

Welcome

Houses That Work

Energy Design Conference – Duluth, MN

February 20th, 2018



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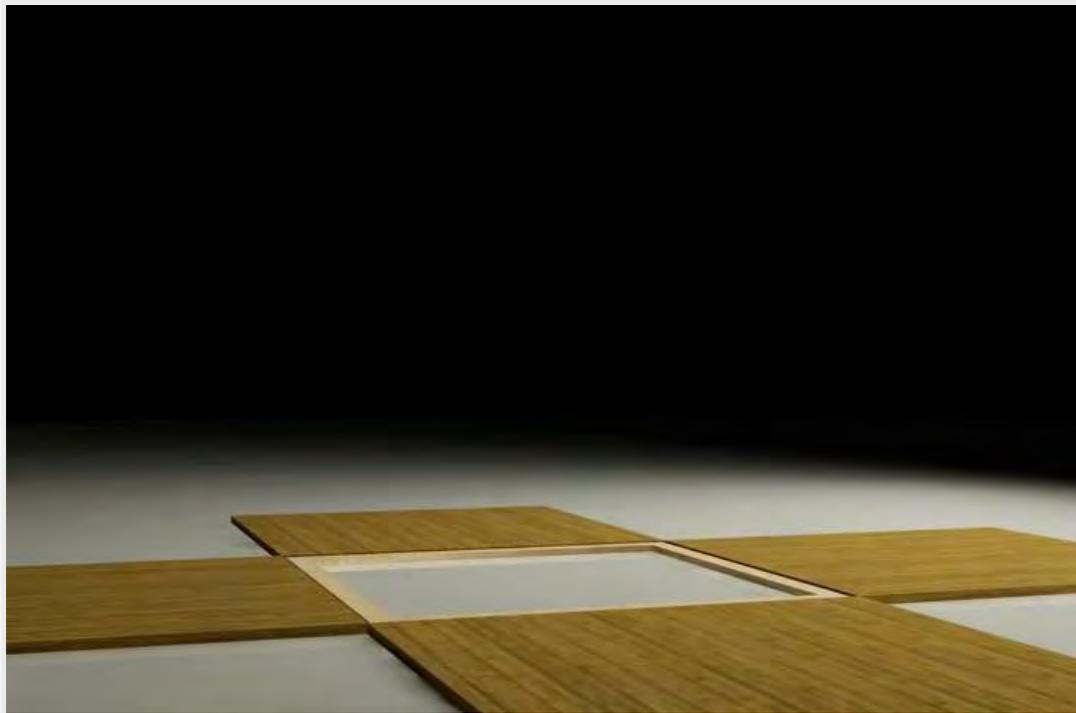
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EEBA Certified Trainer
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Who's here and What would you like to talk about??

5



Today's Agenda

- Industry trends
- Essential elements in a home
- Basic building science to effectively manage Heat, Moisture and Air in buildings
- Creating systems that work for healthy, safe durable, efficient and sustainable homes.
 - Foundation systems
 - Above grade wall systems
 - Roof systems
- Heating, Ventilation and Air Conditioning Systems (HVAC)
- Marketing and selling basics

What is our goal?

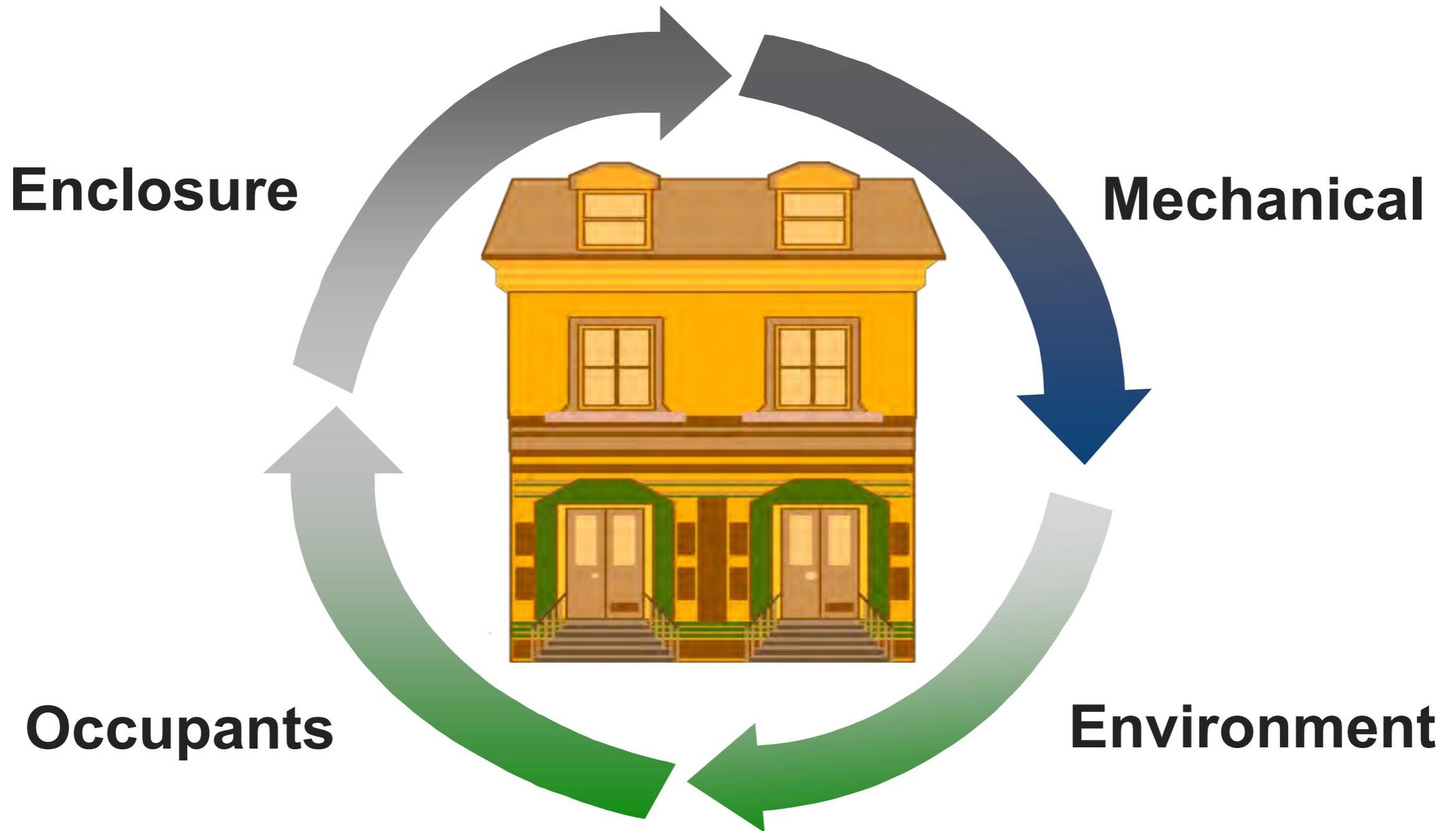
“Create an enclosure that separates the indoors from the outdoors...and is safe and healthy for the people inside.”

In addition to:

Creating a high performance home that is; energy efficient, durable, healthy, aesthetically pleasing, respectful to the environment and profitable...

House Systems

What's Changed in that home in the last 35 years?
How has this impacted the home?



What's the decision tree?

- Decisions made on price
- Decision made on warranty/service issues
- Customers satisfaction/expectations
- Process/cycle times
- Supplier availability
- We are here to help reinforce your decision process

What's Changing quicker....? Codes or expectations of consumers?

10

- Comfort
- Quiet
- Lifestyle
- Investment quality
- Demographics
- Access to information



THERMAL COMFORT DEFINED: ASHRAE 55(40 years old)

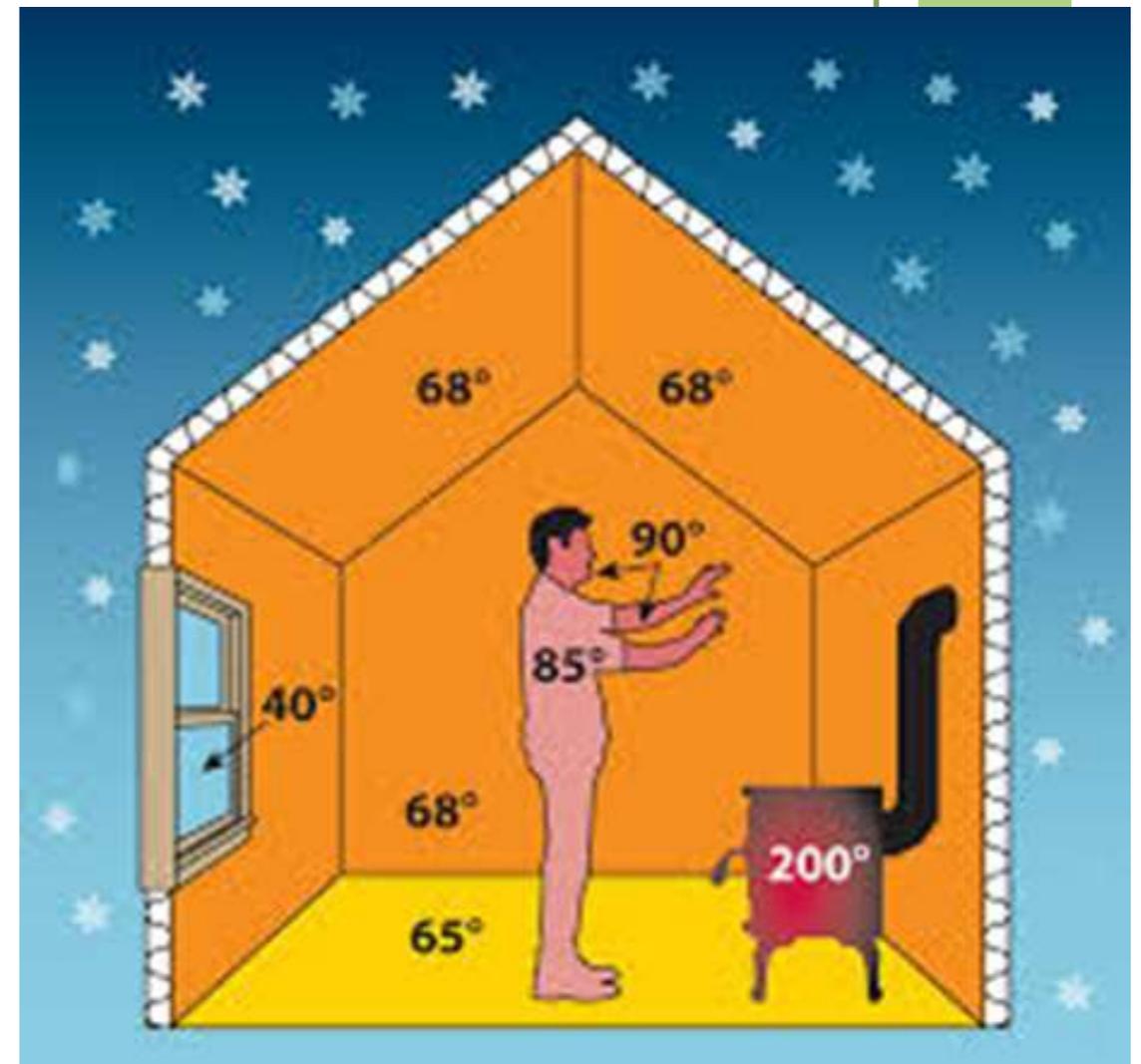
1. Air Temperature(Ambient)
2. Surrounding Surface Temperature(MRT)
3. Humidity

PERSONAL FACTORS:

1. Air movement-Drafts(Air Speed)
2. Occupant Activity AND Sensitivity(Metabolic Rate and Clothing)

ASHRAE 55....”Mean Radiant Temperature”

<http://comfort.cbe.berkeley.edu/>



The Temperatures of the surrounding walls ,floors and windows impacts comfort MORE than air temperature(Thermostat).

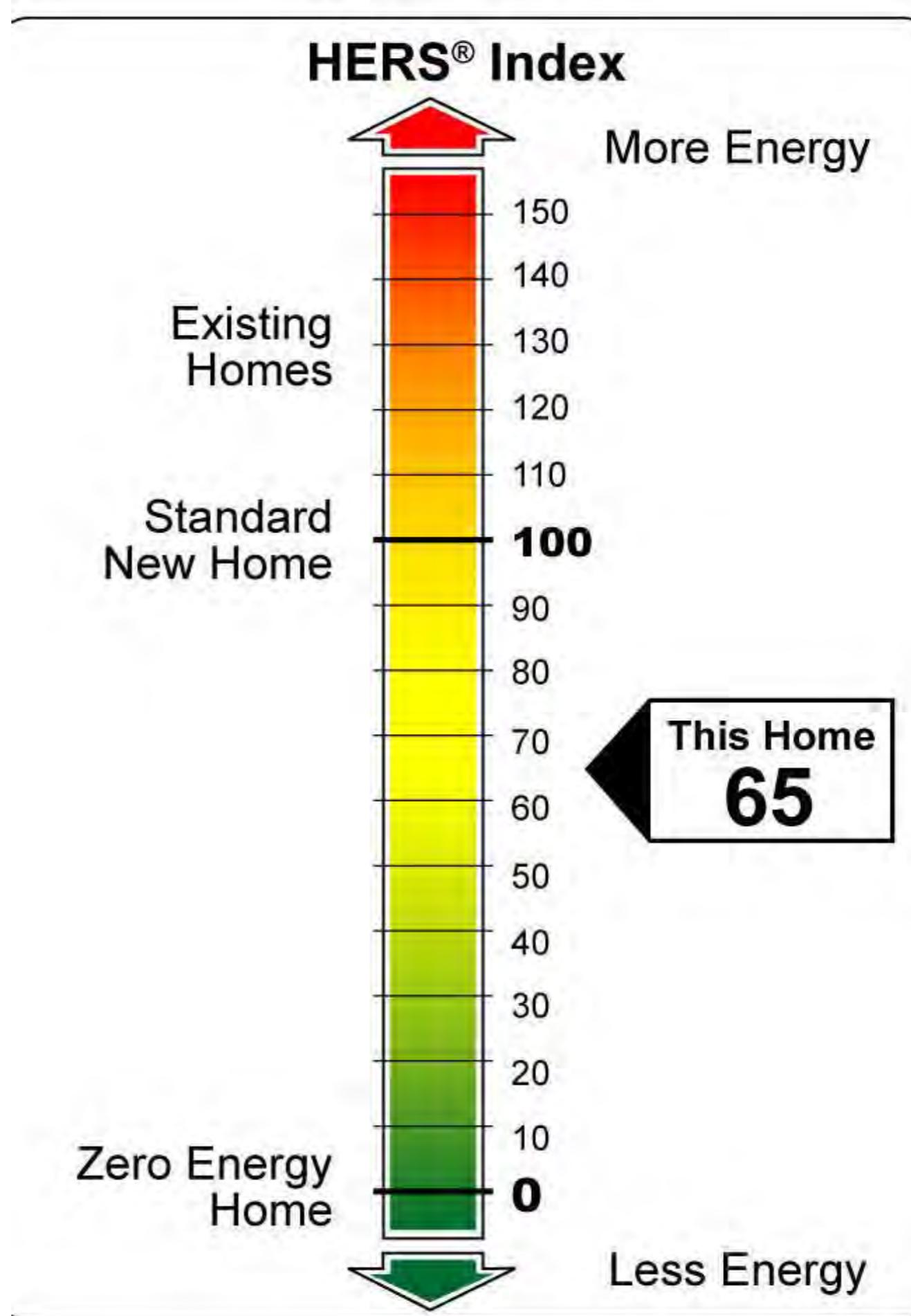
How does the body lose (transfer) heat?

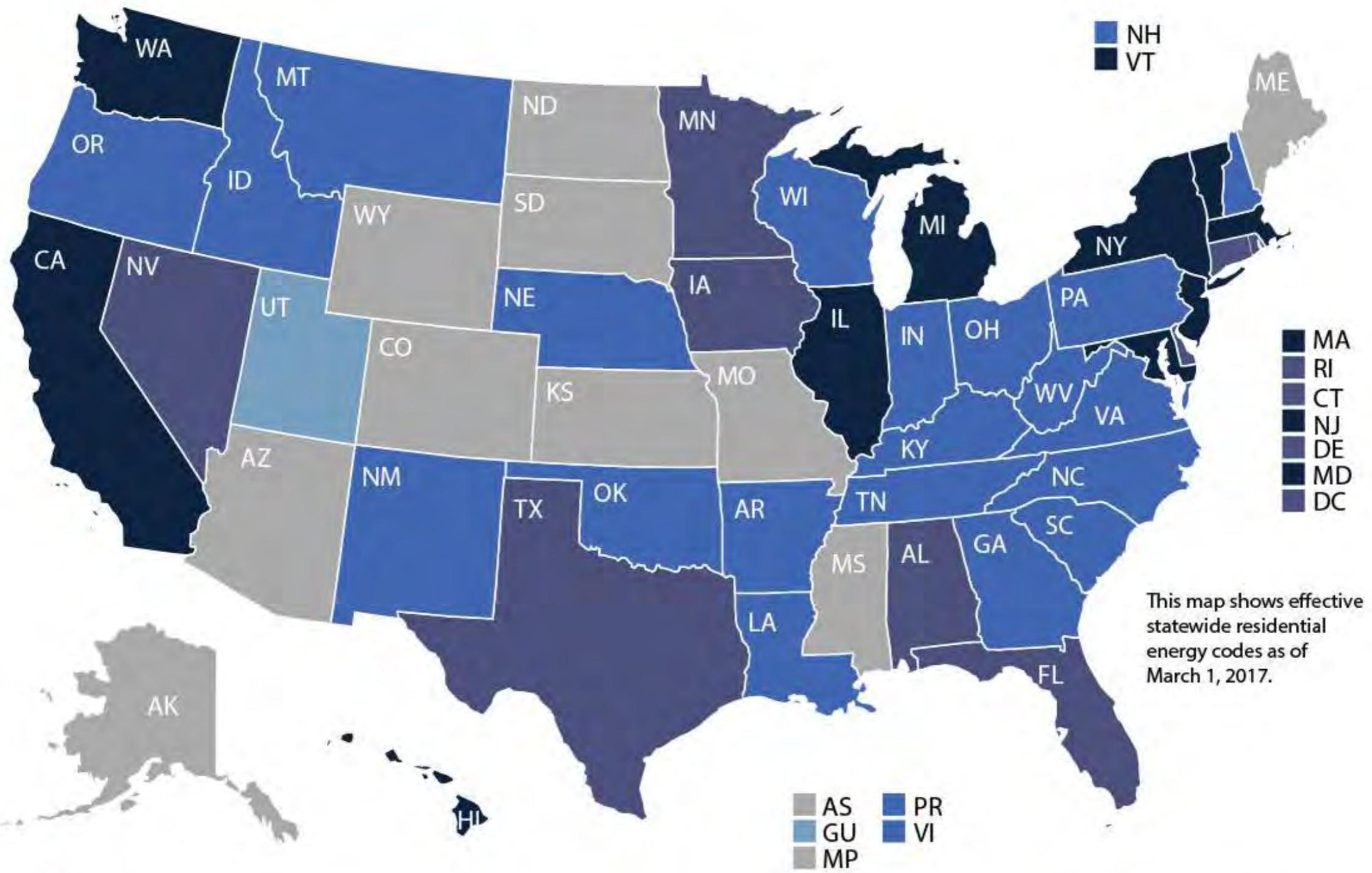
- 15% humidity/perspiration
- 35% convection/air movement
- **50% radiation heat exchange.**



Energy Efficiency Scale

- Every 1 point reduction is equal to a 1% reduction in energy use





- meets or exceeds the 2015 IECC or equivalent (10)
- meets or exceeds the 2012 IECC or equivalent (10)
- meets or exceeds the 2009 IECC or equivalent (22)
- meets or exceeds the 2006 IECC or equivalent (2)
- no statewide code or precedes the 2006 IECC (12)



Code adoption as of March, 2017

Codes respecting the science

The 2015 IECC: A "Whole House" Approach to Efficiency



Codes will be more Performance Objectives

Climates	2015 IECC HERS Index Scores
Zone 1 — 2	52
Zone 3	51
Zone 4	54
Zone 5	55
Zone 6	54
Zone 7 — 8	53

Defining High Performance Homes.....

17



Tight Construction



Improved Insulation Systems



Improved Insulation Systems



Improved Durability



High Performance Windows

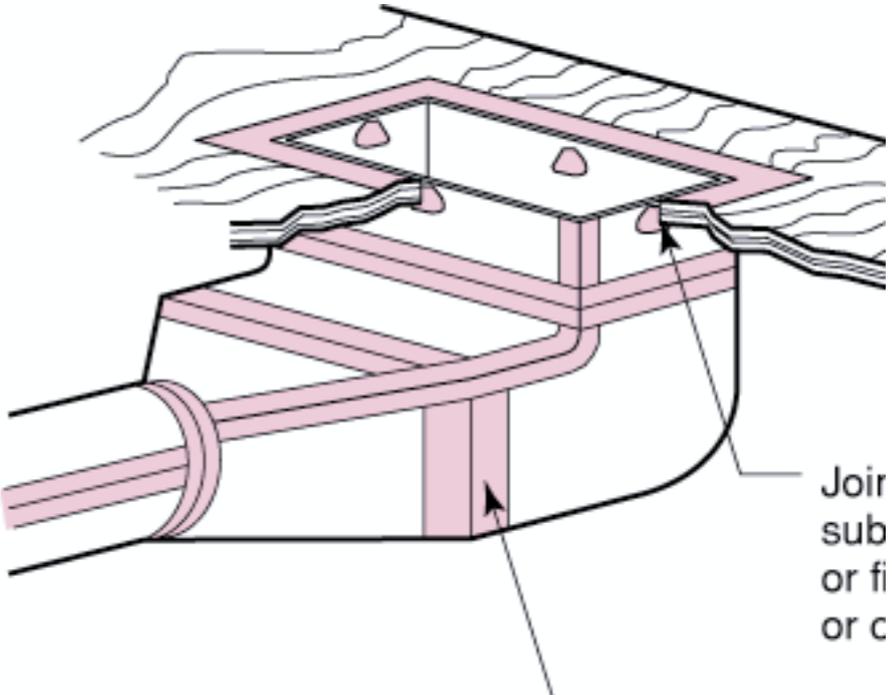
 <p>National Fenestration Rating Council CERTIFIED</p>	<p>WINDOWS • DOORS Andersen </p> <p>Picture Window Vinyl-Clad Wood Frame Dual-Pane Low-E Glazing with Argon</p> <p style="text-align: right;">RES97</p>
<p>ENERGY PERFORMANCE RATINGS</p>	
<p>U-Factor (U.S./I-P) 0.30</p>	<p>Solar Heat Gain Coefficient 0.36</p>
<p>ADDITIONAL PERFORMANCE RATINGS</p>	
<p>Visible Transmittance 0.59</p>	<p>—————</p>
<p>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. www.nfrc.org</p>	
 <p>ENERGY STAR</p>	<p>ENERGY STAR® Qualified in All 50 States</p> 
<p>Design Pressure (PSF) DP 50</p>	<p>WDMA WINDOW AND DOOR MANUFACTURERS ASSOCIATION CERTIFIED</p> <p>F-C50 60" x 72" Tested to ANSI/AAMA/NWDA 101/I.S.2-97 or NAFS-1</p>



Efficient Heating and Cooling Equipment



Effective Distribution



Efficient Water Heating



Ventilation & IAQ Systems



Lighting-Energy Efficiency Compact fluorescent Bulbs

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Appliances



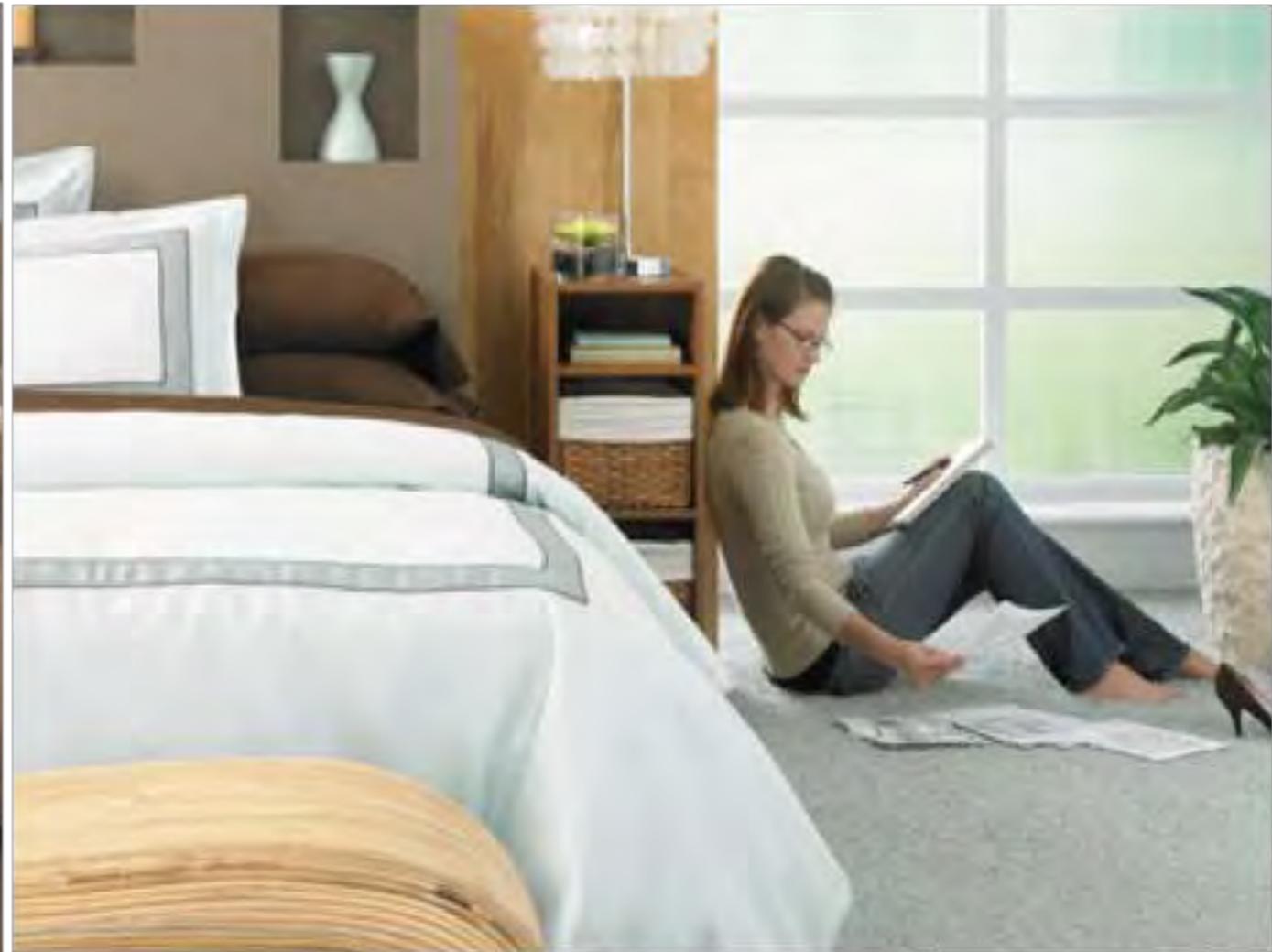
Water Efficiency



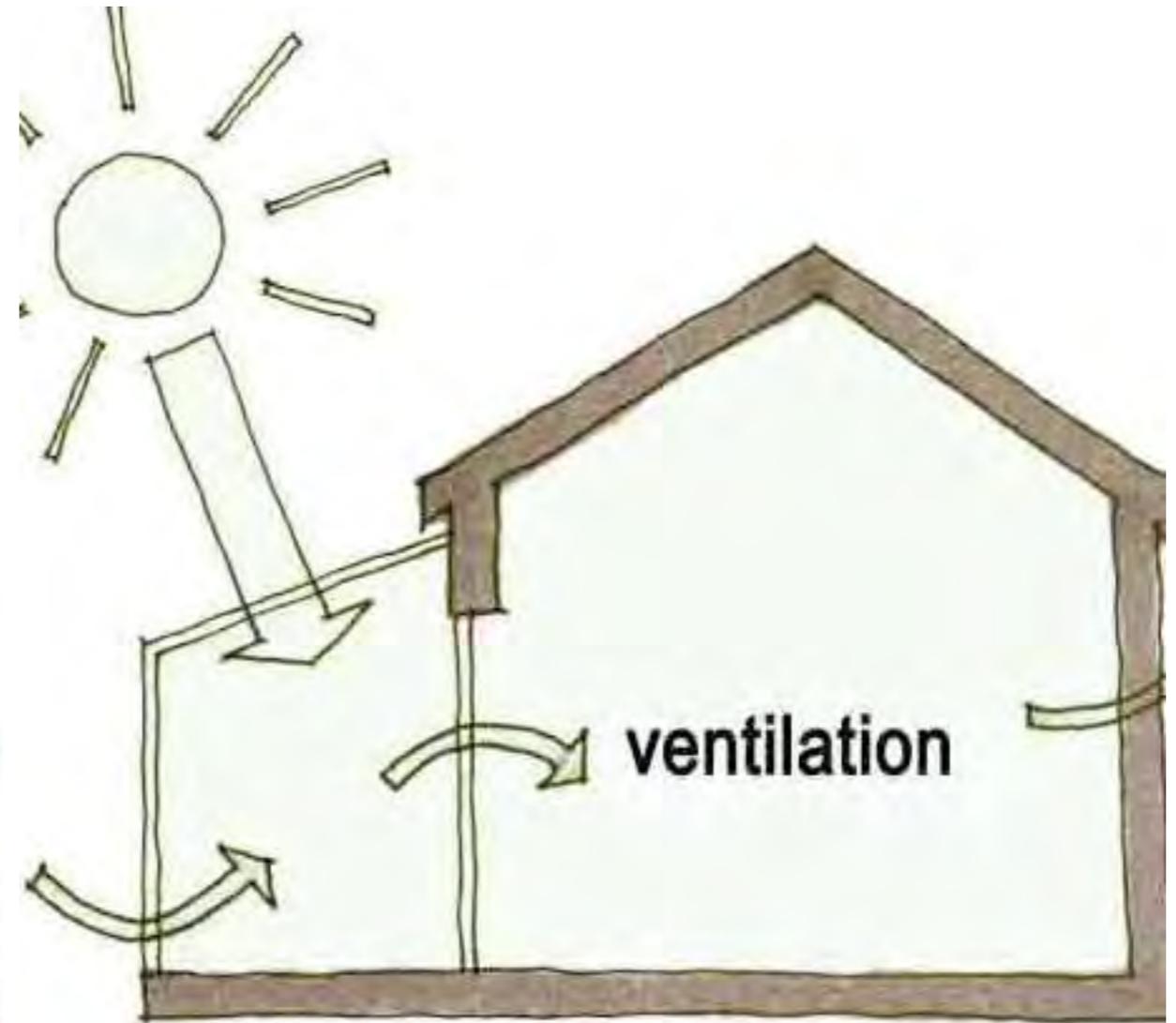
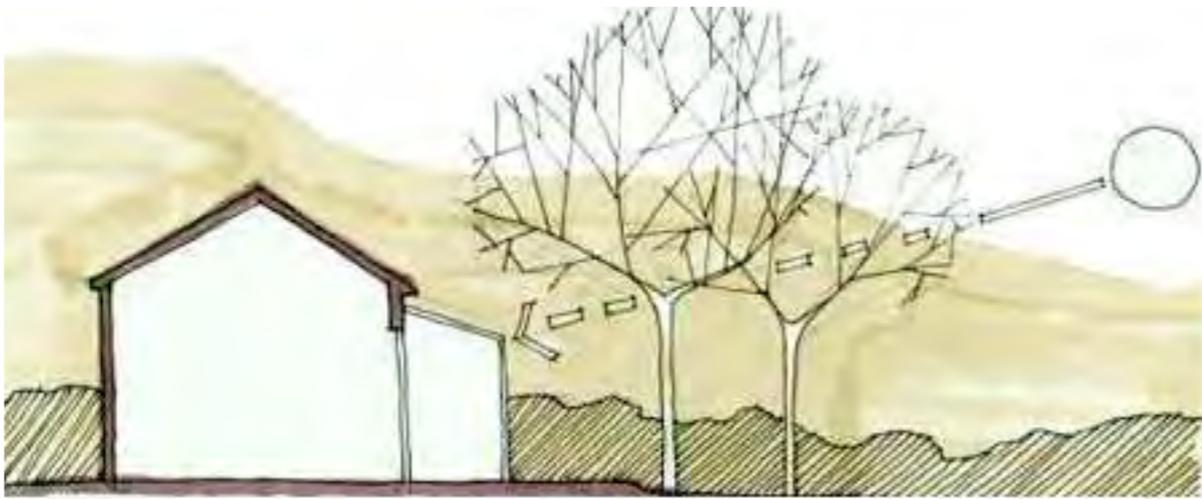
Smart Technology



Sustainable Materials



Site planning



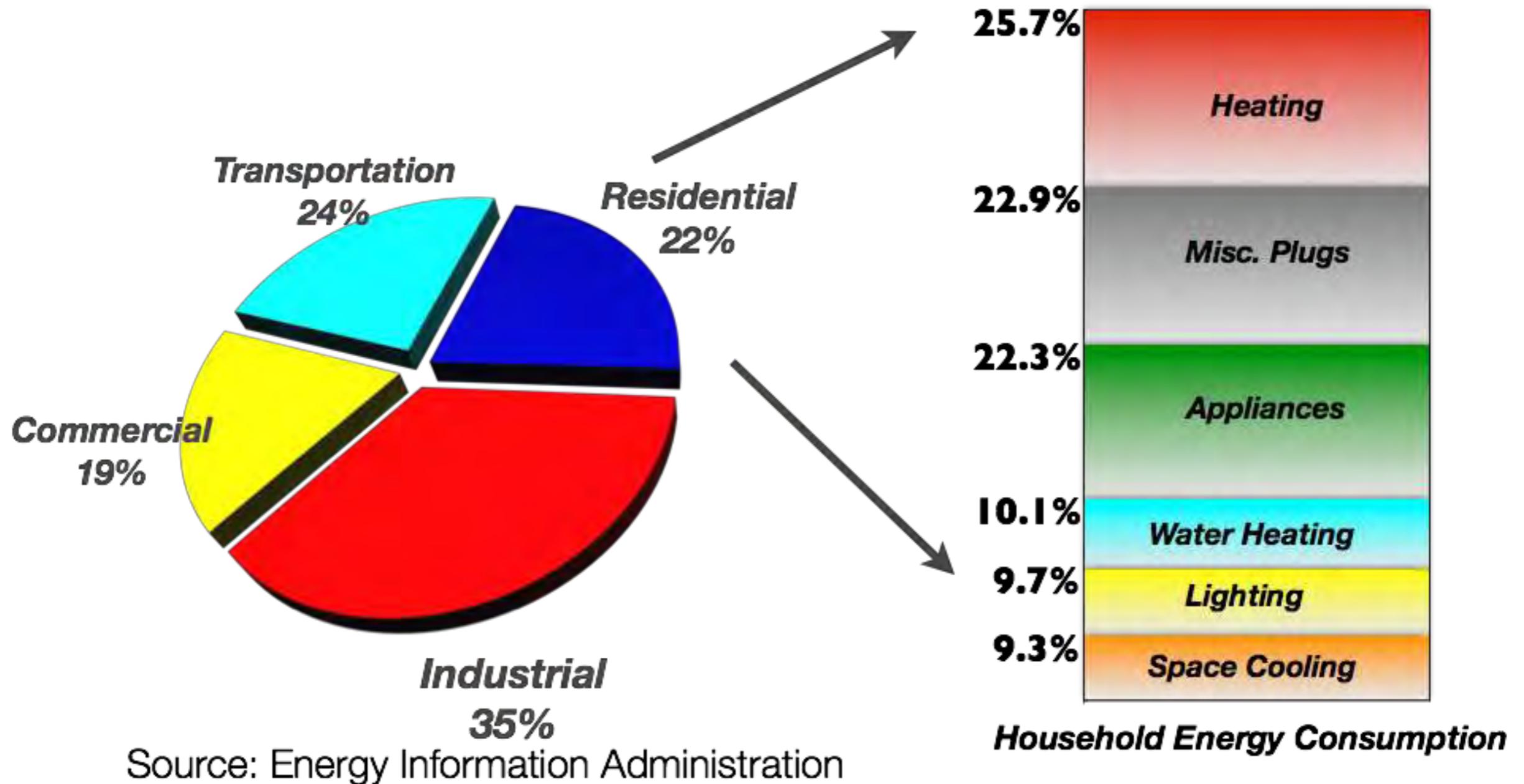
Renewable Energy Systems

33

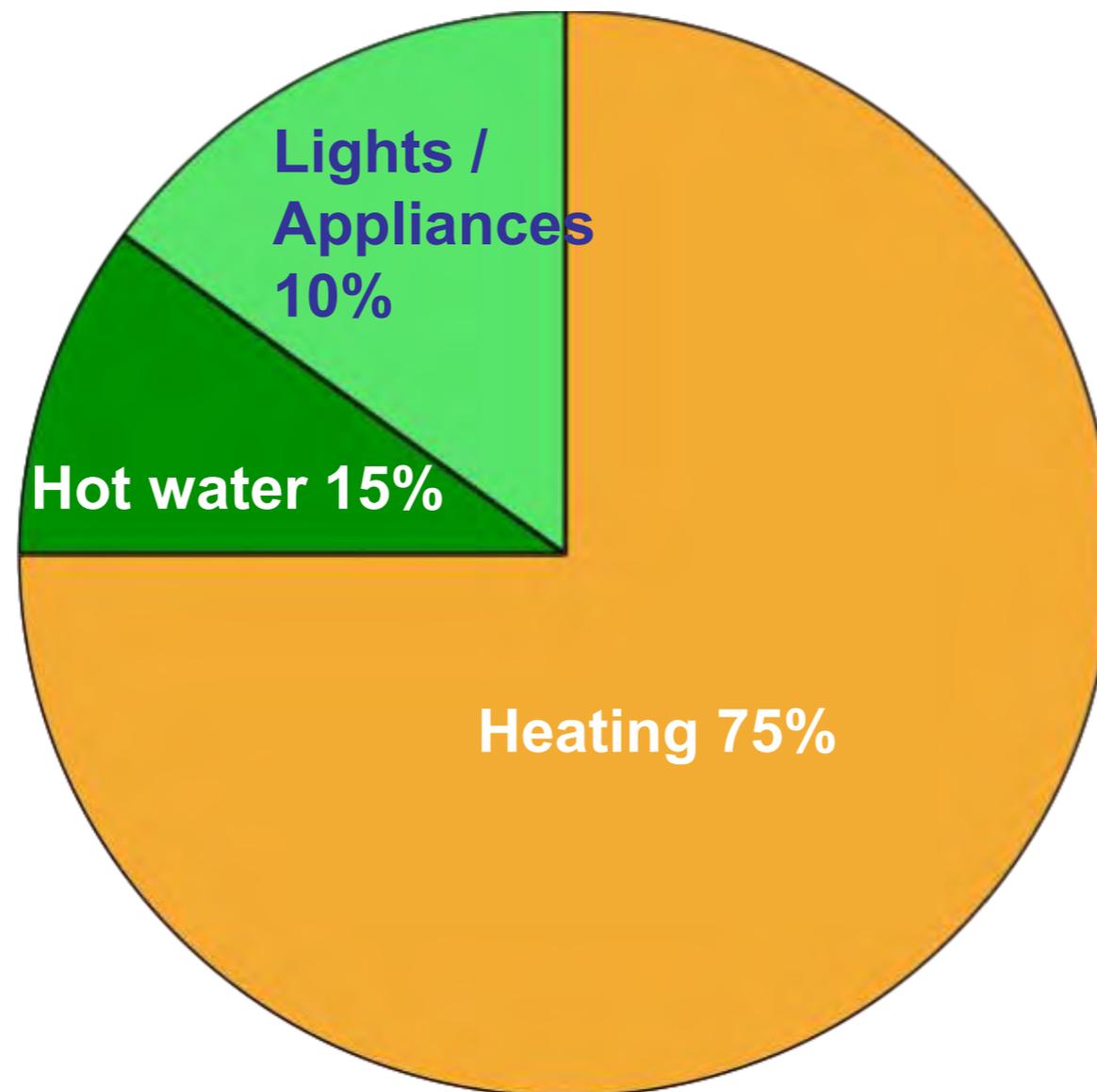




Total U.S. and Household Energy Use

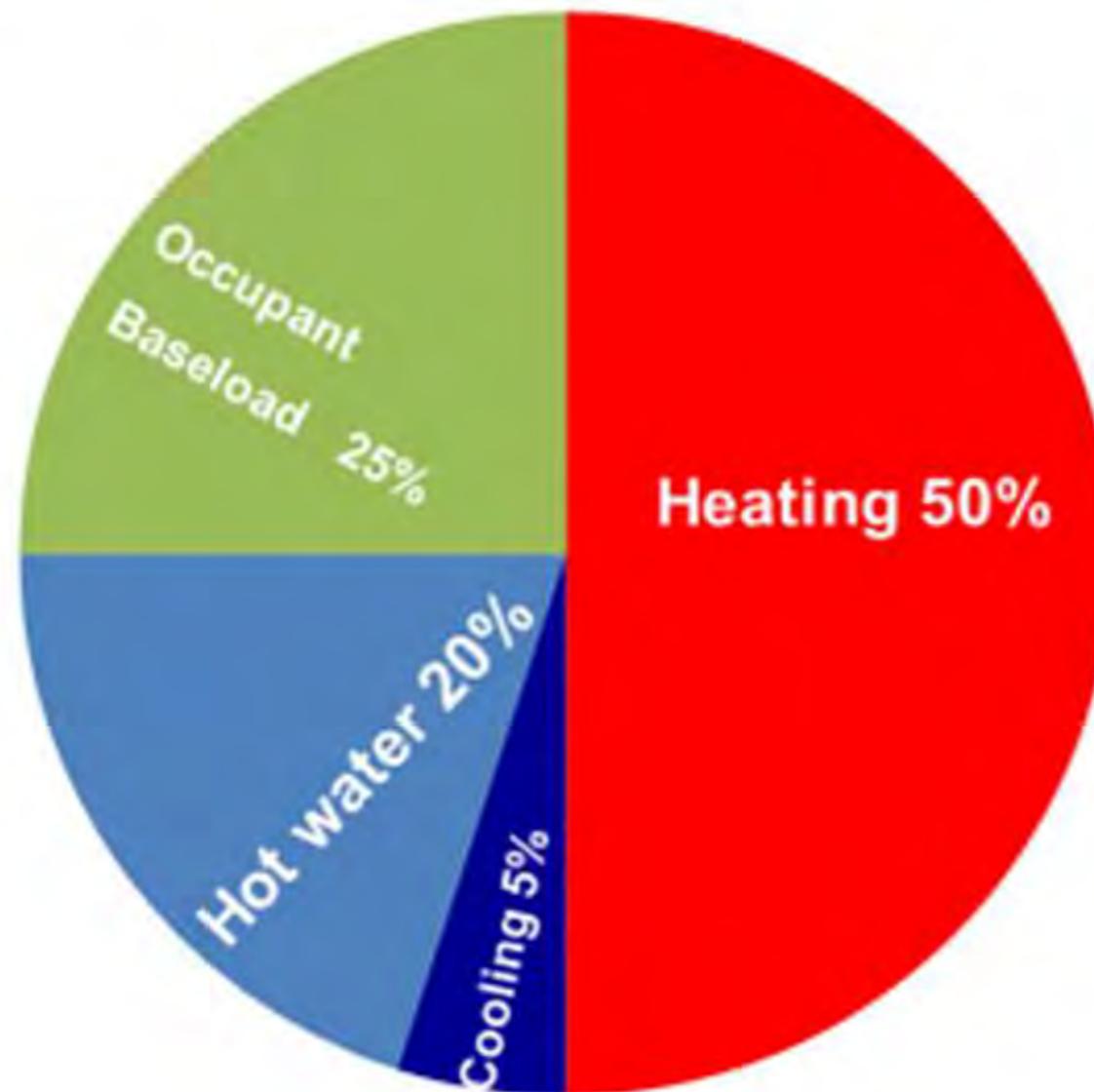


30 years ago....

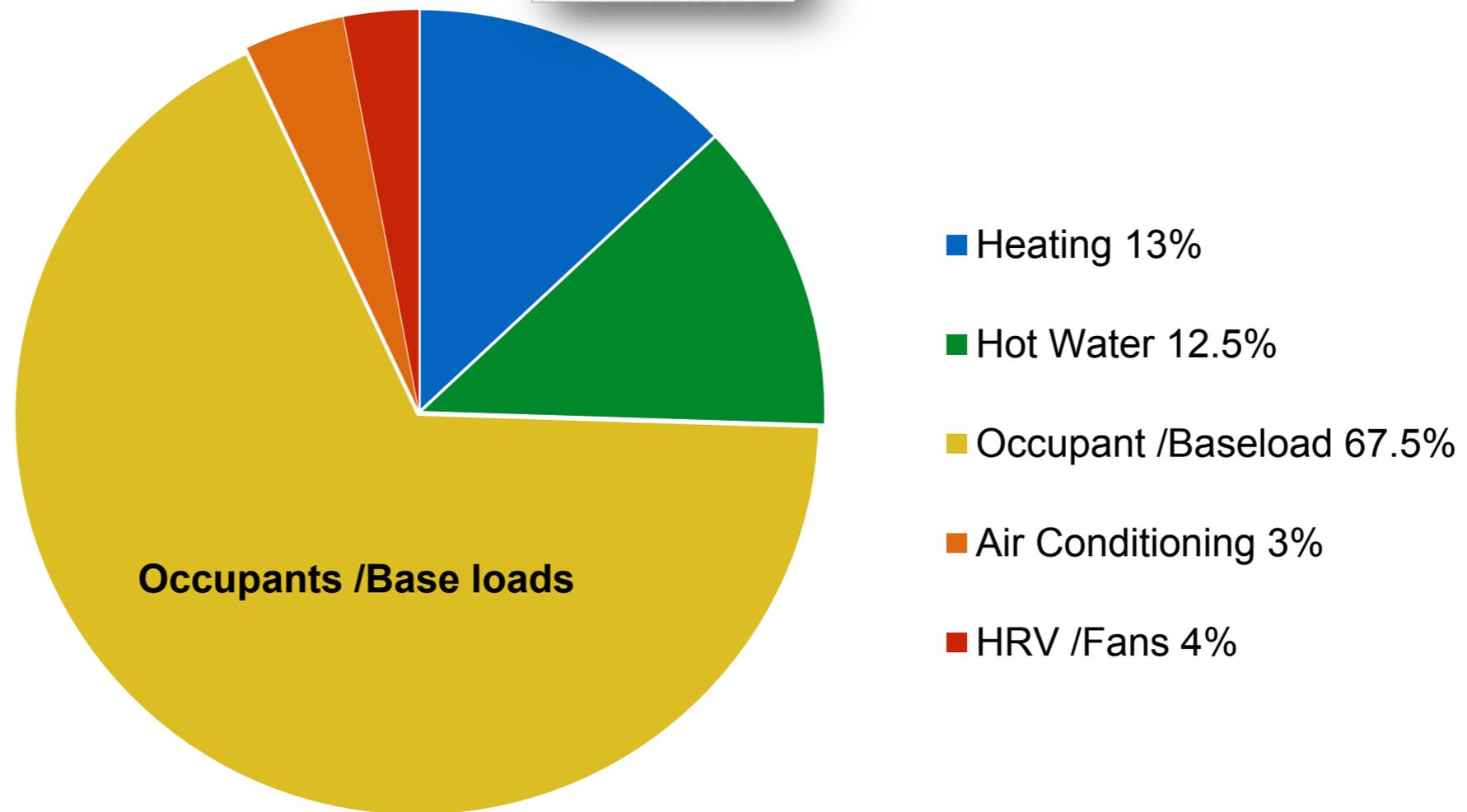


IECC 2015....

