

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

Building Science

Adventures In Building Science

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There Is No Such Thing As A Free Thermodynamic Lunch

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

Thermodynamics

Zeroth Law – $A=B$ and $B=C$ therefore $A=C$

First Law - Conservation of Energy

Second Law - Entropy

Third Law – Absolute Zero

2nd Law of Thermodynamics

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

Rudolf Clausius

Thermodynamic Potential



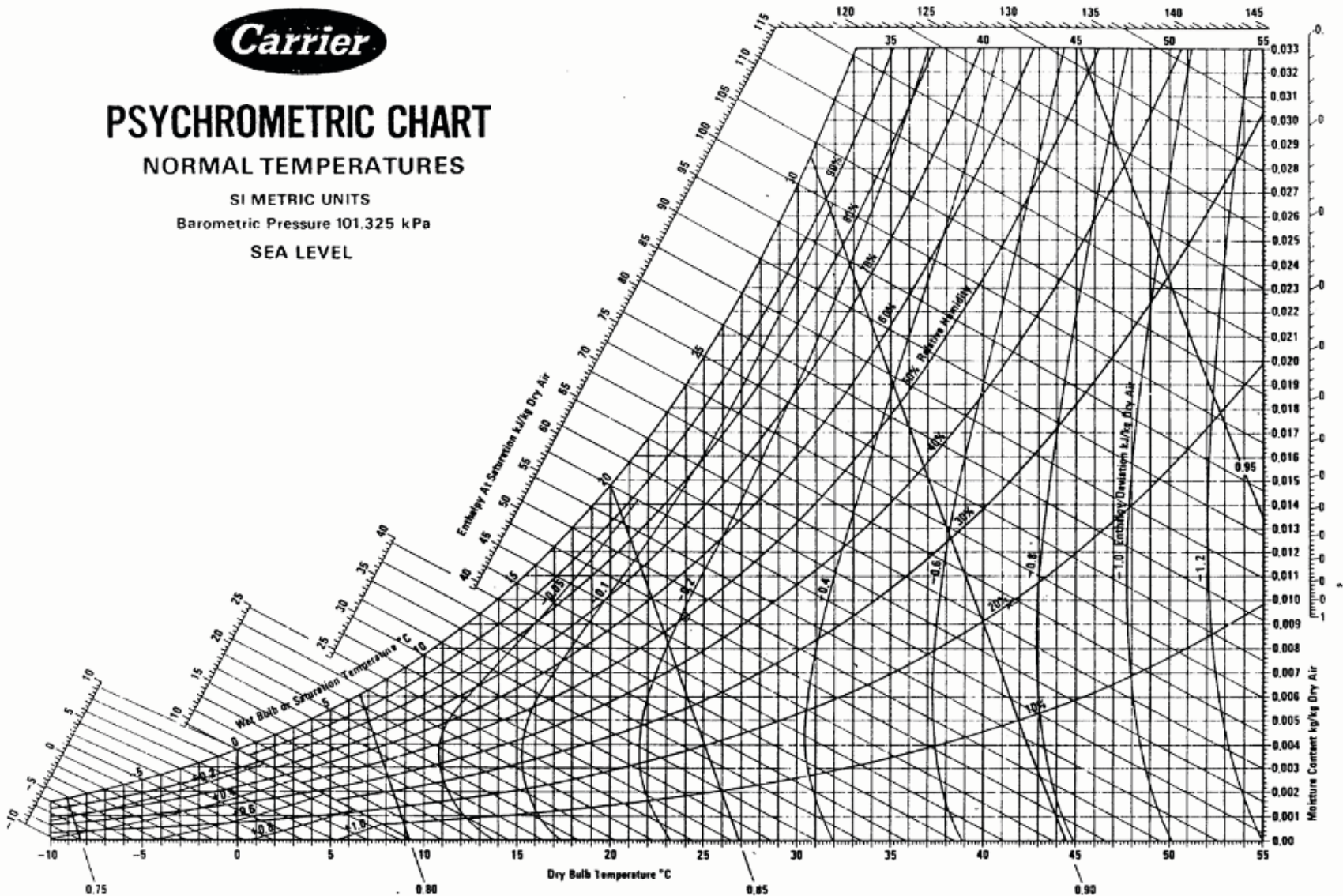
PSYCHROMETRIC CHART

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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Heat Flow Is From Warm To Cold

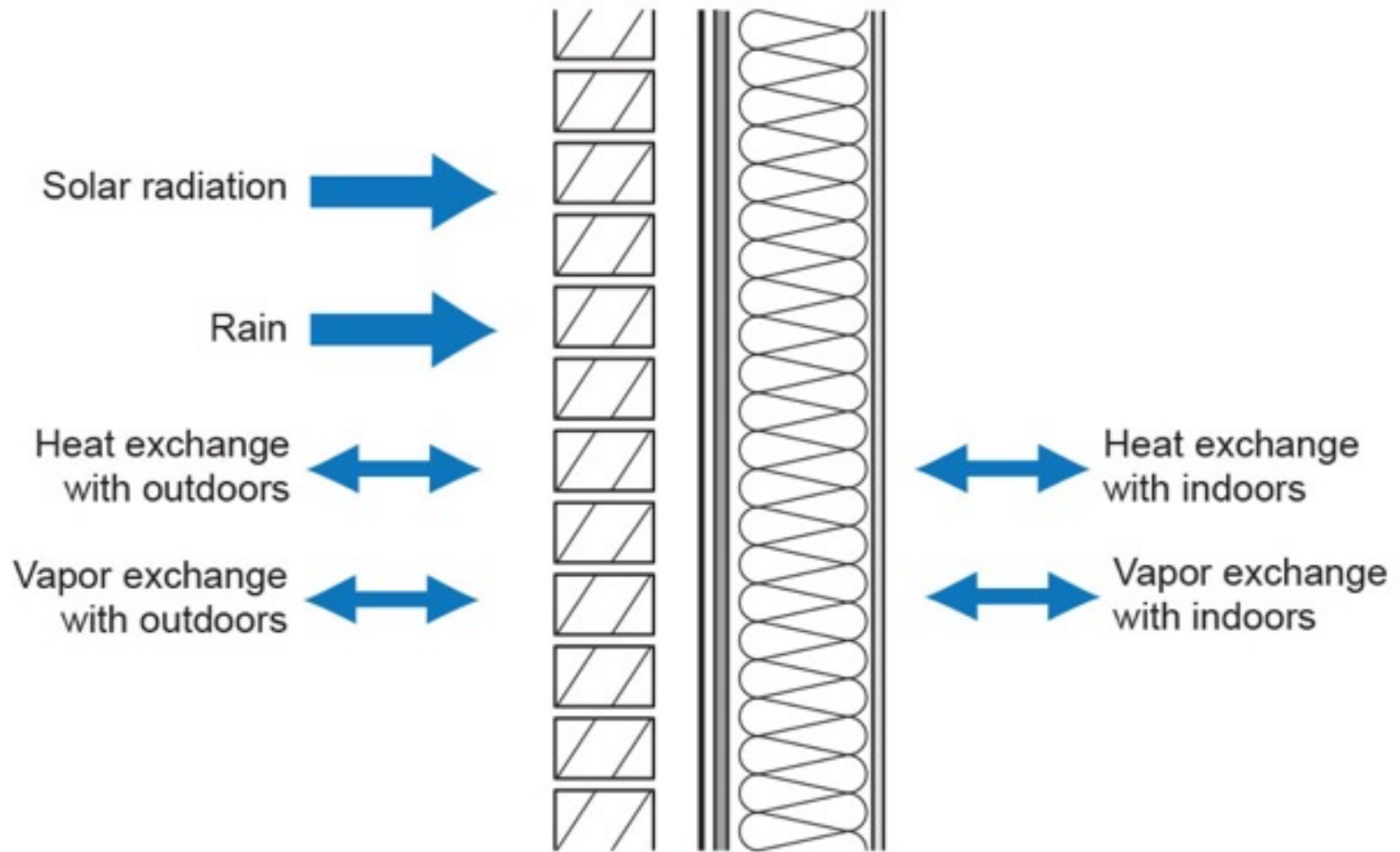
Moisture Flow Is From Warm To Cold

Moisture Flow Is From More To Less

Air Flow Is From A Higher Pressure to a
Lower Pressure

Gravity Acts Down

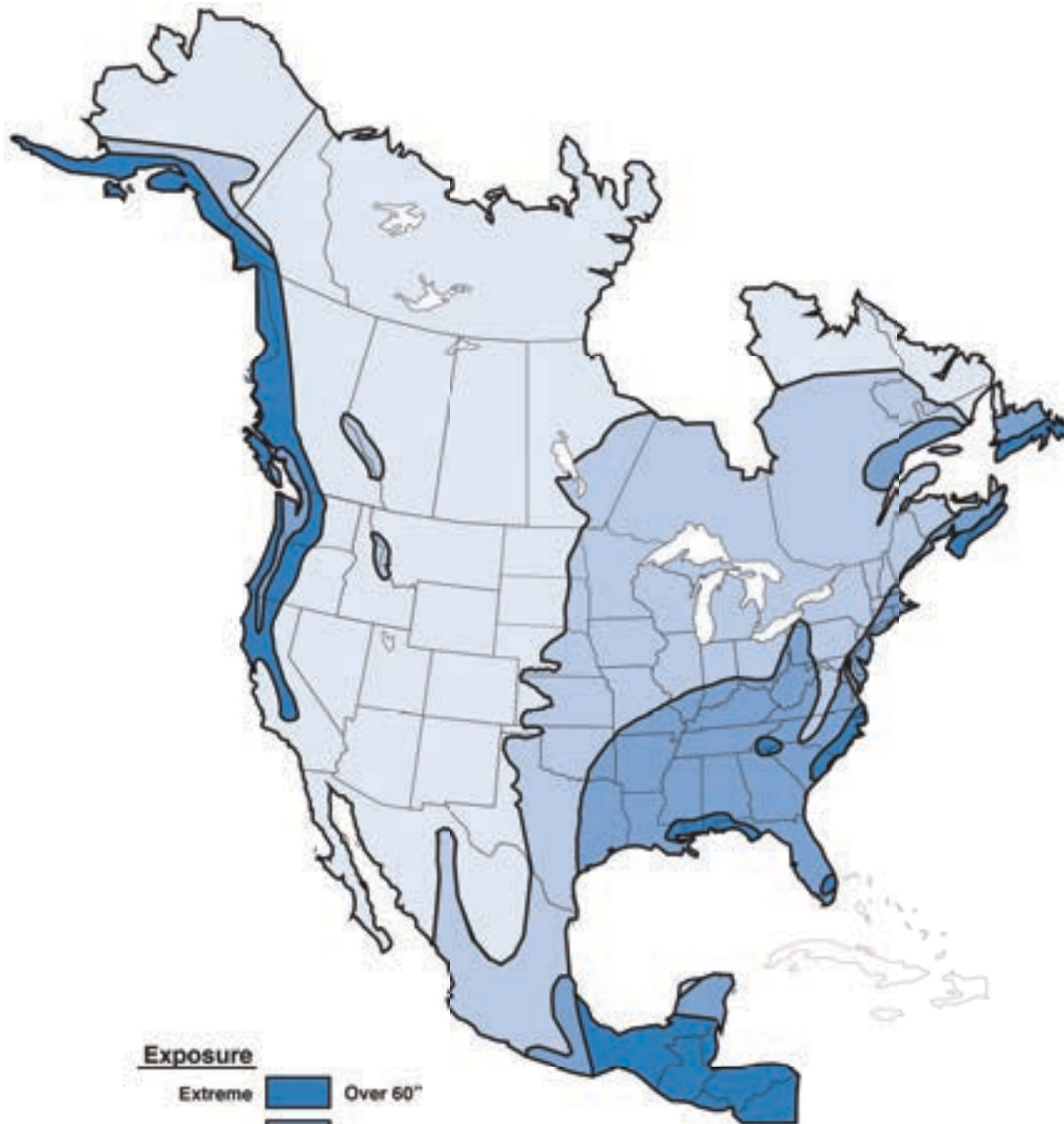
Hygrothermal Analysis

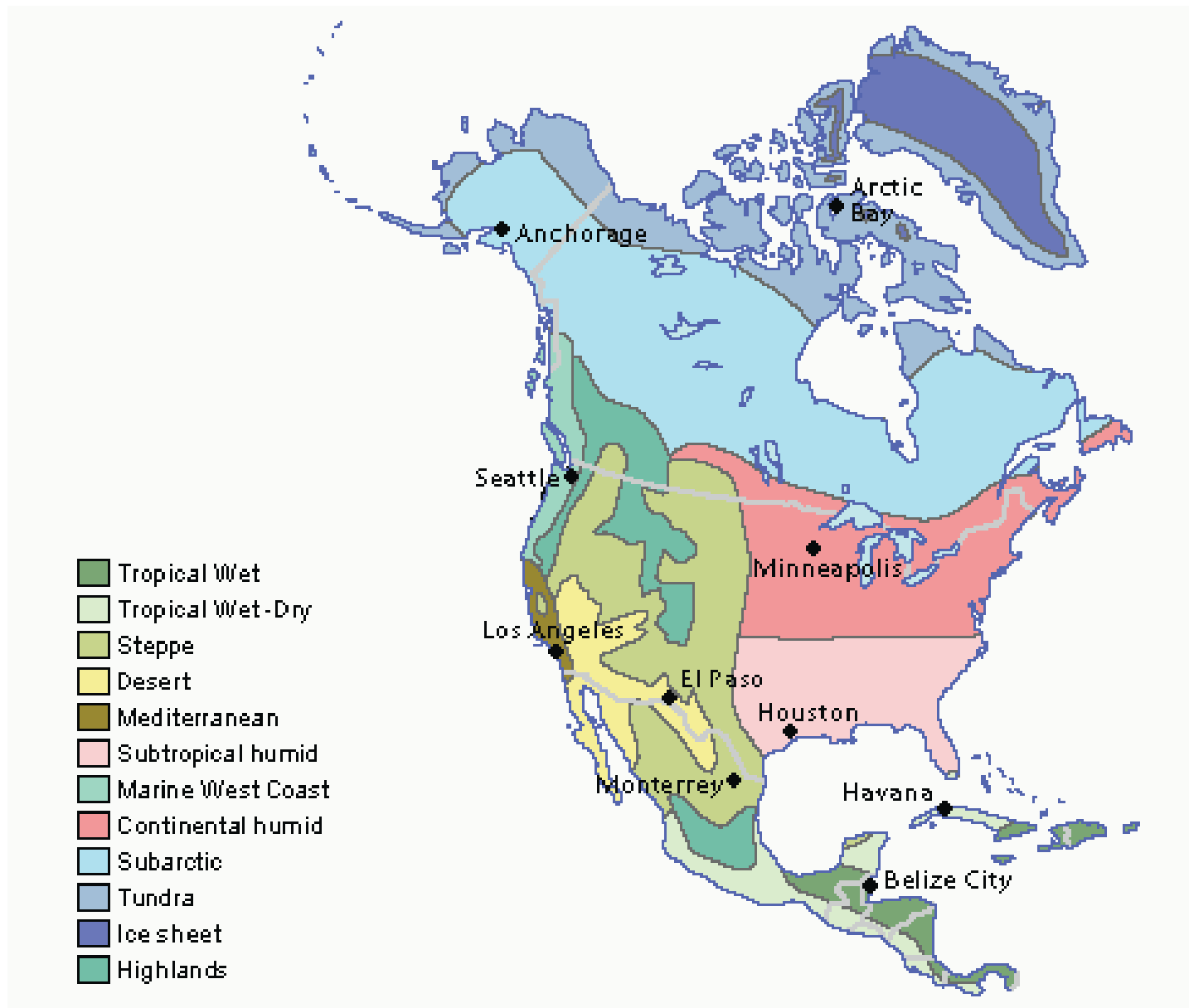


Firmness, Commodity and Delight

“These are properly designed, when due regard is had to the country and climate in which they are erected. For the method of building which is suited to Egypt would be very improper in Spain, and that in use in Pontus would be absurd at Rome: so in other parts of the world a style suitable to one climate, would be very unsuitable to another”

