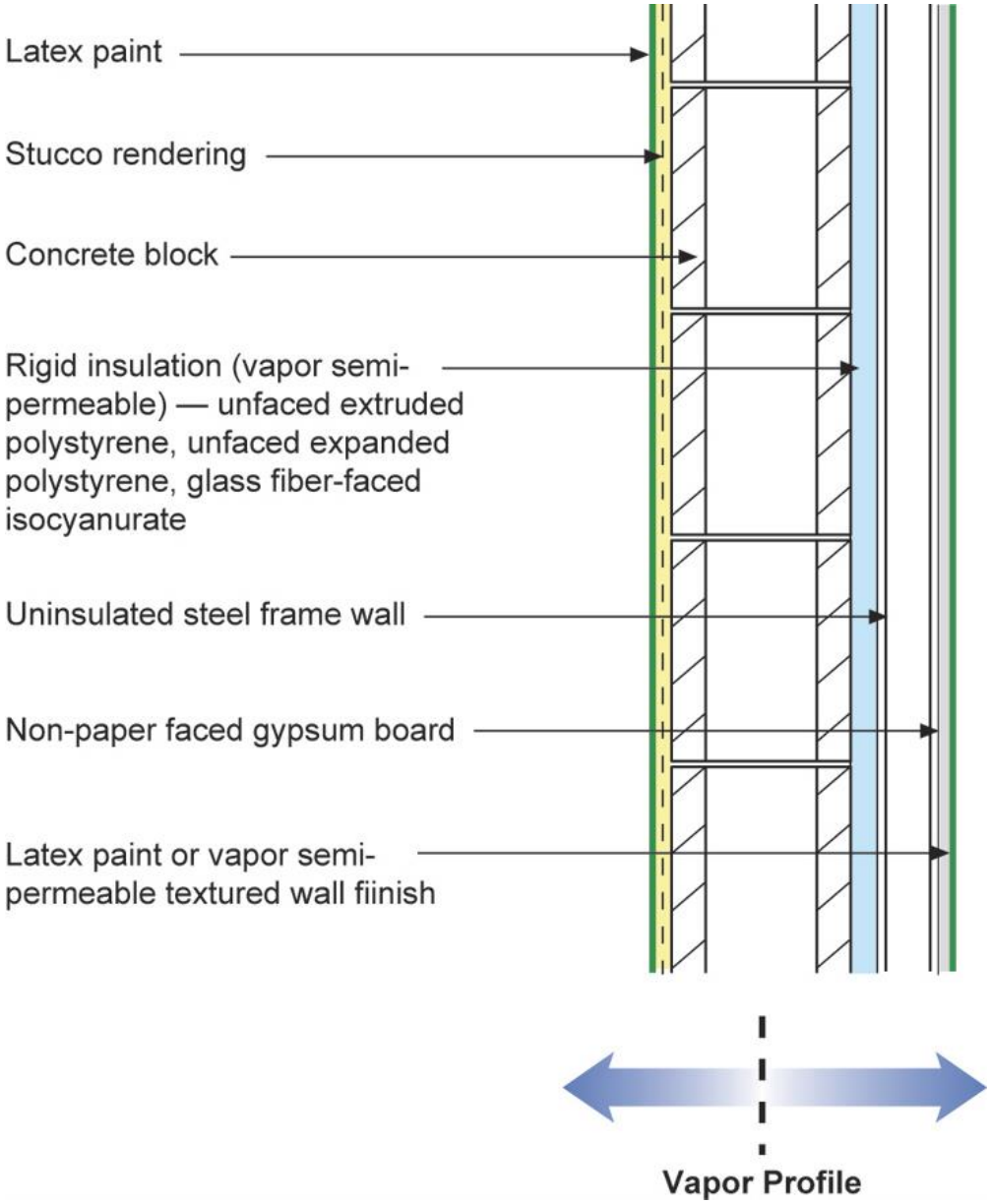

BUILT BY
EDDIE EVANS
CONSTRUCTION
1994

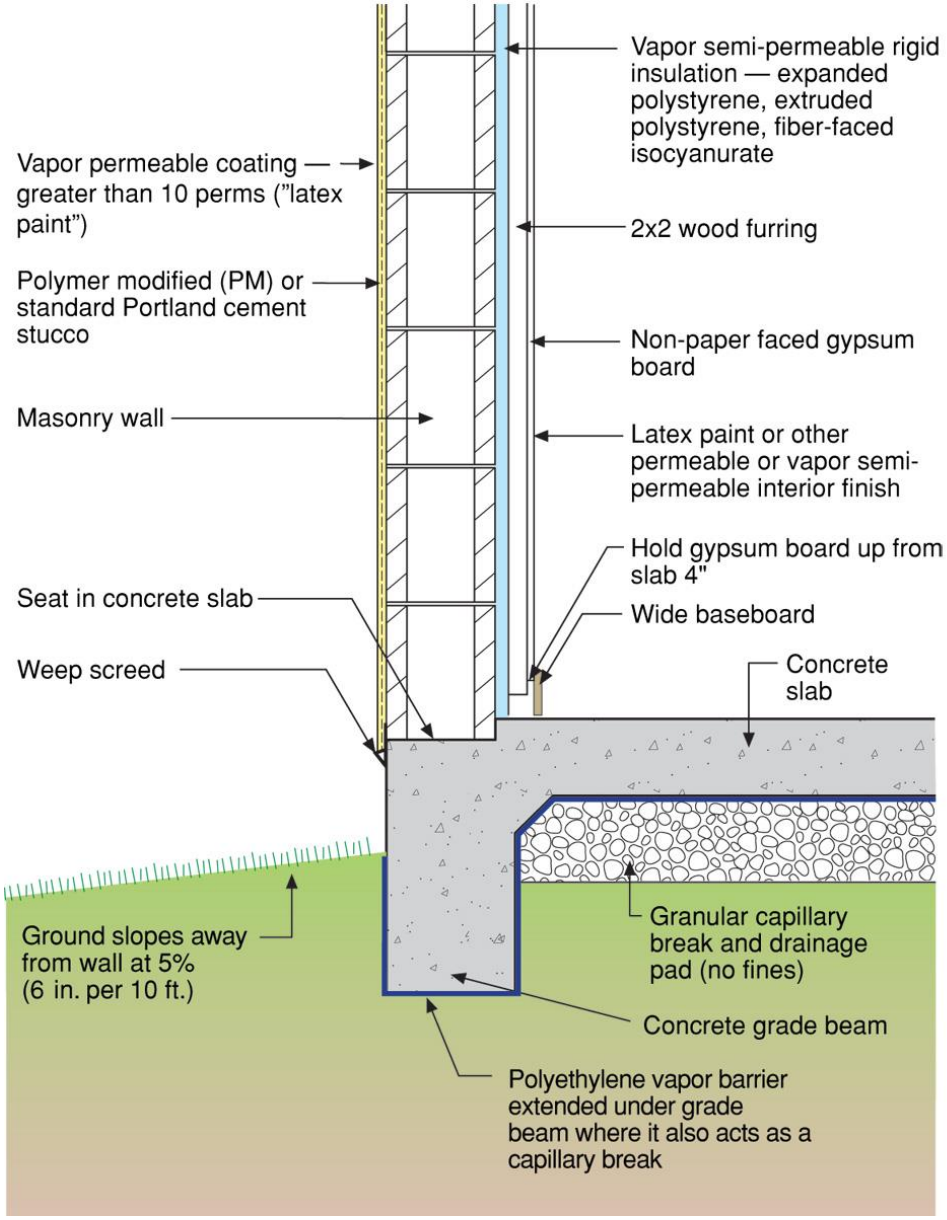
Life Is Hard Enough As It Is

It’s Harder When You Are Stupid

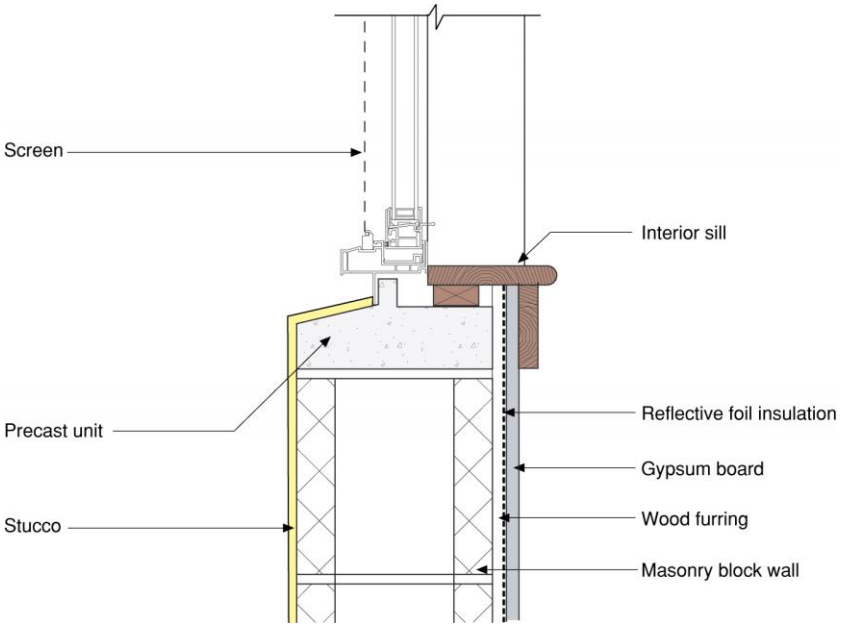
Don’t Do Stupid Things

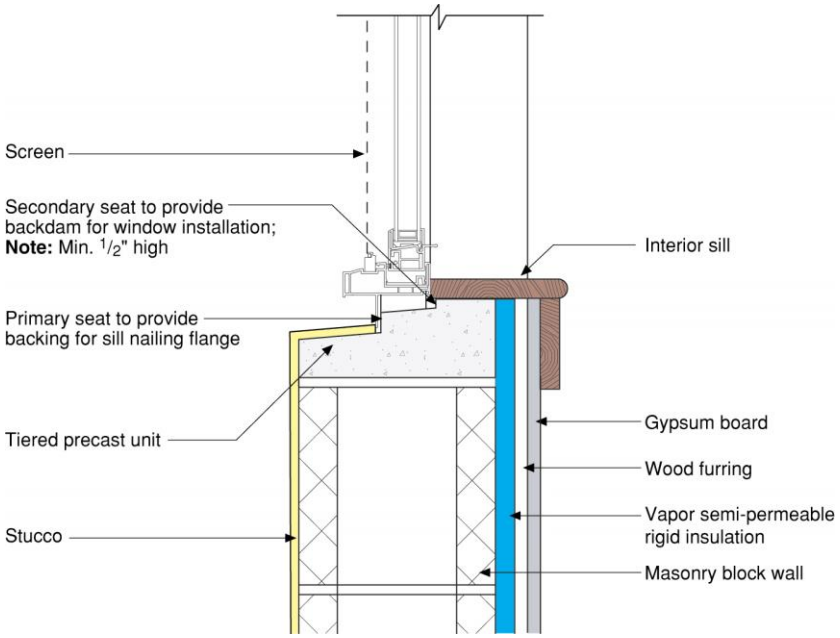
Can Barrier or Face Seal Work?


Latex paint
Stucco rendering
Concrete block
Rigid insulation (vapor semi-permeable) — unfaced extruded polystyrene, unfaced expanded polystyrene, glass fiber-faced isocyanurate
Uninsulated steel frame wall
Non-paper faced gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile


Vapor semi-permeable rigid insulation — expanded polystyrene, extruded polystyrene, fiber-faced isocyanurate
Vapor permeable coating — greater than 10 perms ("latex paint")
2x2 wood furring
Polymer modified (PM) or standard Portland cement stucco
Non-paper faced gypsum board
Masonry wall
Latex paint or other permeable or vapor semi-permeable interior finish
Hold gypsum board up from slab 4"
Seat in concrete slab
Wide baseboard
Weep screed
Concrete slab
Granular capillary break and drainage pad (no fines)
Ground slopes away from wall at 5% (6 in. per 10 ft.)
Concrete grade beam
Polyethylene vapor barrier extended under grade beam where it also acts as a capillary break

Styrofoam
SCOREBOARD
Styrofoam
SCOREBOARD


Screen
Interior sill
Precast unit
Reflective foil insulation
Gypsum board
Stucco
Wood furring
Masonry block wall


Screen
Secondary seat to provide backdam for window installation; **Note:** Min. 1/2" high
Interior sill
Primary seat to provide backing for sill nailing flange
Tiered precast unit
Gypsum board
Wood furring
Vapor semi-permeable rigid insulation
Stucco
Masonry block wall

Reminder…

Don’t Do Stupid Things

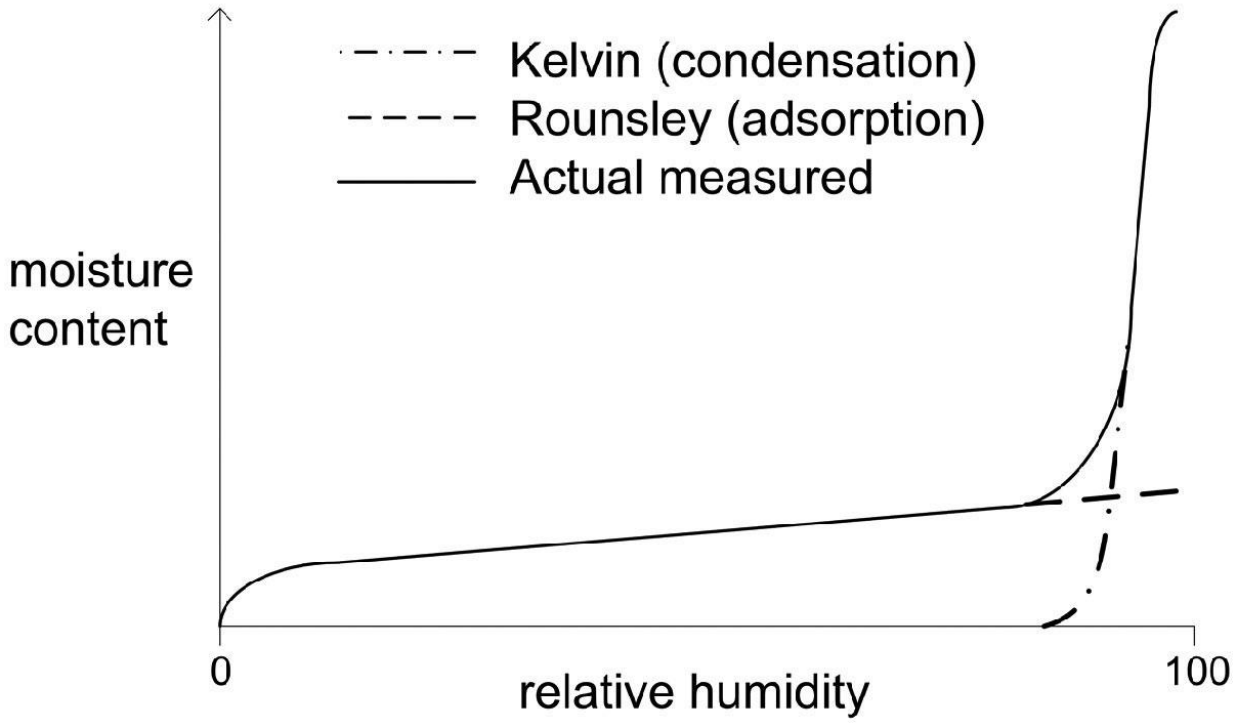

CertainTeed
R19
AL FOL

What Is Going On With Stucco?

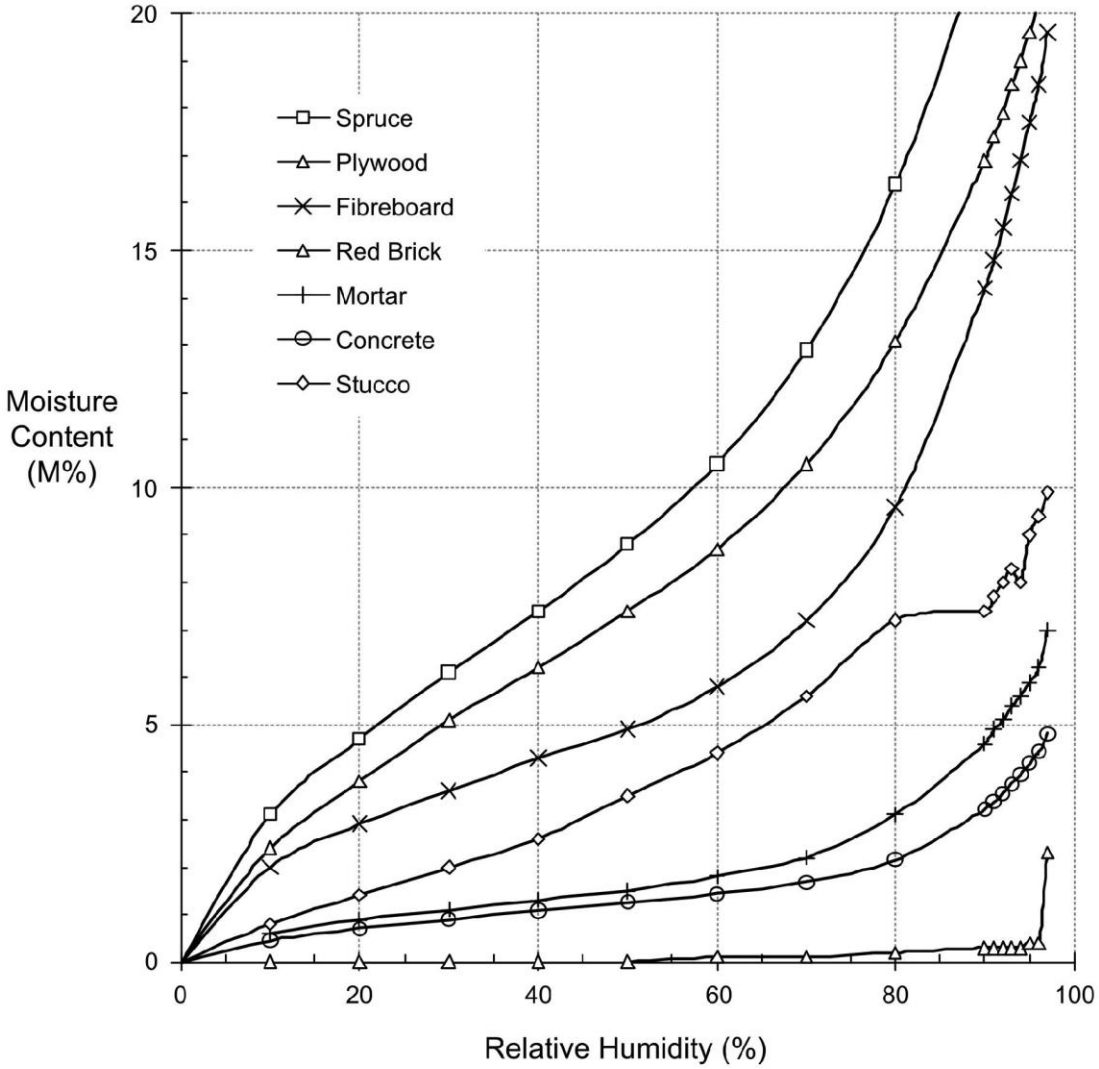
Materials

Inward Drive

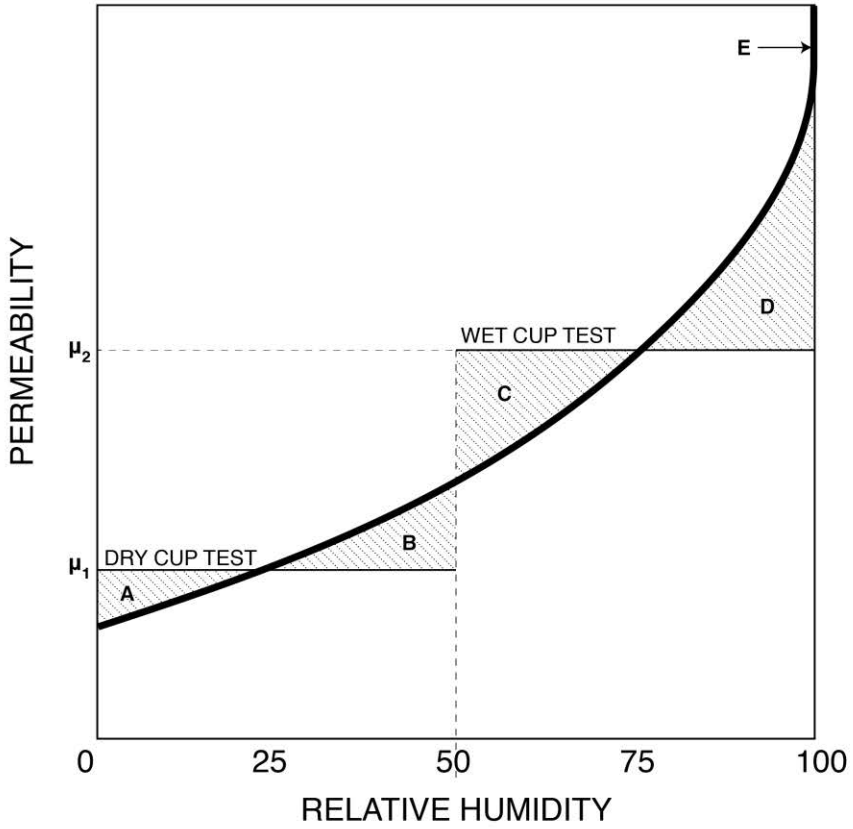
Energy



Typical predicted sorption isotherm according to Kelvin equation and modified BET theory
From Straube & Burnett, 2005



