

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

# Building Science

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Adventures In Building Science

[www.buildingscience.com](http://www.buildingscience.com)

# What is a Building?

# A Building is an Environmental Separator

- Control heat flow
- Control airflow
- Control water vapor flow
- Control rain
- Control ground water
- Control light and solar radiation
- Control noise and vibrations
- Control contaminants, environmental hazards and odors
- Control insects, rodents and vermin
- Control fire
- Provide strength and rigidity
- Be durable
- Be aesthetically pleasing
- Be economical

# Arrhenius Equation

For Every 10 Degree K Rise  
Reaction Rate Doubles

$$k = Ae^{-E_a/(RT)}$$

Damage Functions

Water

Heat

Ultra-violet Radiation

# 2<sup>nd</sup> Law of Thermodynamics



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

Rudolf Clausius

Heat Flow Is From Warm To Cold

Moisture Flow Is From Warm To Cold

Moisture Flow Is From More To Less

Air Flow Is From A Higher Pressure to a  
Lower Pressure

Gravity Acts Down

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

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

Thermal Gradient – Thermal Diffusion  
Concentration Gradient – Molecular Diffusion

# Thermodynamic Potential



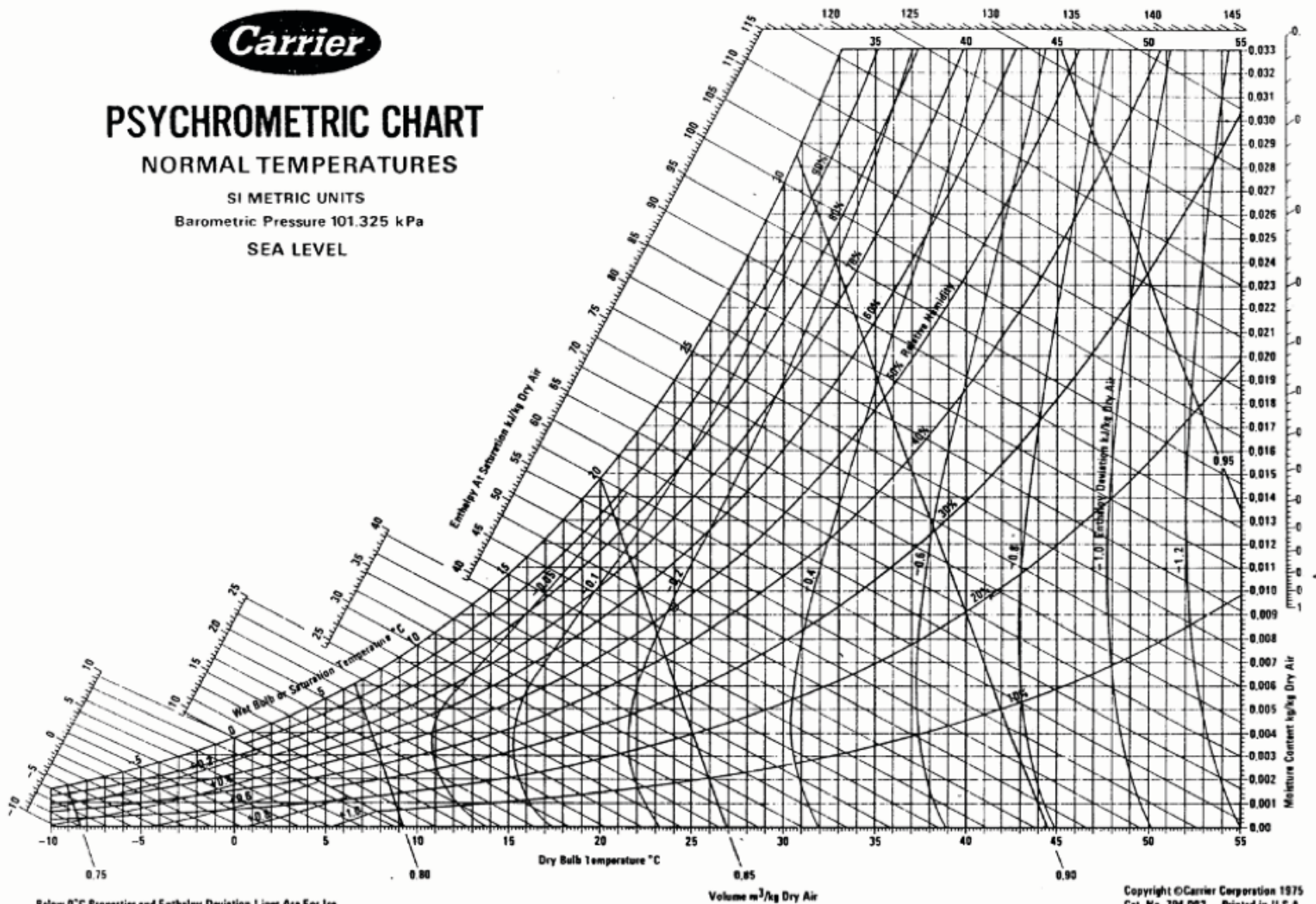
# PSYCHROMETRIC CHART

NORMAL TEMPERATURES

SI METRIC UNITS

Barometric Pressure 101.325 kPa

SEA LEVEL



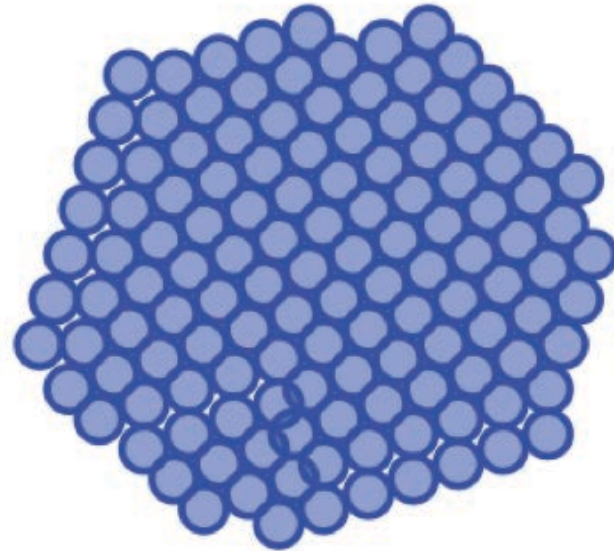
Below 0°C Properties and Enthalpy Deviation Lines Are For Ice

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# Water Molecules



**Vapor**



**Liquid**





**DIFFUSION**



**Higher Dewpoint Temperature  
Higher Water Vapor Density  
or Concentration  
(Higher Vapor Pressure)  
on Warm Side of Assembly**

**Low Dewpoint Temperature  
Lower Water Vapor Density  
or Concentration  
(Lower Vapor Pressure)  
on Cold Side of Assembly**

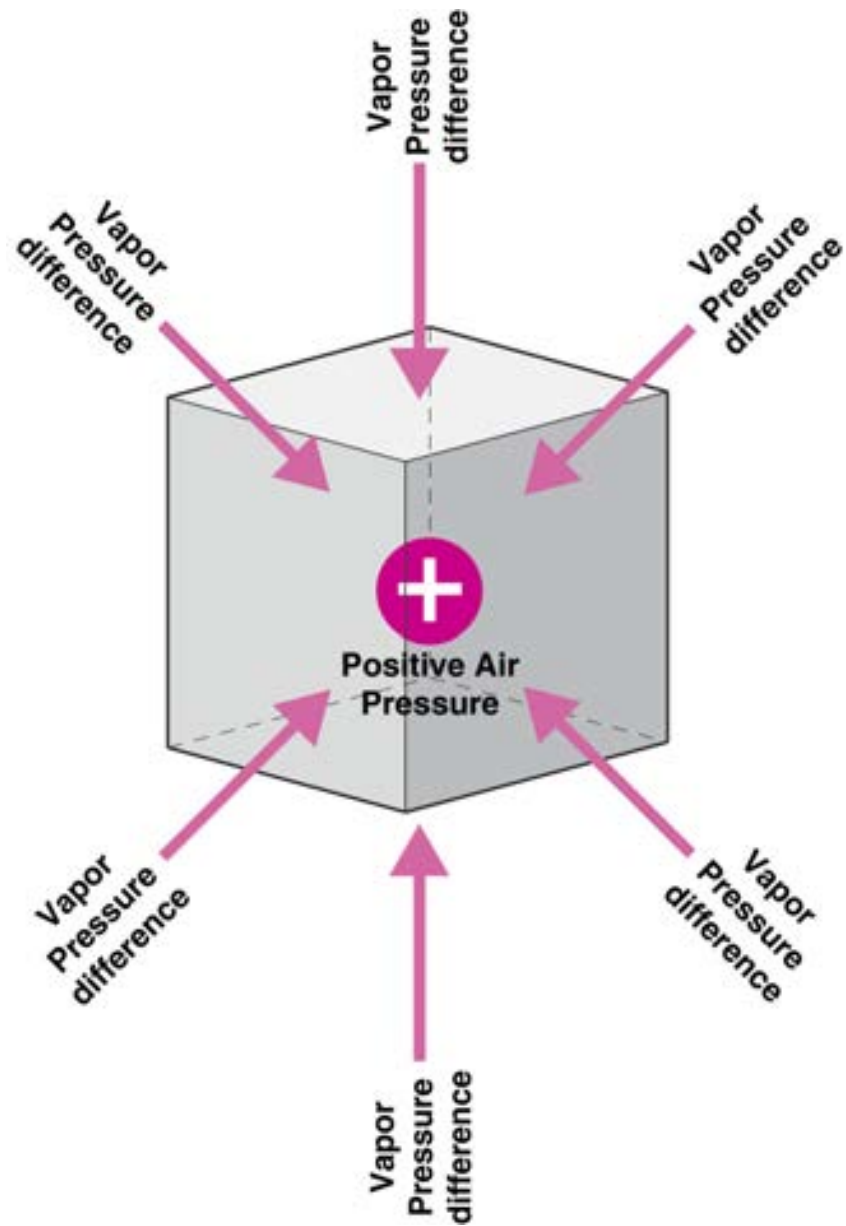


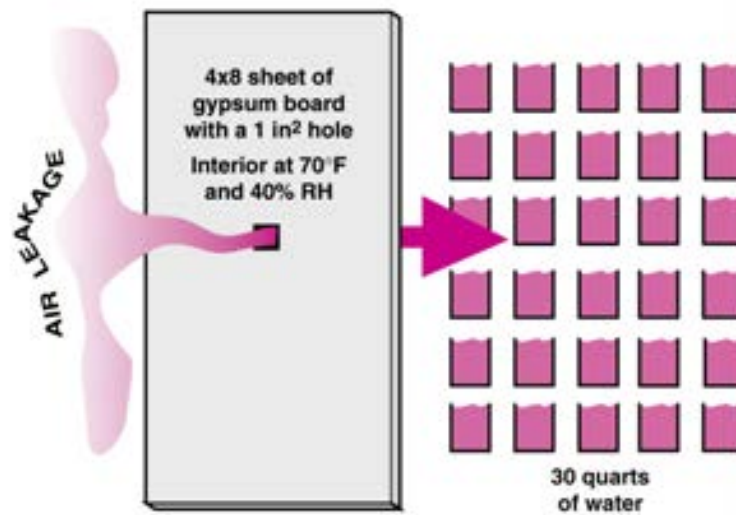
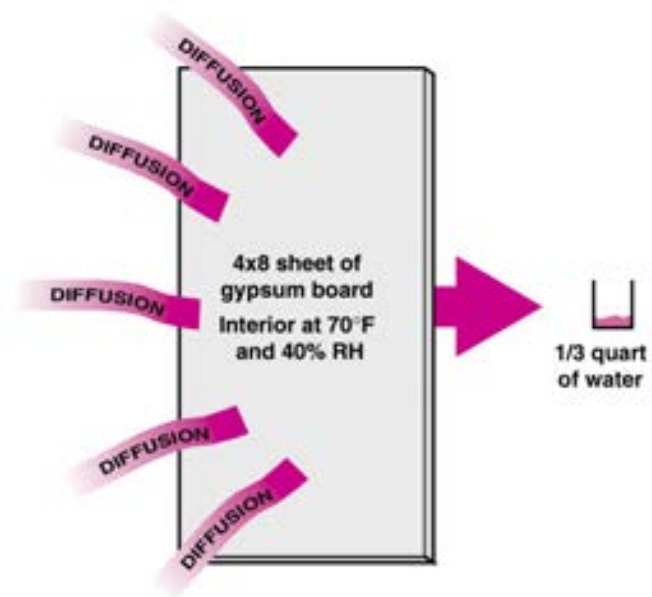
**AIR TRANSPORT**

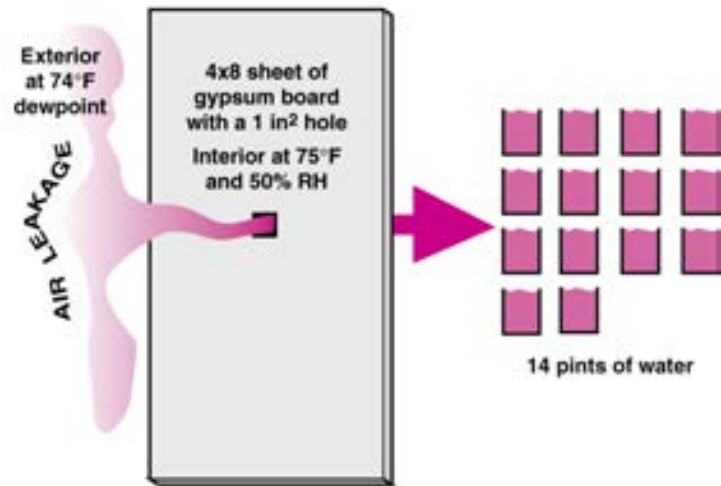
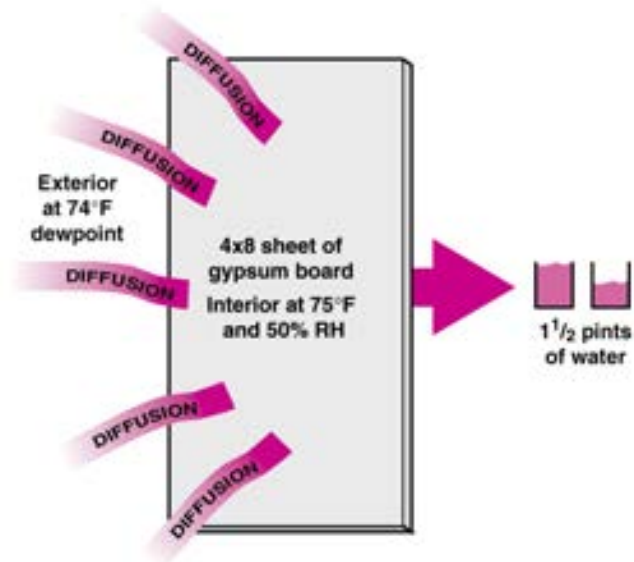


**Higher Air  
Pressure**

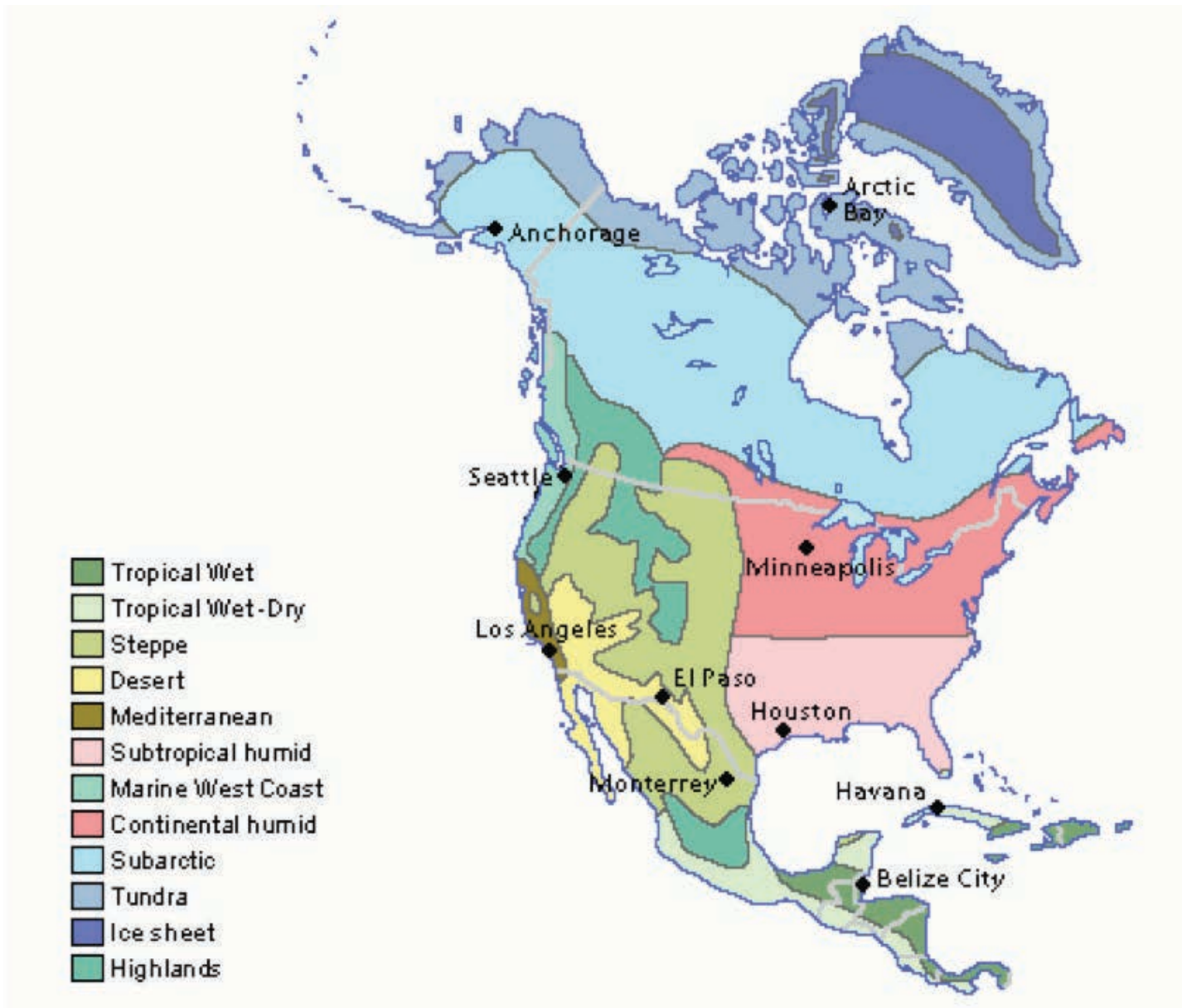
**Lower Air  
Pressure**





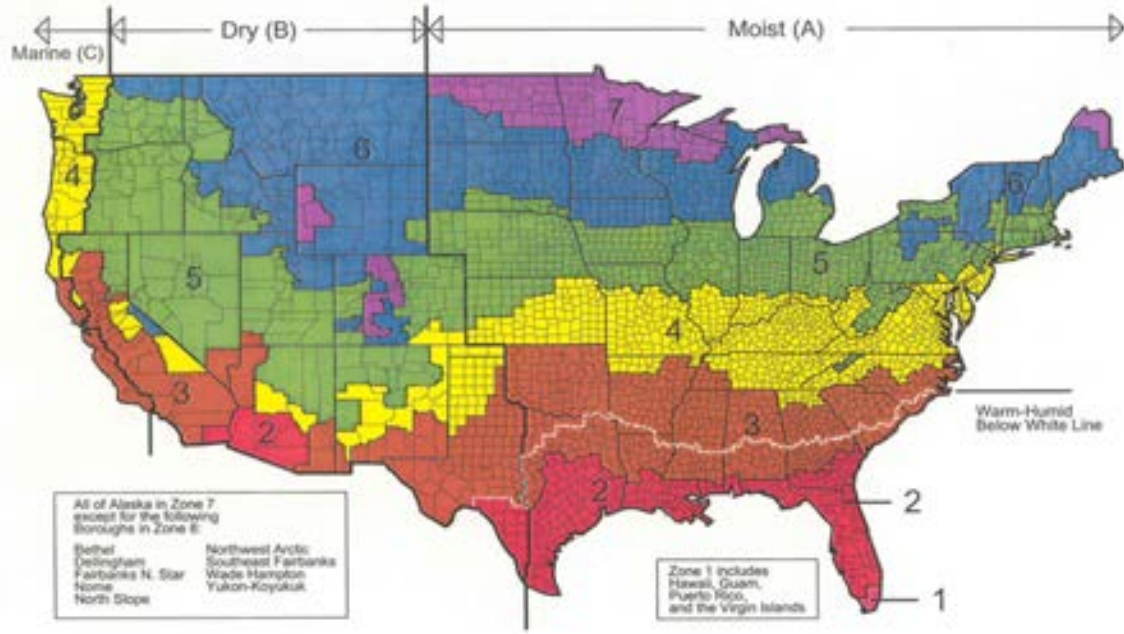








Map of DOE's Proposed Climate Zones



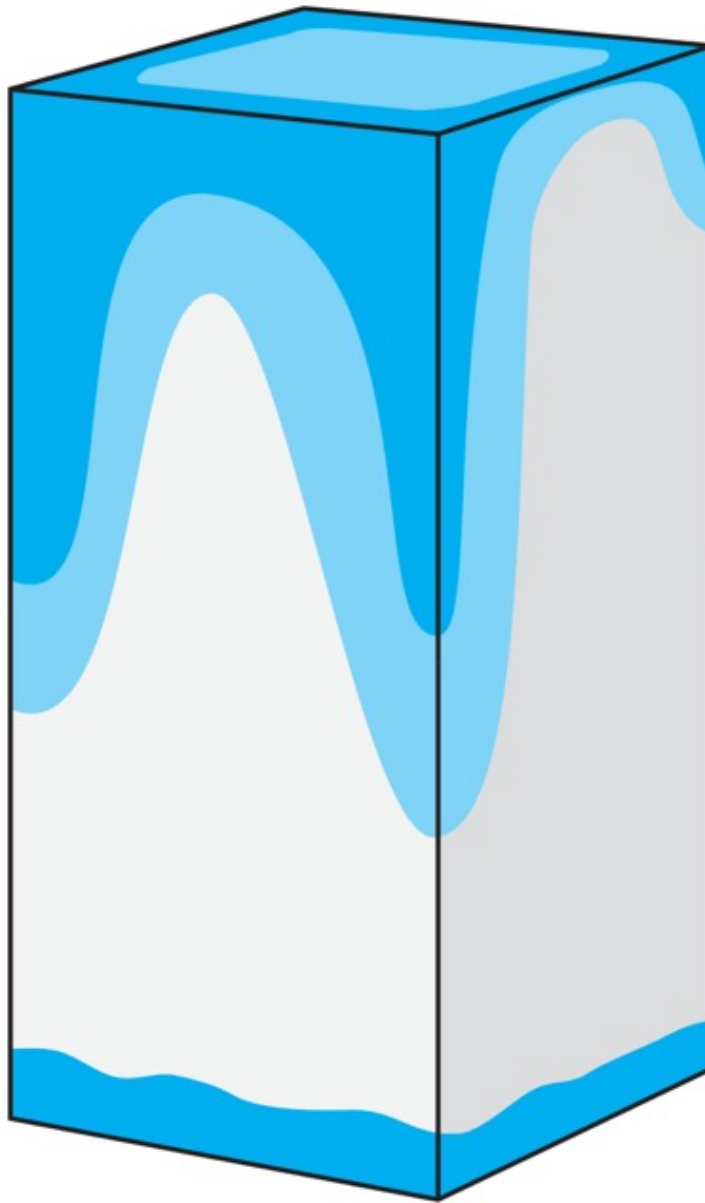
March 24, 2003

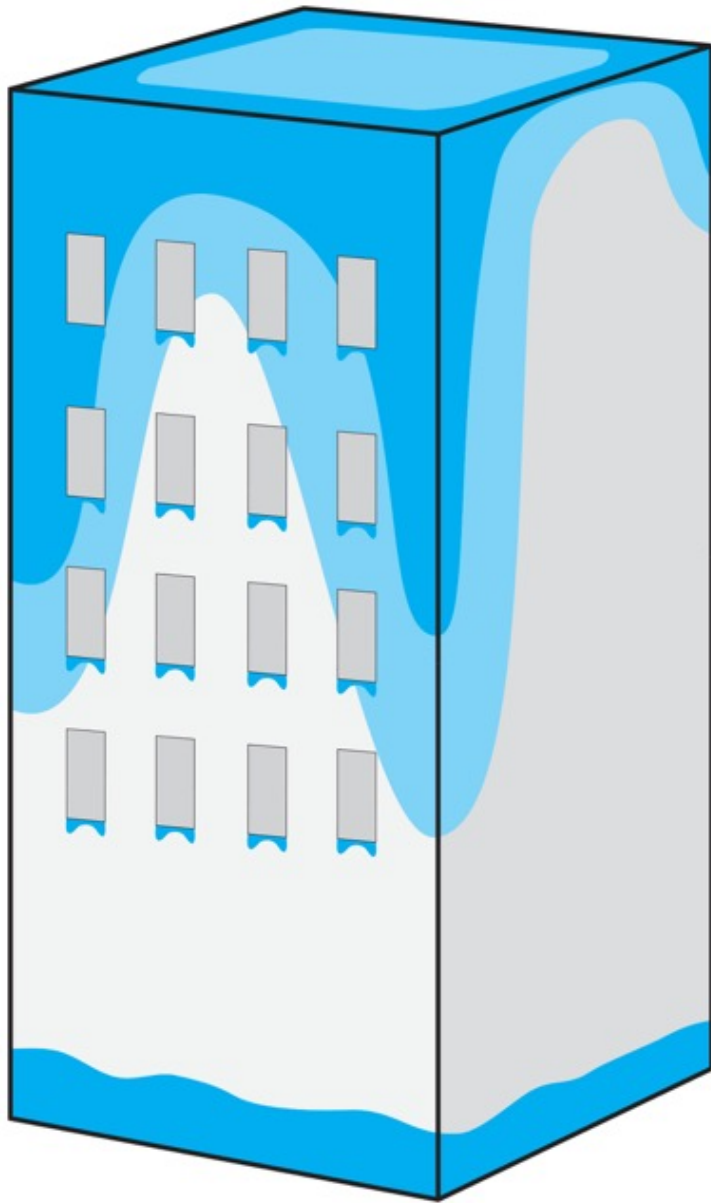


**Exposure**

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





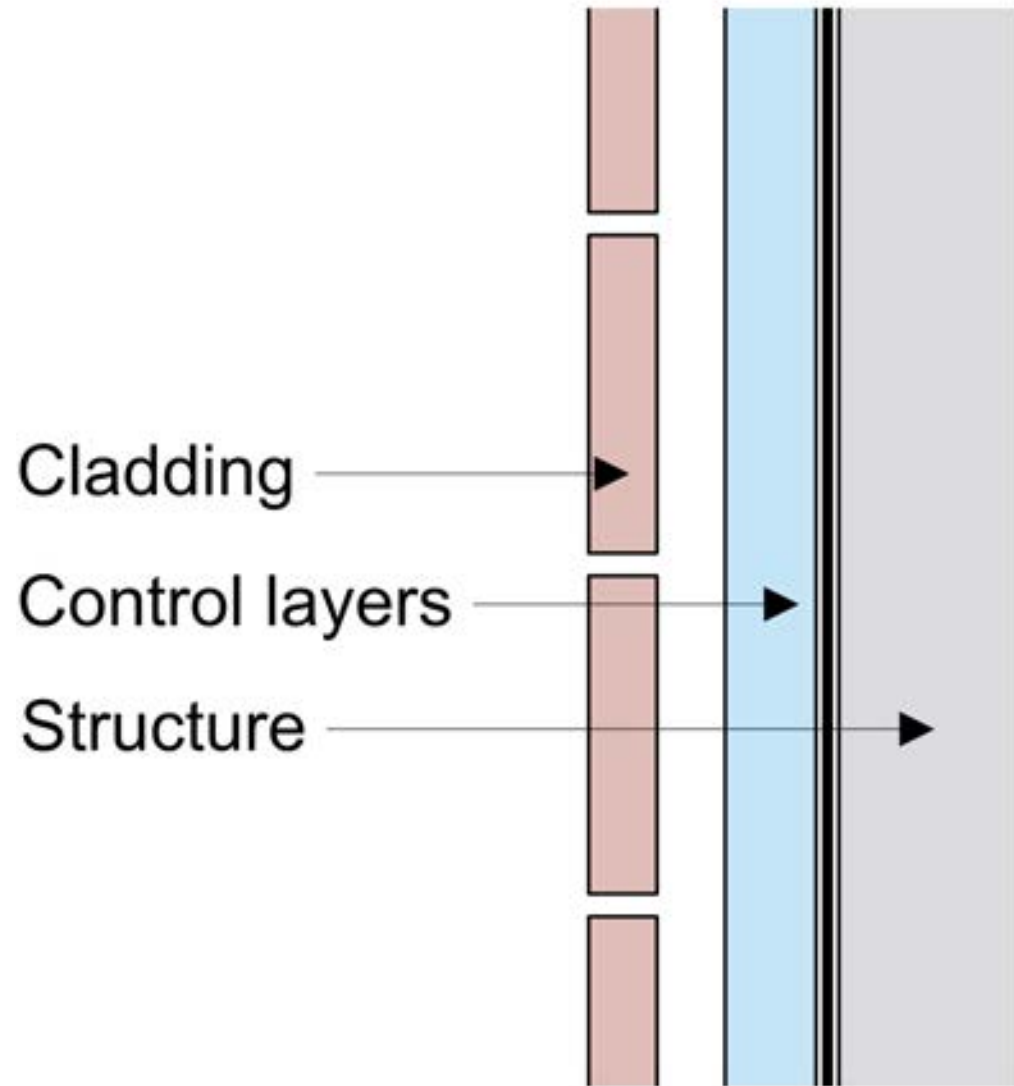


Water Control Layer

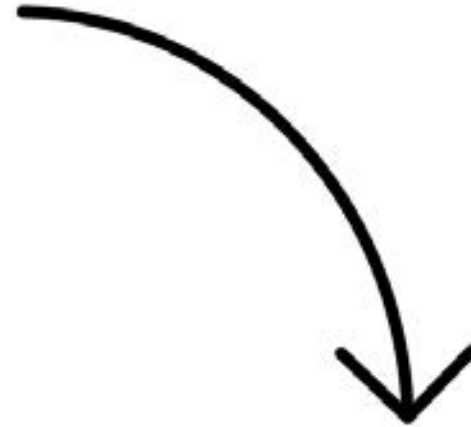
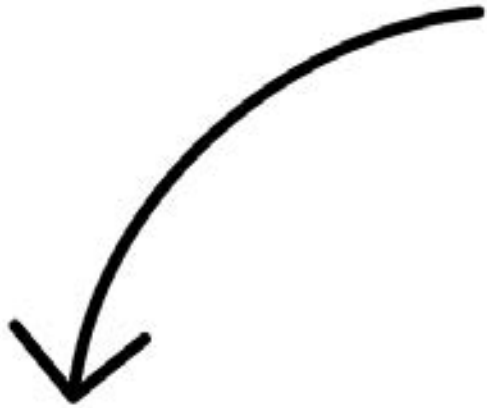
Air Control Layer

