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

Building Science

Enclosure Fundamentals

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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

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

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

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Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

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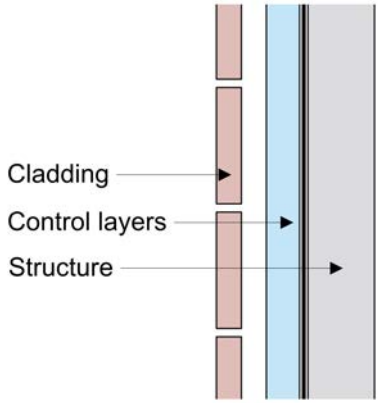

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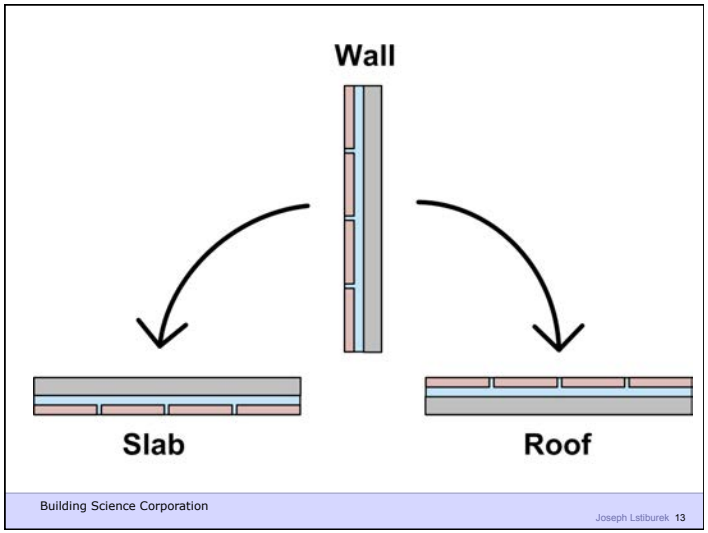
Wall
Slab
Roof