Sorption isotherm for several building materials [Kumaran 2002]
From Straube & Burnett, 2005



A - Single-layer of absorbed molecules
B - Multiple layers of absorbed molecules
C - Interconnected layers (internal capillary condensation)
D - Free water in pores, capillary suction
E - Supersaturated regime

Relationship between Dry Cup and Wet Cup
Adapted from Joy & Wilson, 1963


R-11 3½"
OWENS-CORNING
Fiberglas
Building
Insulation
FIBERGLAS
ASSURED THERMAL
PERFORMANCE
R-11 3½"
OWENS-CORNING
Fiberglas
Building
Insulation
FIBERGLAS
ASSURED THERMAL
PERFORMANCE
R-11 3½"
OWENS-CORNING
Fiberglas
Building
Insulation
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PERFORMANCE
R-11 3½"
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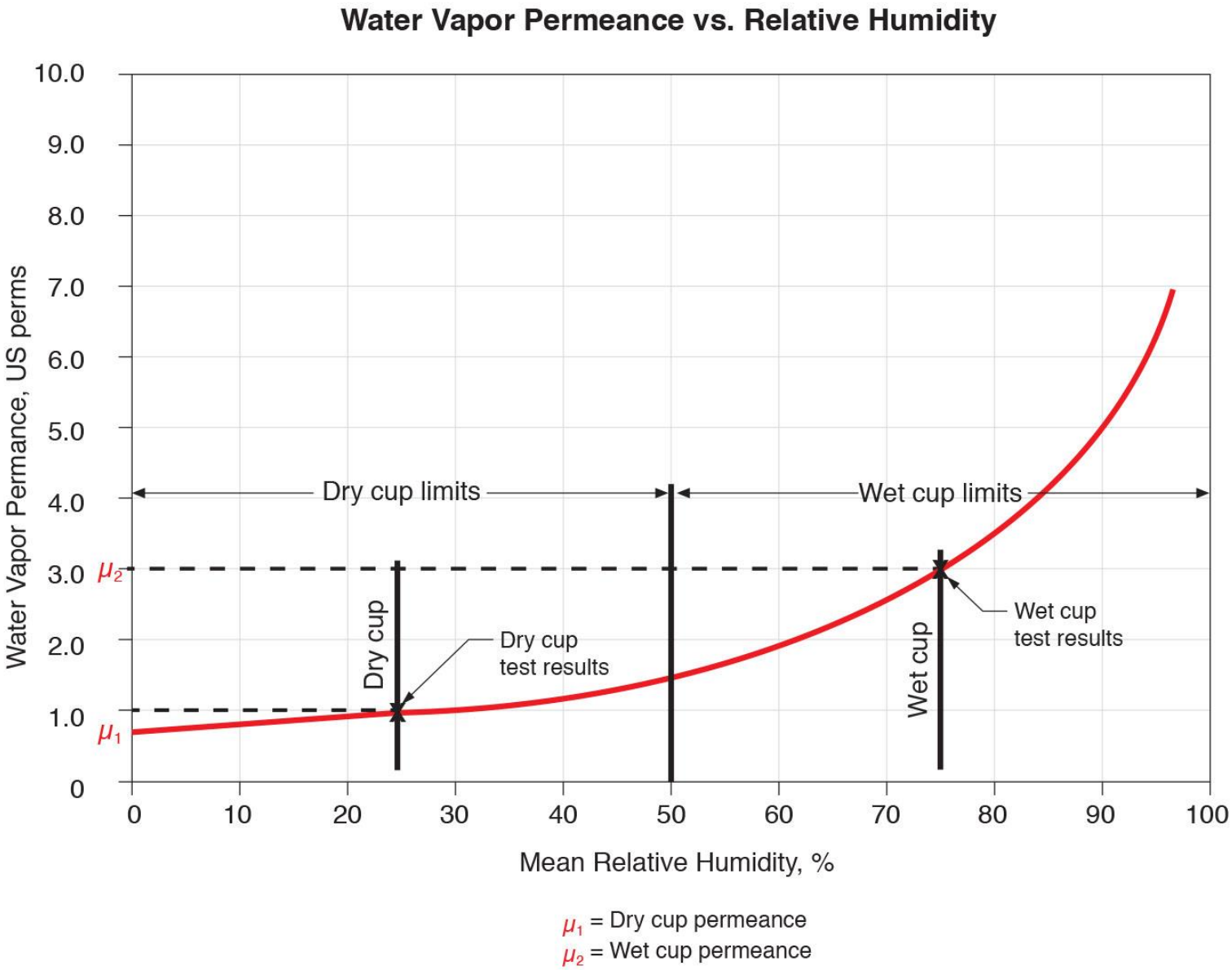
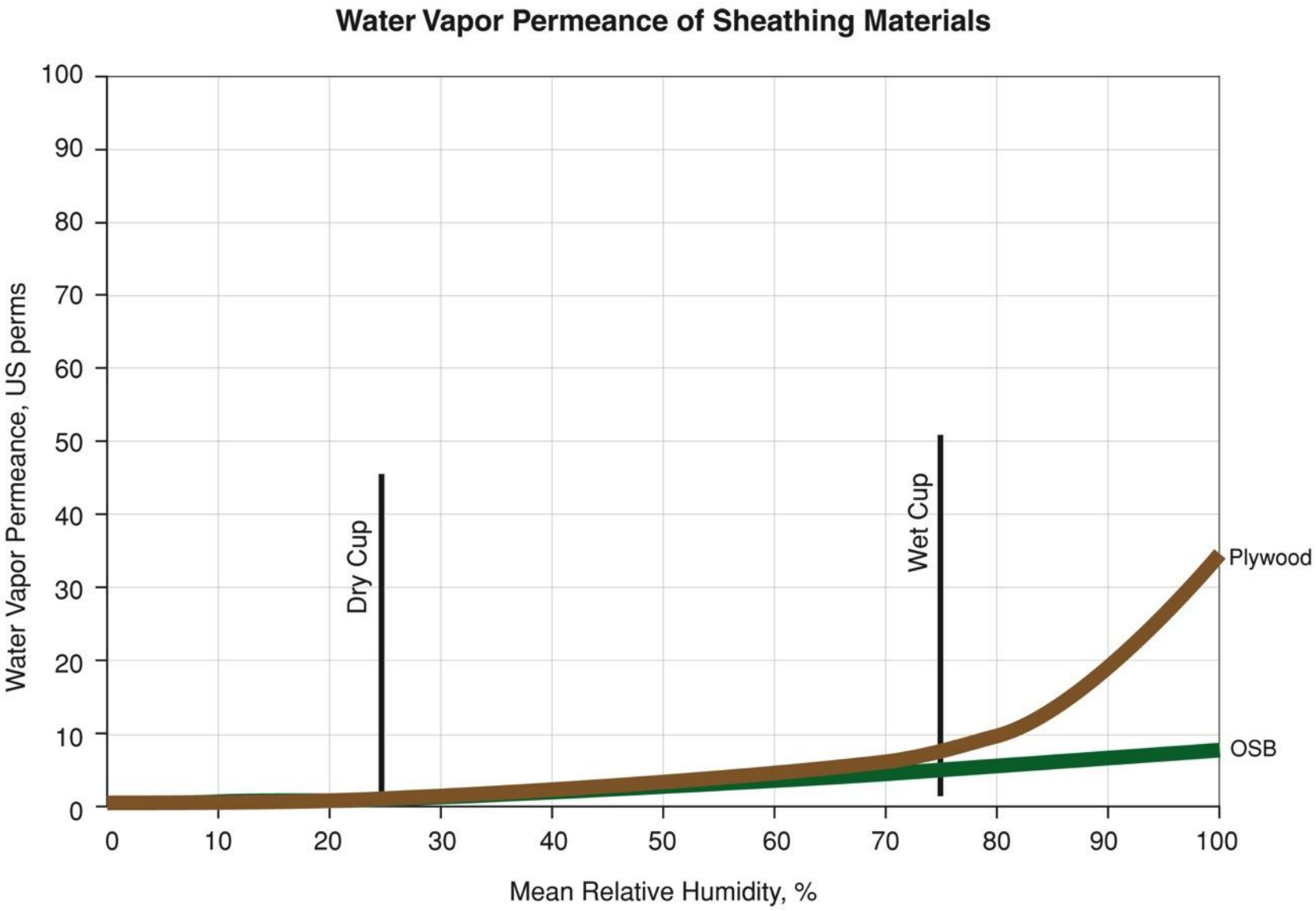
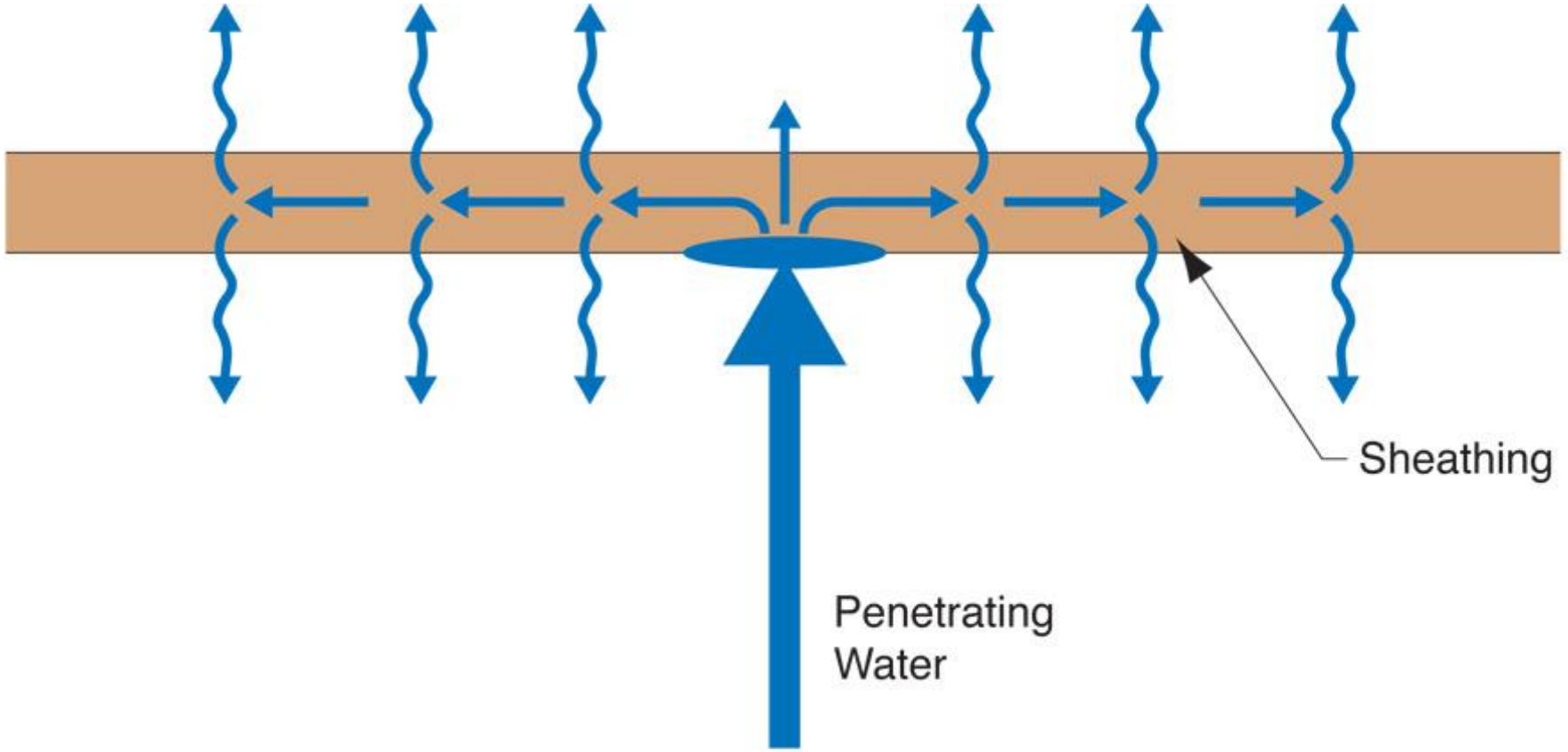
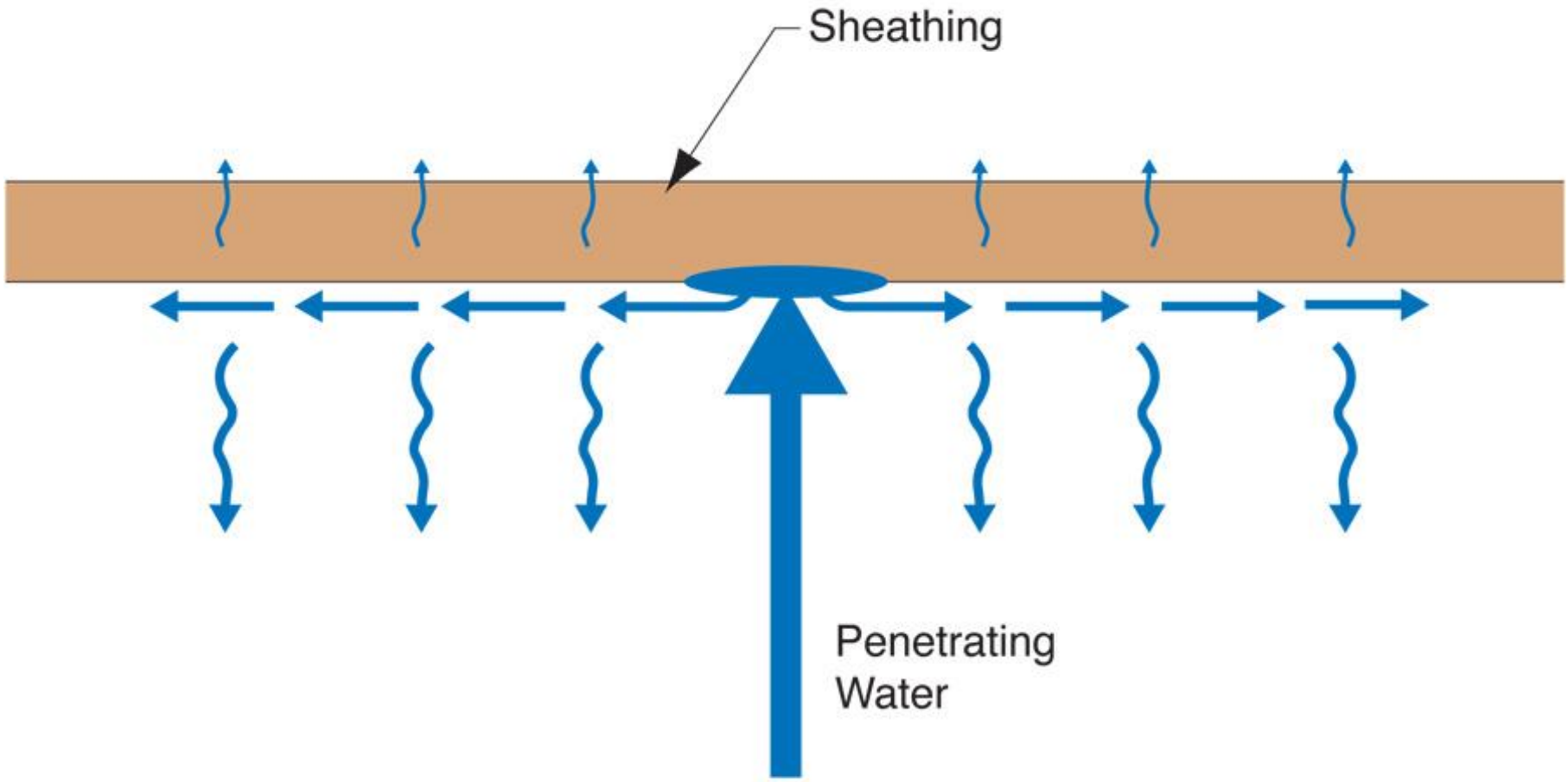
Fiberglas
Building
Insulation
FIBERGLAS
ASSURED THERMAL
PERFORMANCE
R-11 3½"
OWENS-CORNING
Fiberglas
Building
Insulation
FIBERGLAS
ASSURED THERMAL
PERFORMANCE


Water Vapor Permeance vs. Relative Humidity
Water Vapor Permance, US perms
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
μ_2
μ_1
Dry cup limits
Wet cup limits
Dry cup
Dry cup
test results
Wet cup
Wet cup
test results
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %
μ_1 = Dry cup permeance
μ_2 = Wet cup permeance

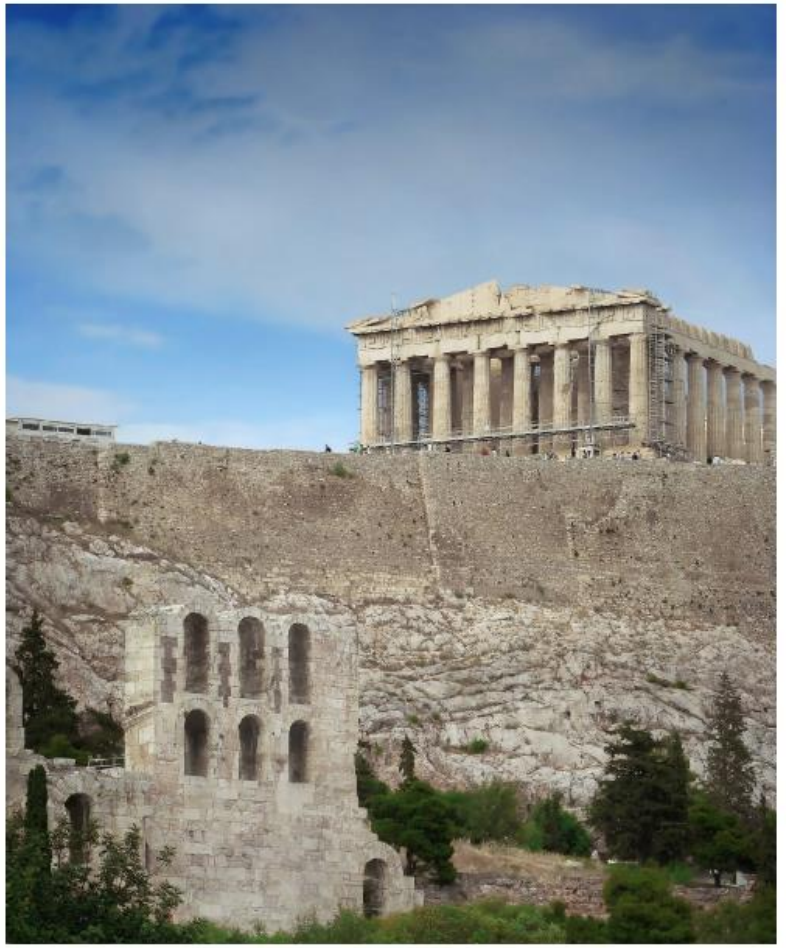

Water Vapor Permeance of Sheathing Materials
Water Vapor Permeance, US perms
100
90
80
70
60
50
40
30
20
10
0
Dry Cup
Wet Cup
Plywood
OSB
0
10
20
30
40
50
60
70
80
90
100
Mean Relative Humidity, %