Vapor Control Layer

Thermal Control Layer



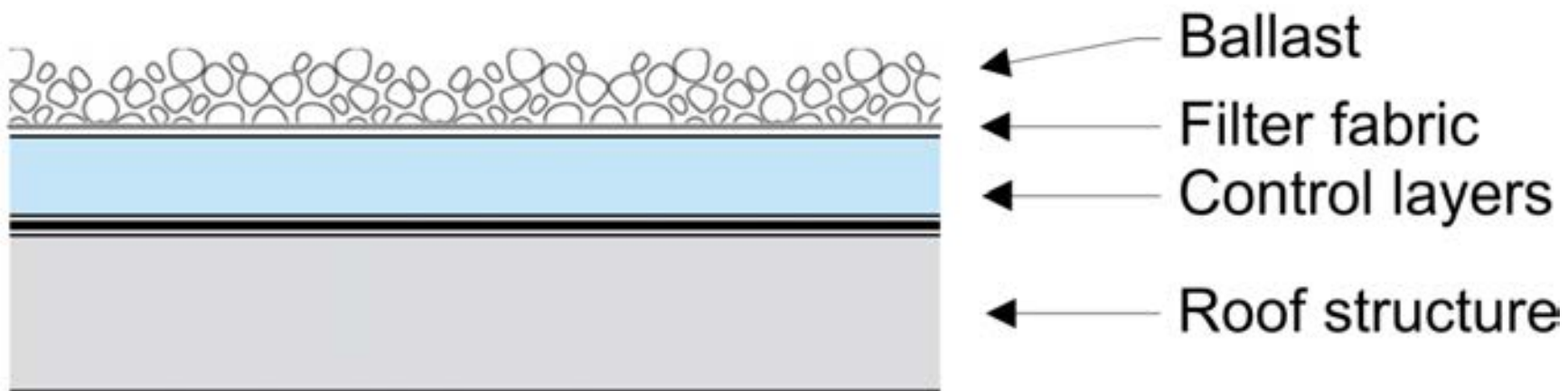
**Wall**

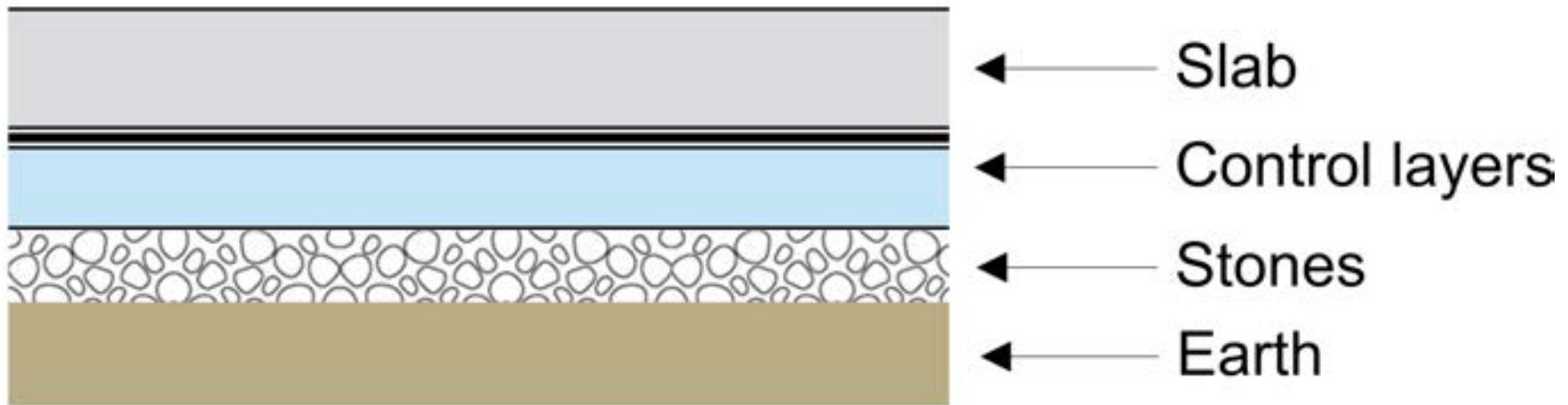


**Slab**



**Roof**

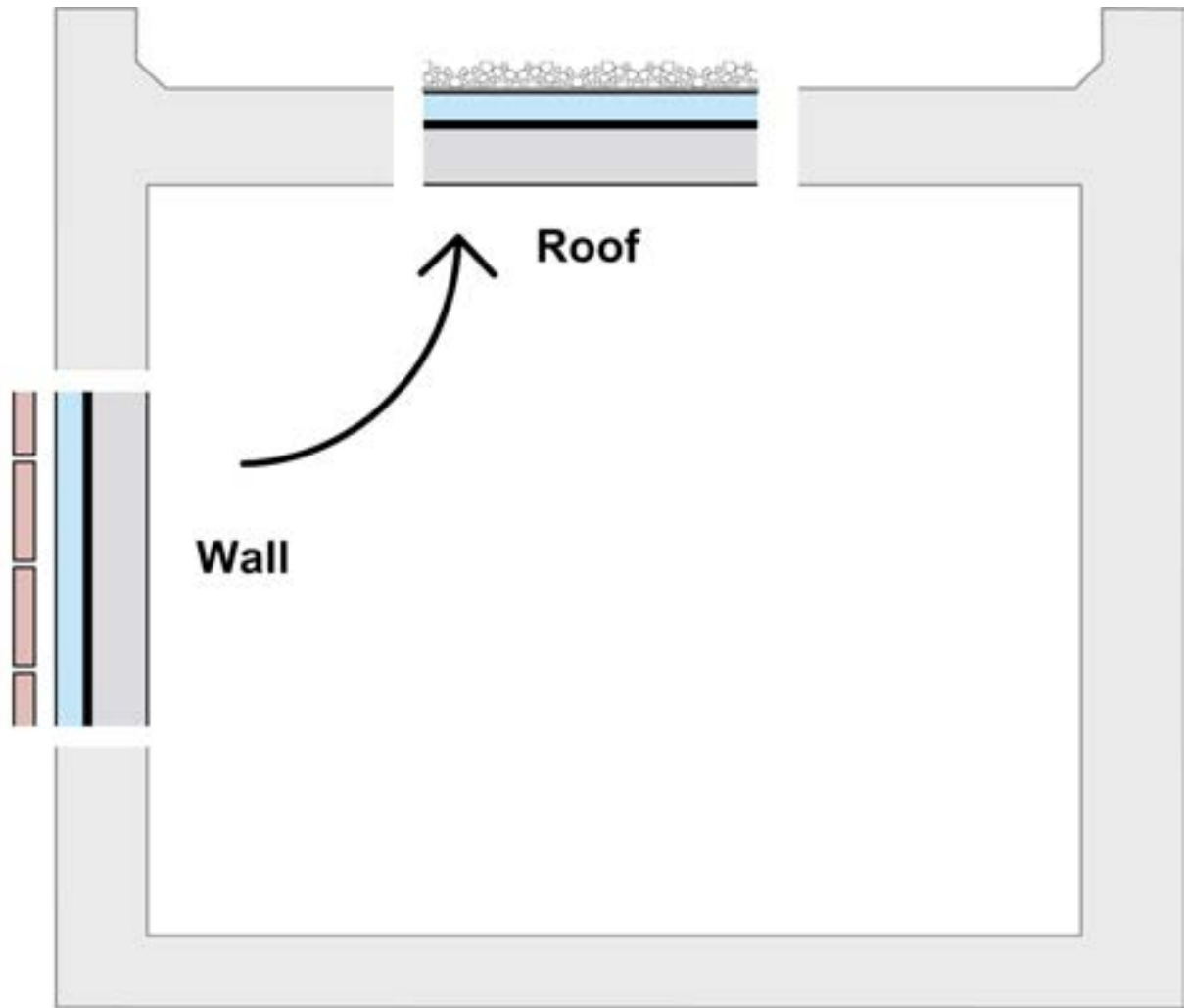


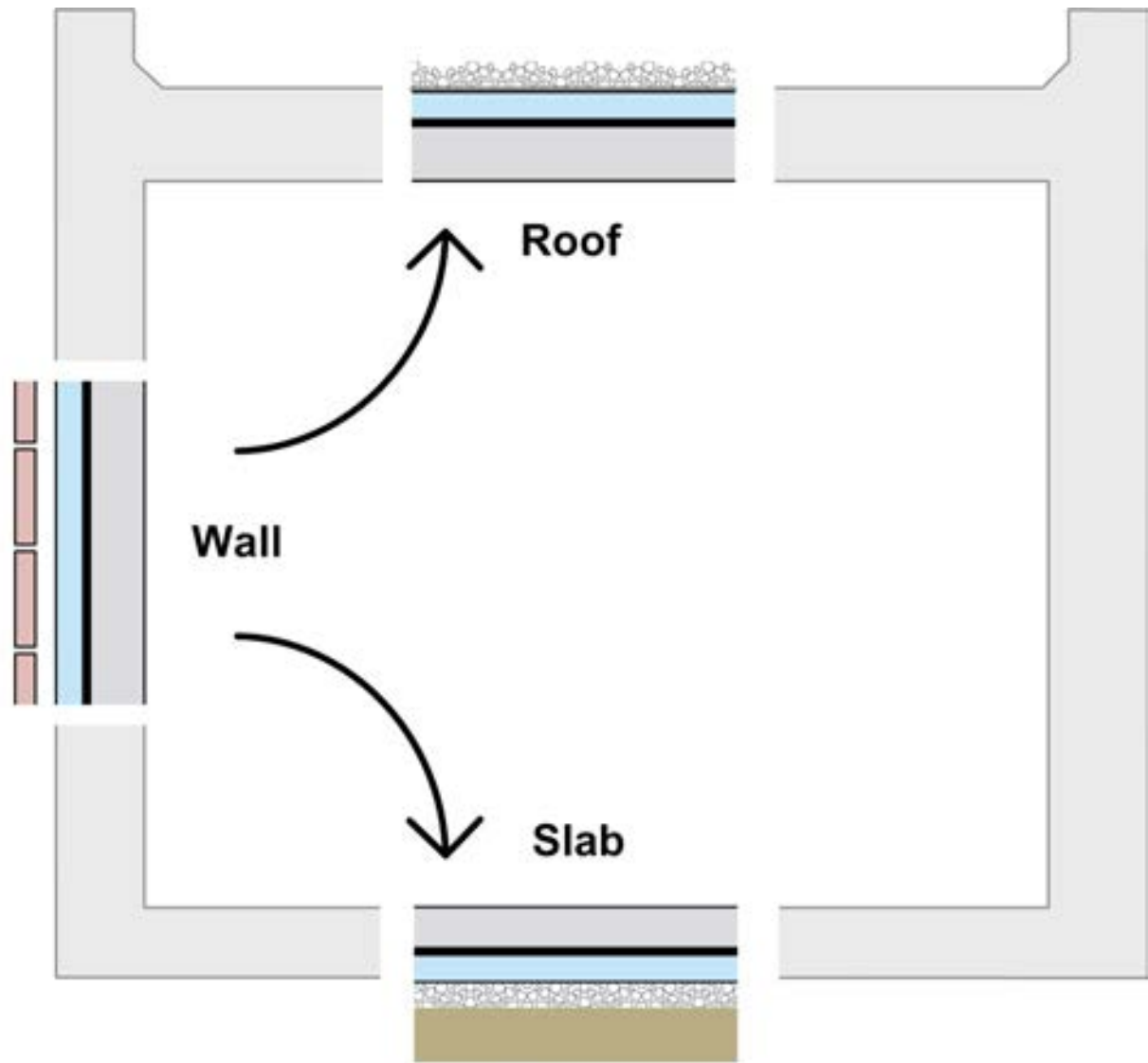


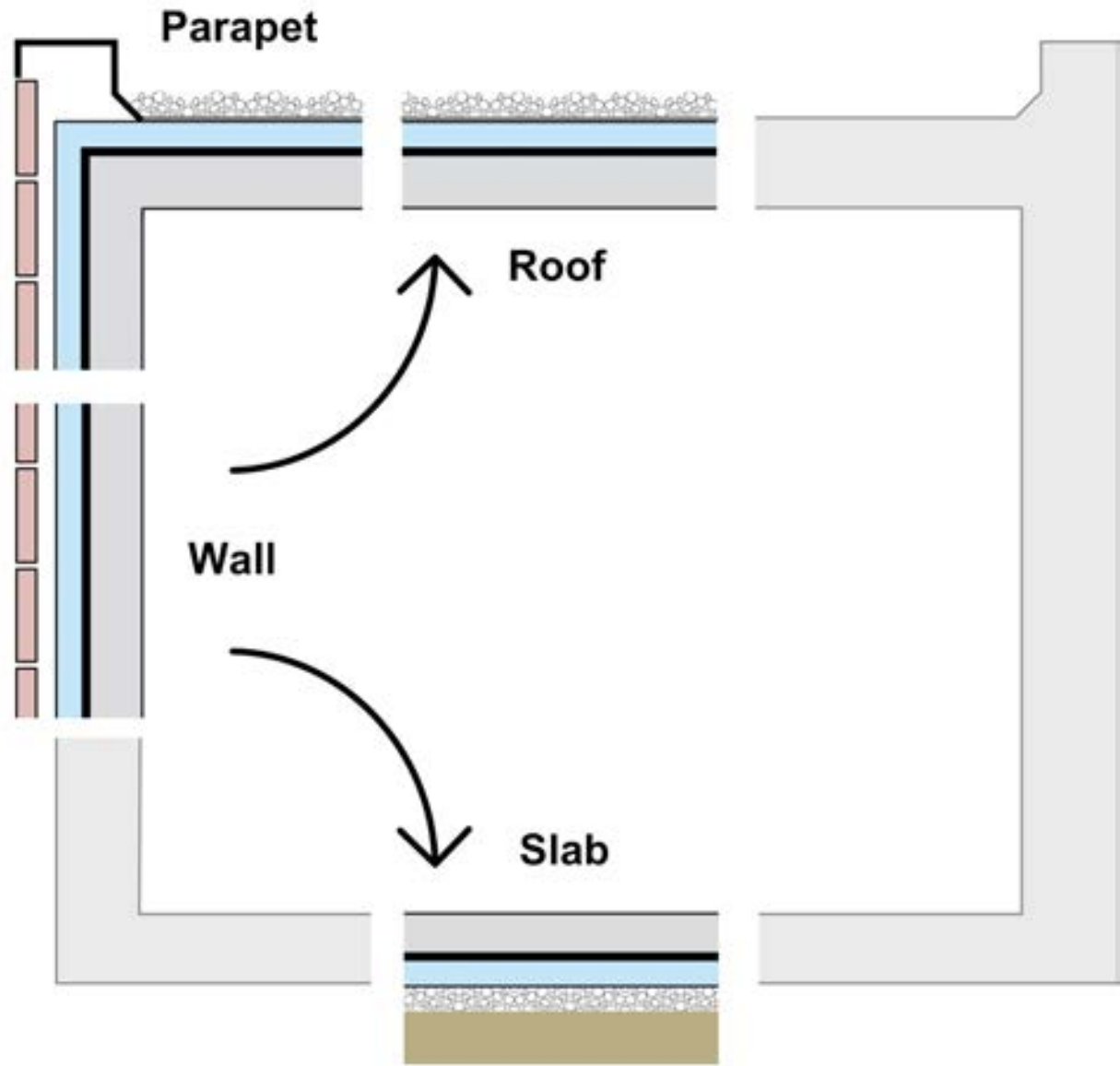


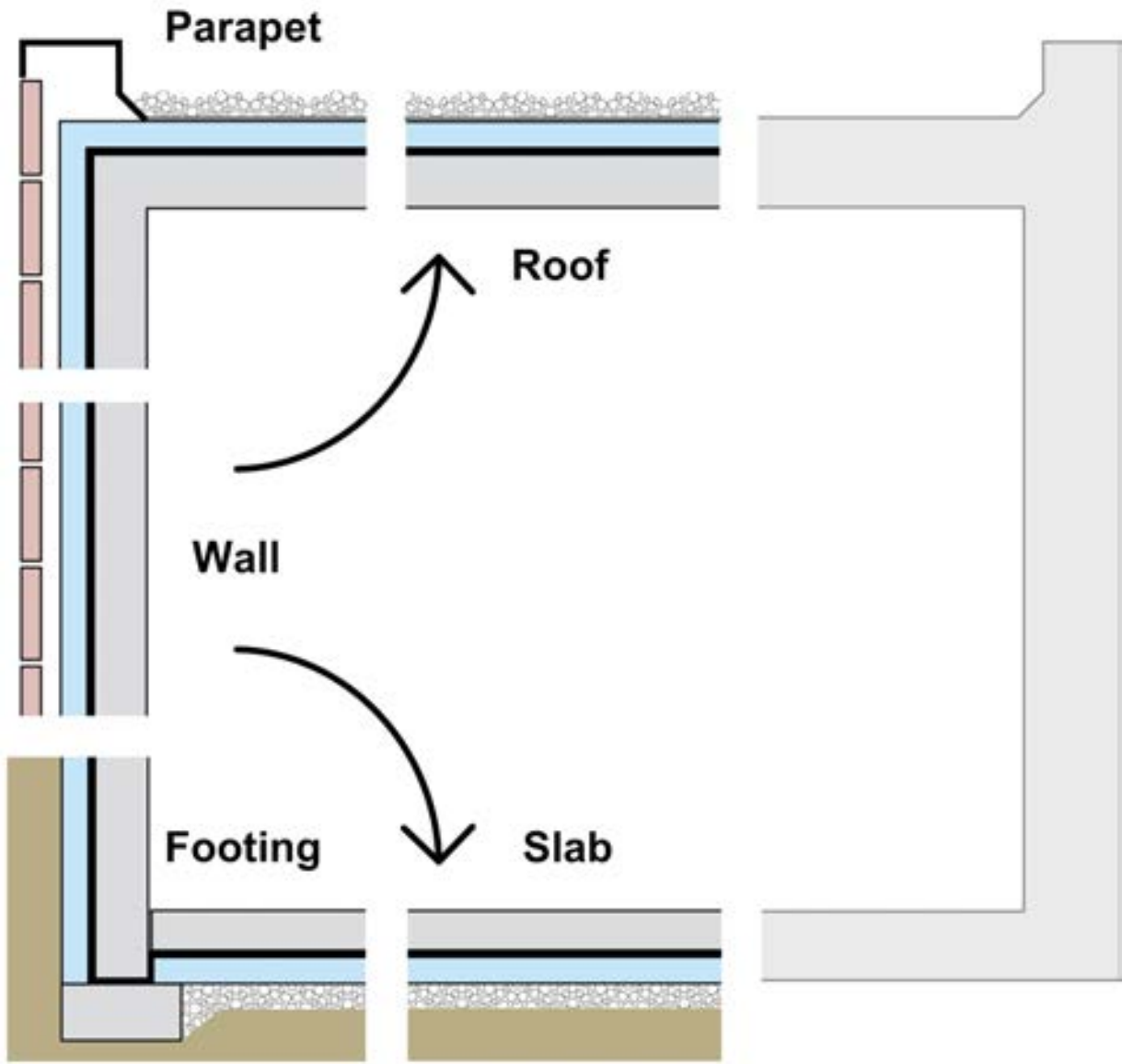


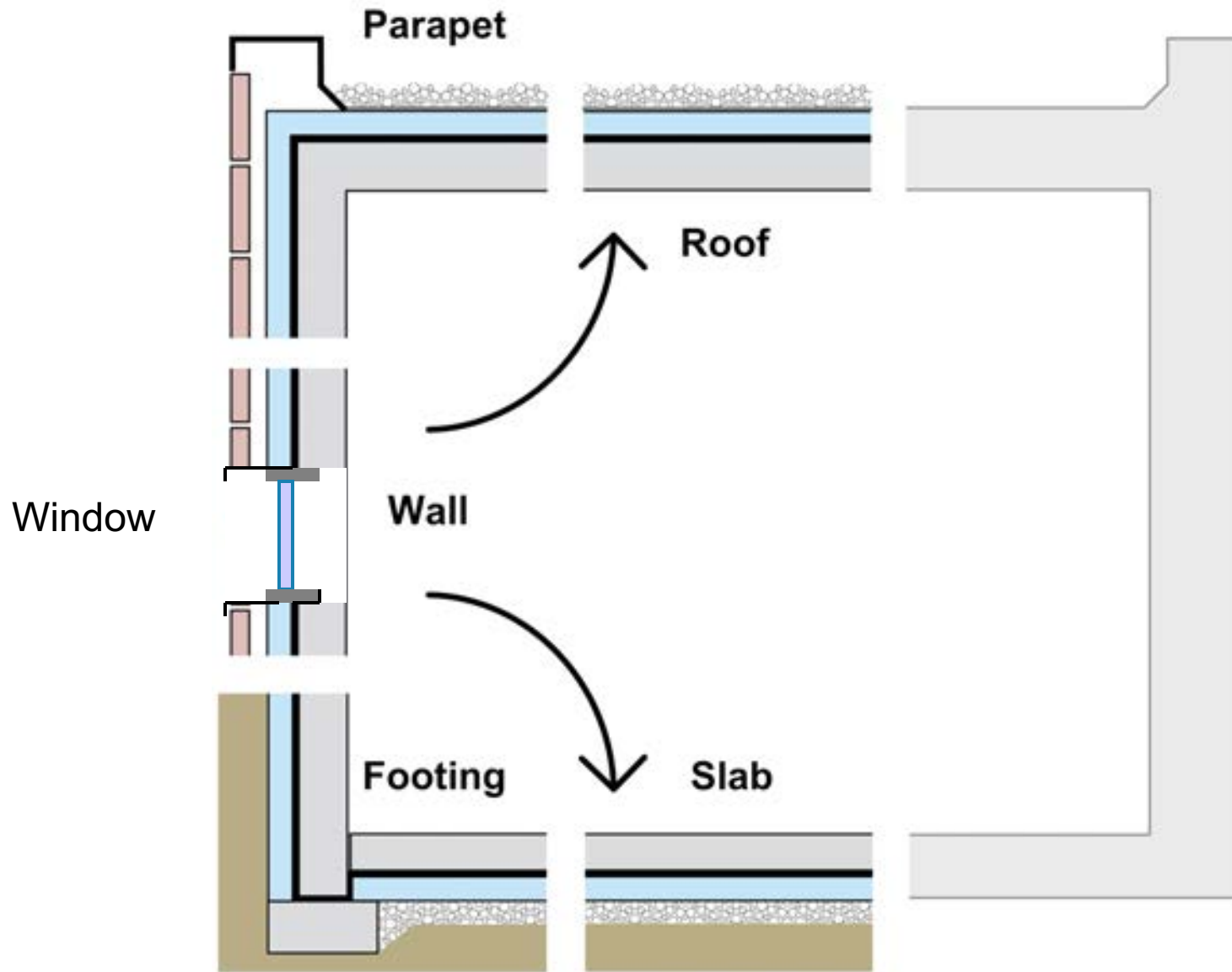




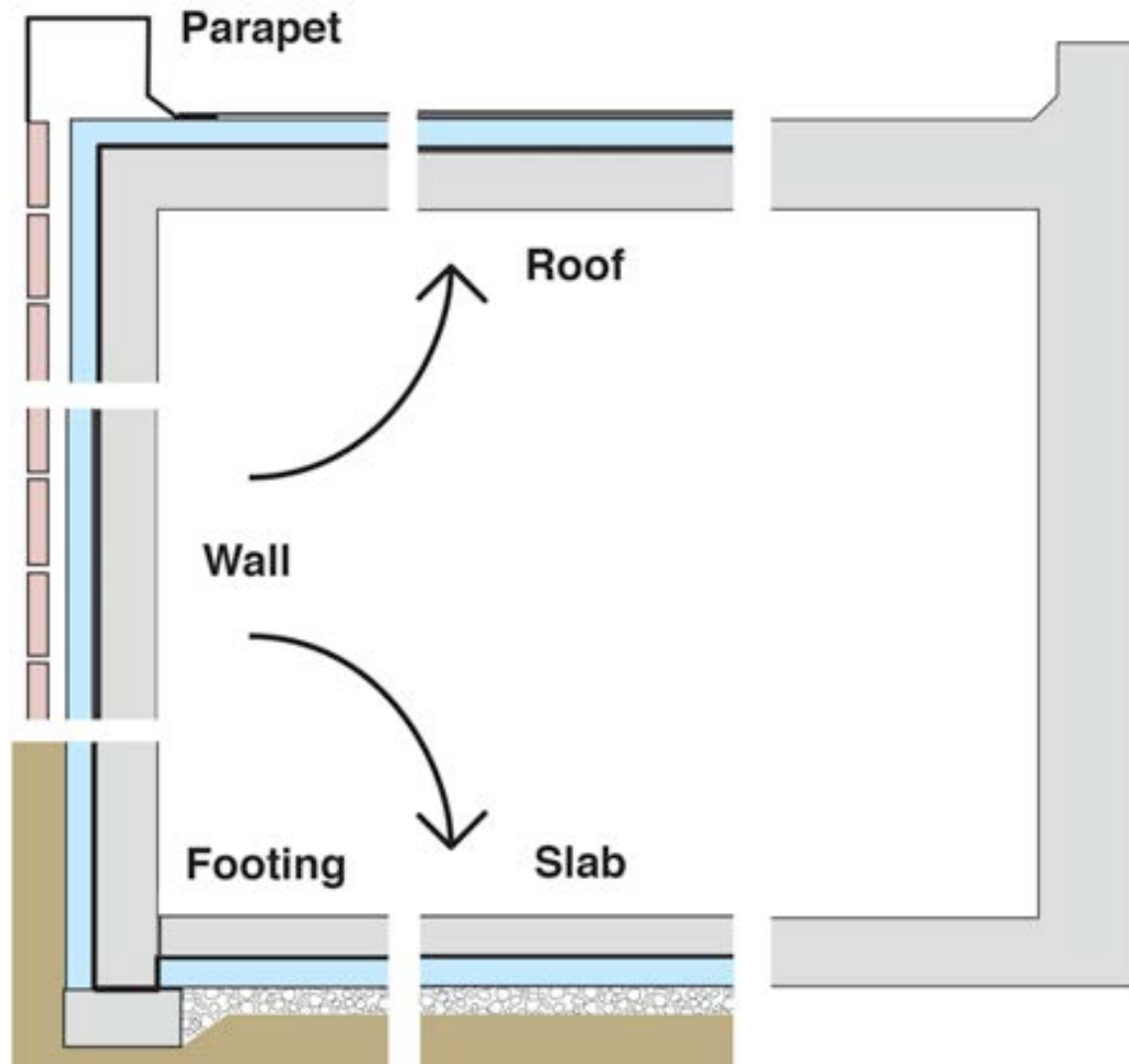




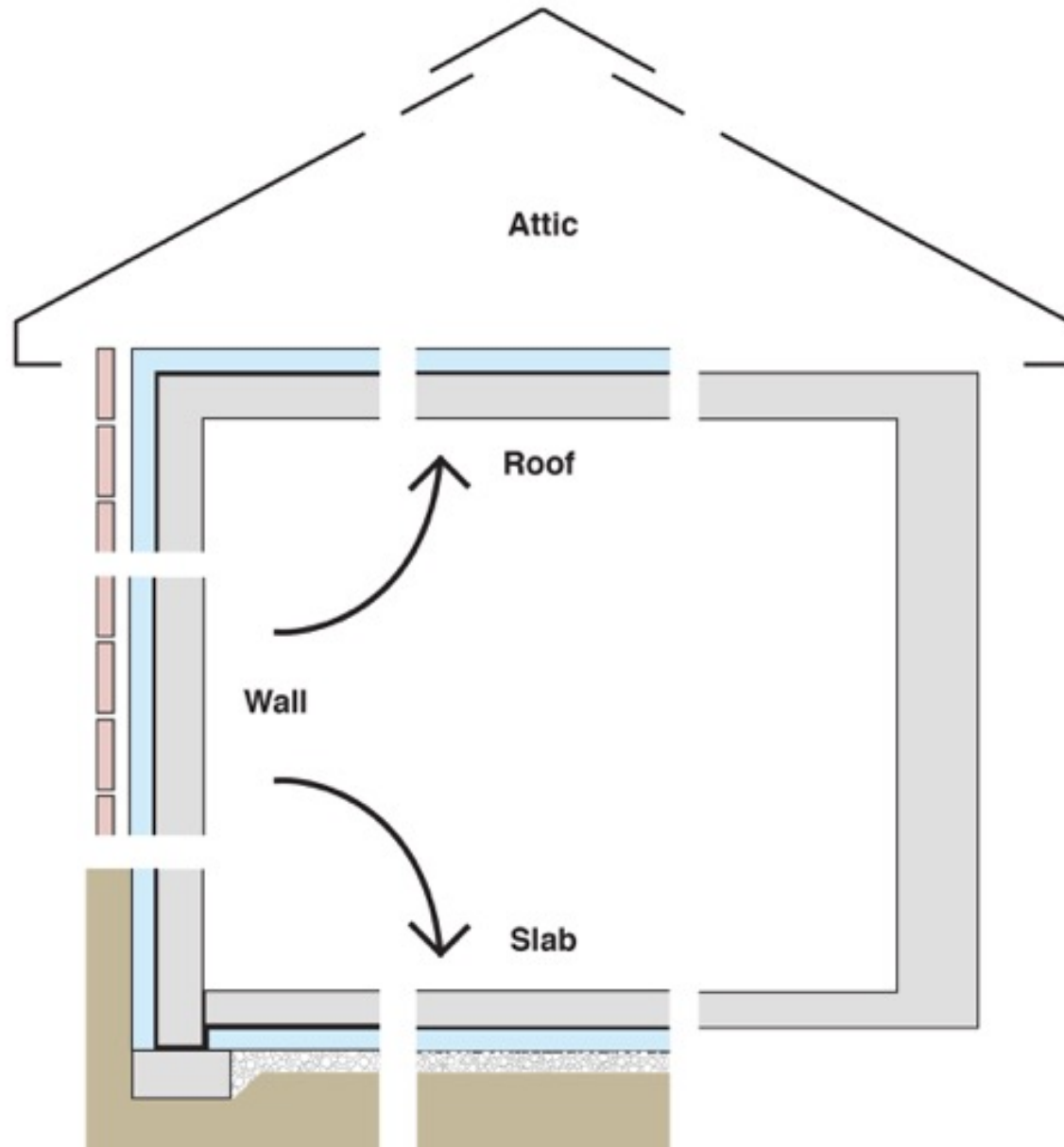


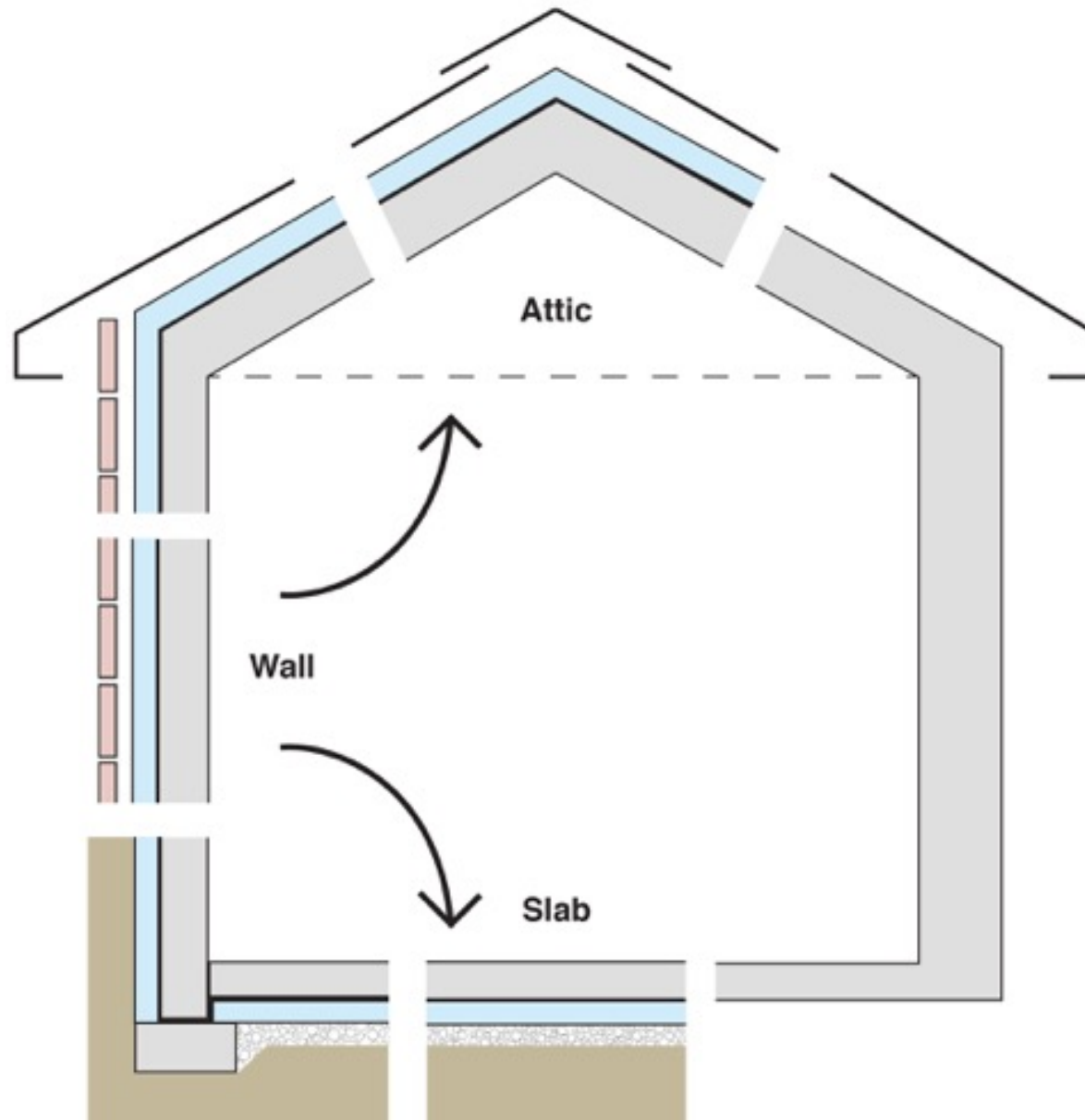