SMALLER TOTAL CIRCLE
LOAD PROFILE HAS CHANGED

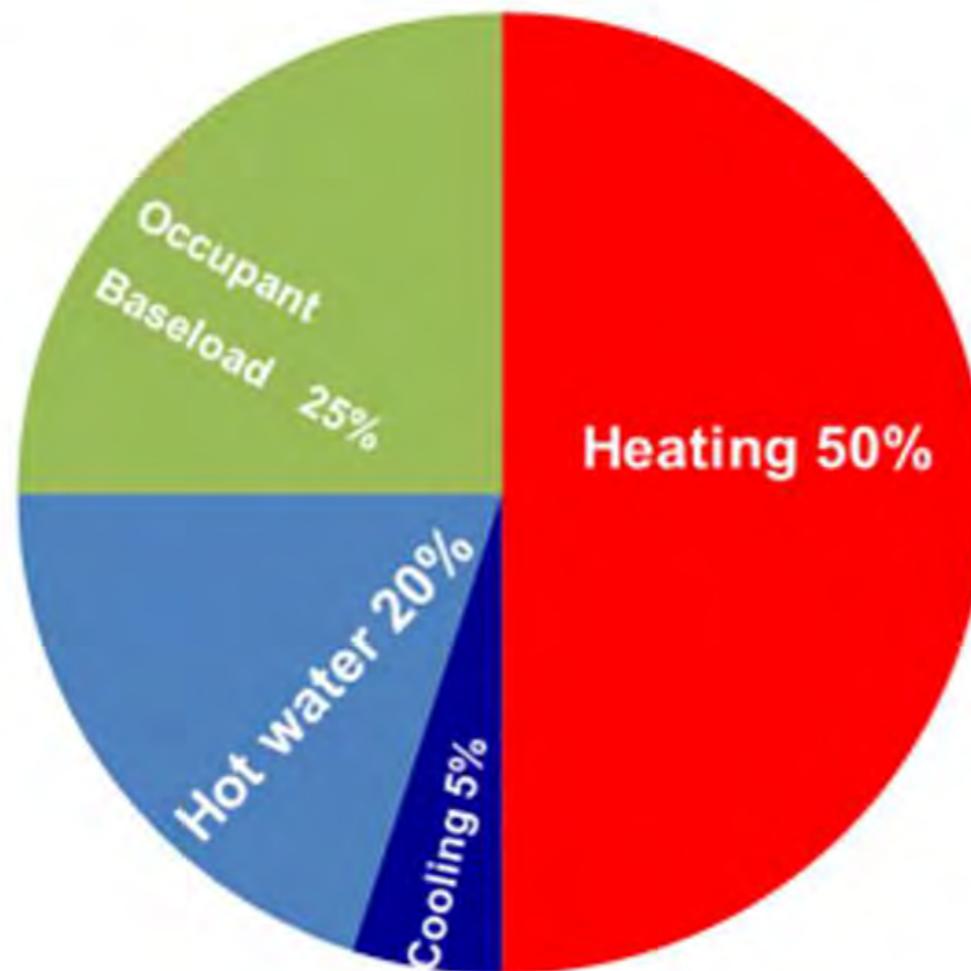


NET ZERO / ZERH....



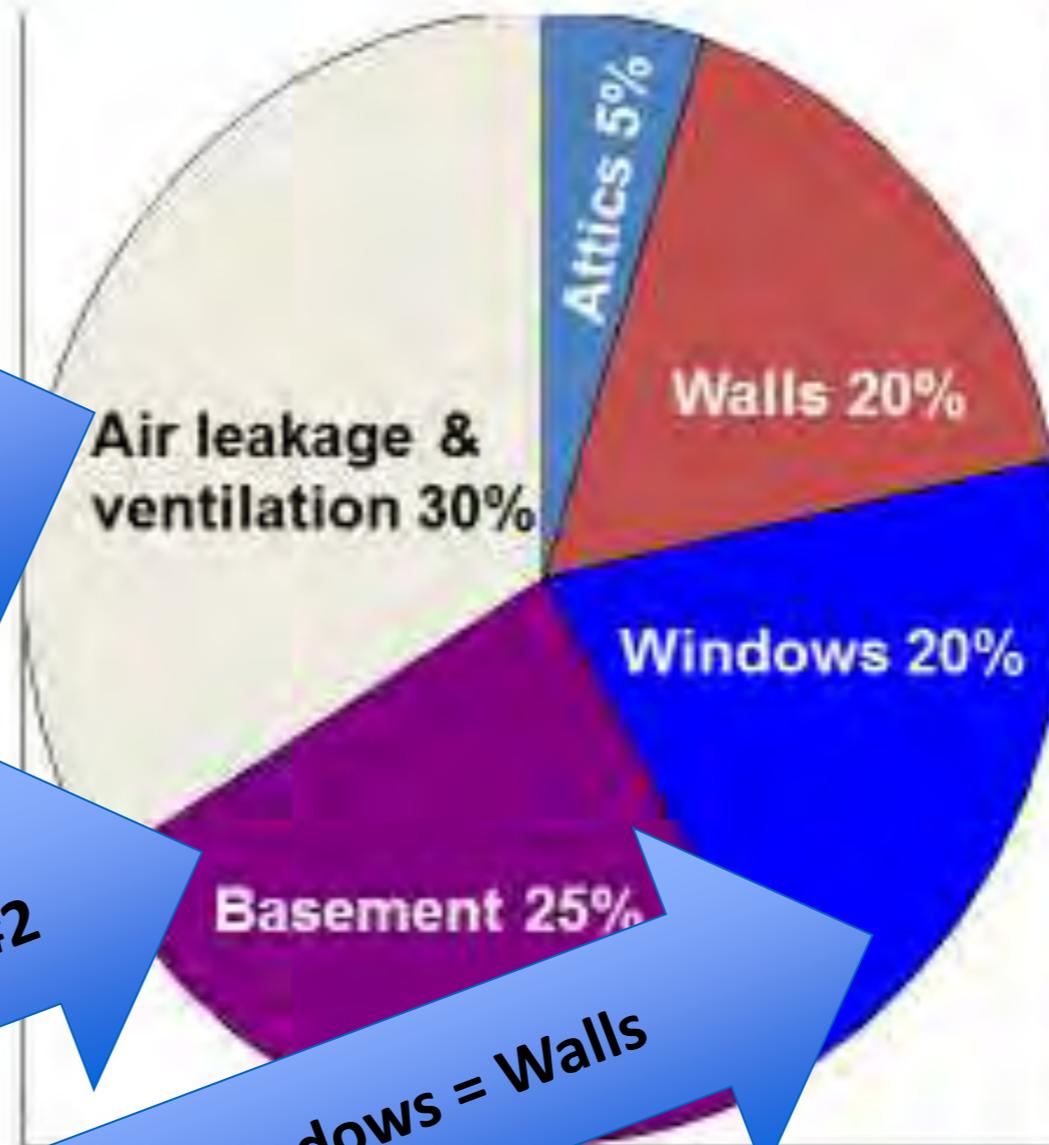
WHERE DO WE START?....

START WITH THE LARGEST
ENERGY CONSUMPTION
ACTIVITY (BTU & KWH, NOT \$...)



...THE LARGEST CONTRIBUTORS TO THE ALMIGHTY SPACE HEATING LOAD

Anatomy of Heat Loss



LARGEST HEAT LOSS
Air Leakage & Ventilation

Below grade heat loss #2

#3 Windows = Walls

A Complicated Business

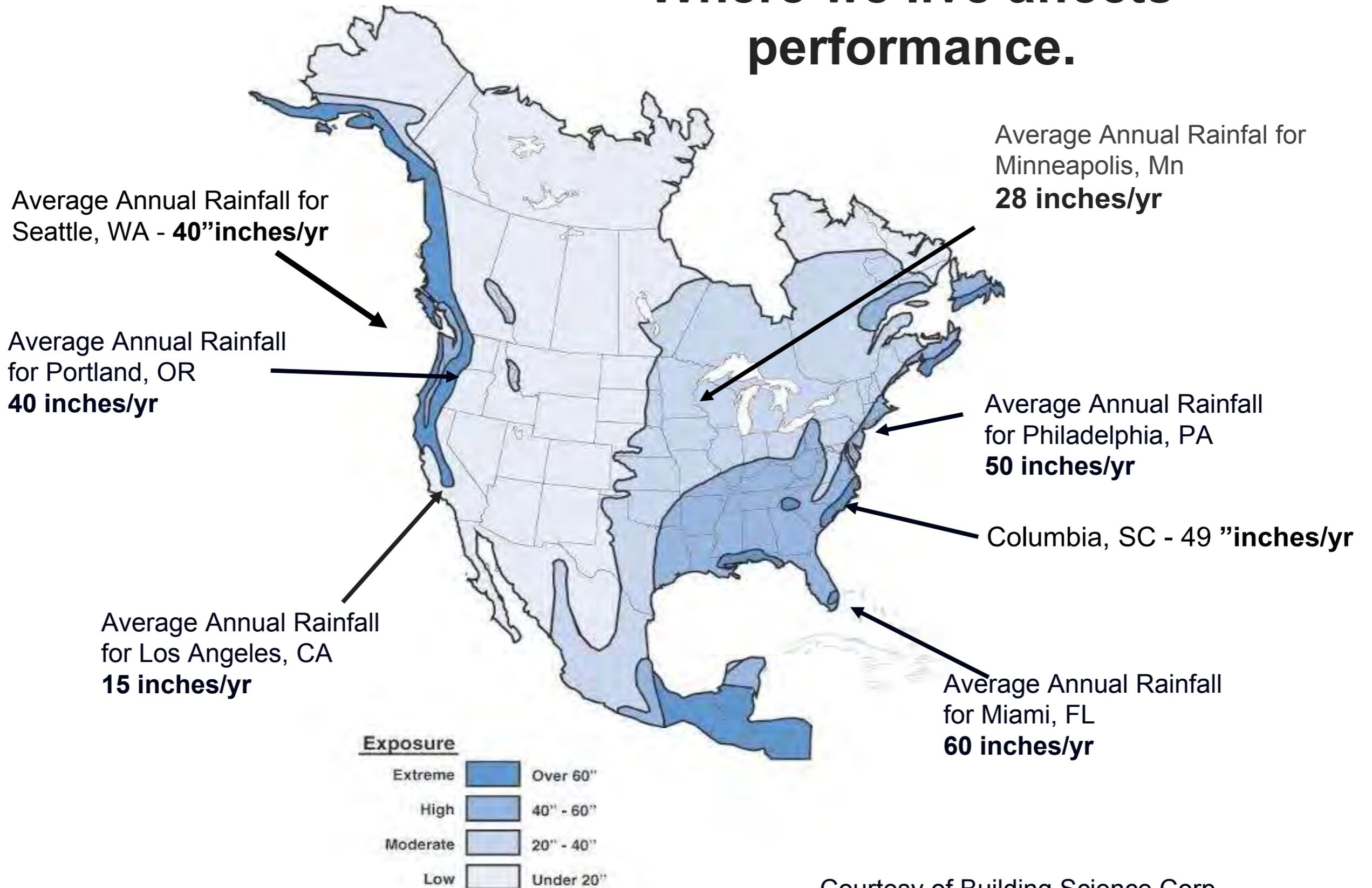
41

- Extensive collection of materials
- Uncontrolled building conditions
- Communication challenges
- Workforce training
- Changing codes
- Elevated consumer expectations



discussing a high performance heating system installation in field

Where we live affects performance.



Courtesy of Building Science Corp.

Minneapolis, MN

- design conditions

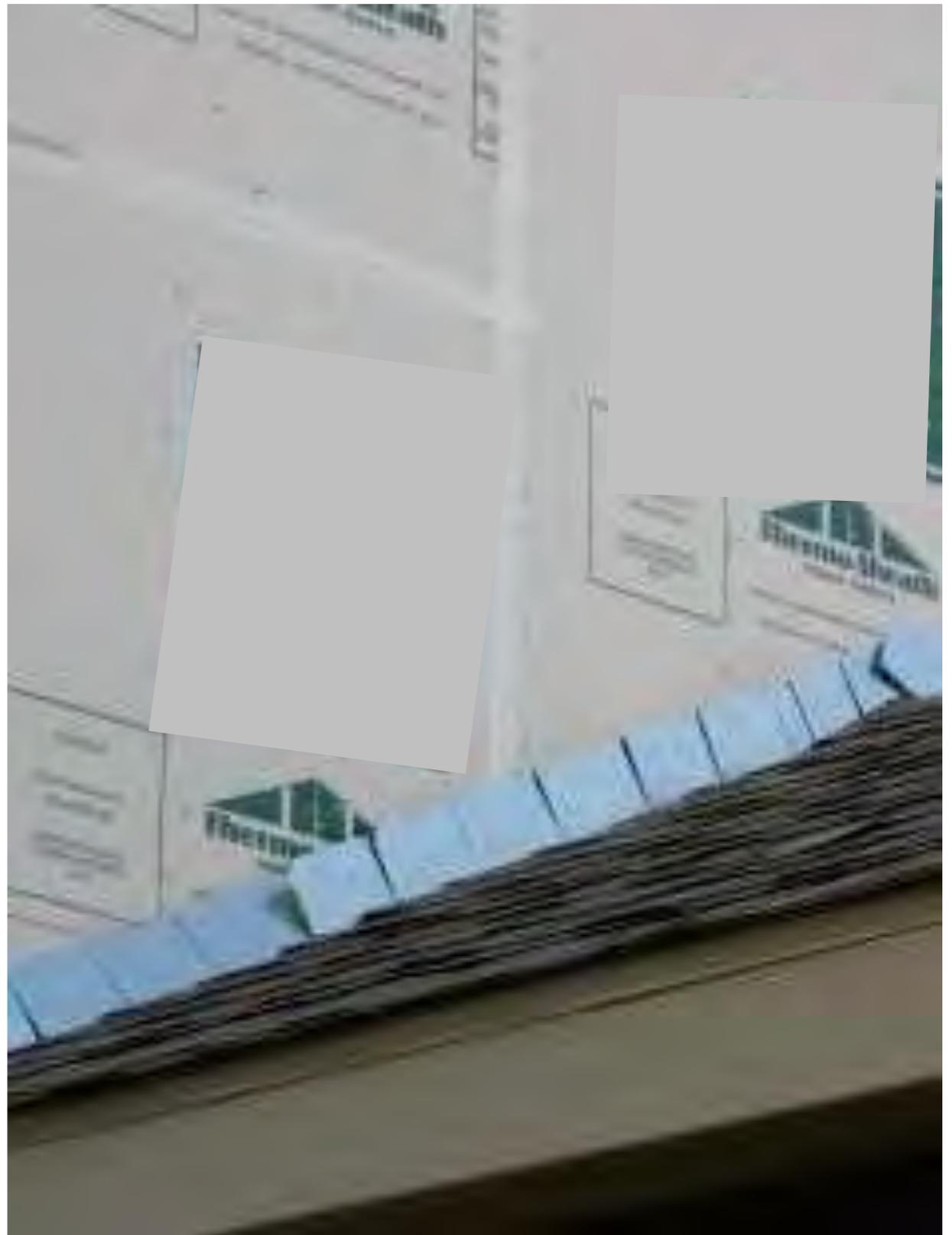
43

Condition	ASHRAE 99% / 1%
Winter, design dry bulb (F)	-8°F
Summer, design dry bulb (F)	87.9°F
Summer, design wet bulb (F)	72.3°F
Degree days-heating	7565
Degree days-cooling	751
Precipitation	28

Our investment in the structure is significant



We often under invest in managing moisture. 80% of building failures=water related...yet less than 1% of total construction cost spent on managing water -flashings





The resulting damage can be extensive



What defines durability?

48

1. Design
2. Material selection
3. Installation detail
4. Maintenance

Will they be affected by:

- ▶ Water
- ▶ Heat
- ▶ Radiation
- ▶ Insects









The Building Industry is Changing

52

“You must learn from the mistakes of others. You can’t possibly live long enough to make them all yourself.”

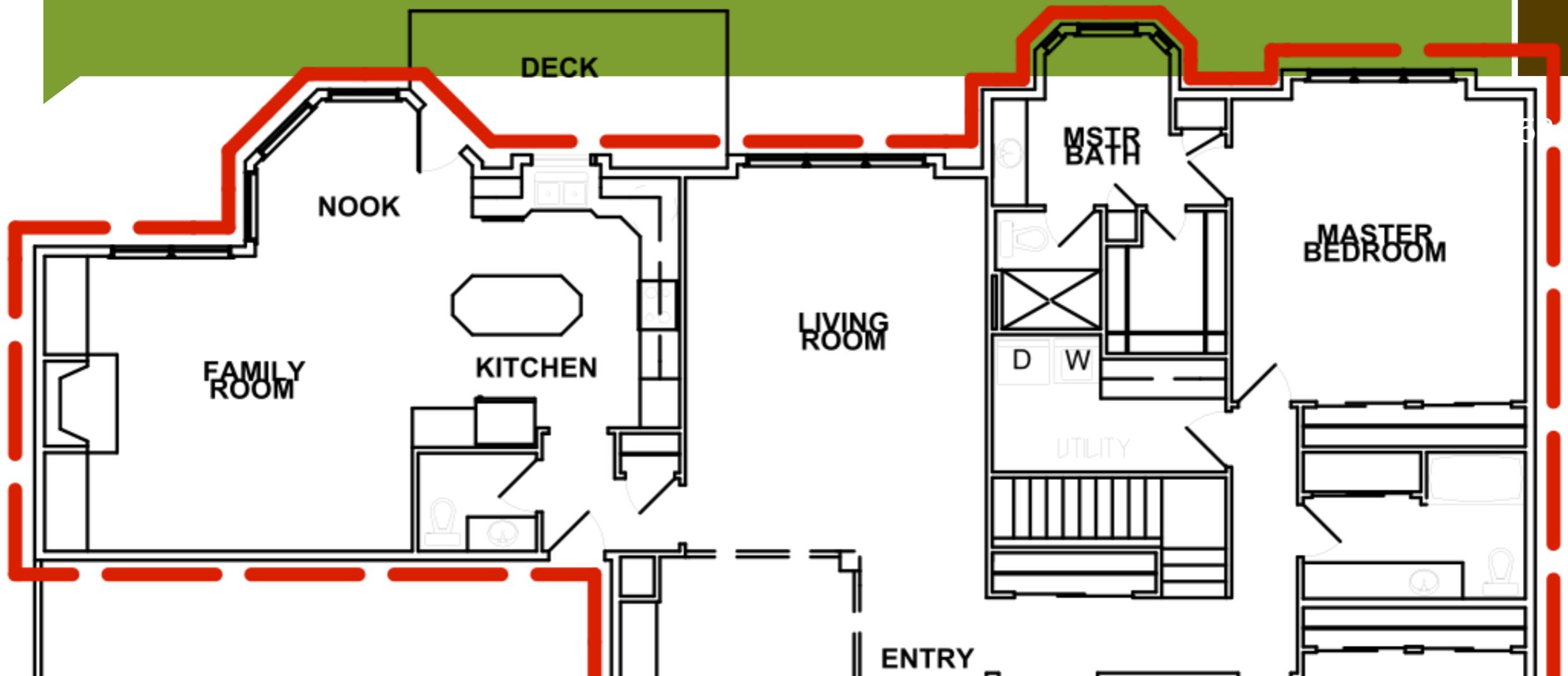


Humorist Sam Levenson, 1911-1980.

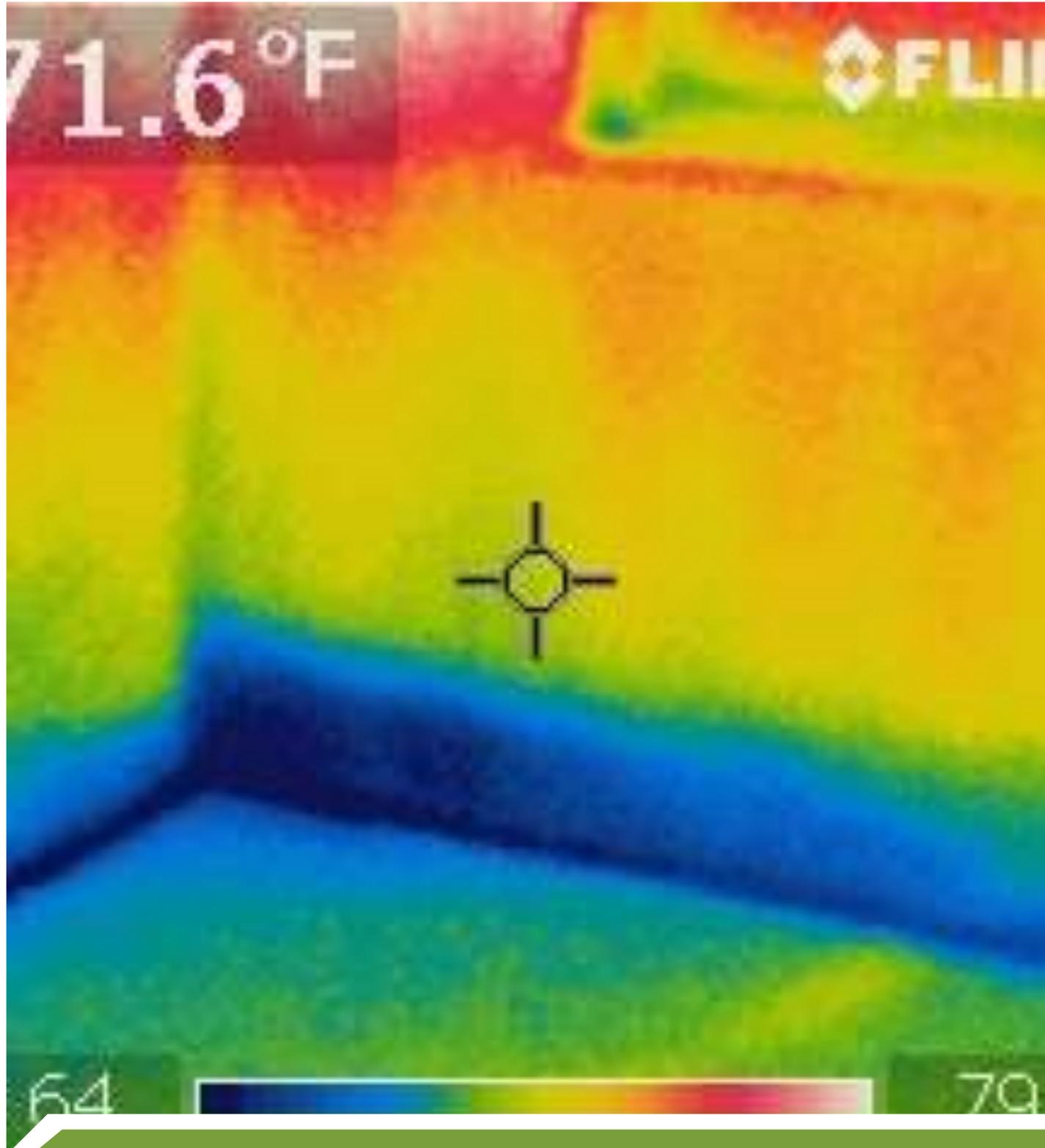
Sam Levenson

The Building Enclosure

- Developing a strategic approach



What rules must be followed?



Heat

Air

Moisture

The Physics of Buildings

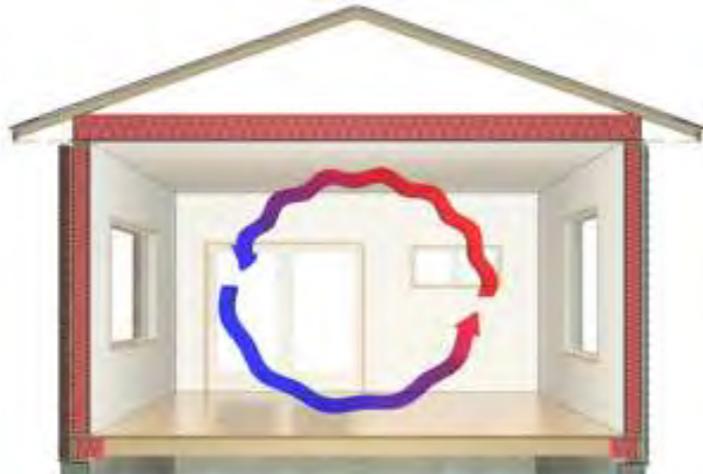
56

- Moisture moves from more to less
- Moisture moves from warm to cold
- Heat flows from warm to cold
- CFM (air) out equals CFM (air) in
- Heat, air & moisture are one
- Drain the rain
- Things always get wet - let them dry
- All the action happens at the surface

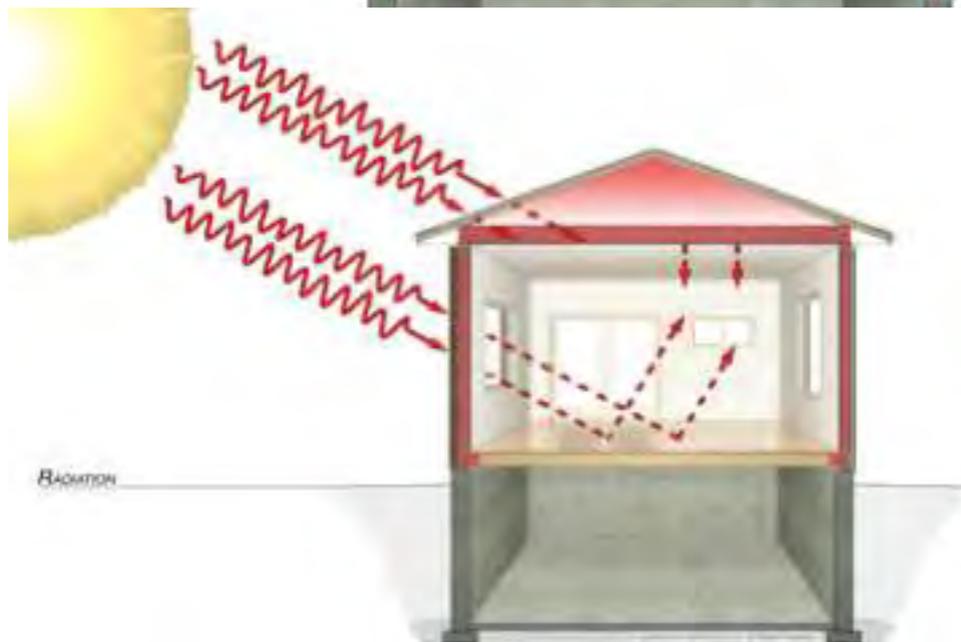
Methods of Heat Transfer



▶ Conduction



▶ Convection



▶ Radiation

Conduction Heat Loss/Gain

$$\text{Heat flow} = \frac{\text{Exposed Area} \times \text{Temp. Difference}}{\text{R-Value}}$$

Example: With R-30 insulation in the attic

Heat Loss through 1000 sq. ft of ceiling, 70 F inside, -10 F outside

$$= 1000 \times (70 - (-10)) / 40 = 2,000 \text{ BTUs/hr}$$

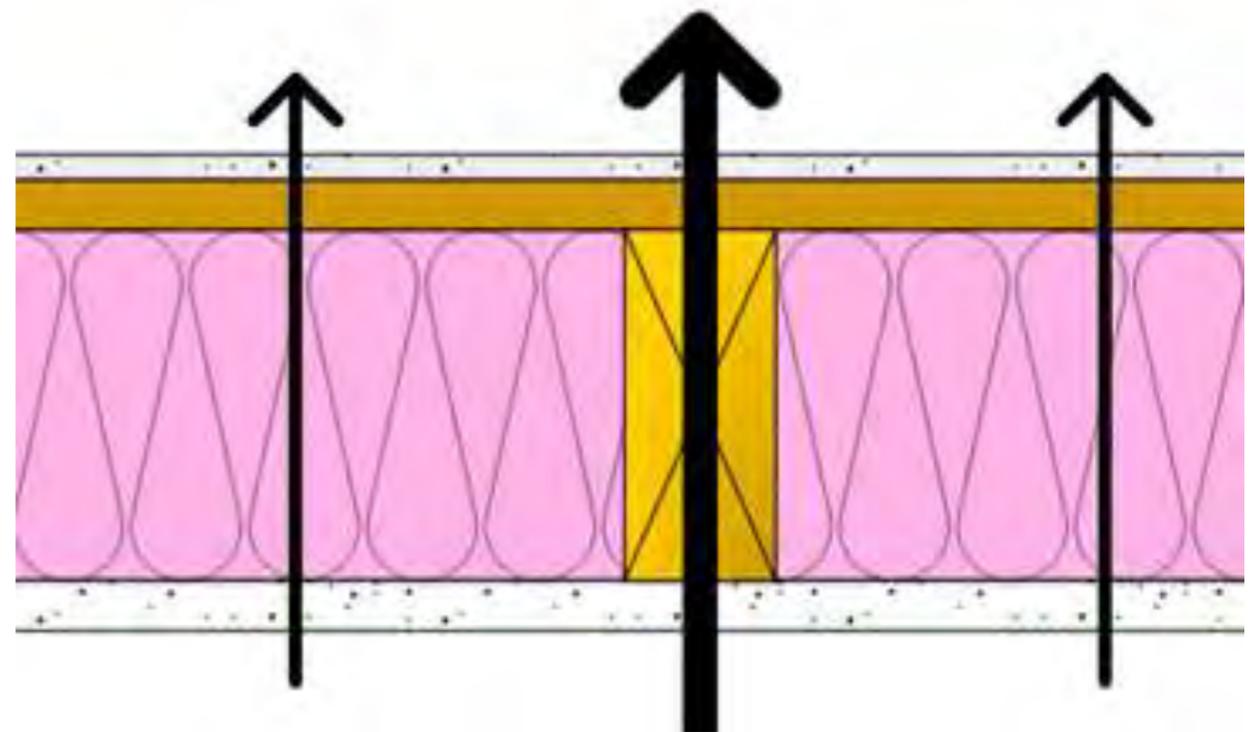
Thermal Bridging- Problem

60

Heat flows more easily through wood studs = Conduction

2" x 6" stud = R-6

Insulation cavity = R-19+

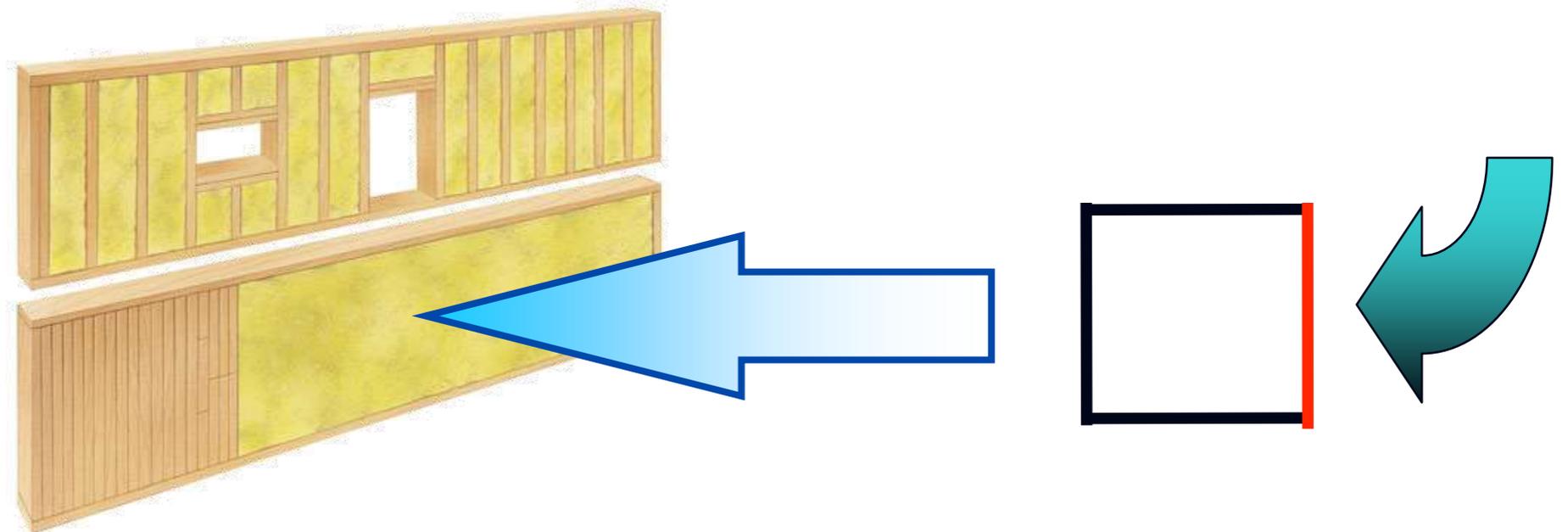


What about...double, triple studs, rim joists, headers and partition wall intersections?

Thermal Bridging - Stud Loss

- Without insulated sheathing, a quarter of your walls are not insulated!
- On a square house, it's the equivalent of one whole wall!

25% of the surface Area is wood!



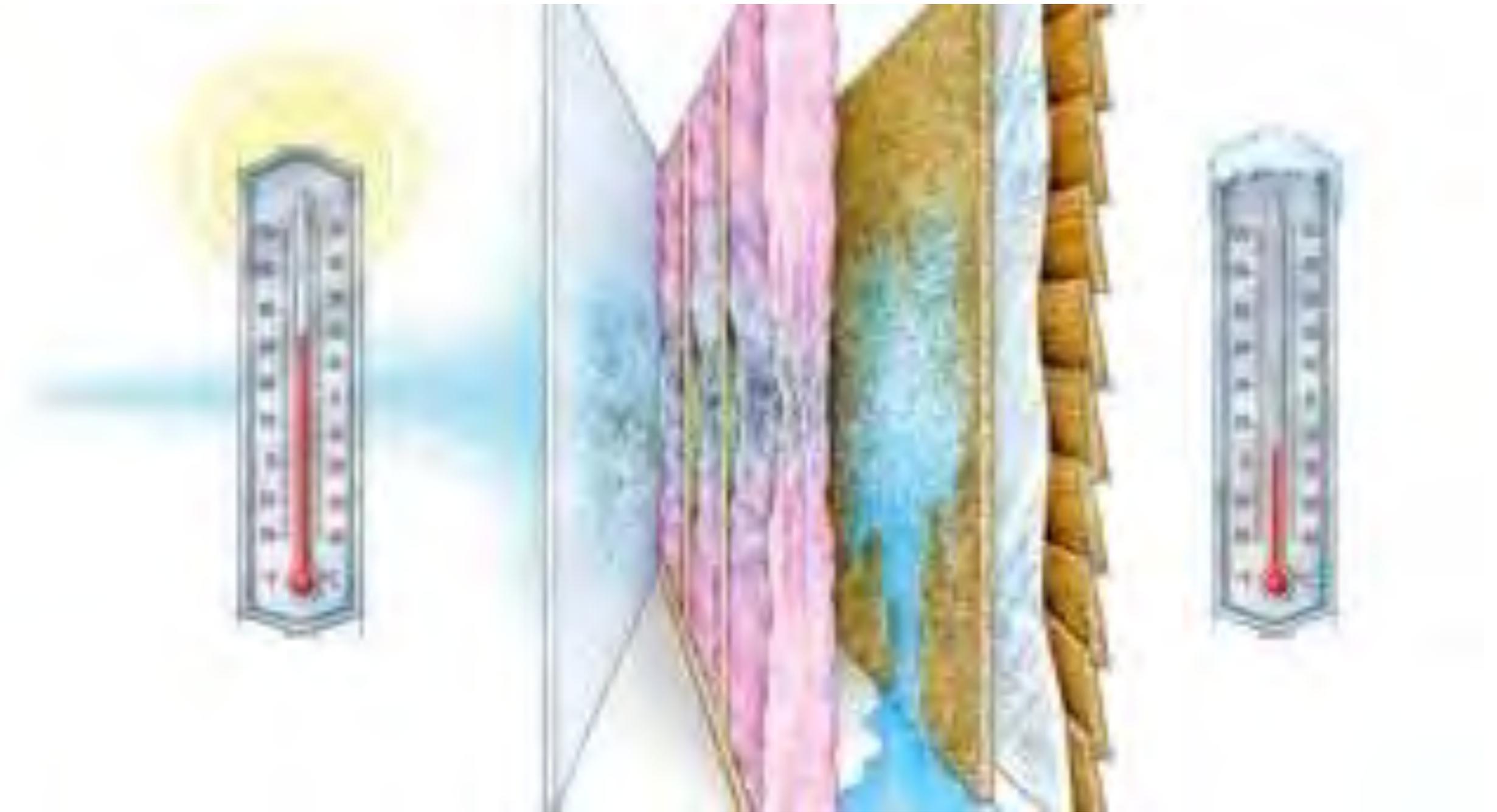
Effective R-value of 2 x 6 wall- no windows or doors

23% framing-no windows	R-Value	
	Cavity	Studs
Outside air film	0.17	0.17
1/2" OSB	0.62	0.62
2 x 6 stud-wood	n/a	5.83
cavity insulation*	21	n/a
1/2" gypsum	0.45	0.45
Interior air film	0.68	0.68
Totals	22.92	7.75
Total wall	15.26	

* denotes "perfect" insulation installation

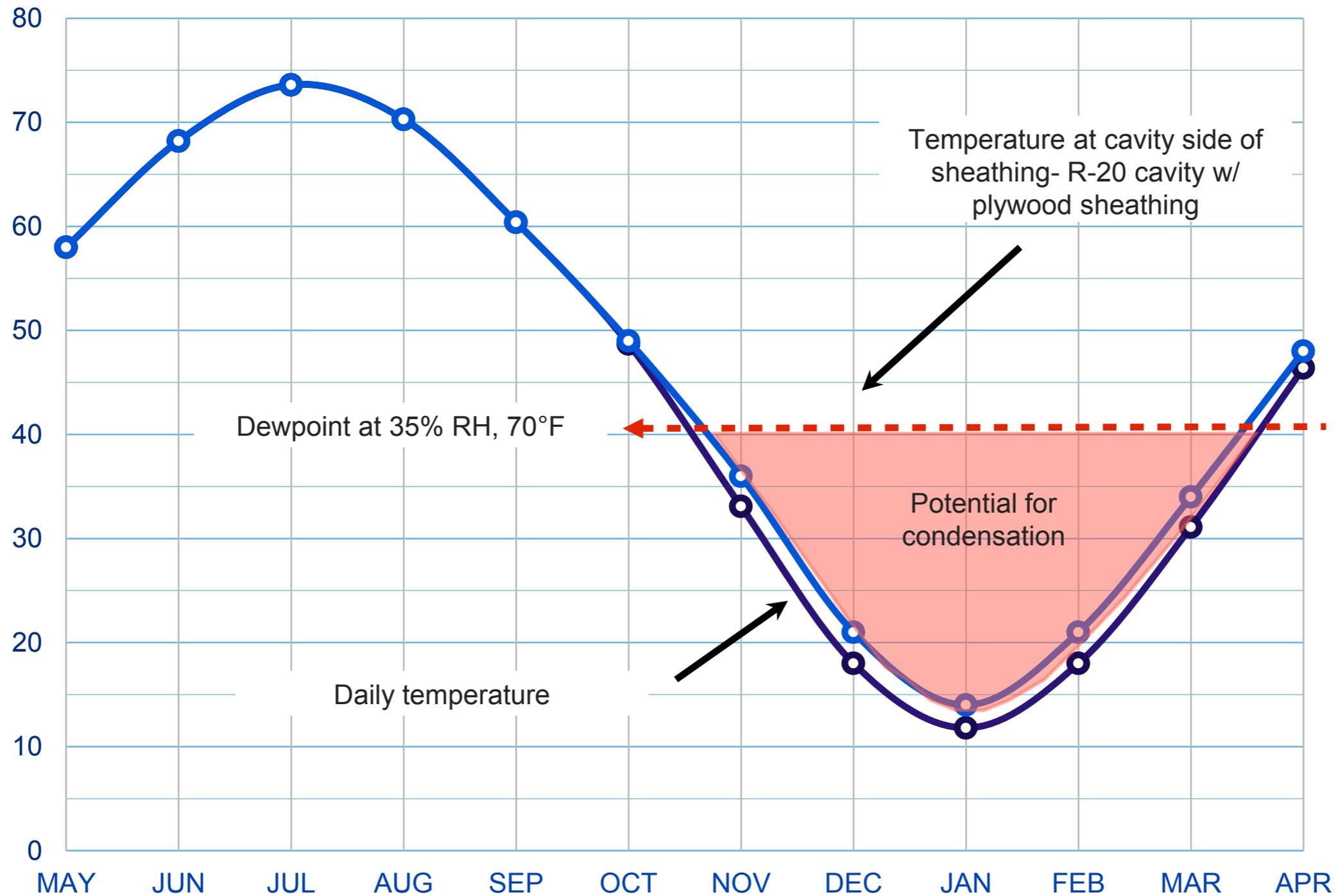
Exterior Insulated sheathing will be normal