Sheathing
Penetrating
Water


Sheathing
Penetrating
Water


panago
QUILTED TREASURES


panago
QUILTED TREASURES

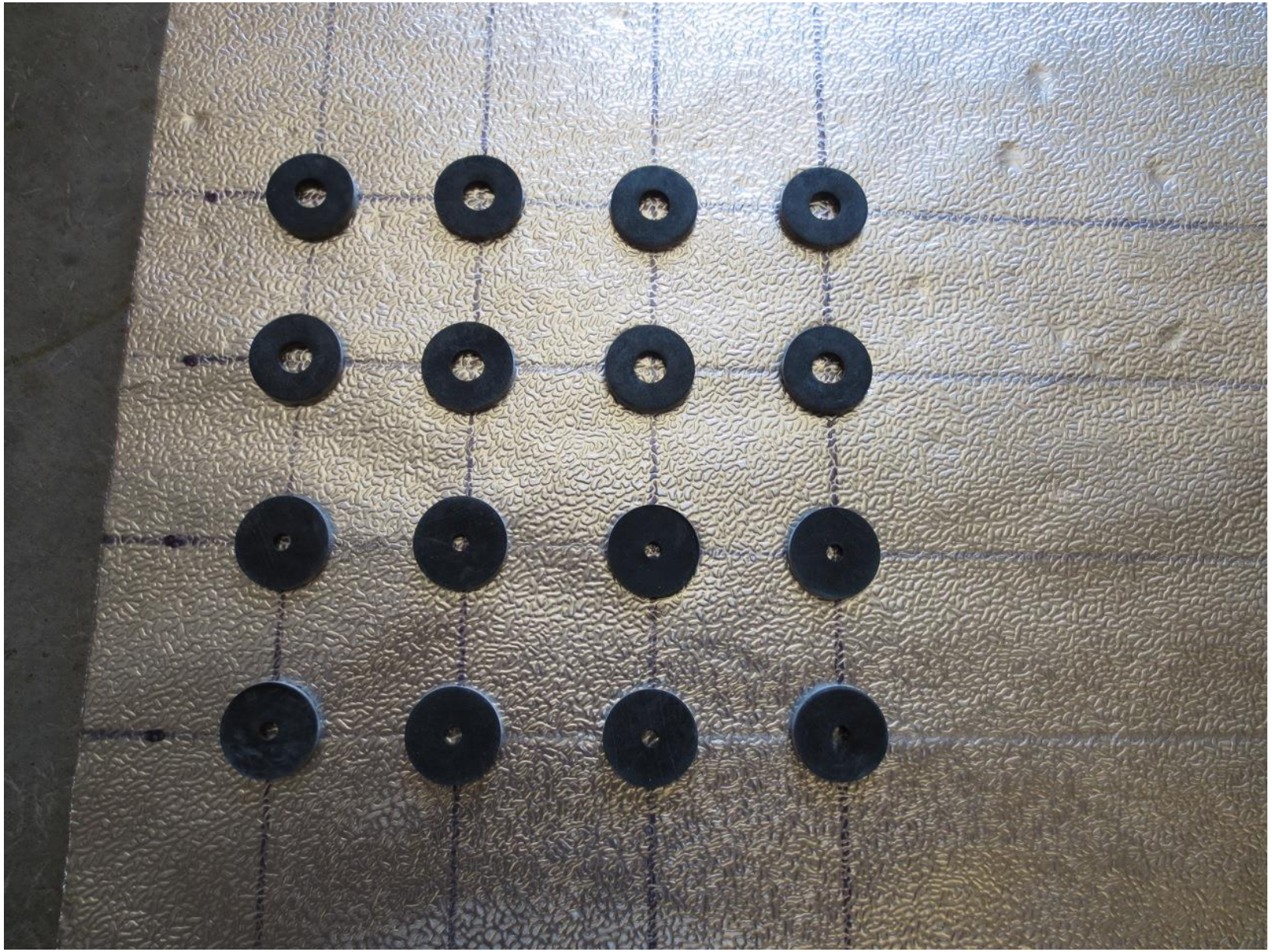



W1
W3

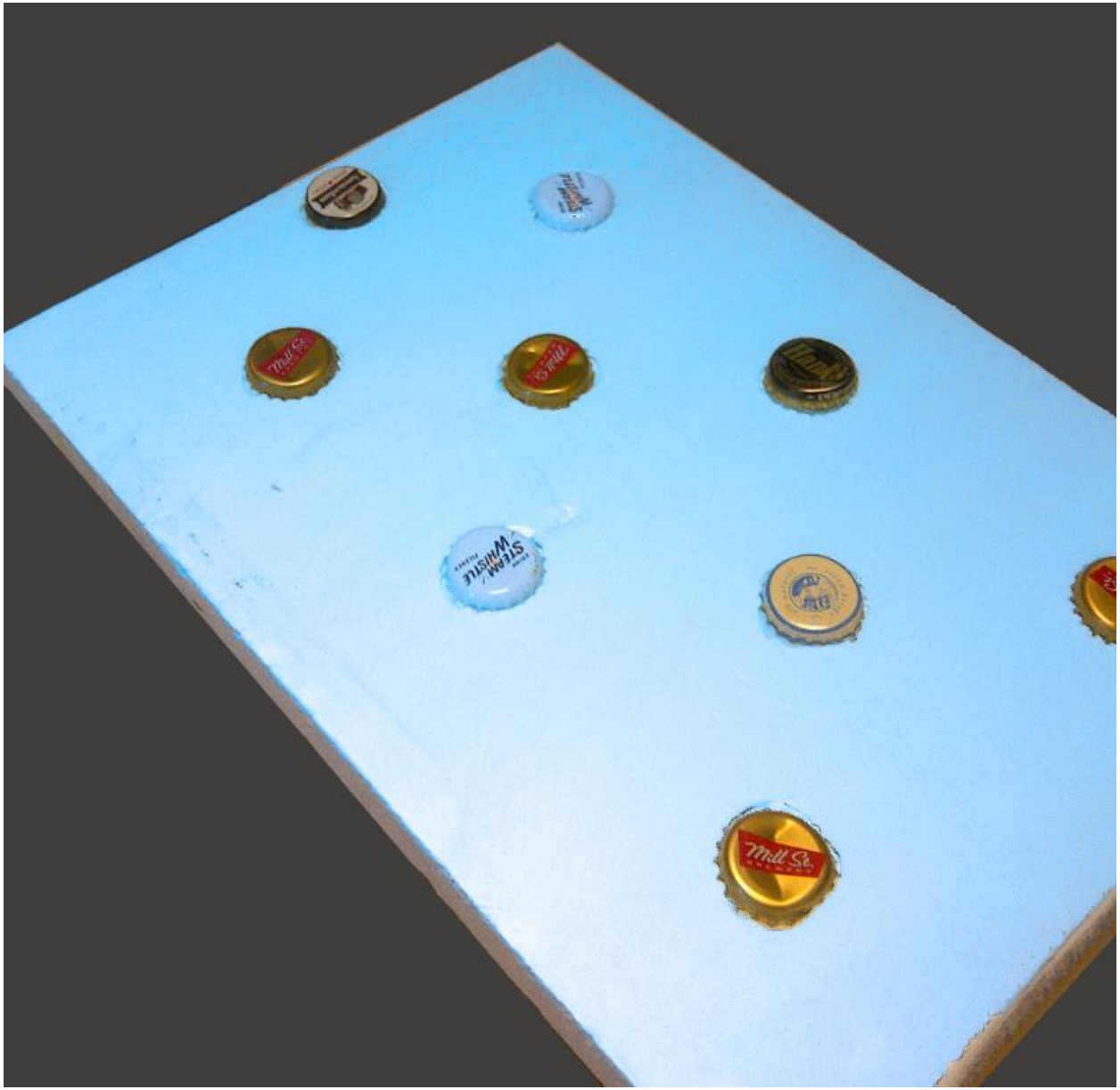

LOWER
N-2

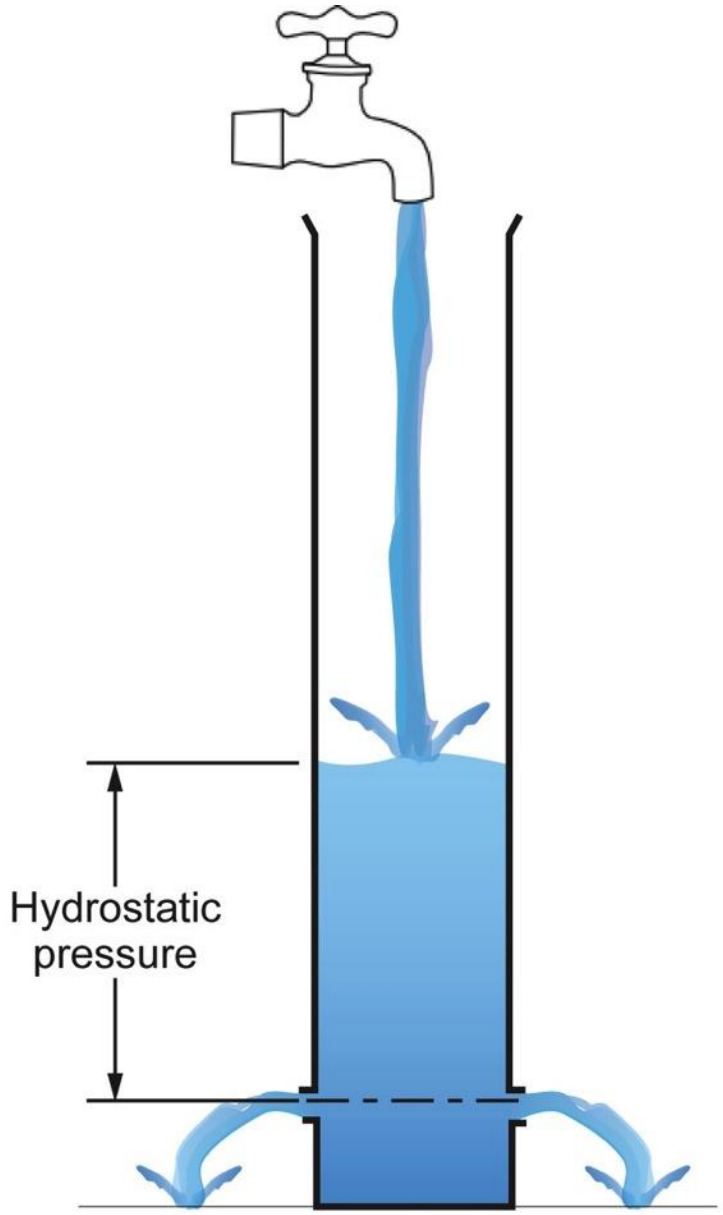

yvek
omeWrap
Tyve
HomeWrap

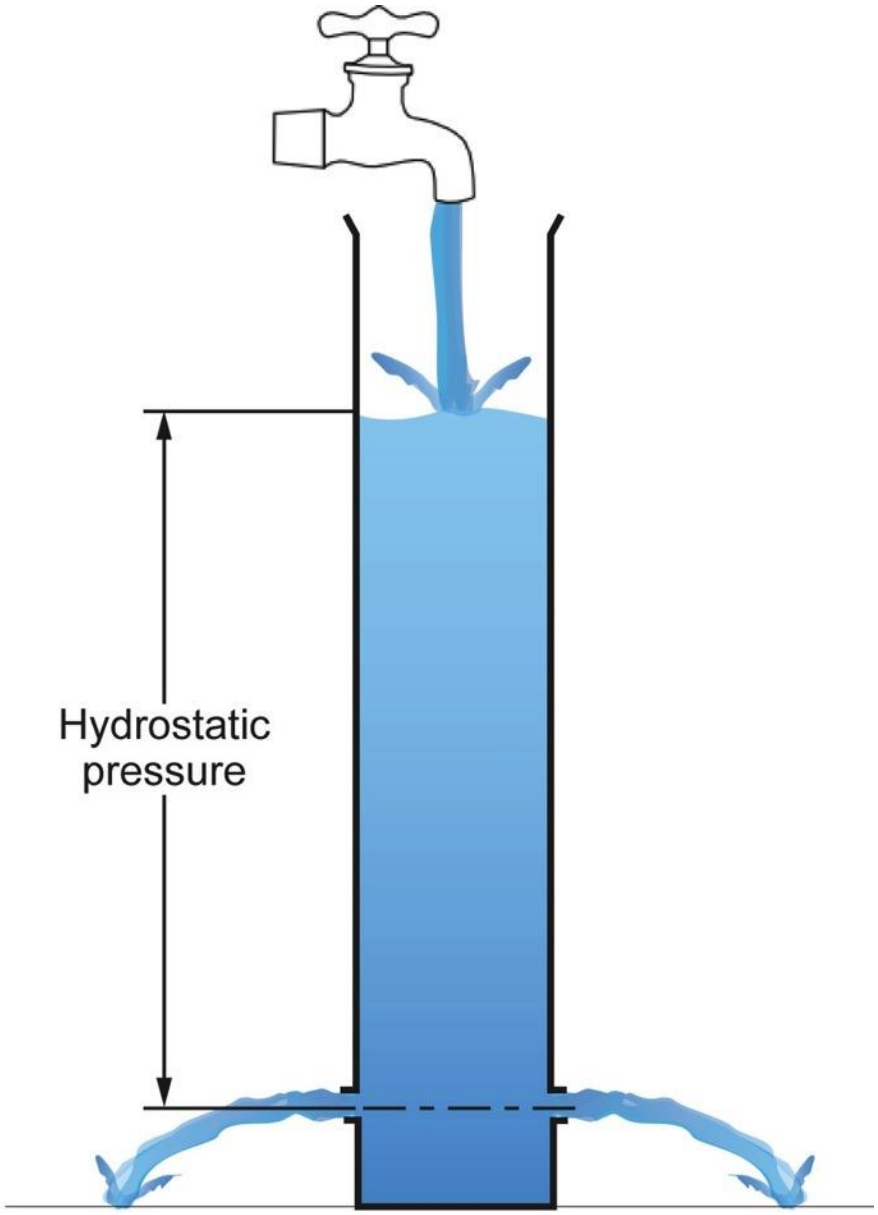
Rain Screen

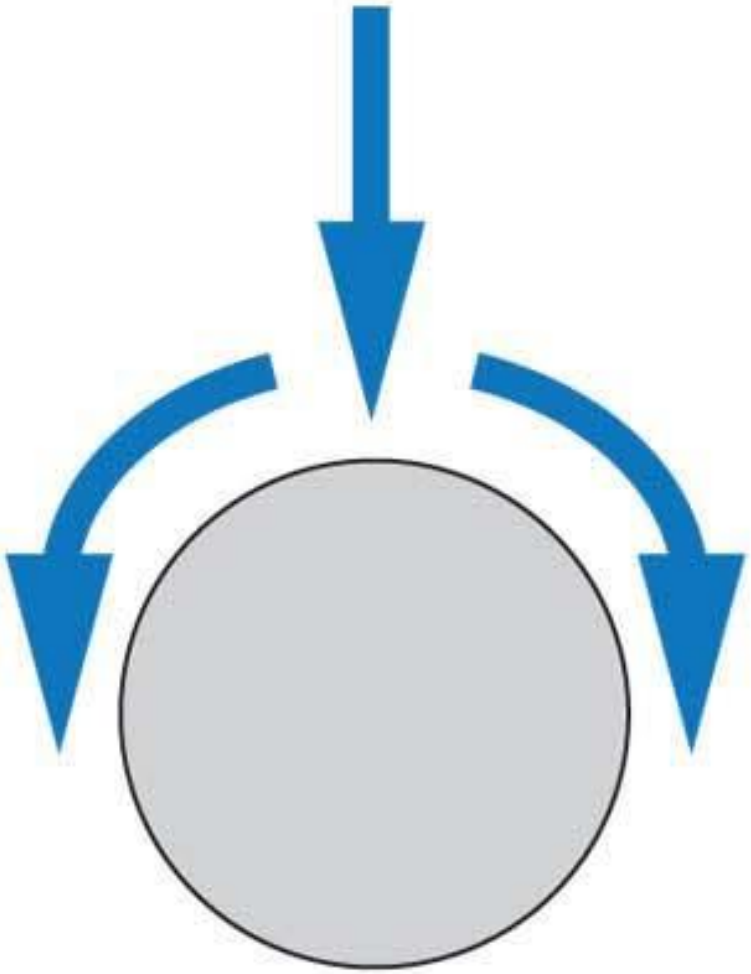


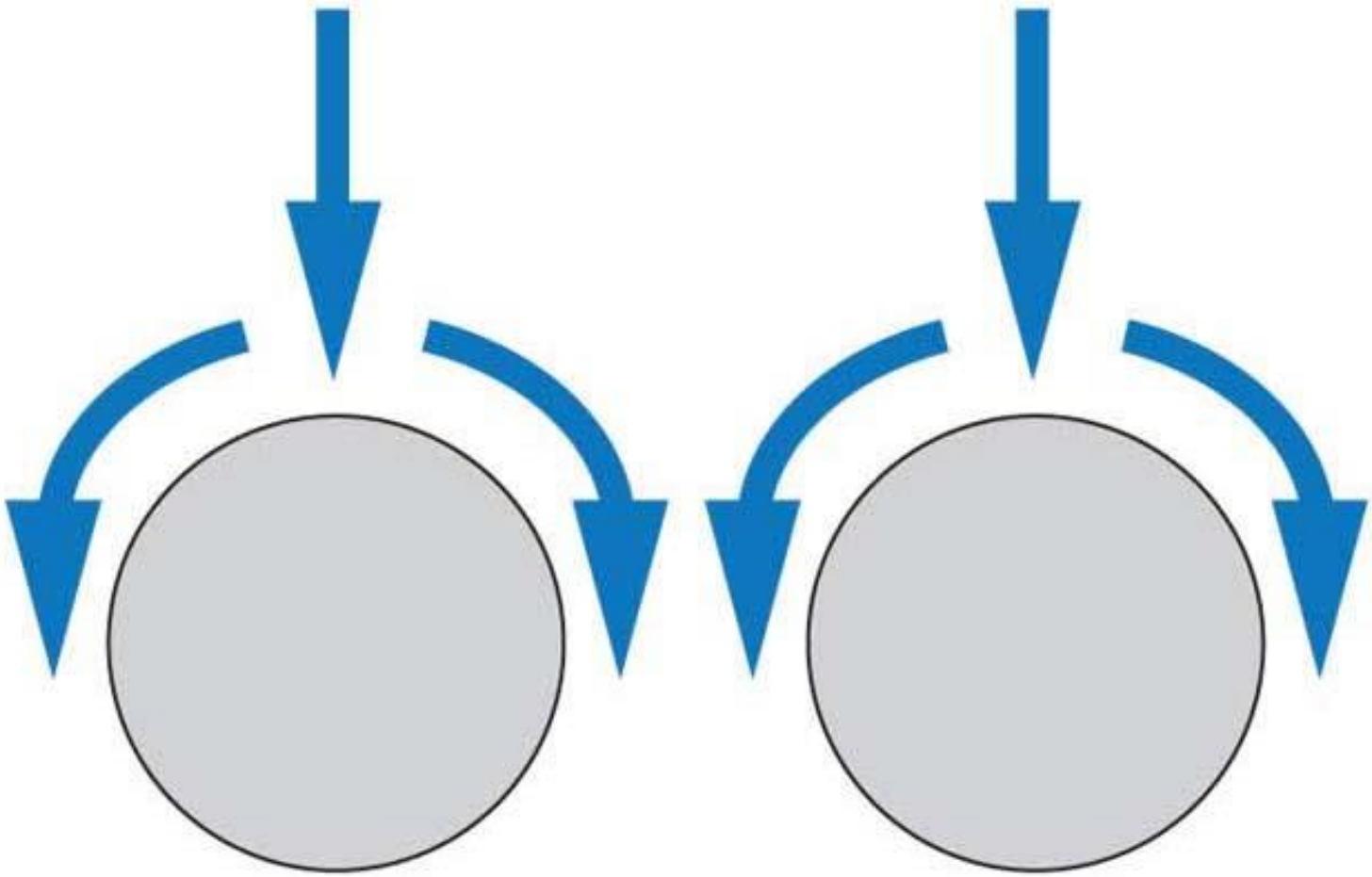
Beer Screen?