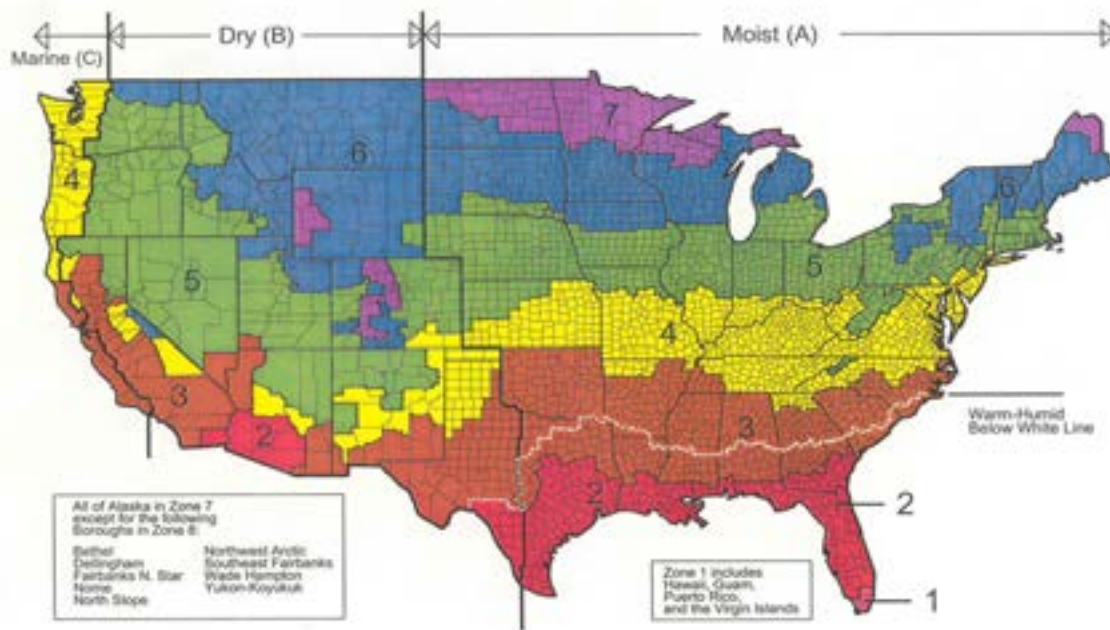
Marcus Vitruvius Pollio (c.90-20 B.C.E.)