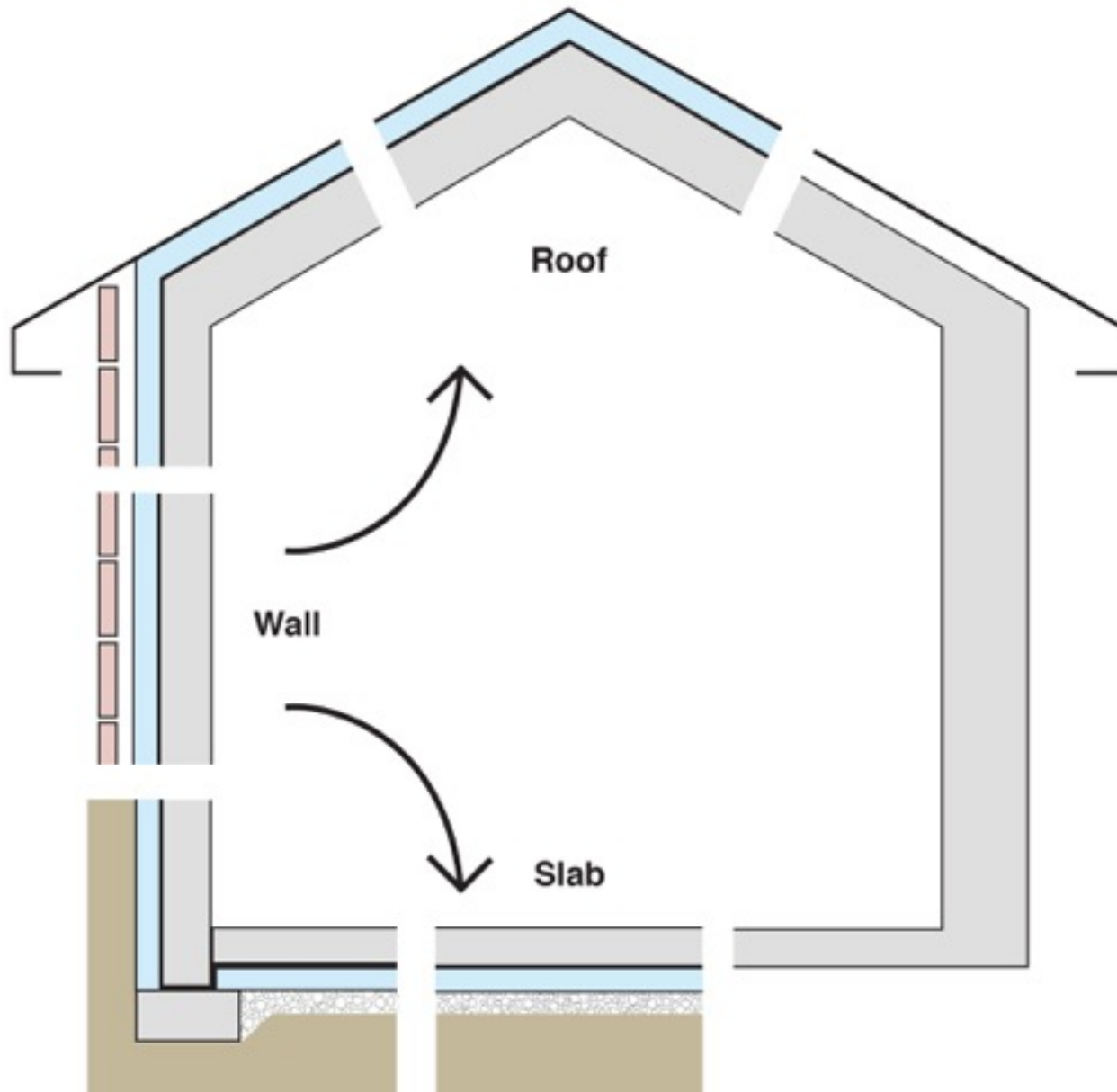


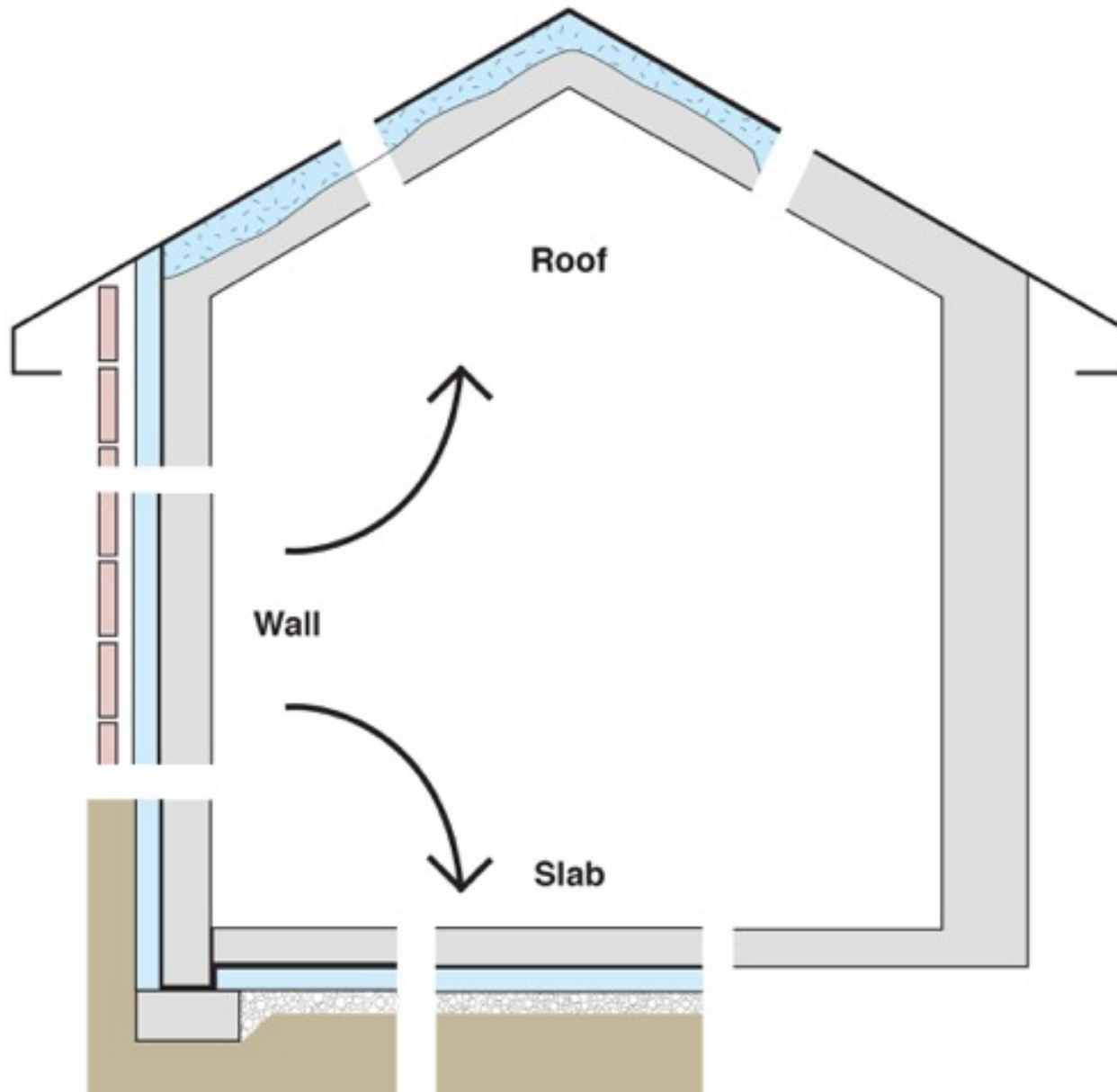




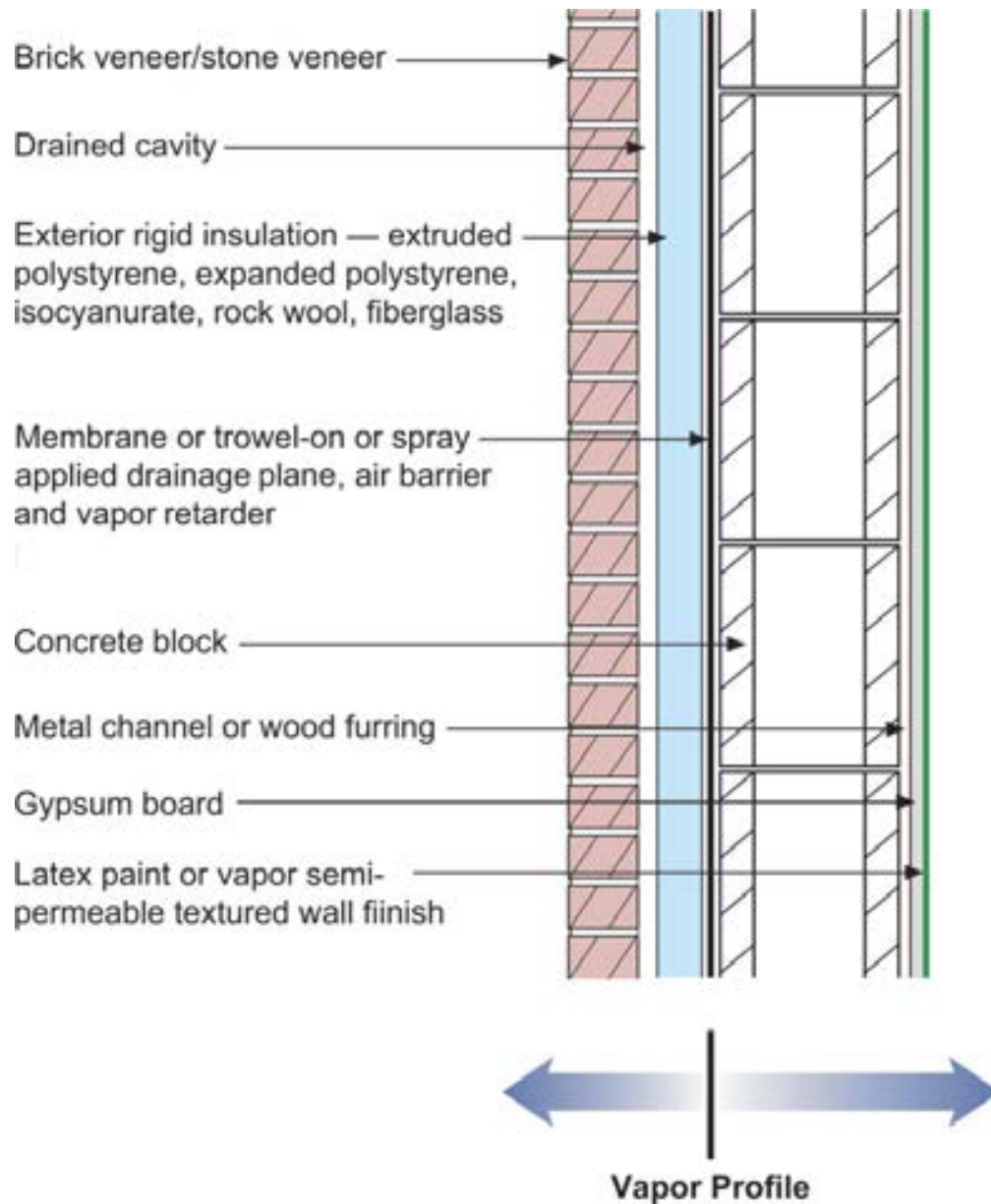


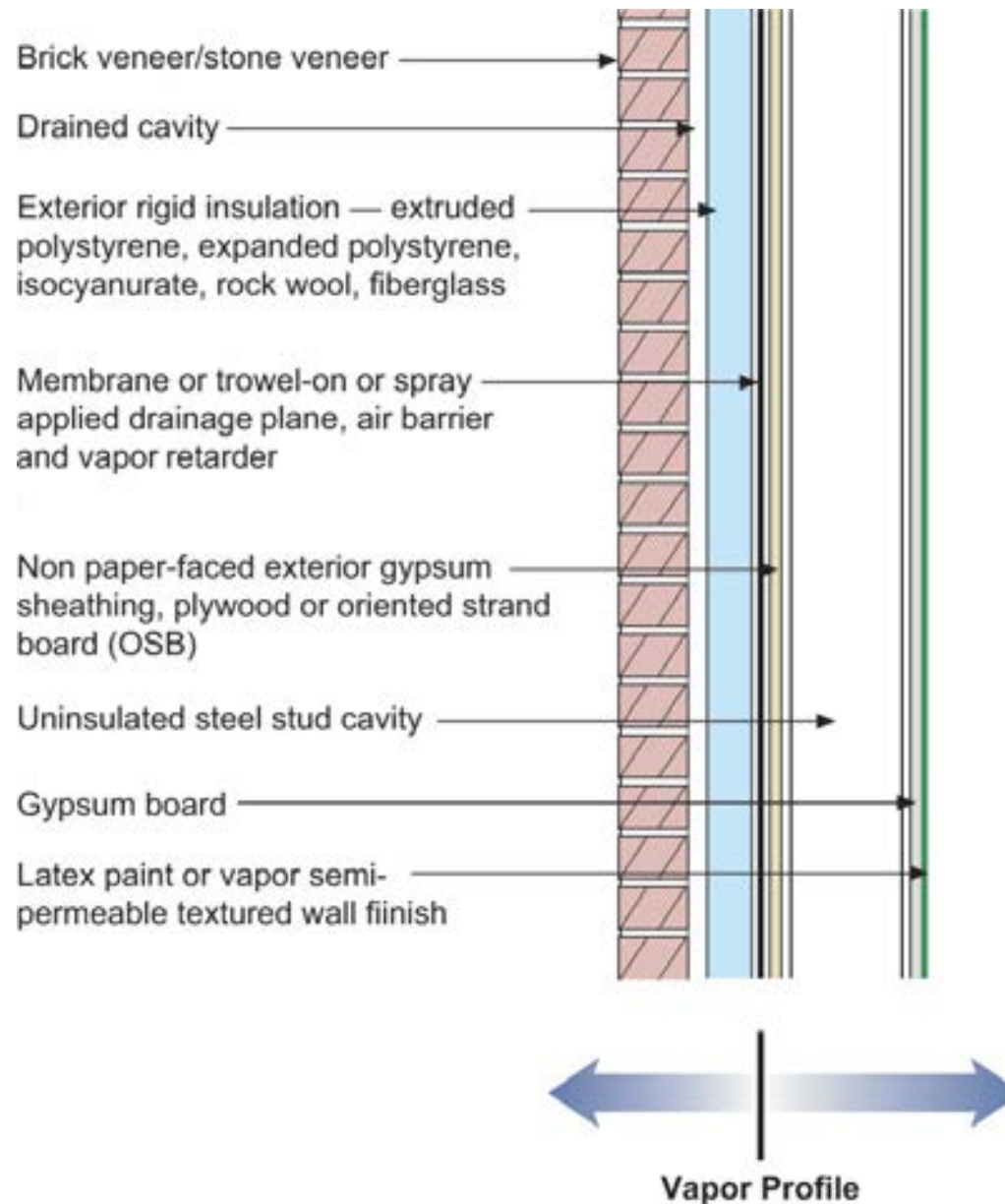


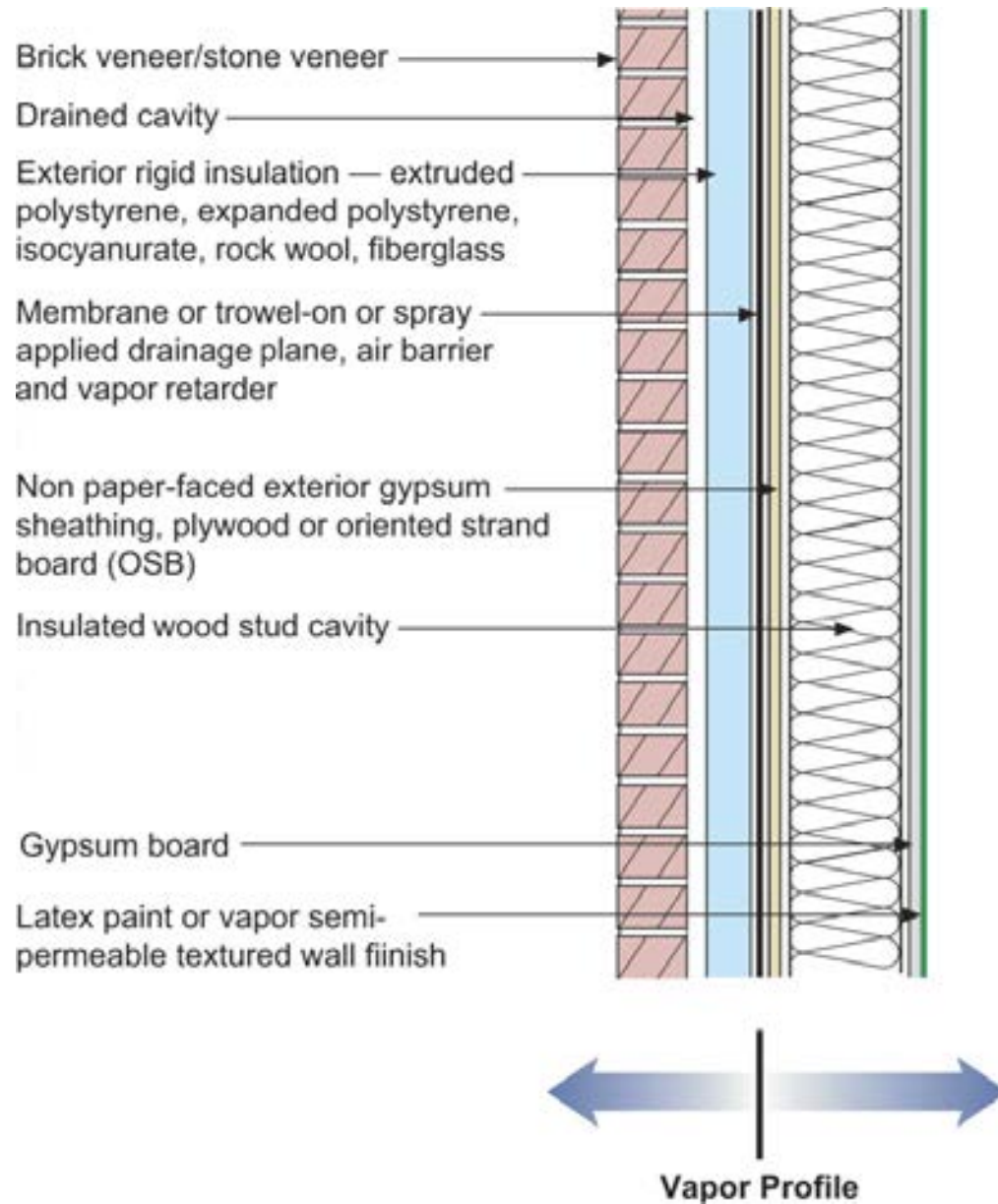




# Configurations of the Perfect Wall









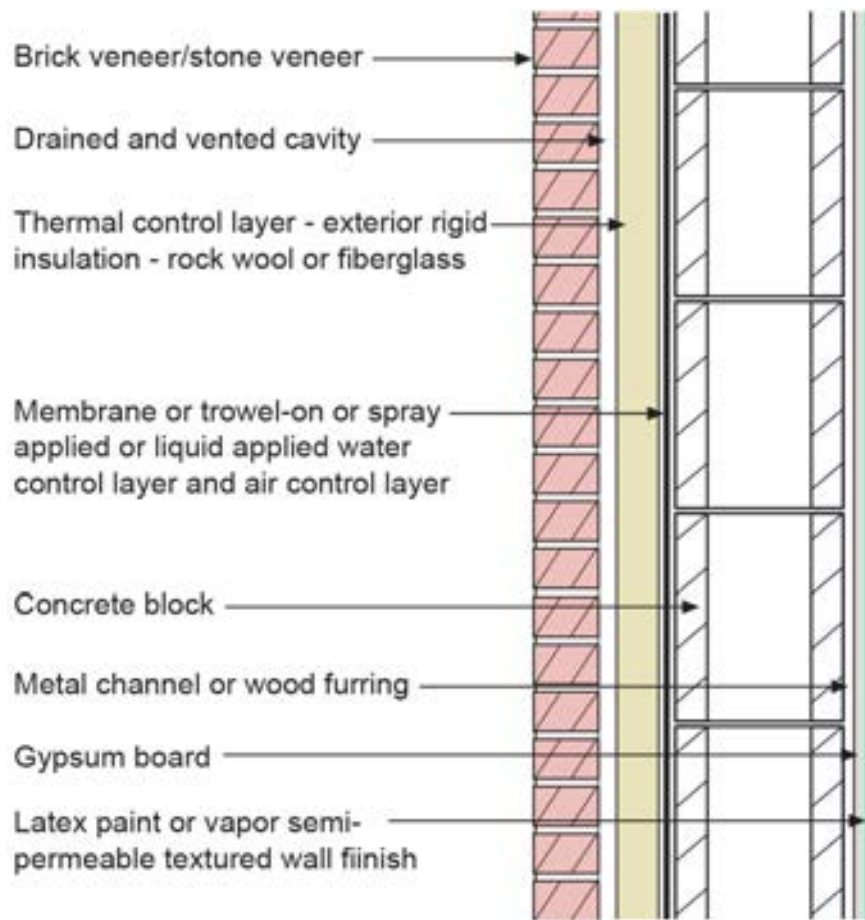


Figure 2a



Vapor Profile

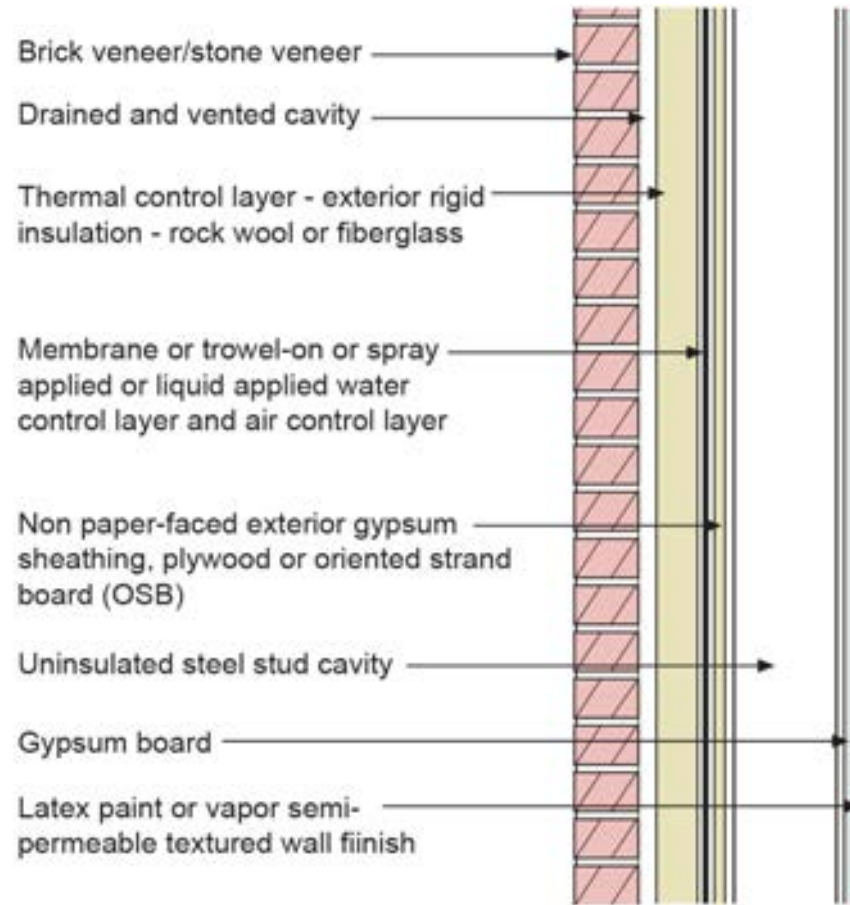


Figure 2b



Vapor Profile

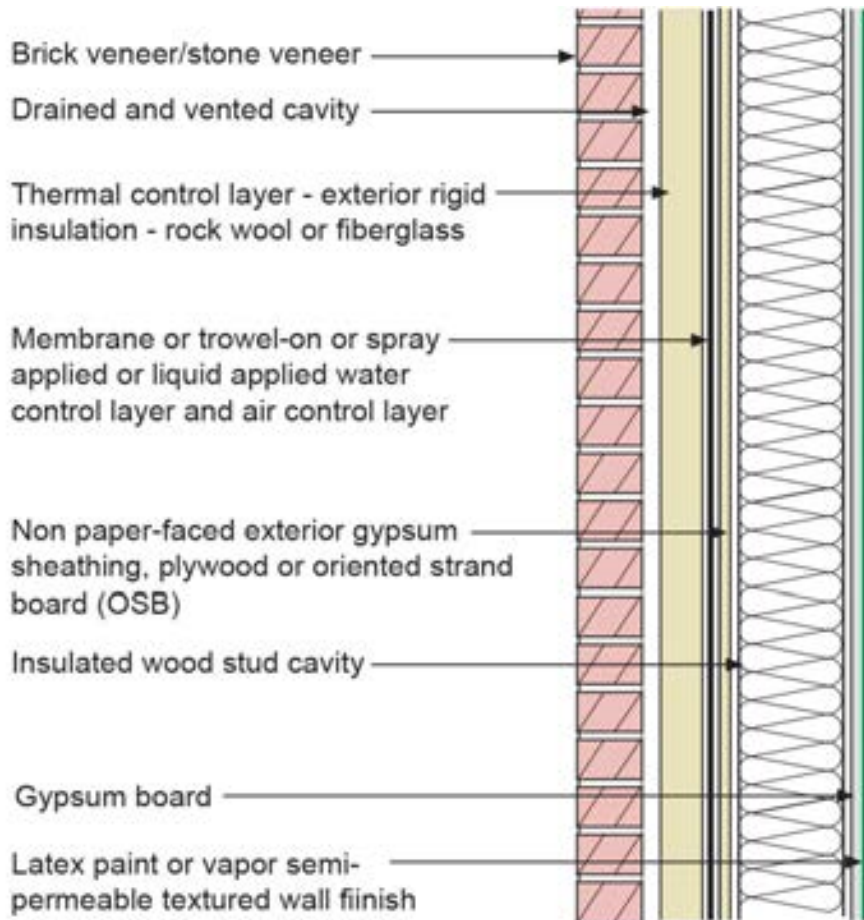
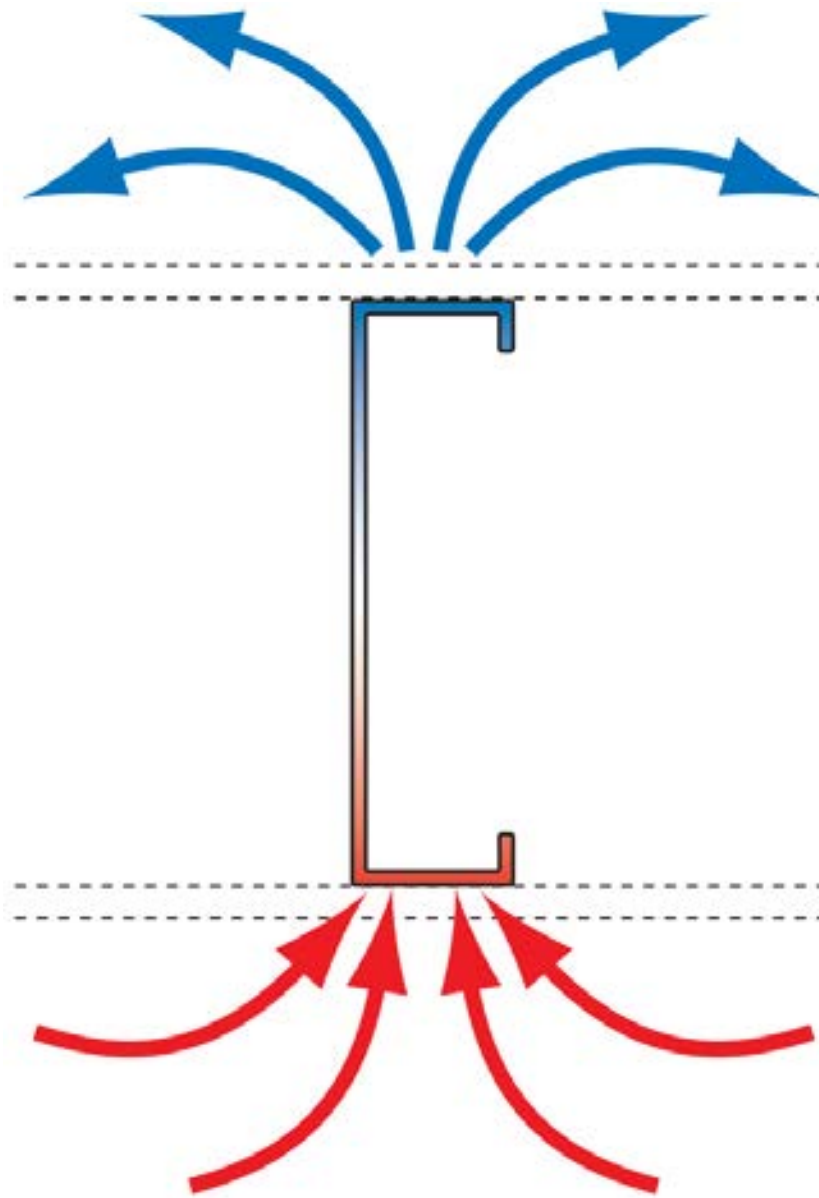