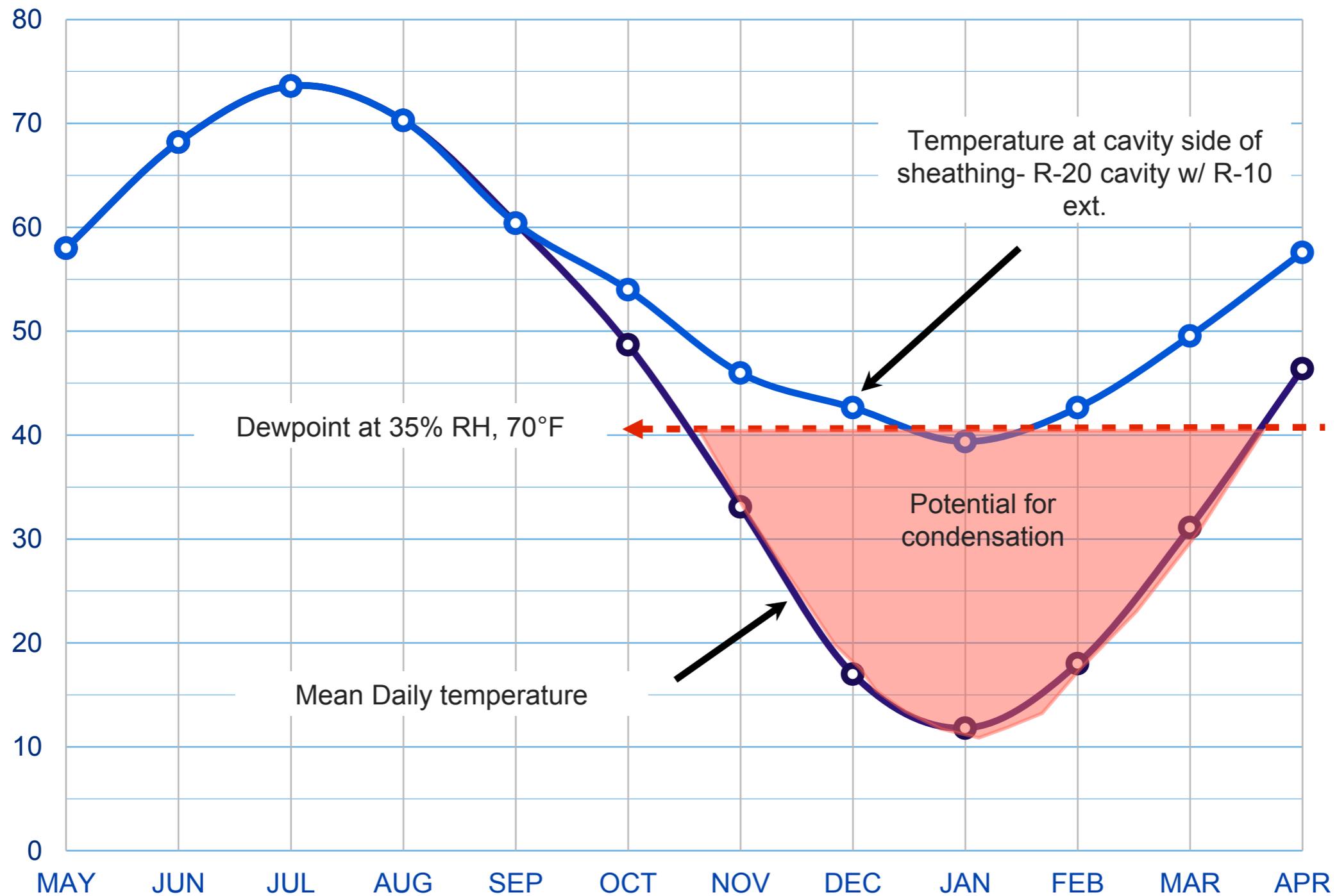


The dew point discussion

2 x 6 wall R21 w/ plywood sheathing



2 x 6 wall w/ R-10 sheathing



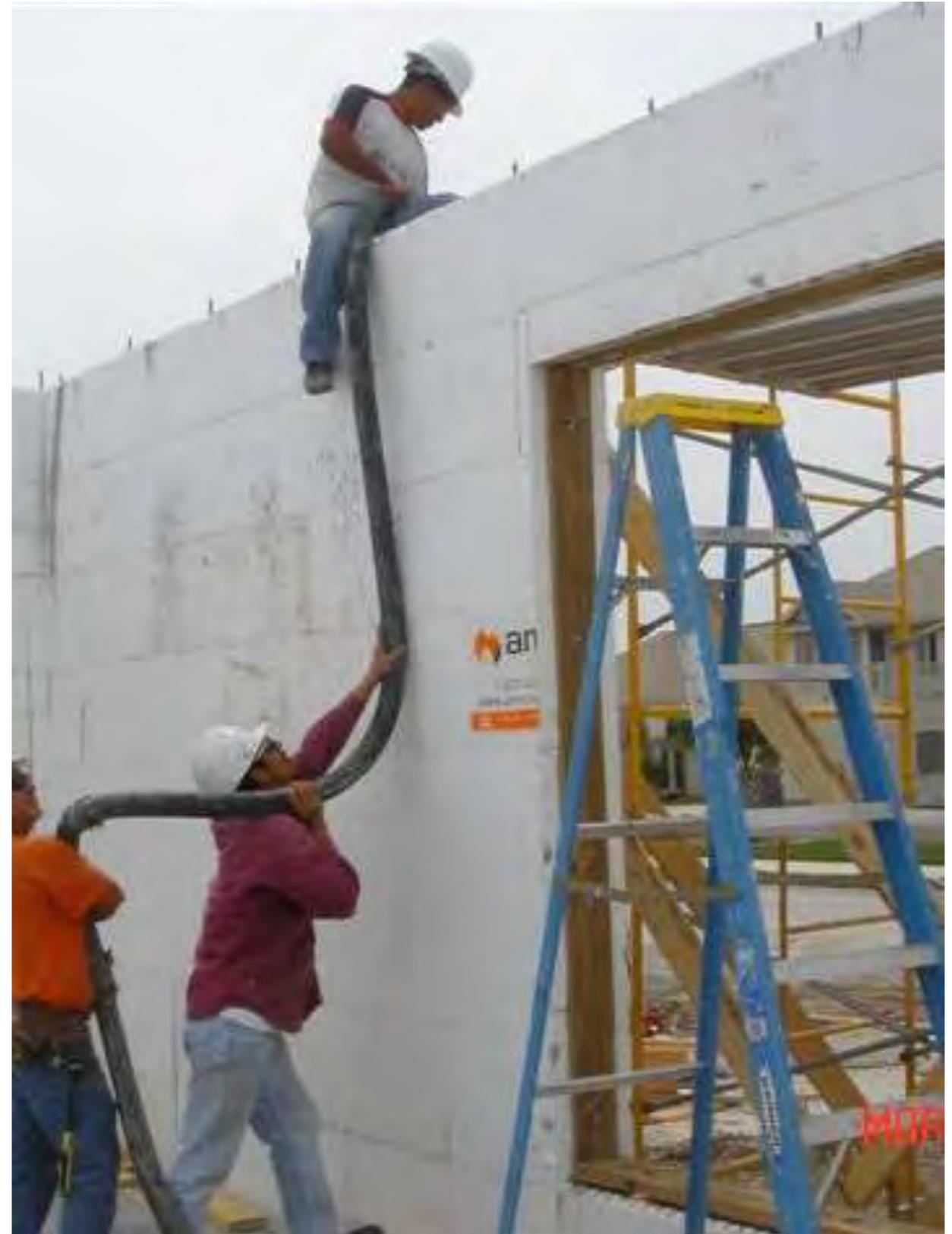




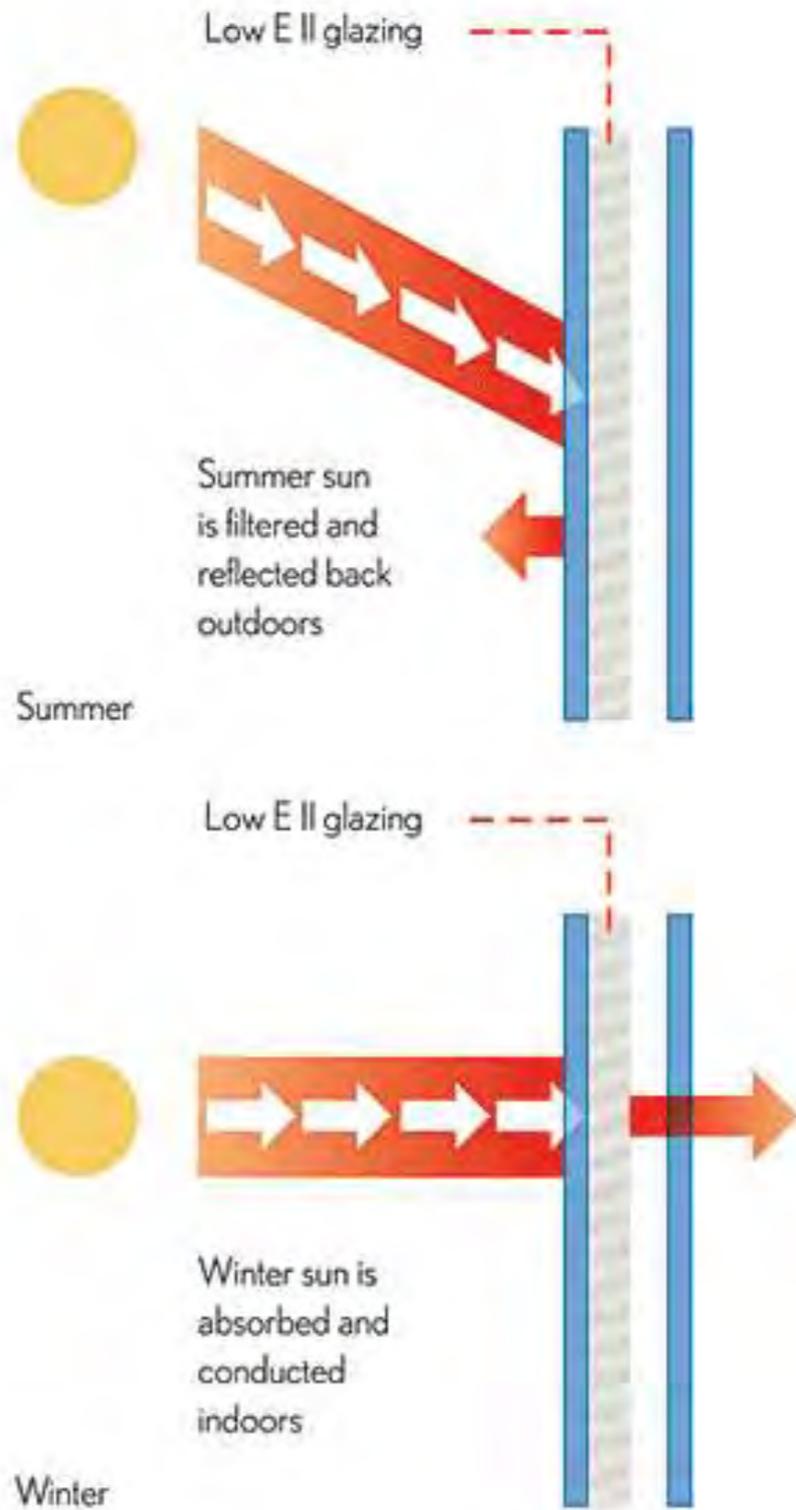
Insulated Concrete Forms

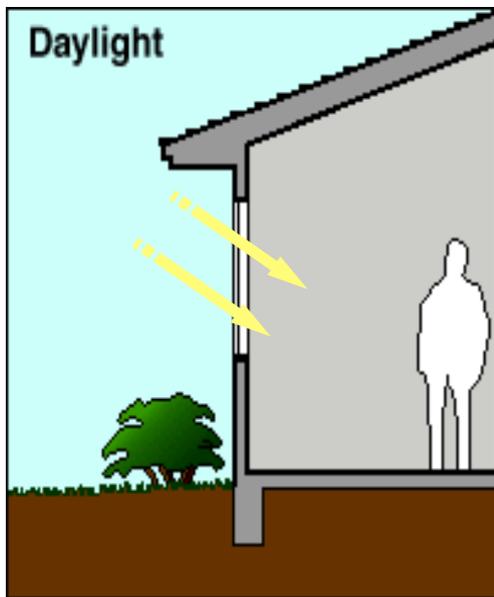
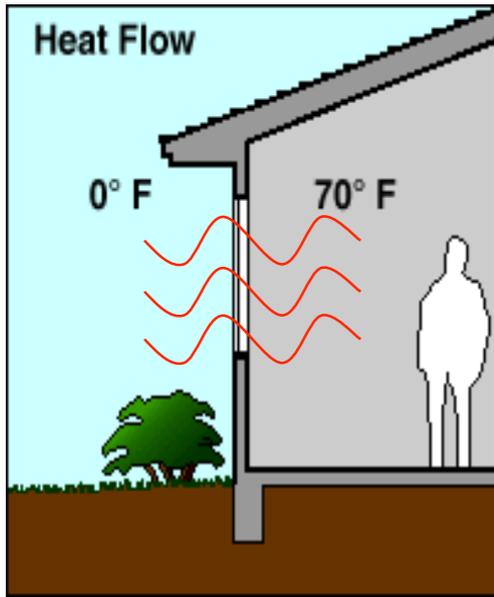
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Increasing use as whole house solution for walls of thermal enclosure from foundation to roof

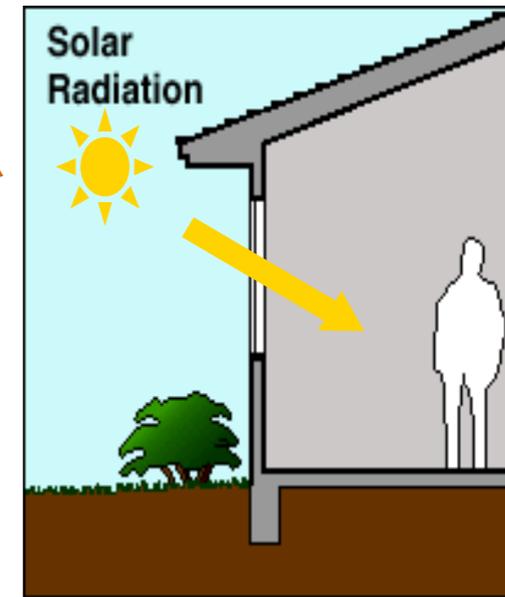


Managing radiant heat flow





 National Fenestration Rating Council CERTIFIED	
ENERGY PERFORMANCE RATINGS	
U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.30	0.36
ADDITIONAL PERFORMANCE RATINGS	
Visible Transmittance	—
0.59	
<small>Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. www.nfrc.org</small>	
 ENERGY STAR	ENERGY STAR® Qualified in All 50 States 
Design Pressure (PSF) DP 30	 HALLMARK WINDOW AND DOOR MANUFACTURERS ASSOCIATION CERTIFIED F-50 60" x 72" <small>Tested to ANSI/AAMA/NWDA 101/1.5.2-97 or NAFS-1</small> <small>Meets or exceeds M.E.C., C.E.C., & I.E.C.C. Air Infiltration Requirements WDMA Hallmark Certification Program</small> <small>Rev. 1/04 Pac. # 419082</small>



Air Flow...

75

- Understanding pathways & pressures

Reasons we want houses to be tight

76

- Most cost effective energy saving measure - 20% - 30% savings
- Makes homes quieter and cleaner
- Makes homes more “comfortable”
- Reduces water entry - homes last longer
- Makes homes healthier - controlled air quality
- Environmental benefits because we are not wasting energy

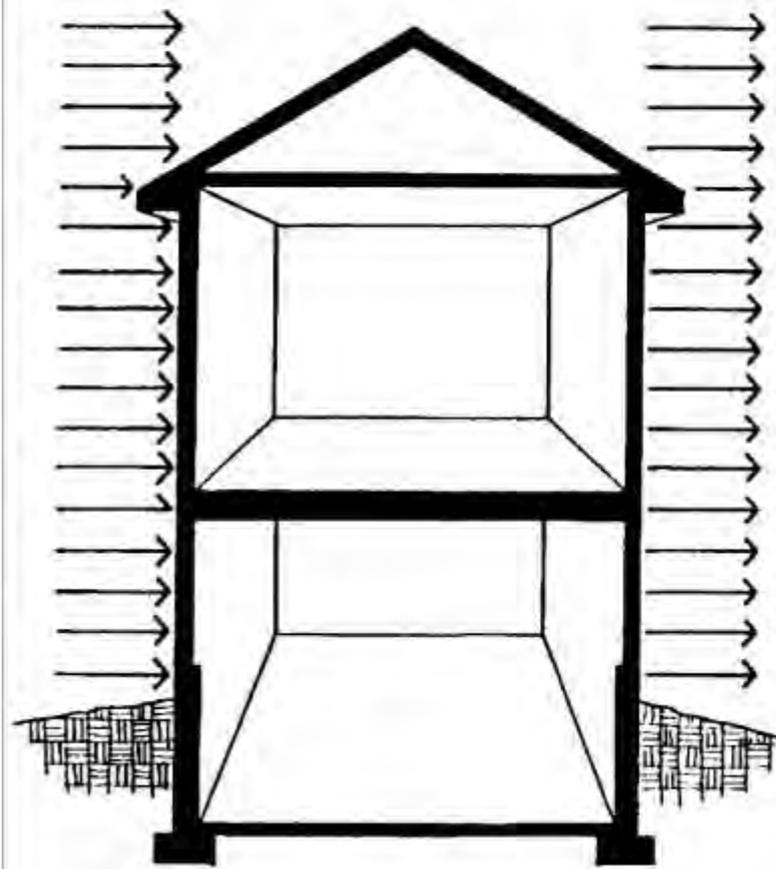
From an Energy Perspective - We Would like Houses to be very tight

77

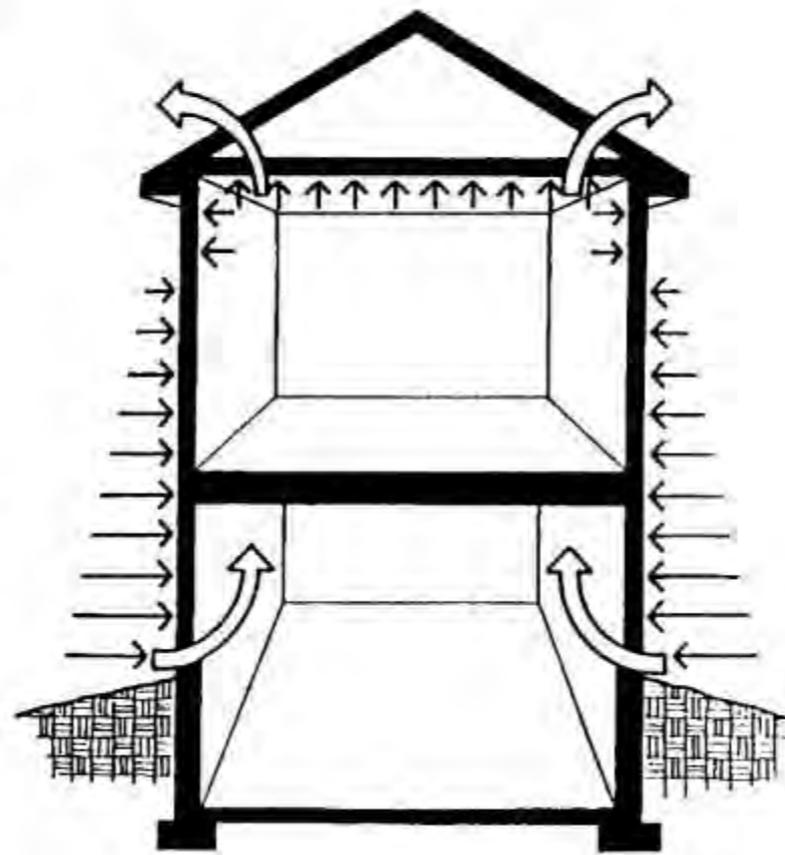
Are there any concerns of Houses Being “Too Tight”?

- Indoor Air Quality
 - Moisture problems
 - Chemical pollutants
- Combustion Safety
- “The walls have to breathe”

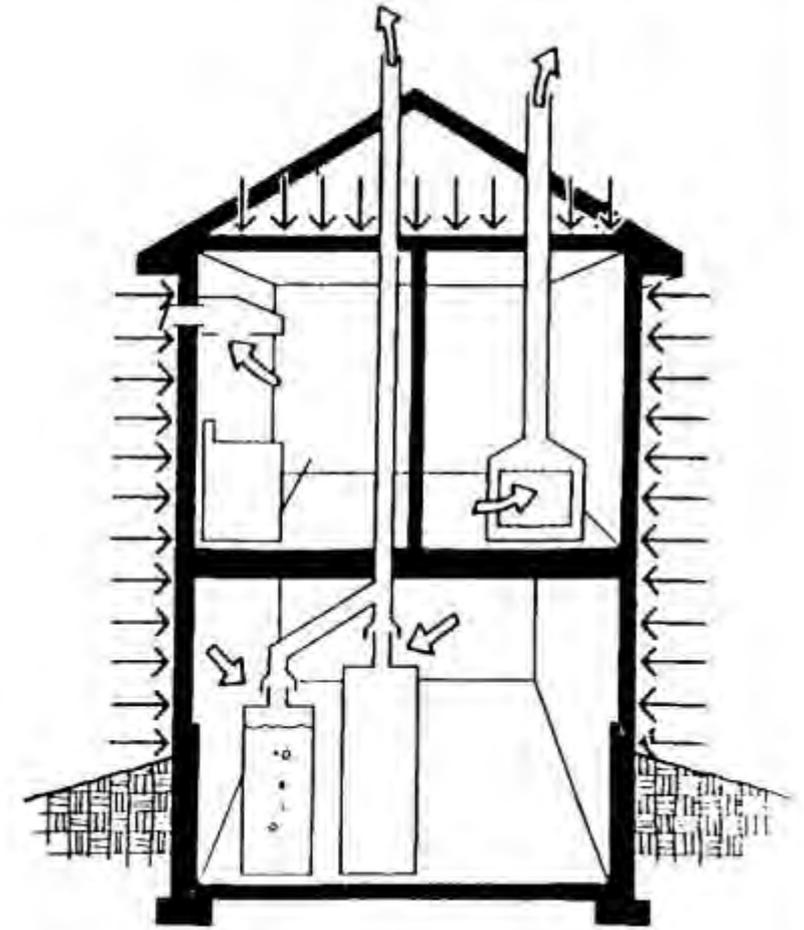
Air pressure in buildings



Wind Pressure



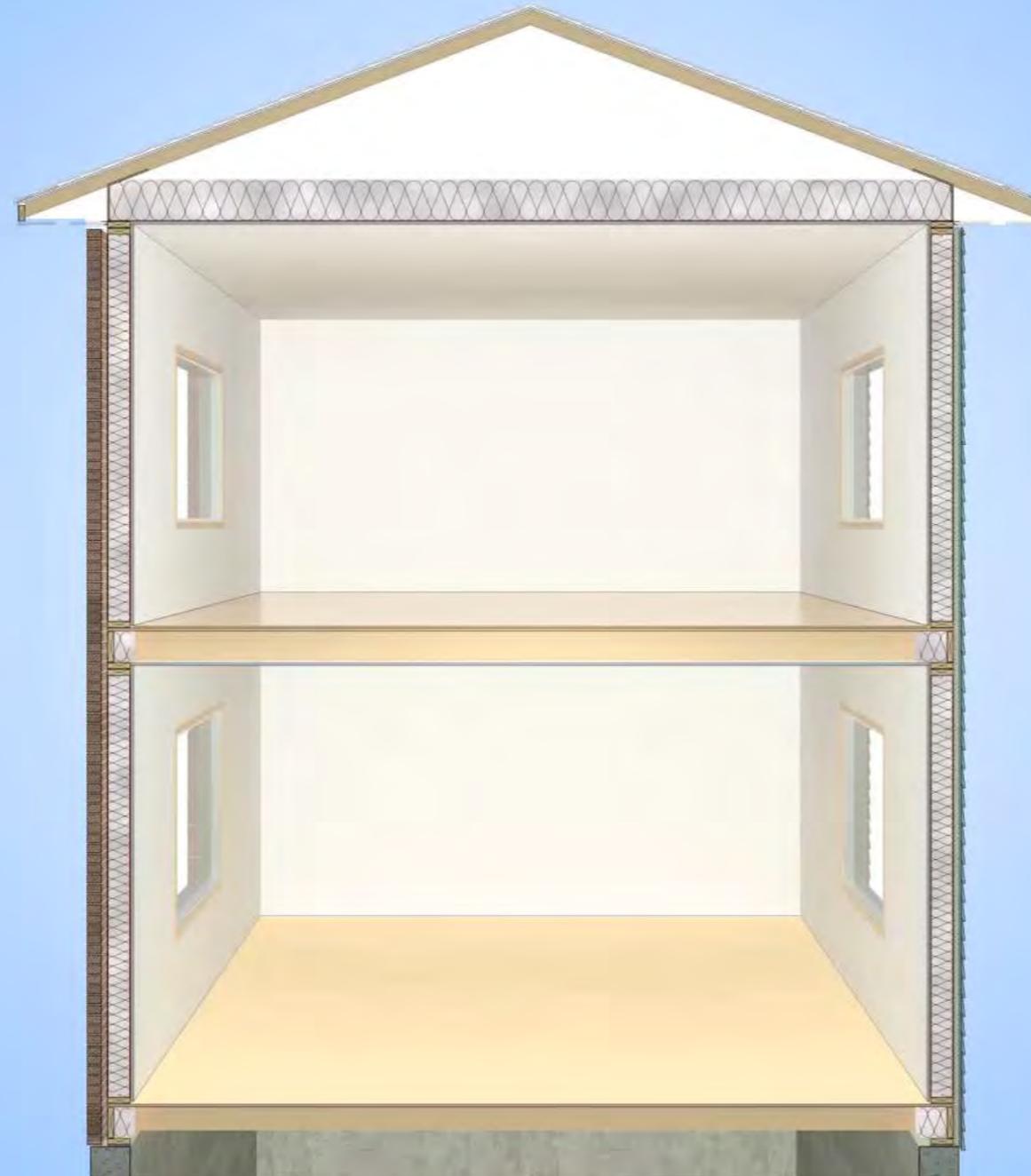
Stack Effect



Mechanical Pressure

Stack effect - pressures created by air temp. differences

79



Neutral
pressure plane
of building



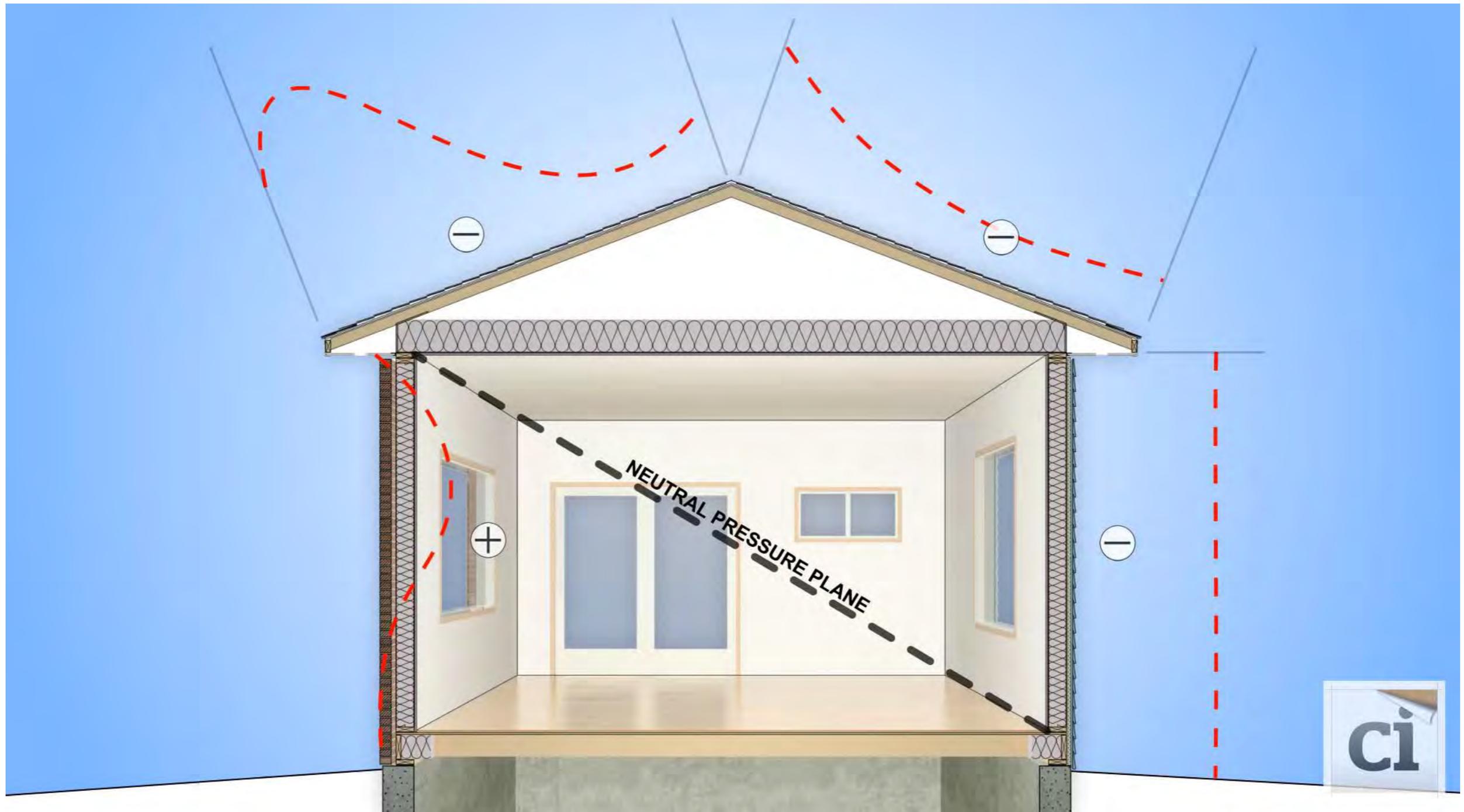
Moisture laden air flow can create problems

81



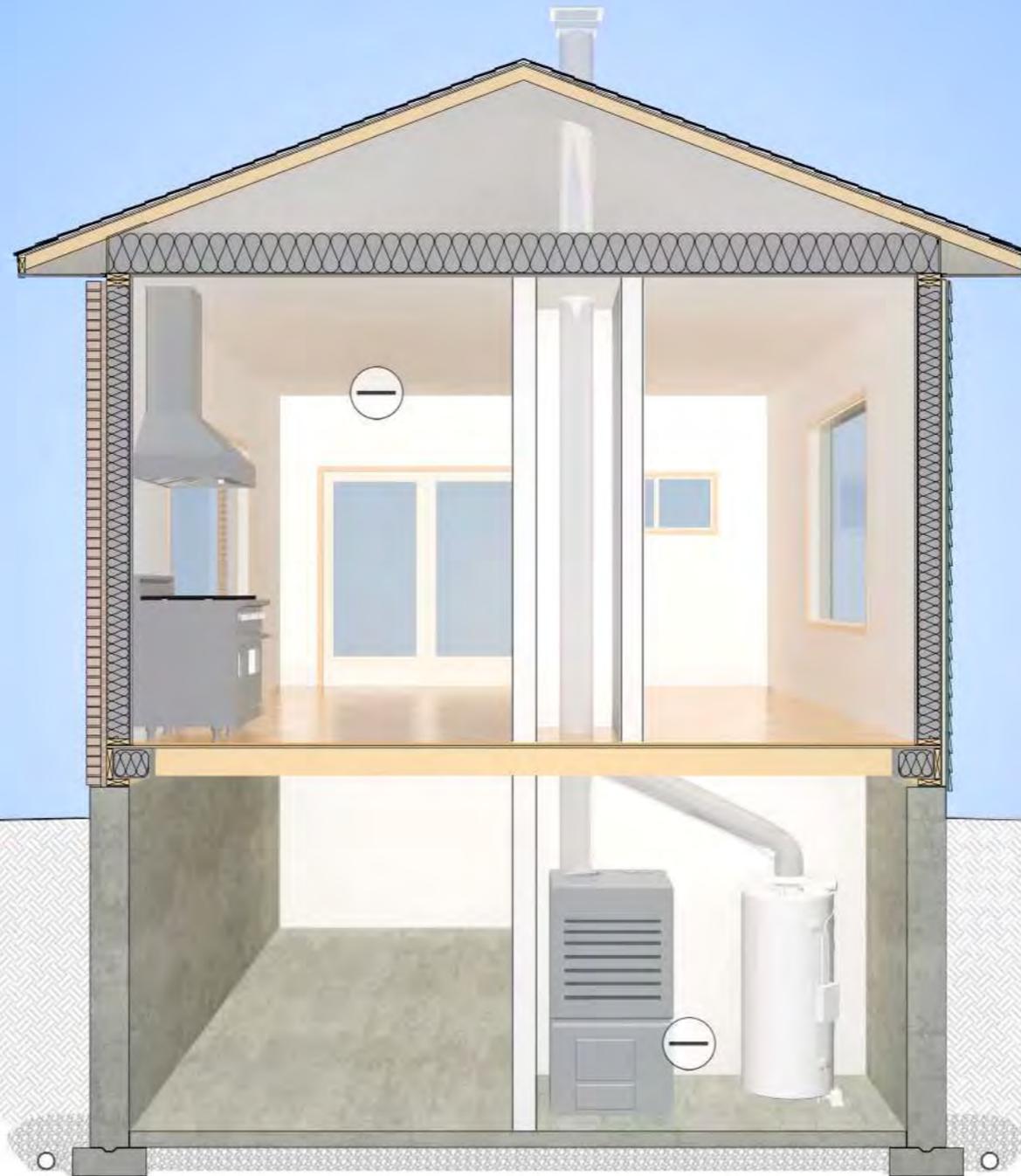
Wind effects are variable

82



Mechanical systems can also adversely affect performance

83



Moisture Flow

85

- The basic principles of a complicated subject

Forms of Moisture

- Solid
 - Snow & Ice
- Liquid
 - Rain, soil moisture & condensed vapor
- Gas (Vapor)
 - Evaporated moisture

Moisture Flows

■ Liquid Flow (gravity driven)

- Rain

■ Capillary

- Material wicking

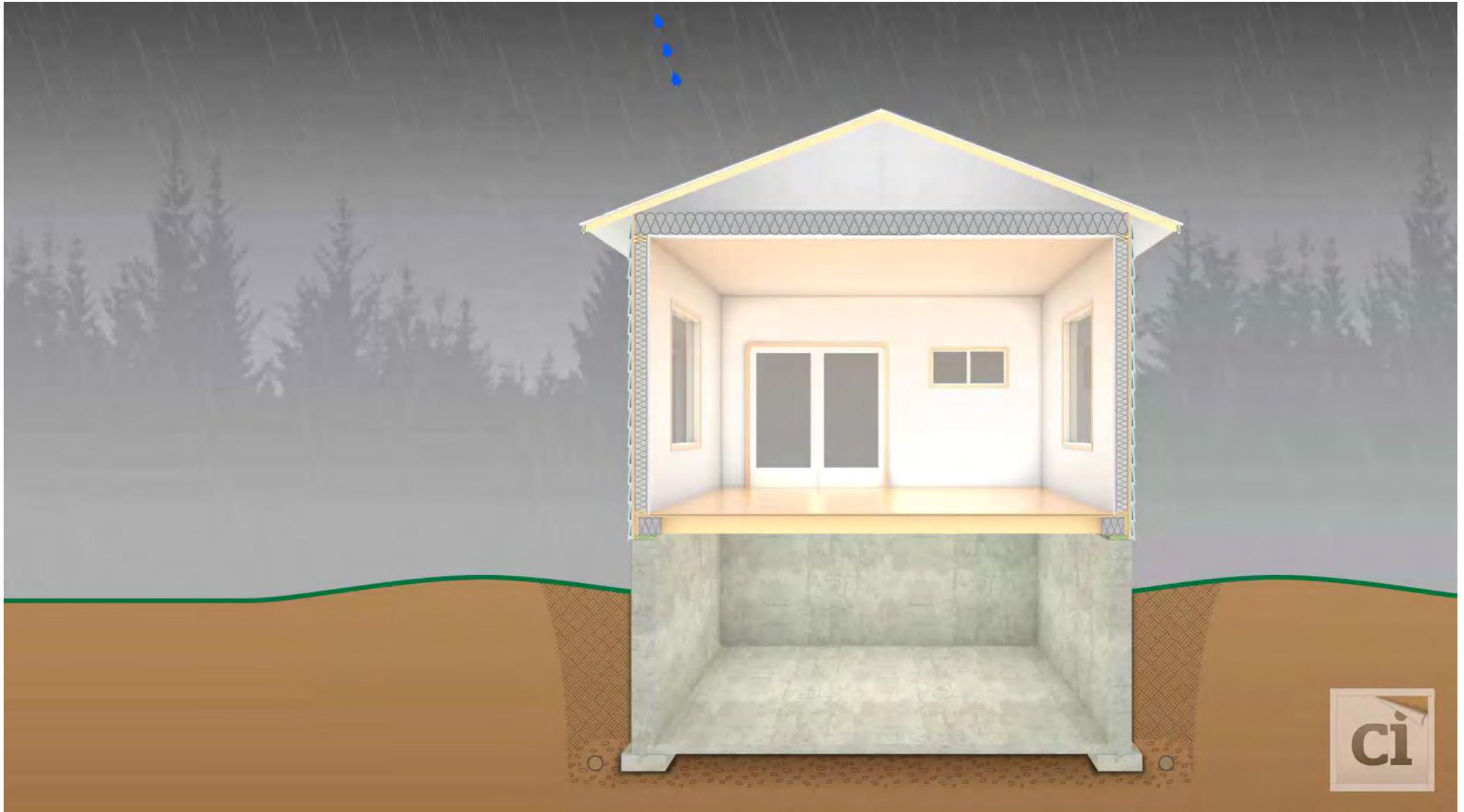
■ Air Transport

- Air pressure induced flows of moisture laden air

■ Diffusion

- Molecular transport via vapor pressure drive (no airflow)

Moisture Flows

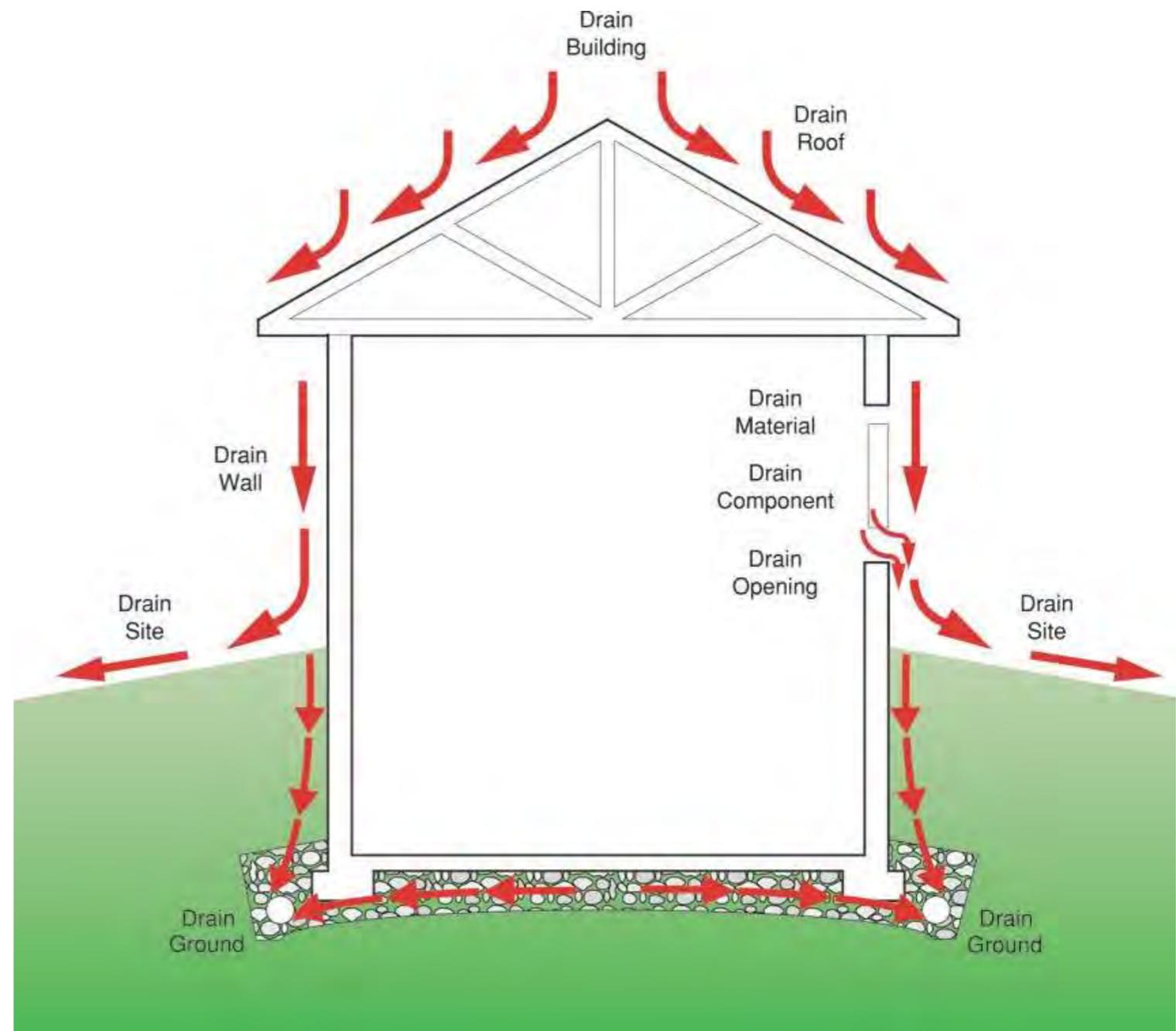


Liquid Water

89

Water follows gravity

- Site
- Foundations
- Walls
- Roof



Capillary Flow

- Wood & concrete wick water
 - Water can climb (in wood) in excess of 300 ft!
 - Water can climb (in concrete) in excess of 1,000 ft!

Material type

Location

Proximity to soil

Spacing

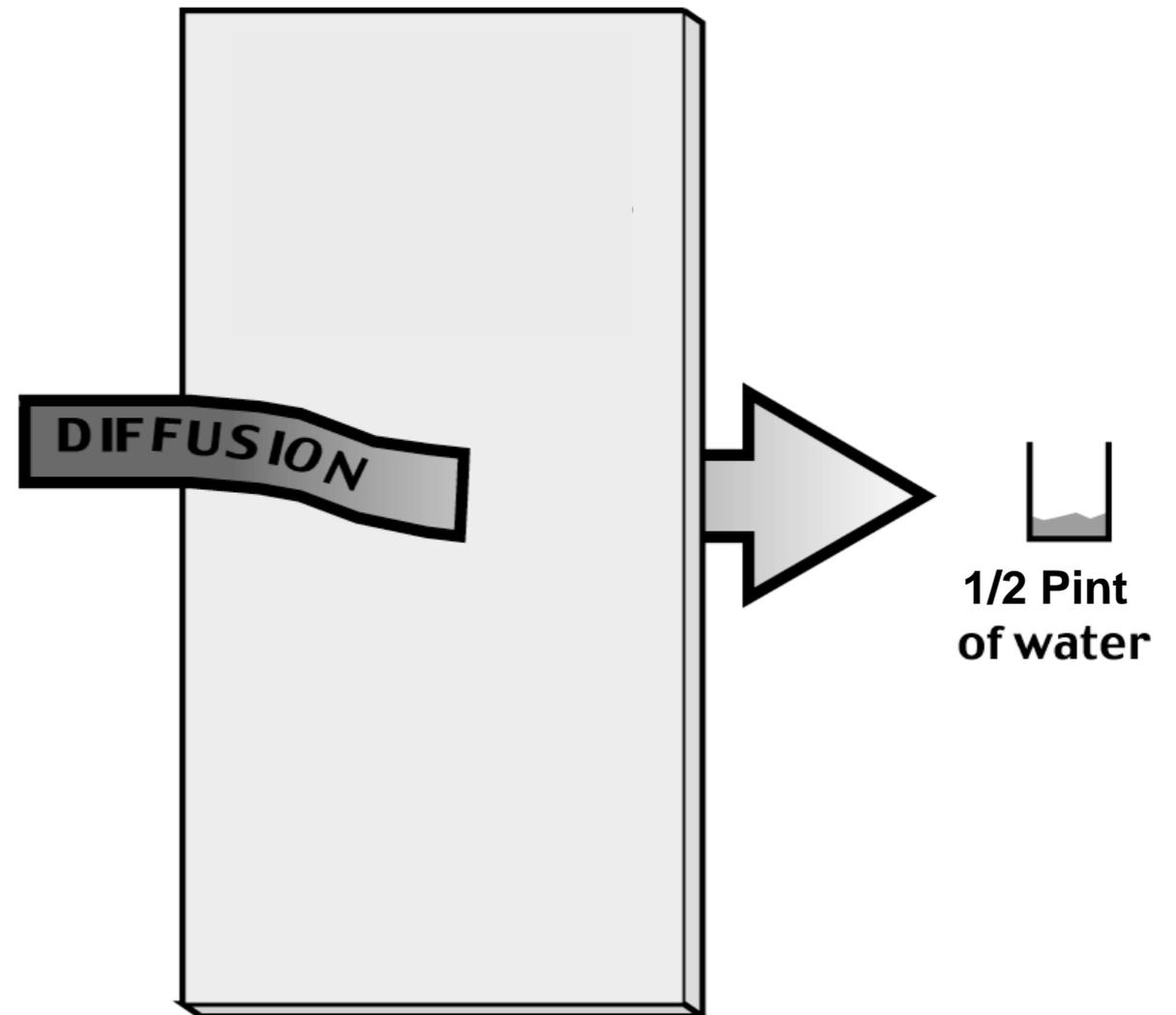
Sealing



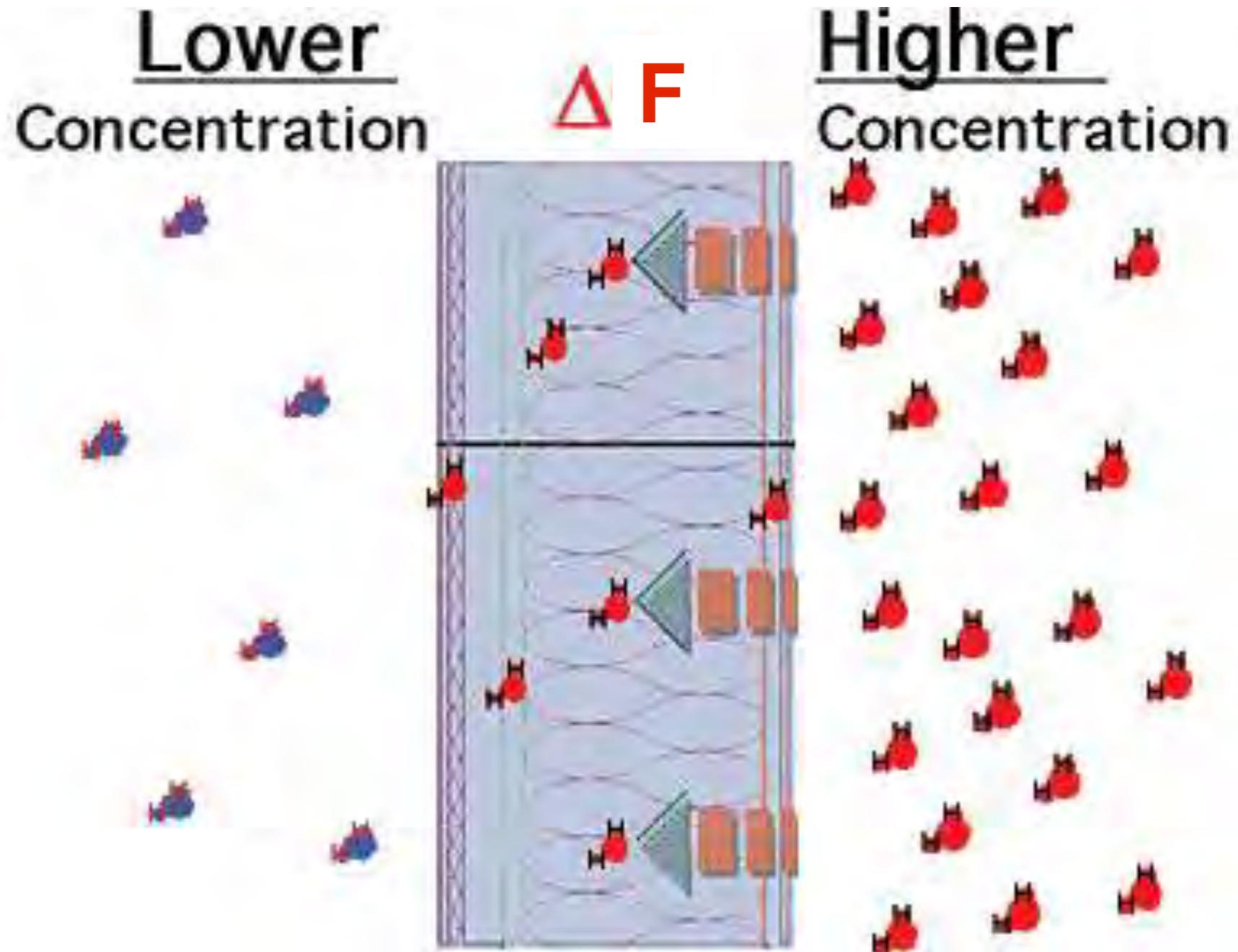
Vapor Diffusion

92

- Diffusion
 - Migration of moisture by means of vapor pressure differential
 - Occurs in either direction based on climate conditions and interior levels of humidity
 - One season



Vapor Diffusion is complex

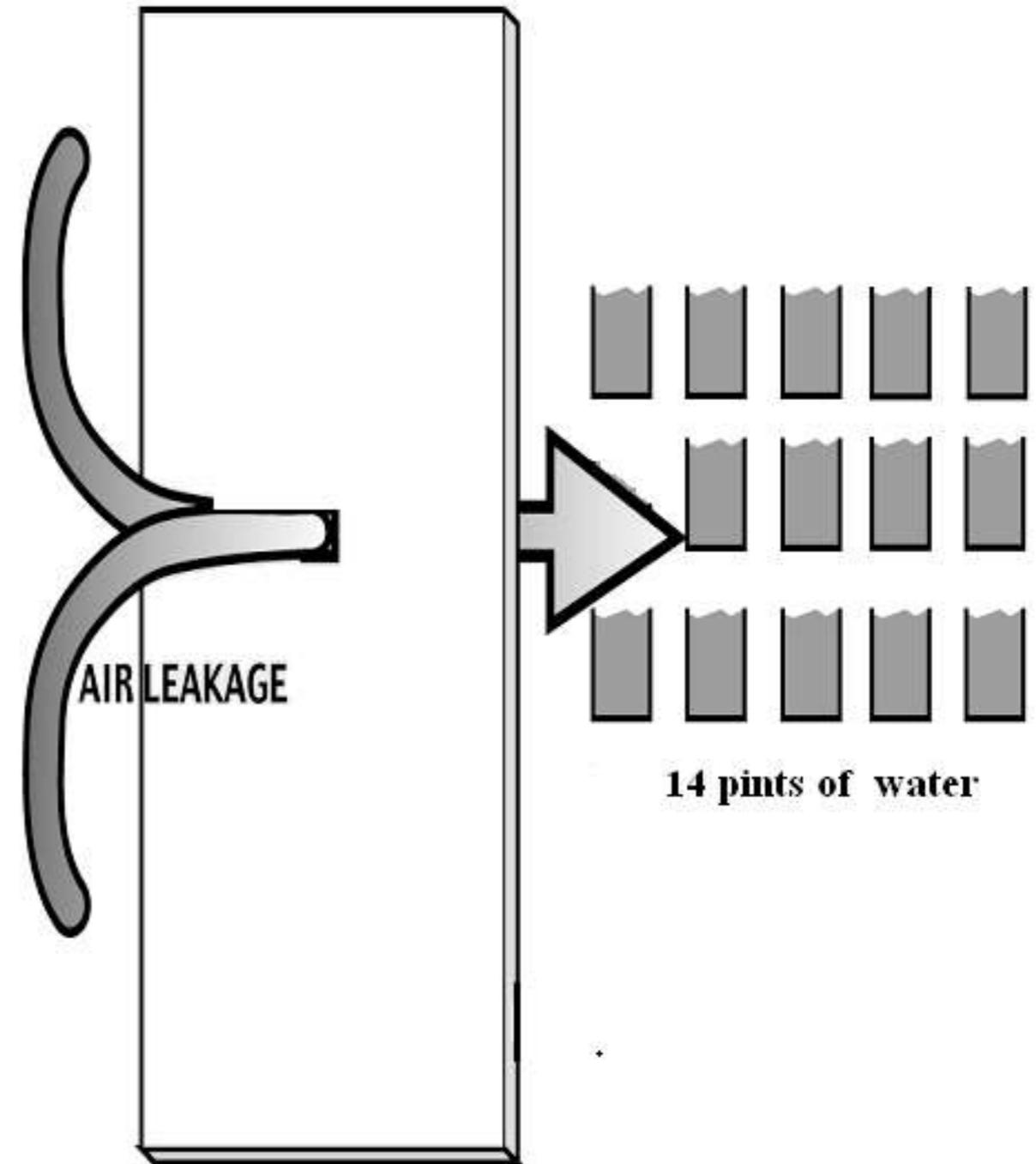


Air Transport of Water Vapor

94

- Air Leakage
 - Moisture flow through a 1in² hole by air leakage
- Flow quantity
 - 14 Pints of water in a two week period

Air barriers are far more important than vapor retarders in most cases





The Physics of Buildings

- Moisture moves from more to less
- Moisture moves from warm to cold
- Heat flows from warm to cold
- CFM (air) out equals CFM (air) in
- Heat, air & moisture are one
- Drain the rain
- Things always get wet - let them dry
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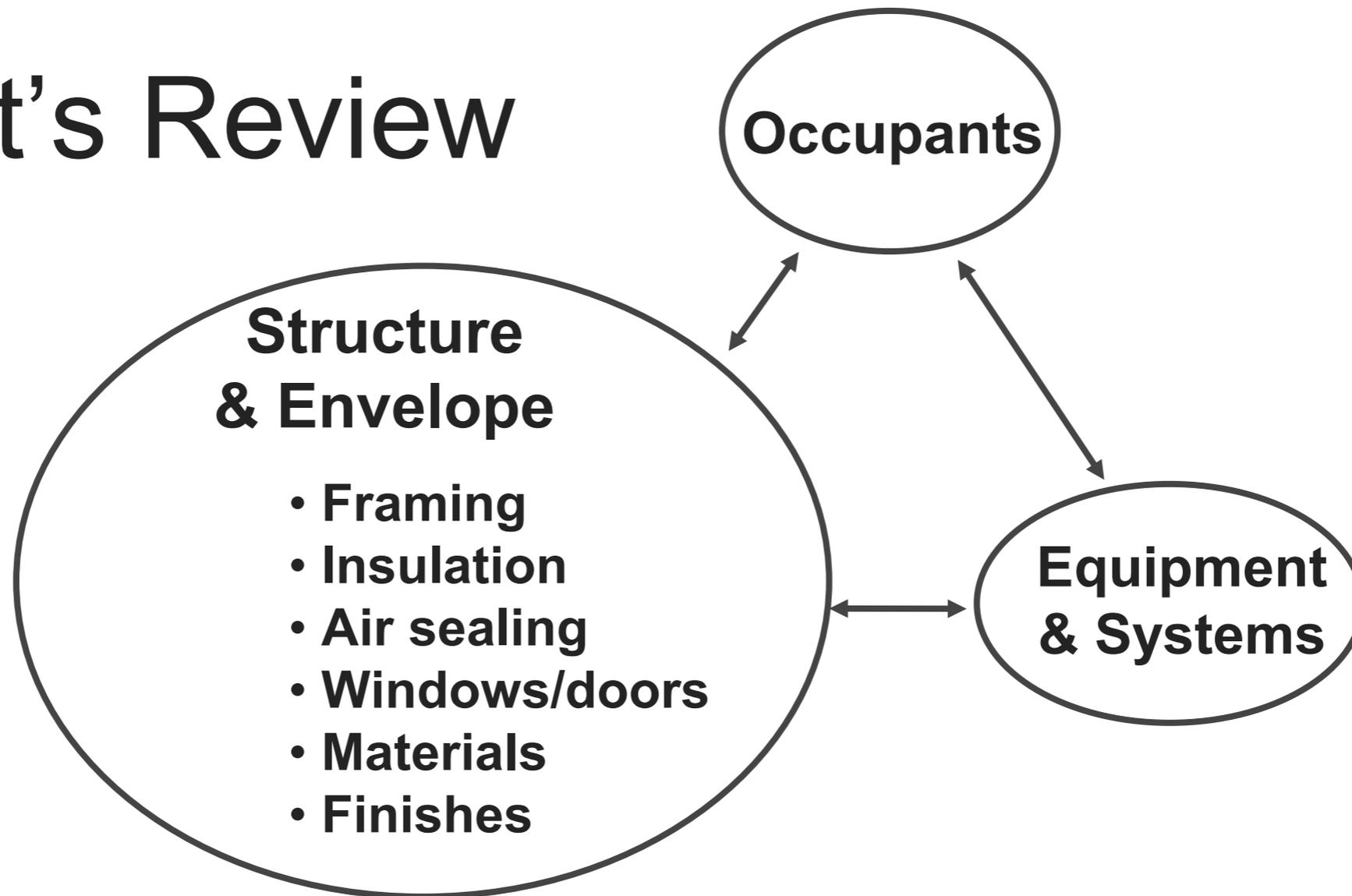
NOW THAT WE KNOW THE BUILDING SCIENCE BASICS....