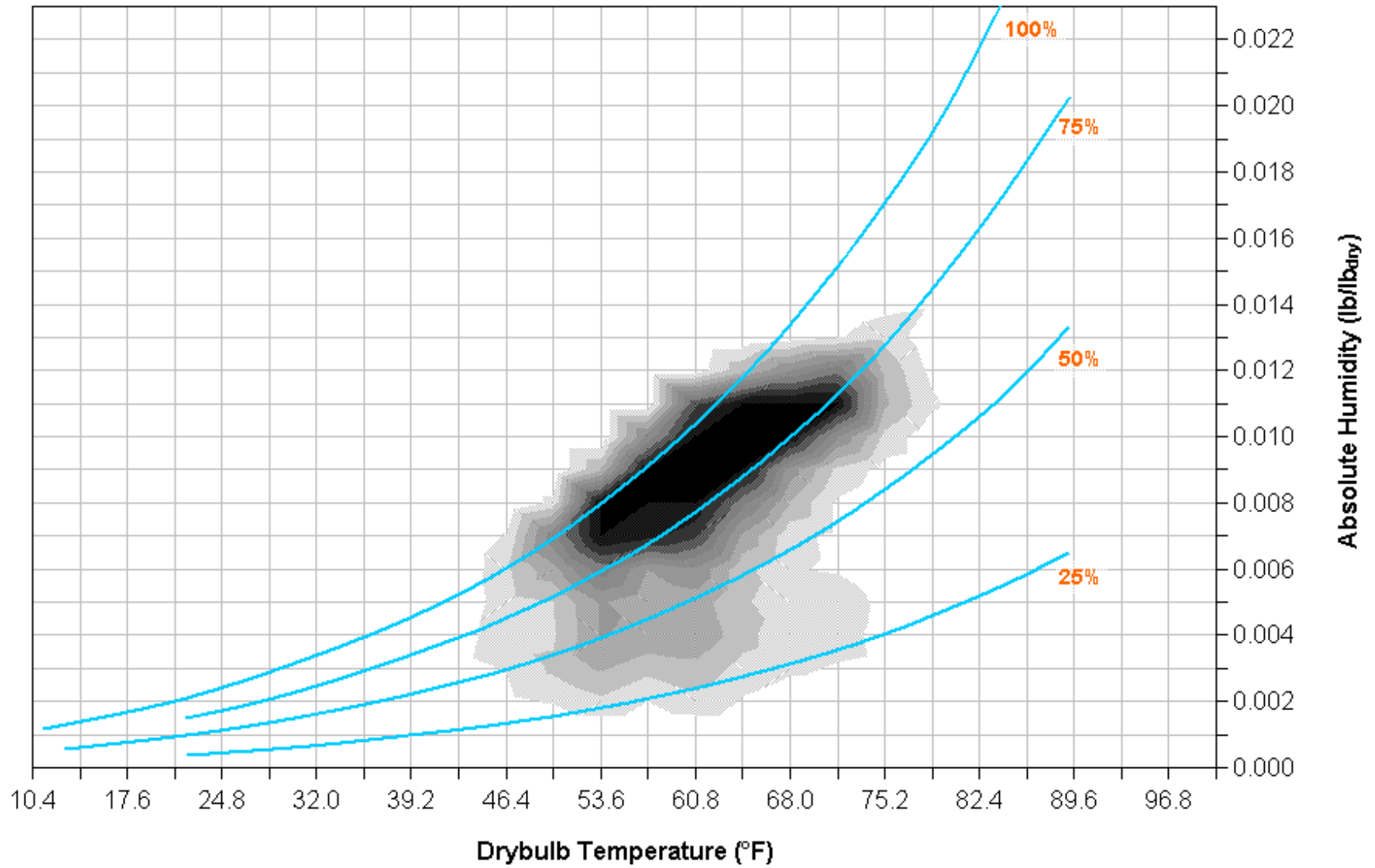


Map of DOE's Proposed Climate Zones

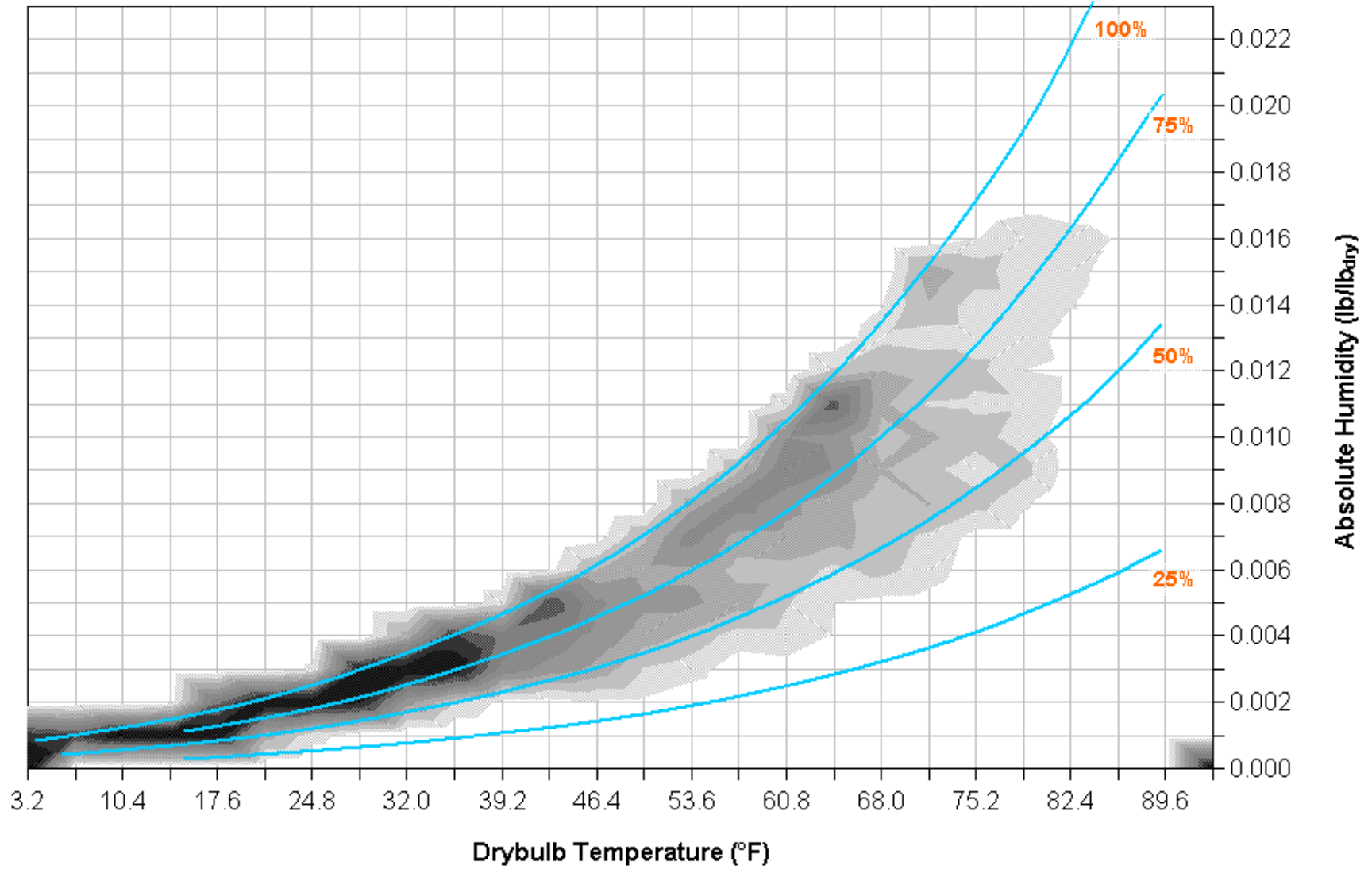


March 24, 2003

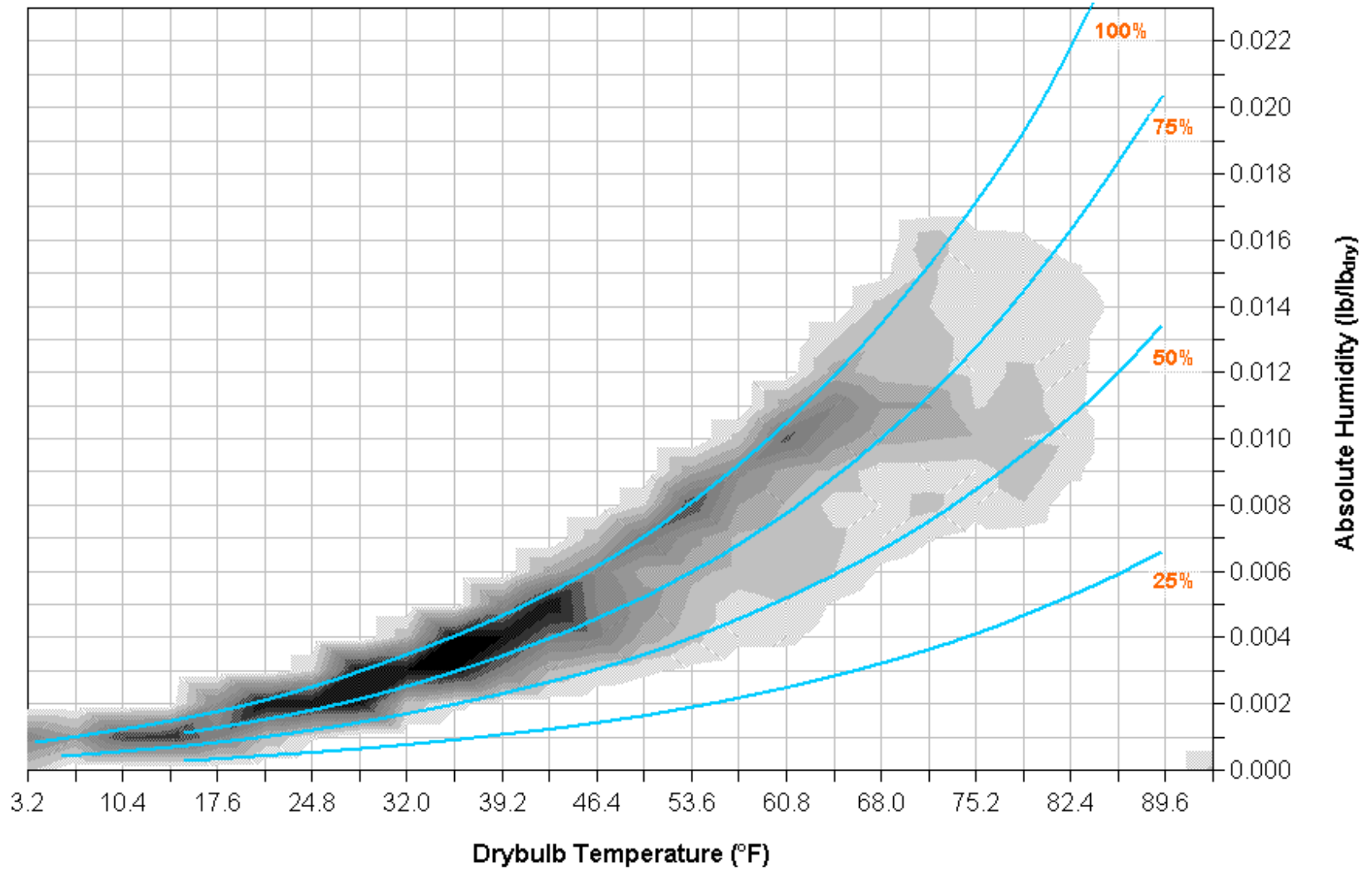
Los Angeles, CA



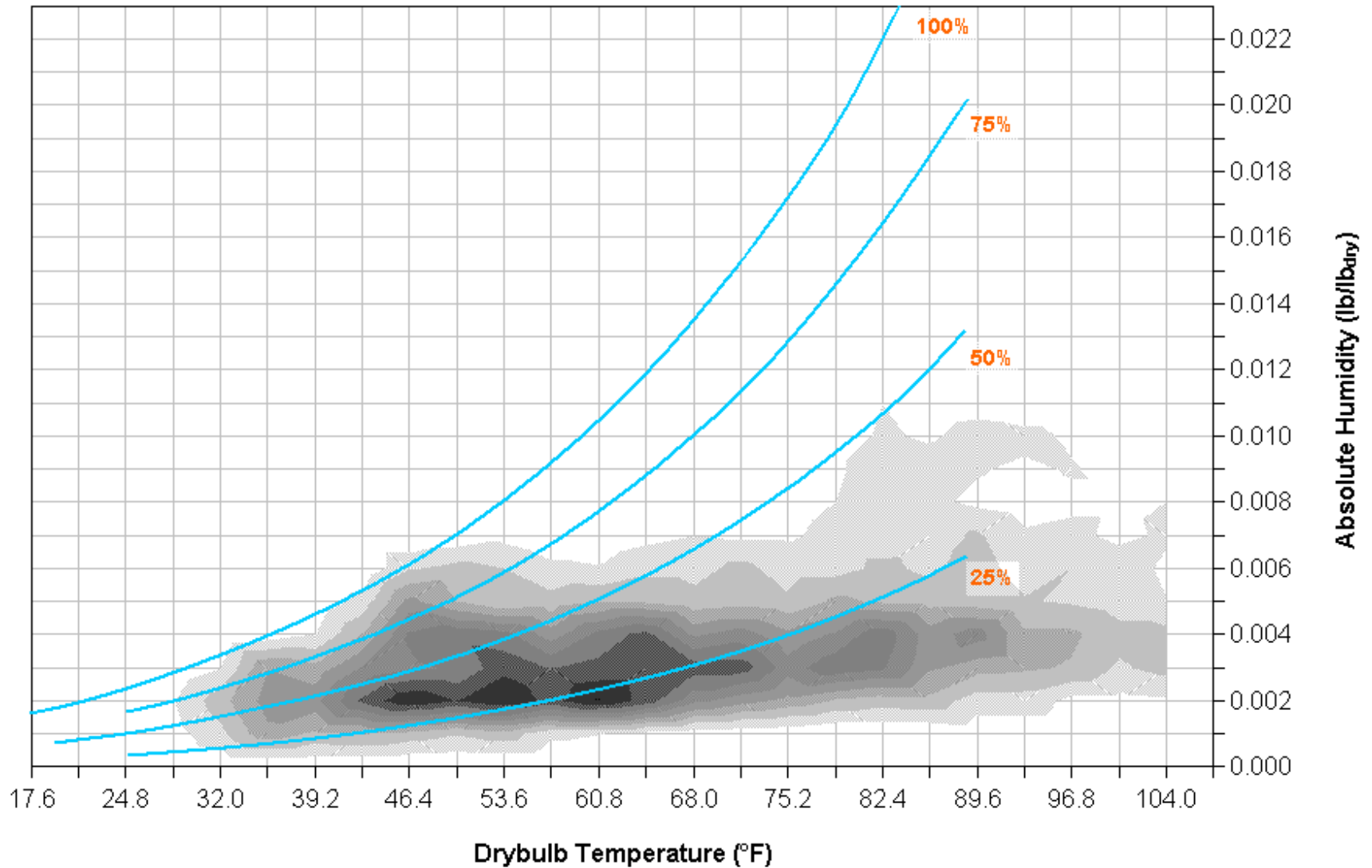
Minneapolis, MN



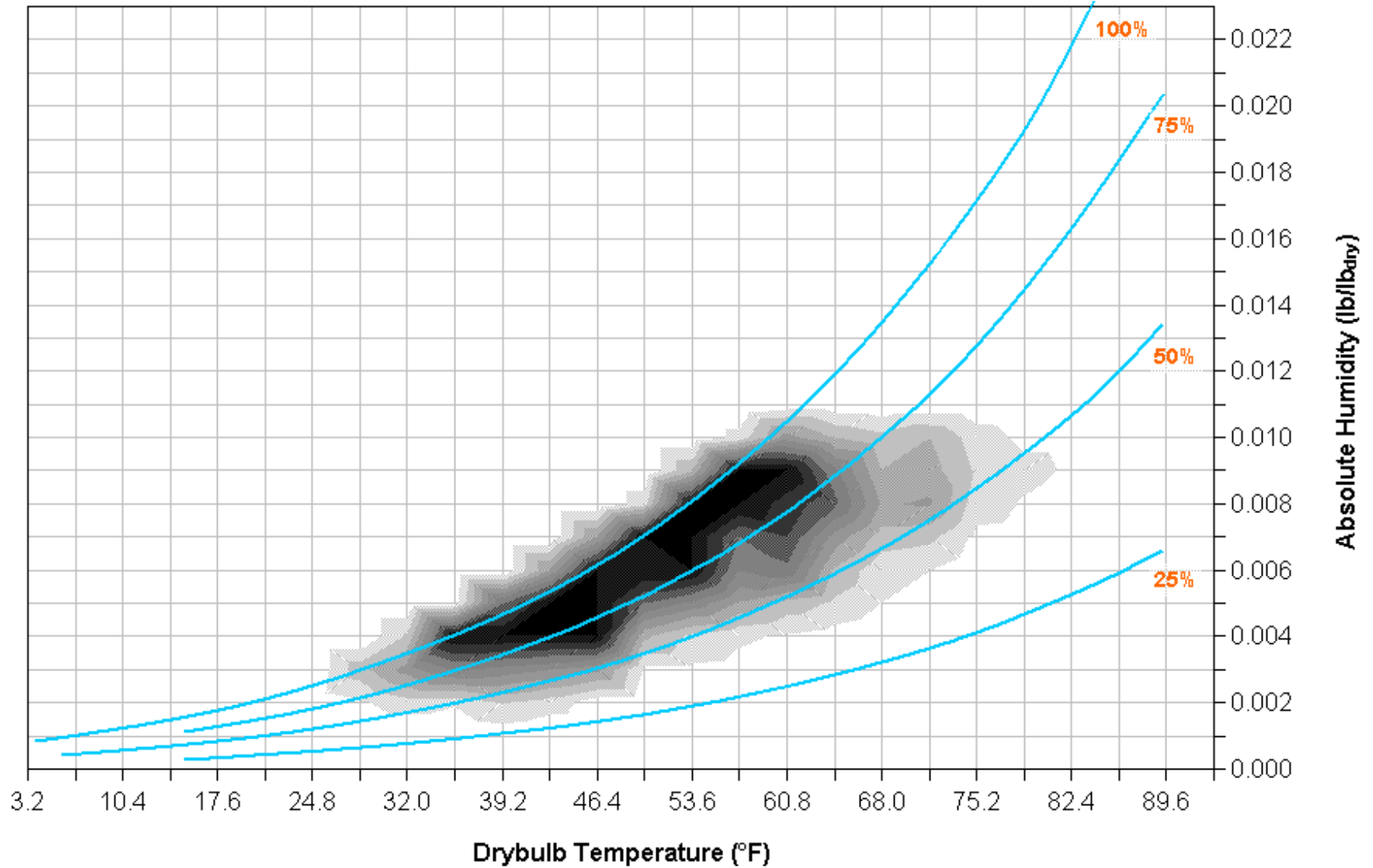
Lansing, MI



Las Vegas, NV



Seattle, WA



Arrhenius Equation

For Every 10 Degree K Rise
Activation Energy Doubles

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

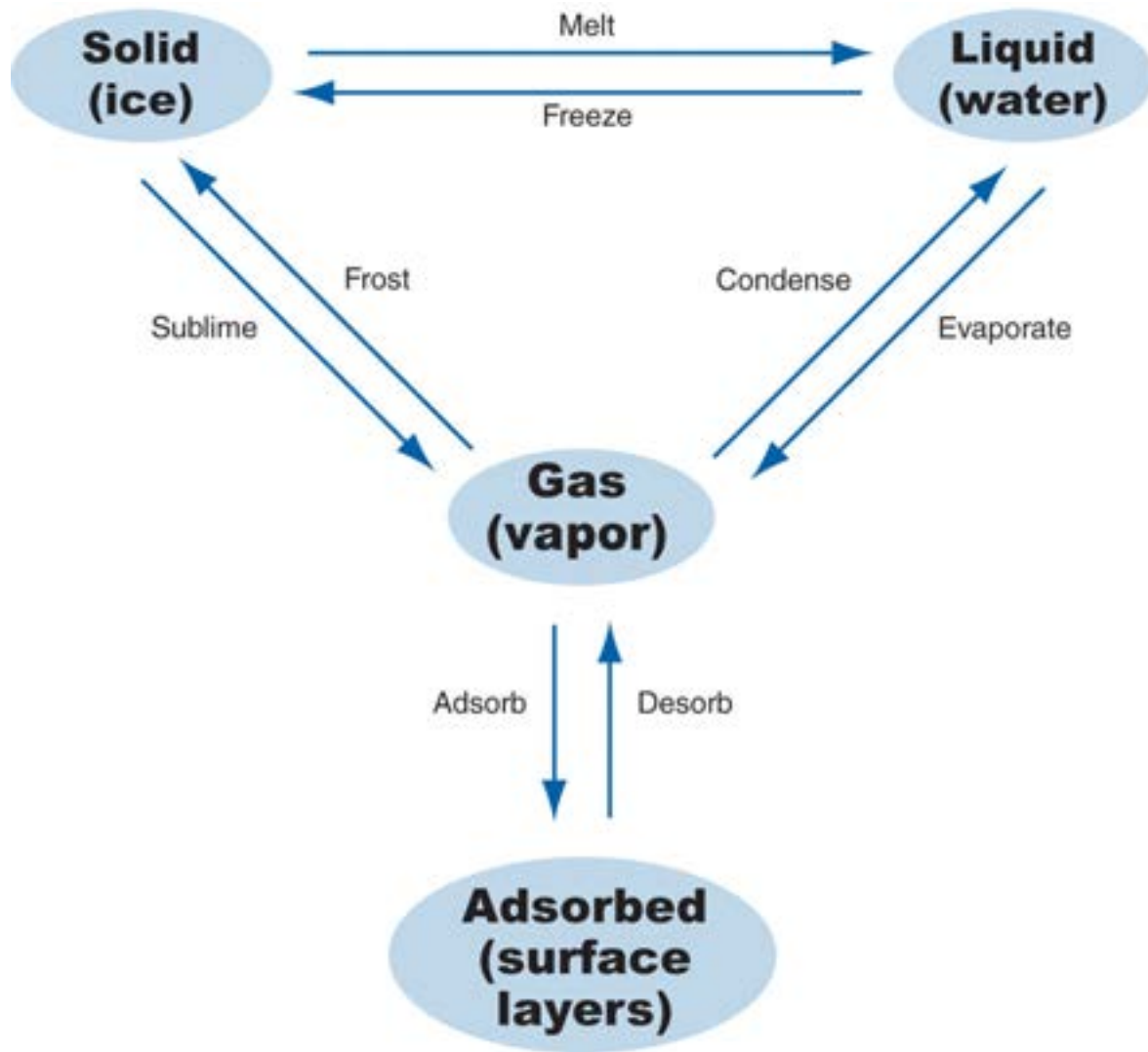
Damage Functions

Water

Heat

Ultra-violet Radiation

The Three Biggest Problems In Buildings Are Water, Water and Water...



Moisture Transport in Porous Media

Phase	Transport Process	Driving Potential
Vapor	Diffusion	Vapor Concentration
Adsorbate	Surface Diffusion	Concentration
Liquid	Capillary Flow	Suction Pressure
	Osmosis	Solute Concentration

Moisture Transport in Assemblies

Phase	Transport Process	Driving Potential
Vapor	Diffusion	Vapor Concentration
	Convective Flow	Air Pressure

Adsorbate	Surface Diffusion	Concentration

Liquid	Capillary Flow	Suction Pressure
	Osmosis	Solute Concentration
	Gravitational Flow	Height
	Surface Tension	Surface Energy
	Momentum	Kinetic Energy
	Convective Flow	Air Pressure

Microclimates and Materials Science

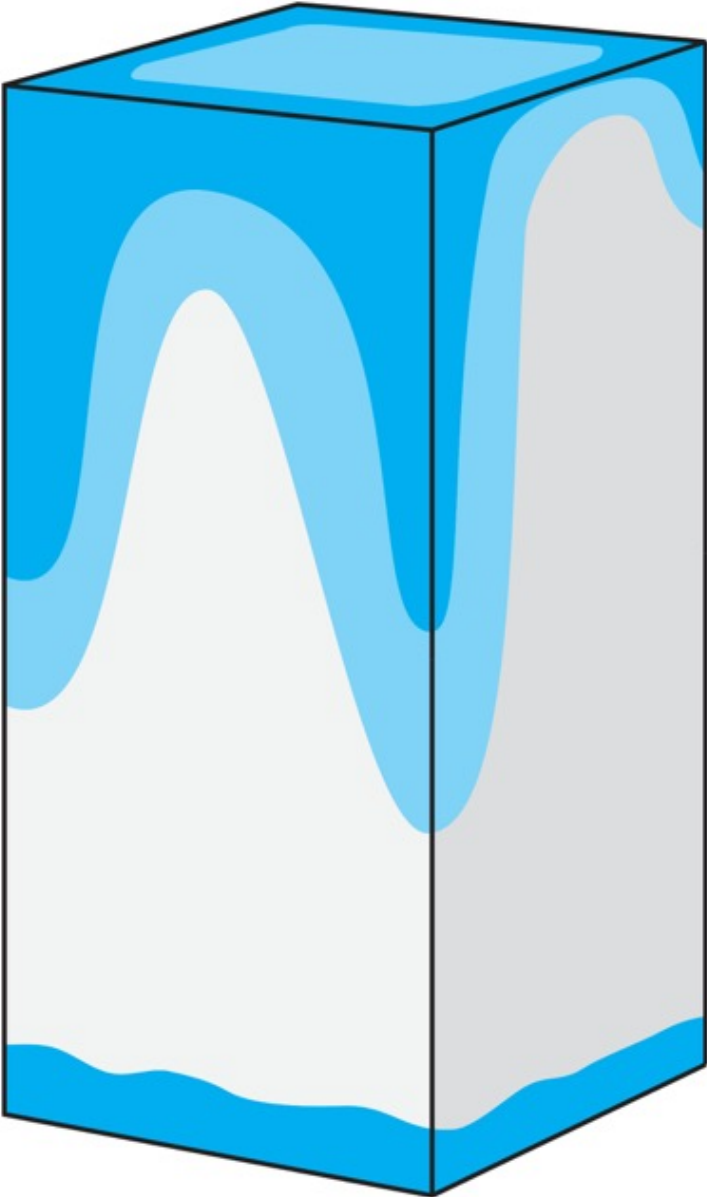


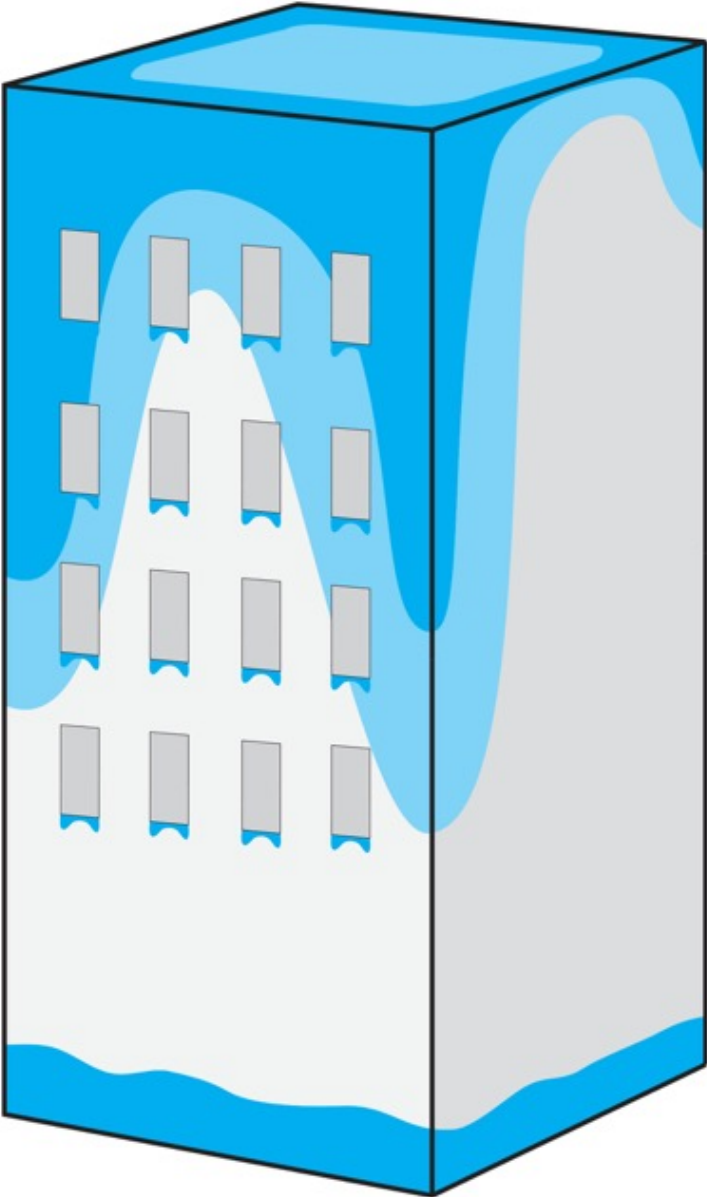






Environmental Loads
Rain Exposure Zone
Hygro-thermal Regions
Interior Climate Class