Figure 2c

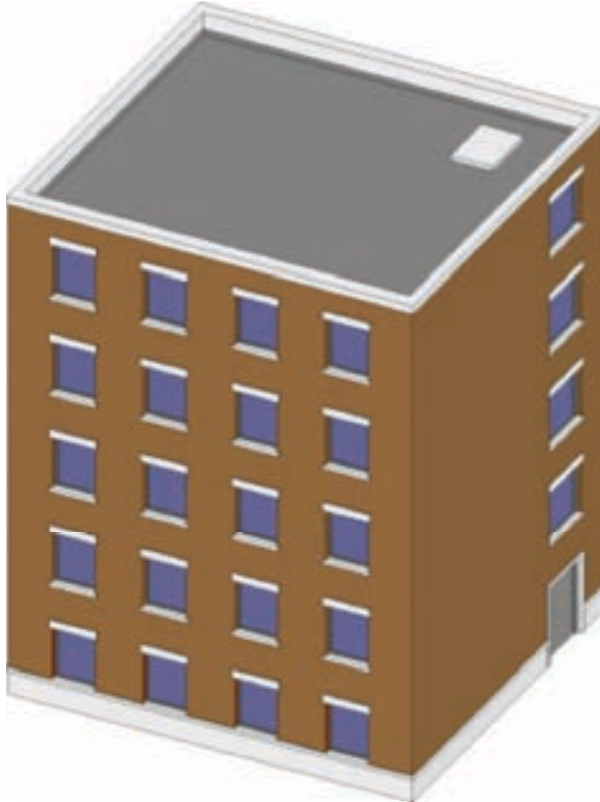


Vapor Profile

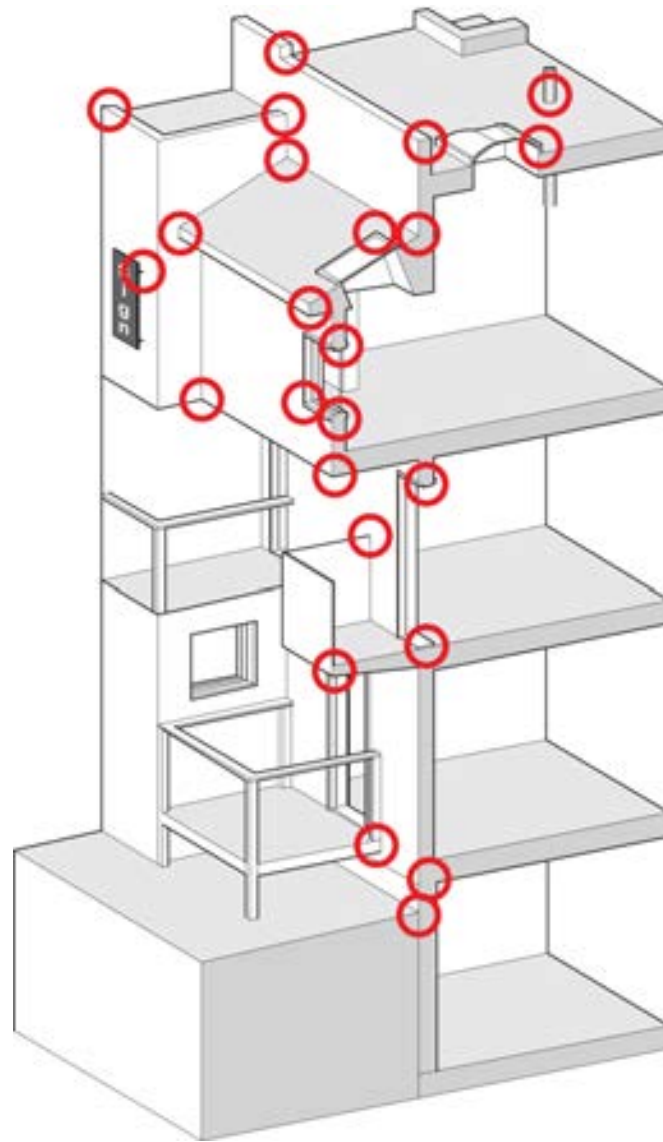




# Commercial Enclosure: Simple Layers



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





















































































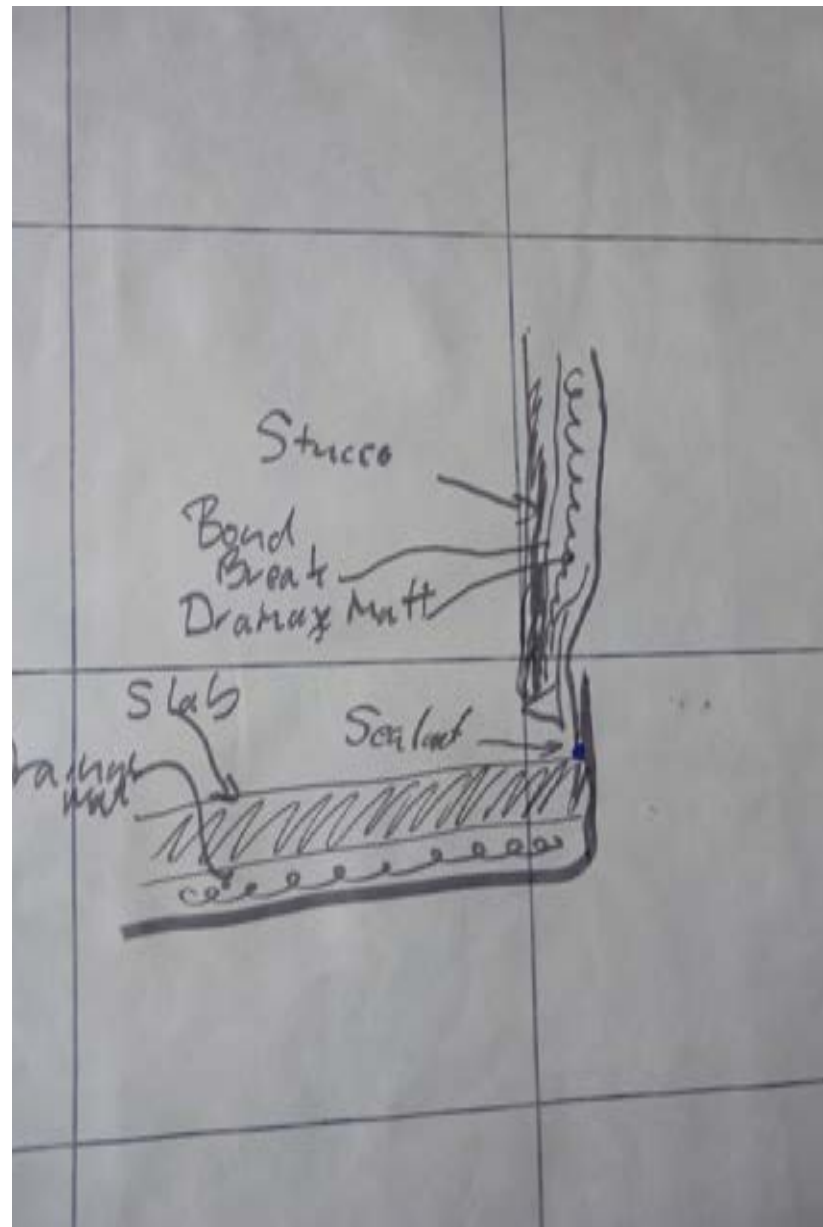






























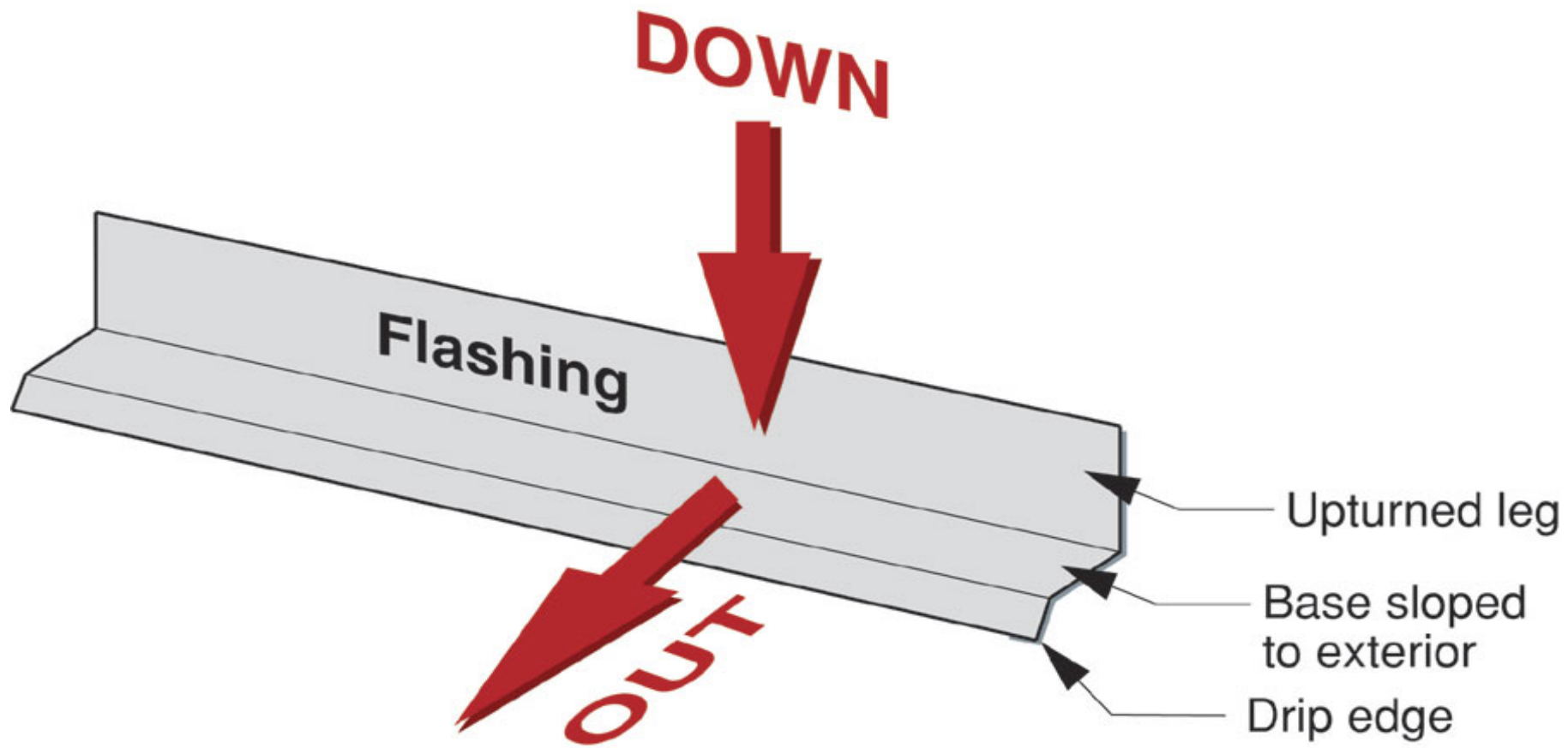


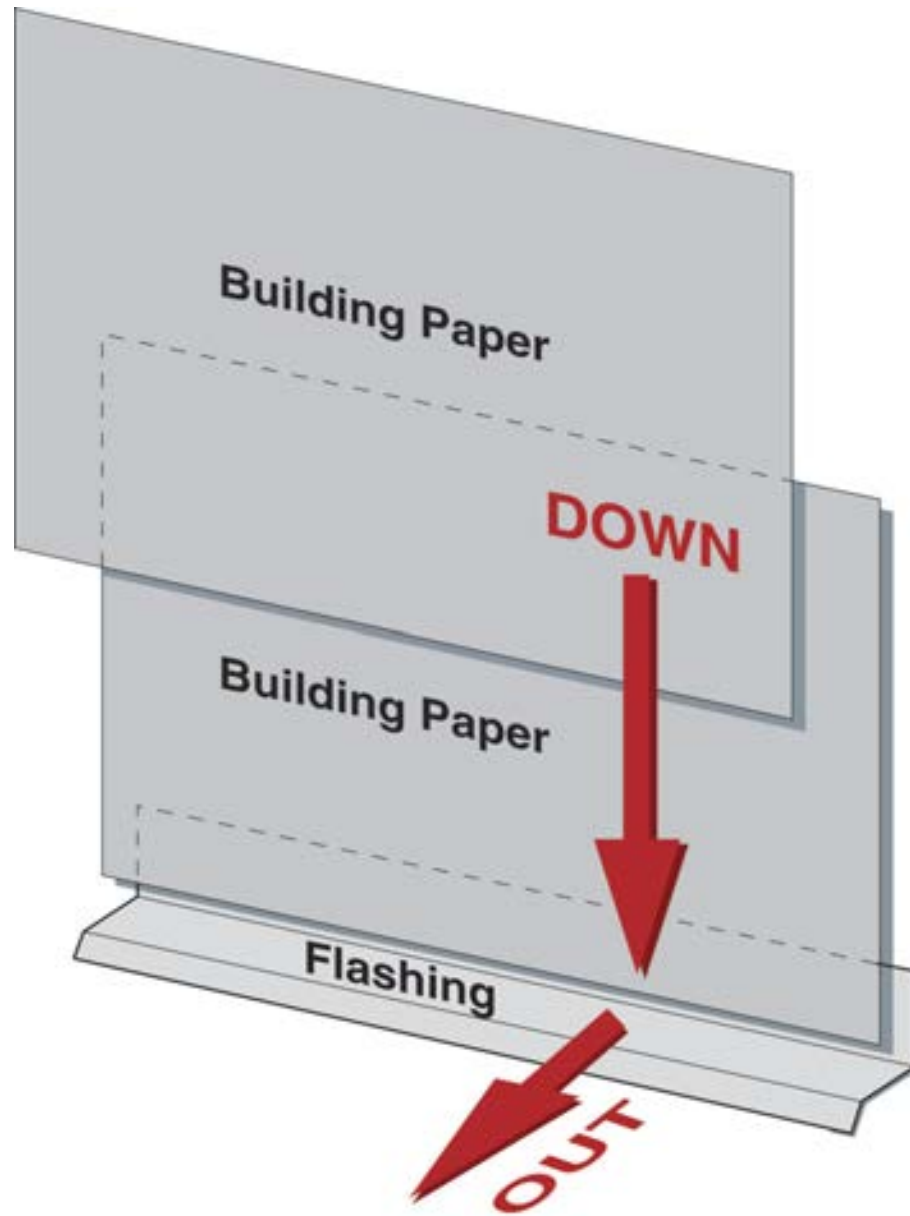




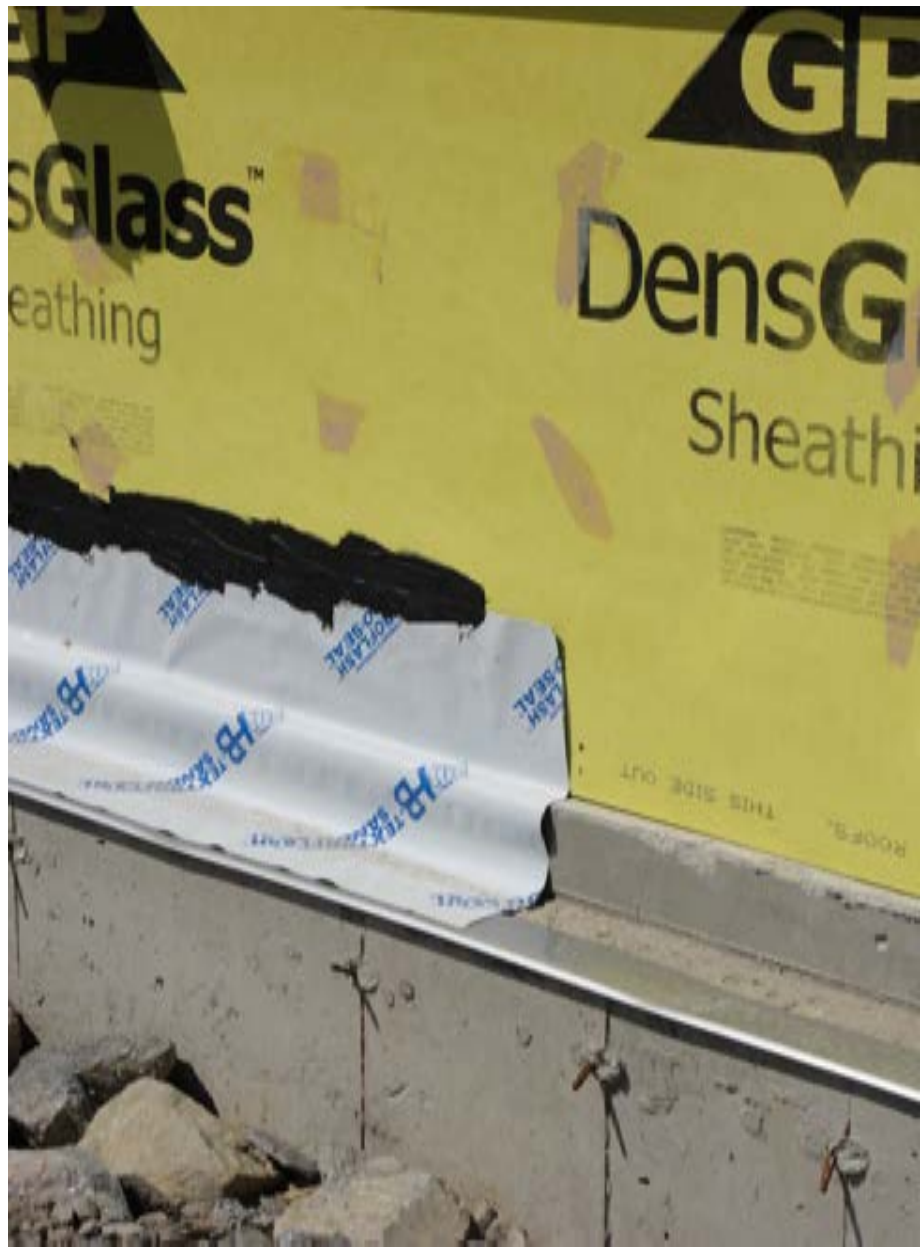
















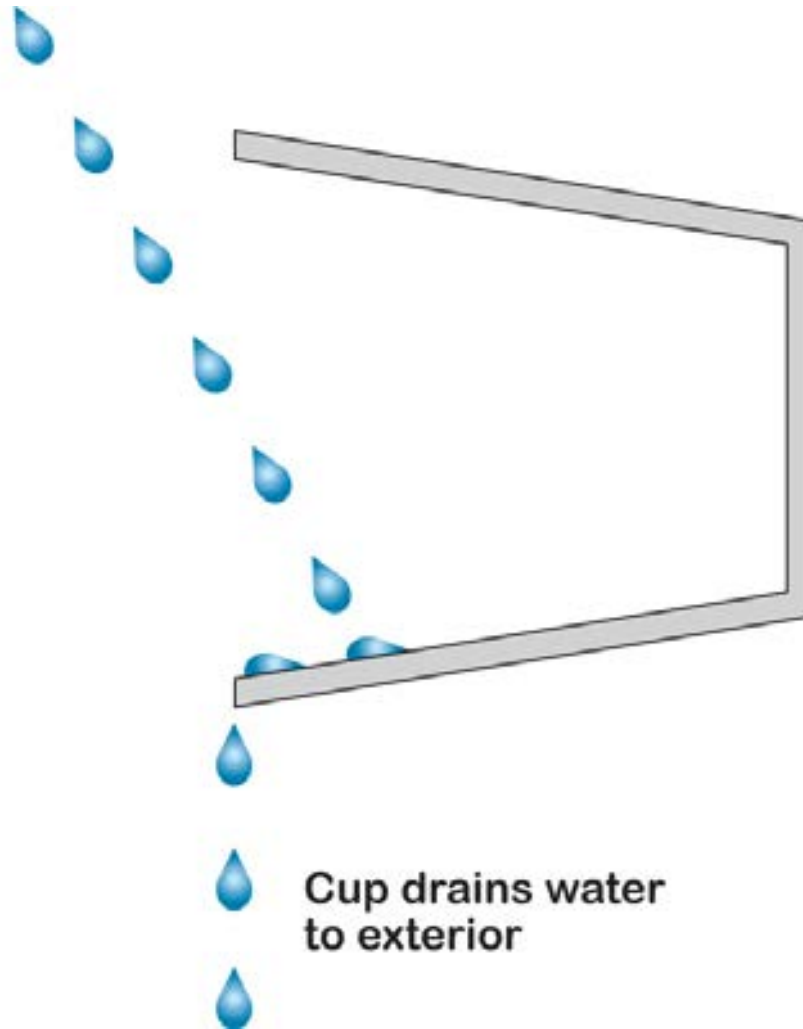








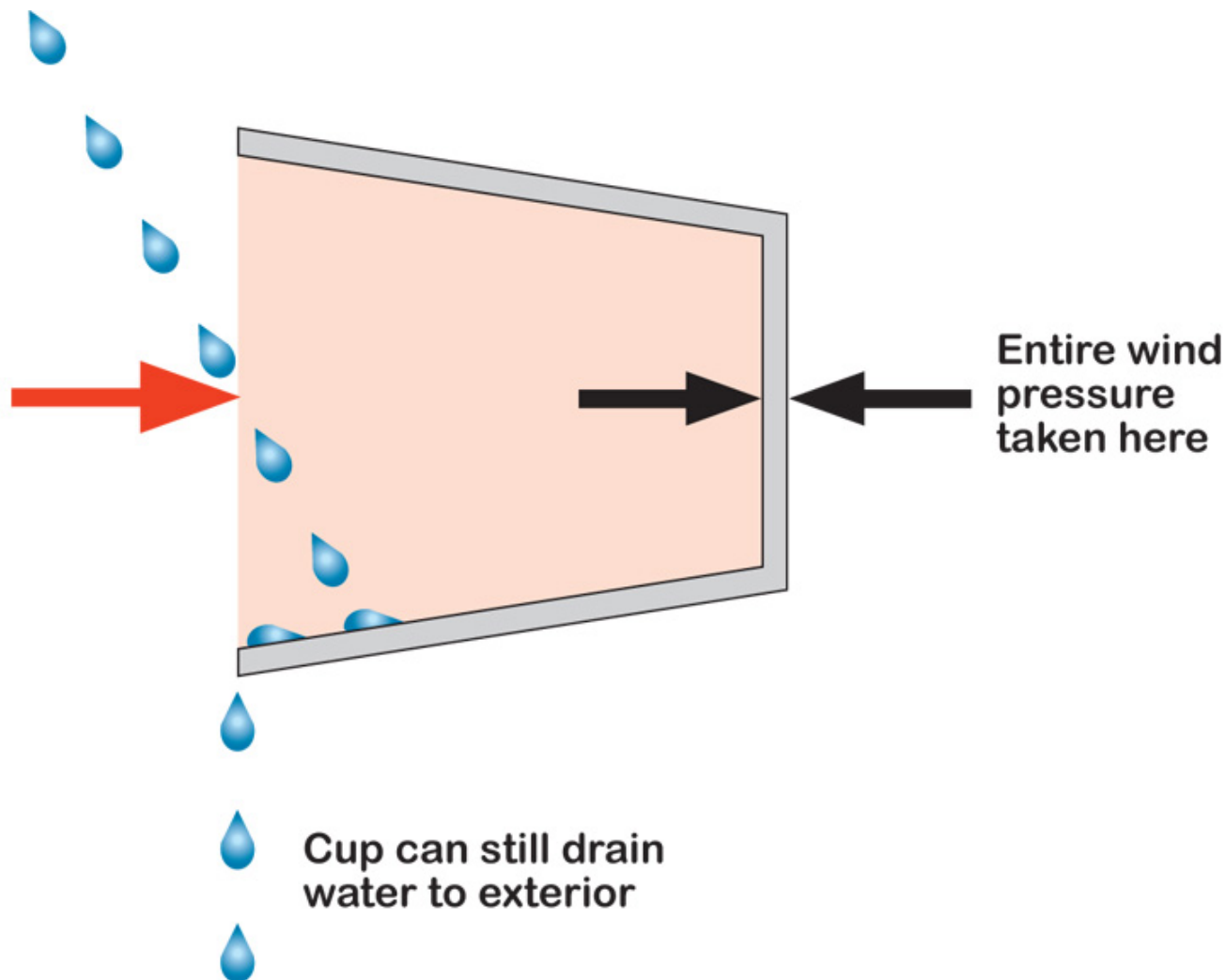
Rain enters cup  
due to momentum  
("kinetic energy")



Cup drains water  
to exterior

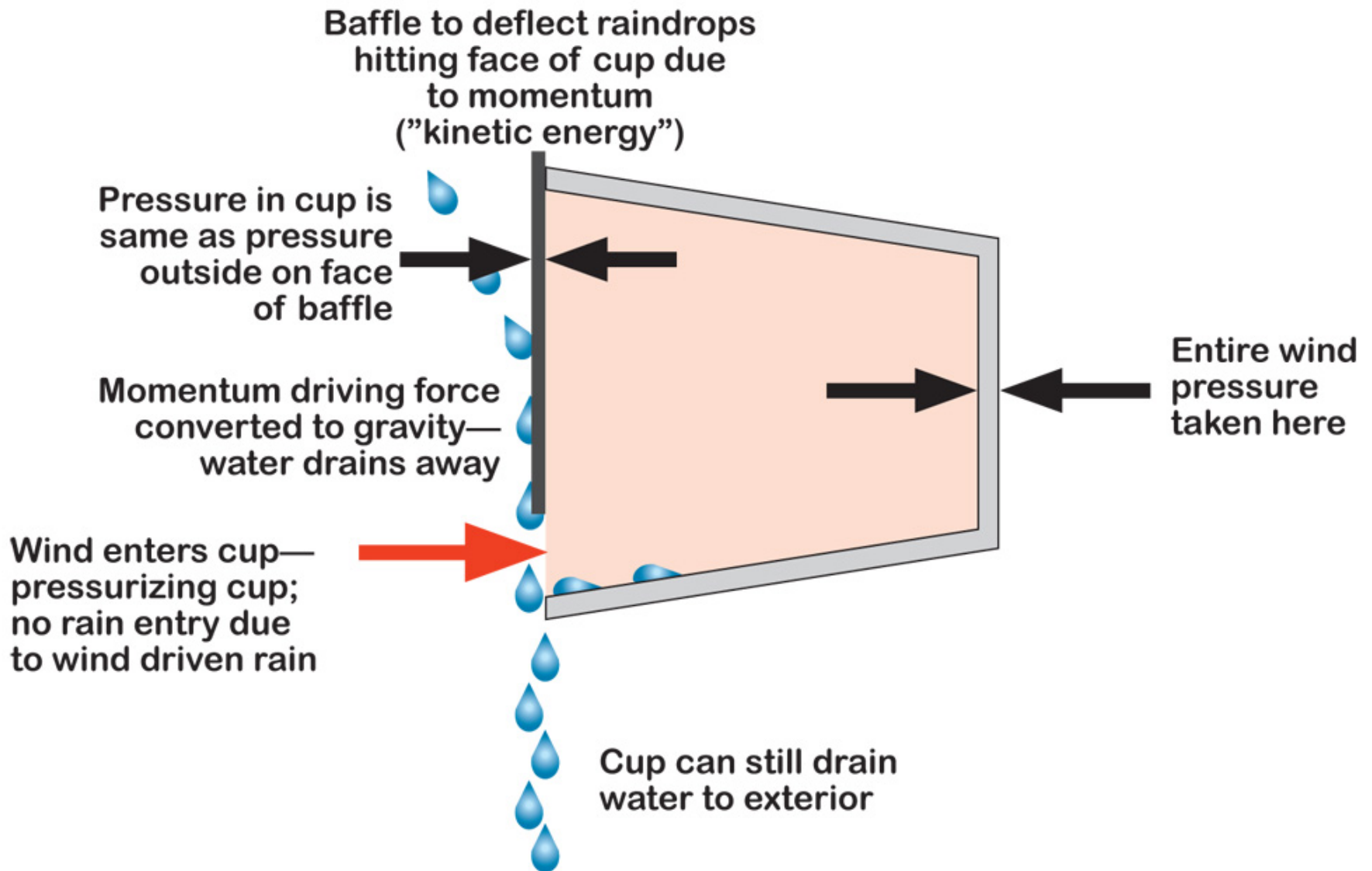
Rain enters cup due to momentum ("kinetic energy")

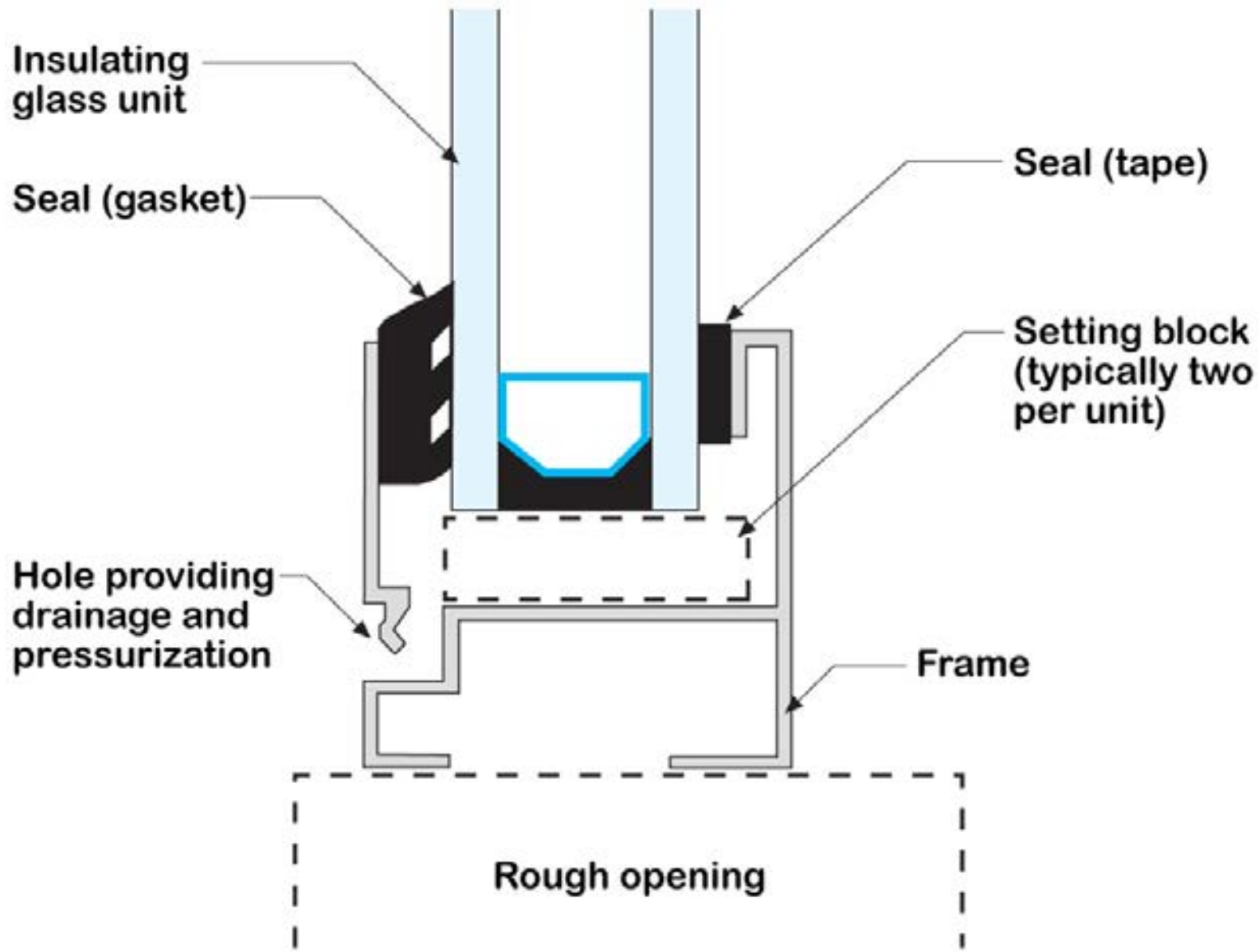
Wind enters cup—pressurizing cup; no rain entry due to wind driven rain