98

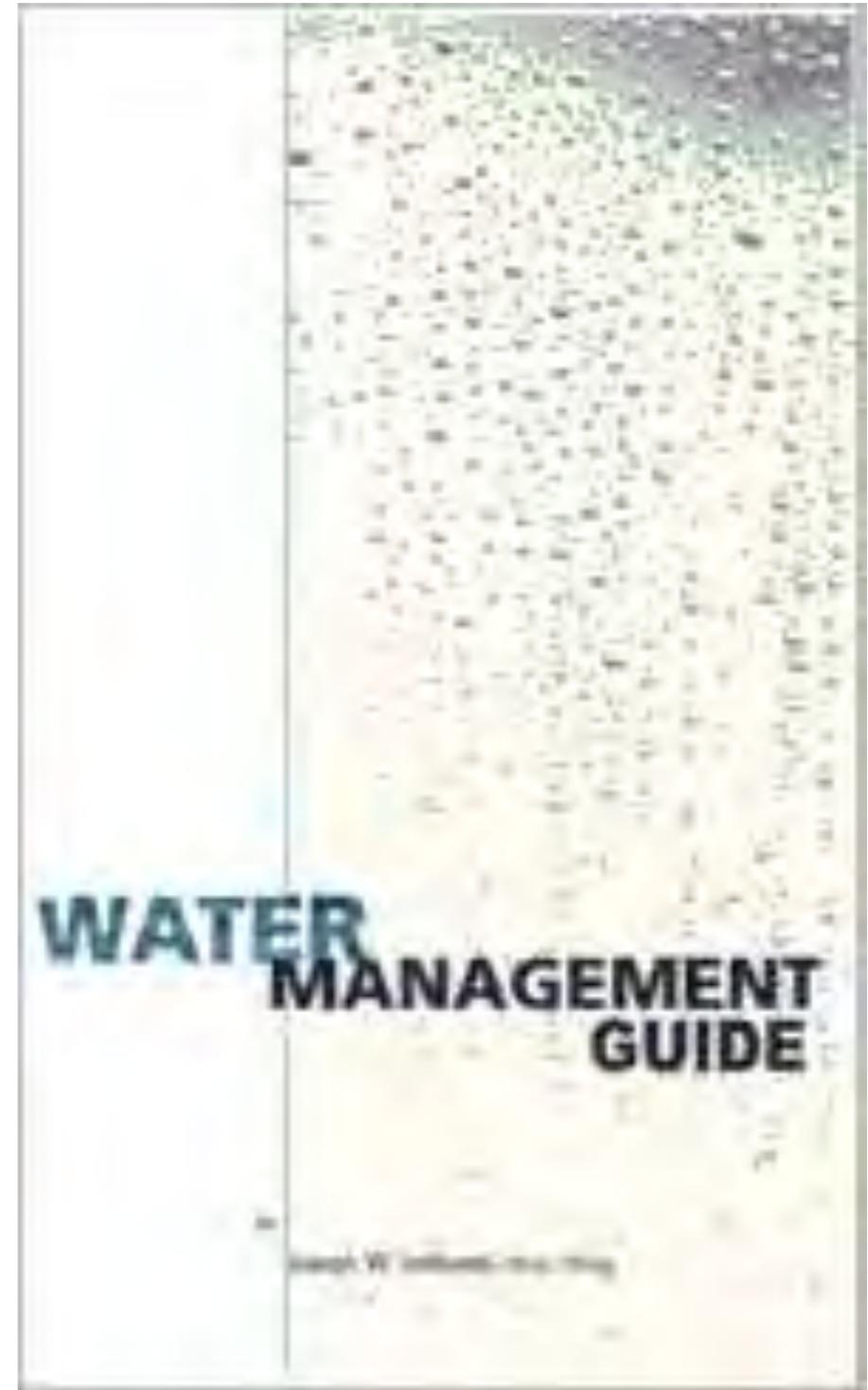
- We can begin to create walls, roofs and foundation systems that work

What are the key components of the structure and envelope?

Let's Review

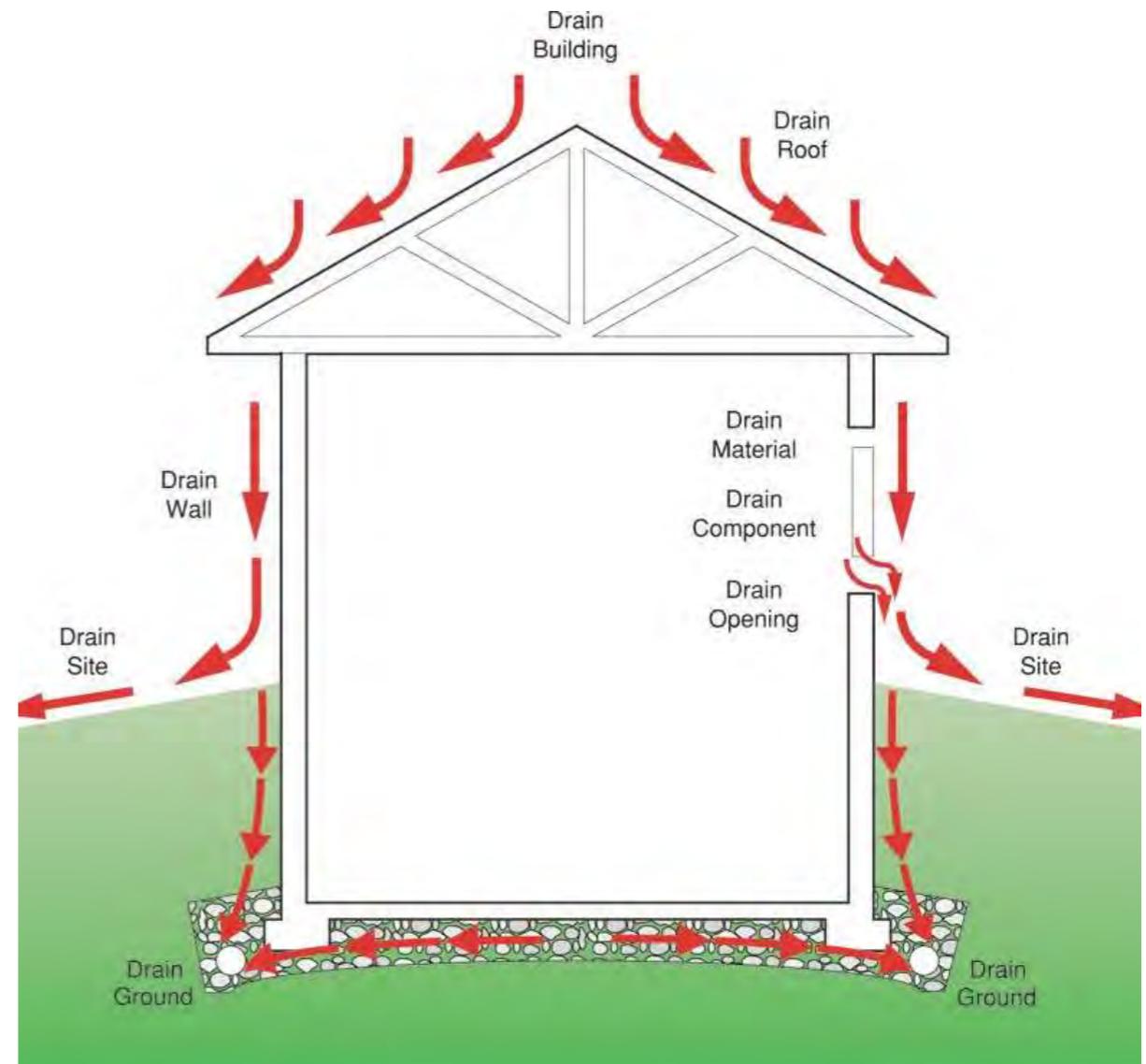


First we need to protect our building system from water

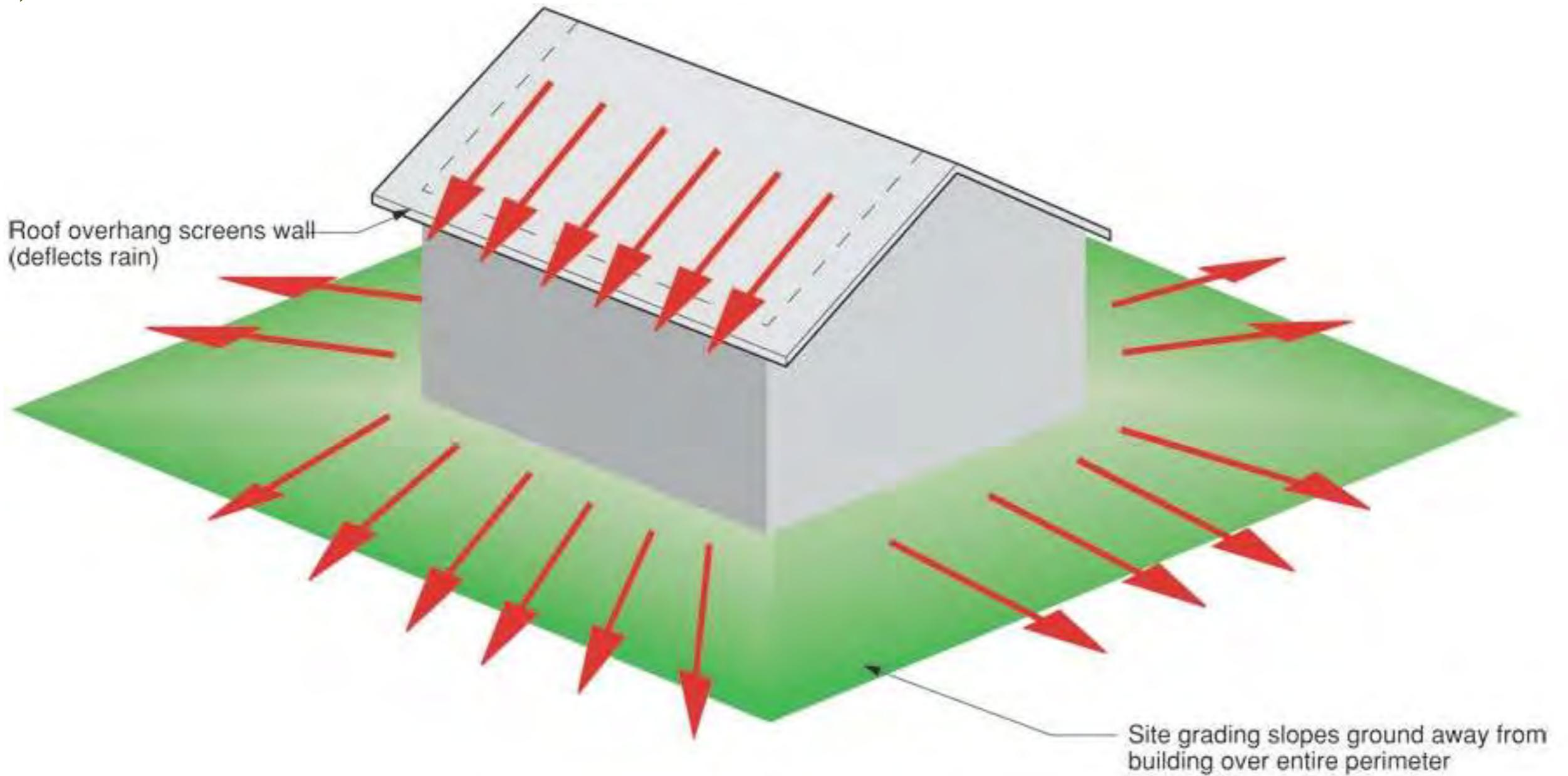


The Six D's:

1. Drain the site
2. Drain the building
3. Drain the assembly
4. Drain the opening
5. Drain the component
6. Drain the material



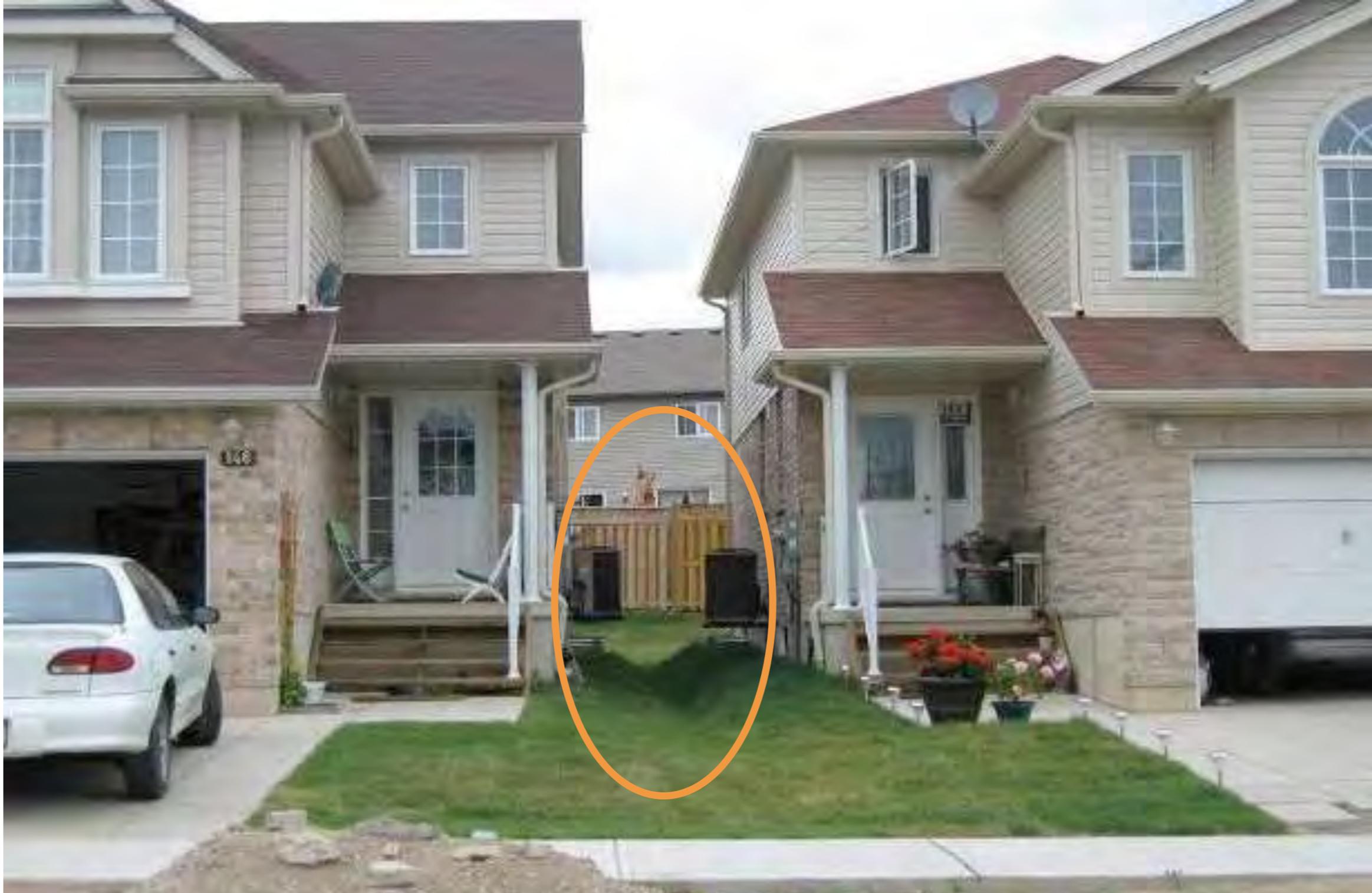
Drain the Site



The site and soil affect many decisions



Text



Adjusting grading to redirect water away from the homes

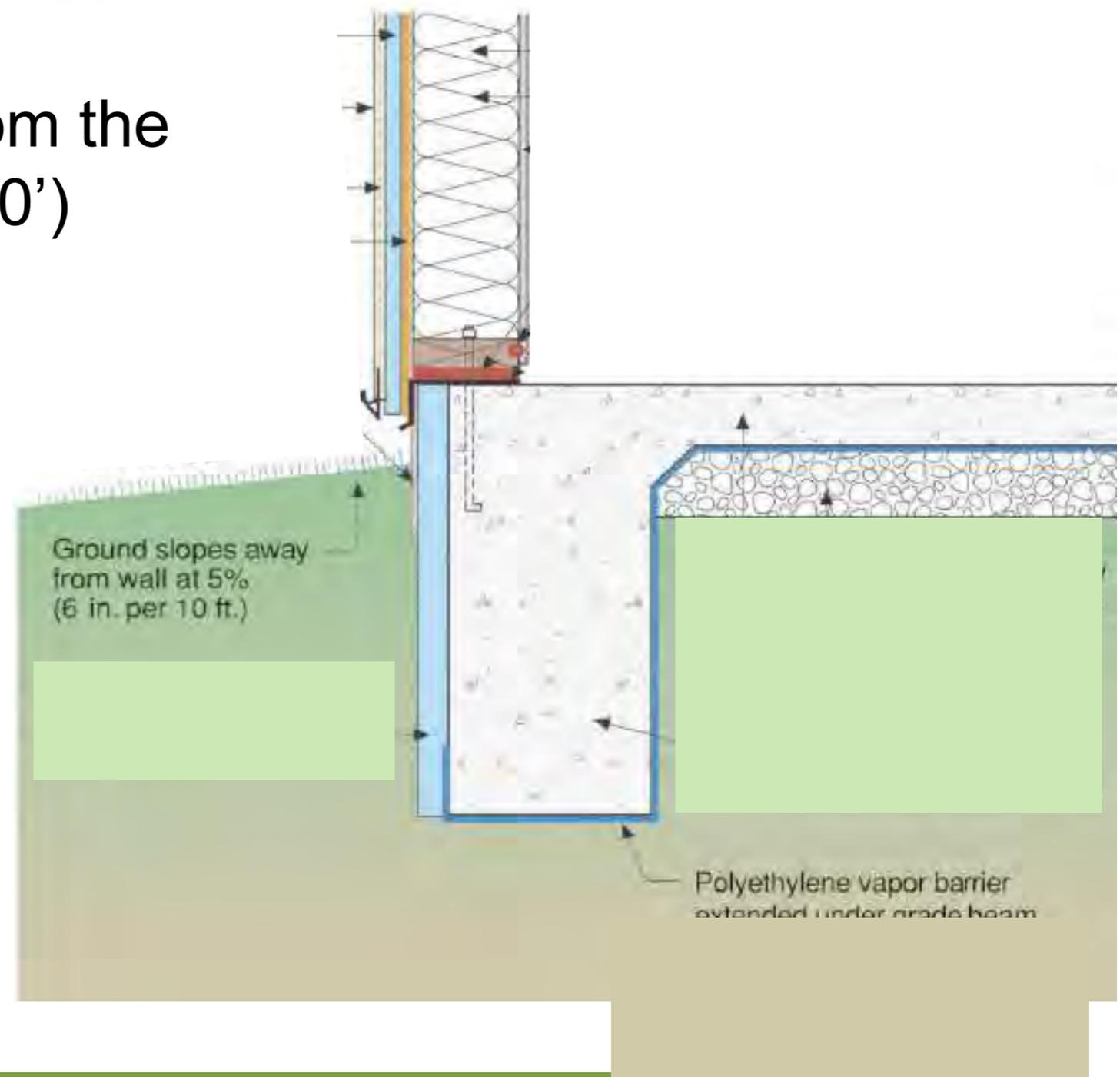
Landscape too close to the foundation



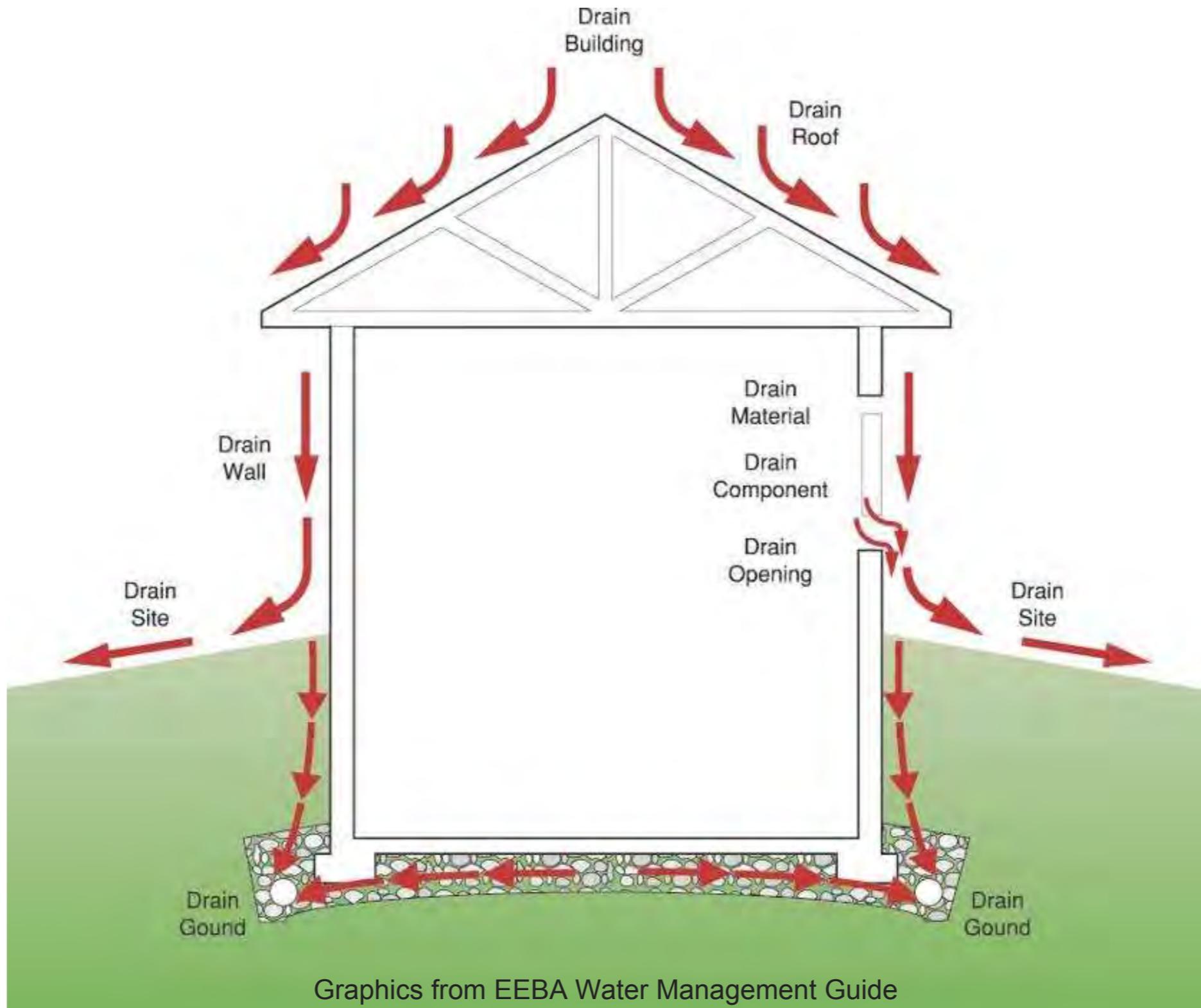


Remember proper grading

Ground slopes away from the wall at 5%. (6" per 10')

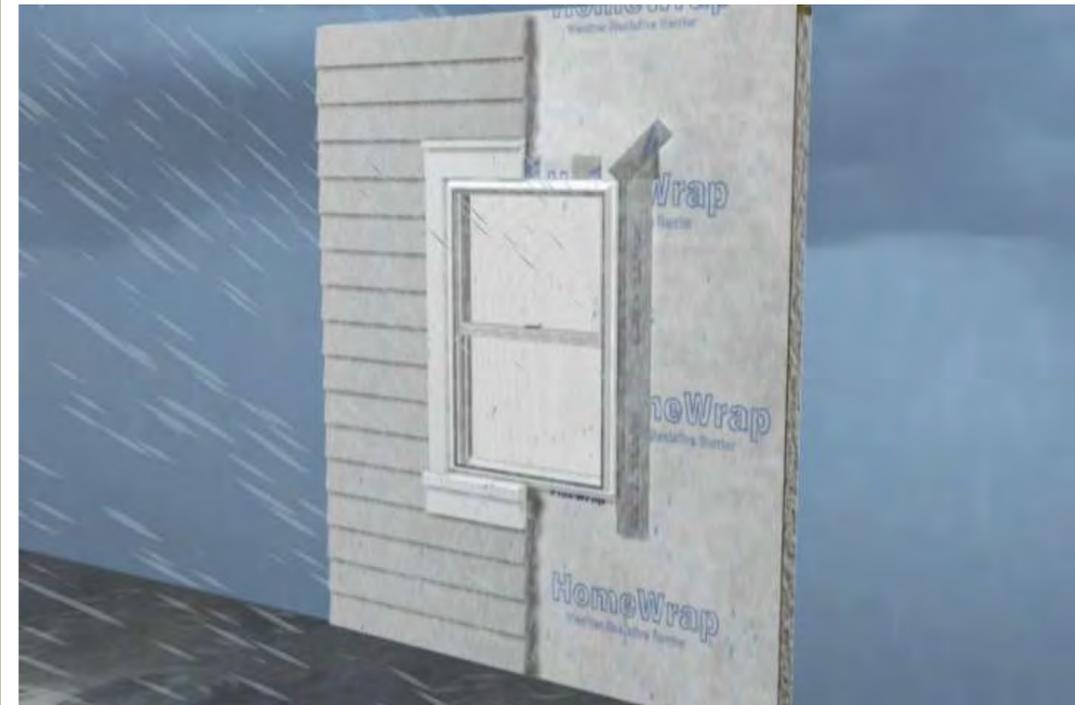


Drain the Building



Graphics from EEBA Water Management Guide

Cladding is 1st line of defence
Water gets behind all types of cladding
by:
Liquid
Capillary
Air pressures



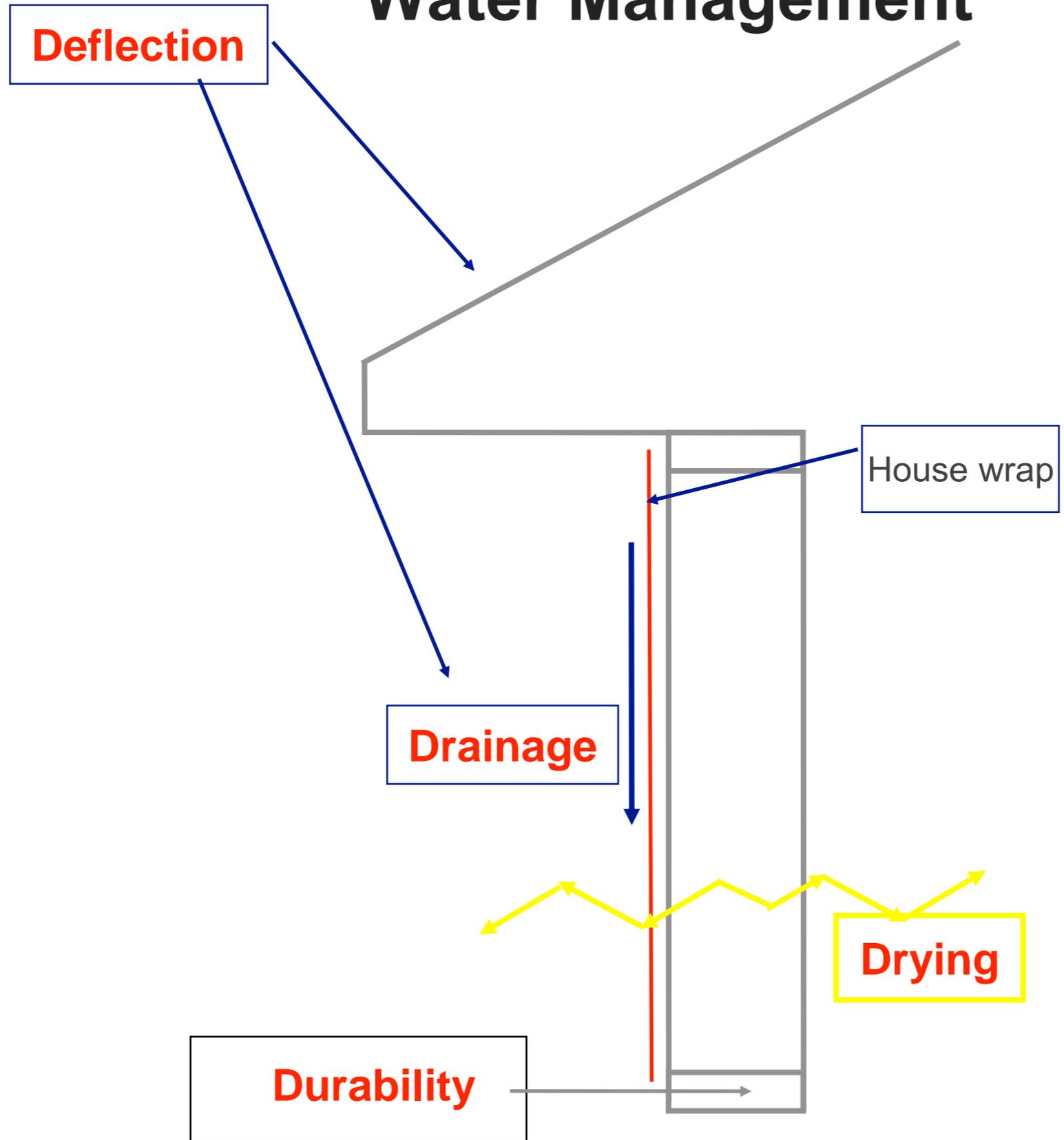
Rain on cladding system

Liquid Water



The Four "D"s

Key Strategies to building Water Management





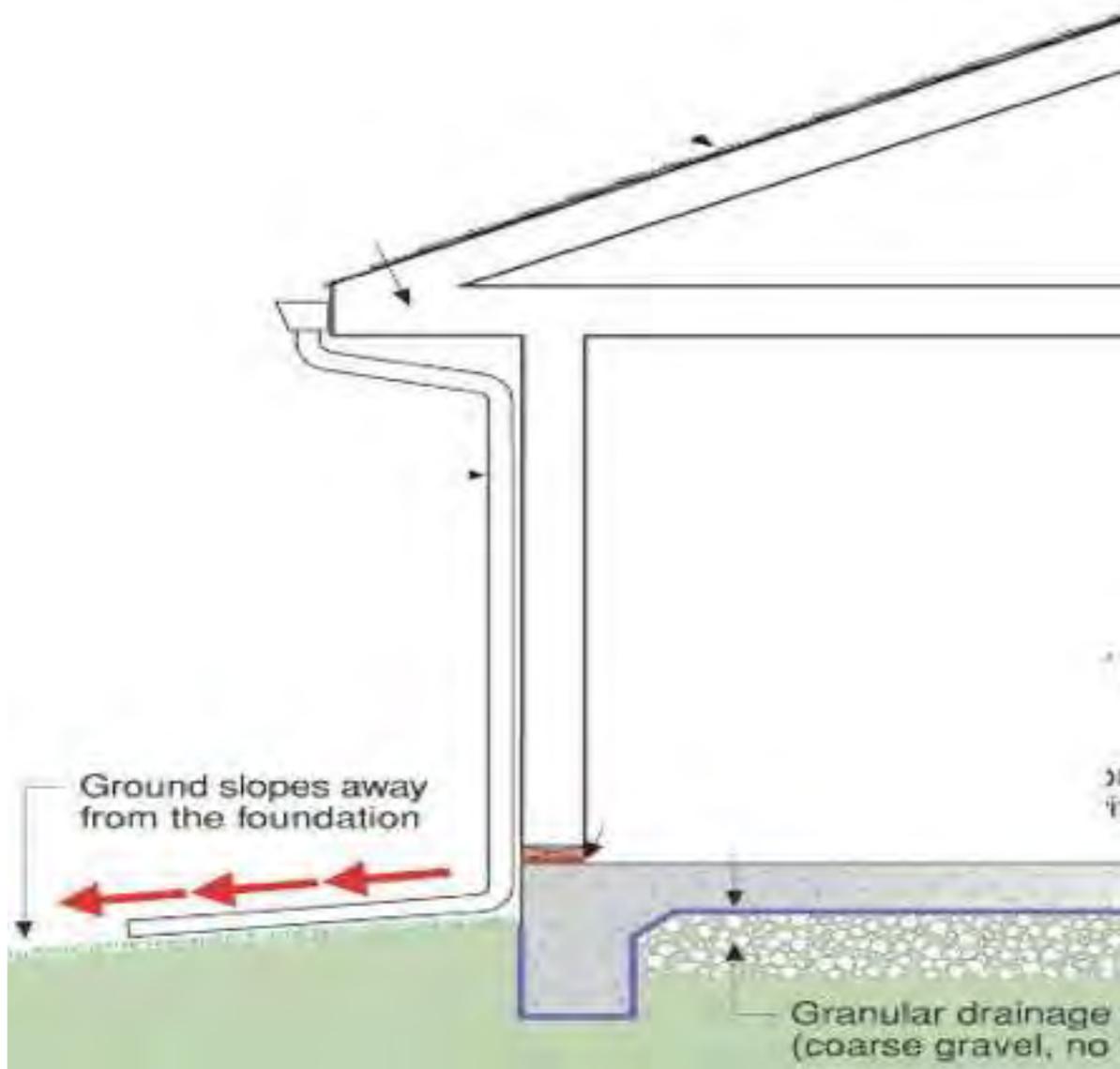
Deflection?





Gutters are important to any water management strategy

116





Follow the path of water will it create a problem?

Flashing & Gutters must effectively redirect water

118

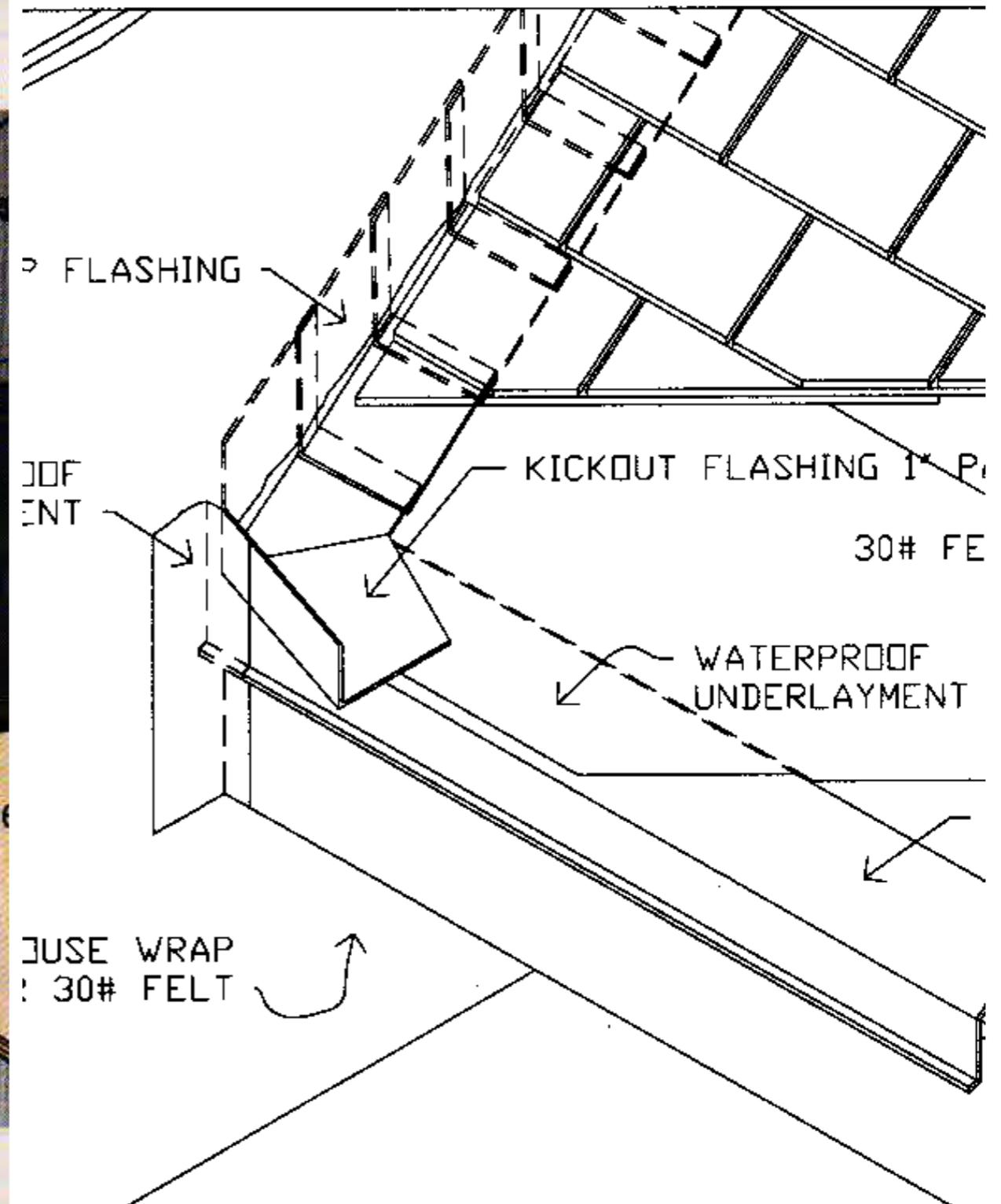
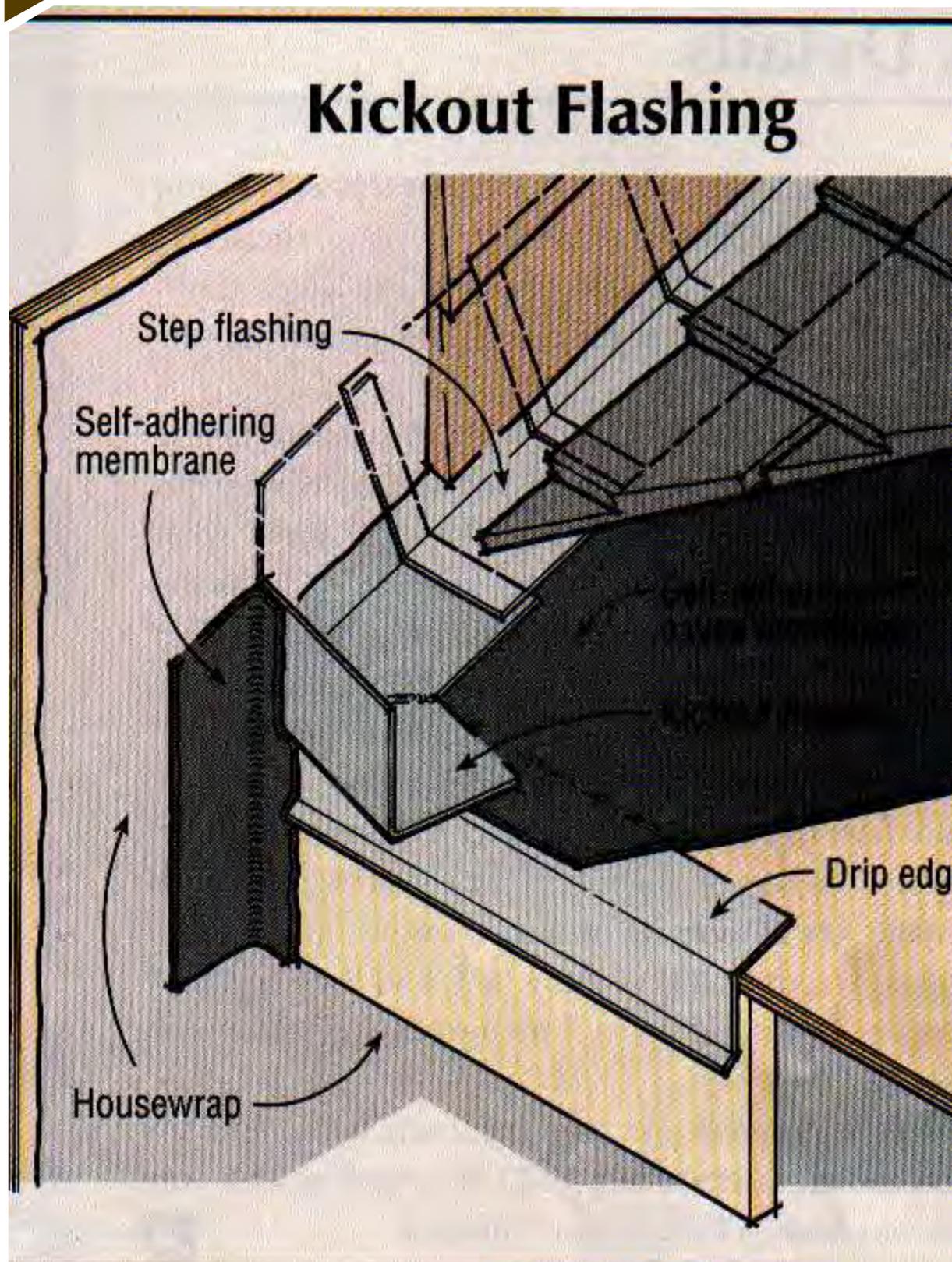




119

Concentrate on the path of flow...