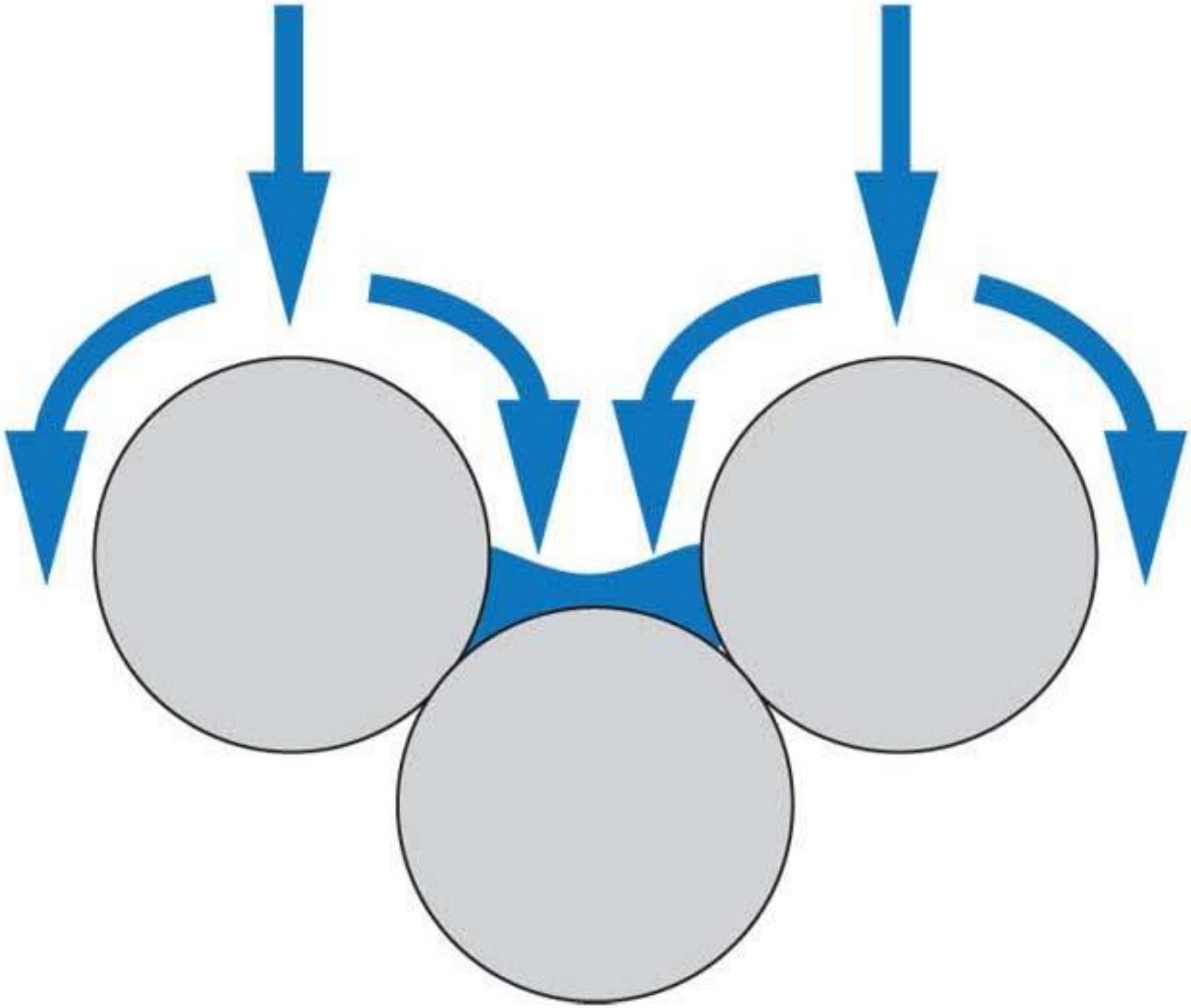

Mill St.
Steam Whistle

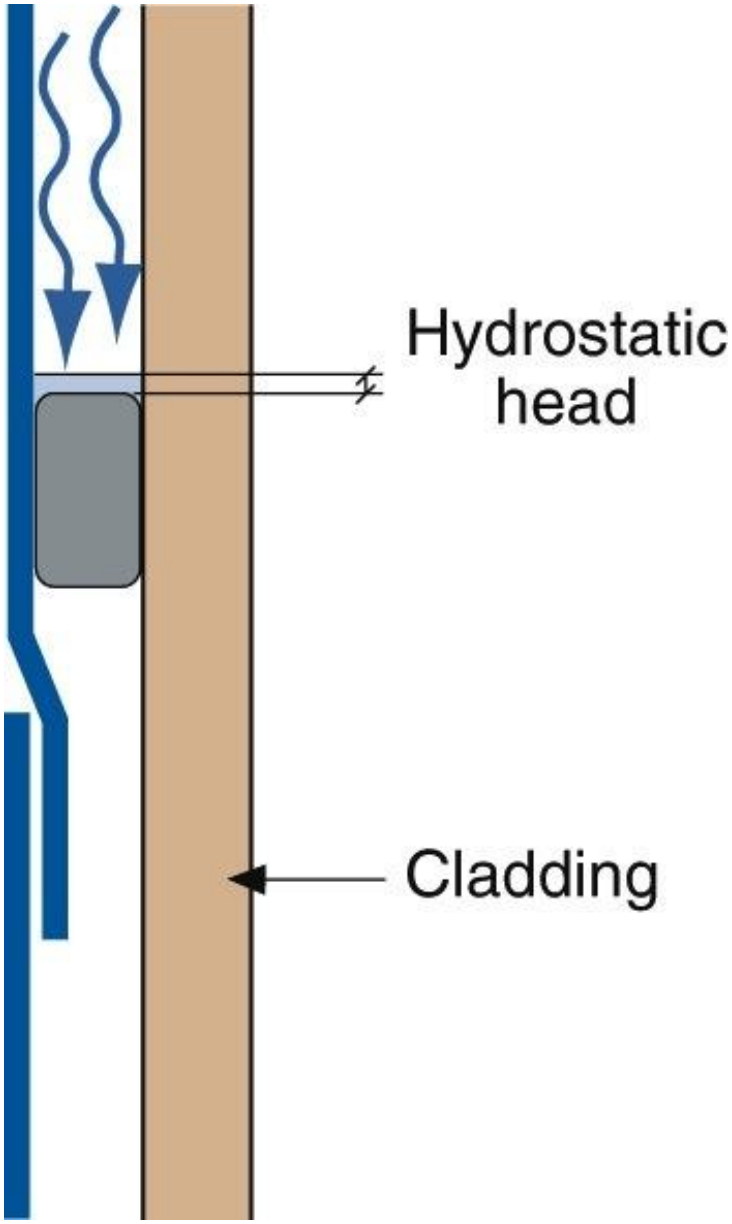

Hydrostatic
pressure

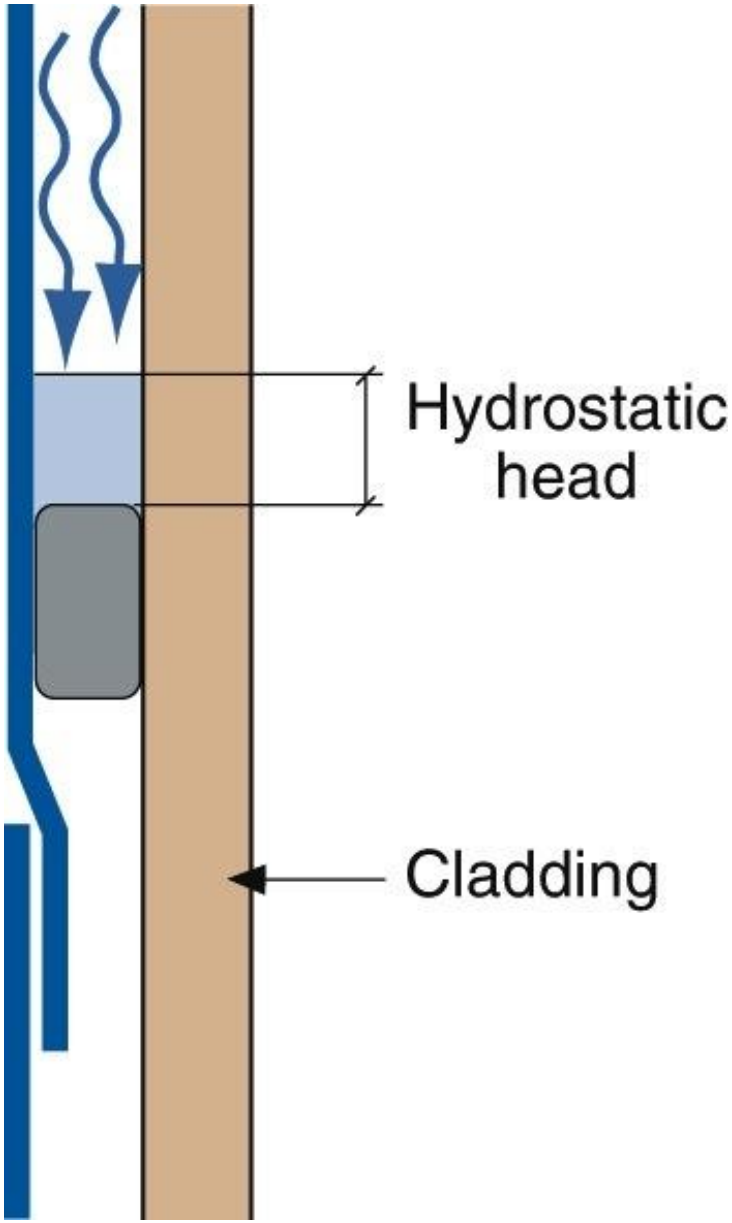

Hydrostatic
pressure

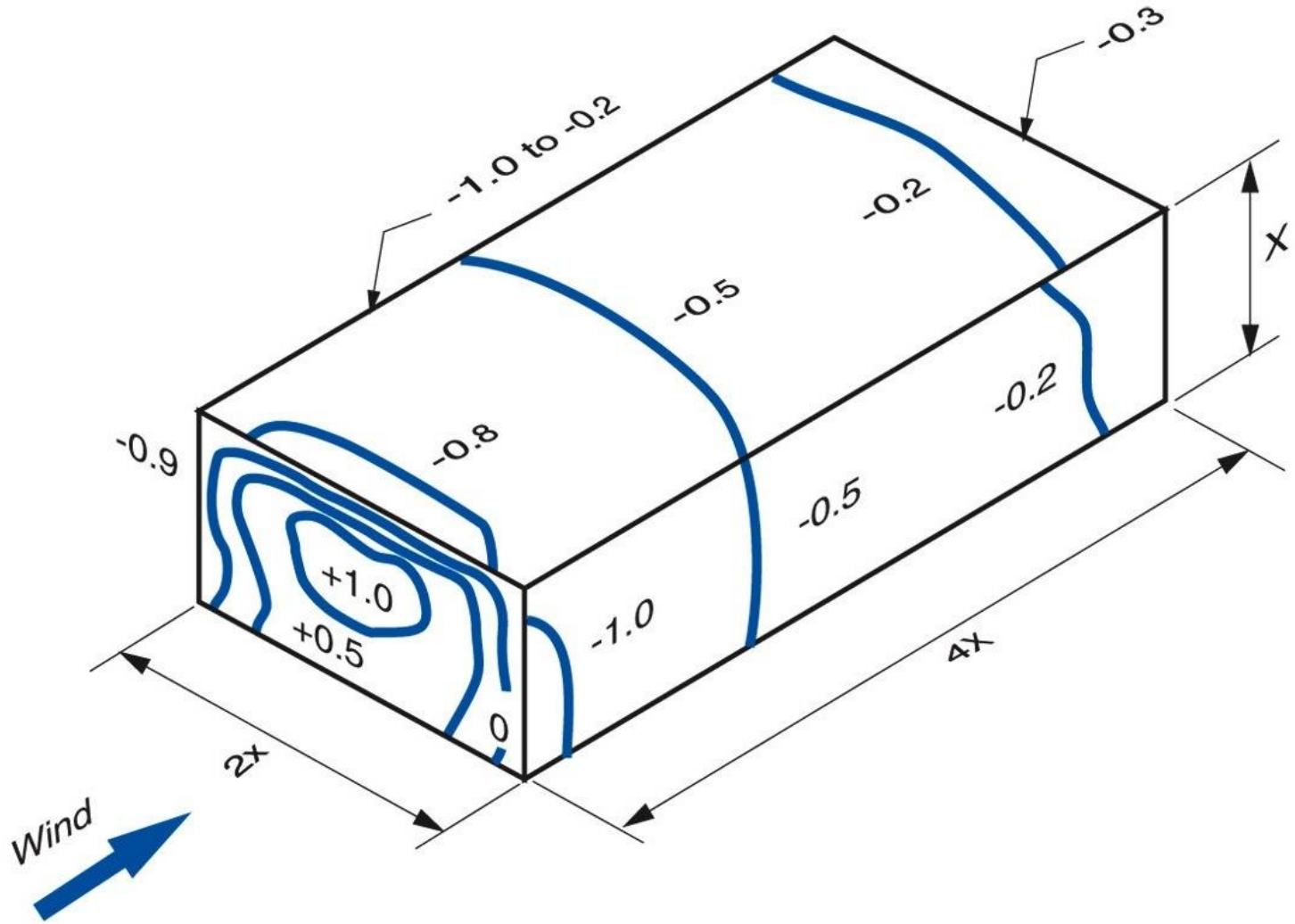




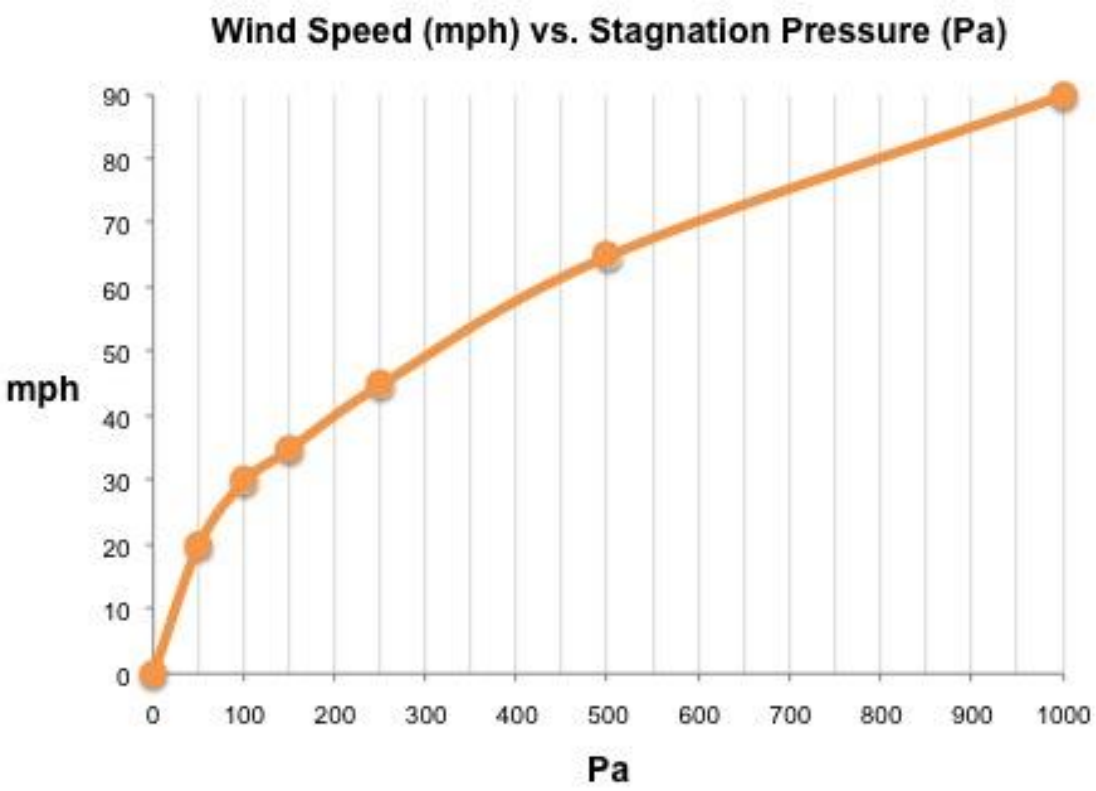



Hydrostatic
head
Cladding


Hydrostatic
head
Cladding


-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

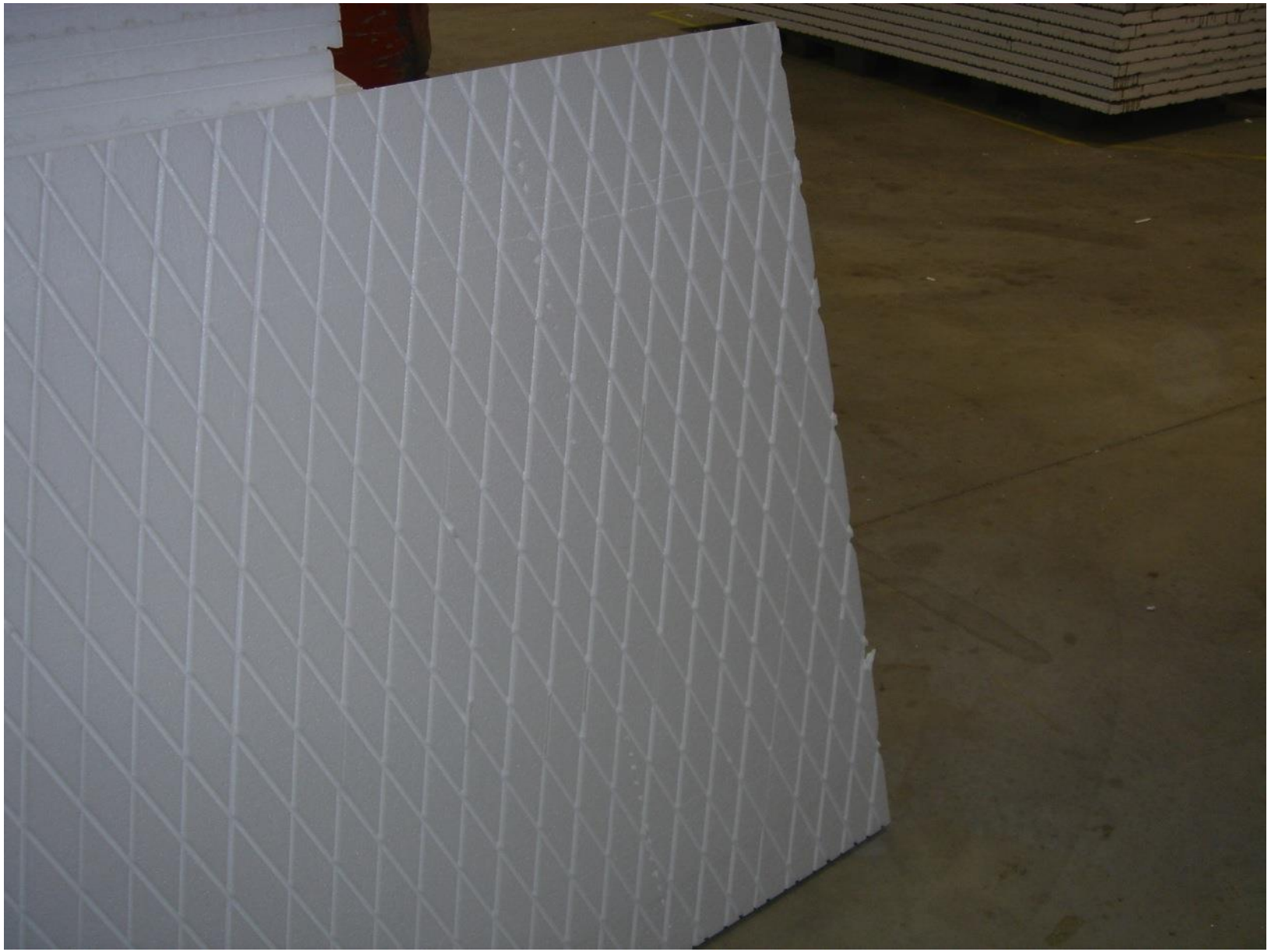
Pascals		mph
50	Pa =	20 mph
100	Pa =	30 mph
150	Pa =	35 mph
250	Pa =	45 mph
500	Pa =	65 mph
1,000	Pa =	90 mph