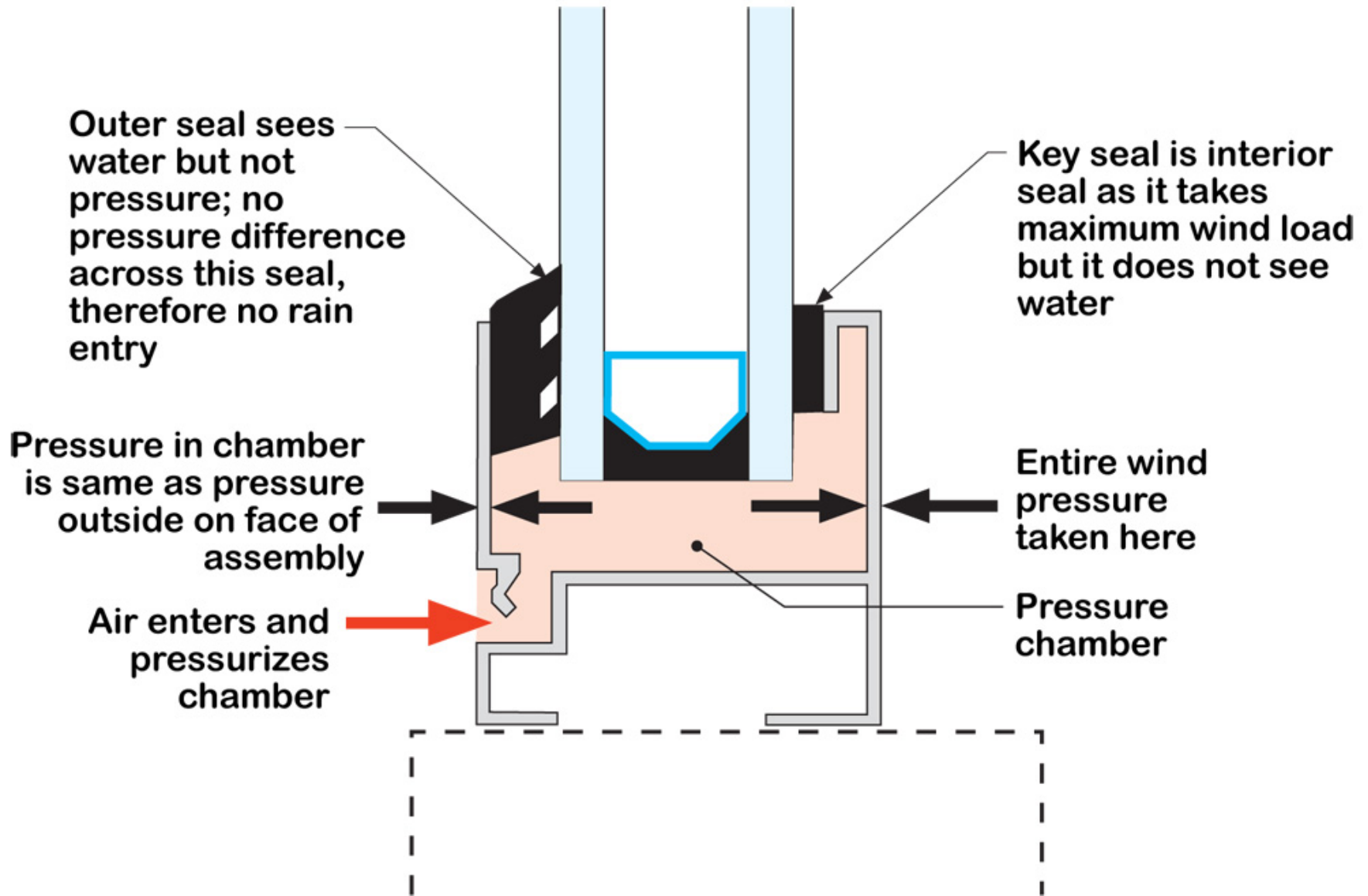


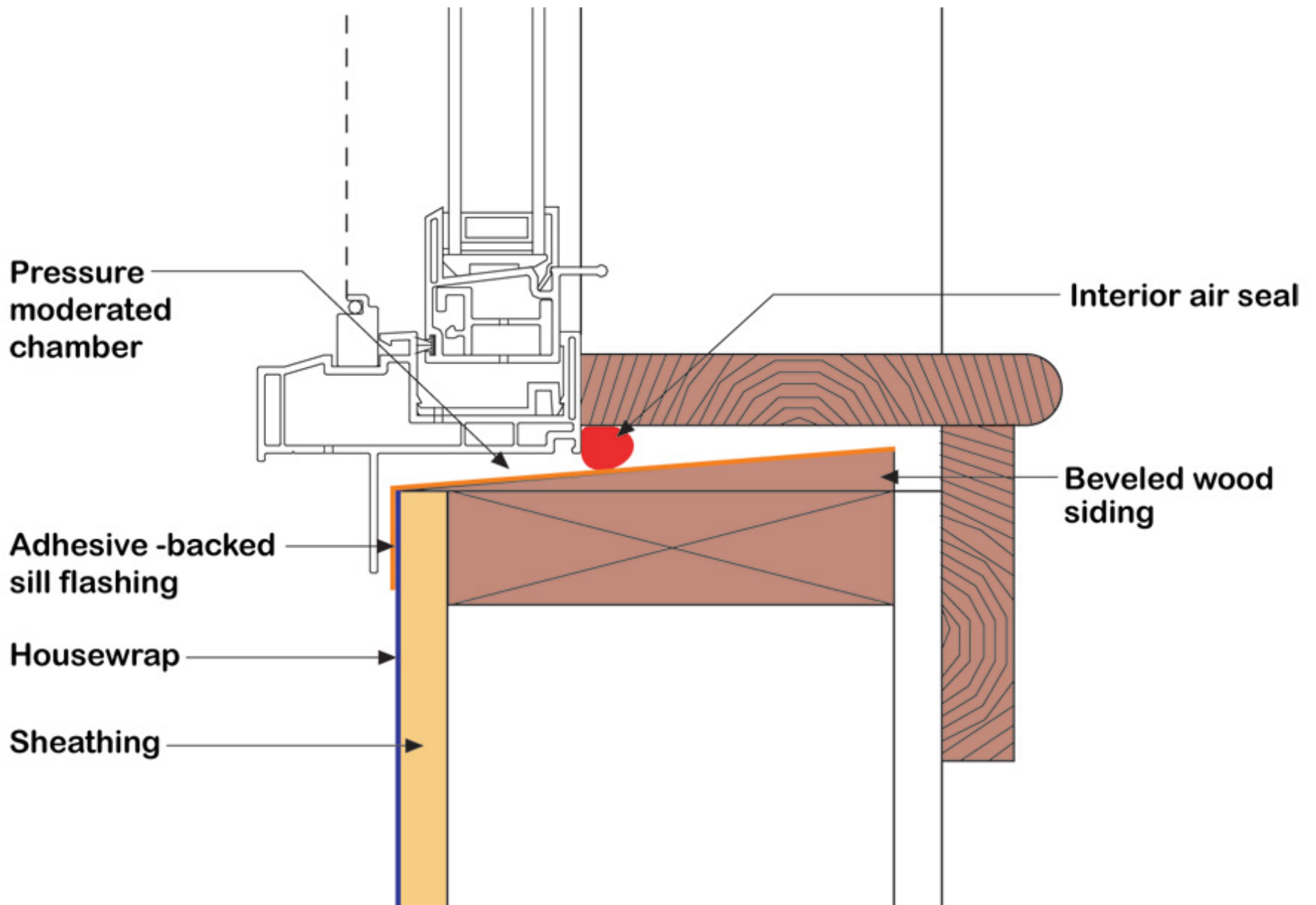
Cup can still drain water to exterior















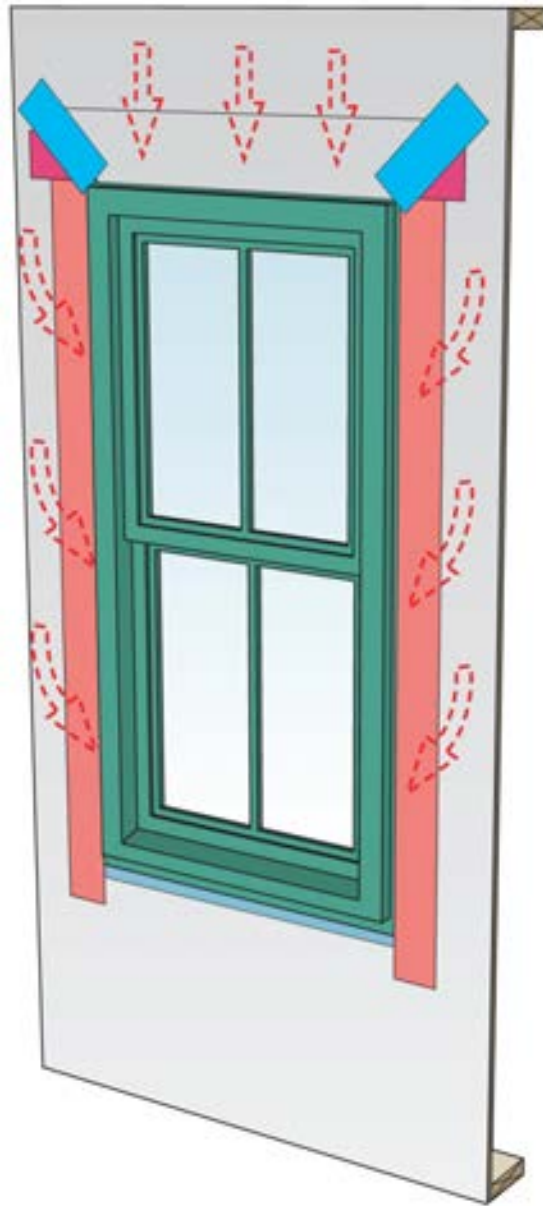




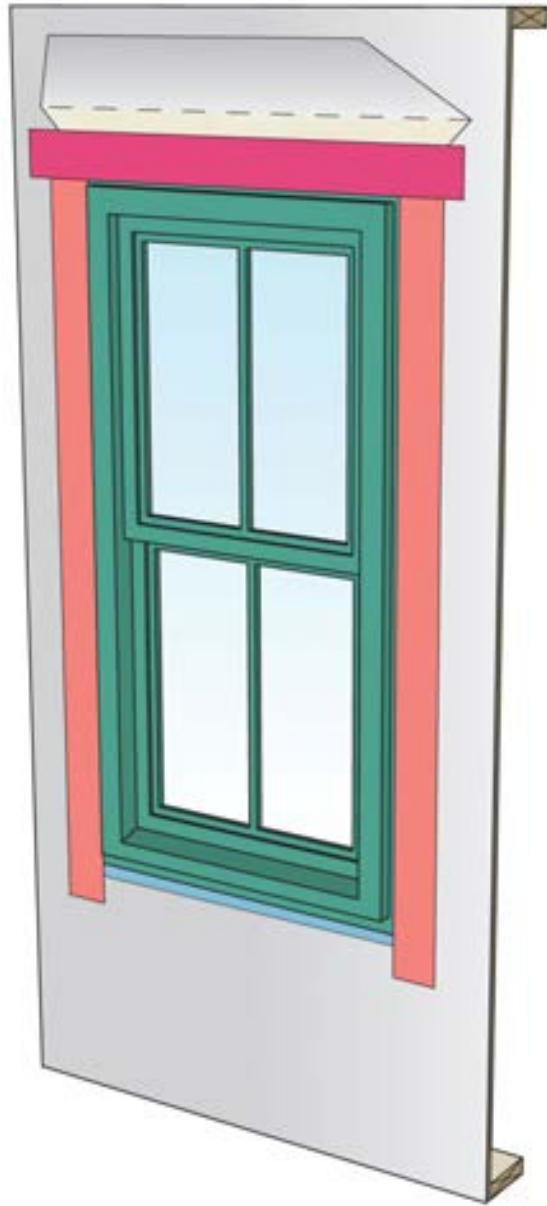




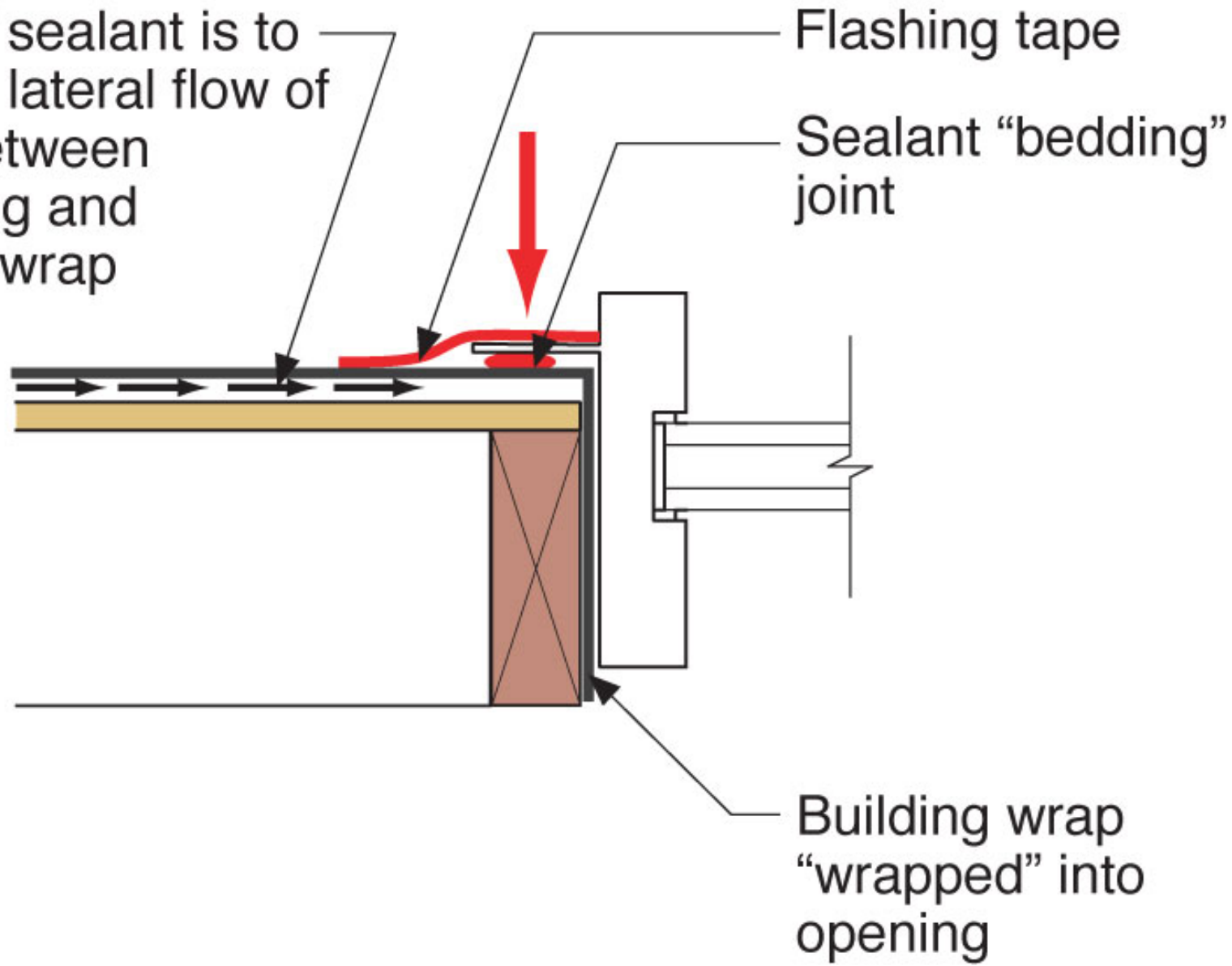


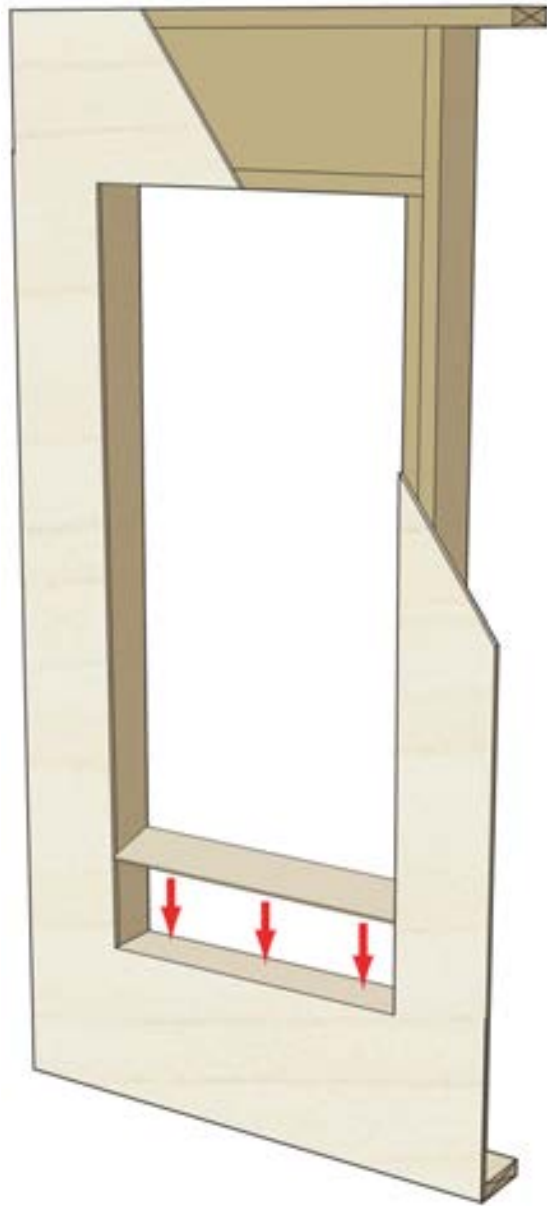


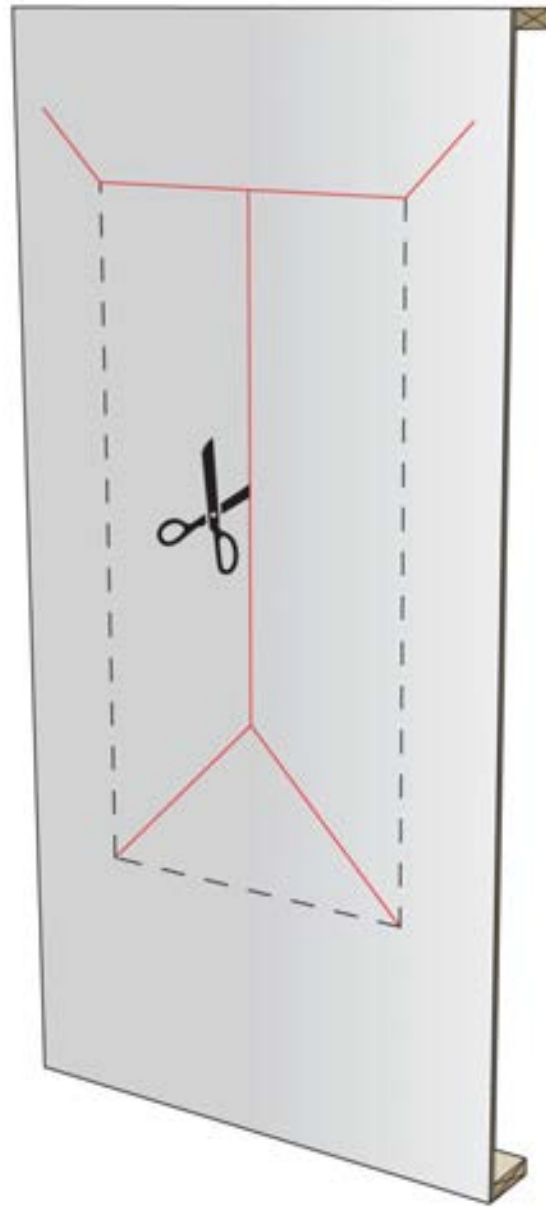


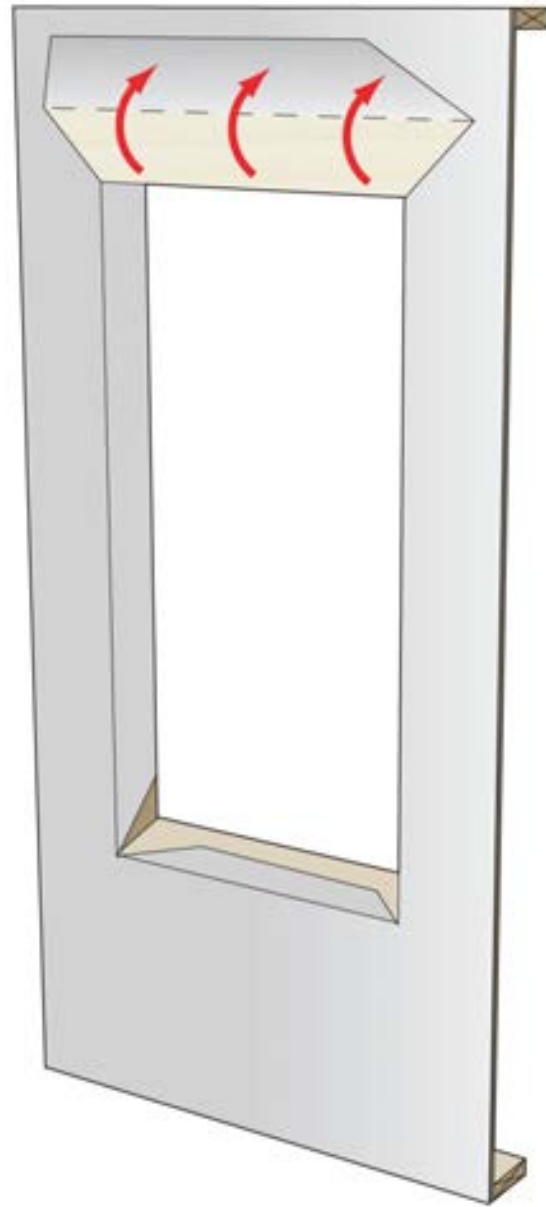


Intent of sealant is to limit this lateral flow of water between sheathing and building wrap