Kickout Flashing

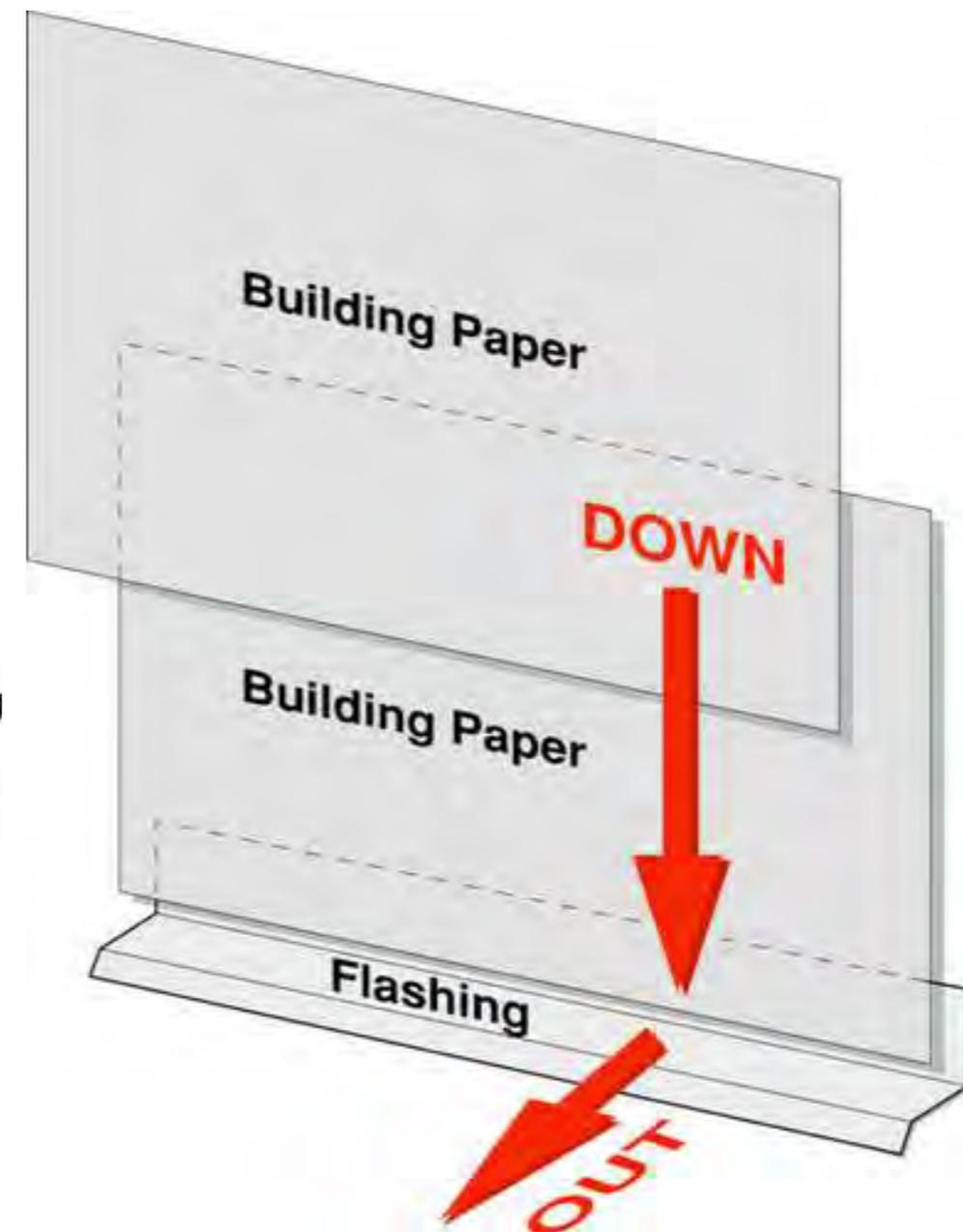
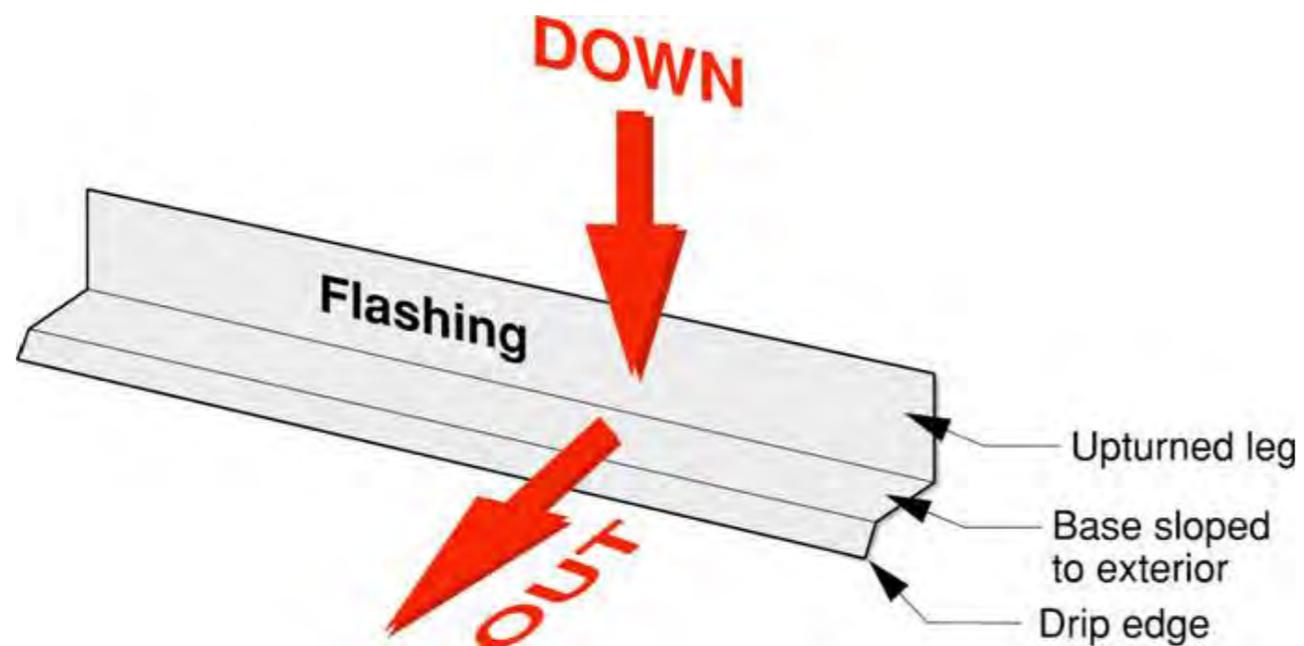




Drainage?

Integration of flashing systems

122



From EEBA Water Management Guide

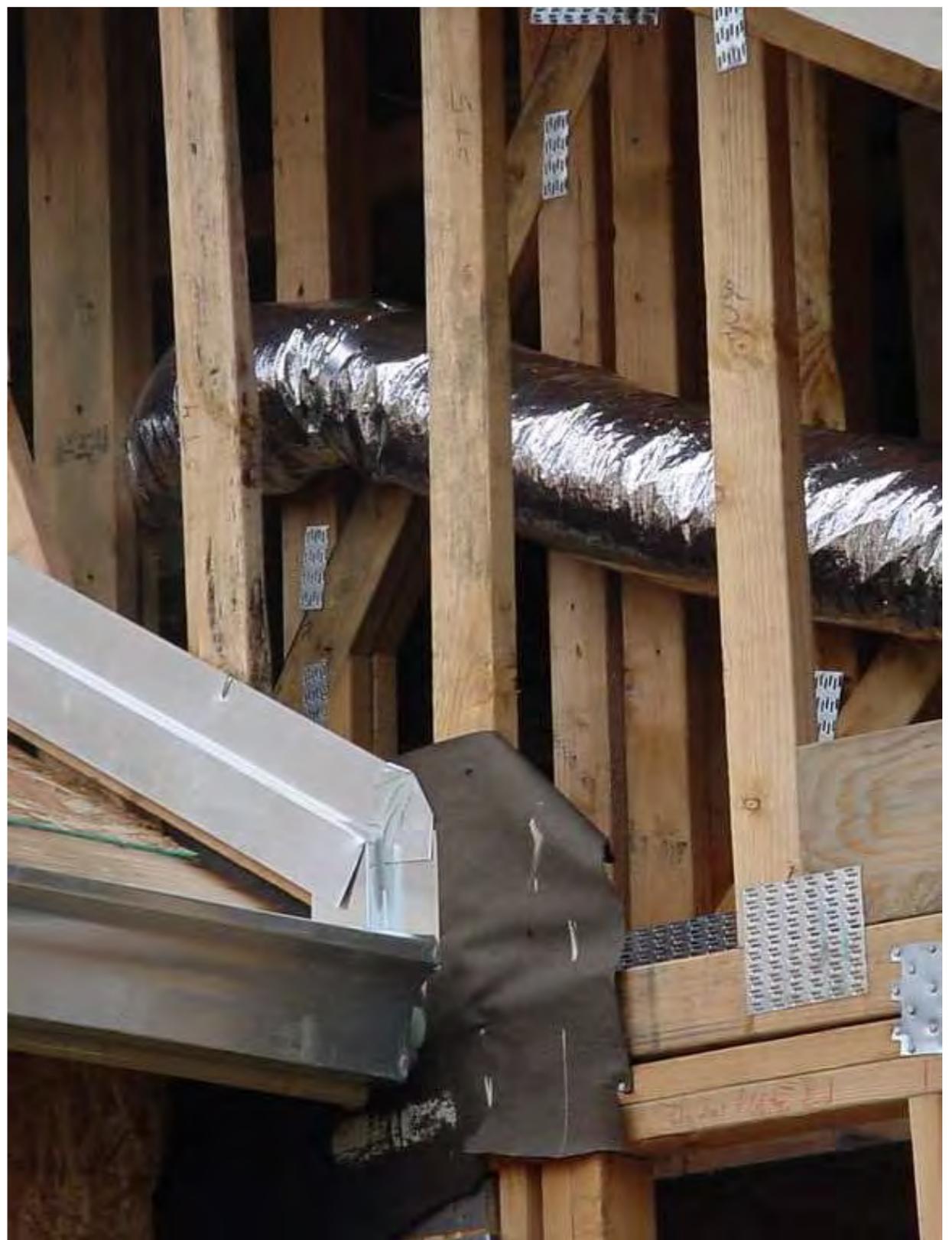
Flashing must be integrated with the drainage plane

123





Flashing needs backing too







Inadequate pan flashing

129





Barrier Wall Installation has limitations

131









Drying?





Demonstrating a Method

137

- The pan flashing system connects to the drainage plane

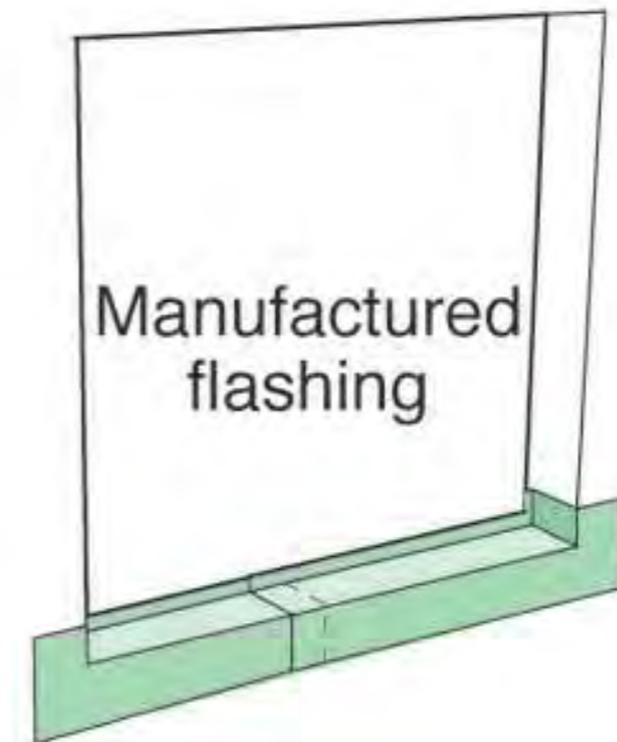
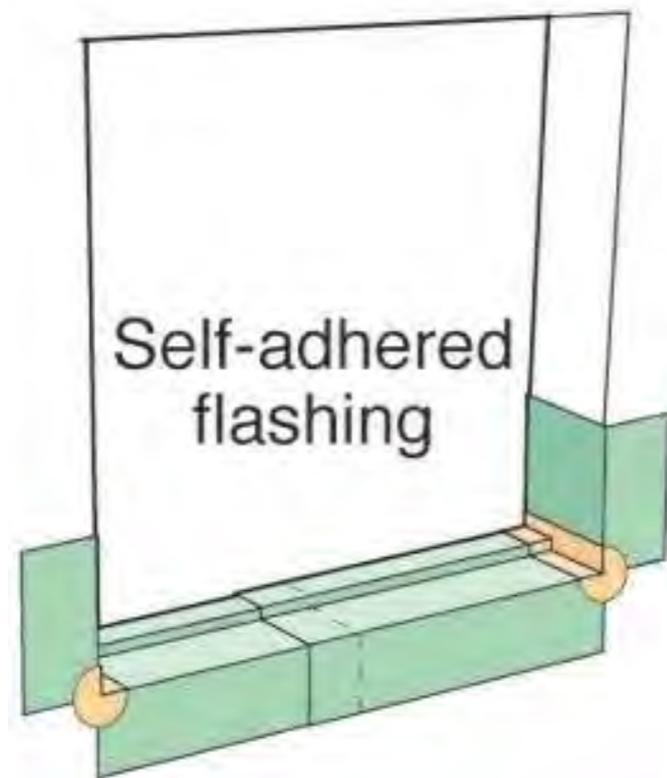
Windows need special attention

138



Site-Constructed or manufactured pan flashings for window and door openings in frame walls

139









Use low pressure, low expanding foam around openings

144

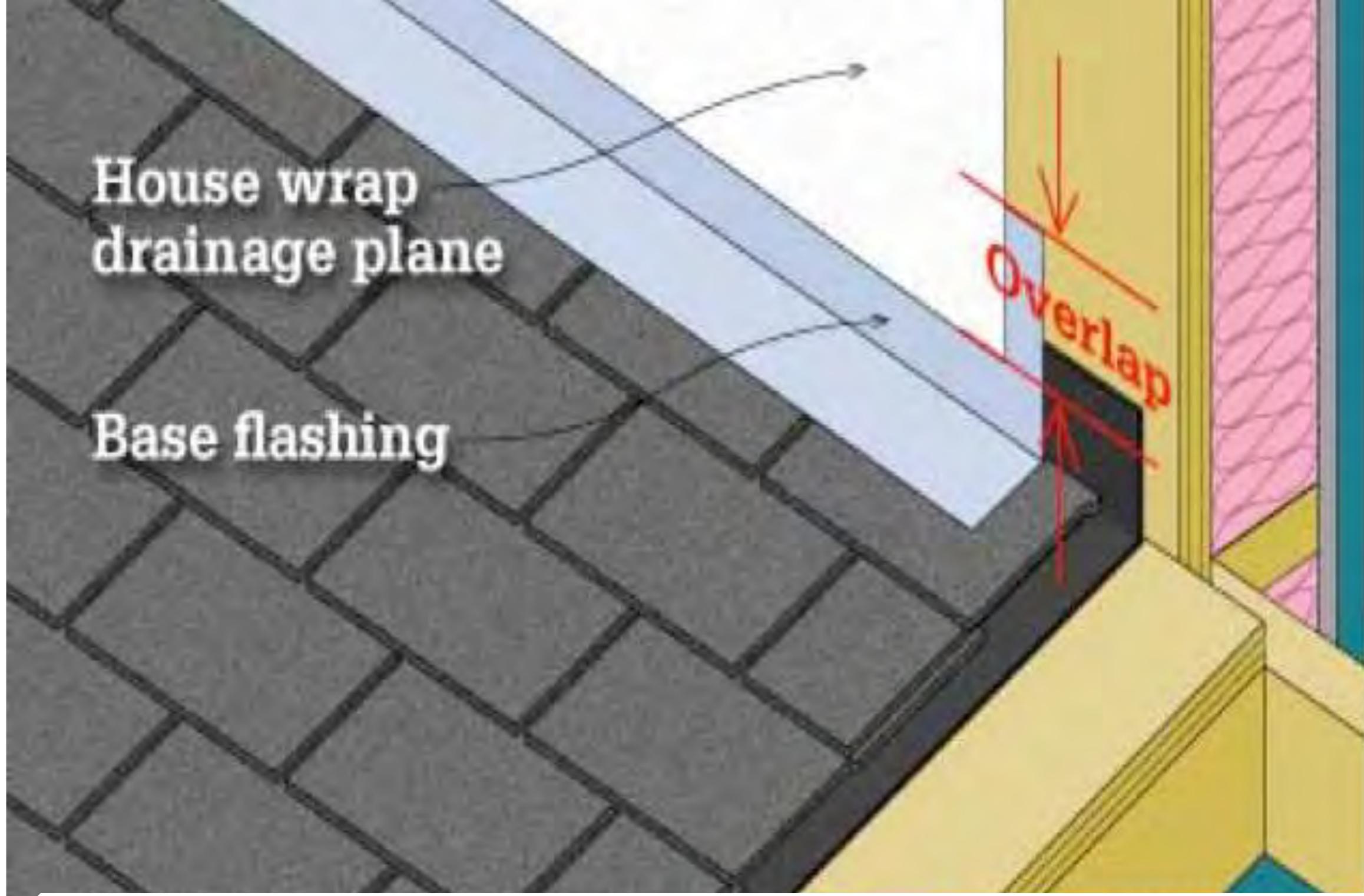




Window Installation-Great Job!

146





Flashing at Shed Roofs

Draining Housewraps

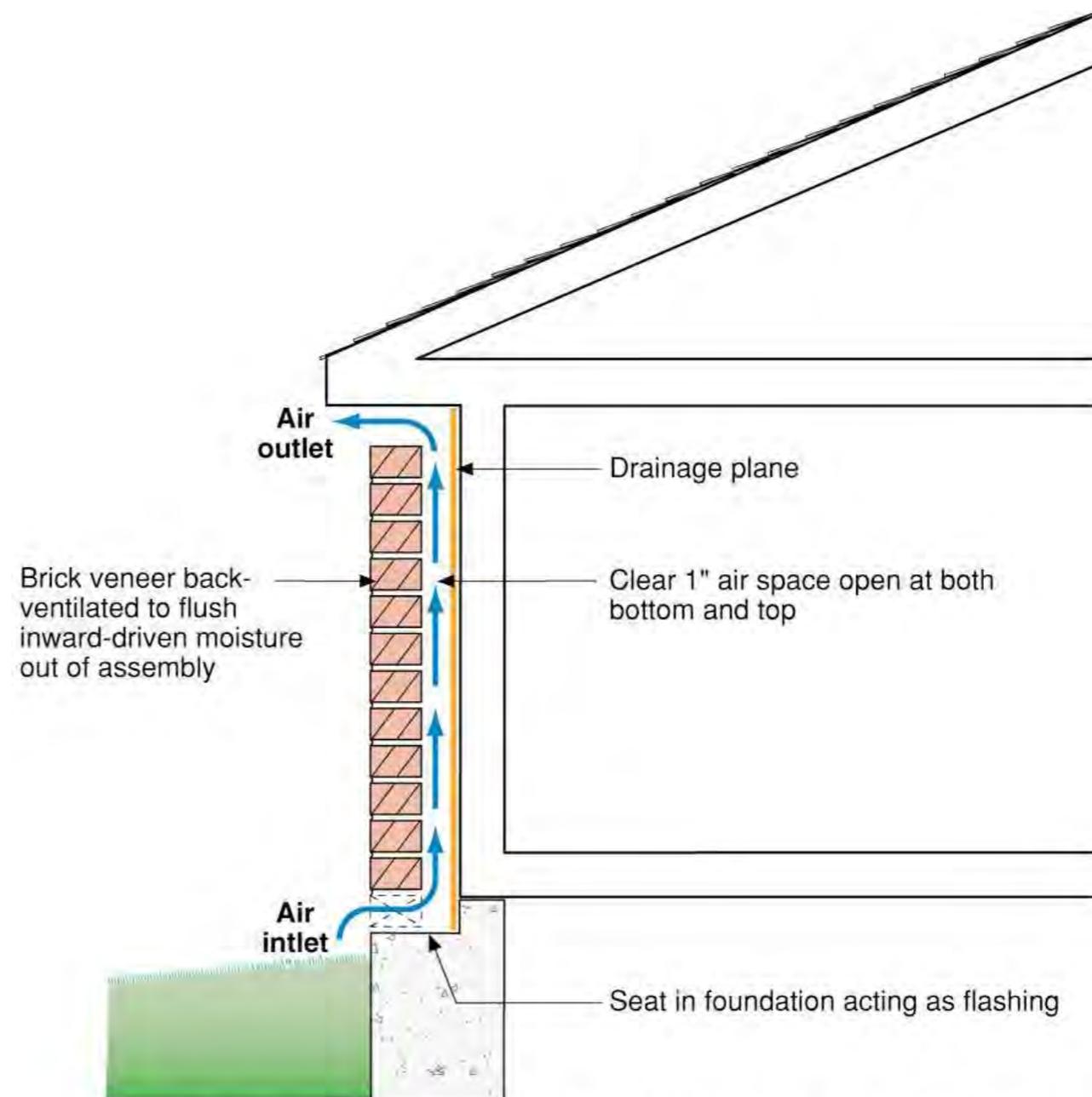
148



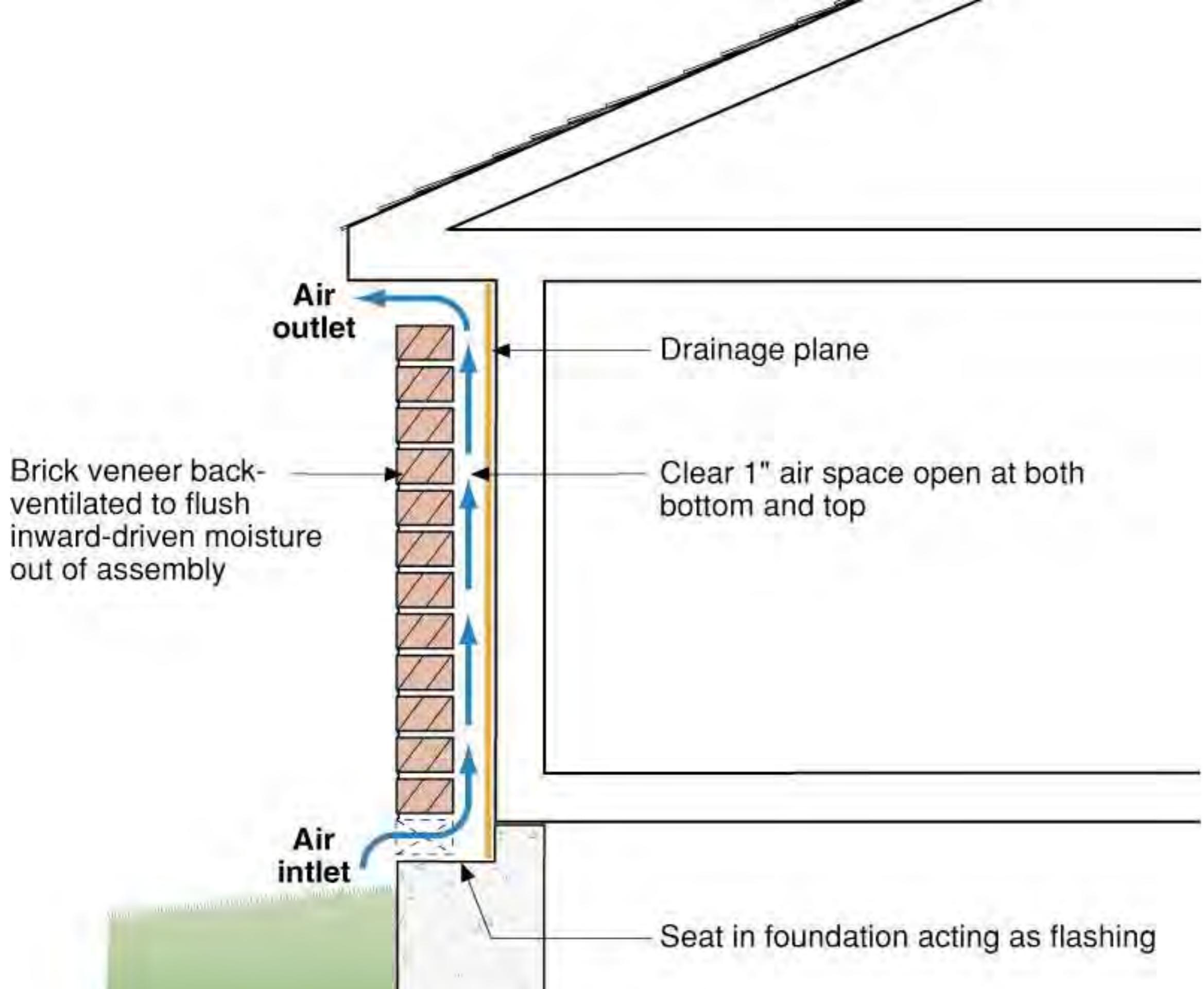
Venting our Cladding

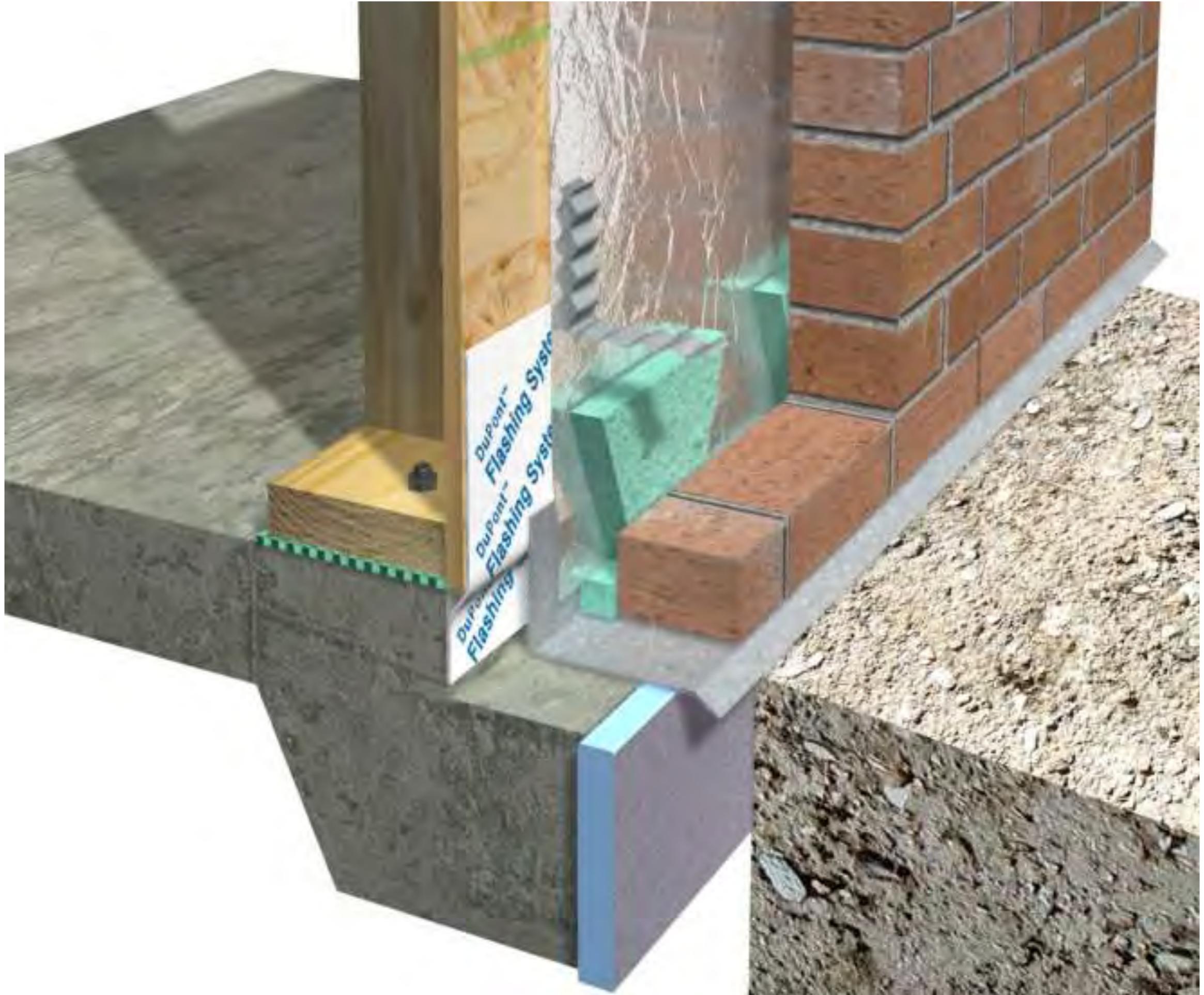
Air Flow assists drying

Create intentional airflow
When using brick & stone &
siding in:
Humid summer climates
Rainy climates
Wood sheathing
applications



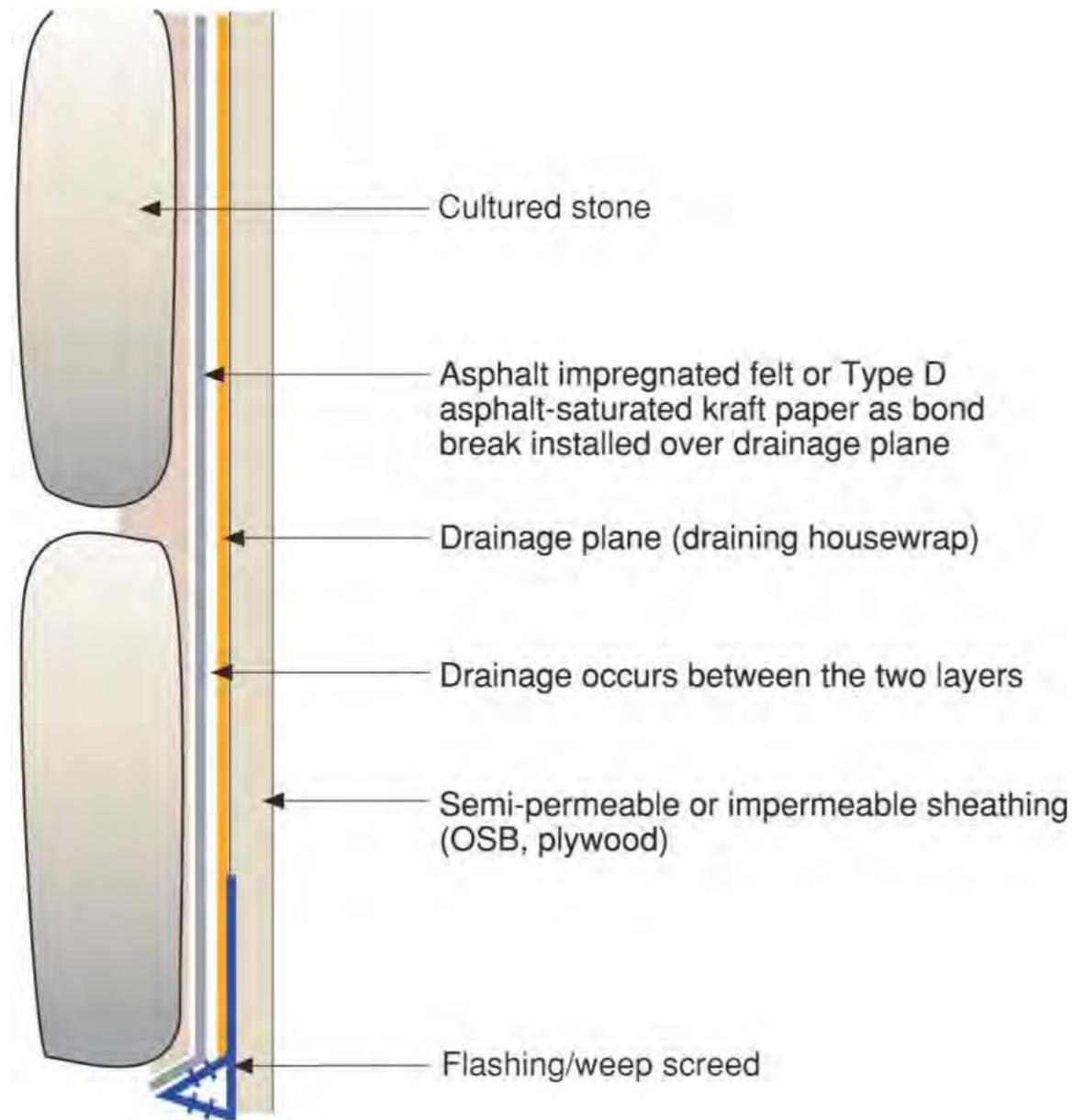
- To effectively uncouple a brick veneer from a wall system by using back ventilation a clear cavity must be provided along with both air inlets at the bottom and air outlets at the top



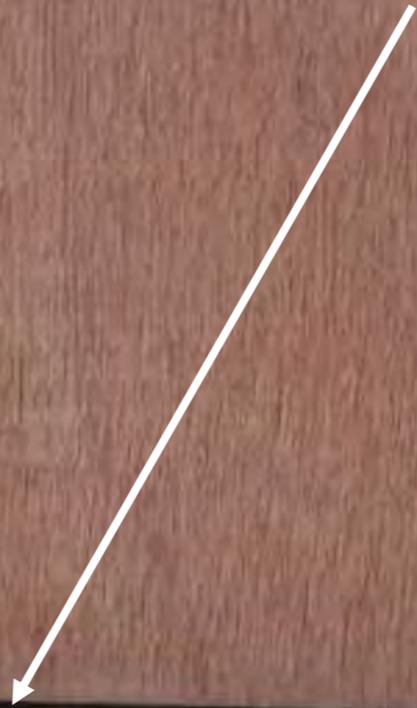


Stone should have drainage and ... ventilation

153



Create an intentional gap
between trim and flashing



Home

WARNING: Tyvek® protective material is slippery and should not be used in any application where it will be walked on. In addition, (because it is slippery) DuPont recommends using kickjacks or scaffolding for exterior work above the first floor. If ladders must be used, extra caution must be taken to use them safely by following the requirements set forth in ANSI Standards 14.1, 14.2, and 14.5 for ladders made of wood, aluminum, and fiberglass respectively.

The DuPont Oval, DuPont™, The miracles of science™, Tyvek® and

**Meets the ASTM E1677 Type I Air Retarder when installed according to
ICBO ES #4000 • BOCA ES #98-46 • S**

1-800-44TYVEK

DUPONT *The miracles*

T3905



Holes Add Up







NO CHILDREN
ADULTS ONLY PLEASE
FITTED ALL 10" TO 14" DIA. PIPES
PART # 8-100

DO NOT USE WITH OTHER BRANDS OF PIPES
OR FITTINGS. THIS DEVICE IS DESIGNED
TO BE USED WITH THE PIPES AND FITTINGS
SPECIFIED IN THE INSTRUCTIONS.
DO NOT USE WITH OTHER BRANDS OF PIPES
OR FITTINGS. THIS DEVICE IS DESIGNED
TO BE USED WITH THE PIPES AND FITTINGS
SPECIFIED IN THE INSTRUCTIONS.

Electrical Box Panel



PANEL INSTALLATION:
Step 1) Push panel on over electrical box. Panel collar edge **MUST** be flush with box opening edge.

LATHING INSTRUCTIONS:
Step 1) Place building paper (weather resistive barrier) up behind bottom of panel to bottom of box.



Step 2) Place 2nd layer of building paper over top of panel to bottom front edge or further down. Cut paper around protrusion. Now, ready for your choice of exterior finishes.

(IMPORTANT: See Quickflash's Electrical Cross Reference Sheet for box compatibility)

Plumbing Pipe Panel



PANEL INSTALLATION:
Step 1) Push panel on over pipe (flush with structure) for a no caulk weatherproof seal.

LATHING INSTRUCTIONS:
Step 1) Place building paper (weather resistive barrier) up behind bottom of panel to bottom of pipe.



Step 2) Place 2nd layer of building paper over top of panel to bottom front edge or further down. Cut paper around protrusion. Now, ready for your choice of exterior finishes.

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

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CARRIER

WEATHER

FOR VERTICAL STRUCTURE APPLICATION ONLY
MADE IN USA



WEATHER
PART # 6 502



REPLACES YOUR OLD
Made in the USA



Water Managed Foundations

162

- Types and design strategies

When below grade....

- Remember the rules:
 - Moisture is present
 - Insects are close by
 - Soil gas can enter
 - Surfaces can be cool
 - Concrete wicks water
 - Foundations can be very challenging

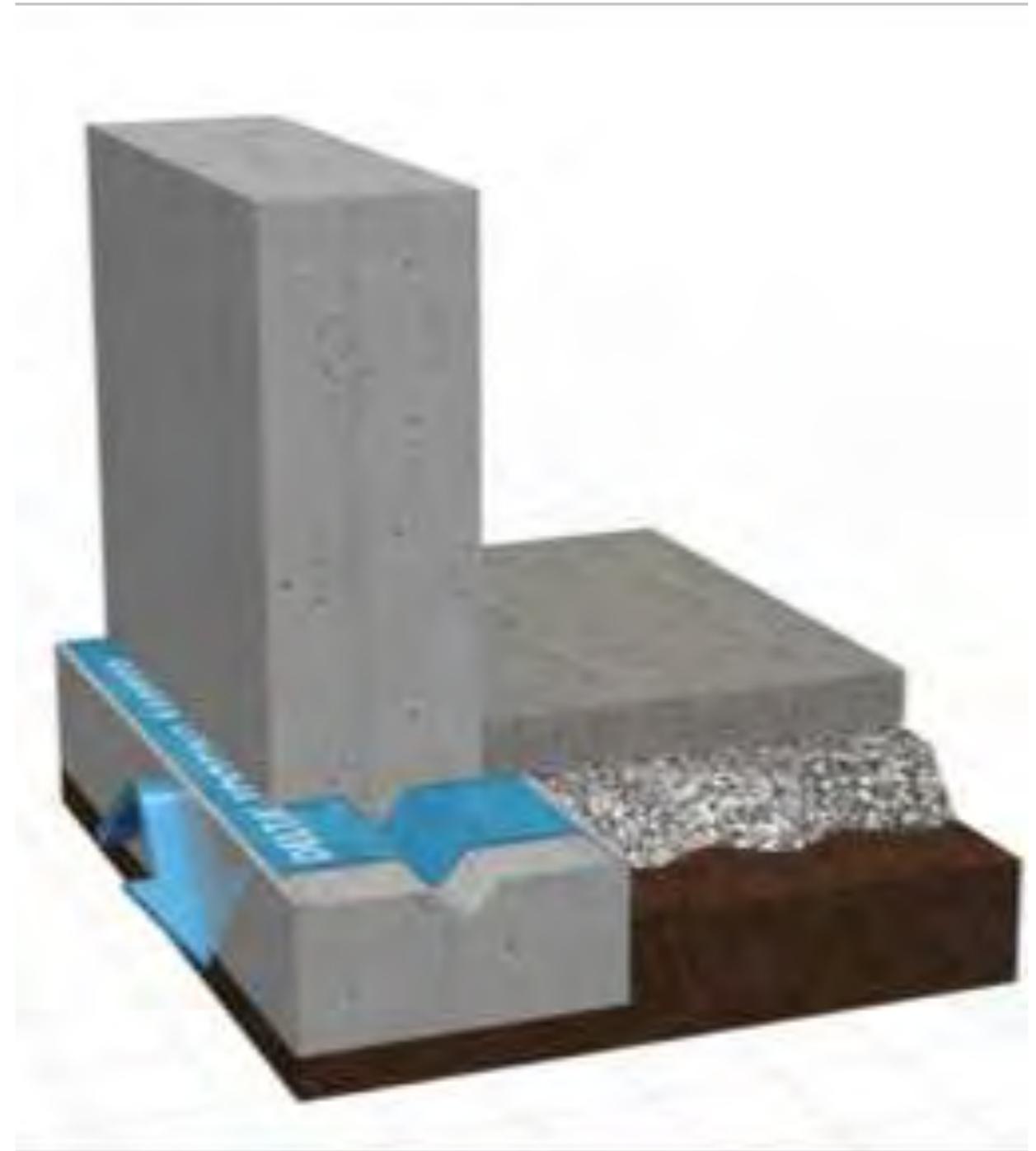
Foundation systems



Capillary break applied between footing and foundation wall

165

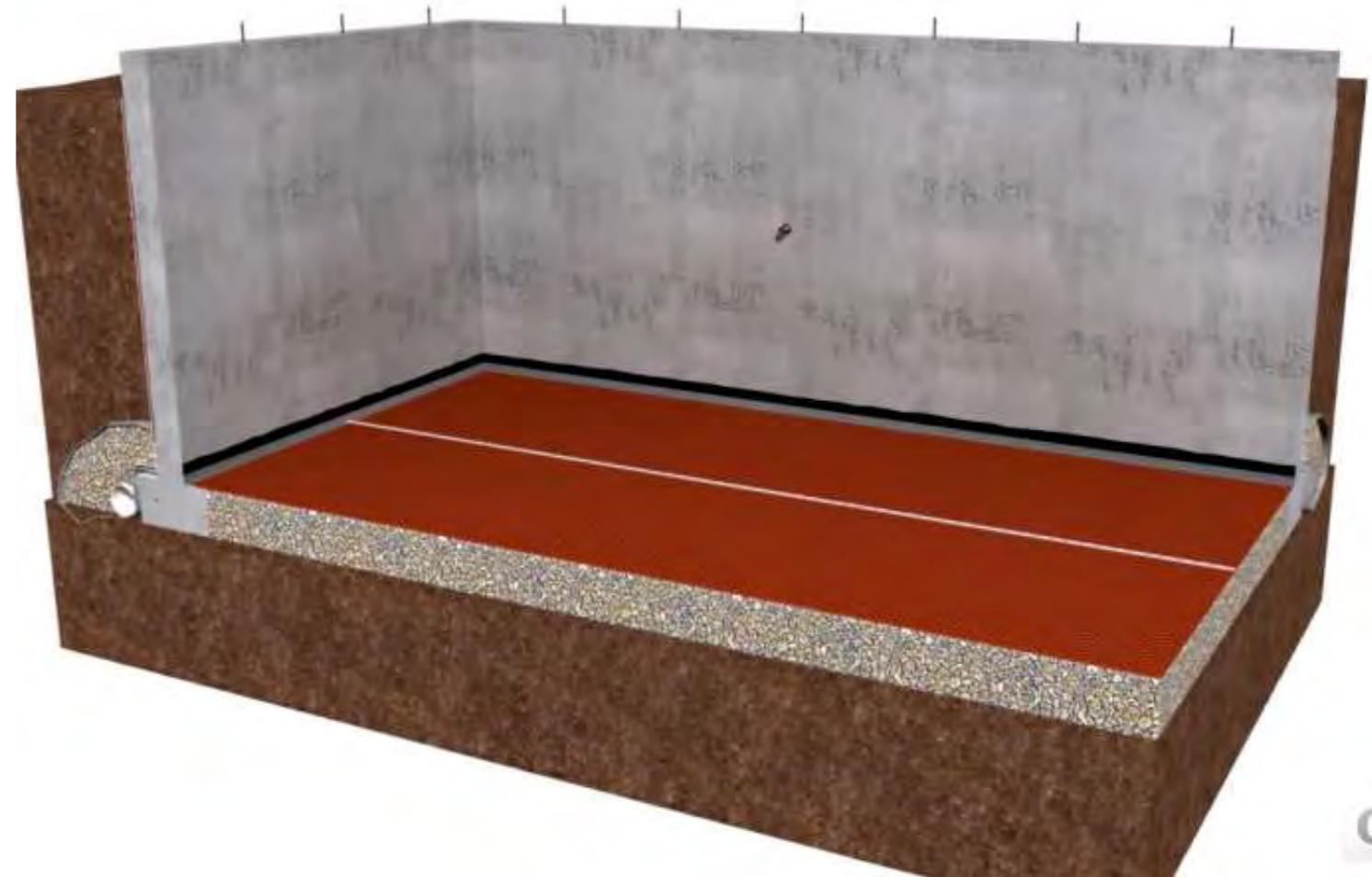
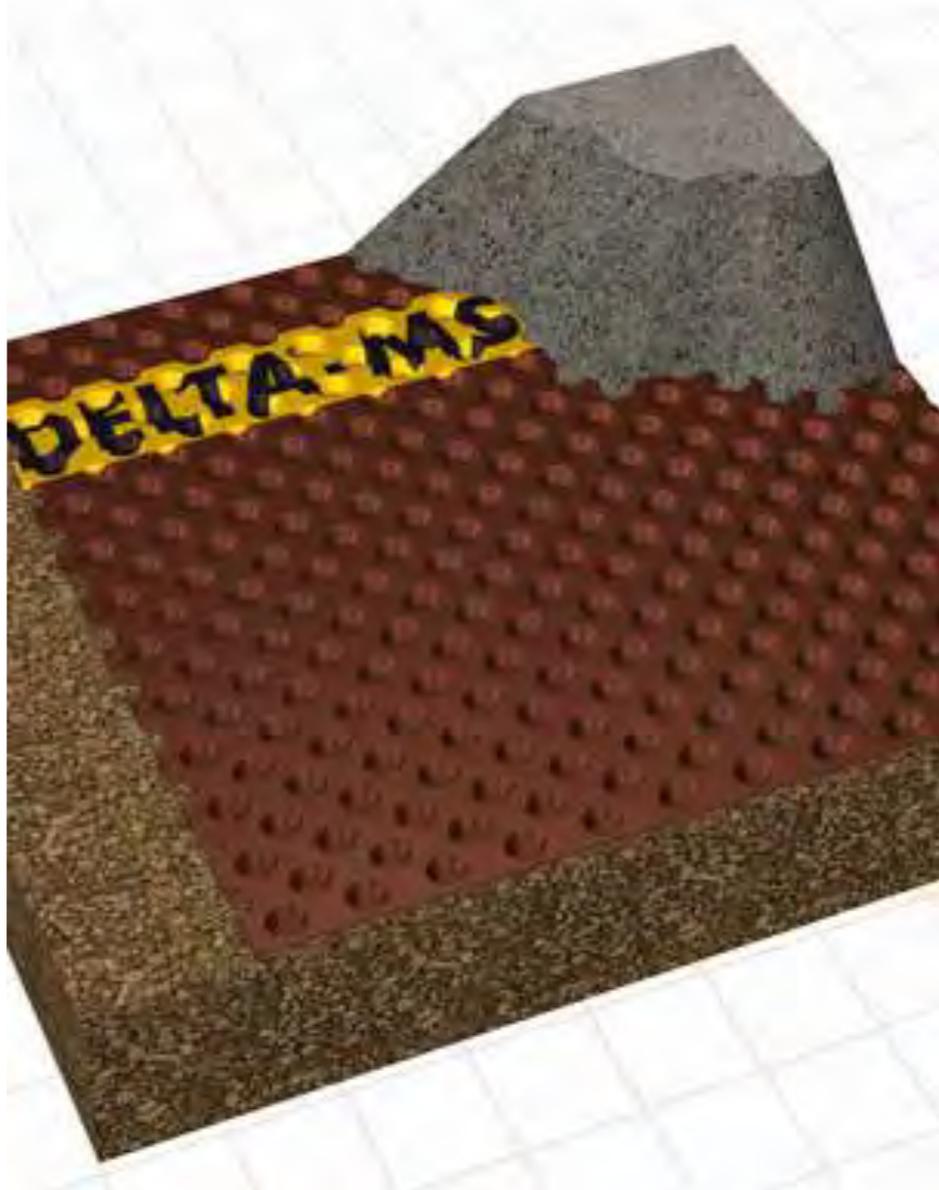
- Required whenever one porous component meets another
- Footing/slab to foundation wall
- Foundation wall to framing
- Under slabs-on grade