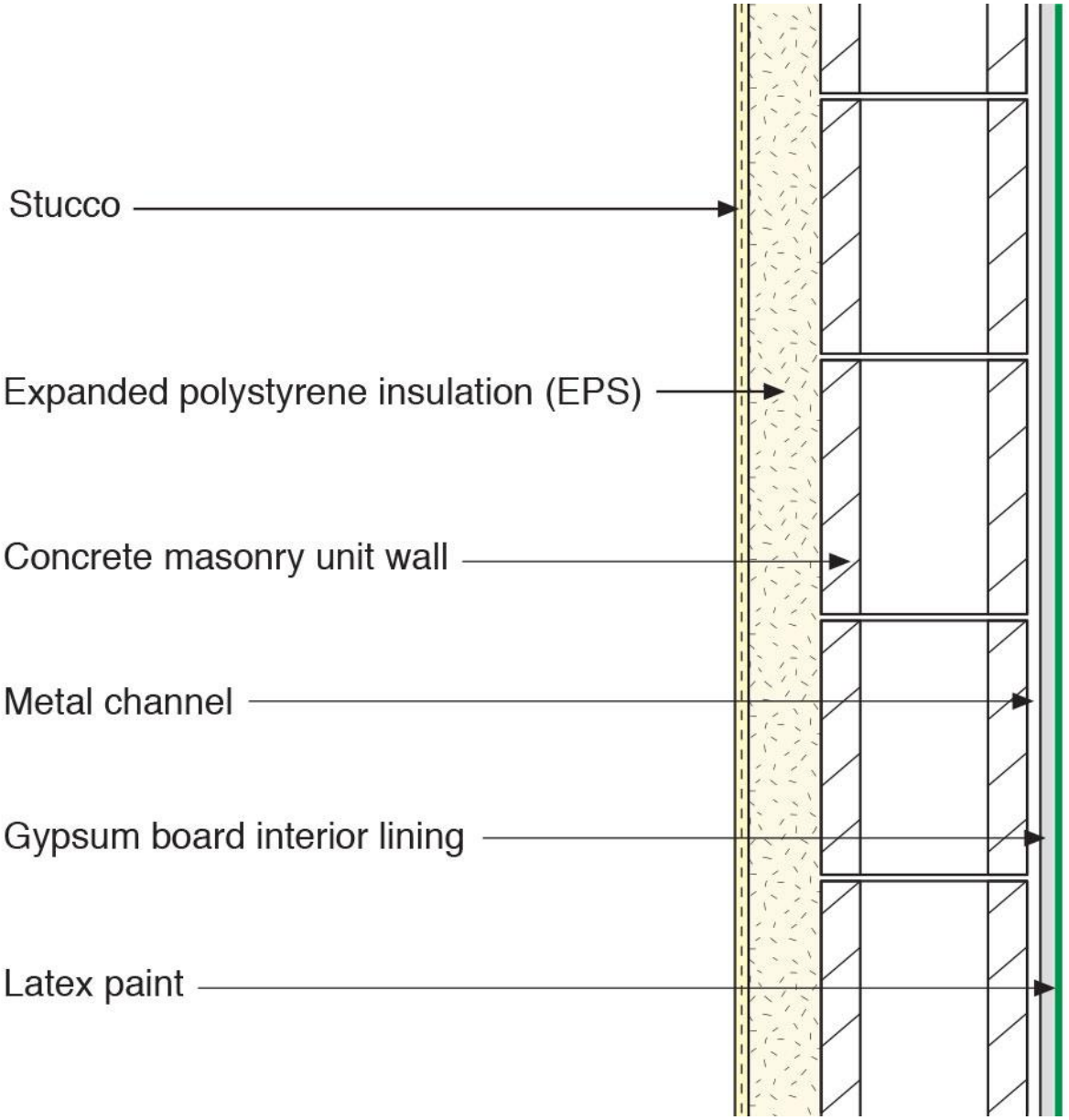

DU PONT
DU PONT

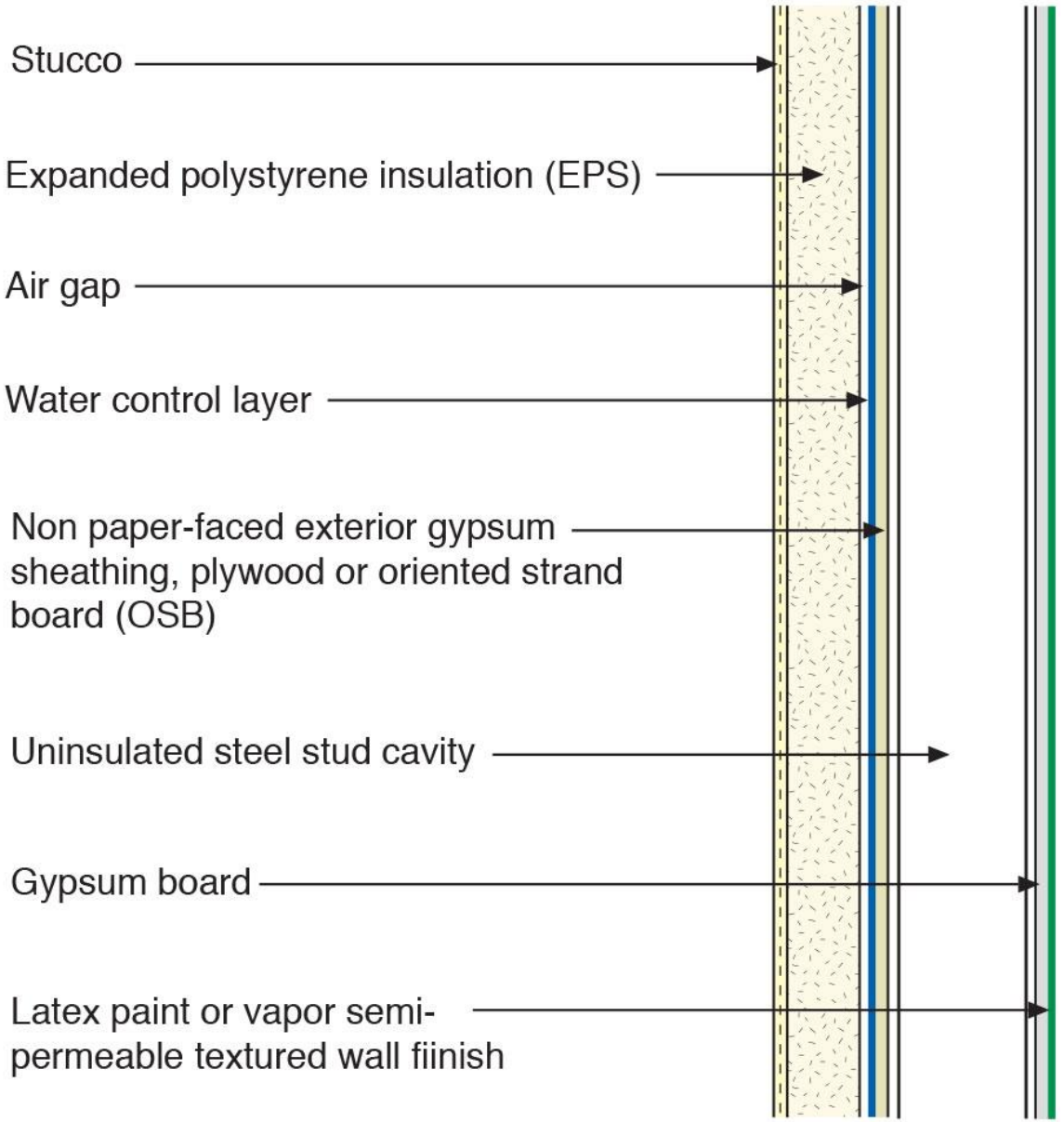

Call 1-800-44TYVEK
WWW.TYVEK.COM

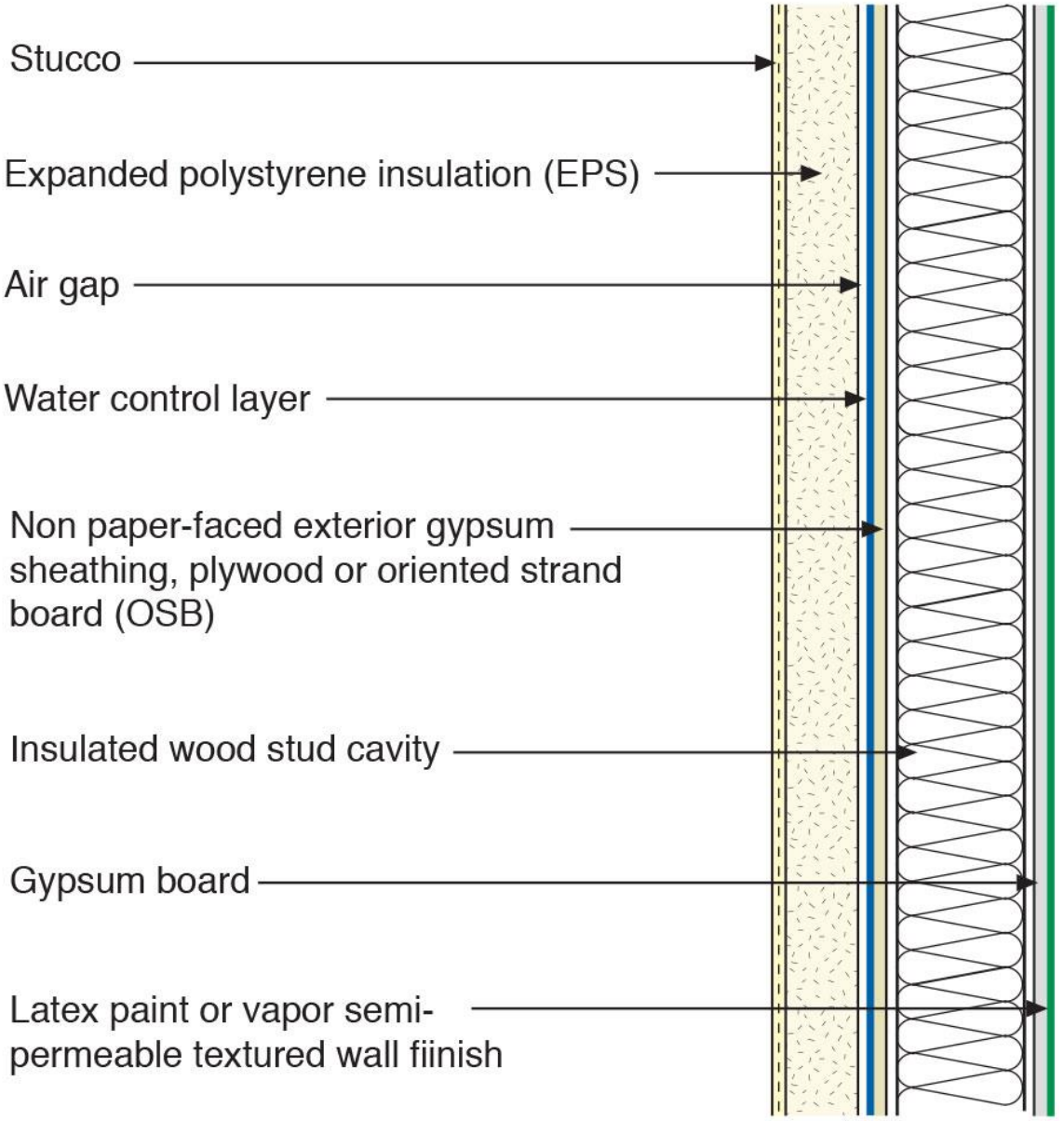

Tyvek
Tyvek

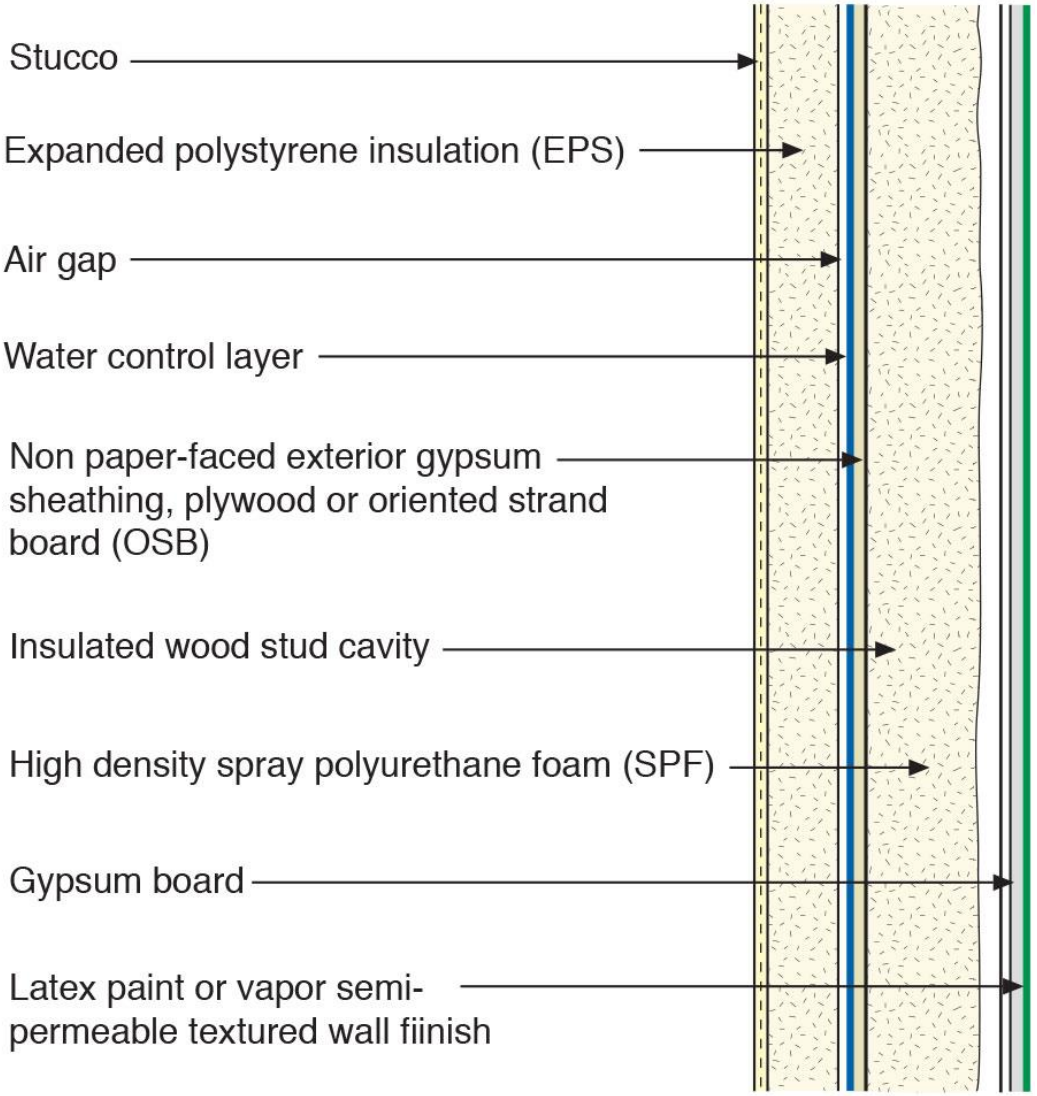


EIFS No Longer Has Issues

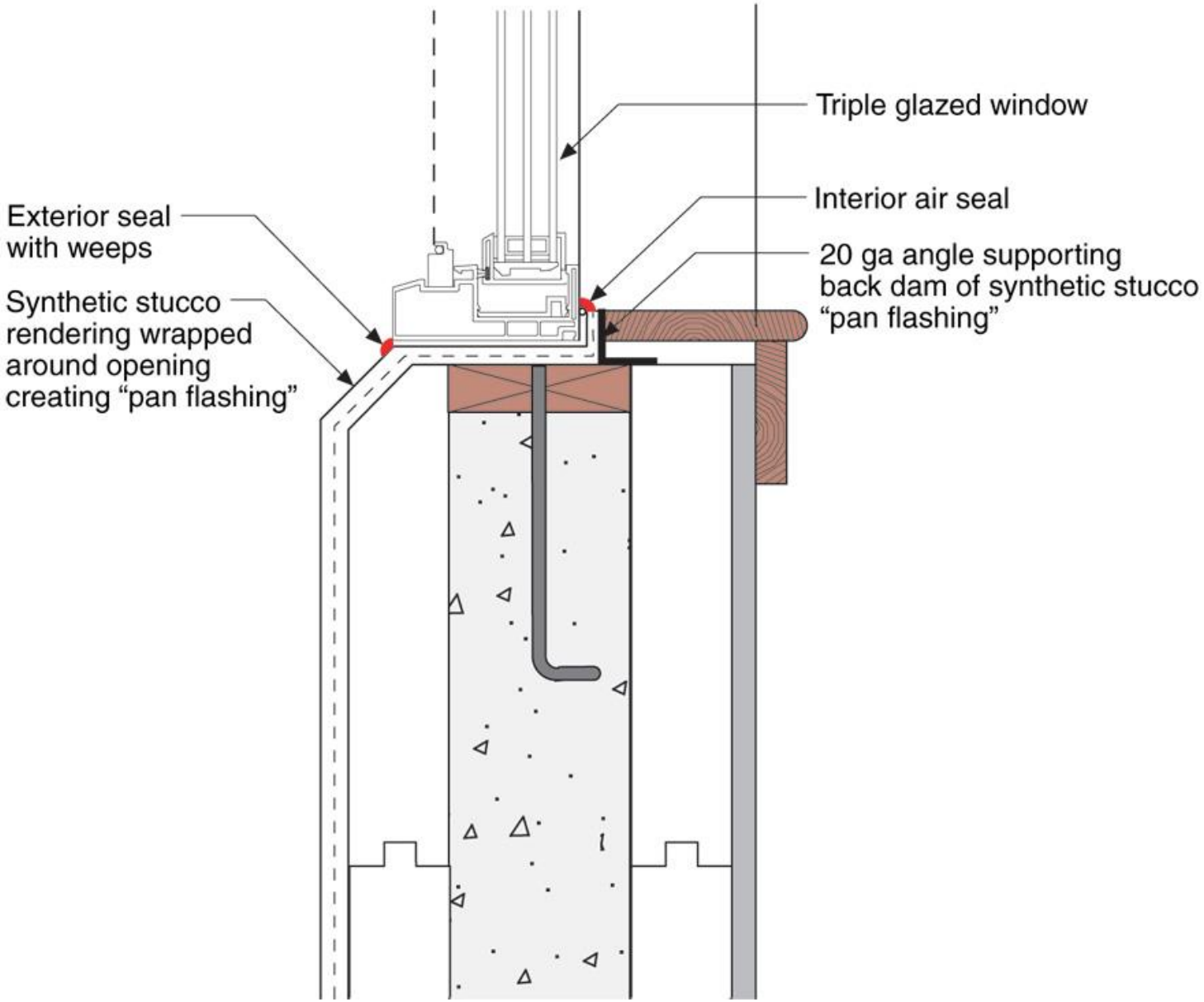

Stucco
Expanded polystyrene insulation (EPS)
Concrete masonry unit wall
Metal channel
Gypsum board interior lining
Latex paint