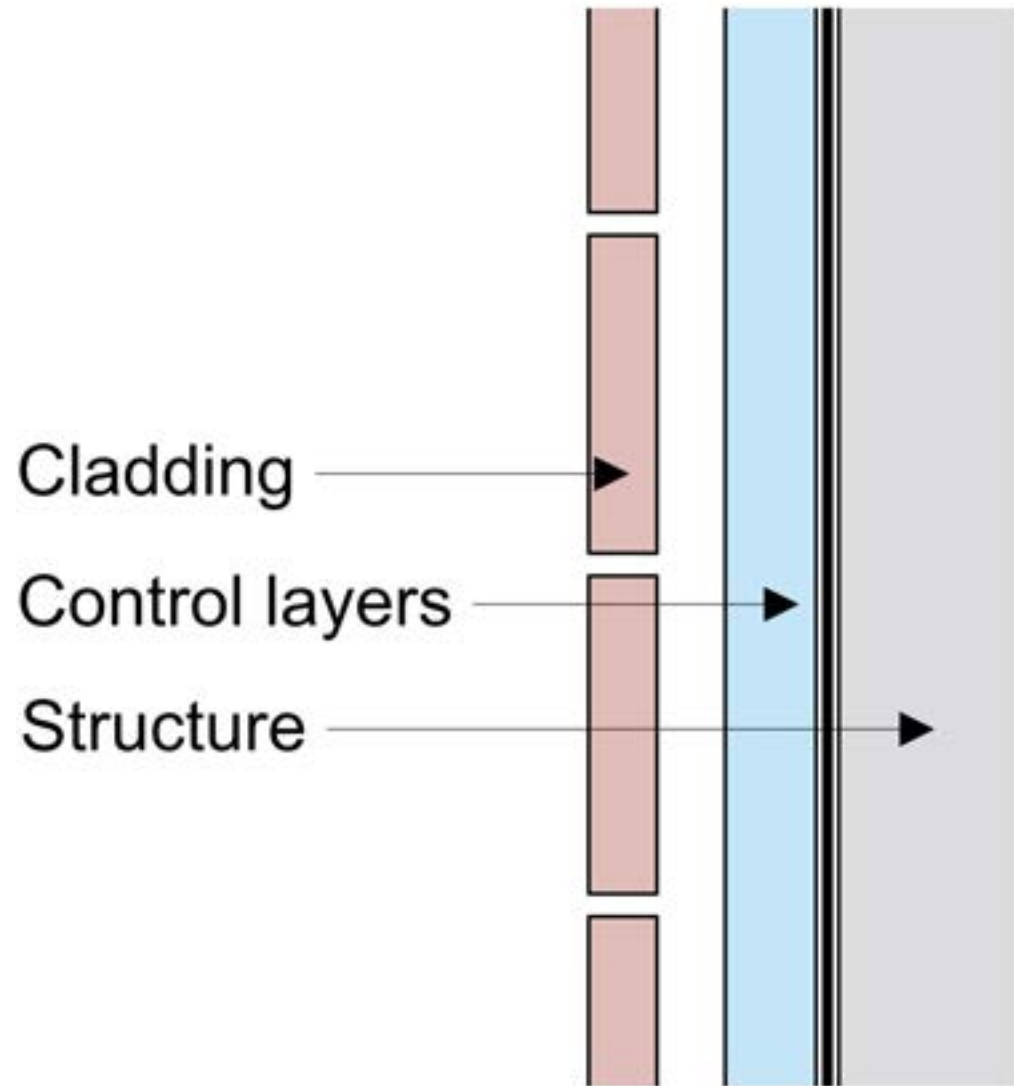


Water Control Layer

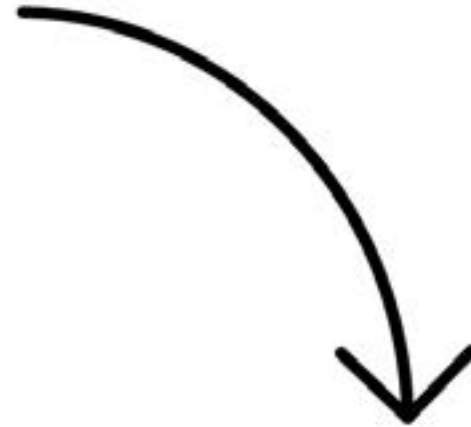
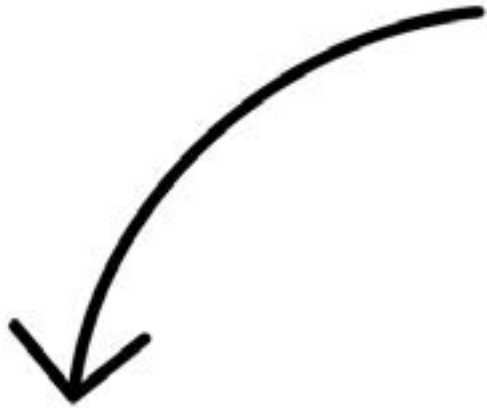
Air Control Layer