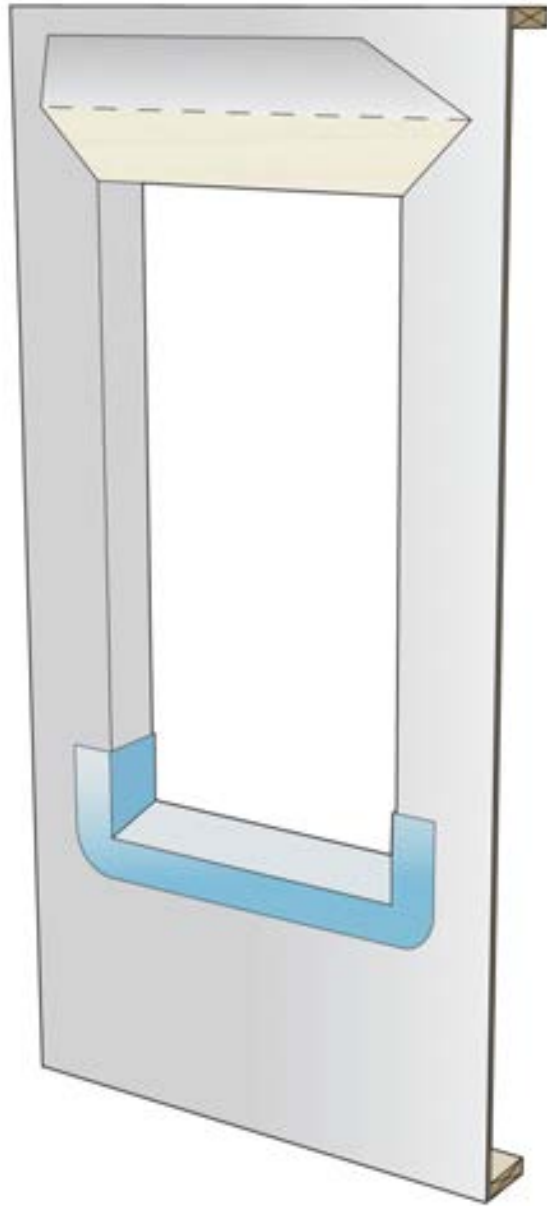


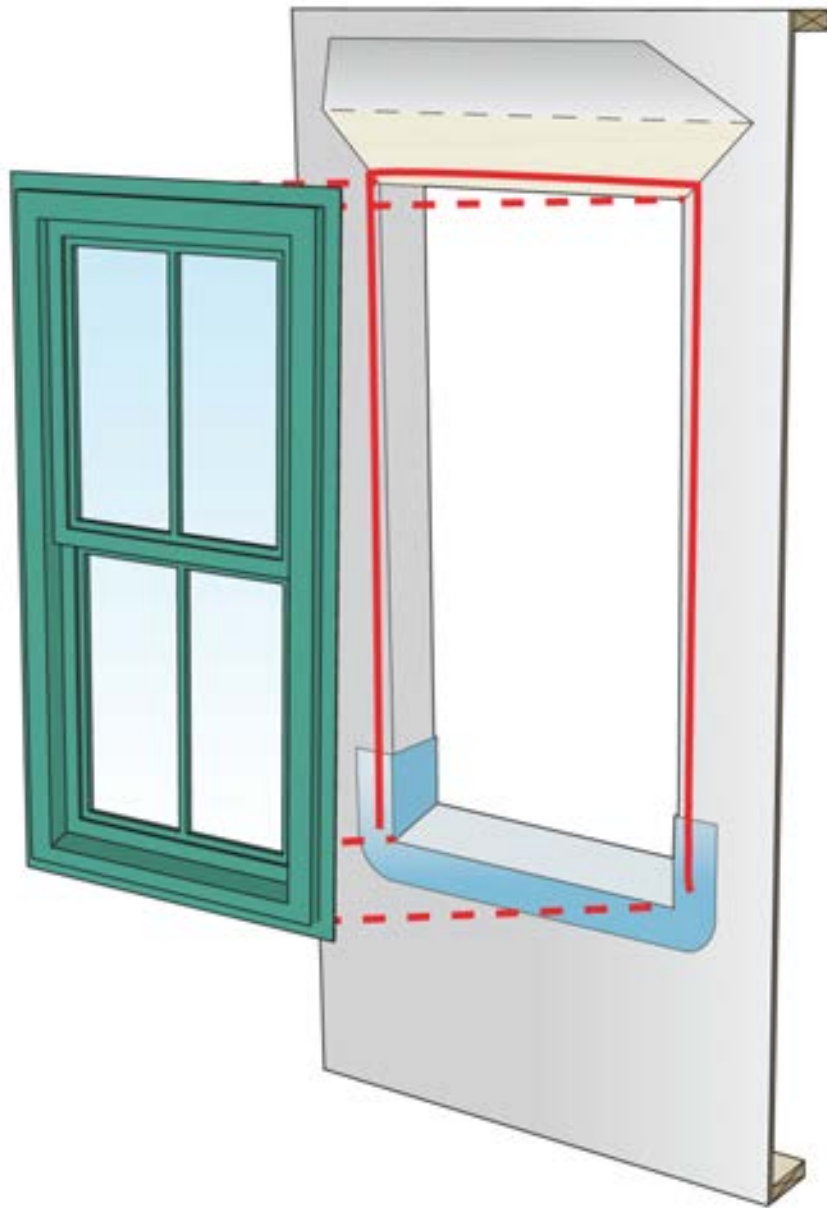


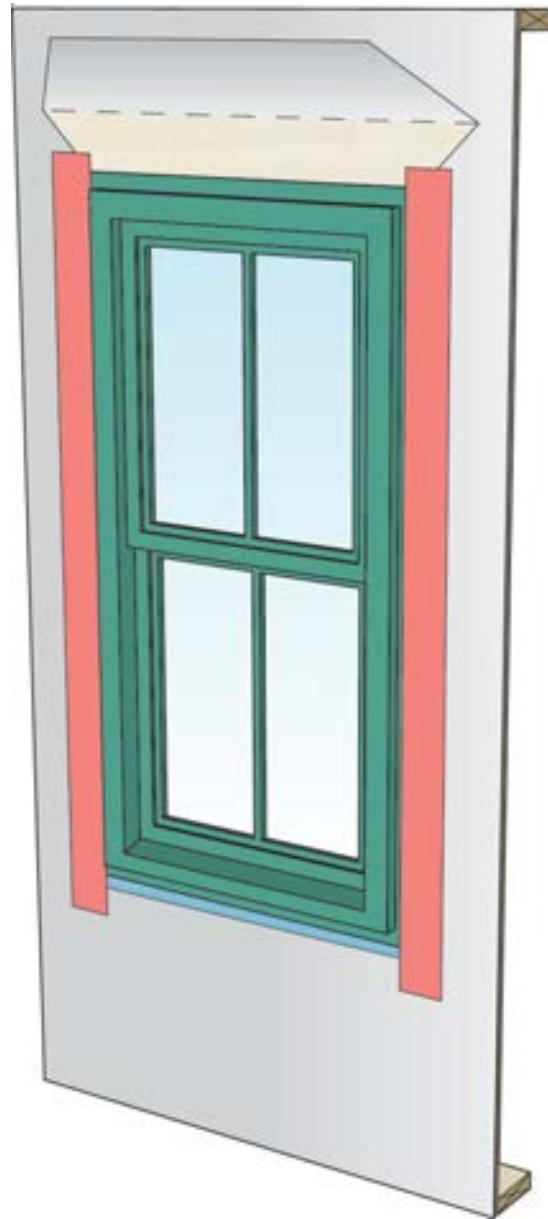


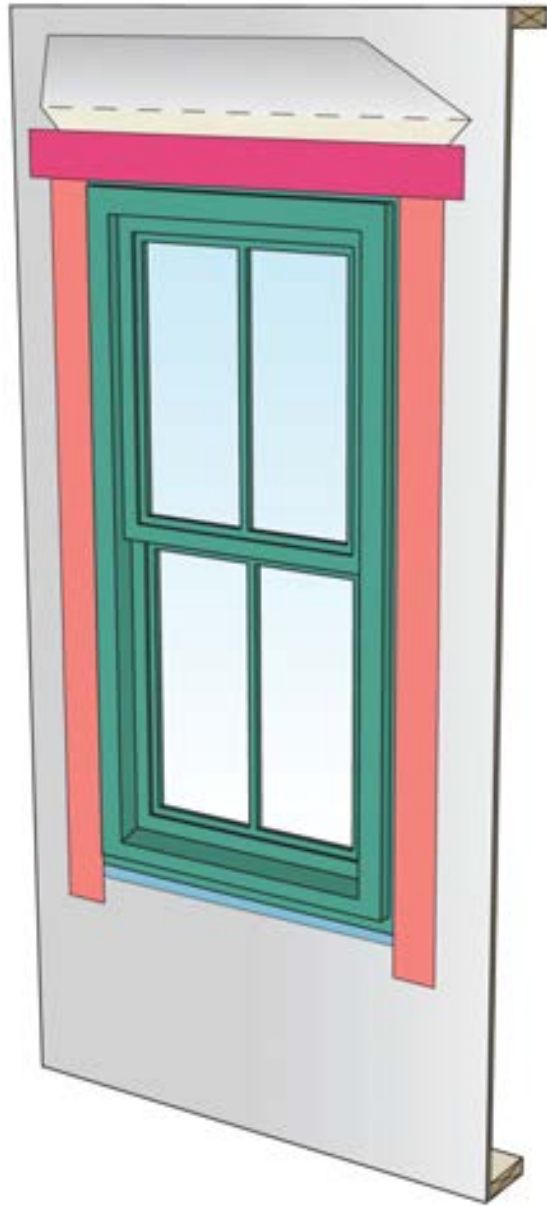


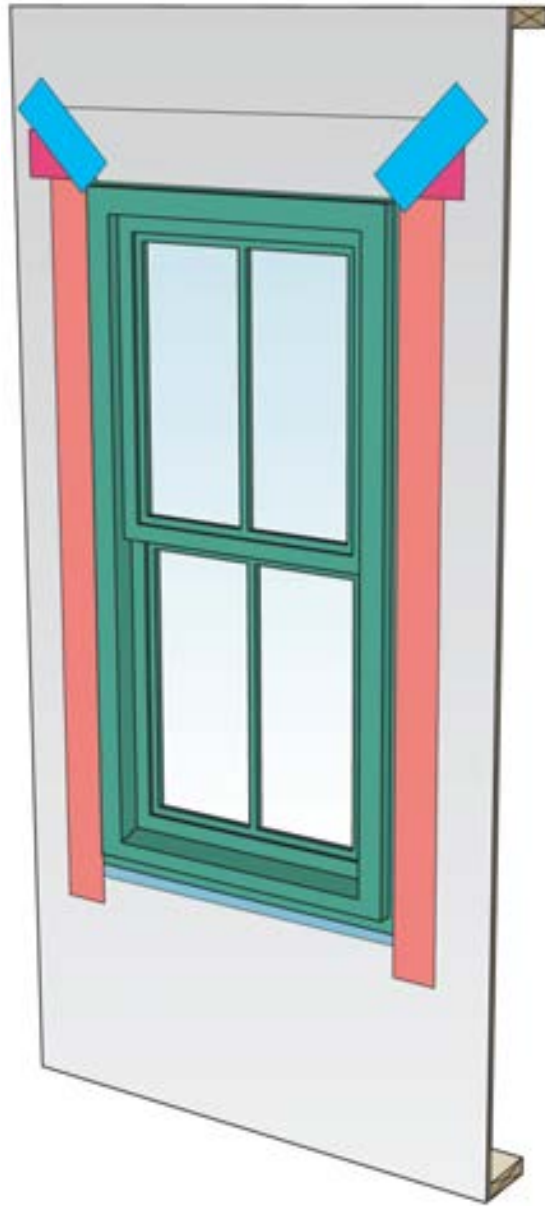




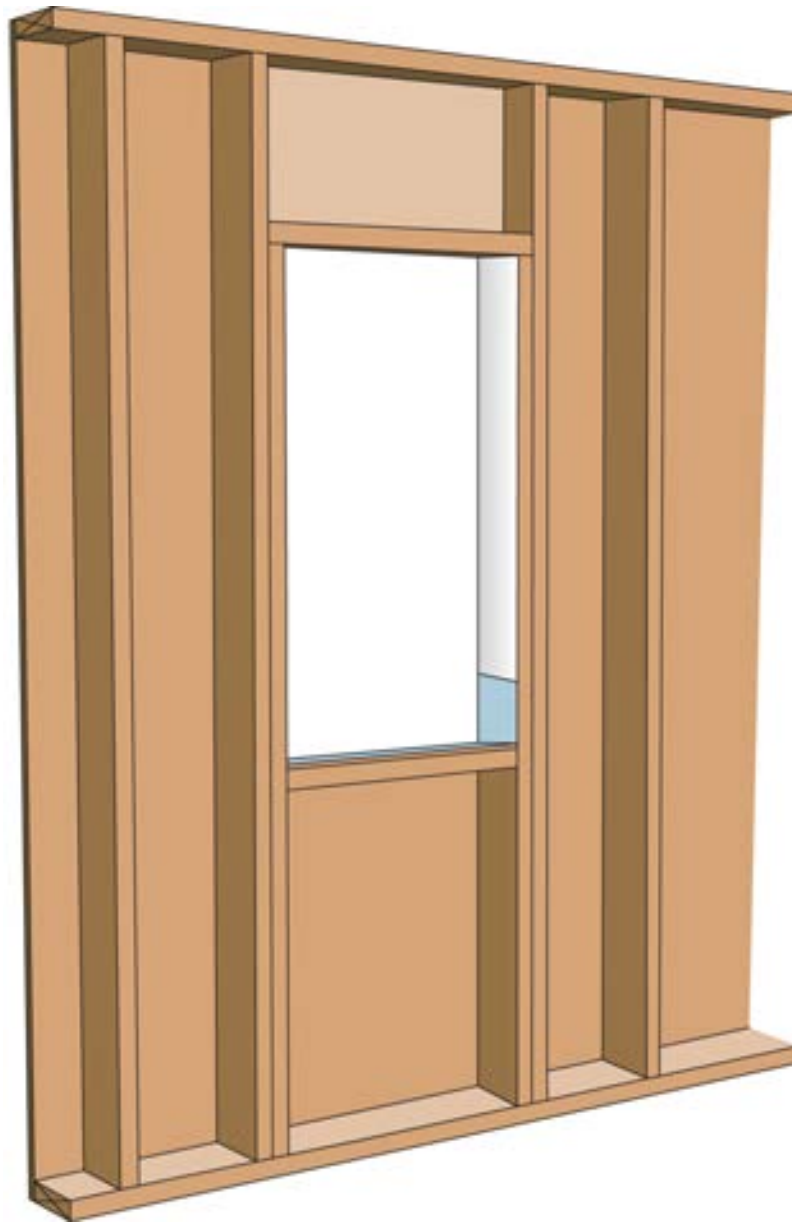








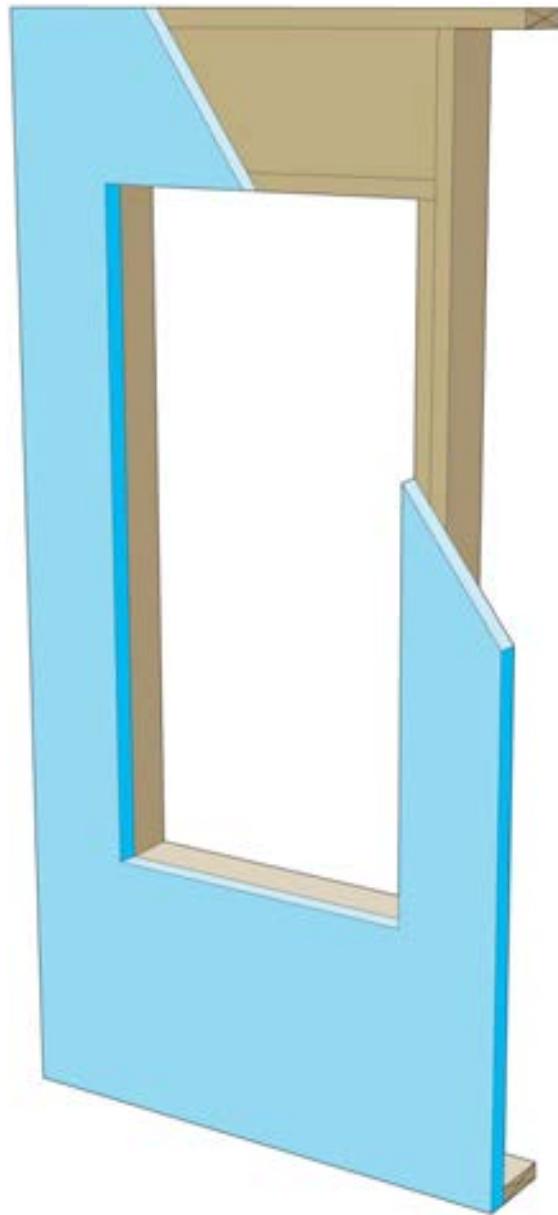




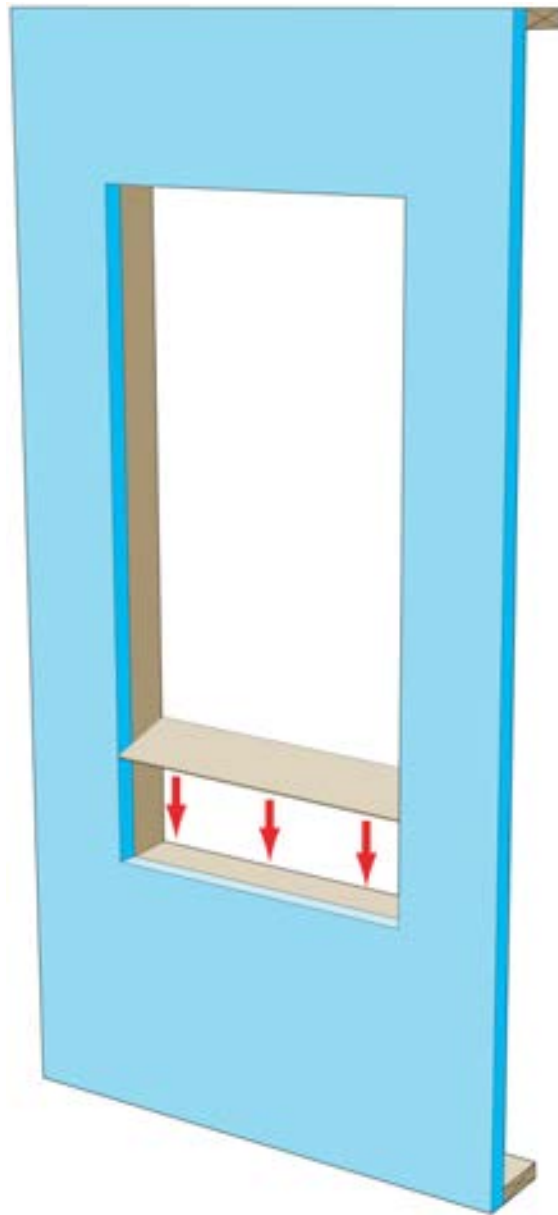


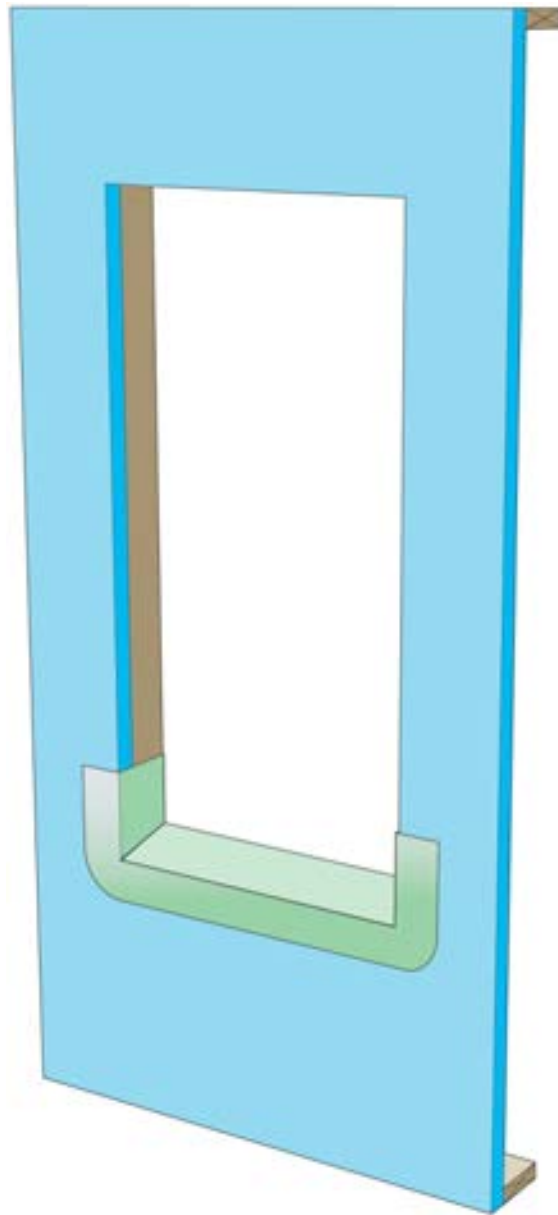


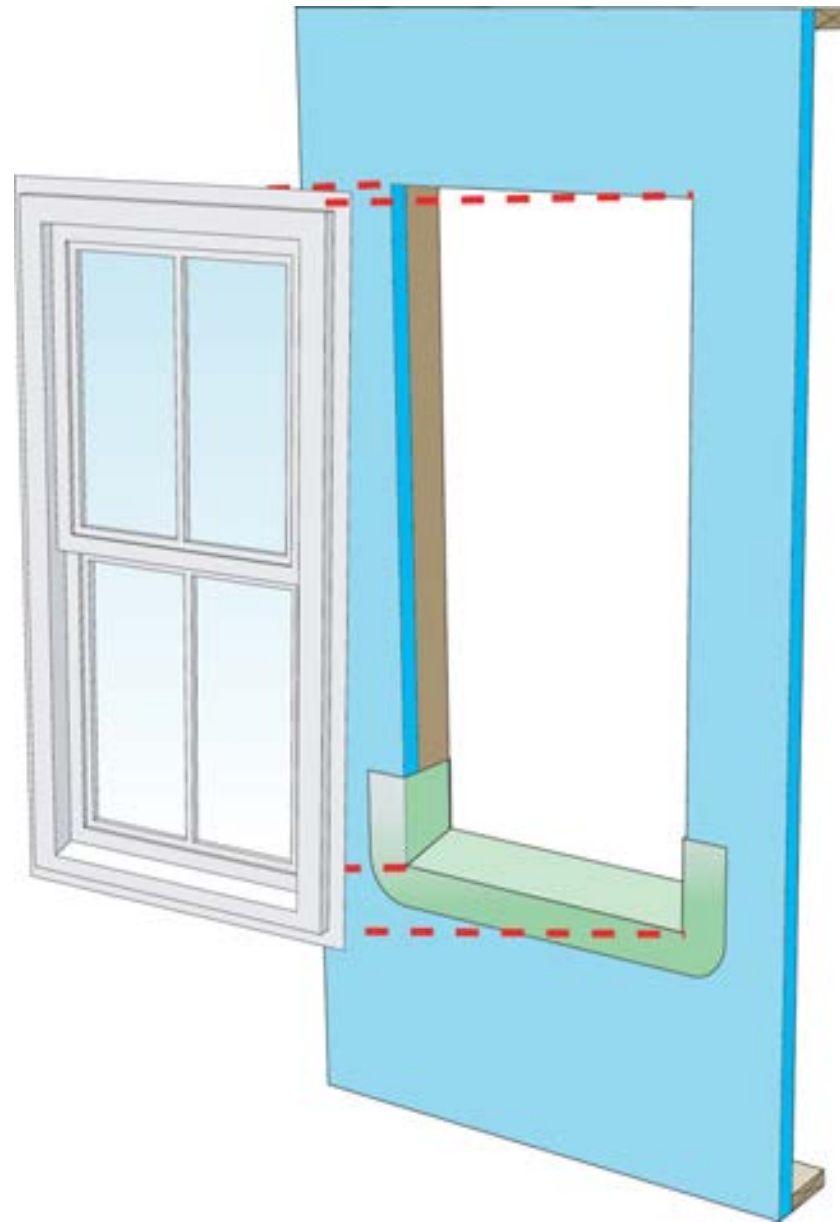










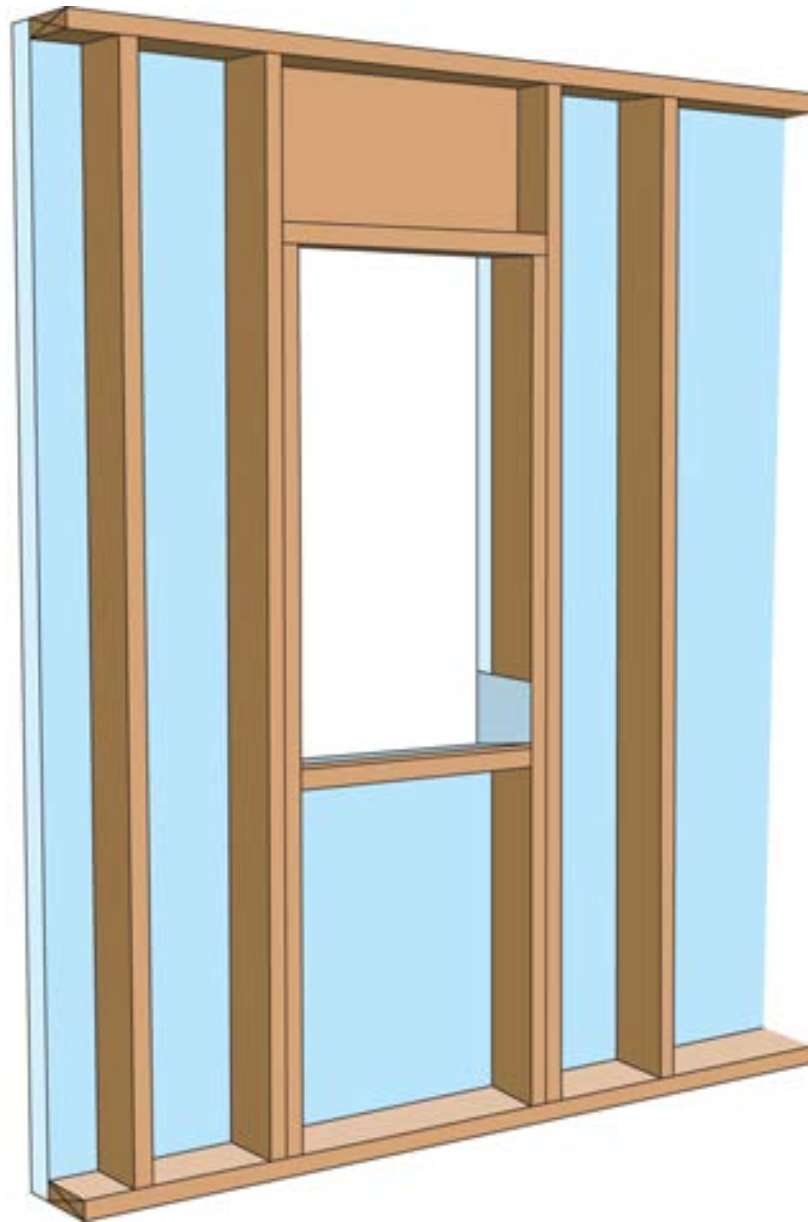