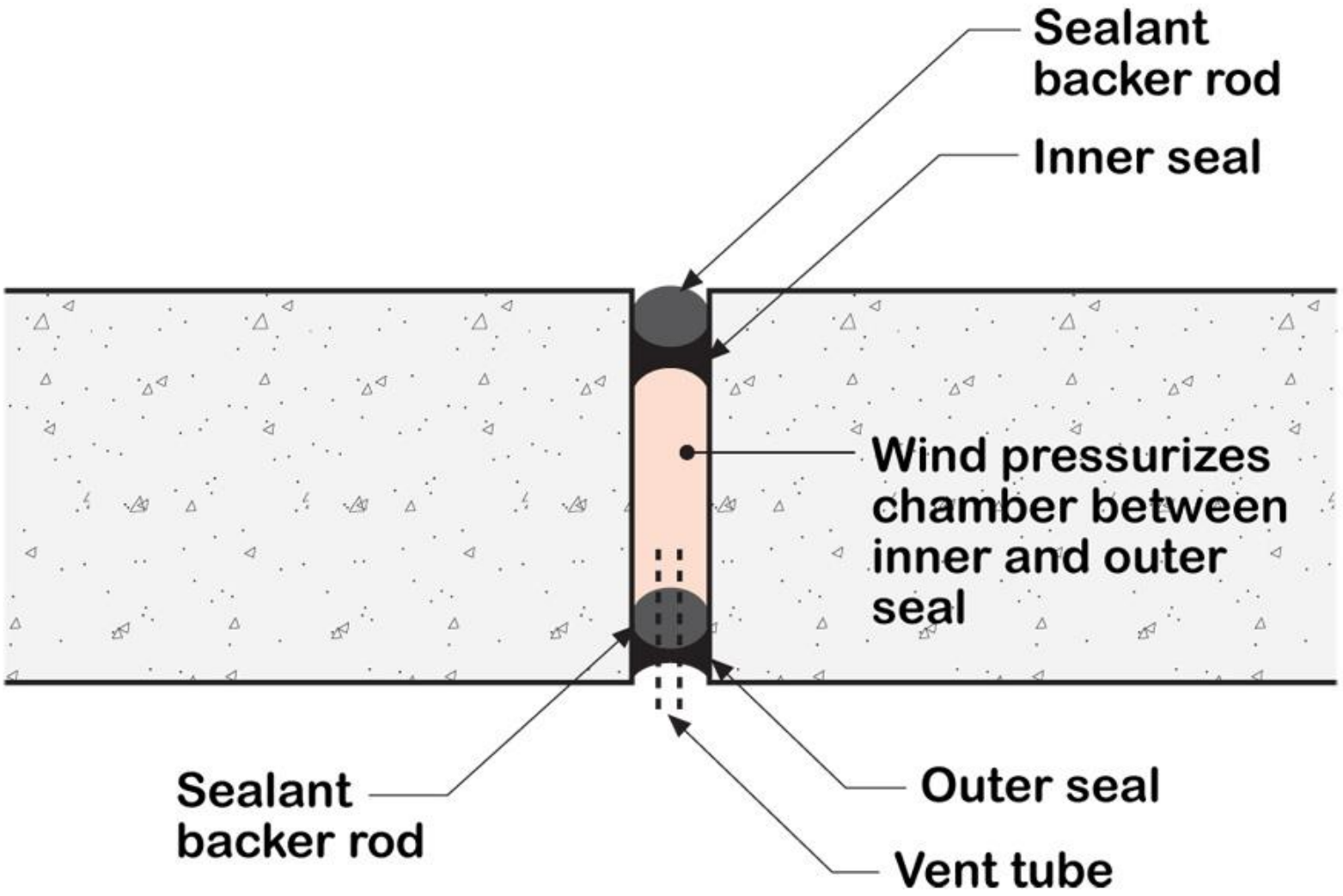

Stucco
Expanded polystyrene insulation (EPS)
Air gap
Water control layer
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish

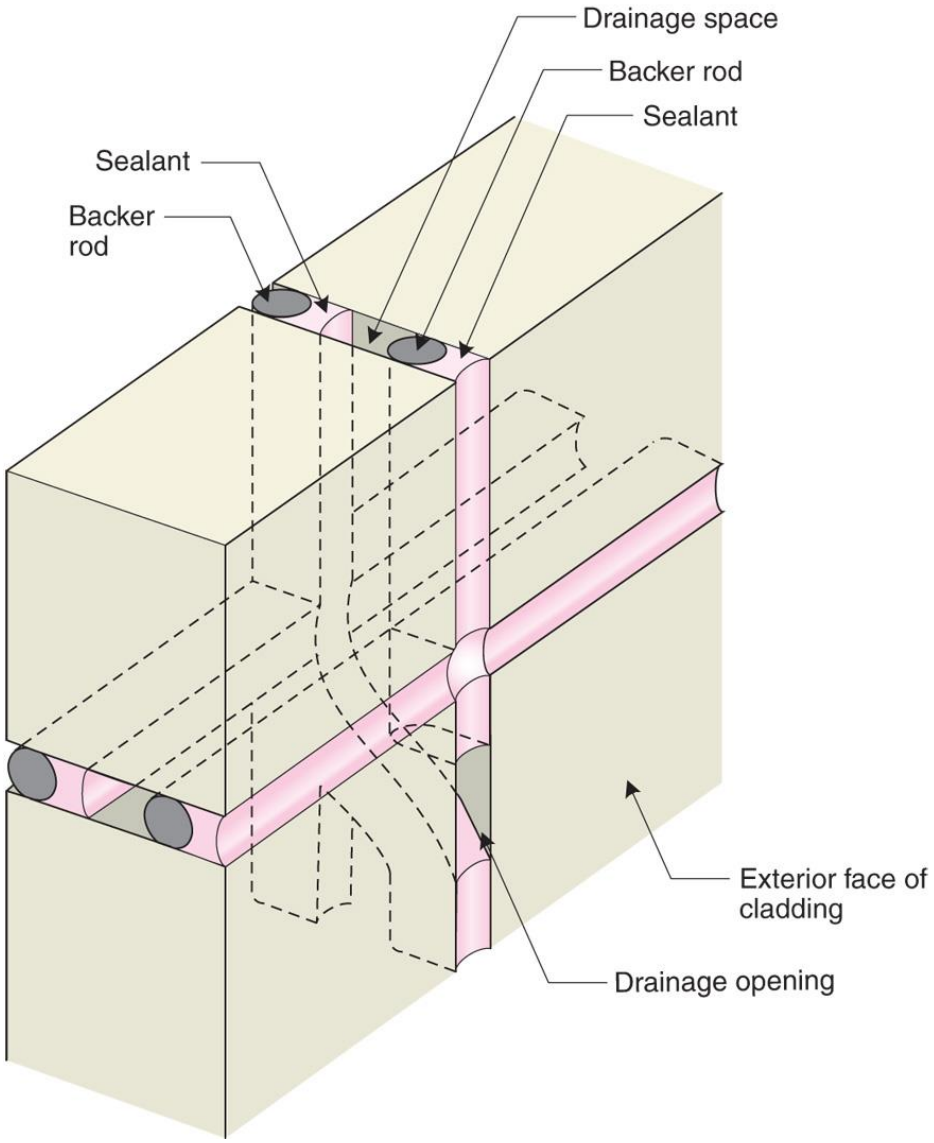

Stucco
Expanded polystyrene insulation (EPS)
Air gap
Water control layer
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated wood stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish

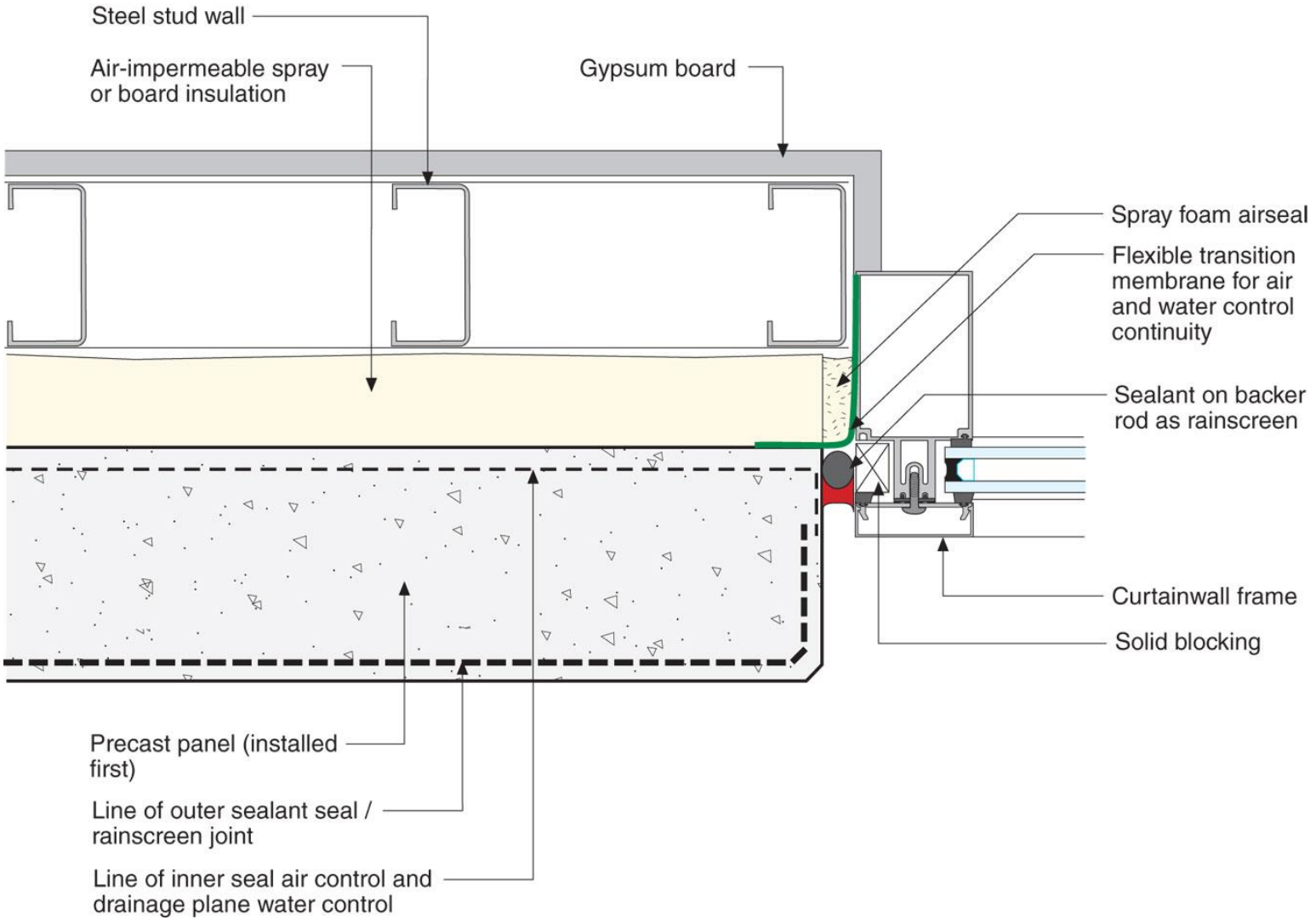

Stucco
Expanded polystyrene insulation (EPS)
Air gap
Water control layer
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Insulated wood stud cavity
High density spray polyurethane foam (SPF)
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish

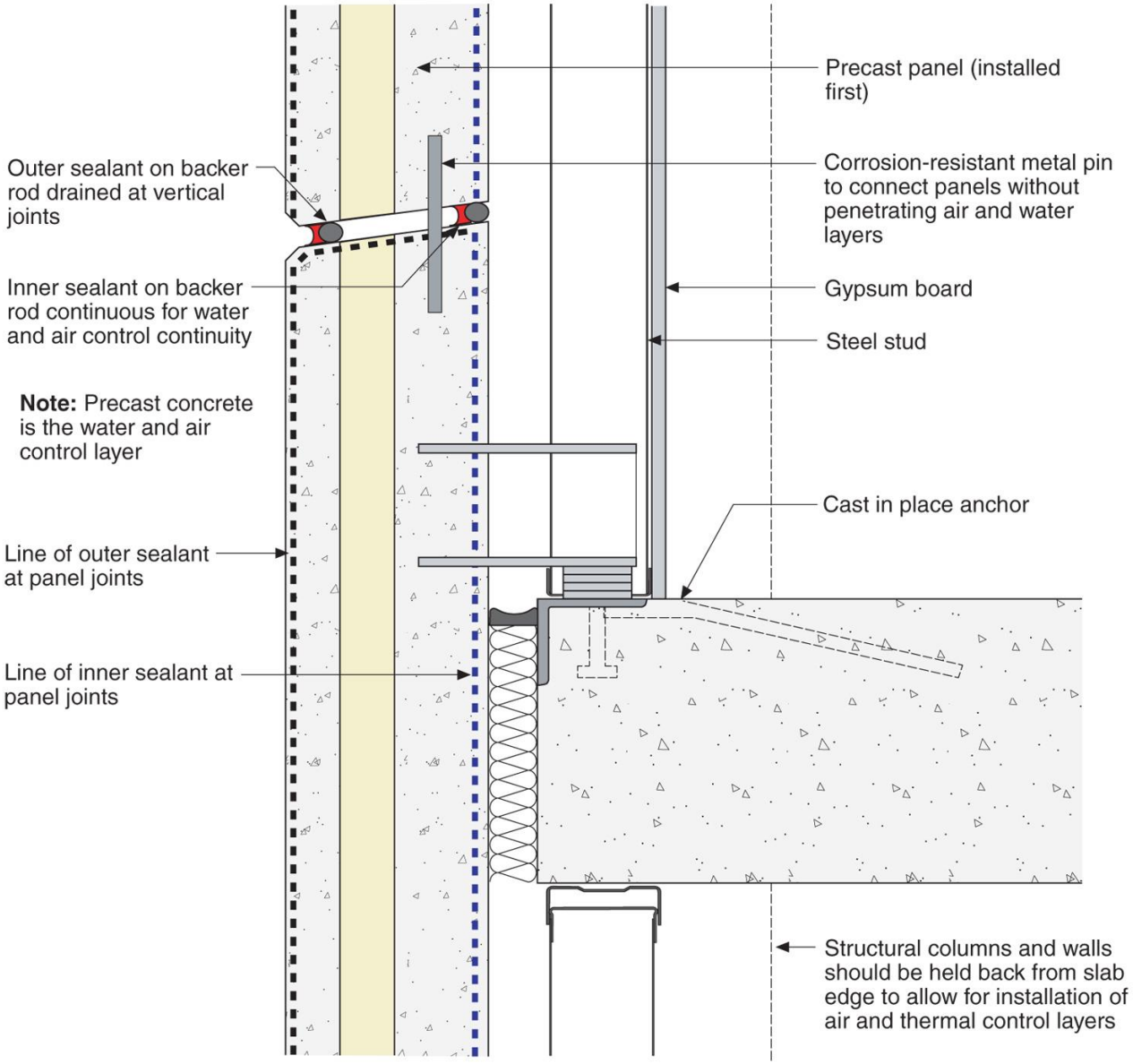
Back to Barrier and Face Seal….


Triple glazed window
Interior air seal
20 ga angle supporting
back dam of synthetic stucco
“pan flashing”
Exterior seal
with weeps
Synthetic stucco
rendering wrapped
around opening
creating “pan flashing”


Sealant backer rod
Inner seal
Wind pressurizes chamber between inner and outer seal
Sealant backer rod
Outer seal
Vent tube


Drainage space
Backer rod
Sealant
Sealant
Backer rod
Exterior face of cladding
Drainage opening


Steel stud wall
Air-impermeable spray or board insulation
Gypsum board
Spray foam airseal
Flexible transition membrane for air and water control continuity
Sealant on backer rod as rainscreen
Curtainwall frame
Solid blocking
Precast panel (installed first)
Line of outer sealant seal / rainscreen joint
Line of inner seal air control and drainage plane water control


Precast panel (installed first)
Outer sealant on backer rod drained at vertical joints
Corrosion-resistant metal pin to connect panels without penetrating air and water layers
Inner sealant on backer rod continuous for water and air control continuity
Gypsum board
Steel stud
Note: Precast concrete is the water and air control layer
Cast in place anchor
Line of outer sealant at panel joints
Line of inner sealant at panel joints
Structural columns and walls should be held back from slab edge to allow for installation of air and thermal control layers

Back To Stucco….