Vapor Control Layer

Thermal Control Layer



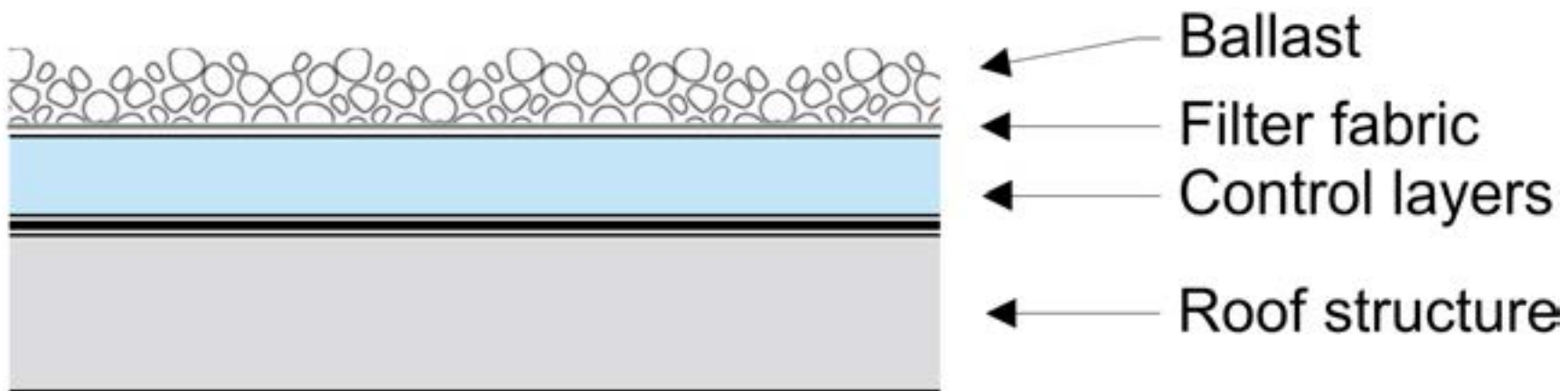
Wall

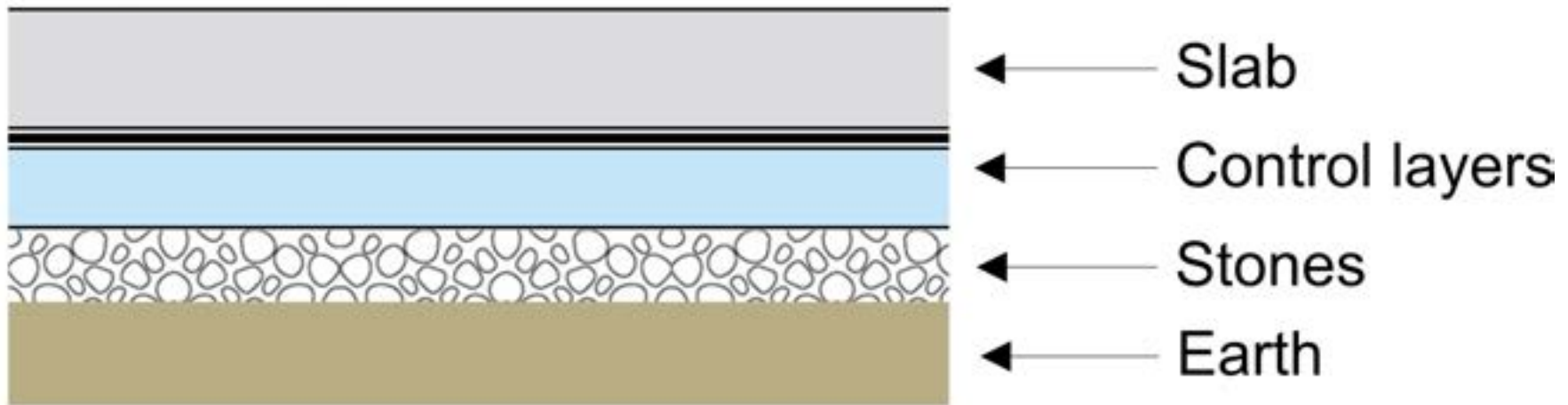


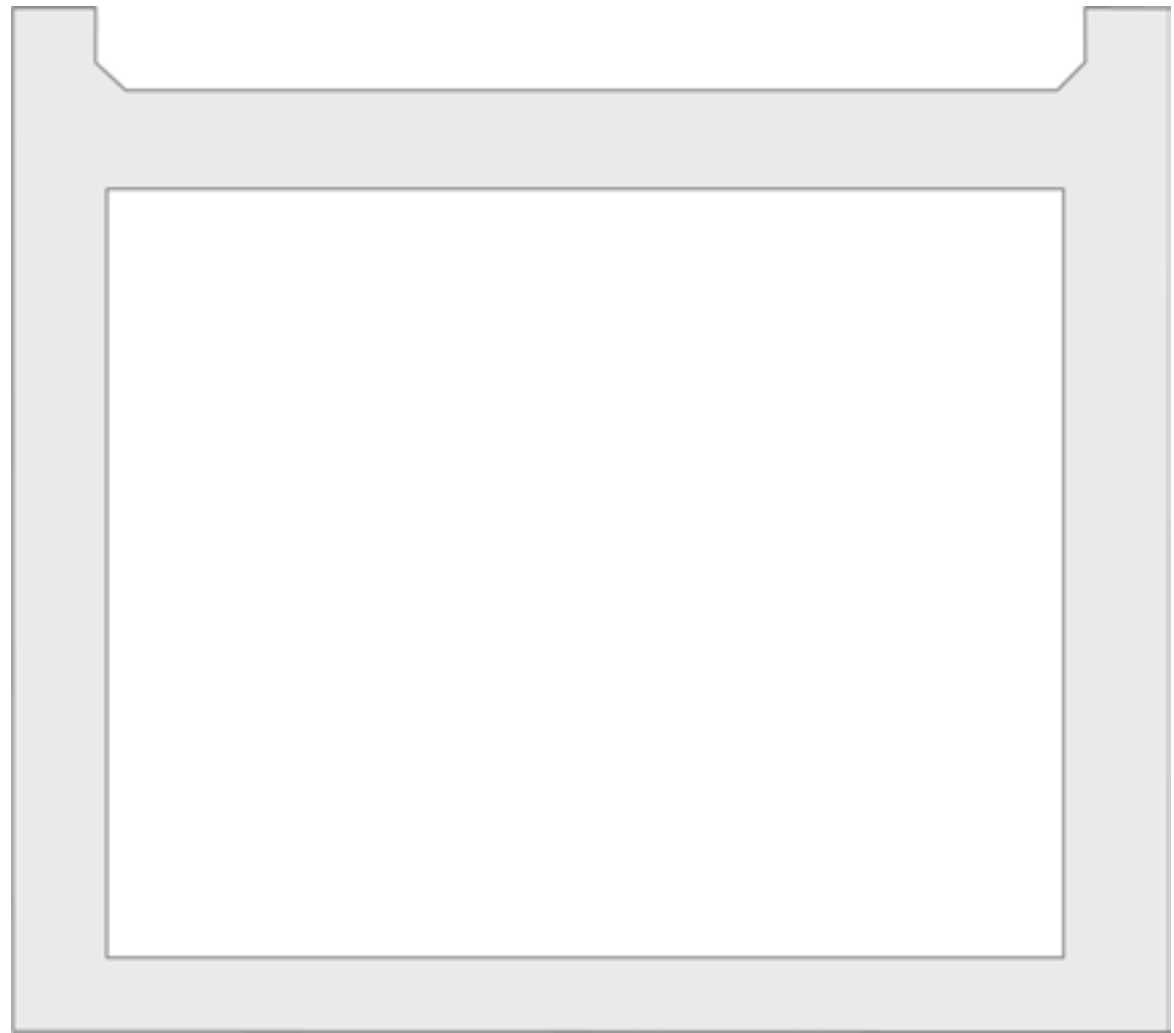
Slab

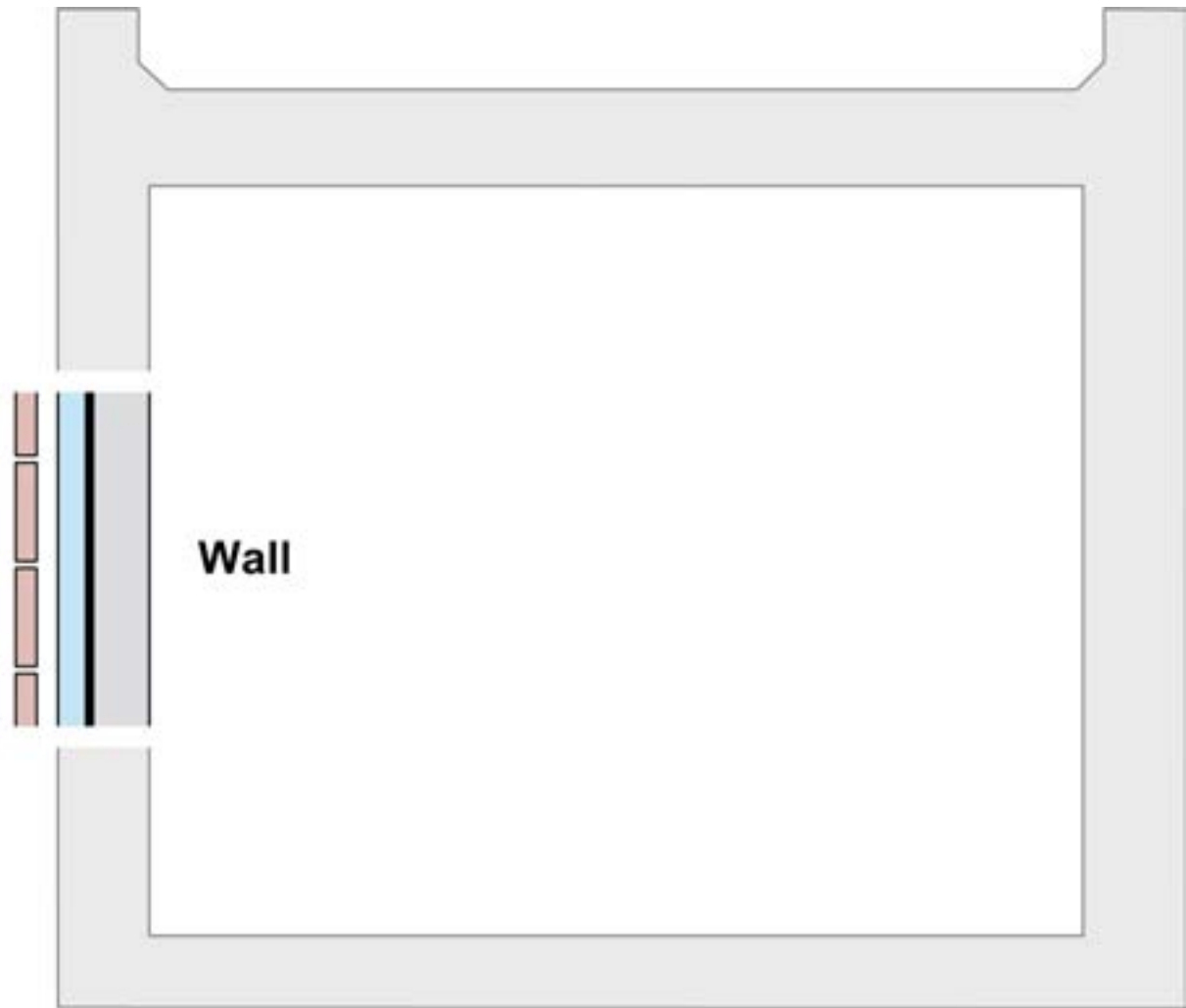


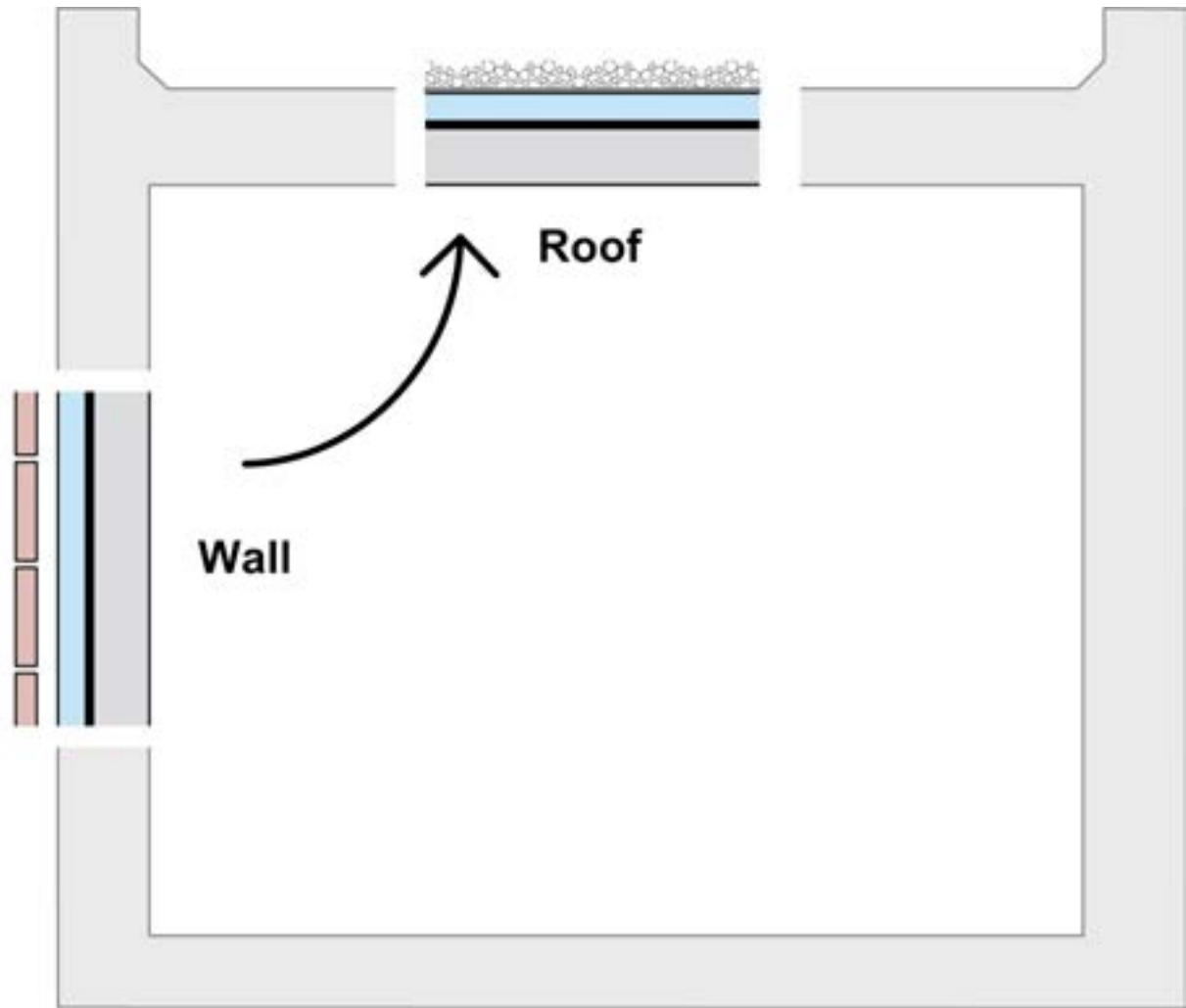