Footing to foundation connection



Membrane under-slab



Drainage Board Application



DELTA-DRAIN TO BE INSTALLED IN ROWS FROM BOTTOM TO TOP OF WALL, OVERLAPPING SHINGLE-STYLE



Foundation Insulation

170

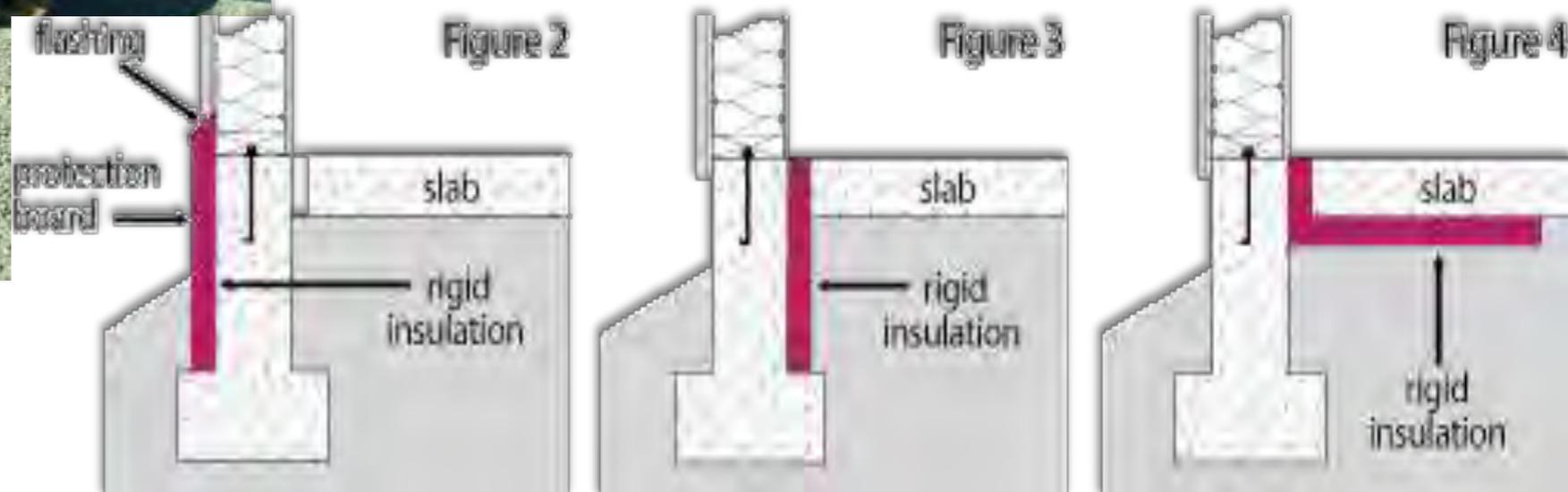


Insulation - Slab Perimeter

- Heat loss is significant - 30% - 50% - in the heating season through an un-insulated slab (FOREVER!!)
- Slab perimeter insulation strategies (vertical, horizontal, interior, exterior)

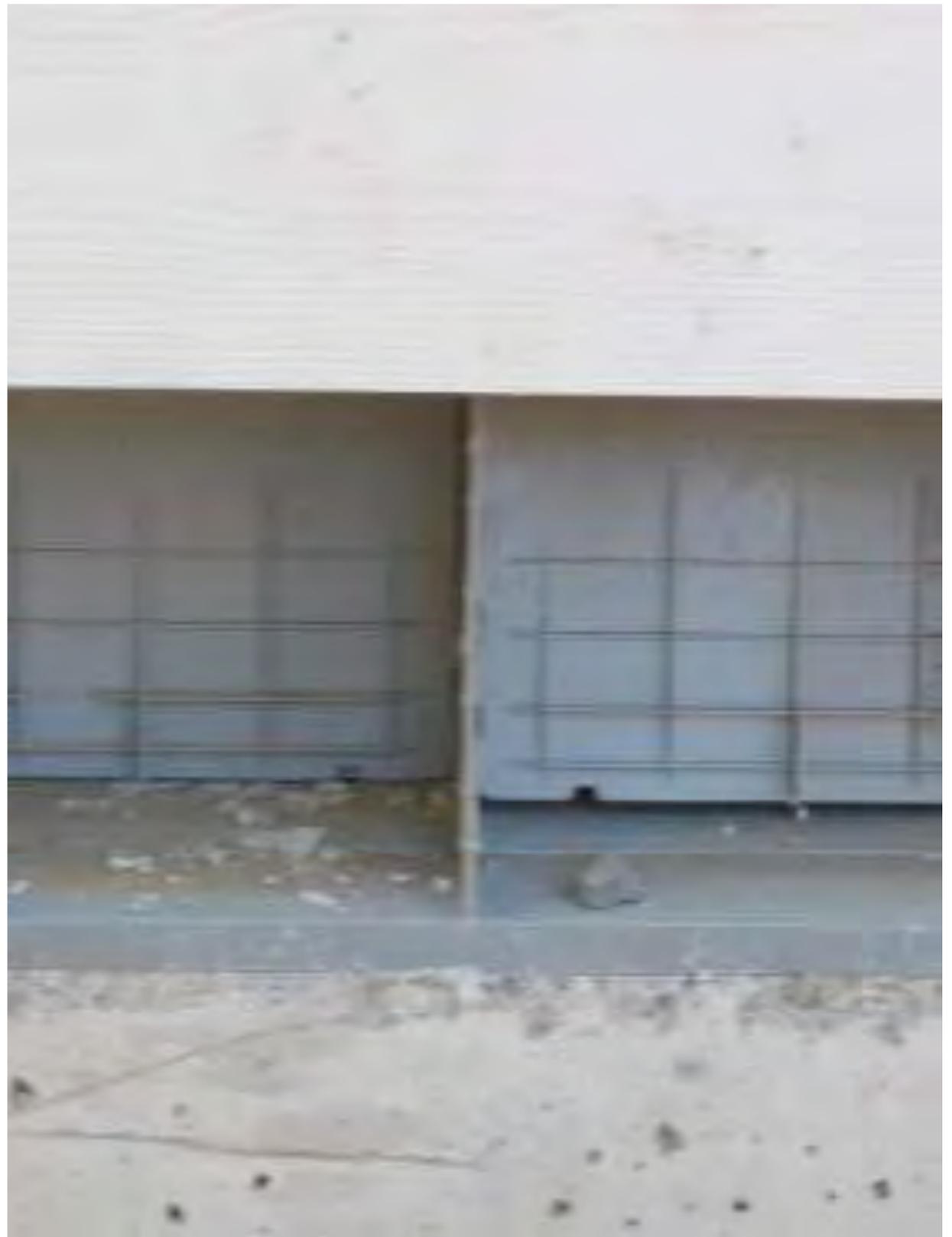


See EEBA Builder's Guide for details



Same house, same time of year, which one is right?

172



Insulating a crawl space floor is difficult and often ineffective

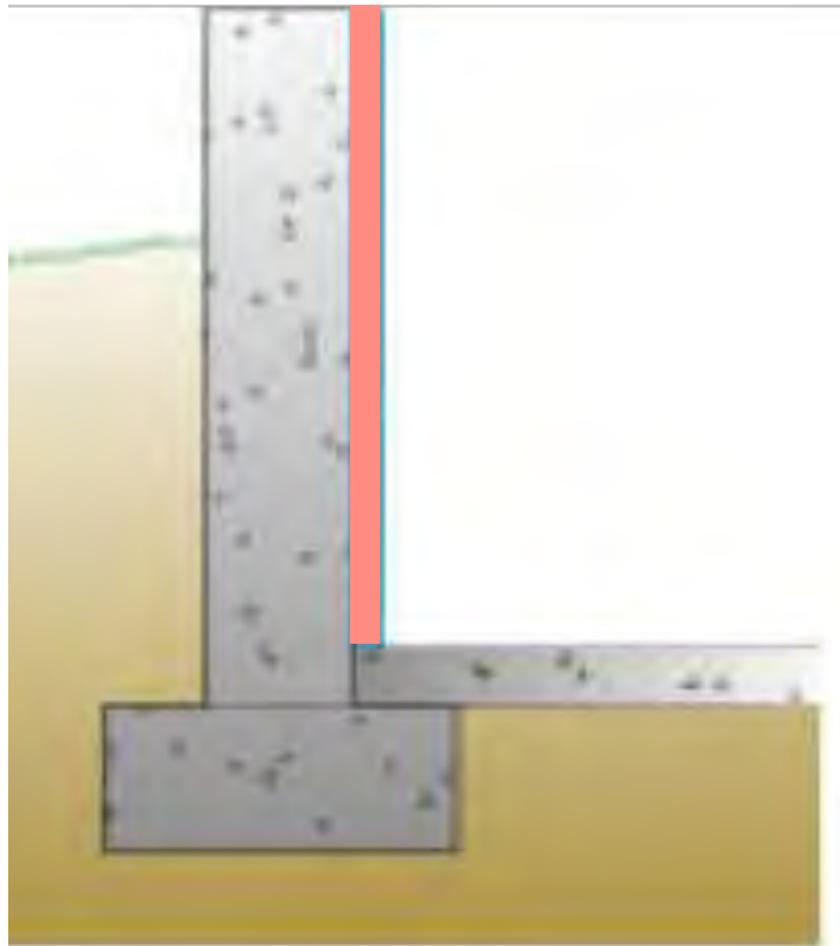
173



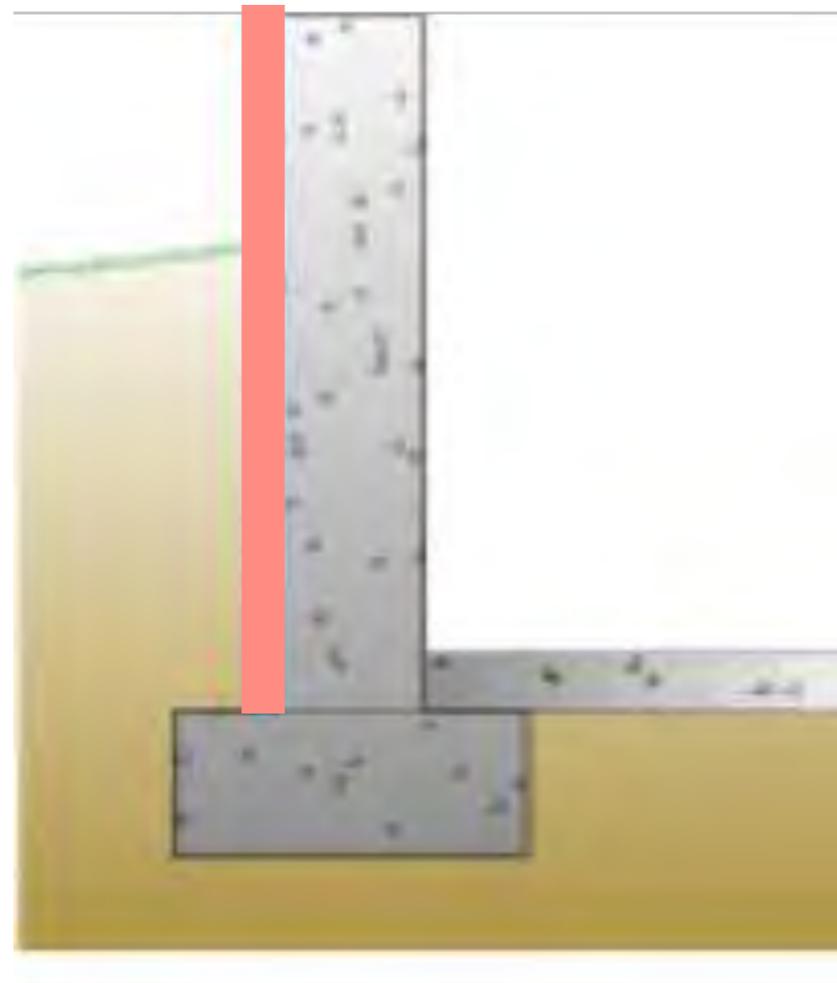


Basements need thermal insulation

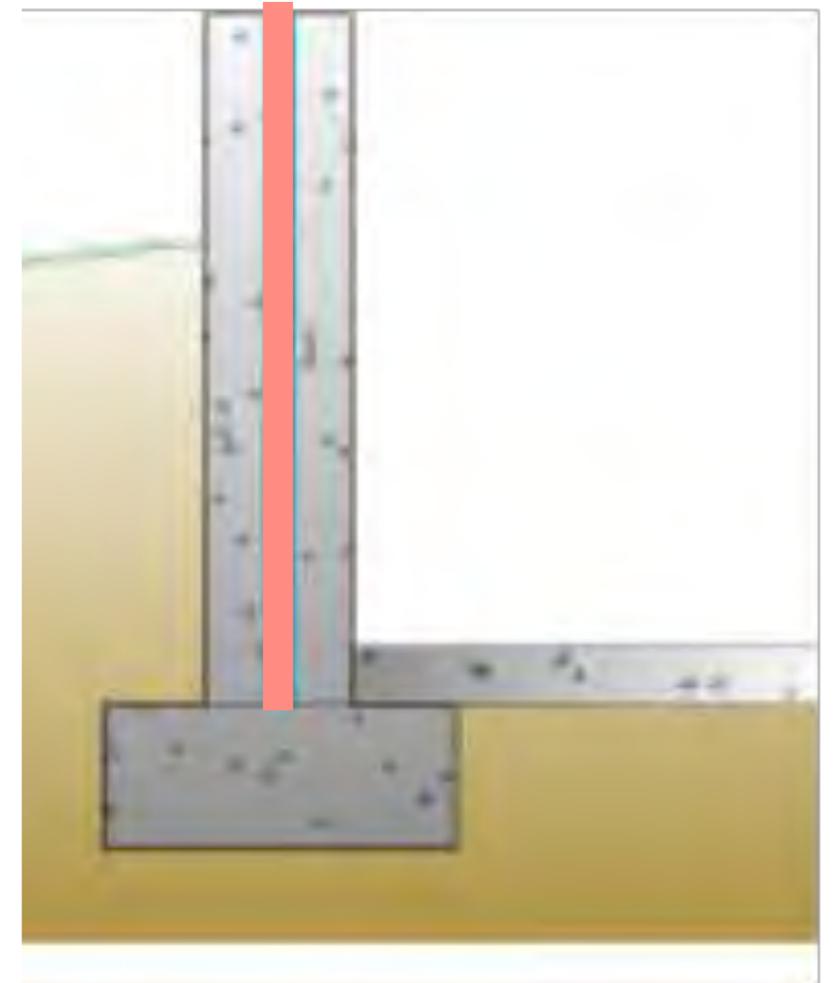
Foundation type, climate and soil conditions all affect performance



Internally
Insulated

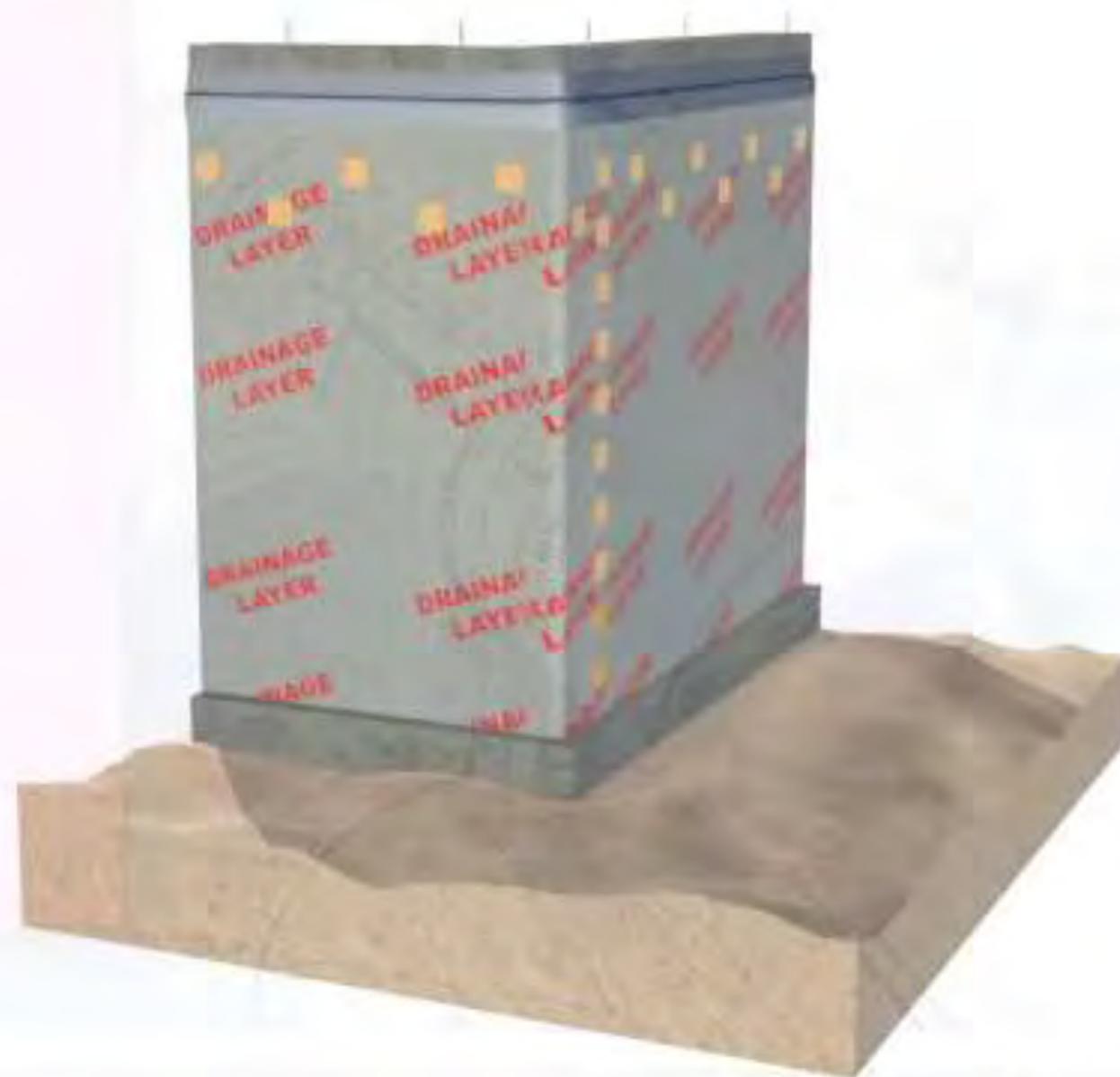


Externally
Insulated



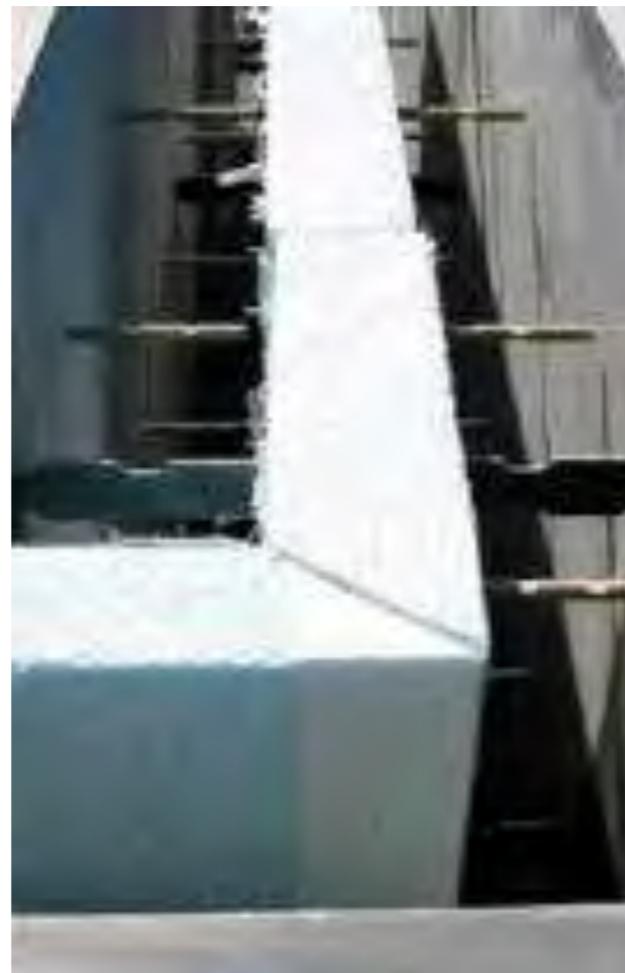
Insulated inside
the wall

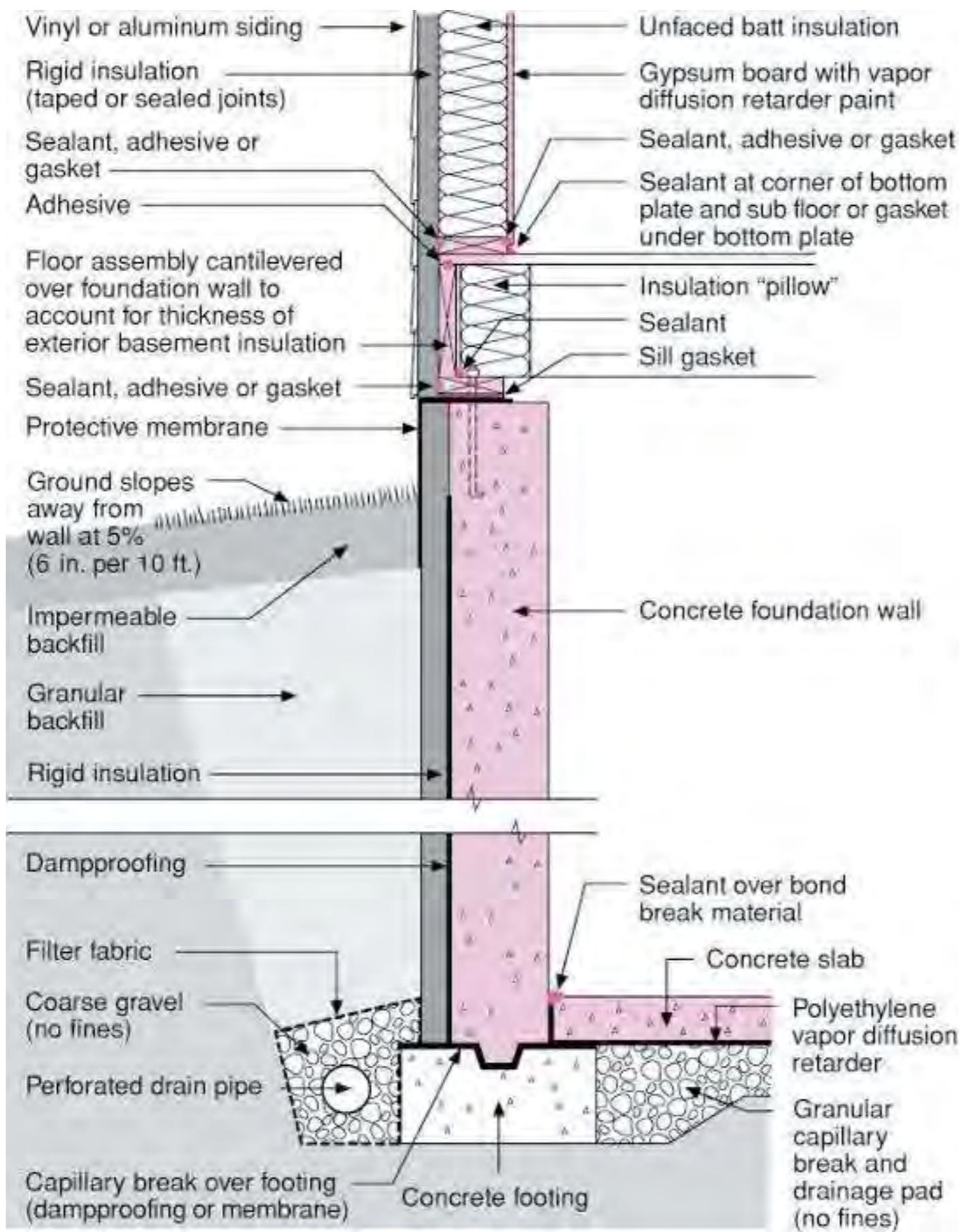
Basement Slab Insulation

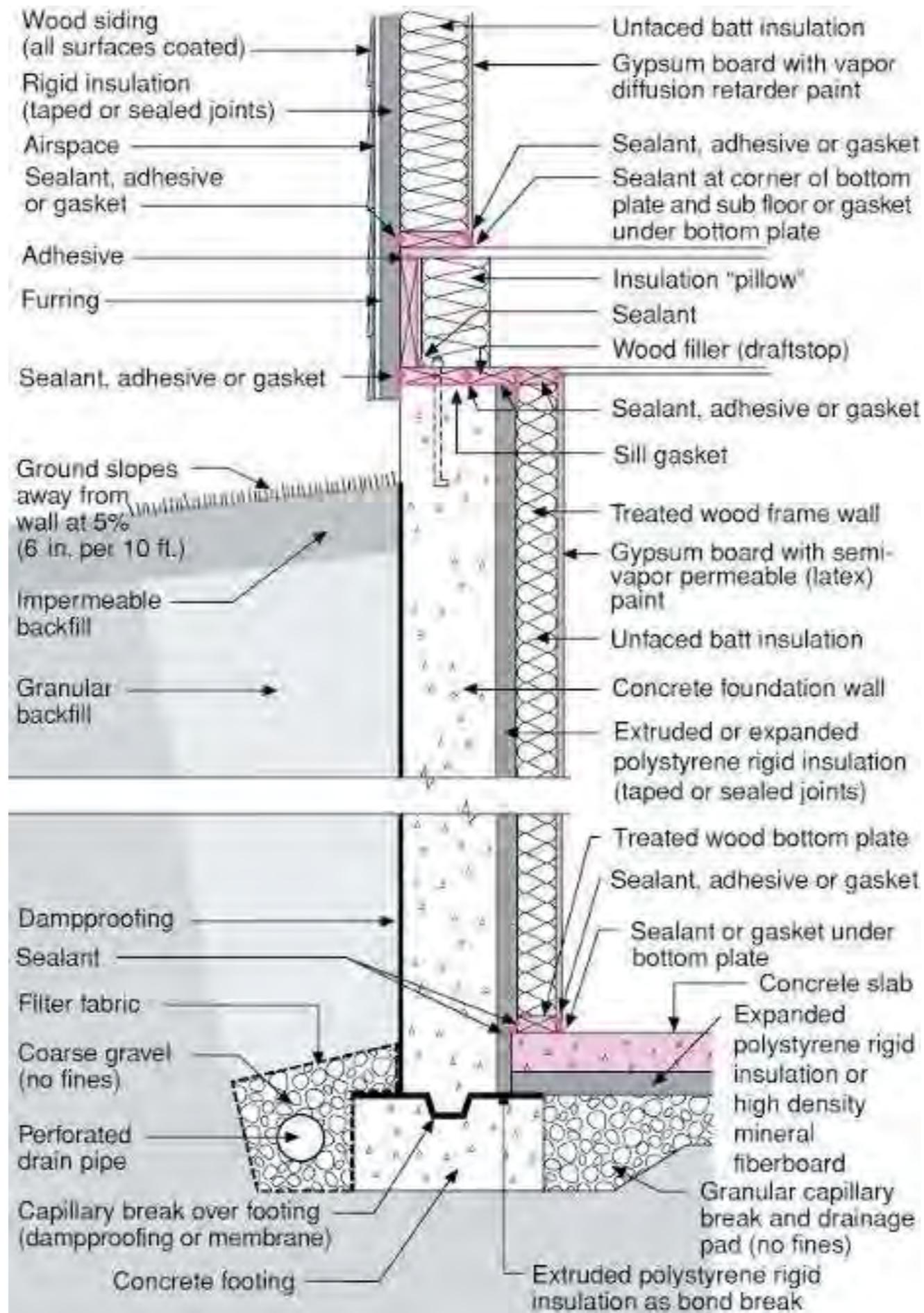


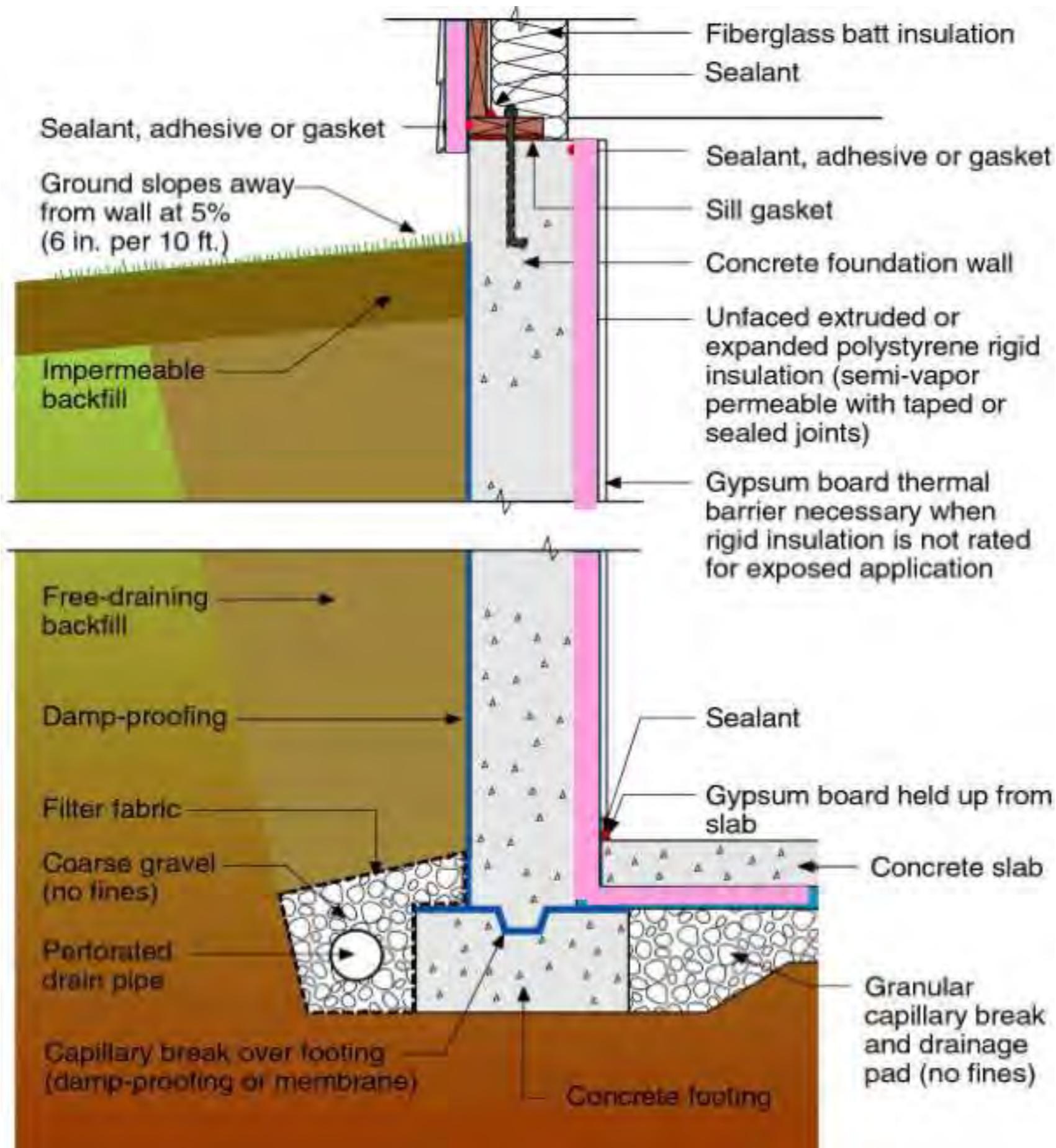
Types

- Block
- Poured
- ICF
- T-bar type
- Precast
- Wood



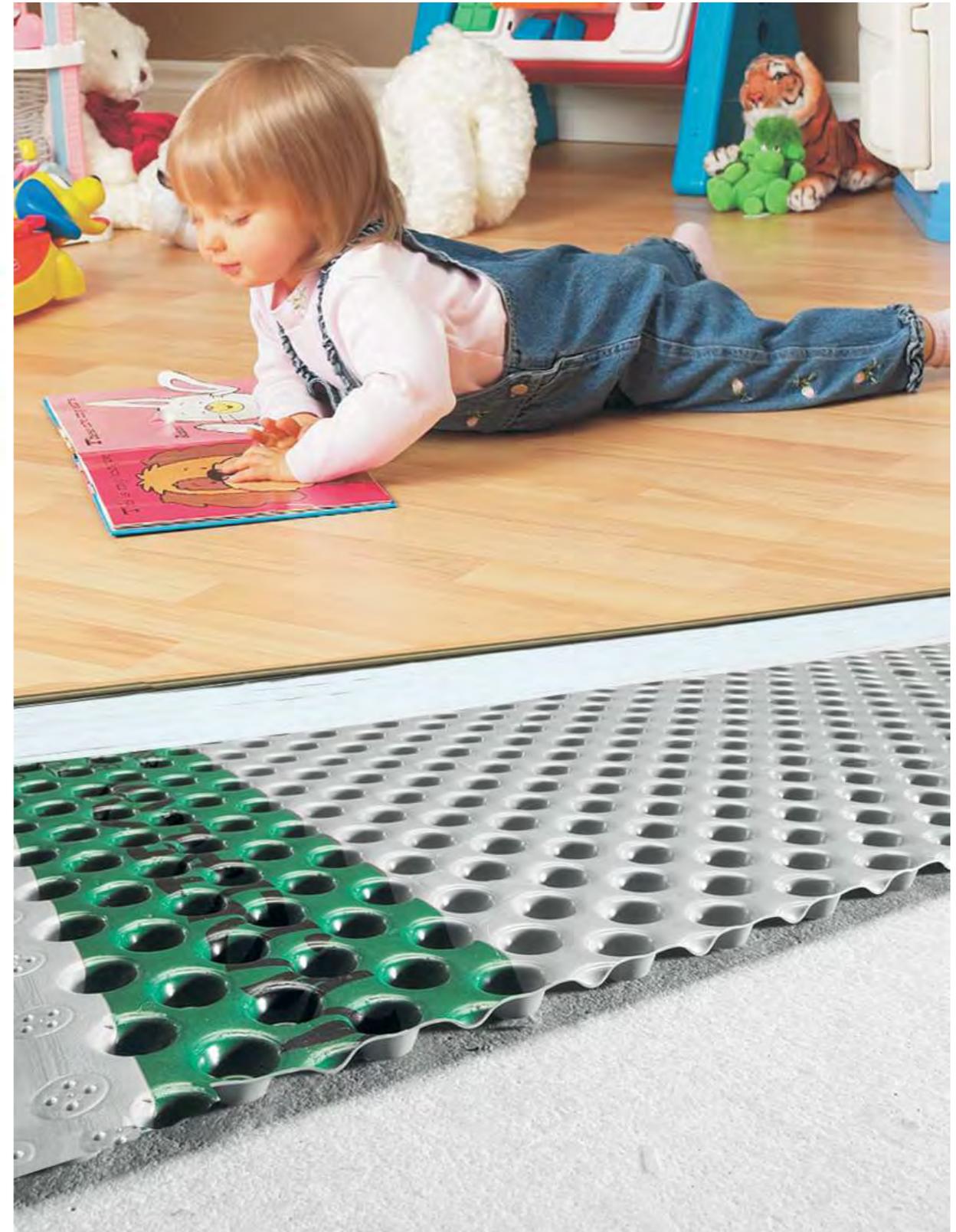
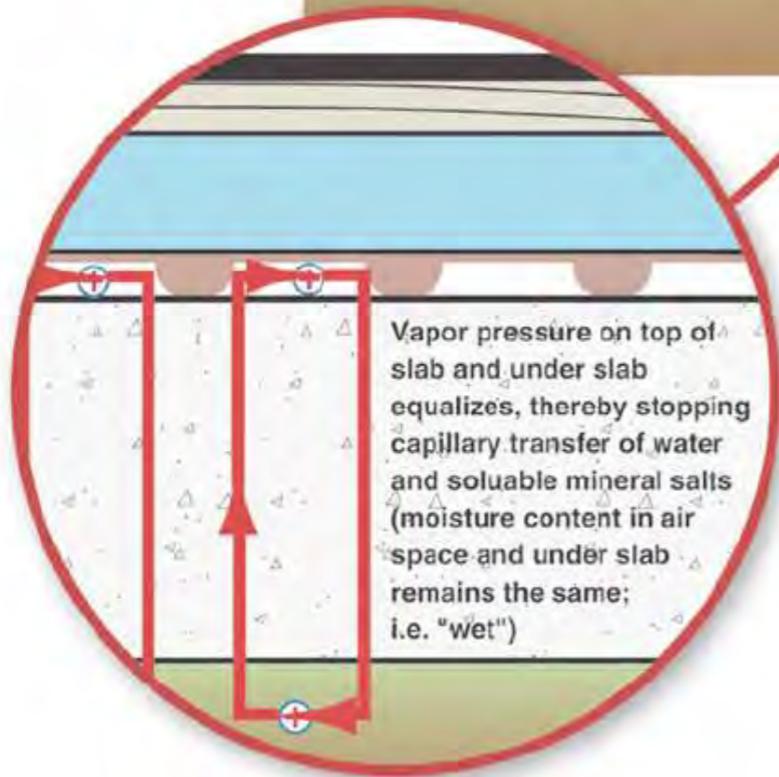
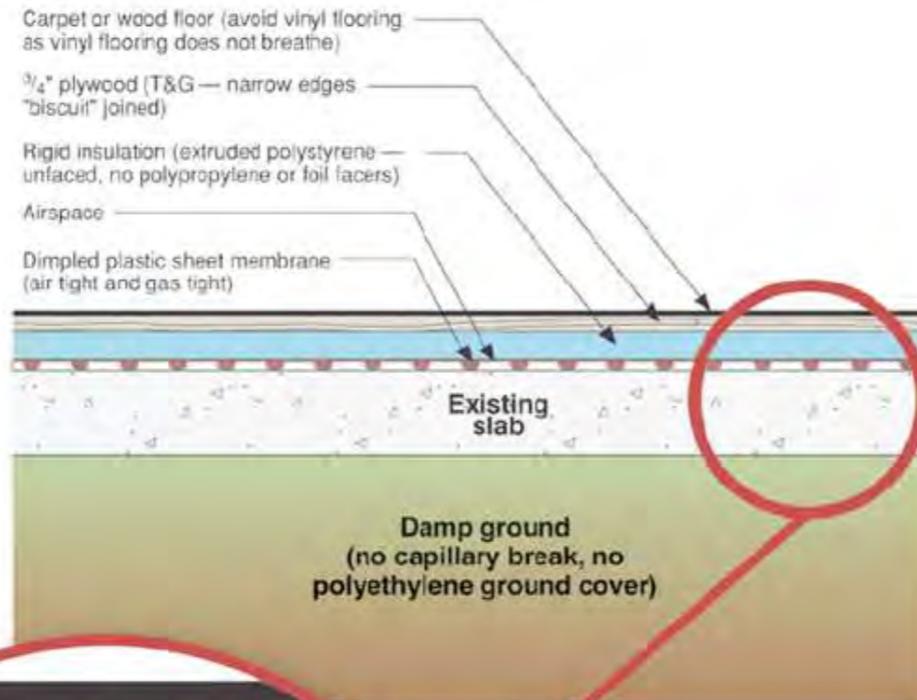








Membrane over slab



Insulated Concrete Forms

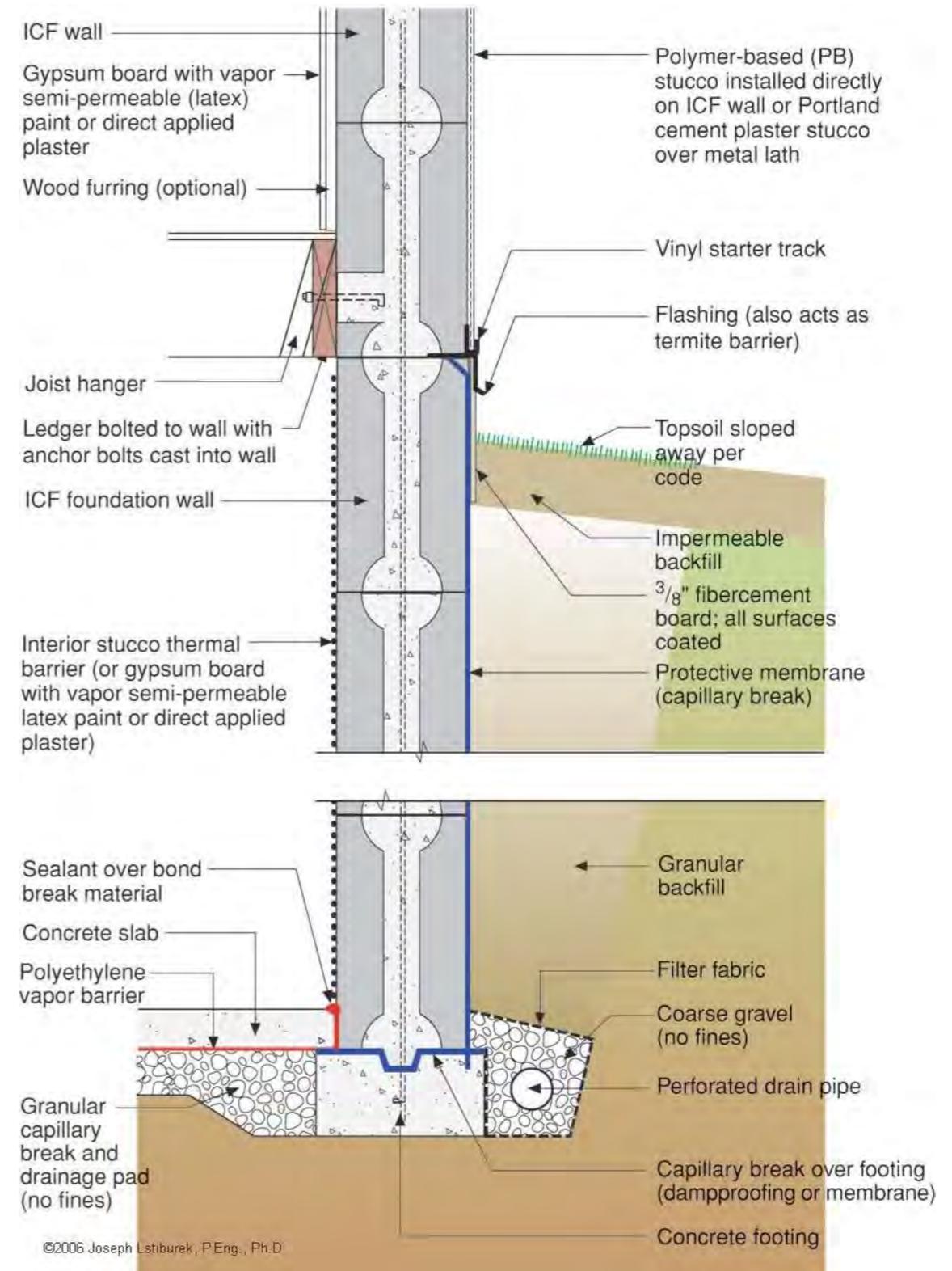
184

- An innovative and proven technology for foundations and walls

Insulated Concrete Forms

185

- Allows for controlled drying towards the interior
- Insulation and foundations in one system
- Interior finished can be directly applied
- Remember the capillary break