STO


DEC 3 2002

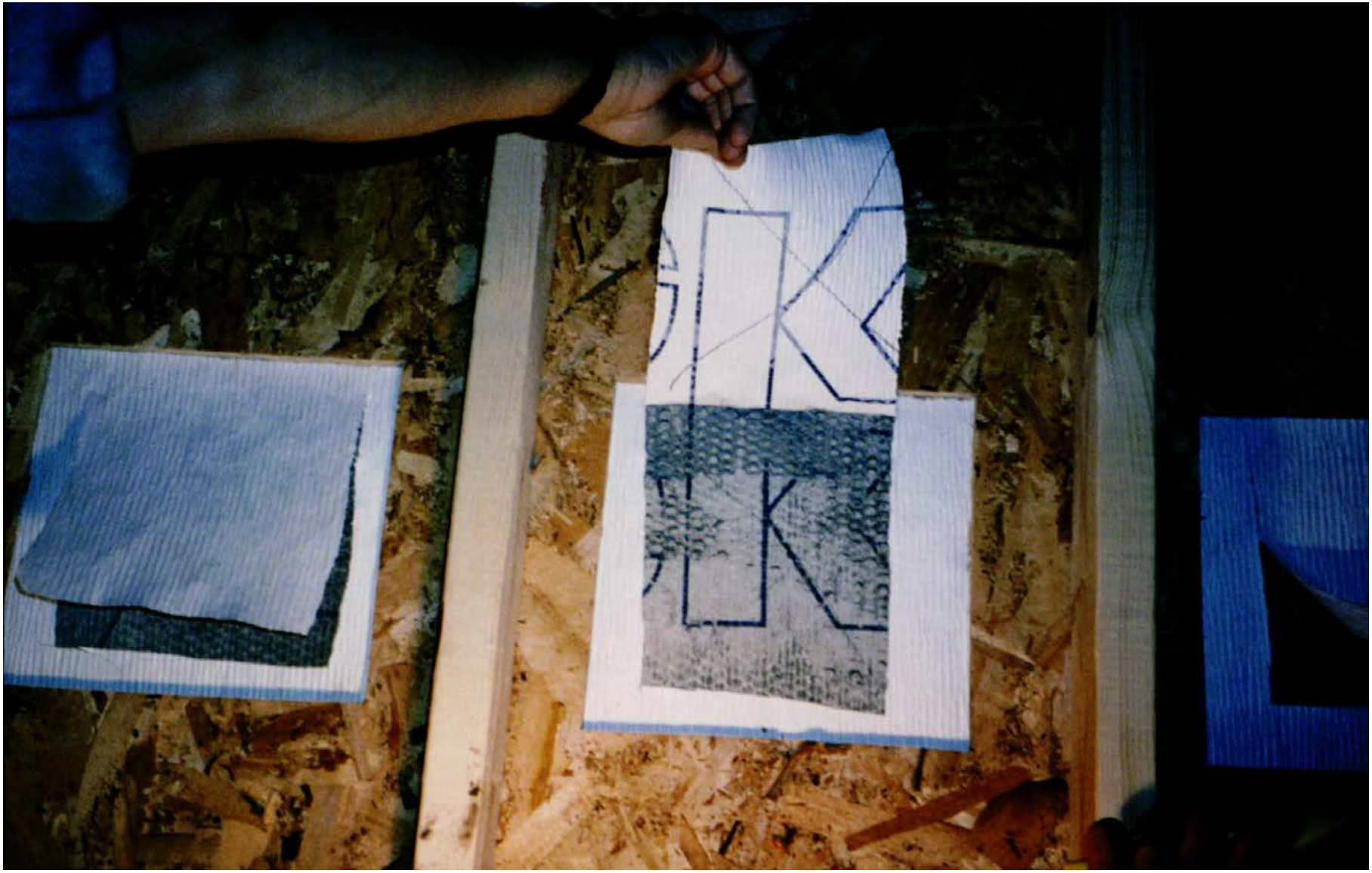

NO PARKING
Parking For Garage
Residents Only
10/24/2002

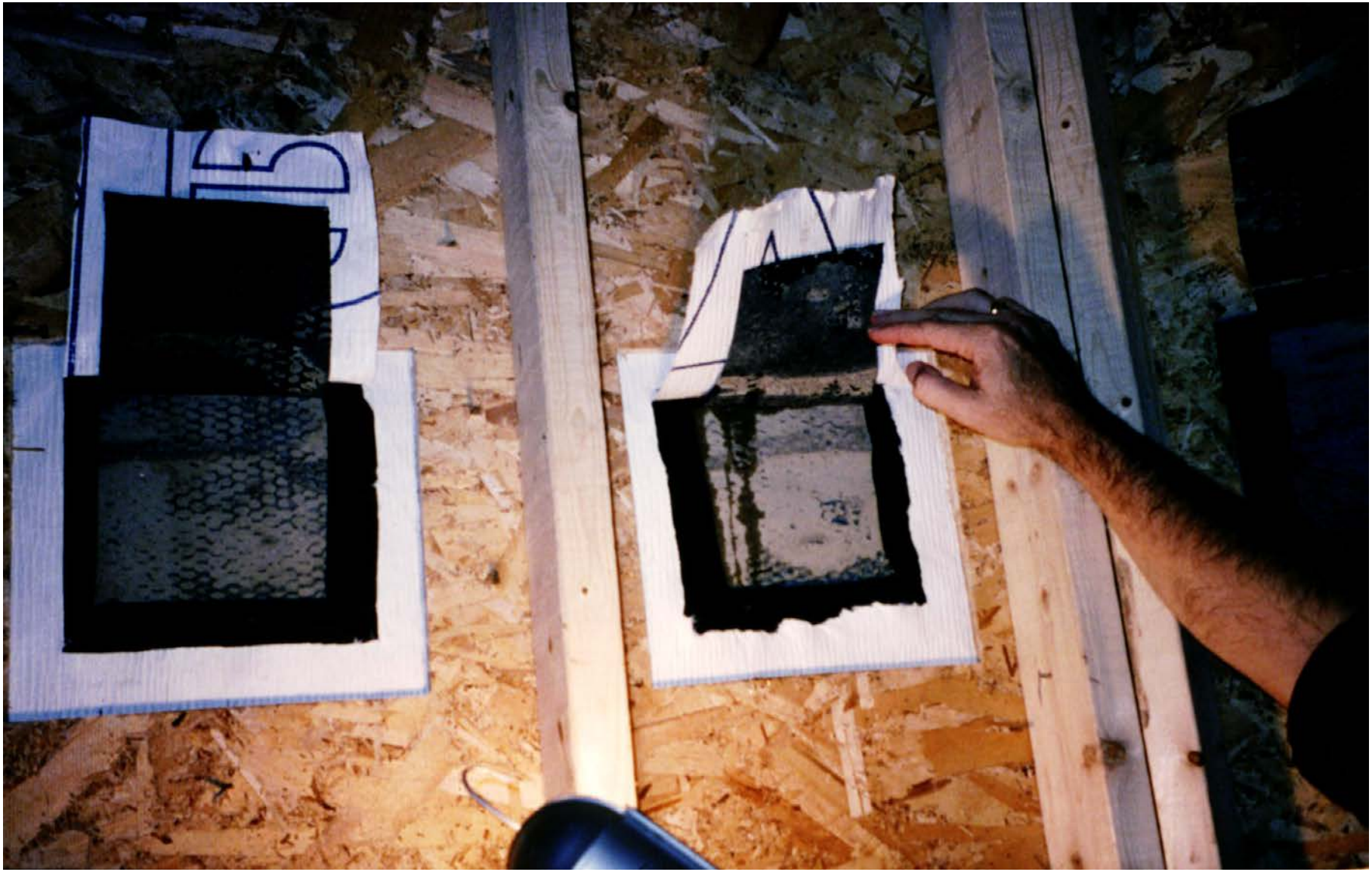

Parking For Garage
Residents Only
12/19/2002

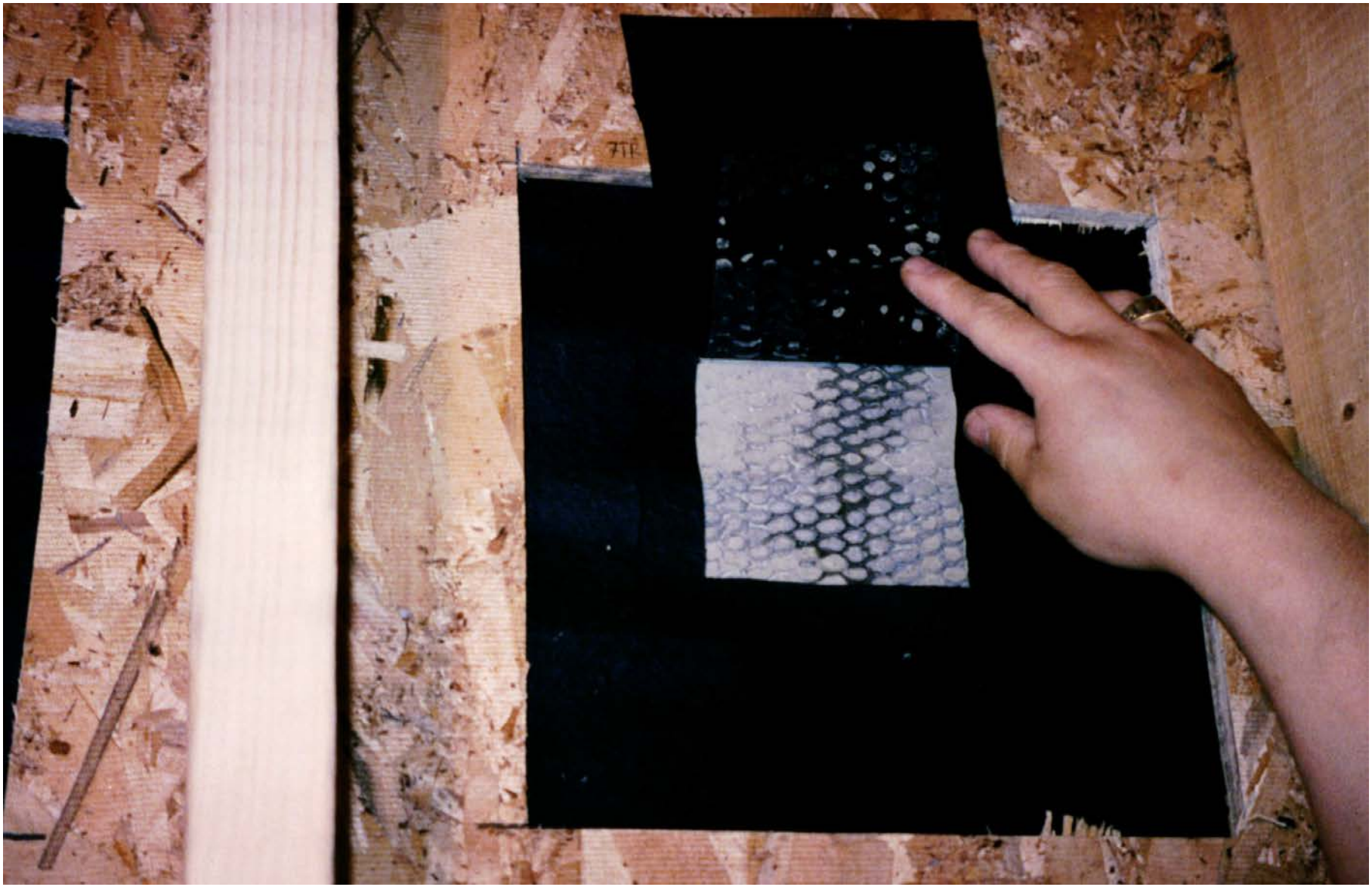

10/24/2002


3514
Finish

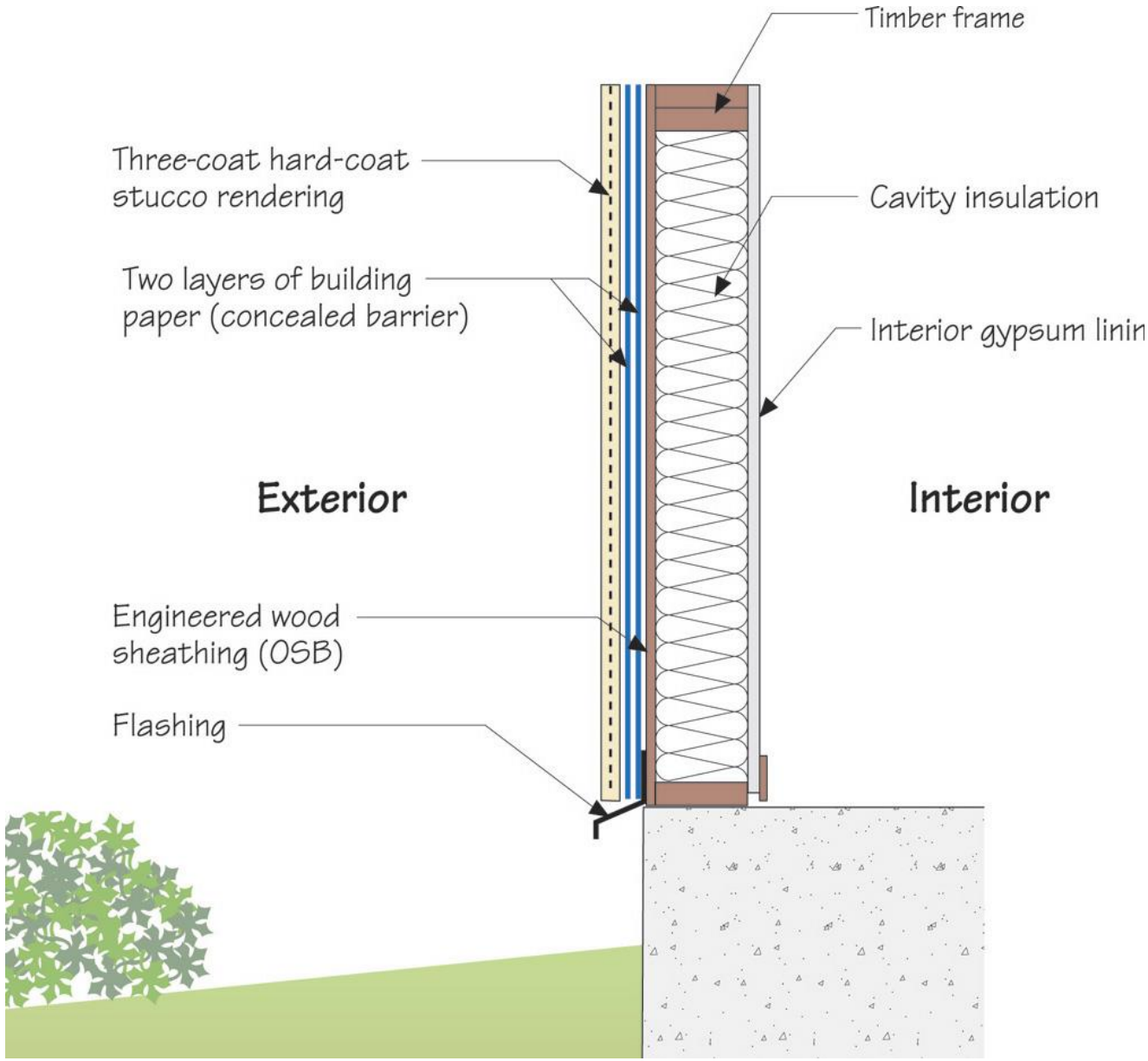
Side Trip To My Backyard….








Gypsum


Timber frame
Three-coat hard-coat stucco rendering
Cavity insulation
Two layers of building paper (concealed barrier)
Interior gypsum linin
Exterior
Interior
Engineered wood sheathing (OSB)
Flashing

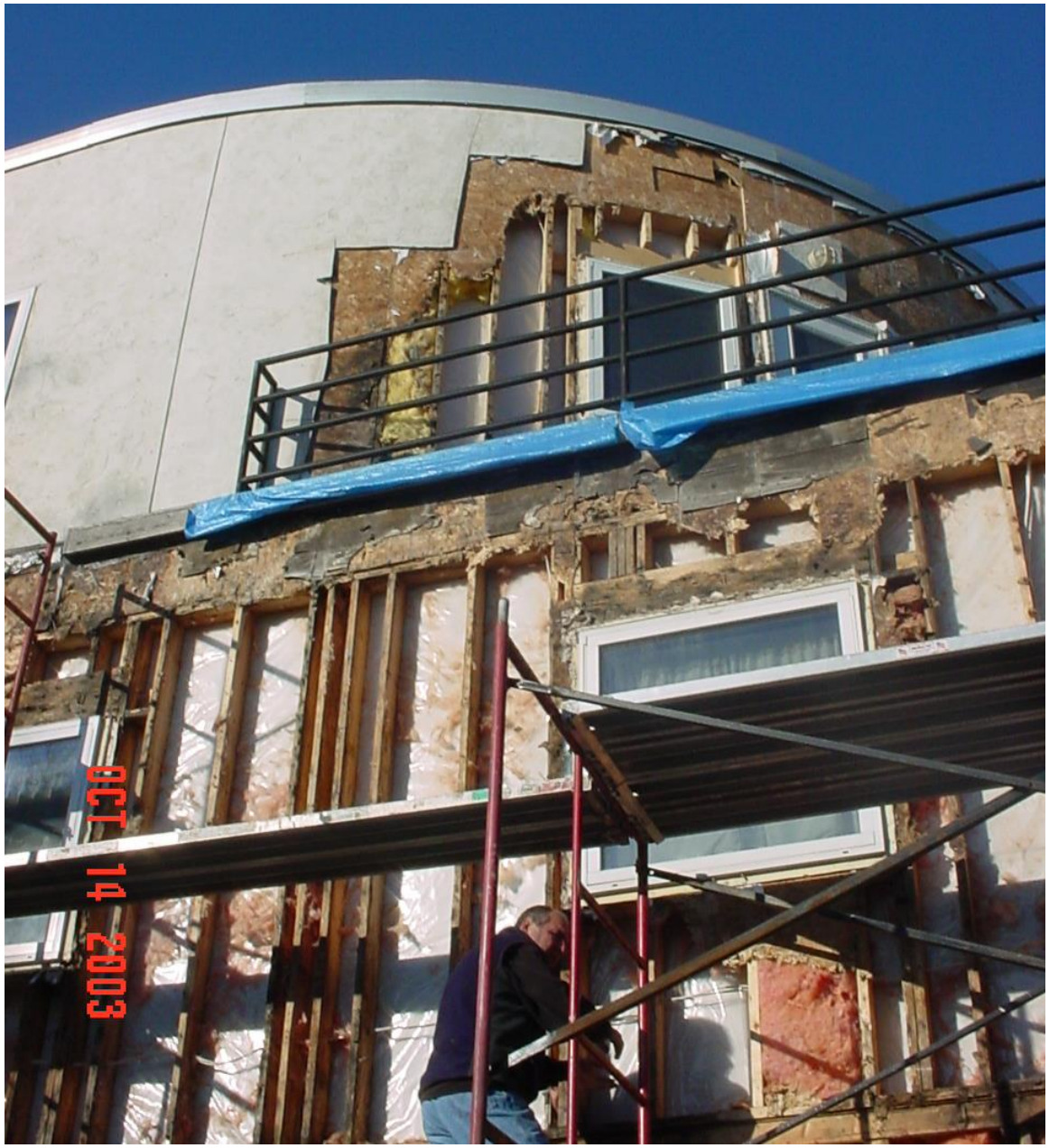
“Lumpy Stucco”….

Should Have Been The Big Warning….


Andersen
AW

Side Trip To Vancouver….


6'8" CLEARANCE 2.0m


OCT 14 2003


OCT 14 2003


OCT 14 2003

Back To America….Pennslyvania….

And Then Pretty Much Anywhere It Rains…


JLG ULTRA
1250AJP
JLG


LOWE'S

Back To Lumpy Stucco….

Easy Solution….


Genie Z-60/34


VRAP

Recommendations….

Provide a 3/8 inch air space behind all stucco in regions where it rains more than 20 inches per year

Provide a 3/8 inch air space behind all stucco over three stories

Don’t install interior vapor barriers

Air space can be reduced to 1/16 inch where inward vapor drive is limited

Recommendations….

Barrier works in Florida over block

Barrier does not work in Florida over OSB

Don’t install interior vapor barriers in Florida

Don’t drain a drained system into a barrier system

Exterior Conditions

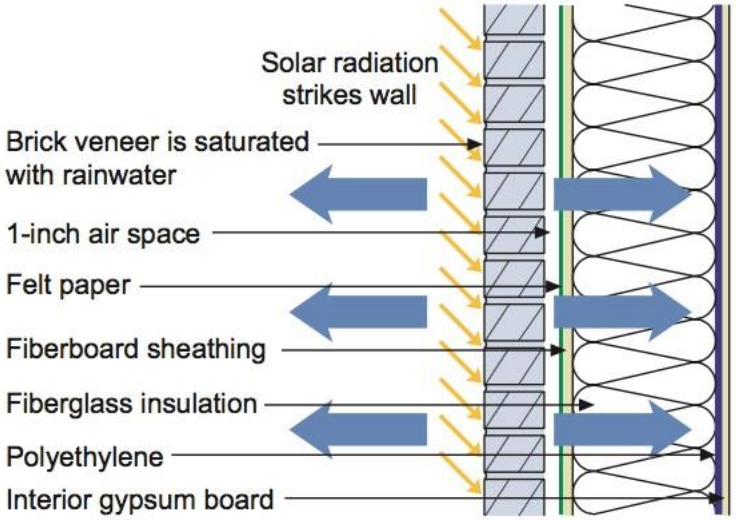
Temperature: 80°F
Relative humidity: 75%
Vapor pressure: 2.49 kPa

Conditions within Cavity:

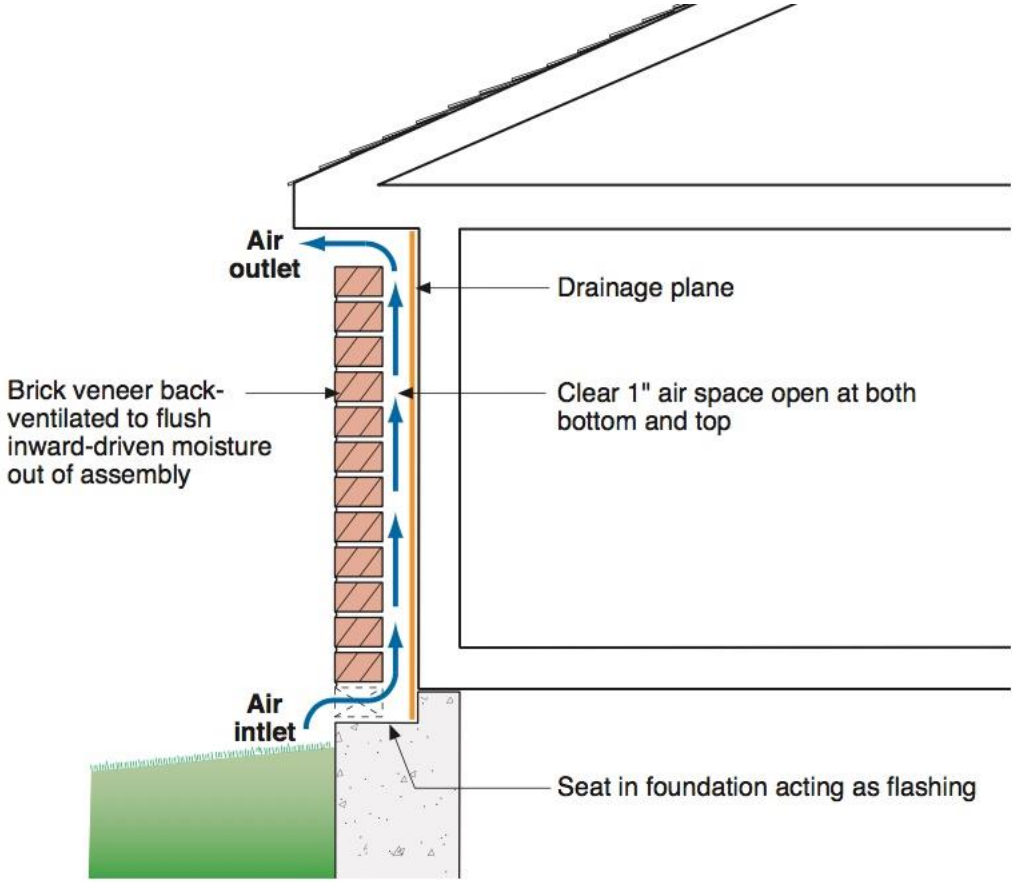
Temperature: 100°F
Relative humidity: 100%
Vapor pressure: 6.45 kPa