Roof

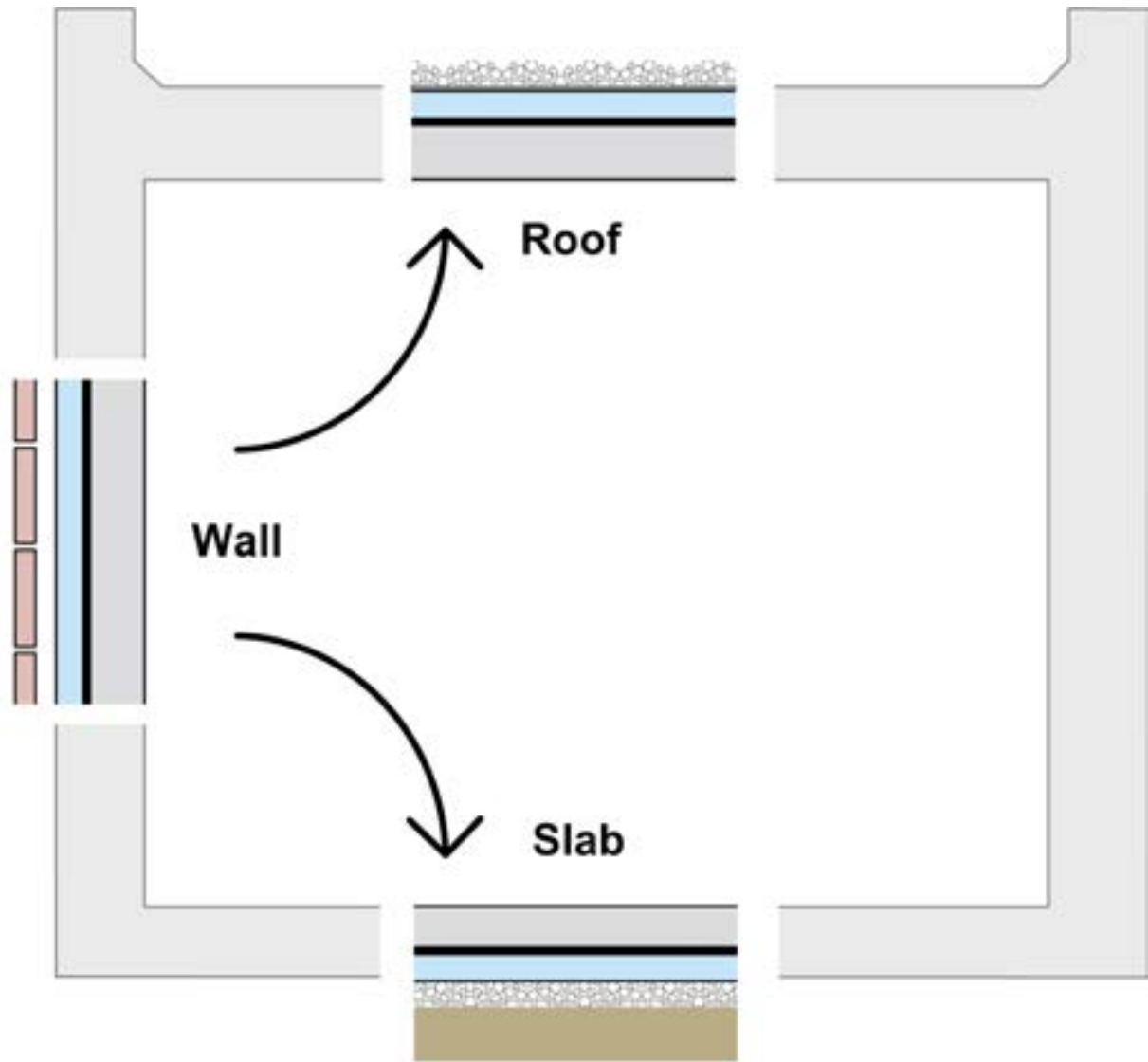


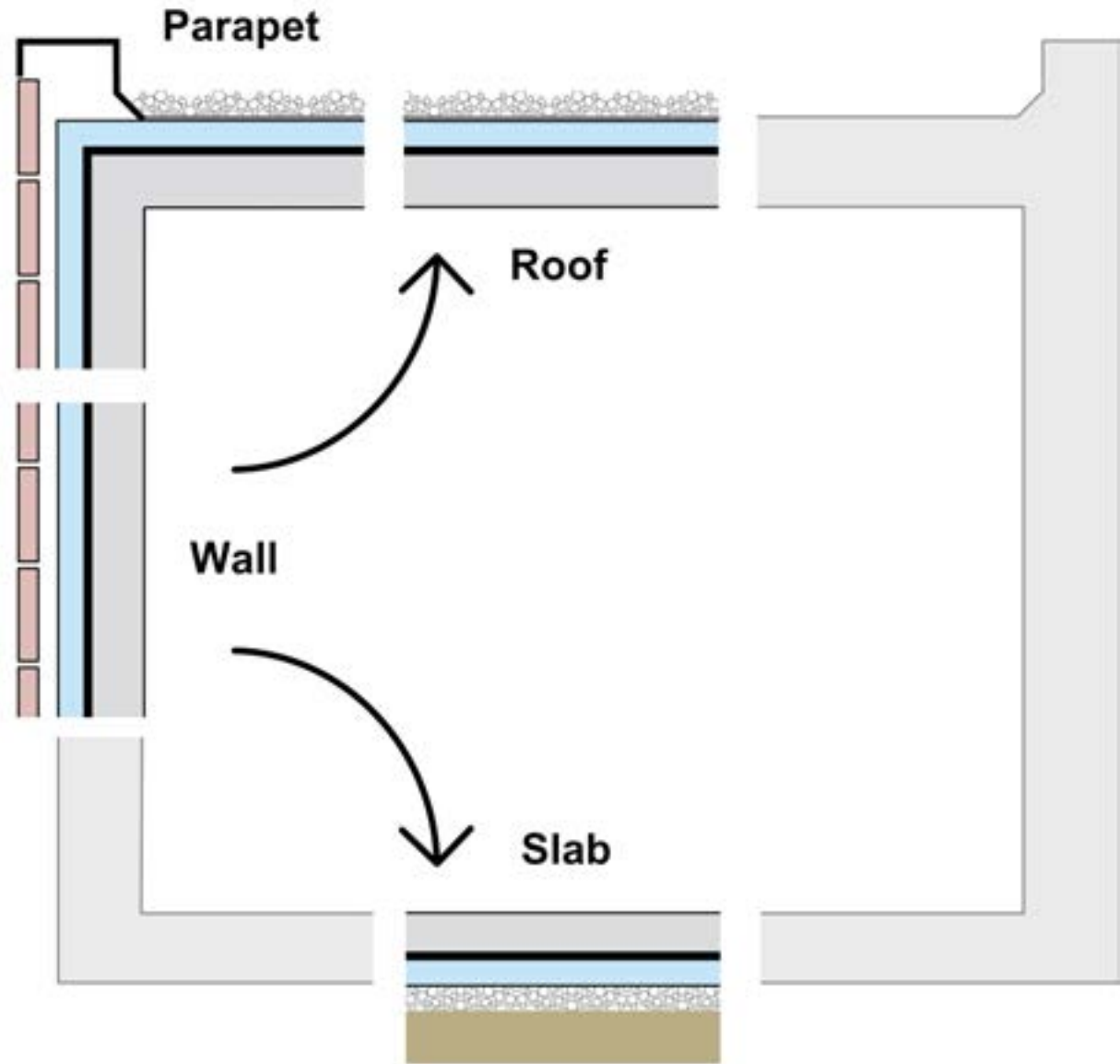


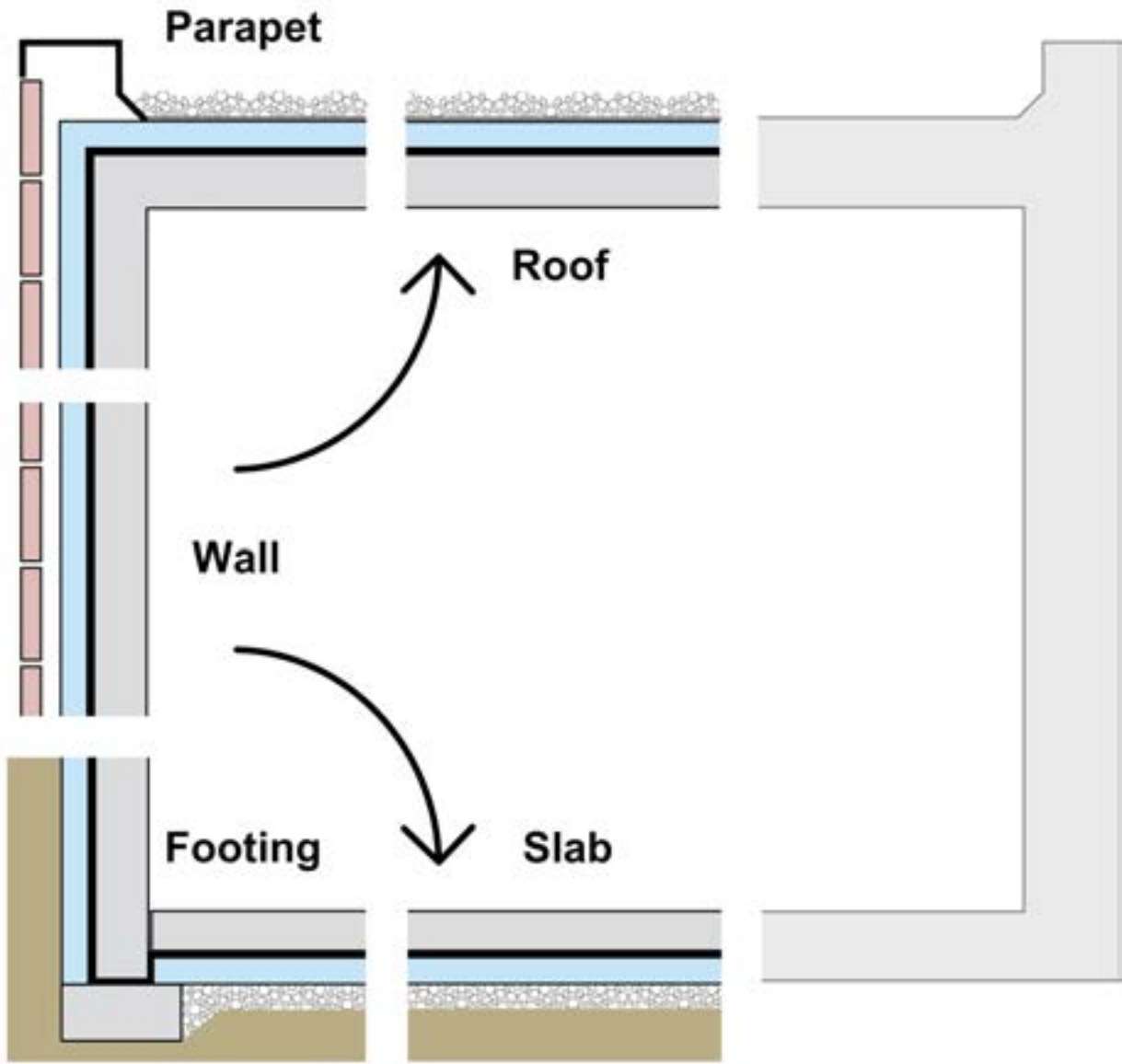


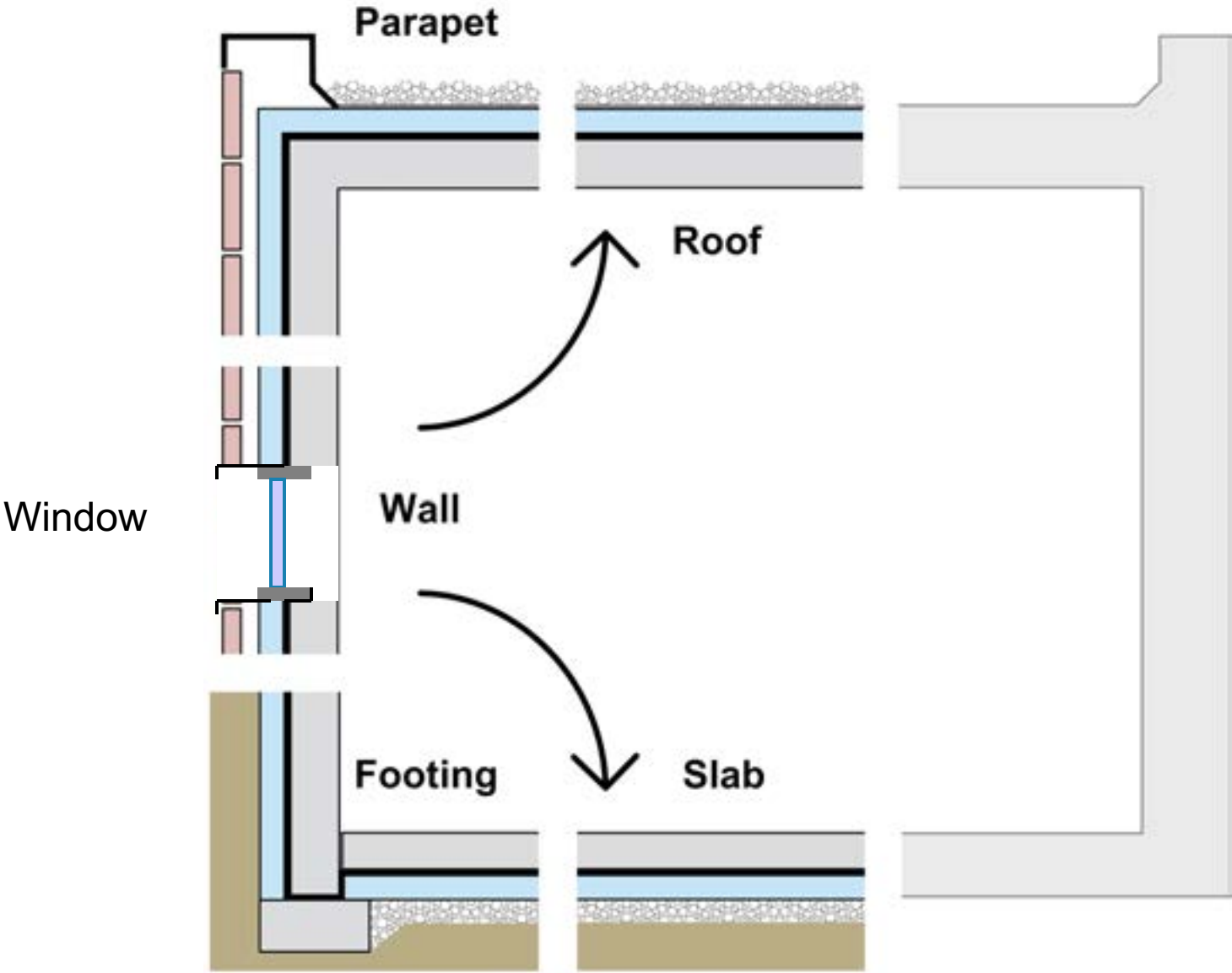




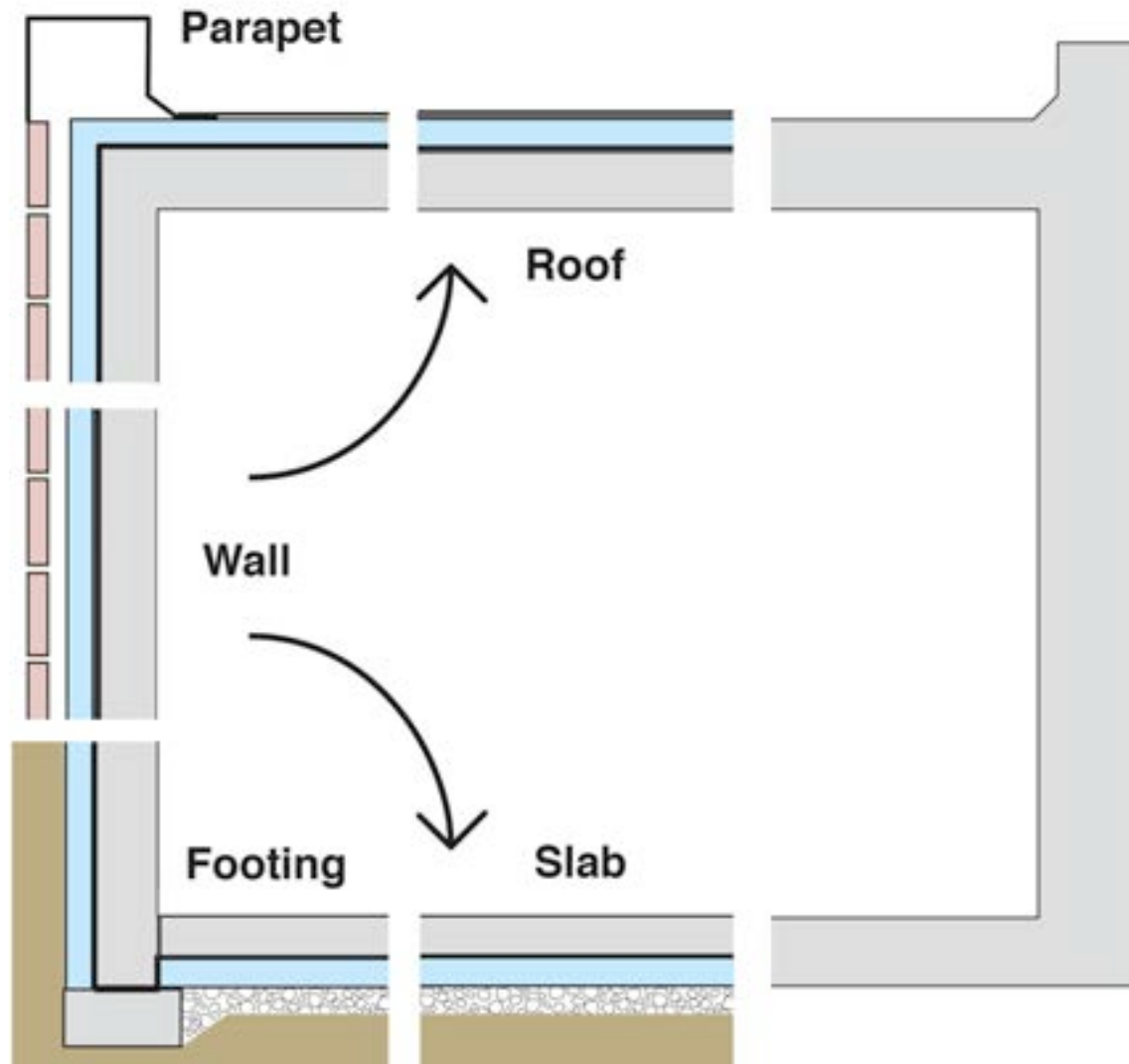