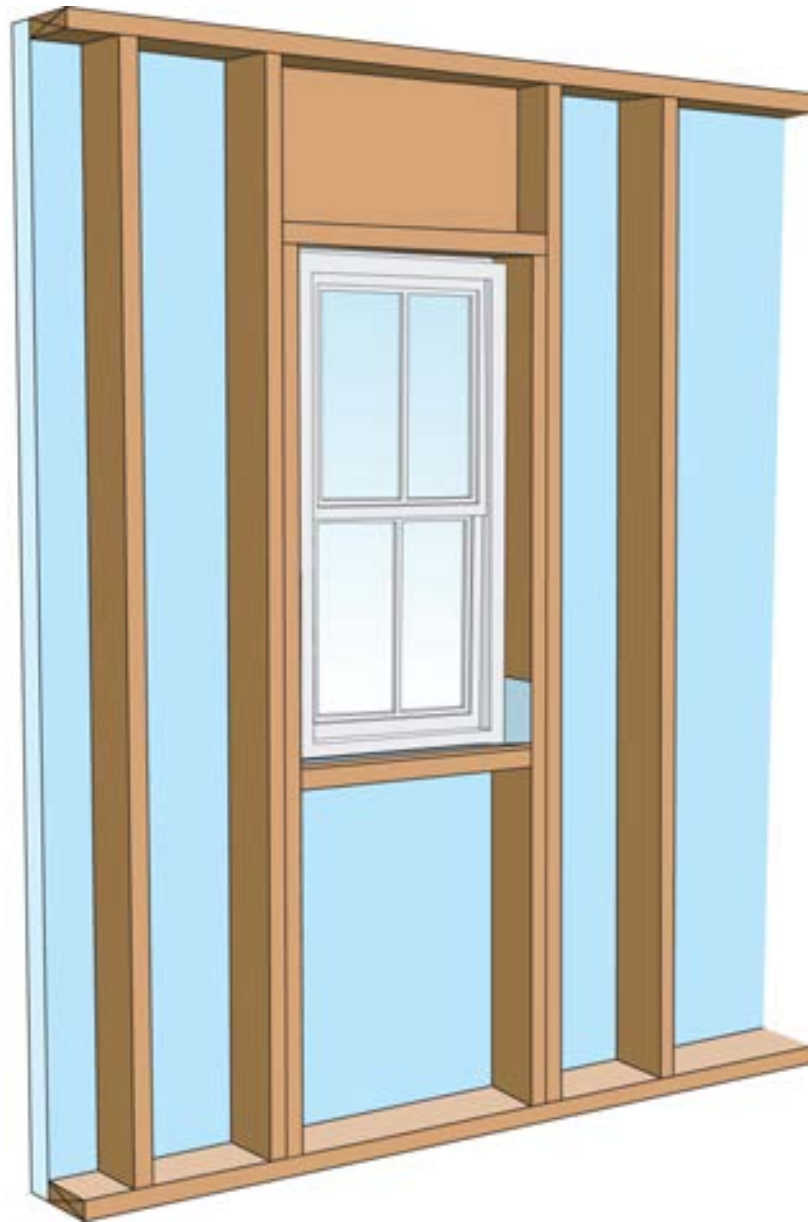


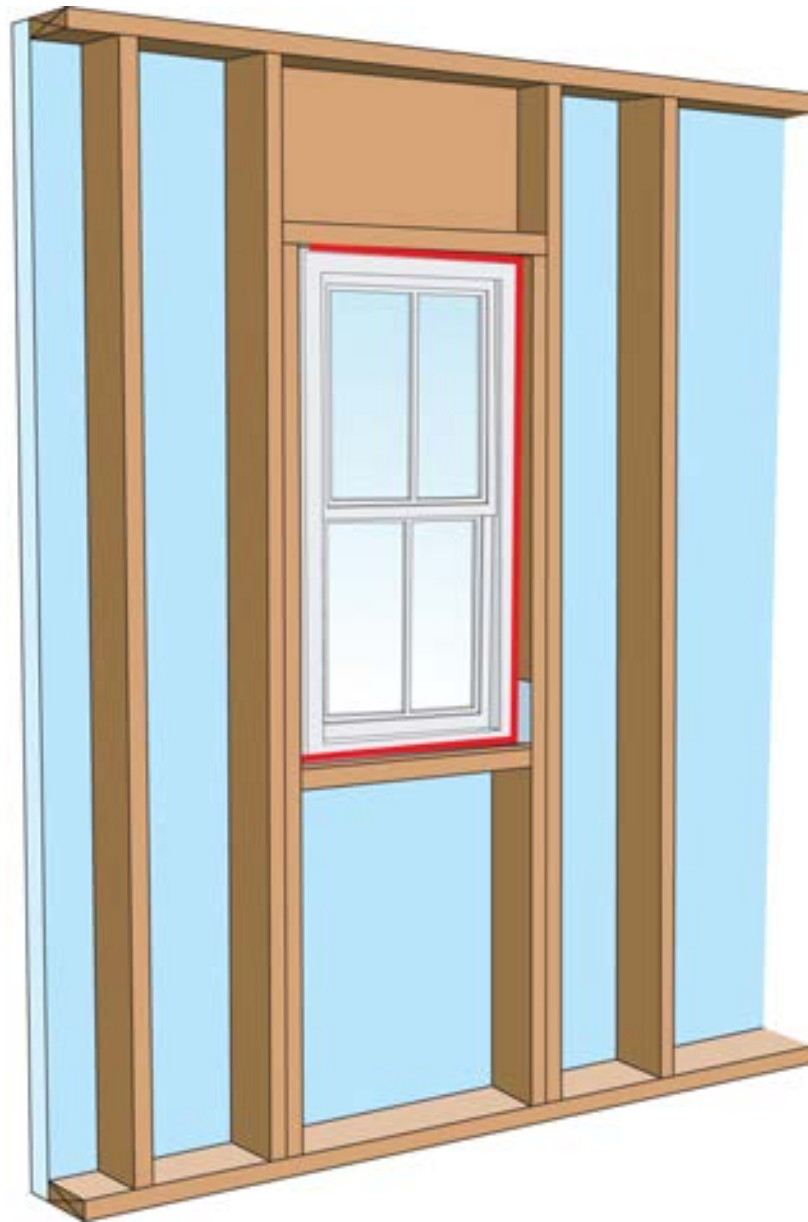






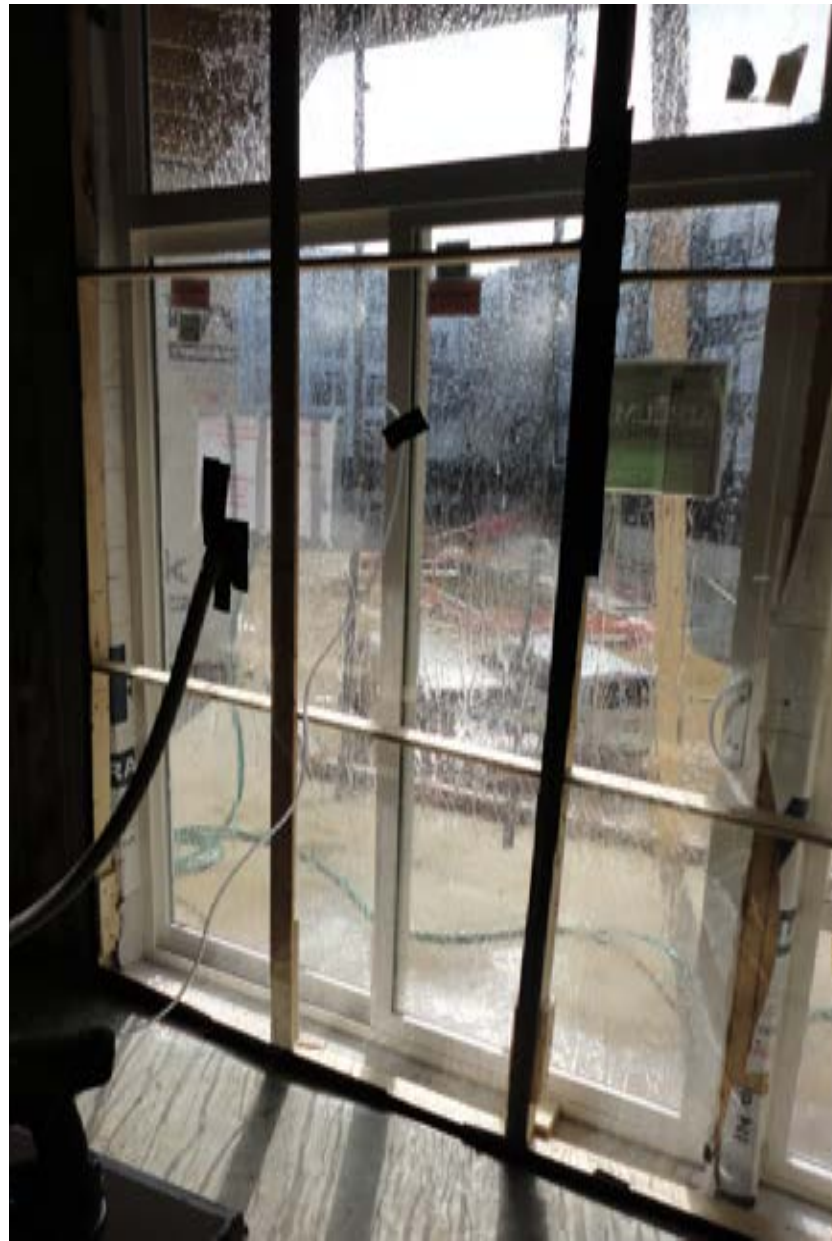


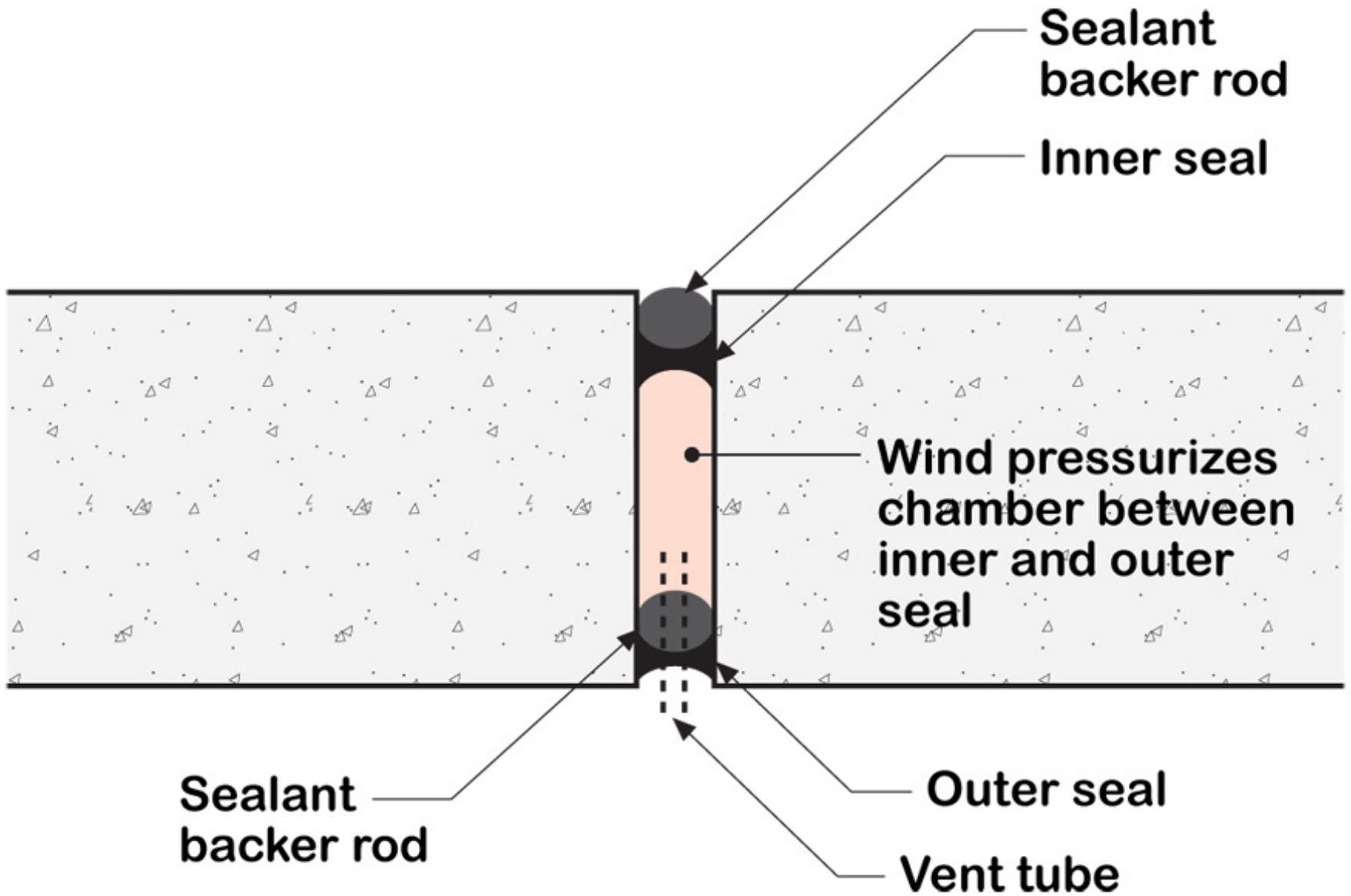


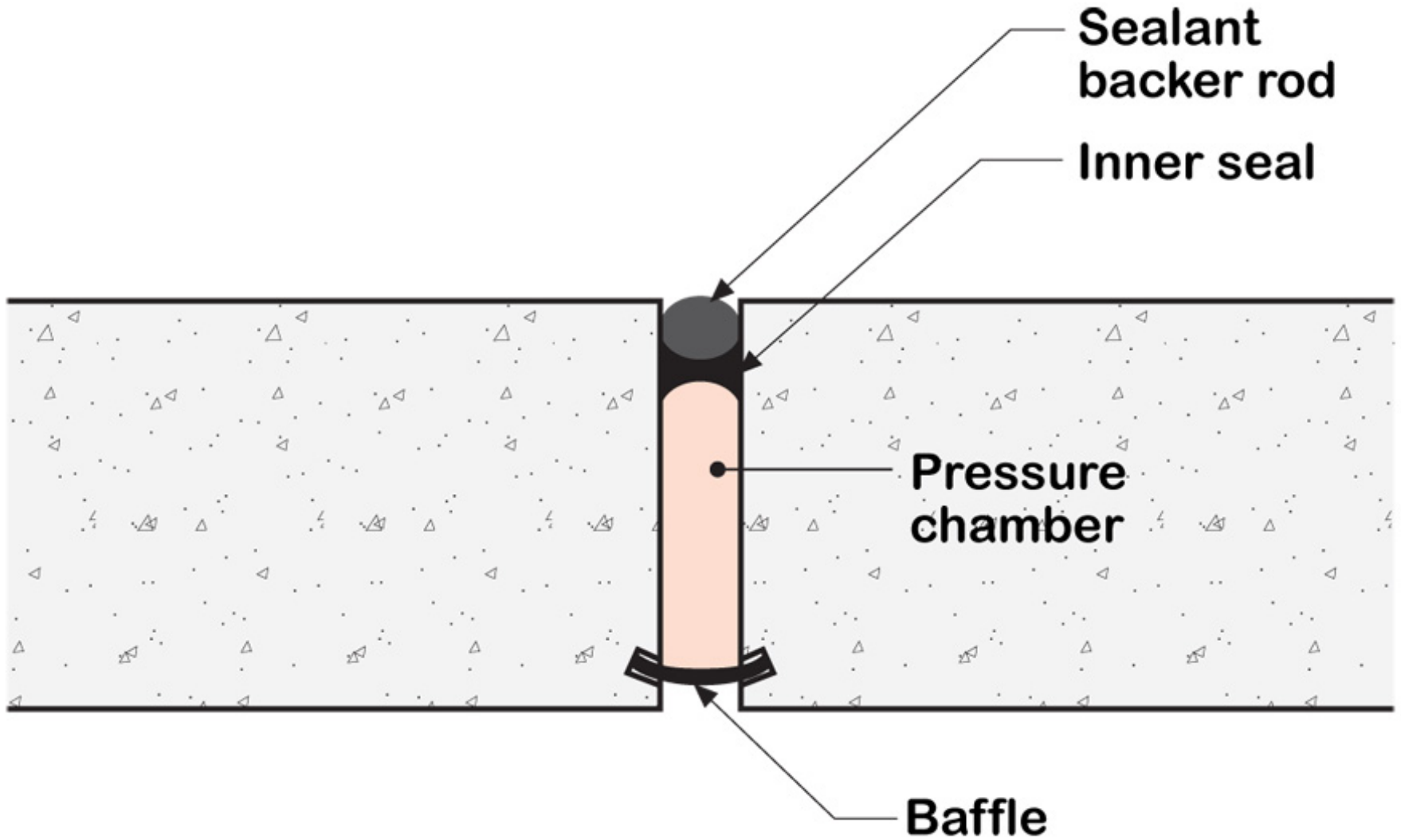


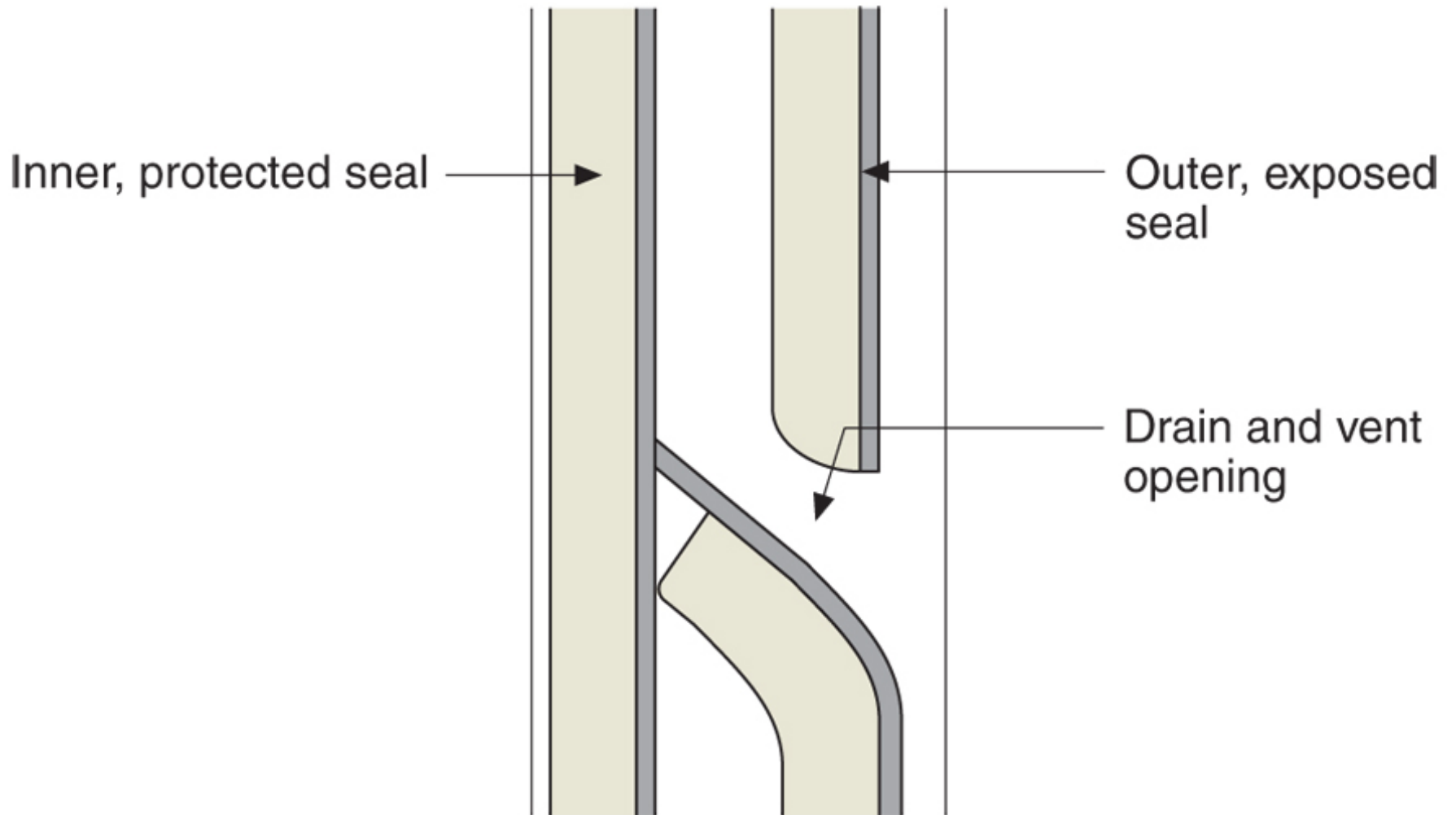


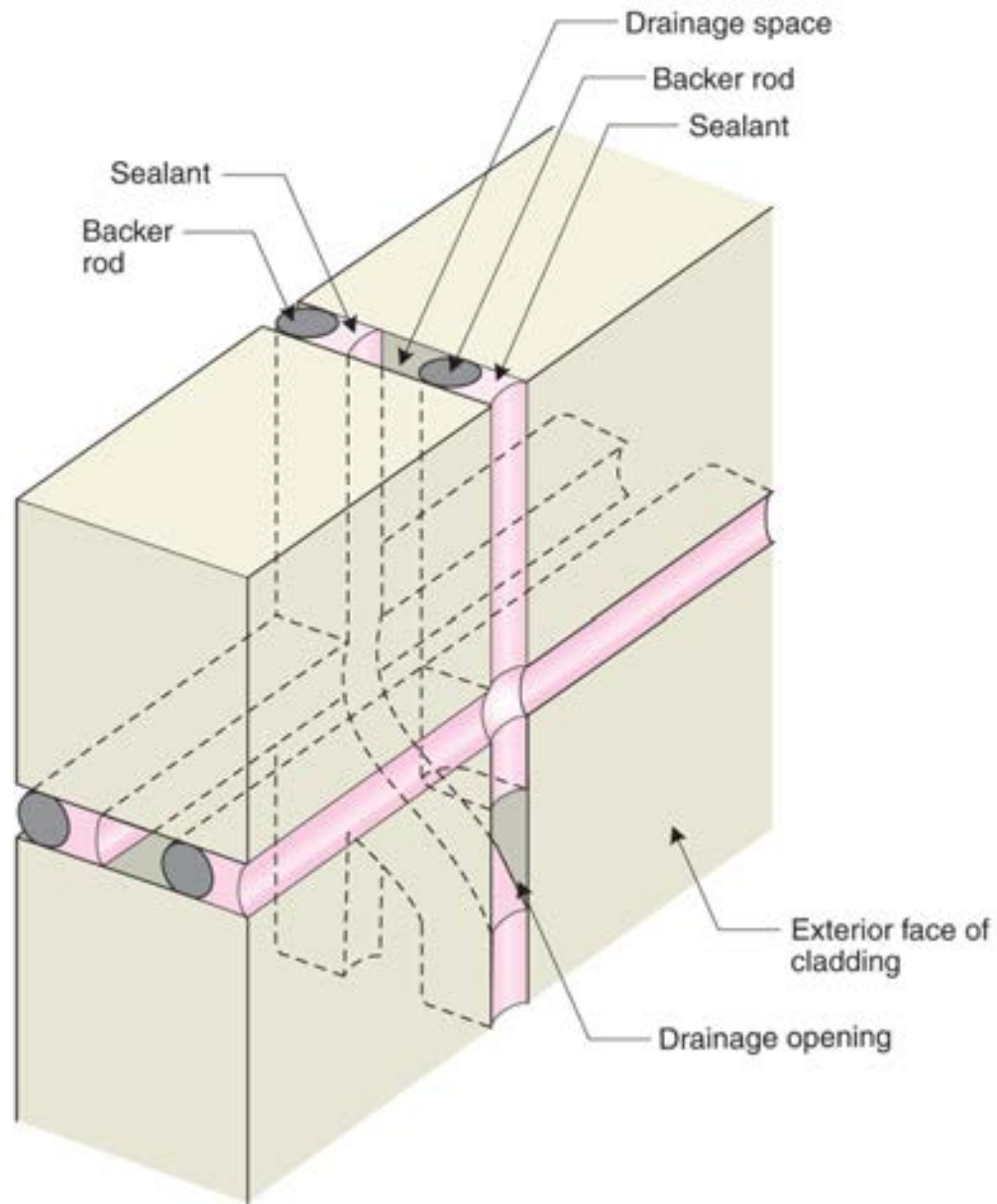






















Life is Tough Enough As it Is...

Life is Tough Enough As it Is...  
It's Harder When You Are Stupid

# Don't Do Stupid Things









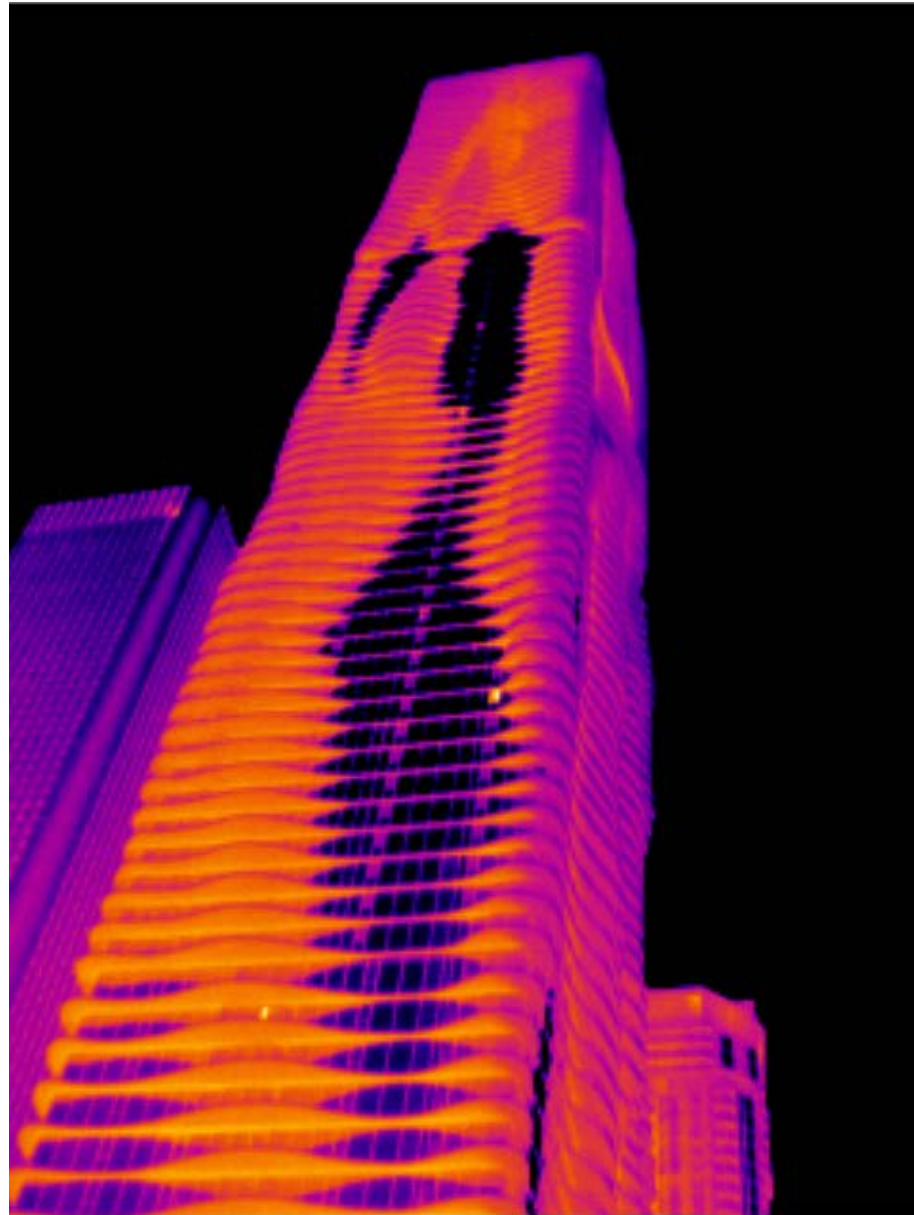