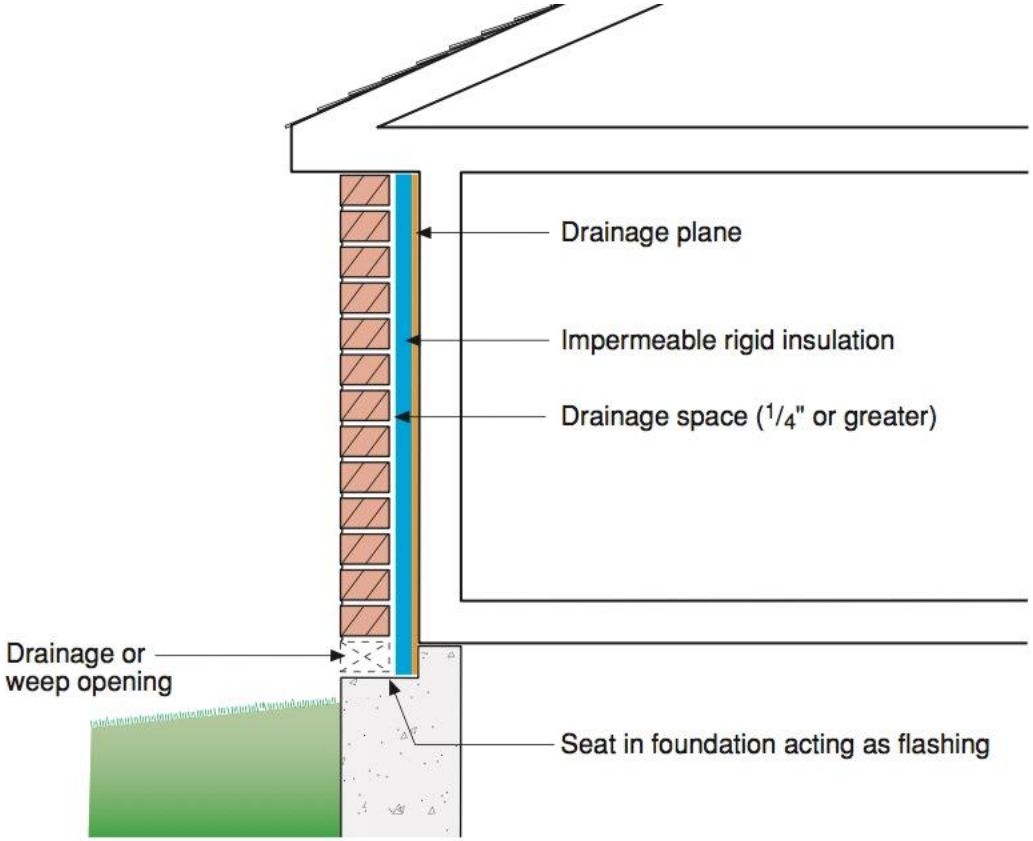
Interior Conditions

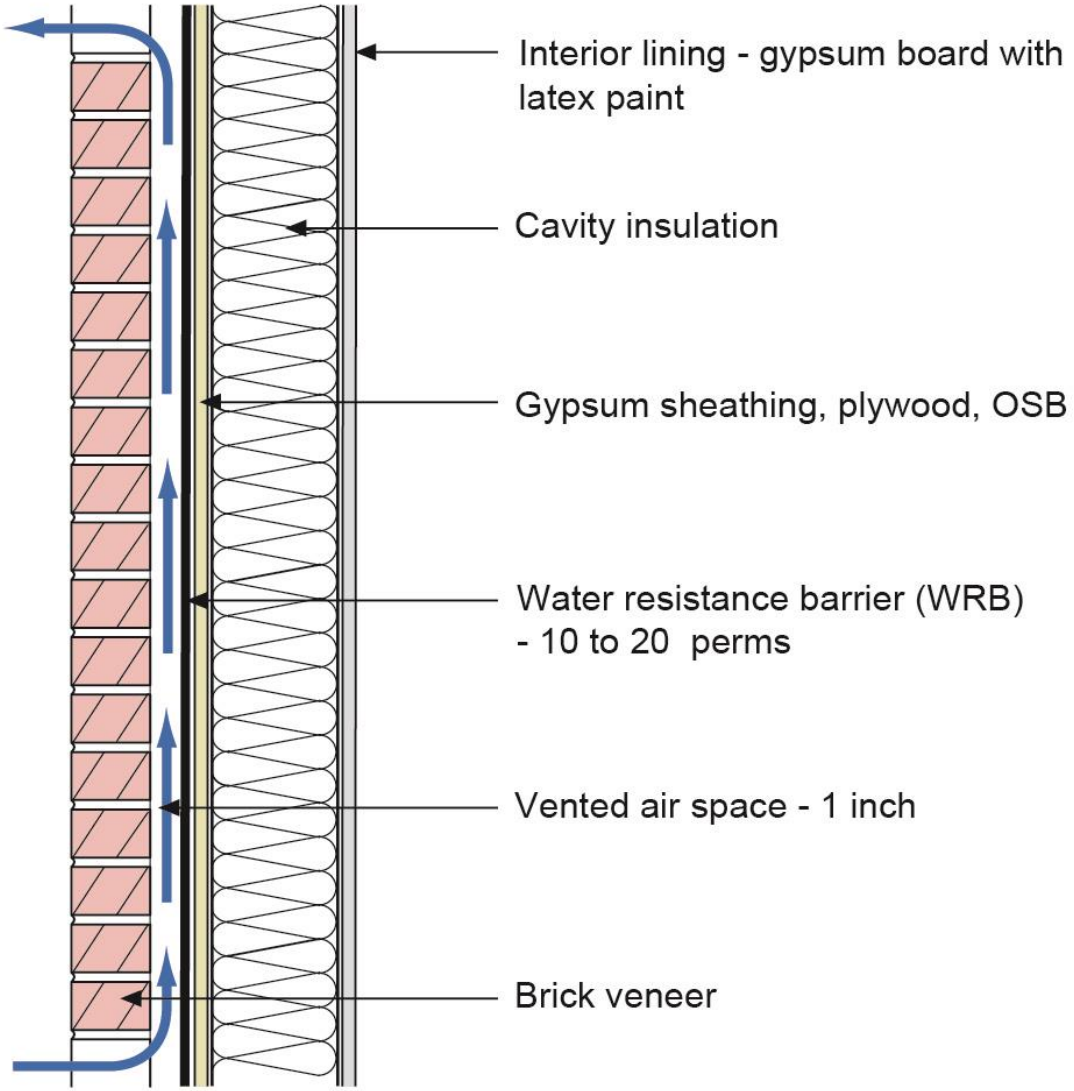
Temperature: 75°F
Relative humidity: 60%
Vapor pressure: 1.82 kPa

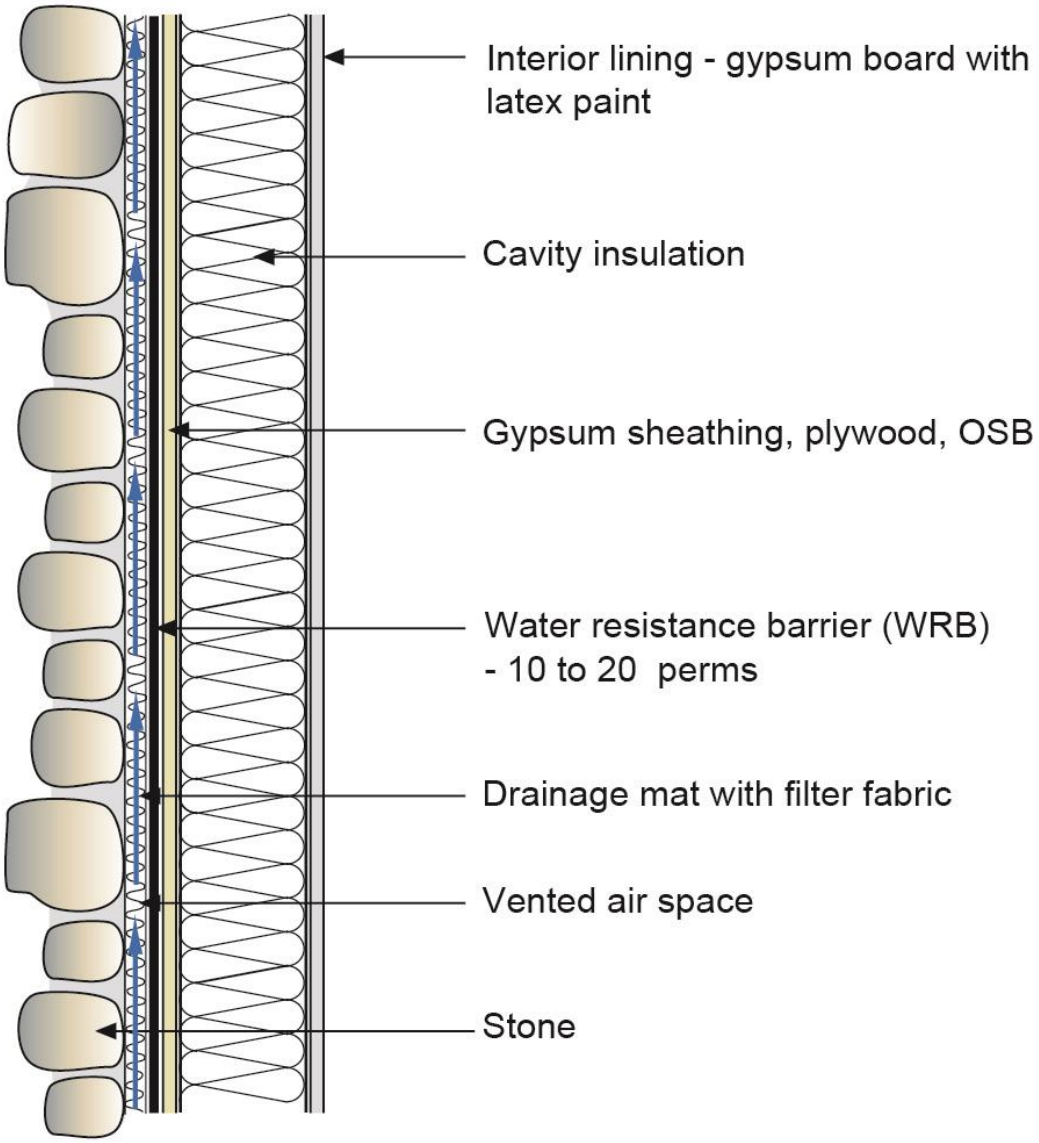


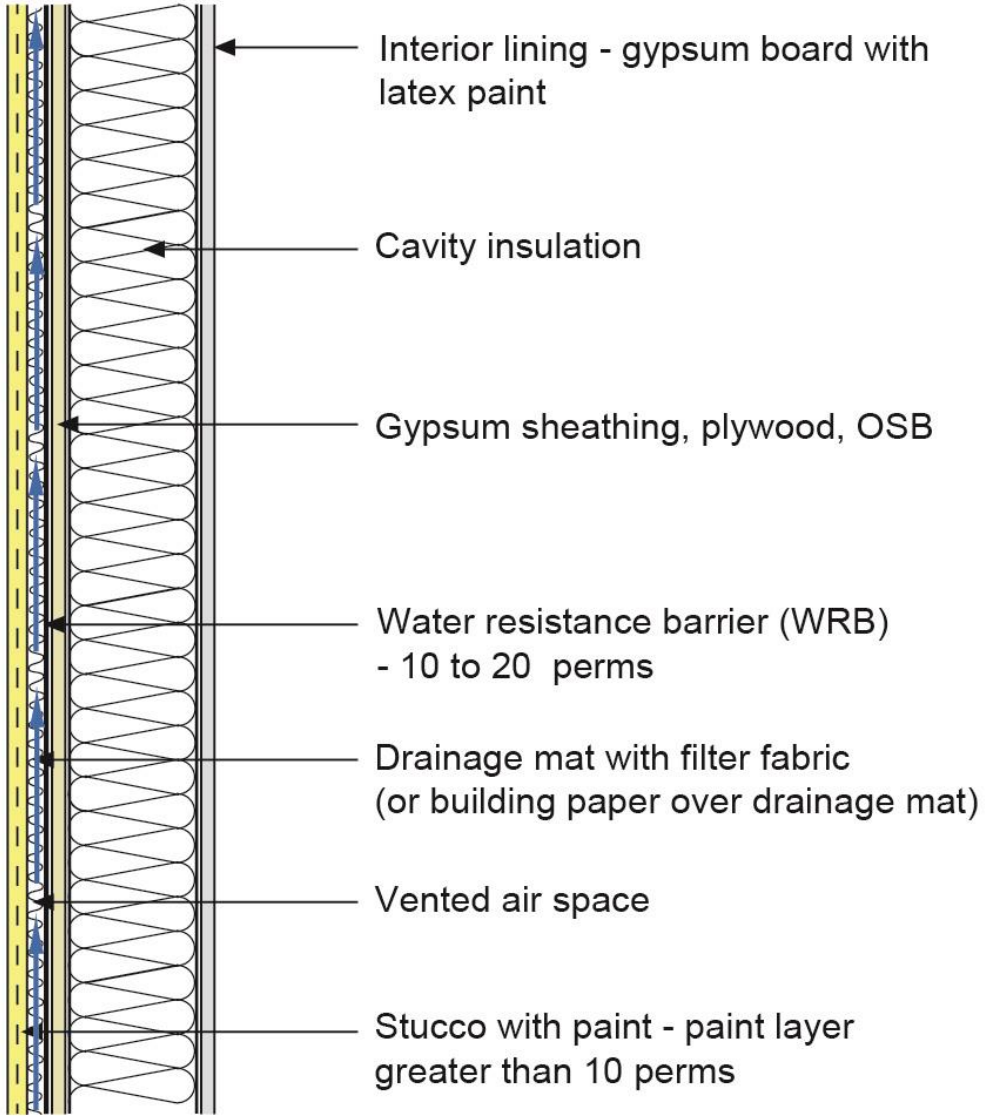
Vapor is driven both inward and outward by a high vapor pressure differential between the brick and the interior and the brick and the exterior.

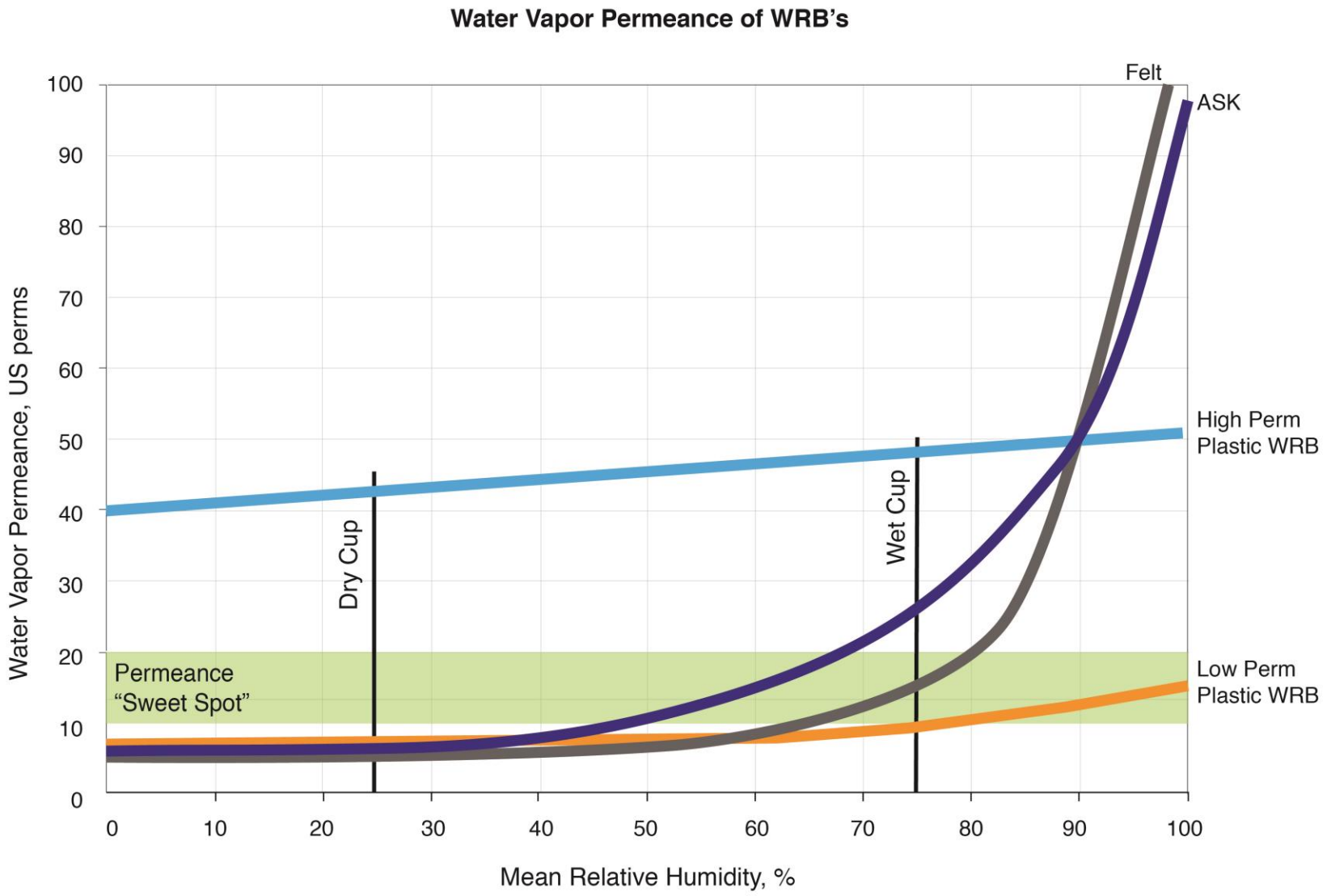

Air
outlet
Drainage plane
Brick veneer back-
ventilated to flush
inward-driven moisture
out of assembly
Clear 1" air space open at both
bottom and top
Air
intlet
Seat in foundation acting as flashing


Drainage plane
Impermeable rigid insulation
Drainage space (1/4" or greater)
Drainage or
weep opening
Seat in foundation acting as flashing


Interior lining - gypsum board with latex paint
Cavity insulation
Gypsum sheathing, plywood, OSB
Water resistance barrier (WRB) - 10 to 20 perms
Vented air space - 1 inch
Brick veneer


Interior lining - gypsum board with latex paint
Cavity insulation
Gypsum sheathing, plywood, OSB
Water resistance barrier (WRB) - 10 to 20 perms
Drainage mat with filter fabric
Vented air space
Stone


Interior lining - gypsum board with latex paint
Cavity insulation
Gypsum sheathing, plywood, OSB
Water resistance barrier (WRB) - 10 to 20 perms
Drainage mat with filter fabric (or building paper over drainage mat)
Vented air space
Stucco with paint - paint layer greater than 10 perms


Water Vapor Permeance of WRB's
Water Vapor Permeance, US perms
Mean Relative Humidity, %
Felt
ASK
High Perm
Plastic WRB
Low Perm
Plastic WRB
Dry Cup
Wet Cup
Permeance
"Sweet Spot"
0
10
20
30
40
50
60
70
80
90
100


DU PONT
DrainWra