ICF Wall

187



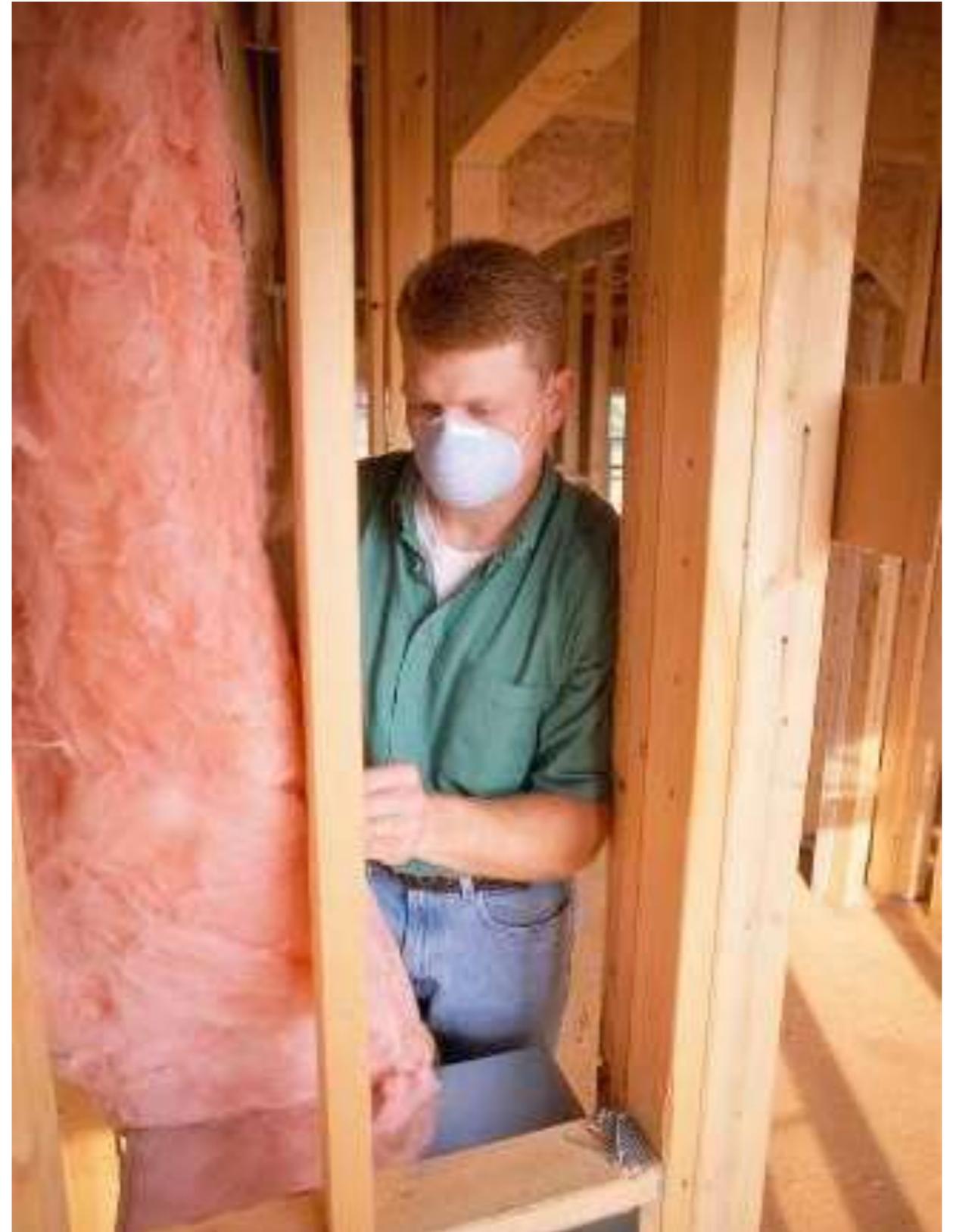




A wall system needs to perform

195

- Provide strength & rigidity
- Be durable
- Control light & solar gain
- Control noise
- Control rain penetration
- Control air flow
- Control heat flow
- Control water & vapor flow

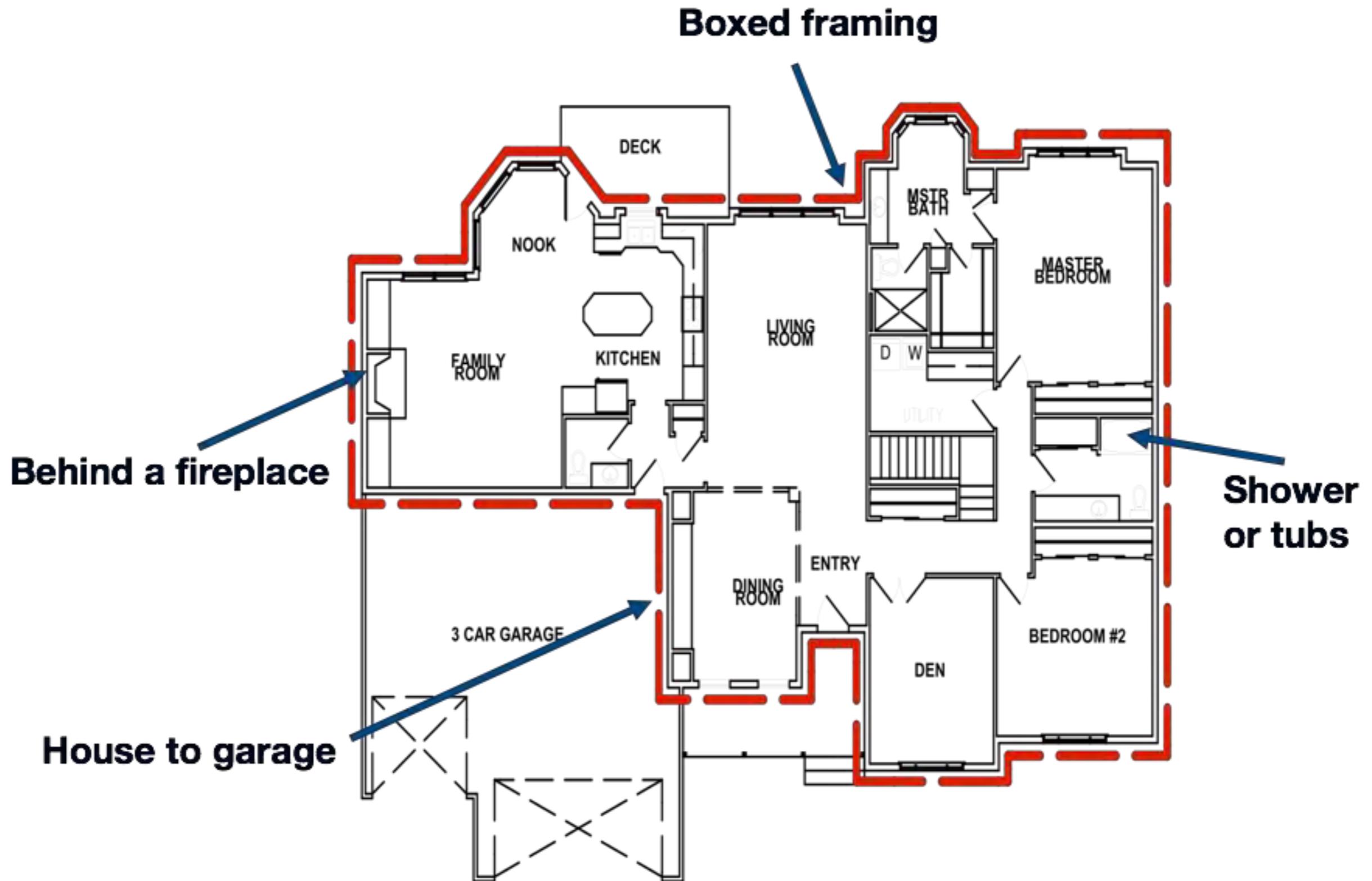


Air Barriers

- Air Barriers are systems of materials
- Designed and constructed to control air flow between a conditioned space and an unconditioned space
- Air barrier system is the primary air enclosure boundary that separates indoor (conditioned) air and outdoor (unconditioned) air

Define breaks and create a plan to manage them

198



Common Holes We Miss

Plumbing
HVAC
Electrical
Framing Holes
Soffits
Behind Tubs
Chimney Shafts
Cantilevers



Air Sealing Bang-For-Your-Buck Ranking

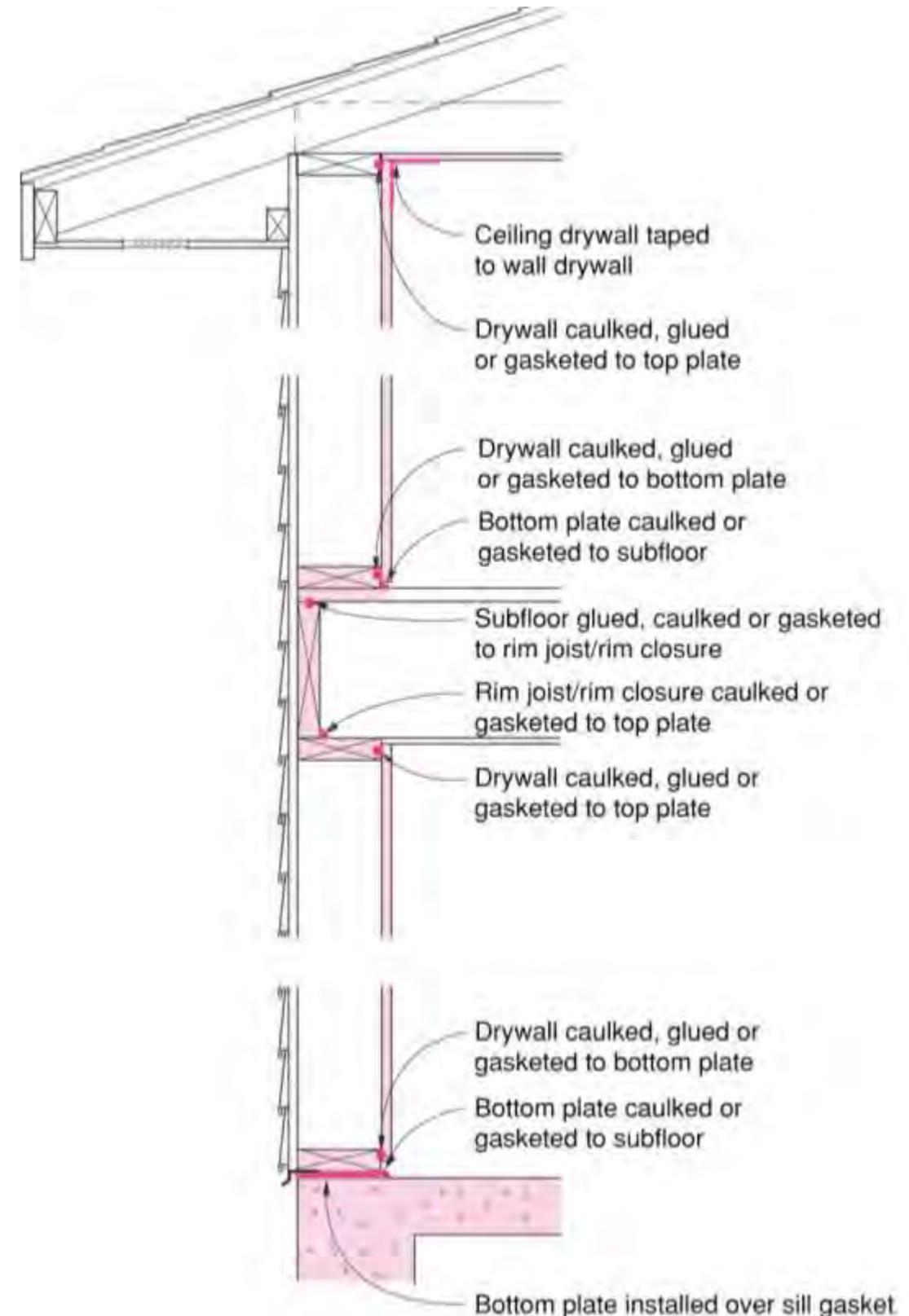
JOINT/OPENING	CFM50*	ACH50†
top plate-to attic	0.29 to 0.68 per foot	0.29 to 1.6
duct boot	7.7 per boot	0.13 to 0.26
recessed light	9.1 per light	0.15 to 0.31
band joist (top & bottom)	0.86 per foot	0.37 to 0.42
garage-house common wall	0.60 per foot	0.14 to 0.26
sheathing-to-plate (top & bottom)	0.074 to 0.62 per foot	0.040 to 0.38
window/door framing-to-sheathing	0.031 to 0.11 per foot	0.020 to 0.10
between exterior top plates	0.10 to 0.11 per foot	0.033 to 0.046
corners (interior pointing)	0.024 to 0.21 per foot	0.0021 to 0.032
corners (exterior pointing)	0.054 to 0.45 per foot	0.0069 to 0.11
bottom plate-to-subfloor	0 to 0.11 per foot	0 to 0.11
vertical sheathing joints	0.010 to 0.090 per foot	0.011 to 0.11
sill plate-to-foundation‡	0 to 0.030 per foot	0 to 0.025

A very helpful OC research project

Air Flow Barrier-Interior

201

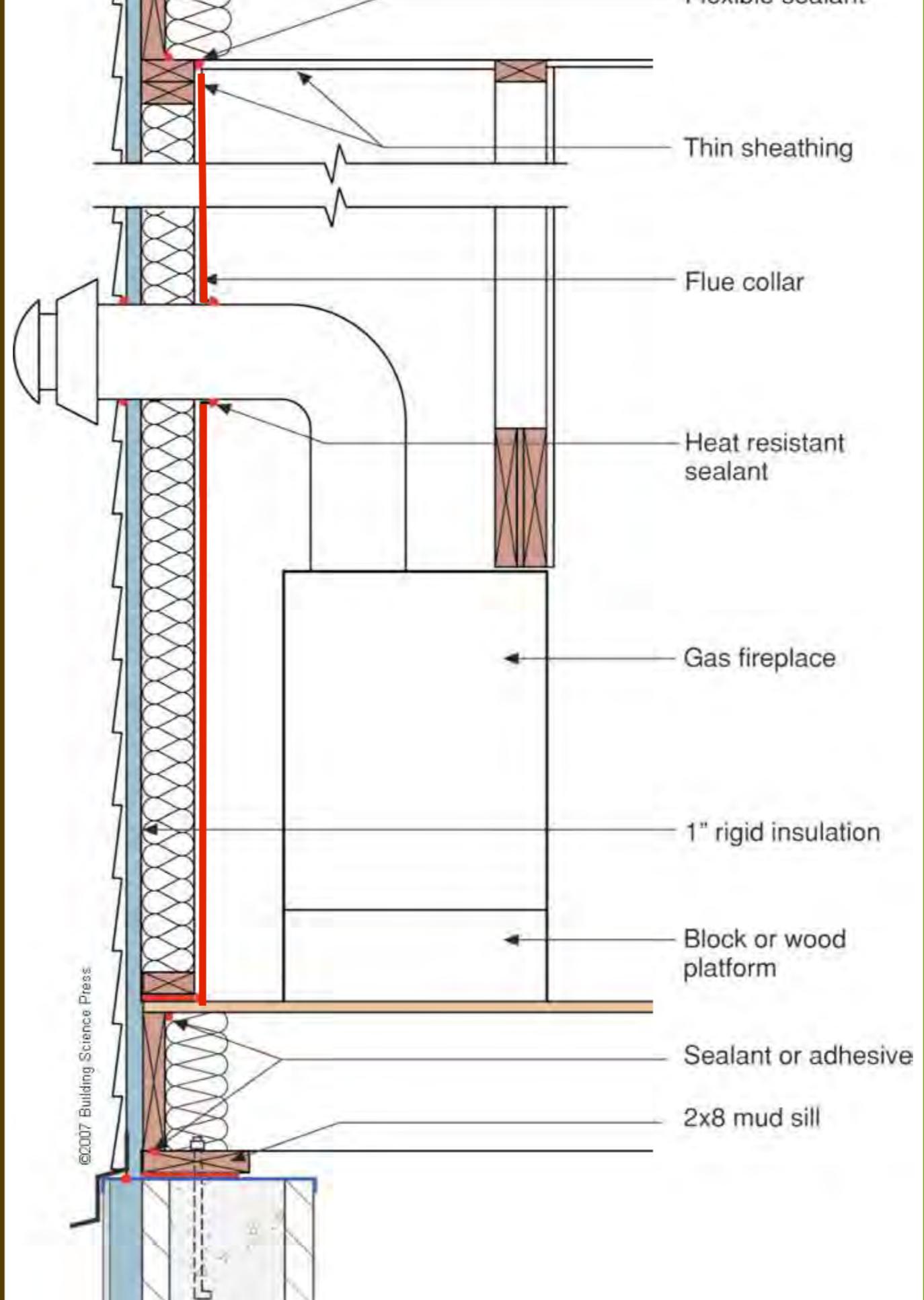
- Airtight Drywall Approach
- Connecting and sealing the materials to stop air flow
- Must be continuous through all penetrations





Tighter is better - any concerns?

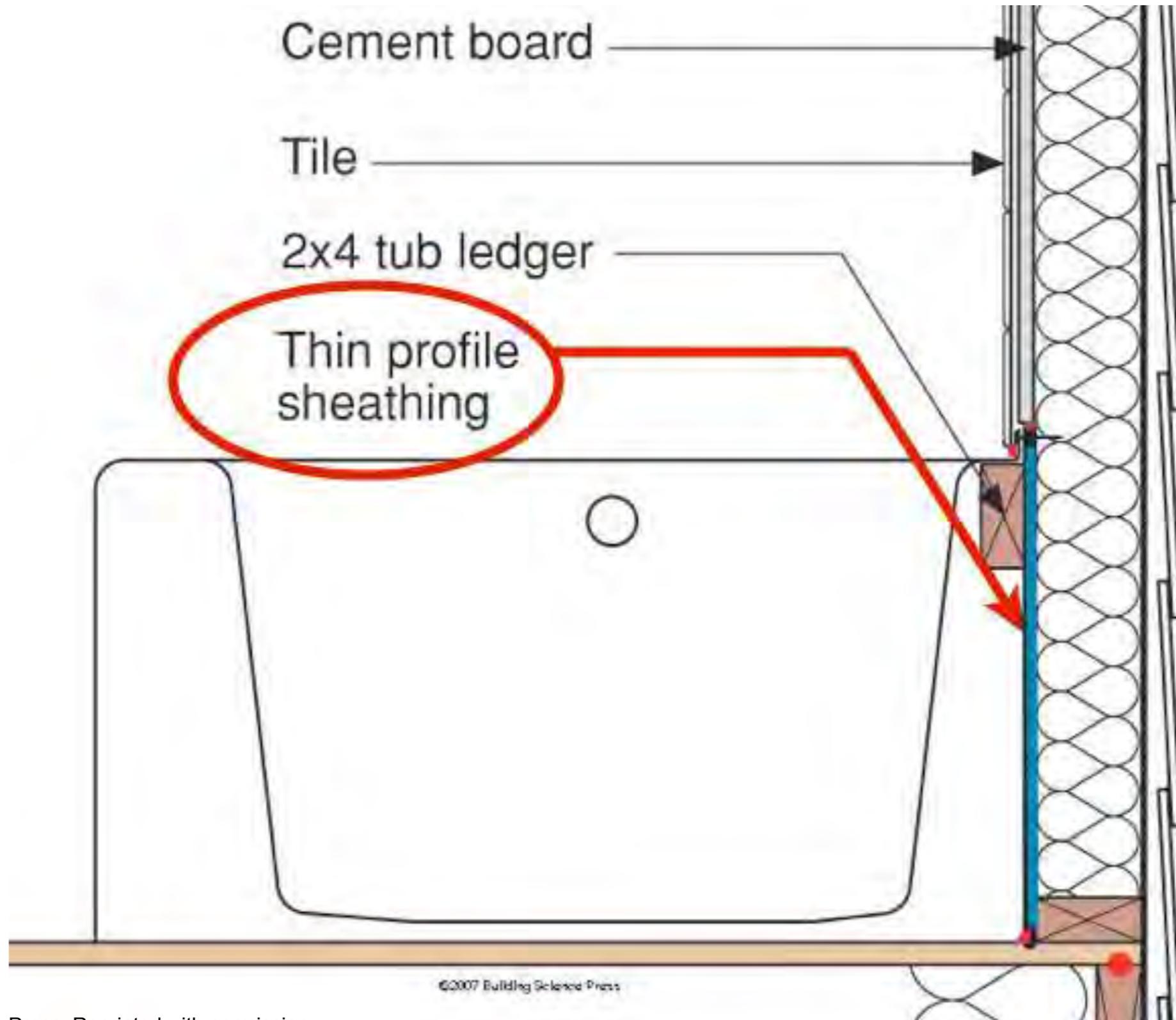
Air barrier at fireplace



Chimney shafts and penetrations



Tub Air Sealing



Prepare for the tub before the plumber arrives

207



Provide rigid blocking

208





Air-seal connections at house to garage

210



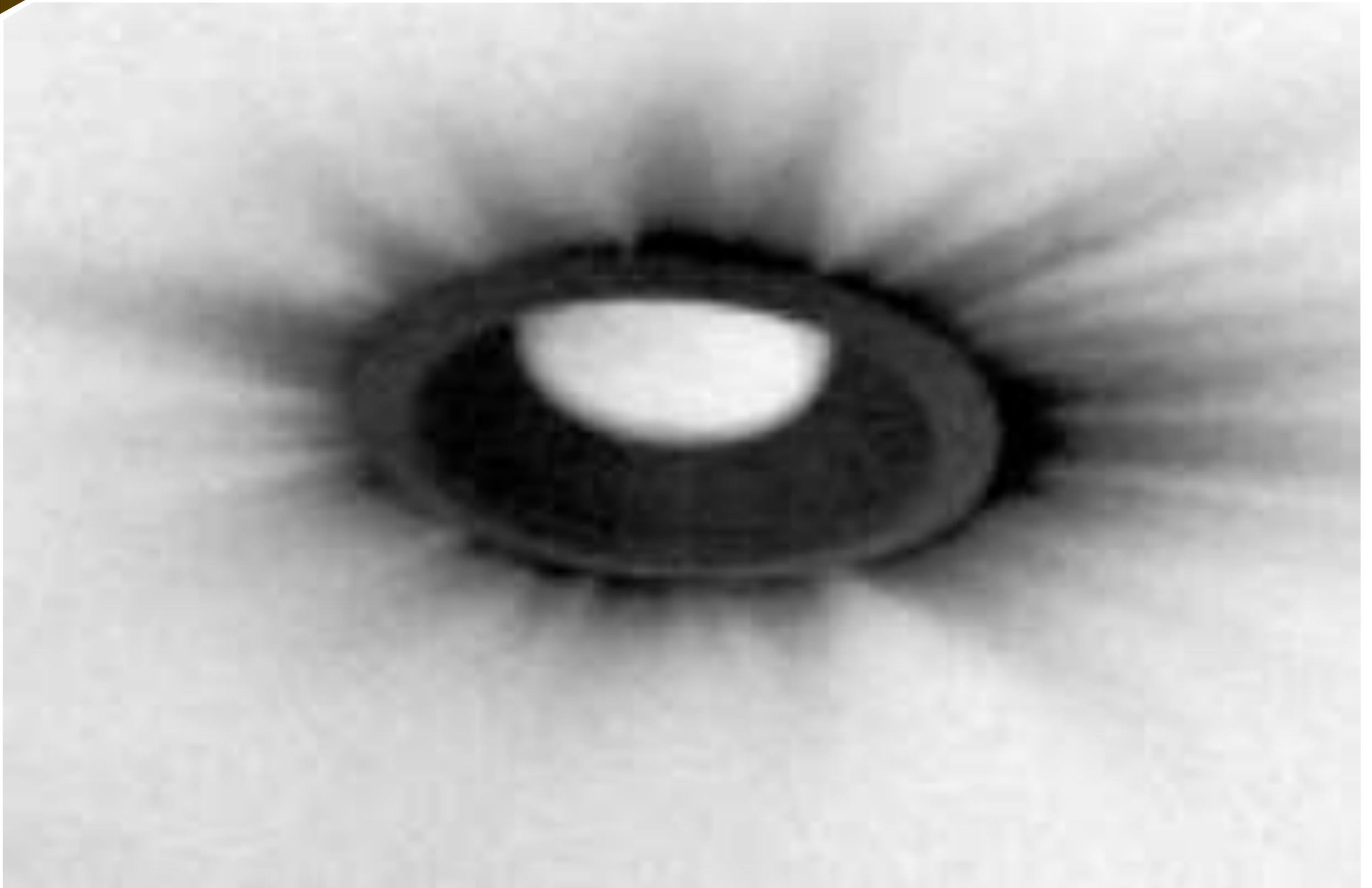
Plumbing, electrical & HVAC penetrations need attention

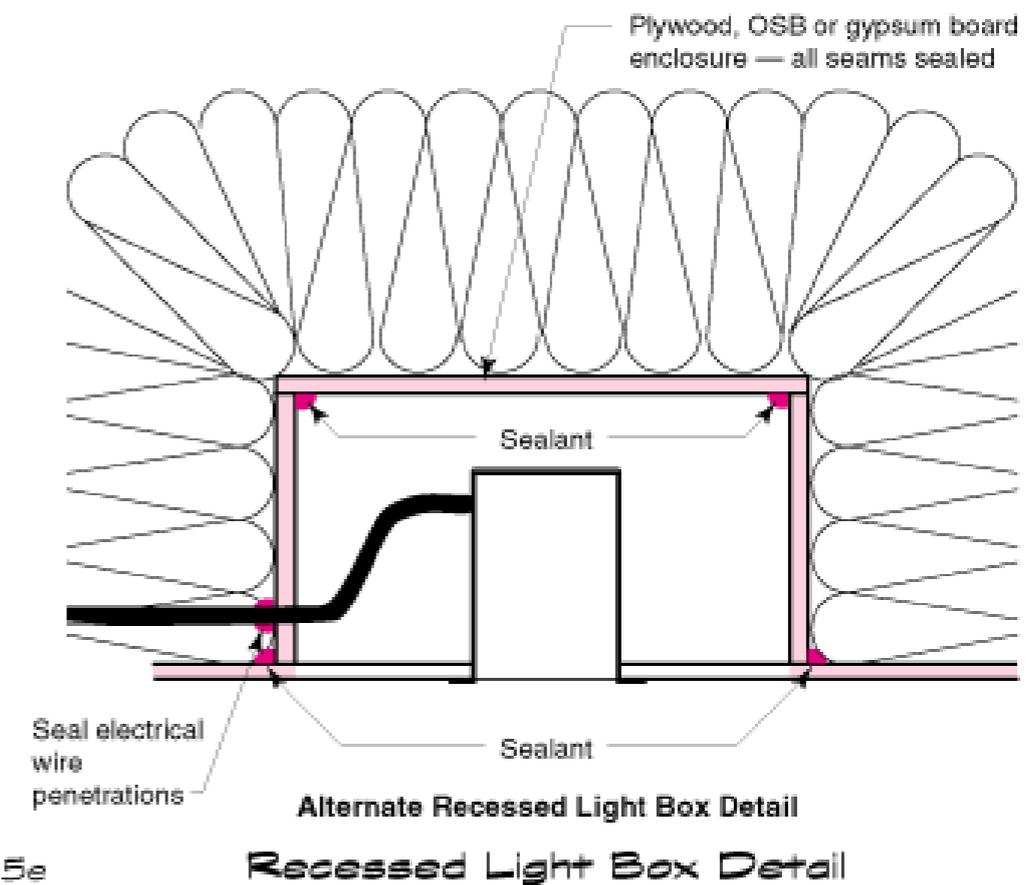
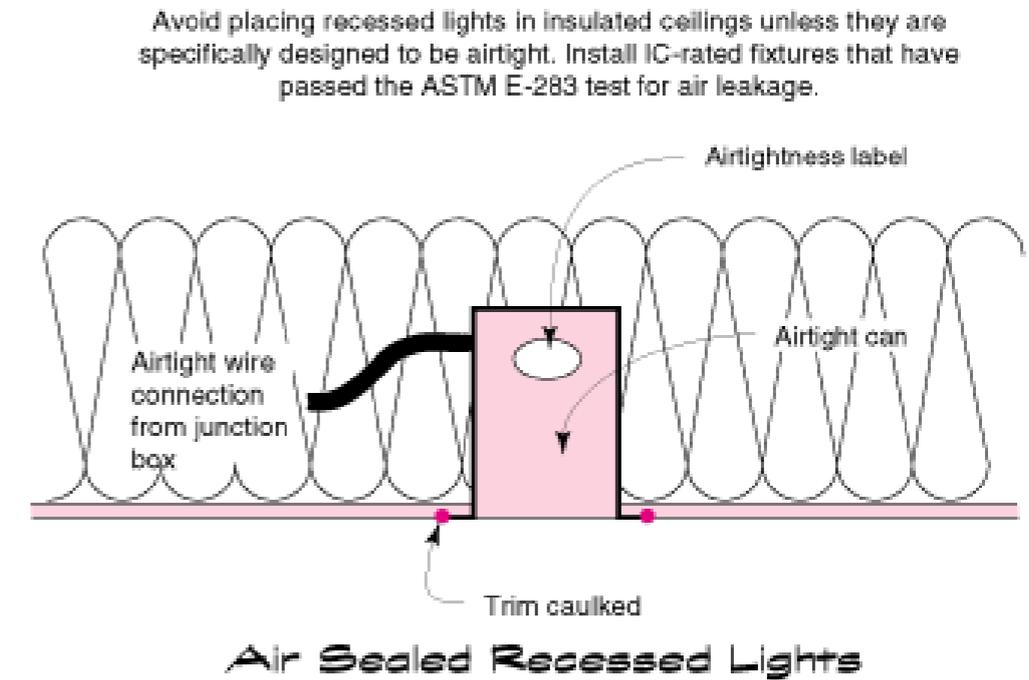
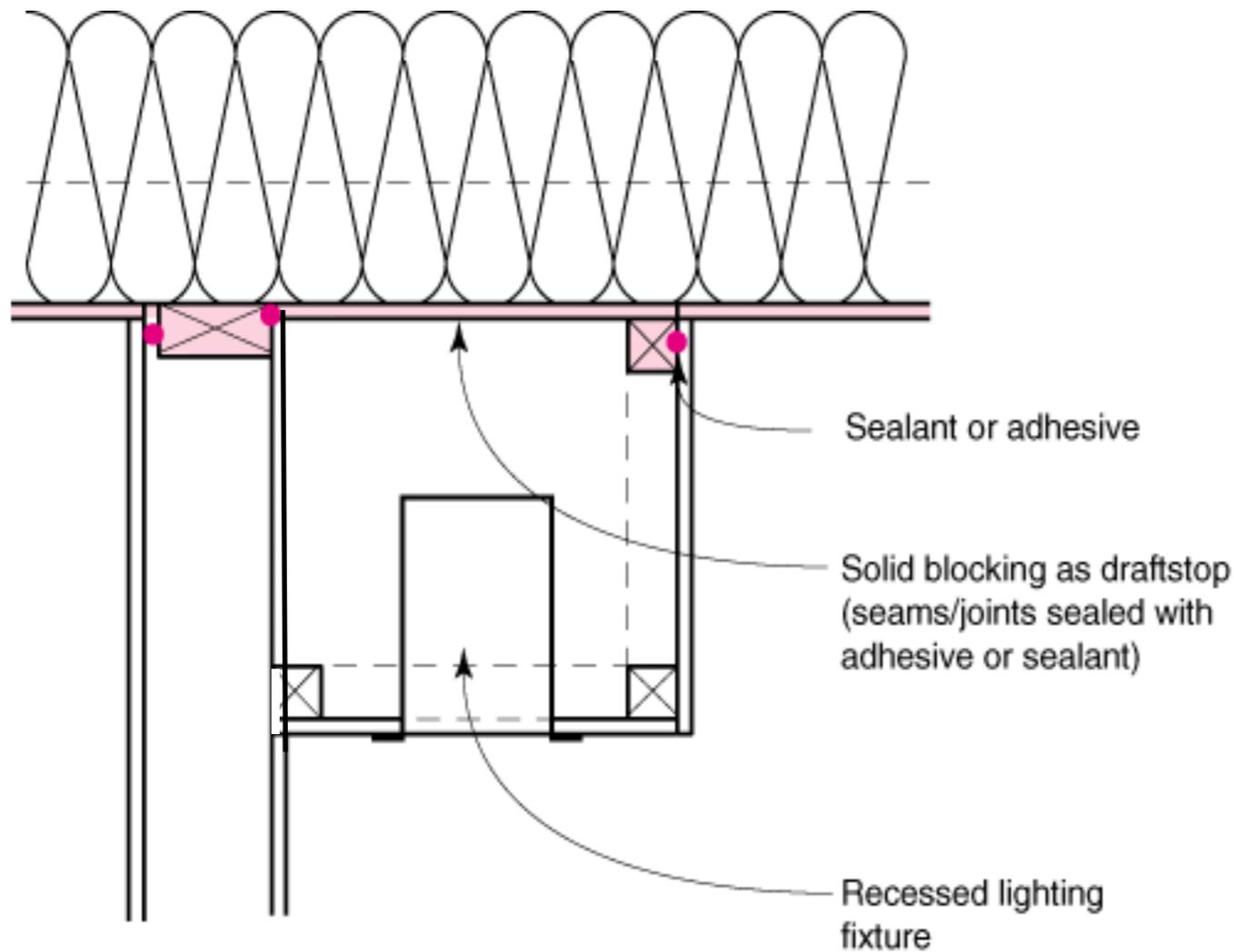




Air Leakage at recessed light

213



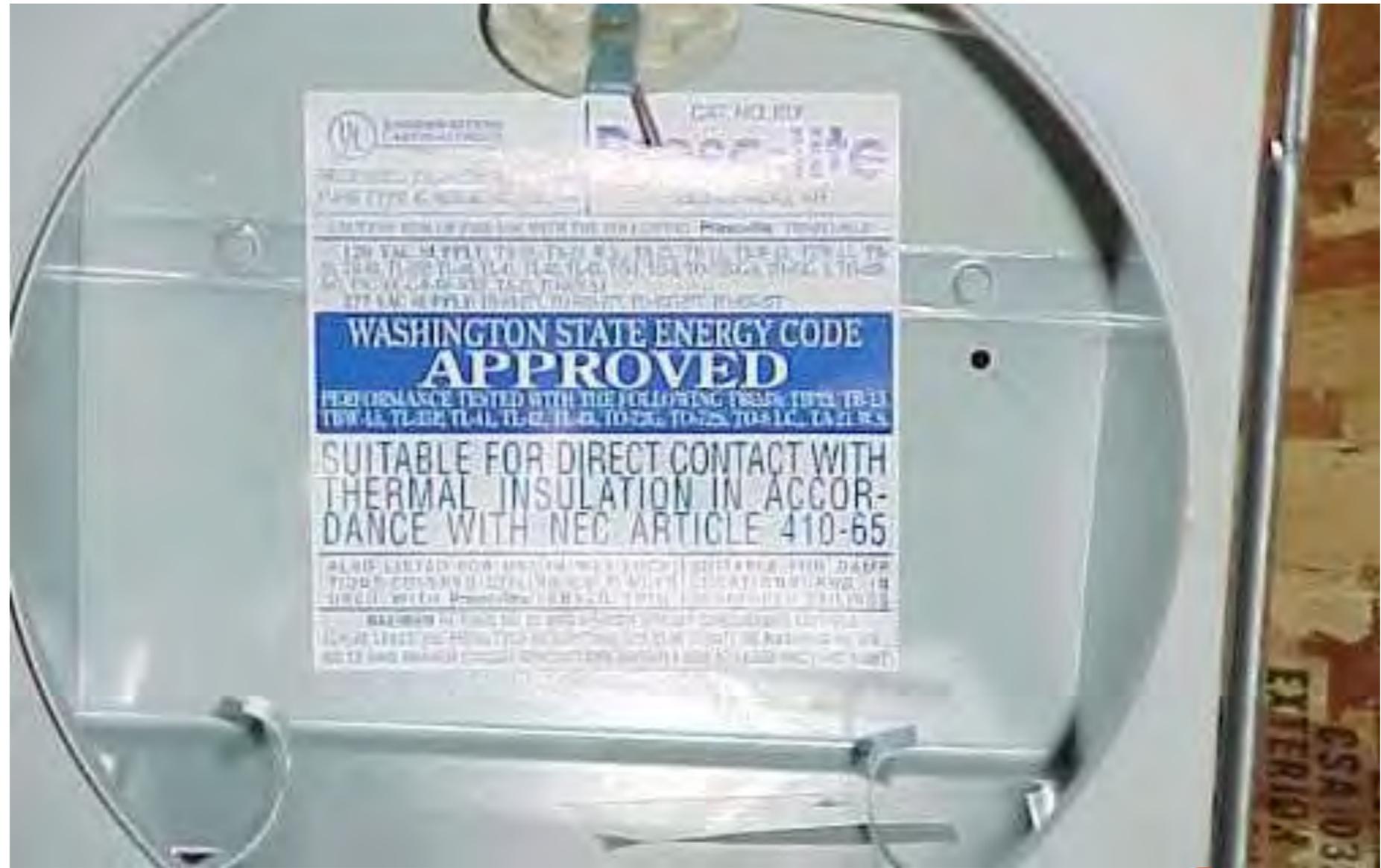


Select the best method for your fixtures

Air Sealed Recessed Light

Figure 5e

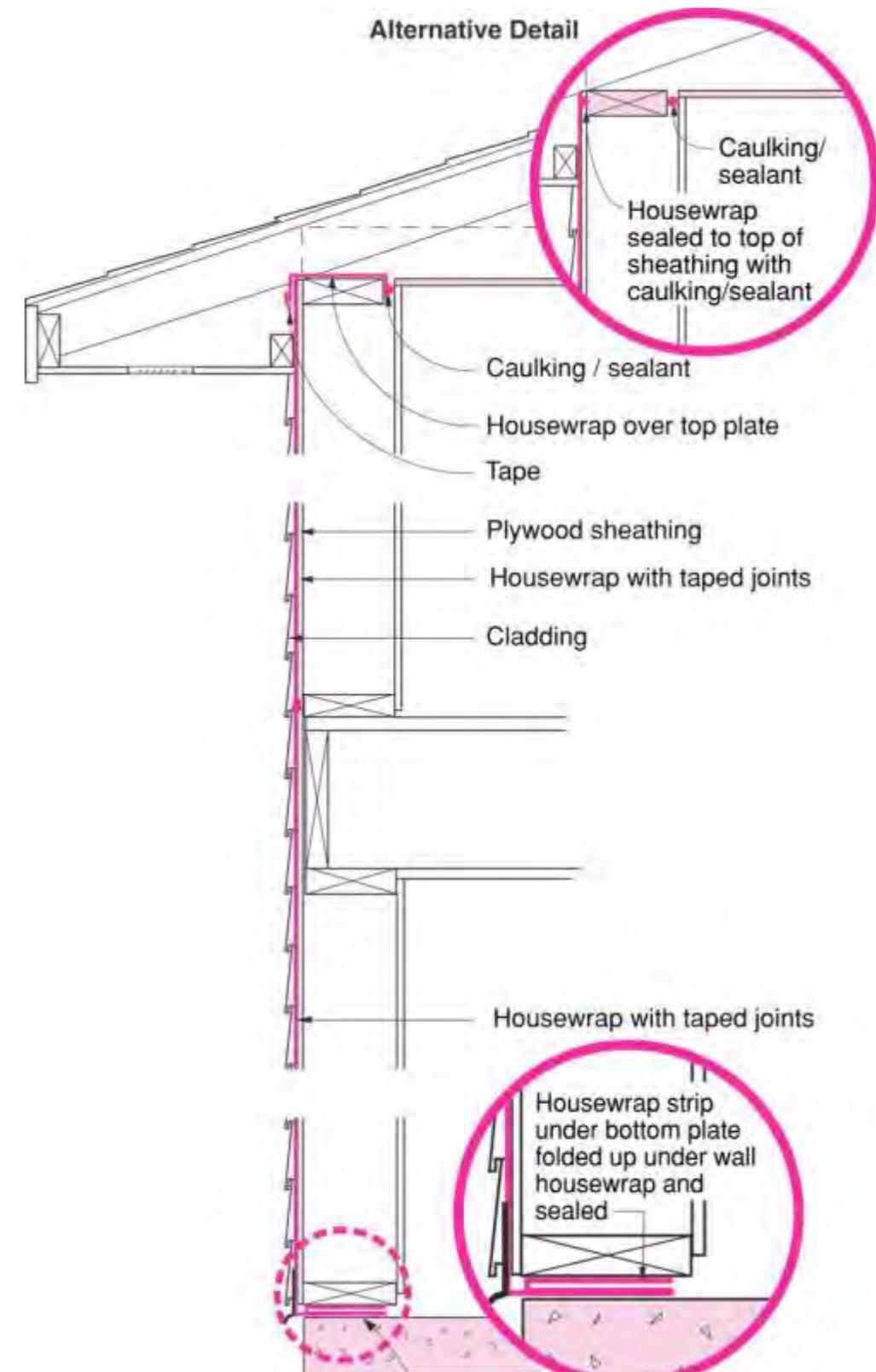
Always choose airtight recessed lights for unconditioned spaces



Air Flow Barrier-Exterior

216

- A well detailed house wrap or weather barrier can also be an effective air barrier
- It must connect to the foundation and the ceiling air barrier
- Must be durable through the construction process

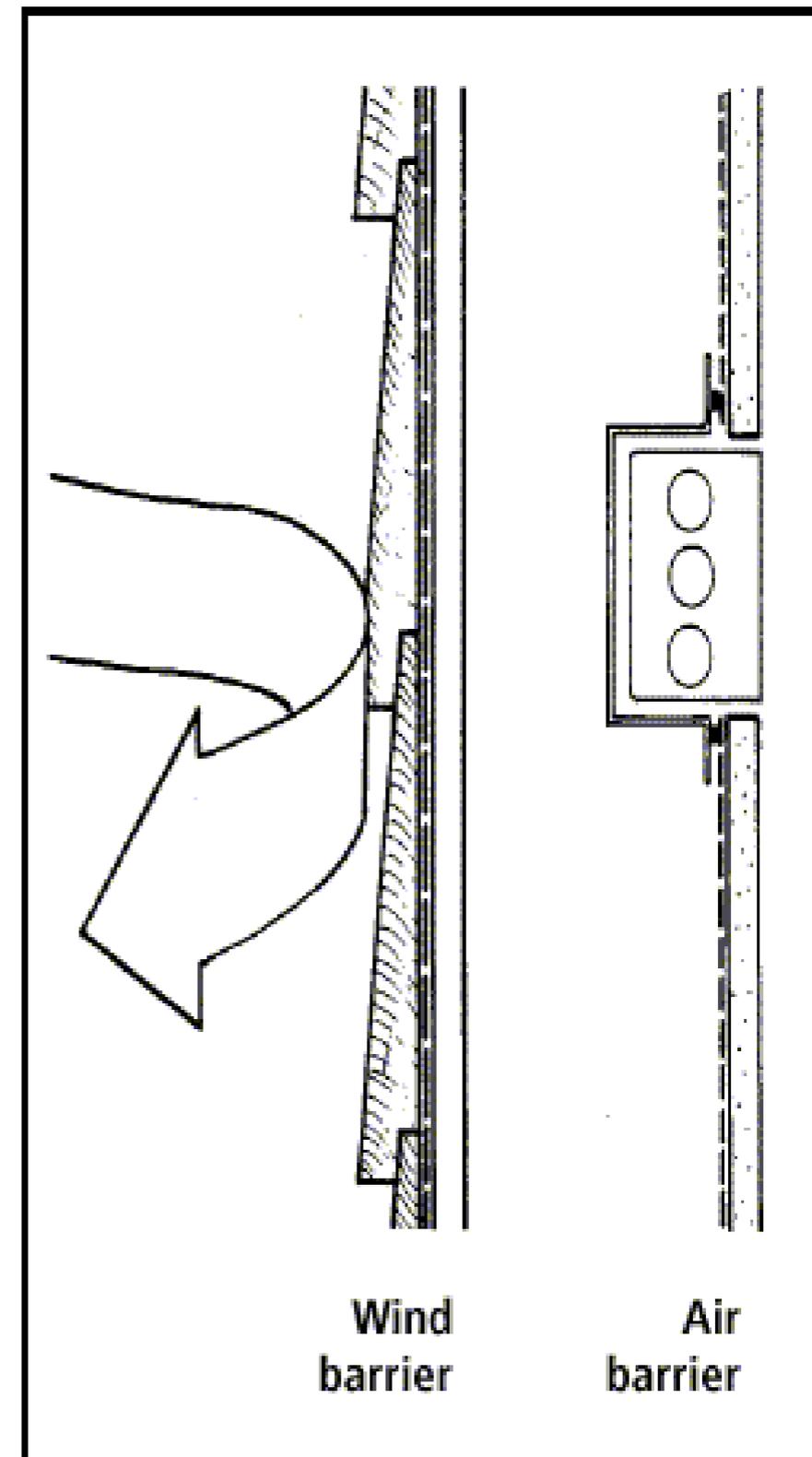




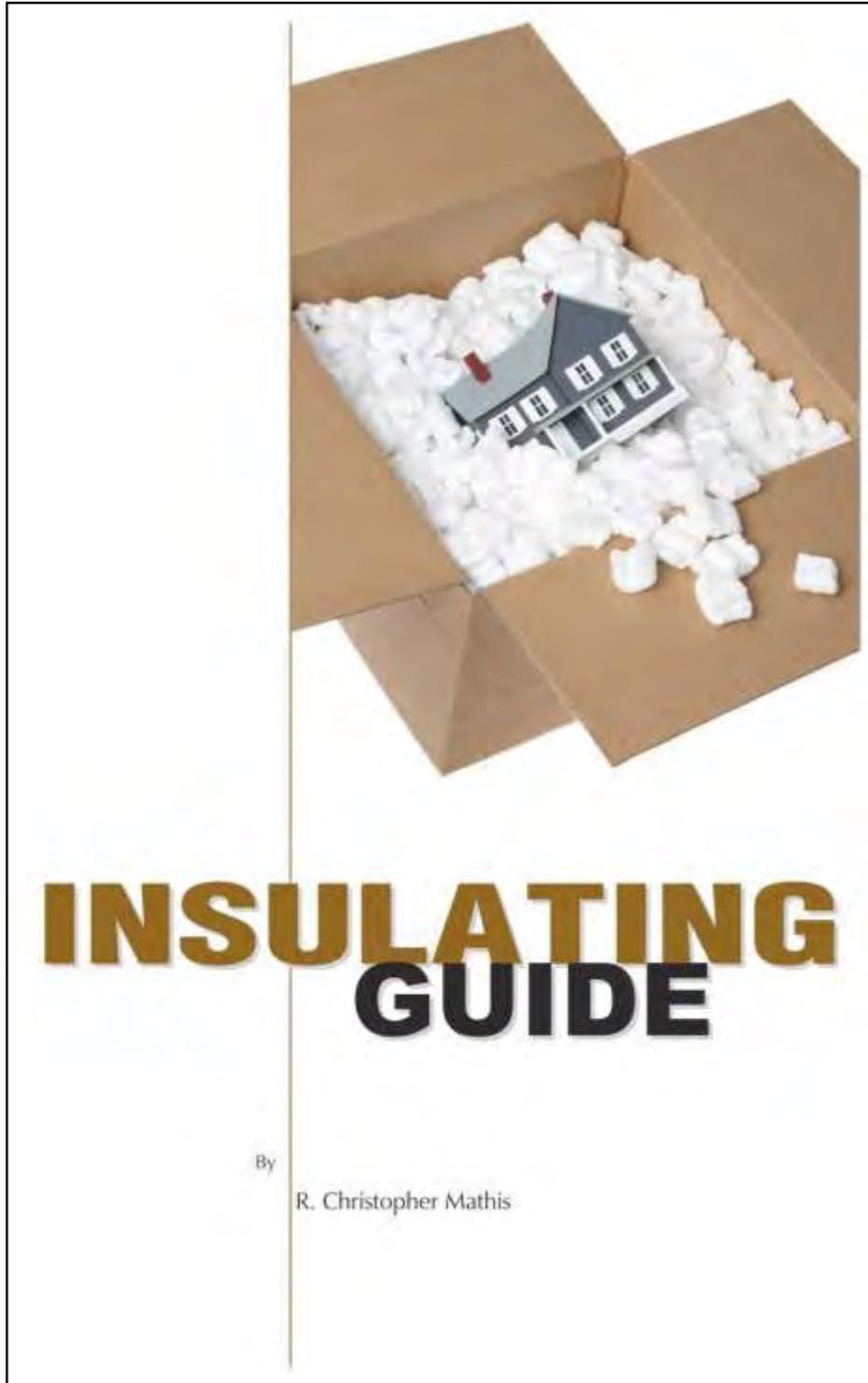
Air Sealing Summary

219

- Reduce energy loss
- 1/3 of htg/clg bill can be from air leakage
- Reduce infiltration of harmful air
- Garage connection
- Improved comfort
- Less drafts
- Less noise & dust