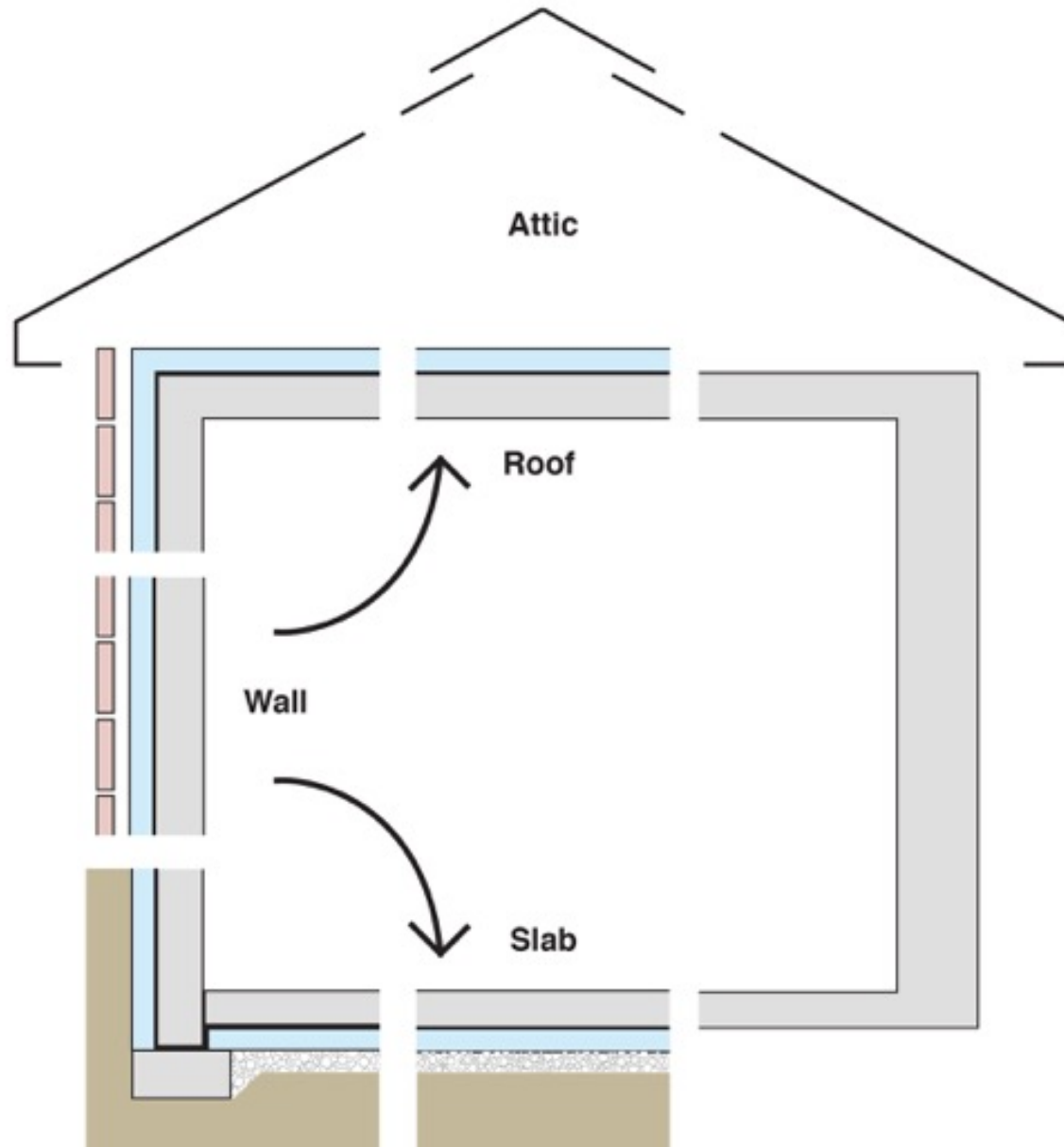


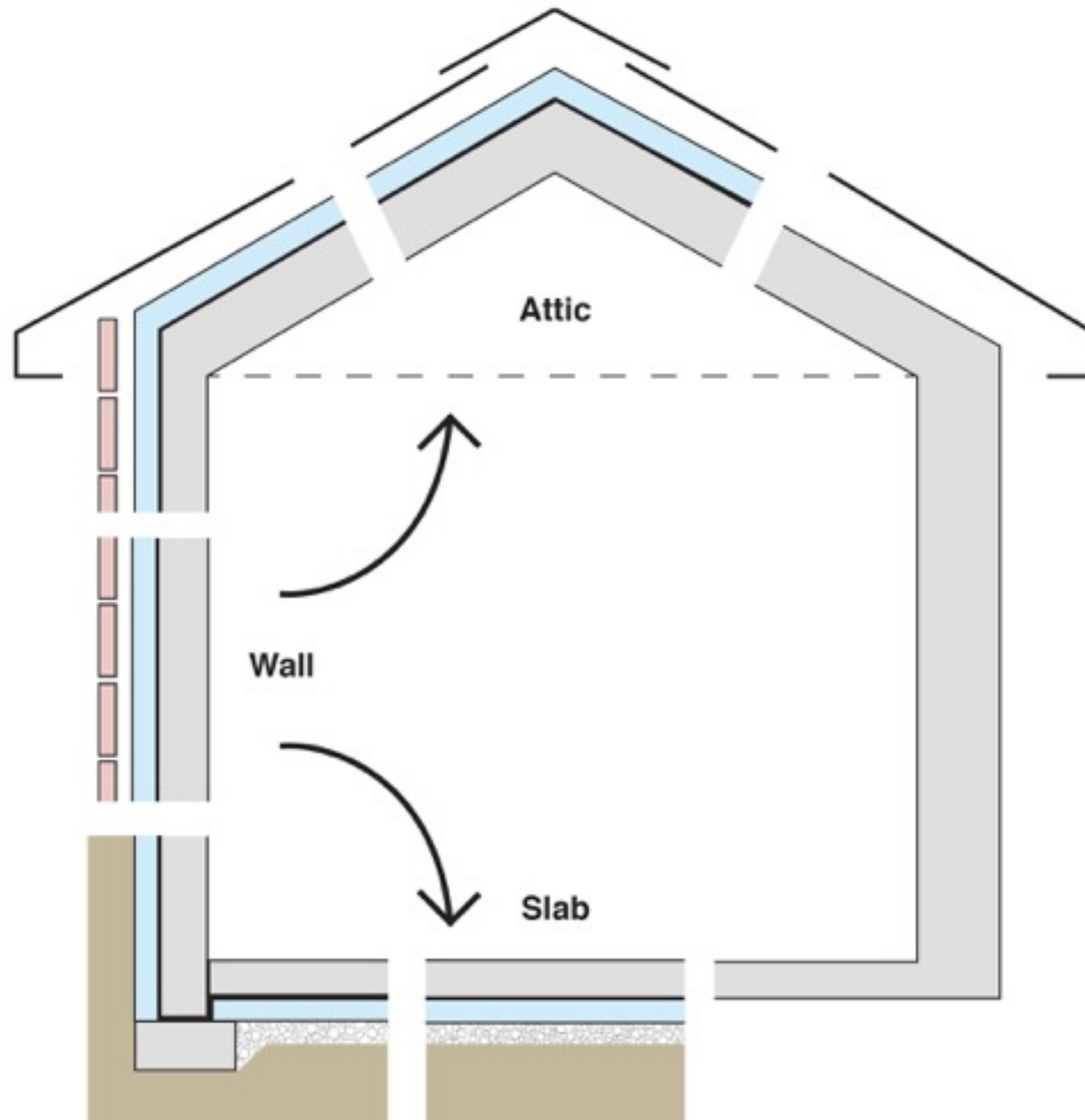


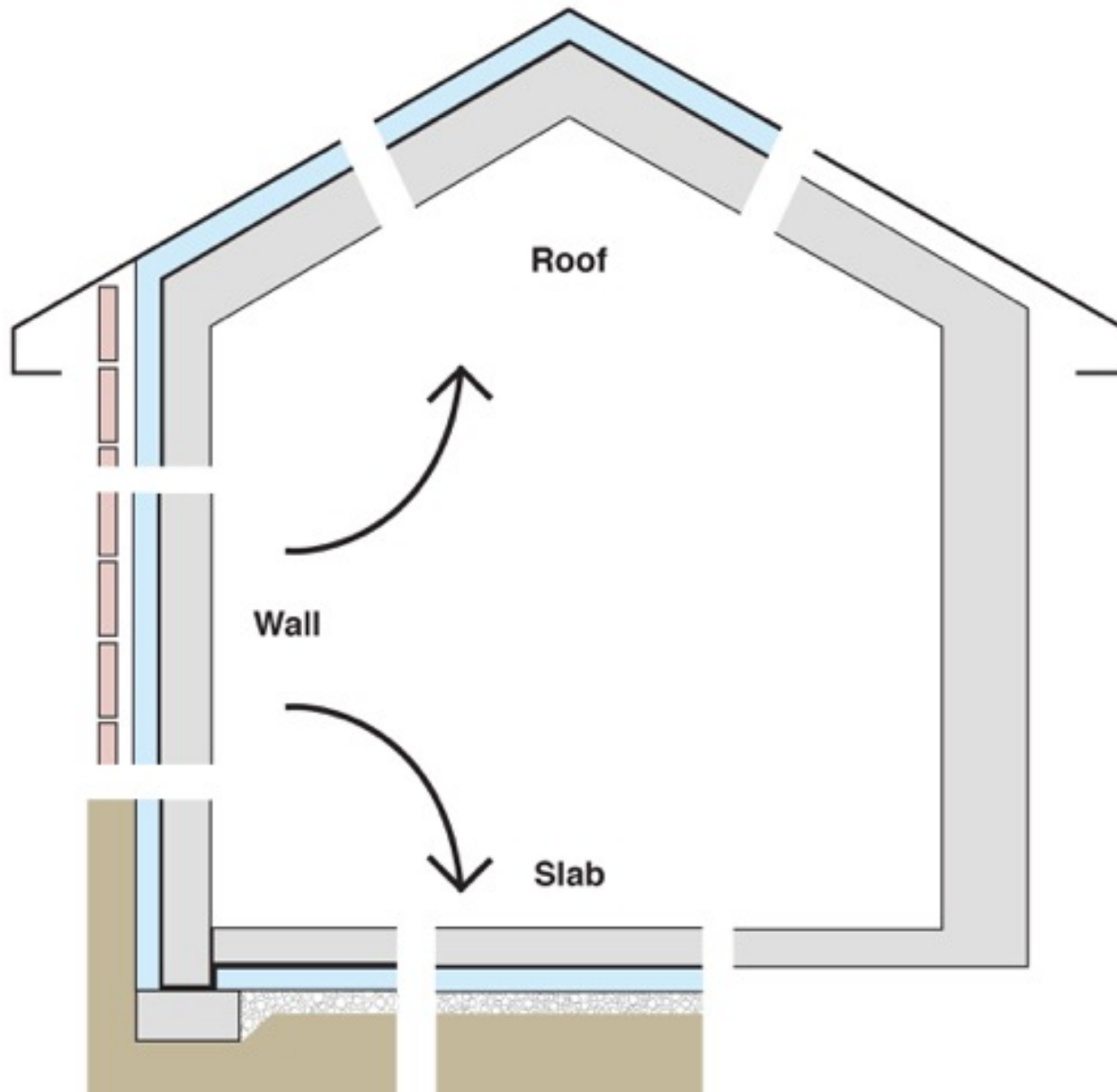


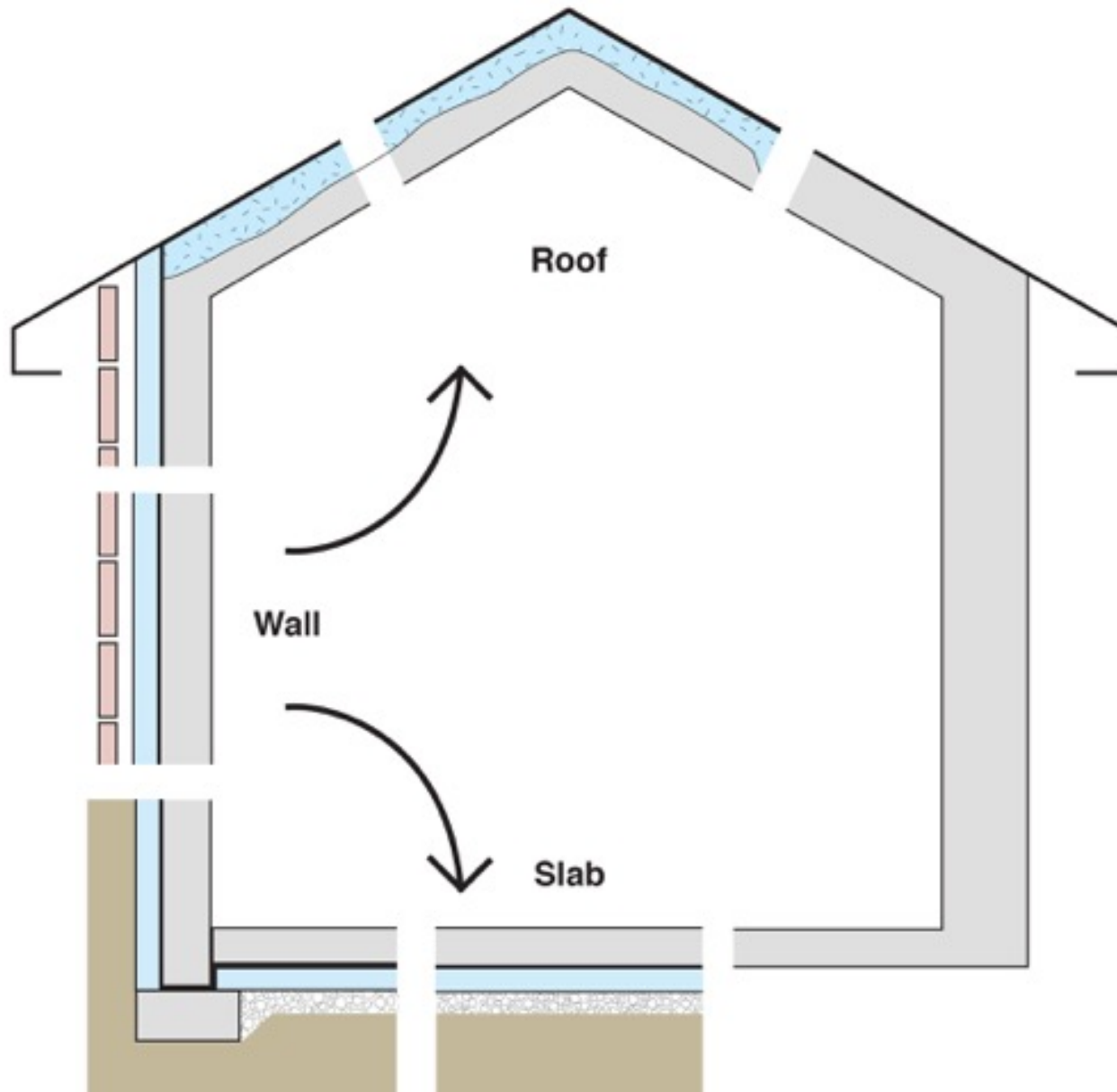




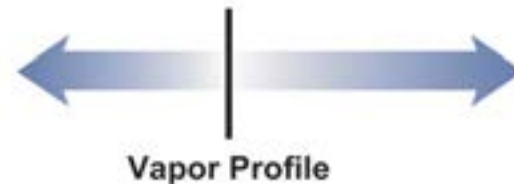
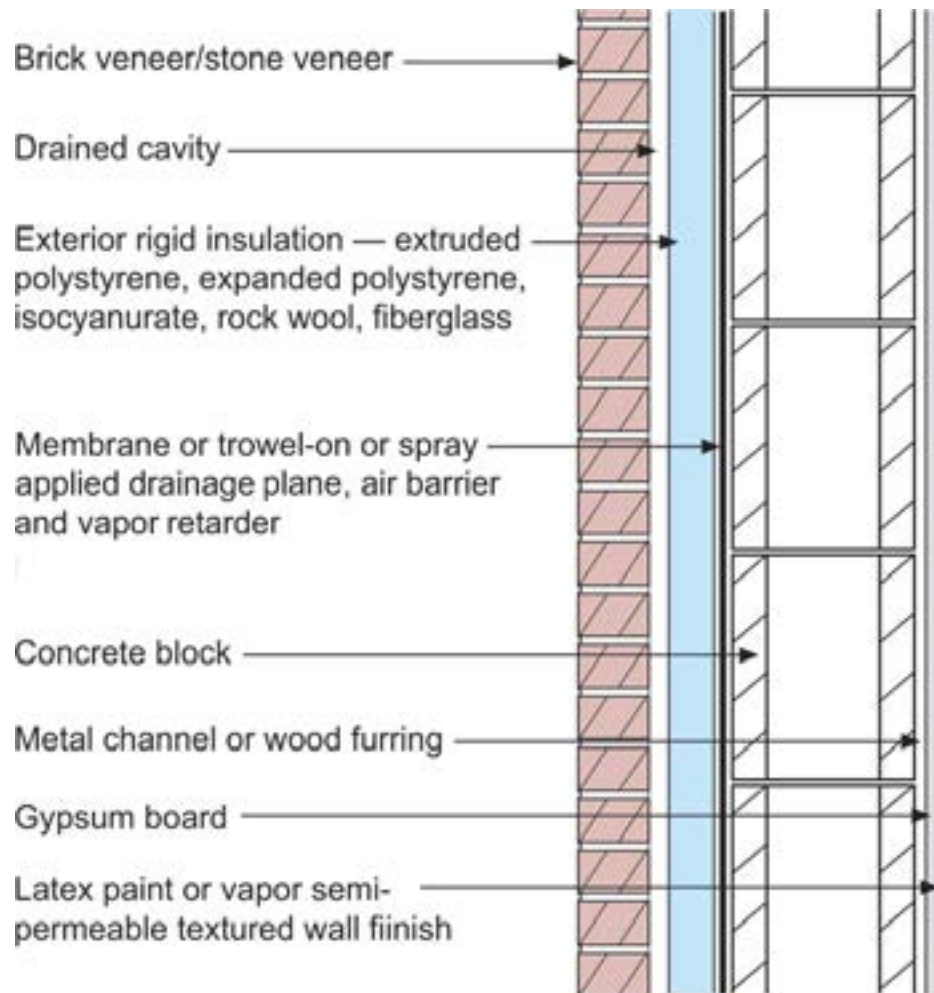