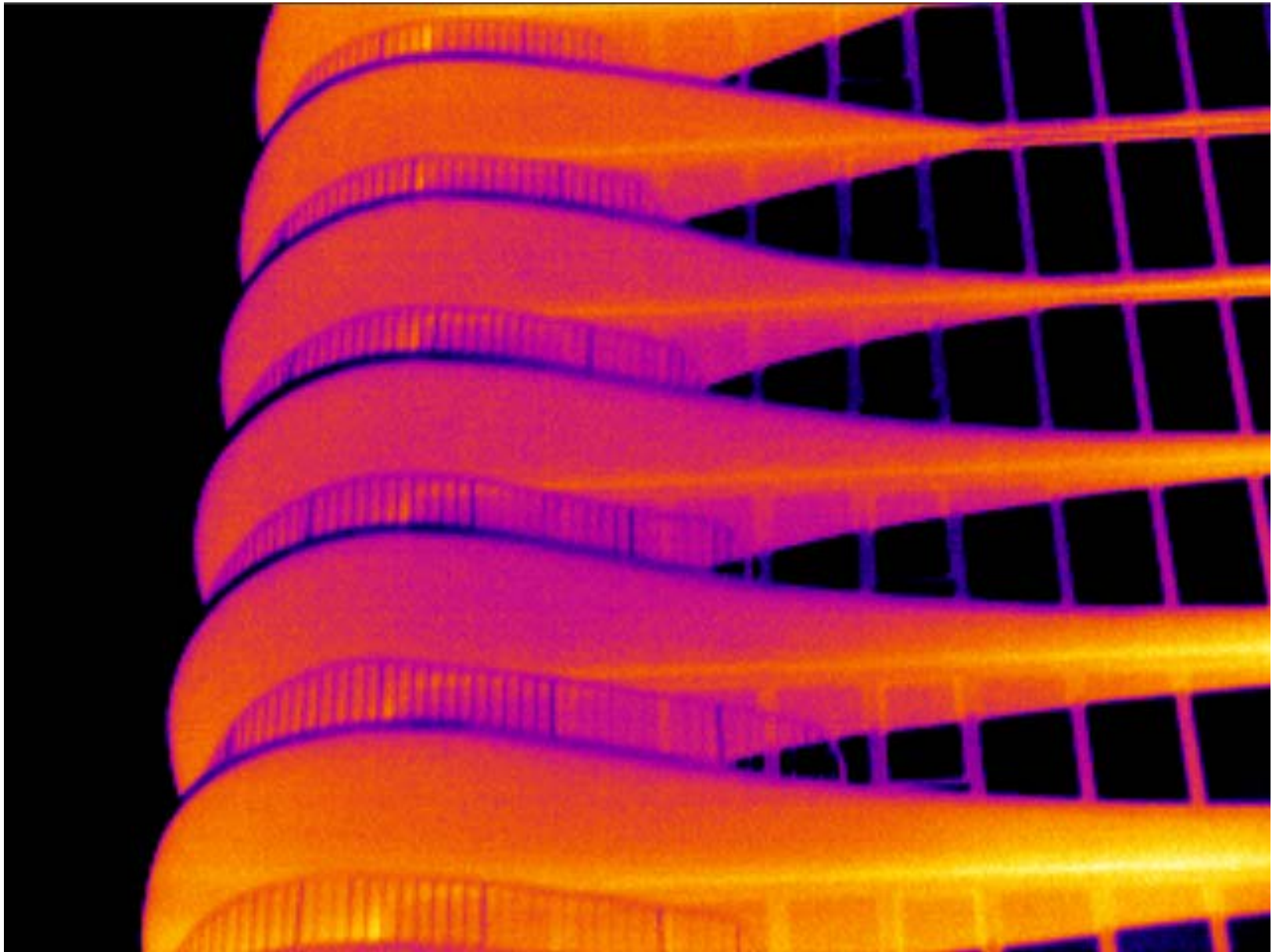


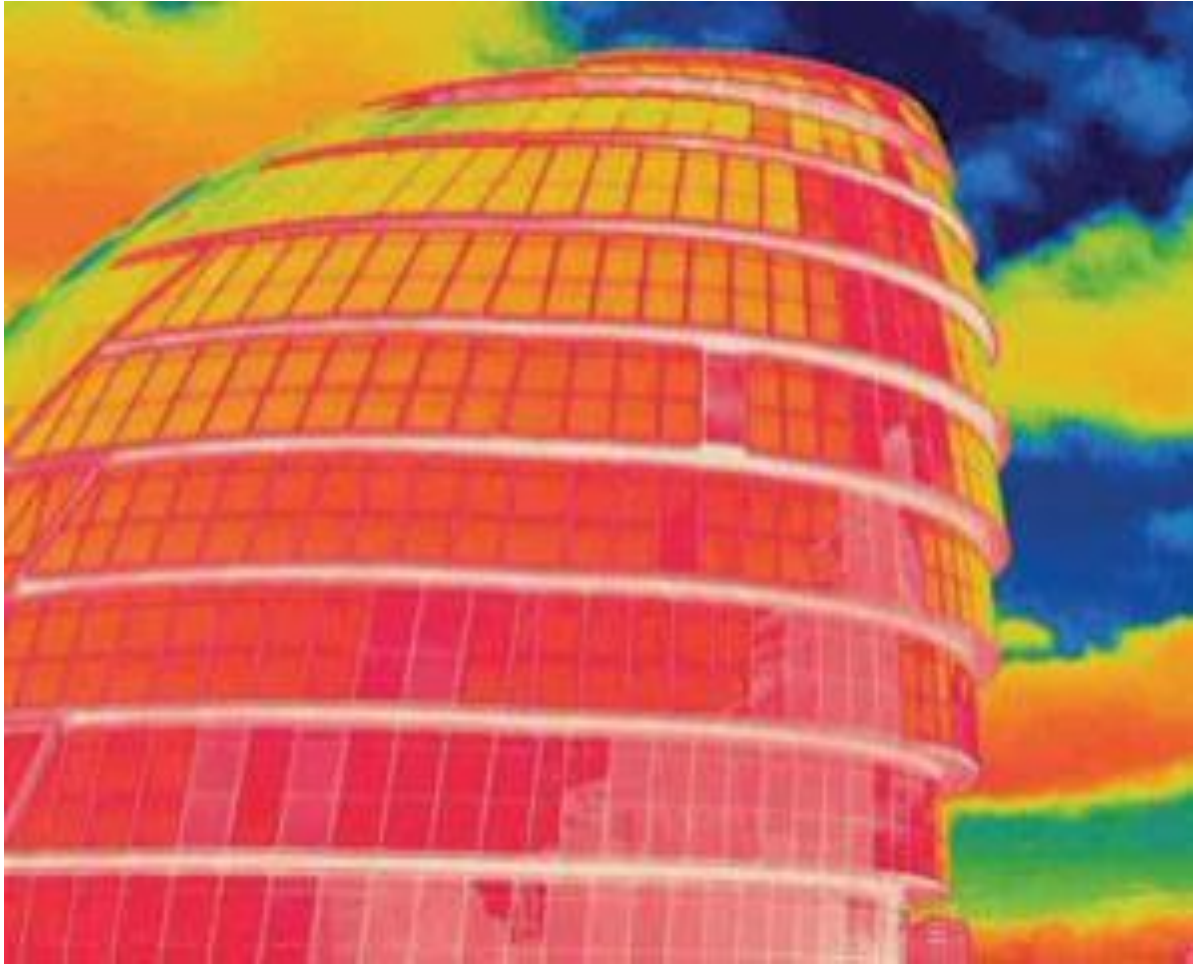










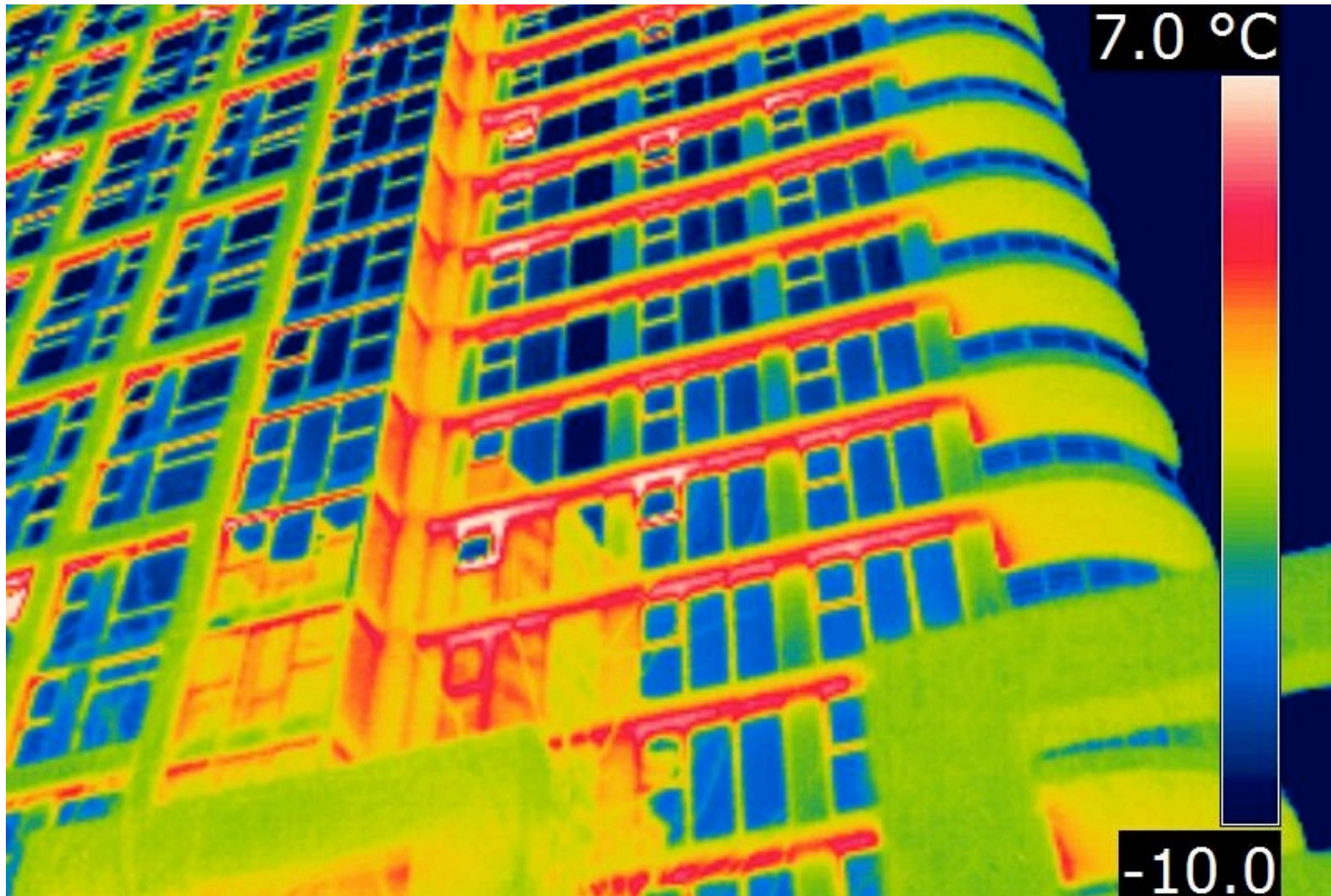


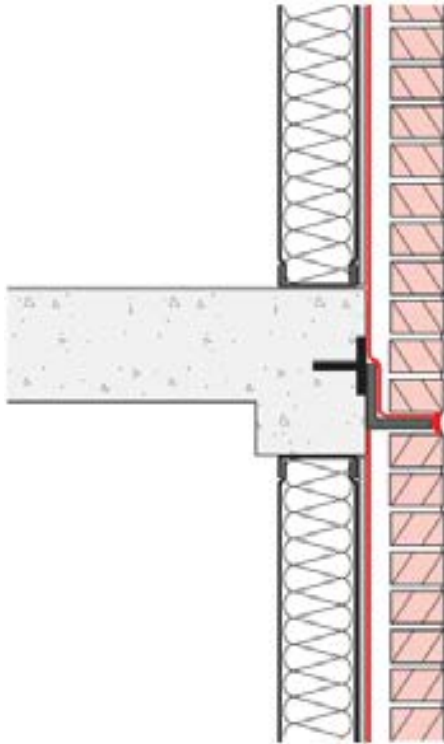




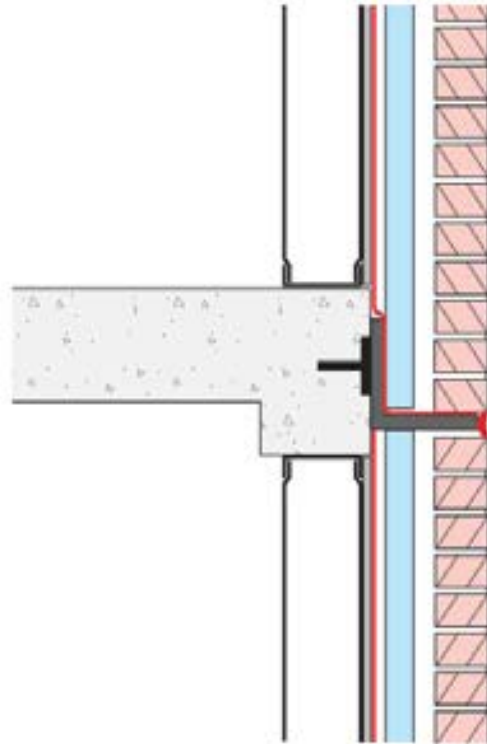




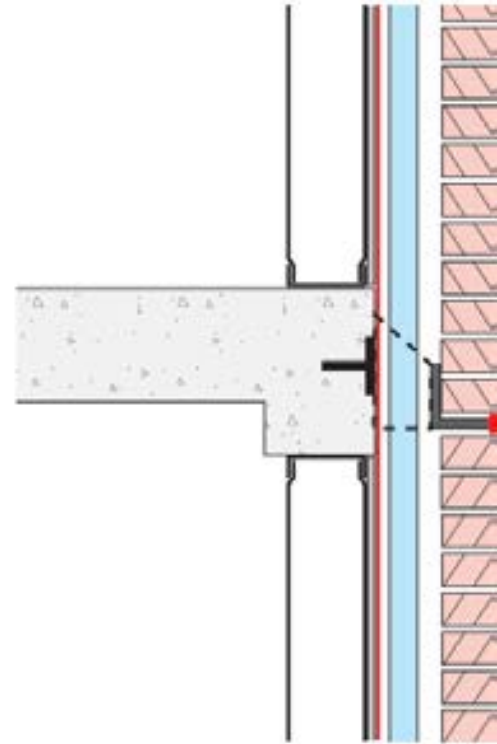




**“The Ugly”**



**“The Bad”**



**“The Good”**













WEDGE SHIMS INSERTED BEHIND/FRONT OF ANGLE TO ENSURE DIRECT BEARING ON BRACKET AND PROVIDE LEVEL (IF NECESSARY)