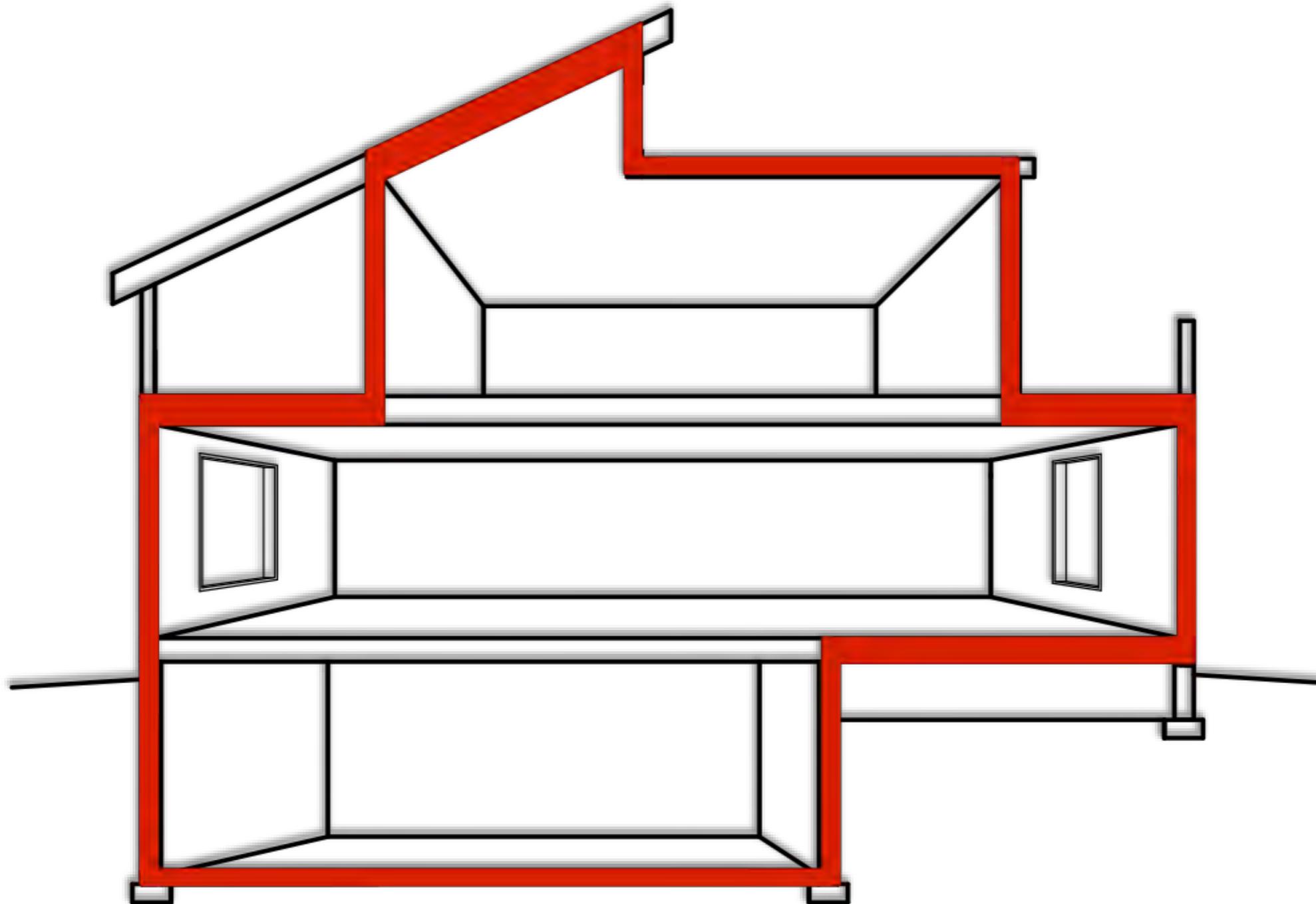


Insulation Installation



Determine the thermal enclosure

221



Insulation essentials

- Most insulation types must be combined with an air barrier...touching on all 6 sides
- Insulation must be free of:
 - gaps
 - voids
 - compressions





ENERGY STAR Qualified Homes, Version 3 (Rev. 02)

Thermal Enclosure System Rater Checklist

Home Address: _____ City: _____ State: _____

Inspection Guidelines	Must Correct	Builder Verified ¹	Rater Verified	N/A
1. High-Performance Fenestration				
1.1 <i>Prescriptive Path</i> : Fenestration shall meet or exceed ENERGY STAR requirements ²	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
1.2 <i>Performance Path</i> : Fenestration shall meet or exceed 2009 IECC requirements ²	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Quality-Installed Insulation				
2.1 Ceiling insulation shall meet or exceed 2009 IECC requirements ^{3,4,5}	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Fully-Aligned Air Barriers⁶

3.1 Walls

3.1.1 Walls behind showers and tubs

3.1.2 Walls behind fireplaces

3.1.3 Attic knee walls / Sloped attics¹¹

3.1.4 Skylight shaft walls

3.1.5 Wall adjoining porch roof

3.1.6 Staircase walls

3.1.7 Double walls

3.1.8 Garage rim / band joist adjoining conditioned space

3.1.9 All other exterior walls

3.2 Floors

3.1.8 Garage rim / band joist adjoining conditioned space

3.1.9 All other exterior walls

3.2 Floors

3.2.1 Floor above garage

3.2.2 Cantilevered floor

3.2.3 Floor above unconditioned basement or vented crawlspace

3.3 Ceilings

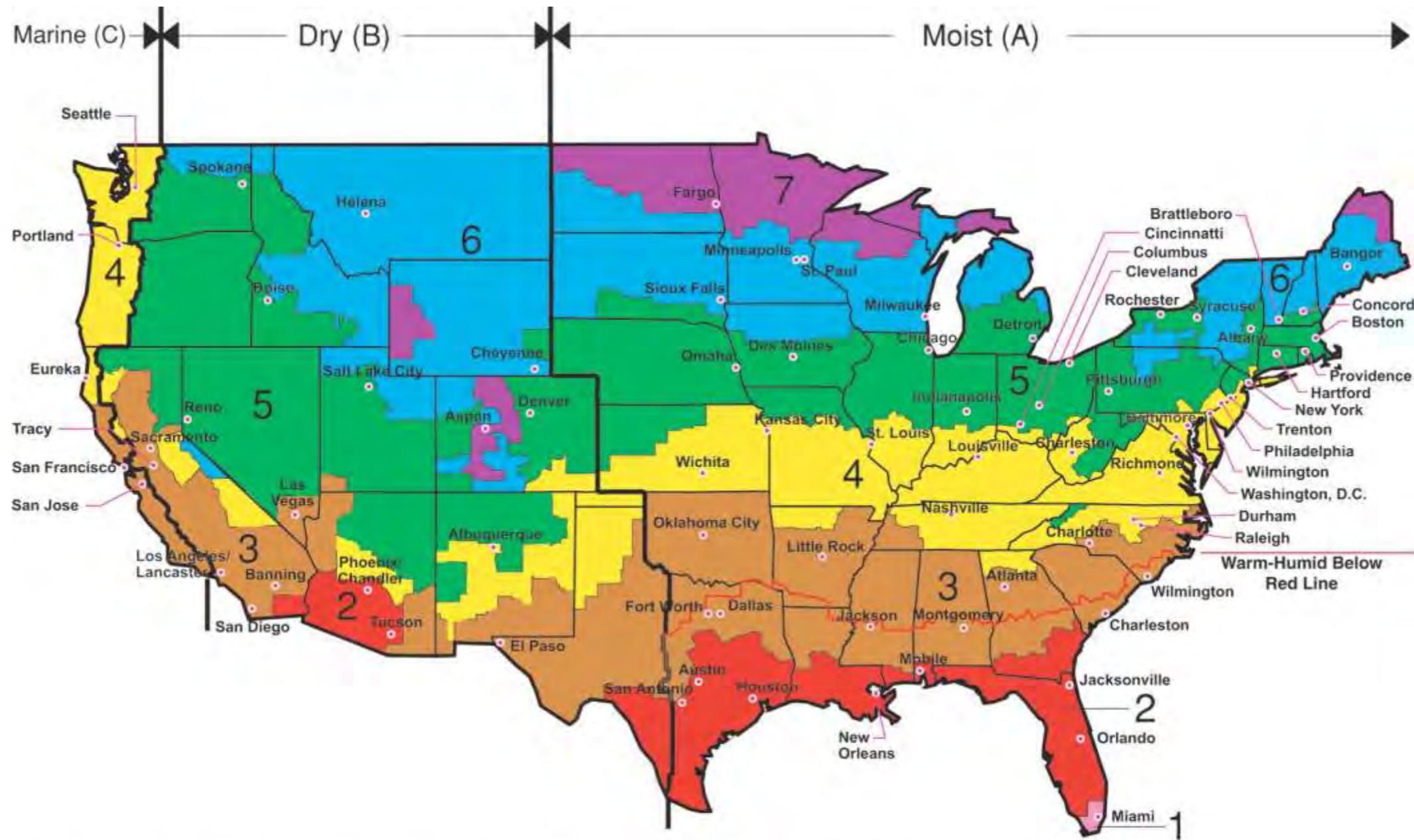
3.3.1 Dropped ceiling/soffit below unconditioned attic

3.3.2 Sloped ceilings¹¹

3.3.3 All other ceilings

4. Reduced Thermal Bridging

IECC Climate Zones- U.S. lower 48



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, and Yukon-Koyukuk

Zone 1 includes: Hawaii, Guam, Puerto Rico, and the Virgin Islands

More Insulation - Minnesota 2015

- Higher R-value requirements for ceilings, walls, basements and crawl spaces ([Table R402.1.1](#)).

Insulation	Ceiling R-value		Wood Frame R-value		Basement R-value		Crawlspace R-value	
	2009	2015	2009	2015	2009	2015	2009	2015
6	38	49	19, 13 + 5	20, 13 + 5	10	15	10	15
7	44	49	19	21	10	15	10	15

What's my R-Value?



226

2" x 4" wall with various cavity and/or continuous insulation	Total wall R-Value - including framing, insulation, sheetrock, OSB etc...
R-13 cavity insulation (batts - perfect install)	10.17
R-13 Batt with R-5 cont. ext. insulation	15.17
R-13 blown cavity + R-10 cont. ext. insulation	20.17
Staggered Stud - 2 x 4 on 2 x 6 plates Completely filled with insulation R-24.5	16.6

What's my R-Value?



227

2" x 6" wall with various cavity and/or continuous insulation	Total wall R-Value - including framing, insulation, sheetrock, OSB etc...
R-19 cavity insulation (batts - perfect install)	14.42
R-19 Batt with R-5 cont. ext. insulation	19.42
R-21 blown cavity (fiberglass etc.)	15.05
R-23.5 blown cavity (HD fiberglass)	15.77
HD spray foam (2" + R-14 blown) a.k.a. flash and blow	16.58
R-21 blown cavity + R-5 cont. ext. insulation	20.05
R-21 blown cavity + R-10 cont. ext. insulation	25.05

Insulated Sheathing will be normal



Framing for Insulation- Wall systems

234

- Provide structural integrity, but insulate areas we sometimes miss.



Where 4 is good....



Graphics Courtesy of Building Science Corp.



5 is better....

9 or more has got to be enough!





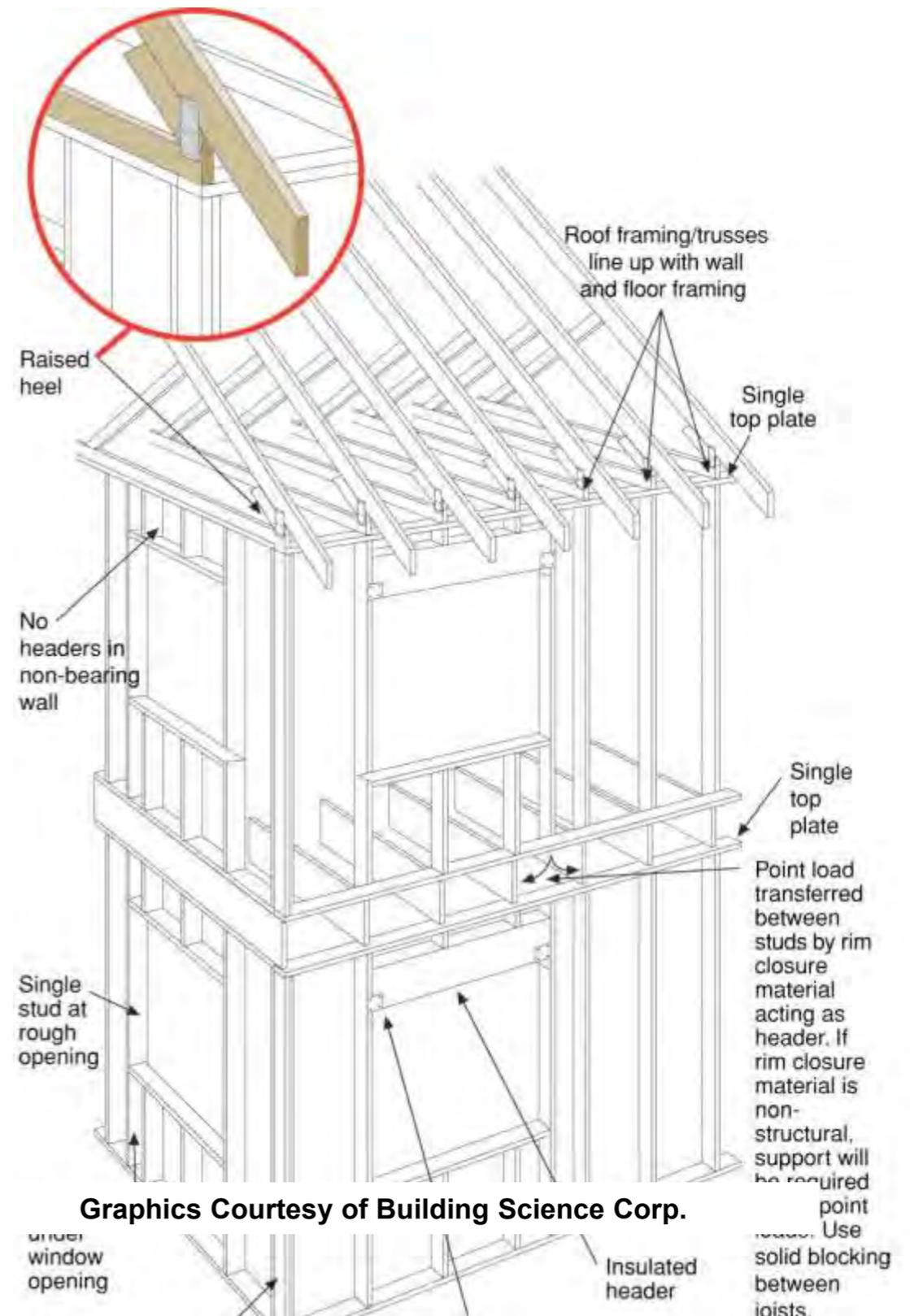
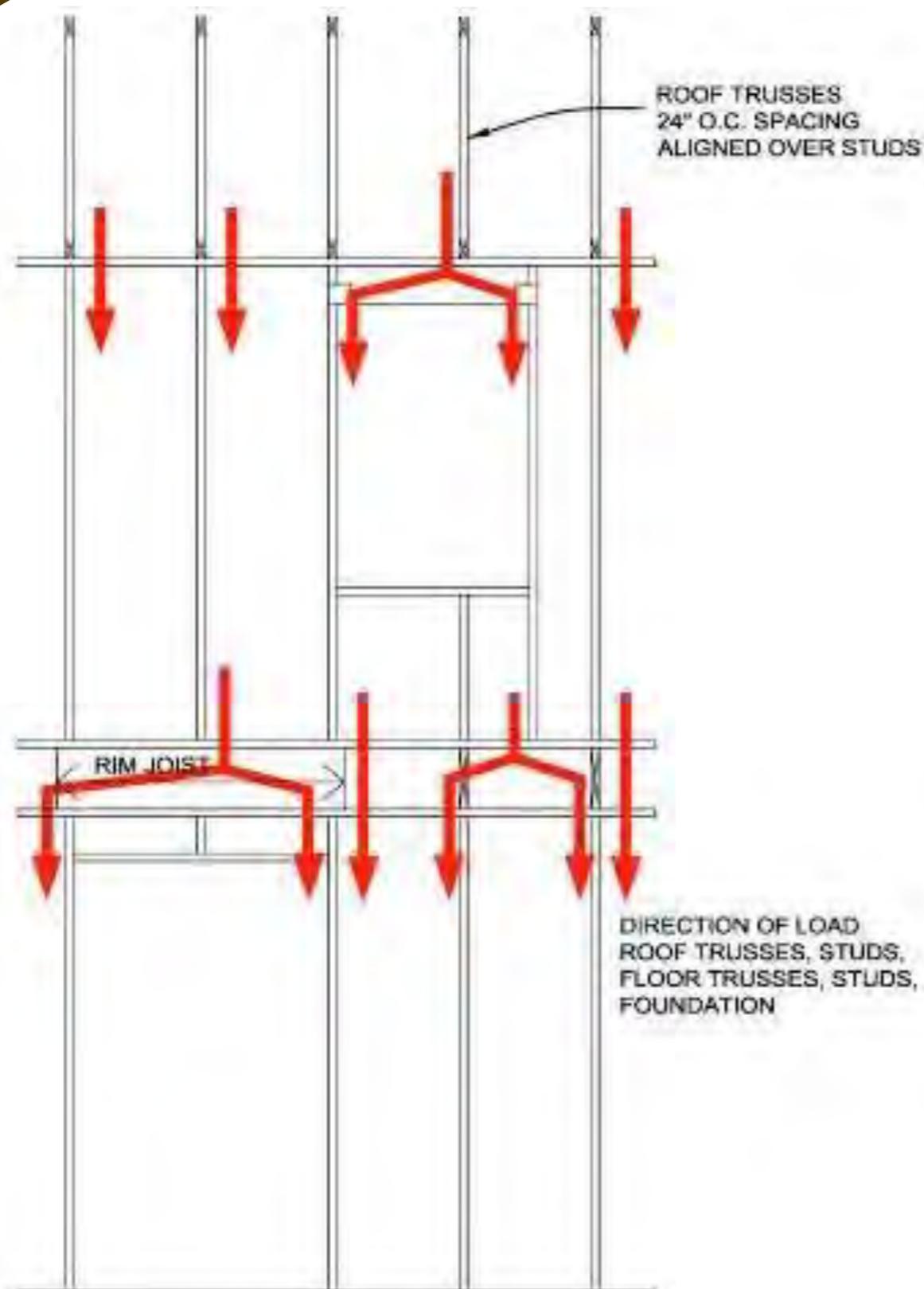
Delivery or Disposal?

239



Graphics Courtesy of Building Science Corp.

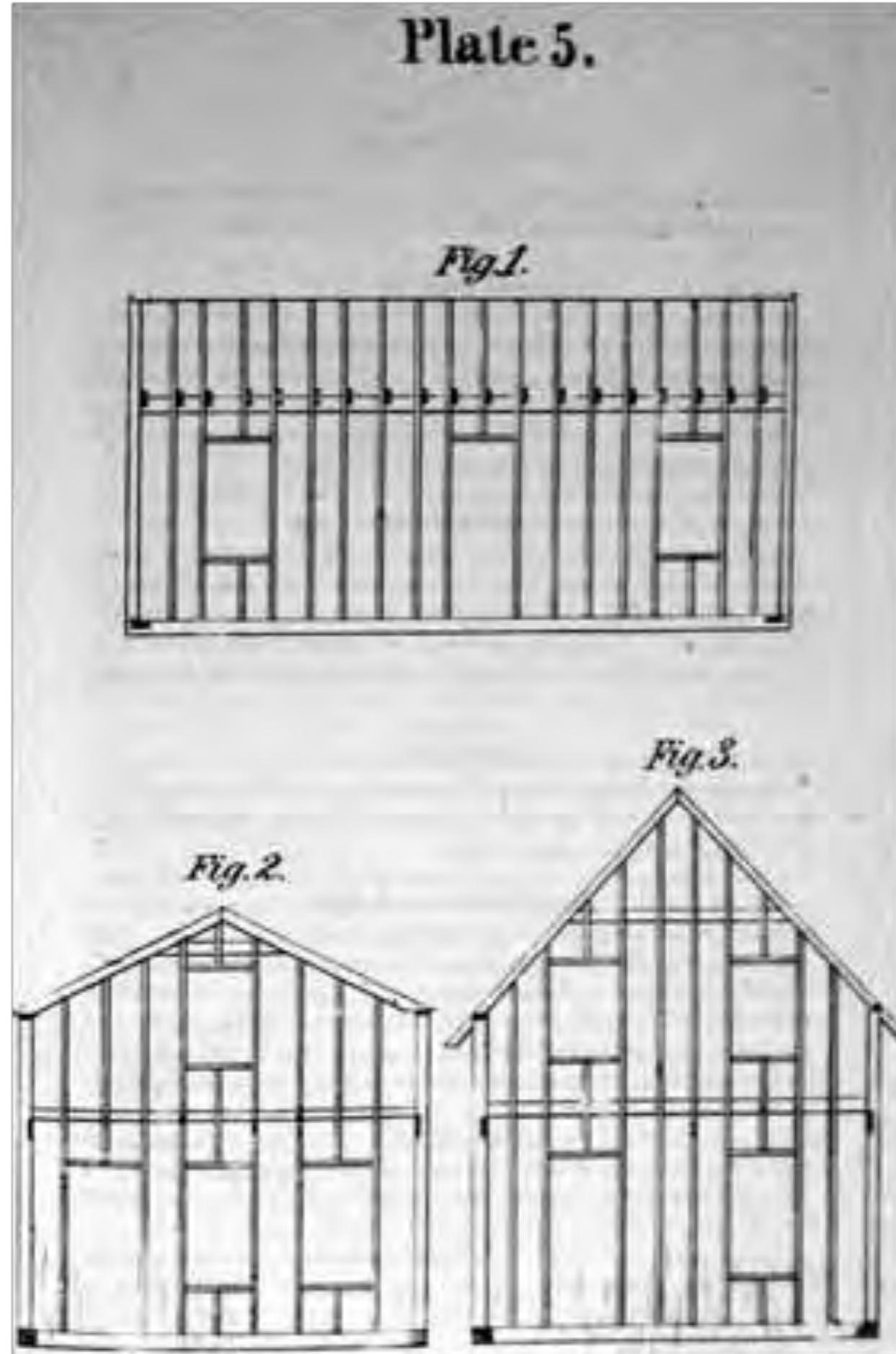
Simplified Framing



Graphics Courtesy of Building Science Corp.

Carpentry Made Easy

William Bell,
1858



A 3 stud corner

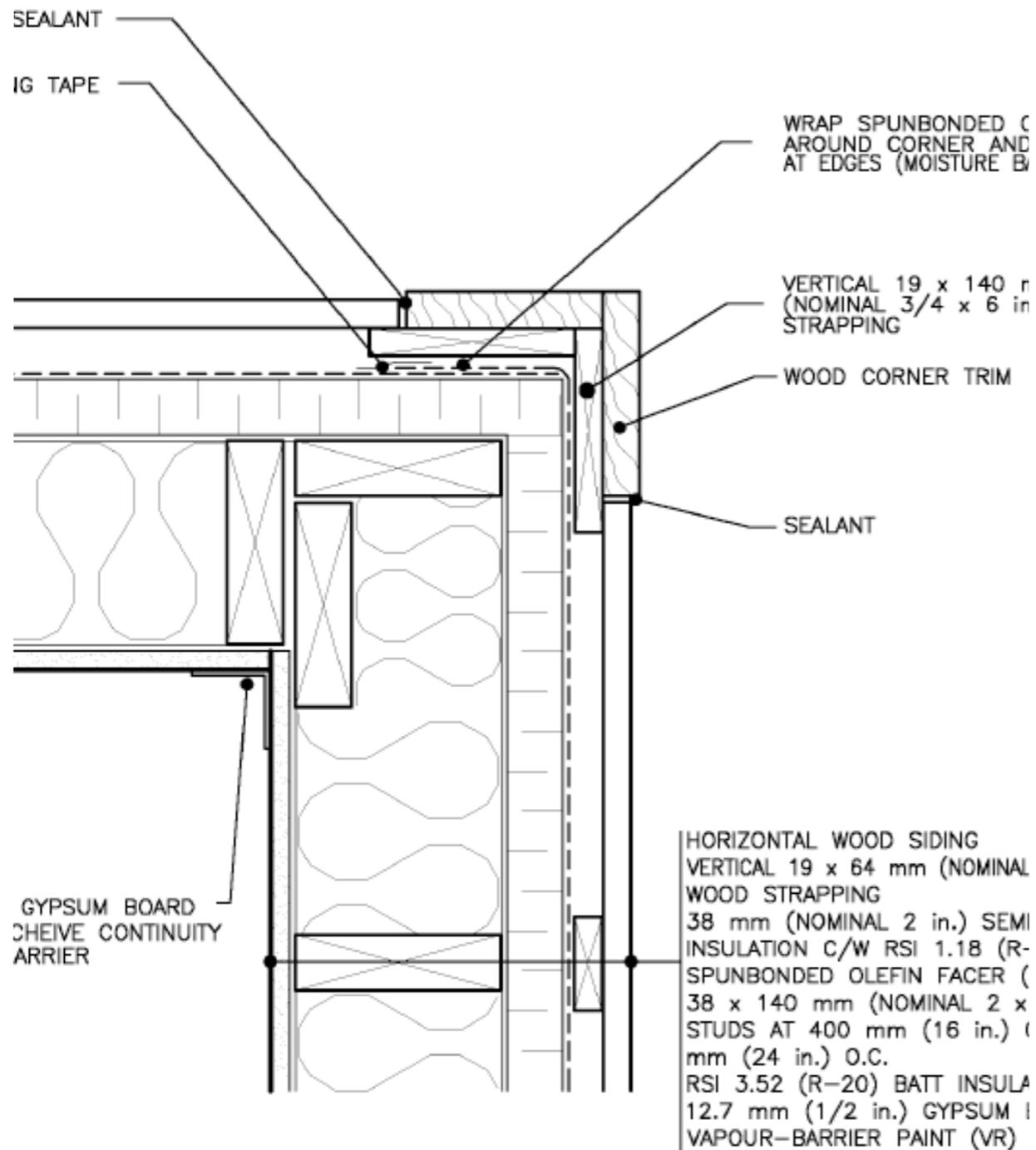
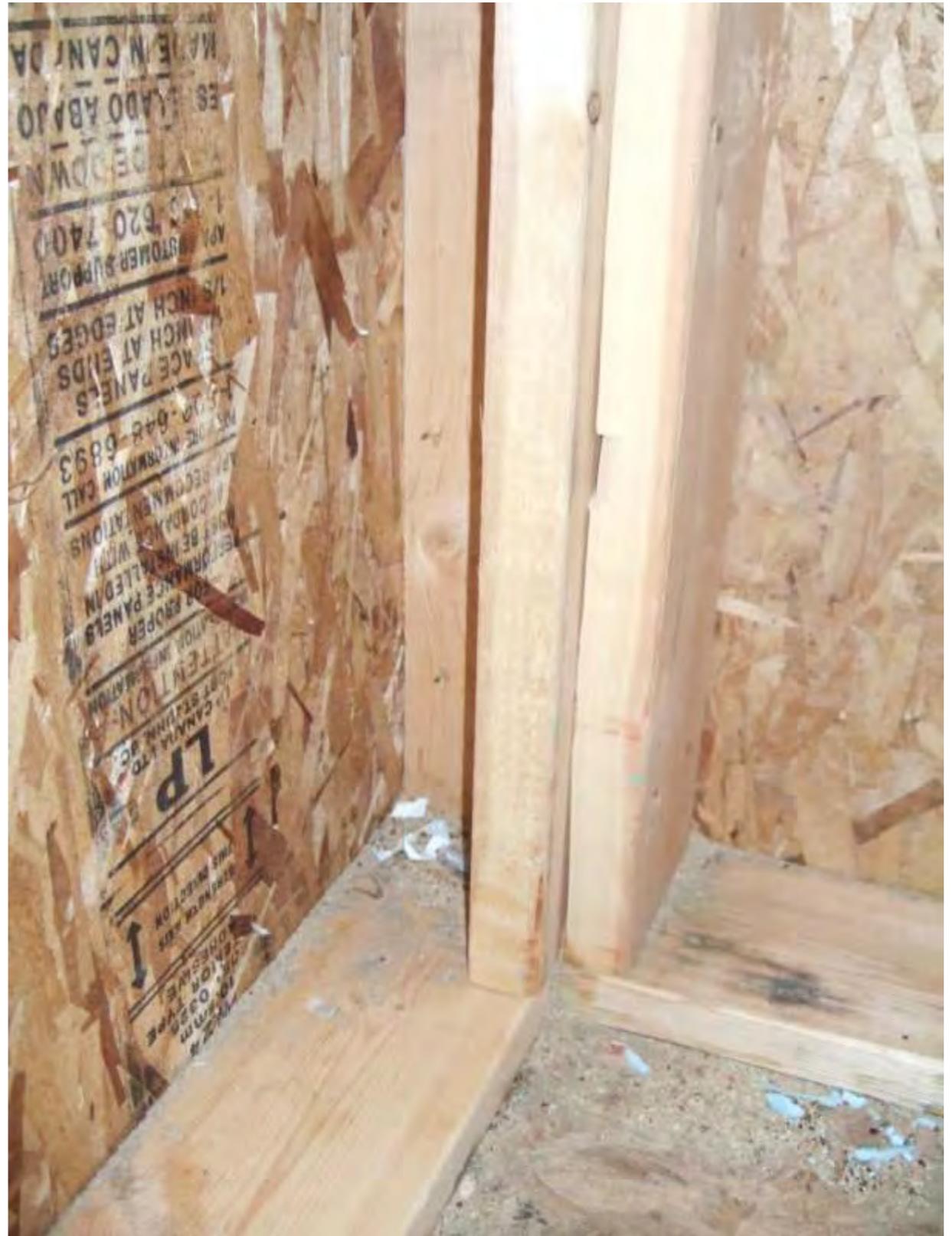
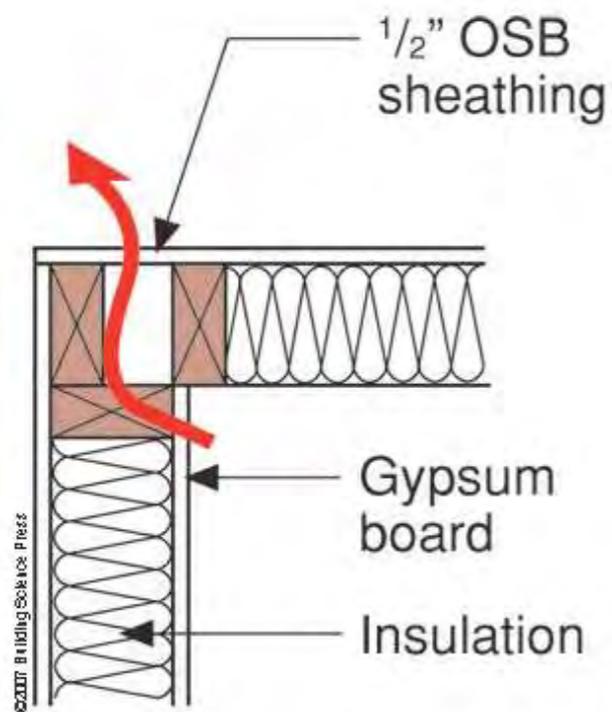


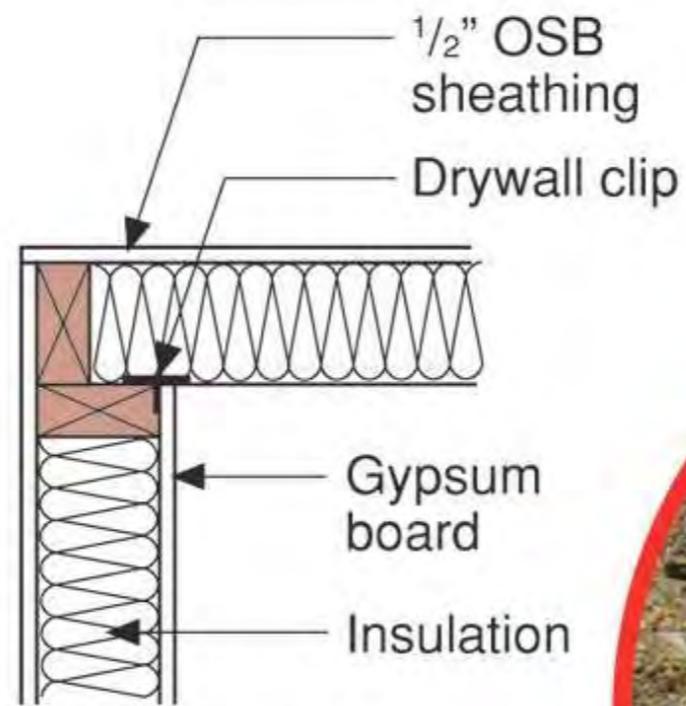
Diagram from CMHC Best Practices



Two-stud corner



Typical

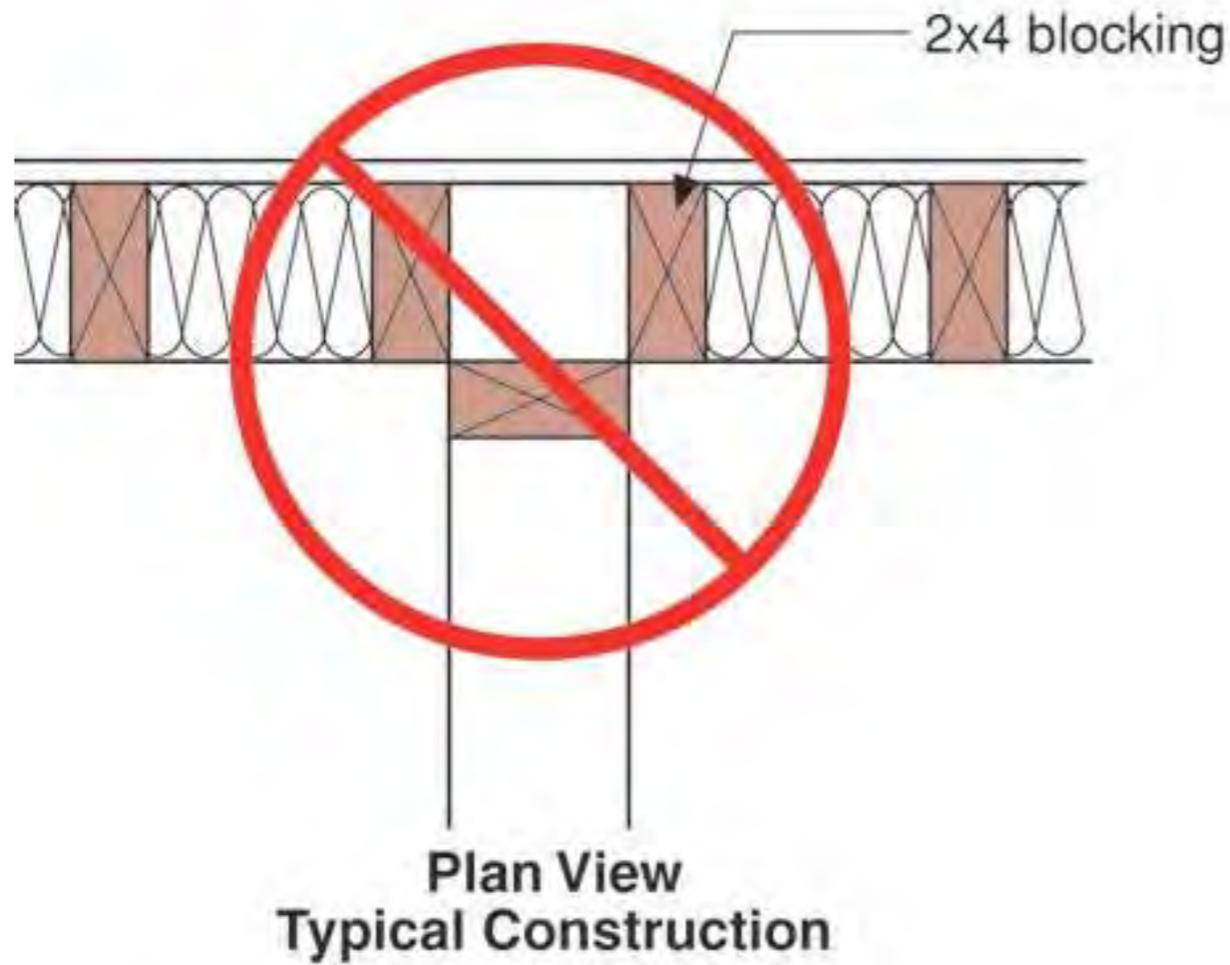


Recommended

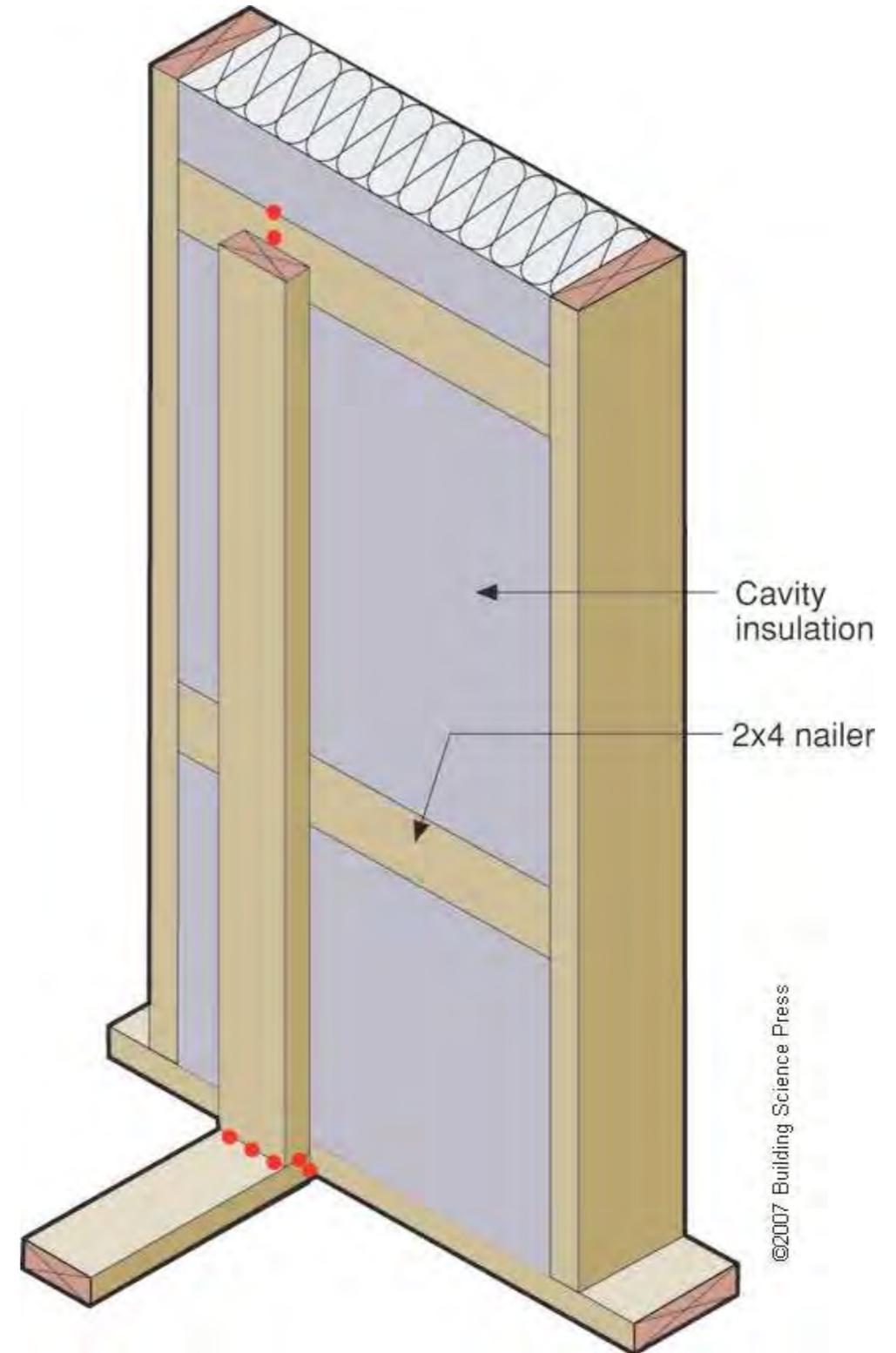
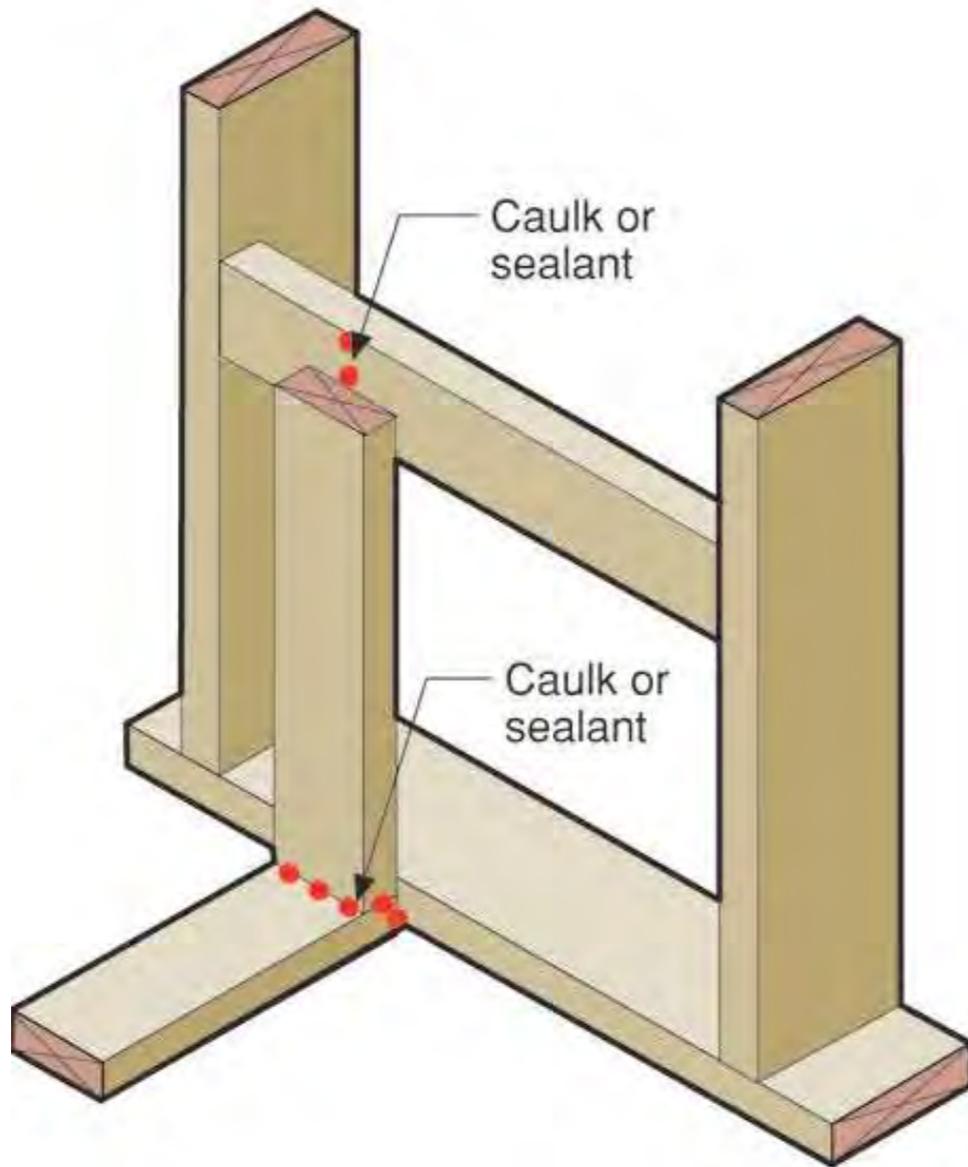


Interior wall junction

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Ladder Blocking



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In the field

246



Framing for Success

247





.....The Same

Insulating the Enclosure

249

- All products have specific needs...

Insulation Must....

251

Be installed properly:

- No compressions
- No voids
- Touching all 6 surfaces
- Be properly mixed (foams)
- Be compatible with other materials
- Be combined with an air barrier or be one
- Not be subjected to constant wetting cycles

Poor installation affects comfort, performance and durability

252



Compressions and voids reduce performance

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