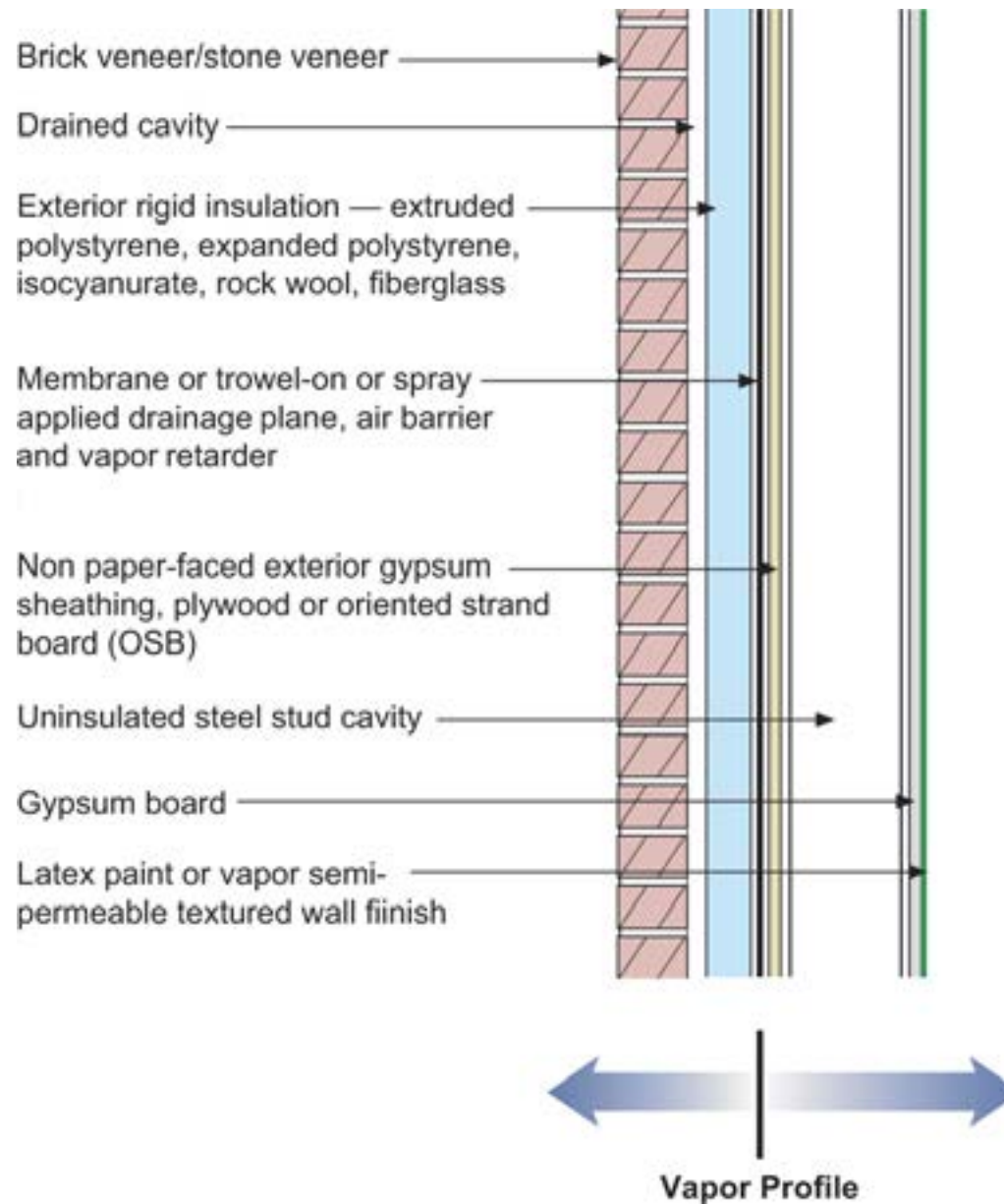


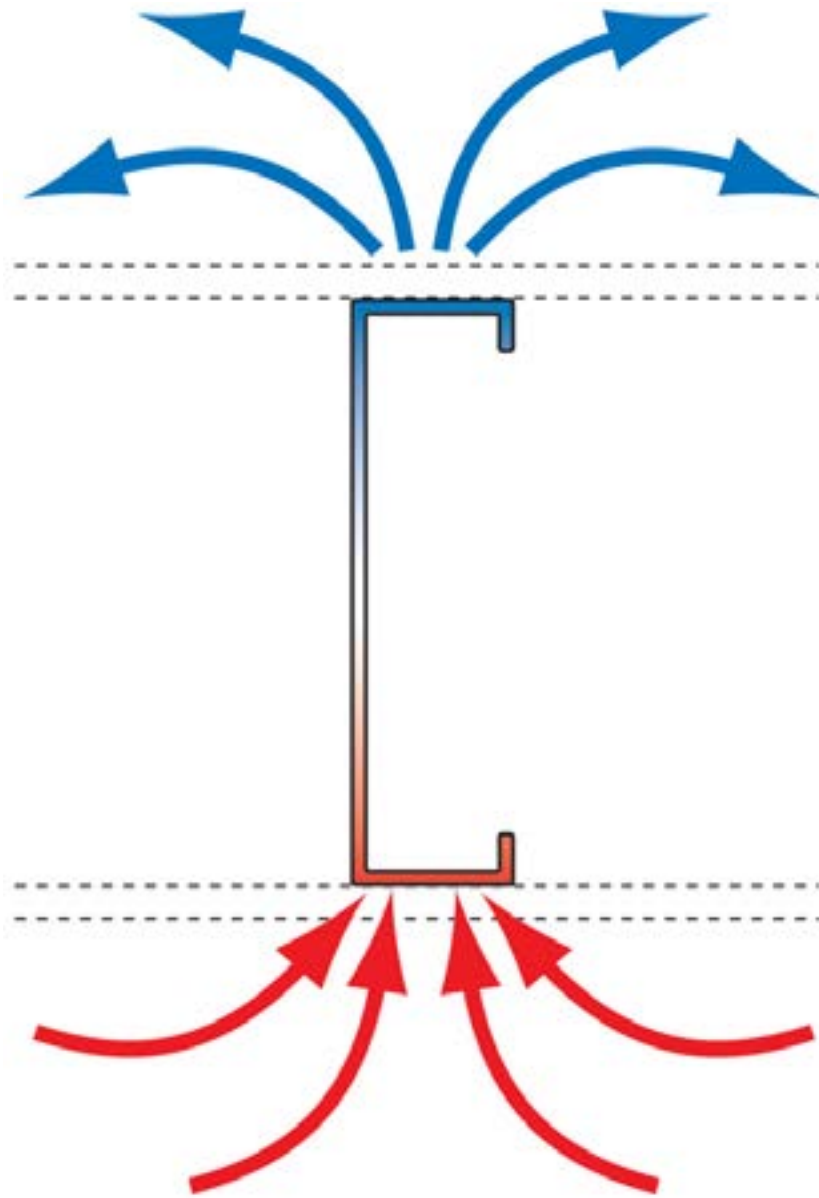




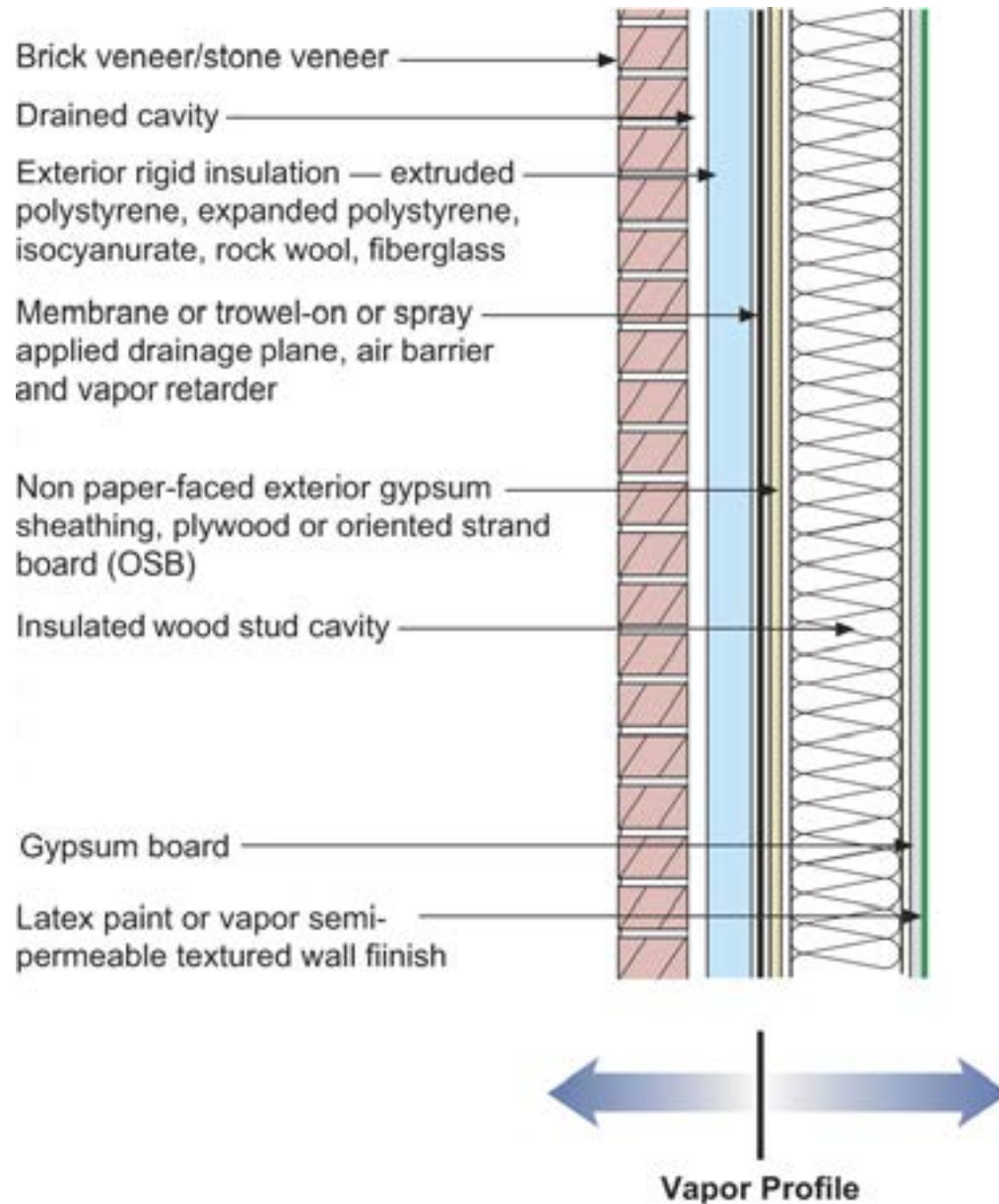
Configurations of the Perfect Wall



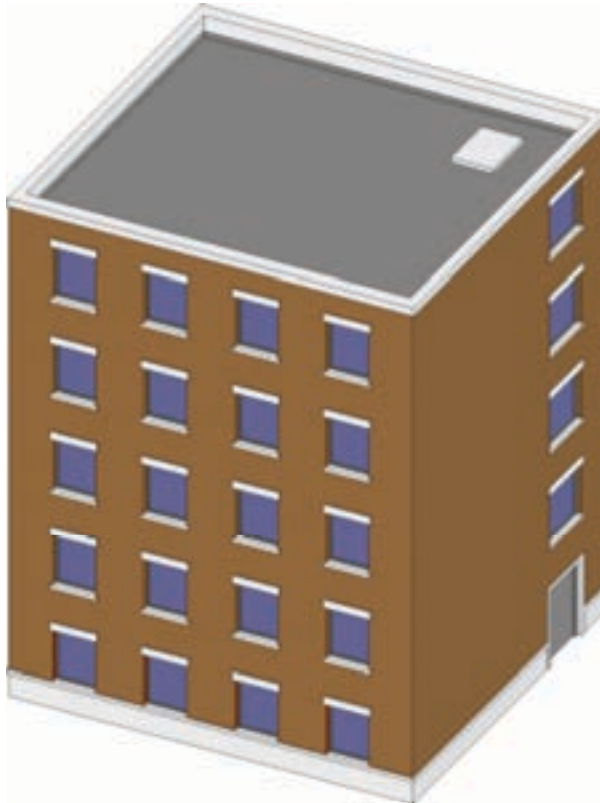




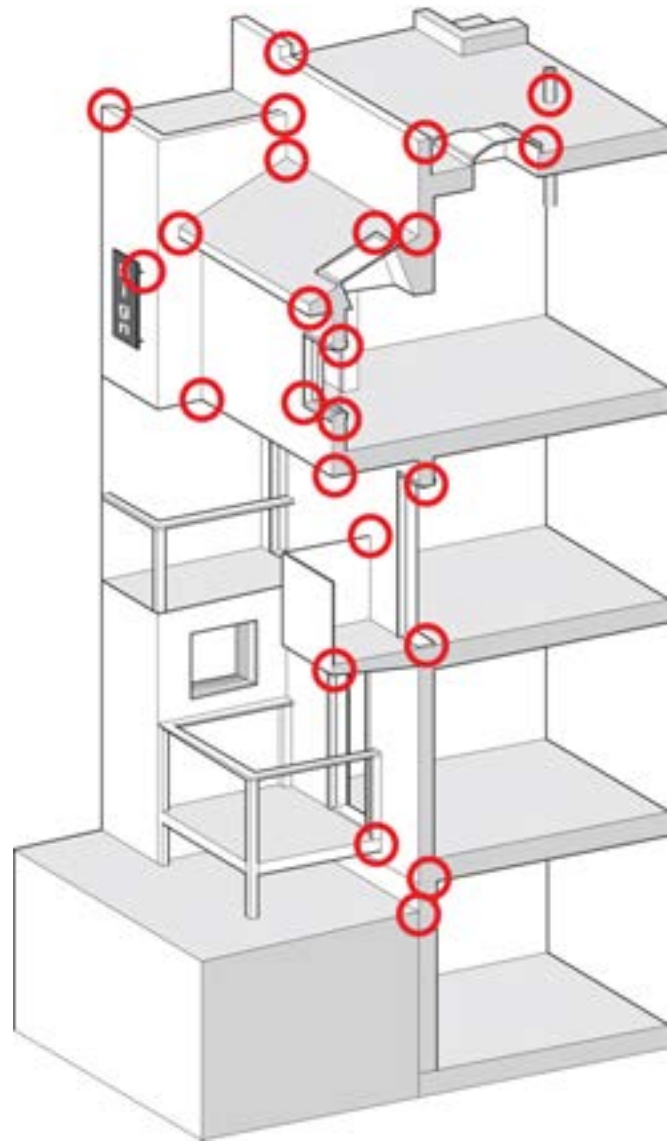




Commercial Enclosure: Simple Layers



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











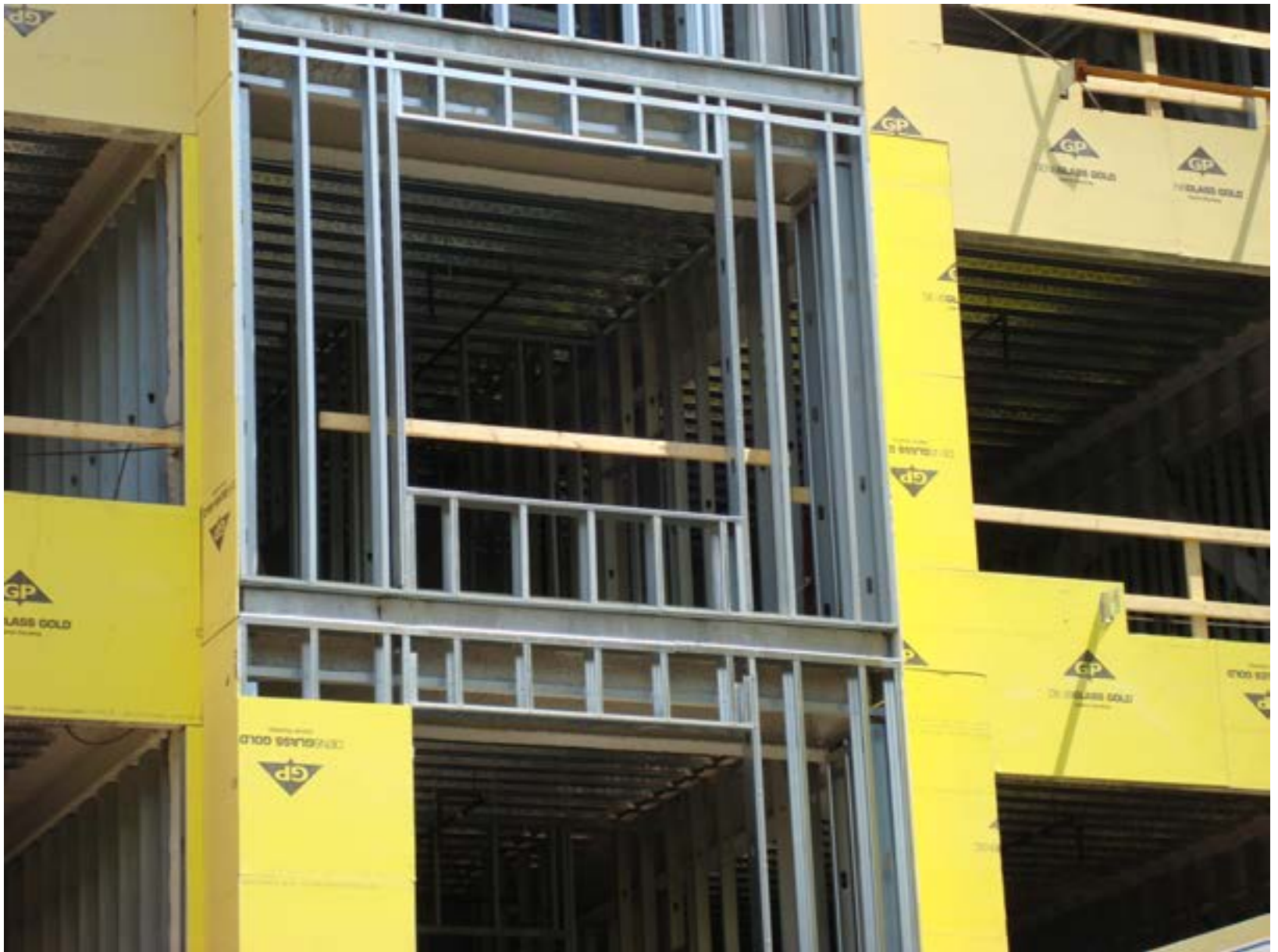
































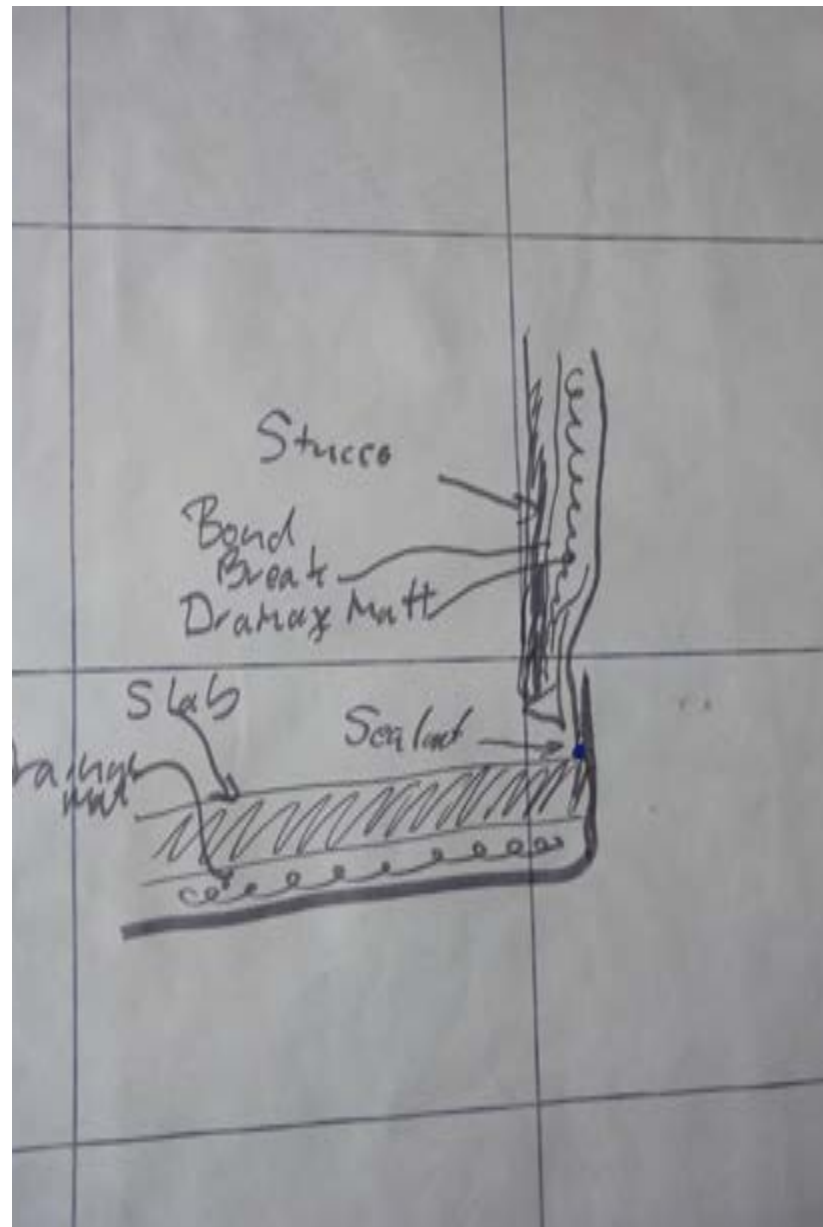




























Don't Do Stupid Things





