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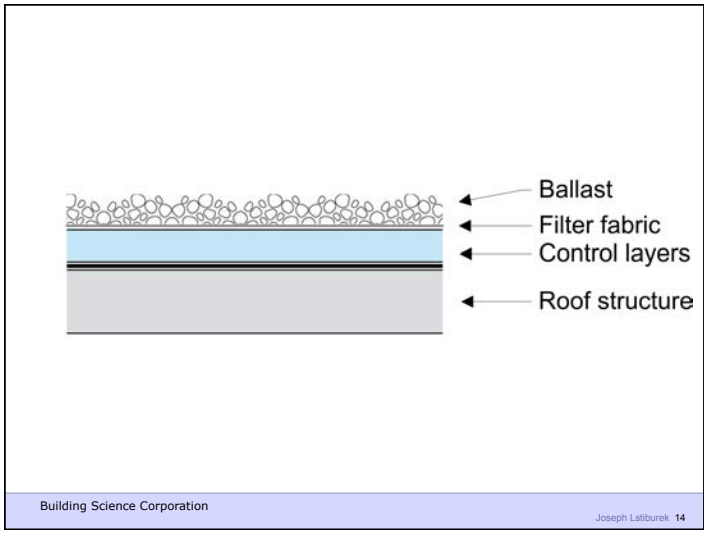
Ballast
Filter fabric
Control layers
Roof structure
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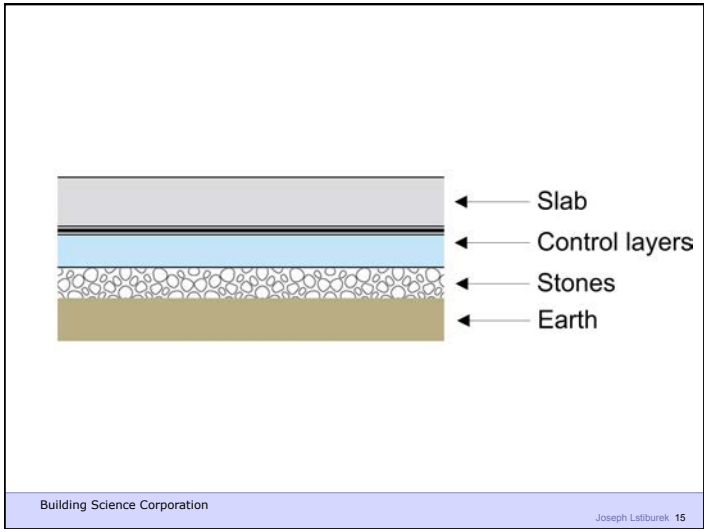
Slab
Control layers
Stones
Earth
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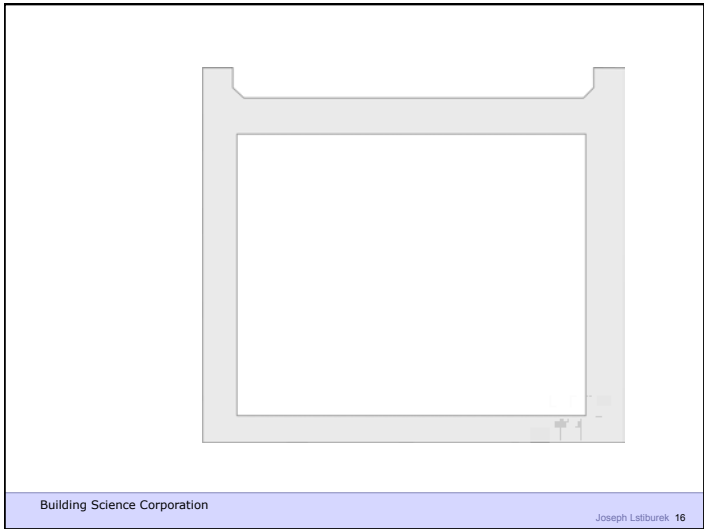
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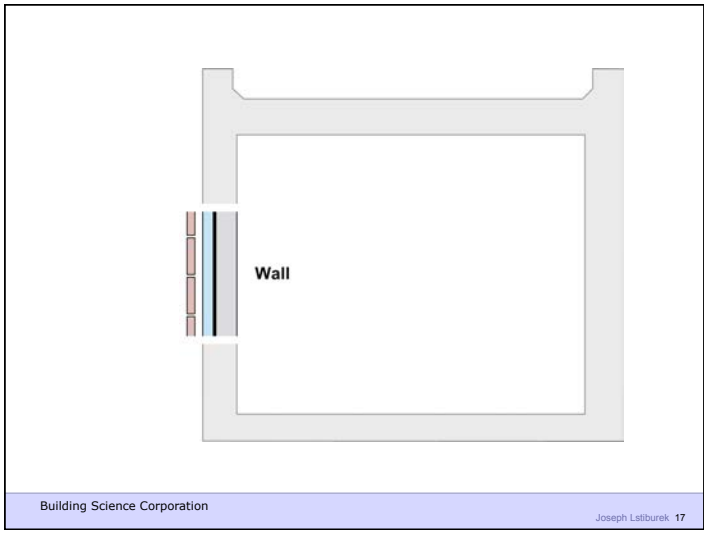
Wall
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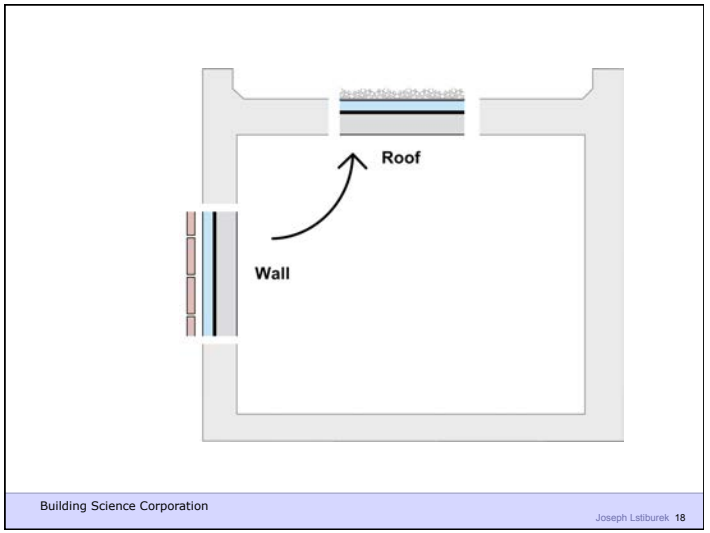
Roof
Wall
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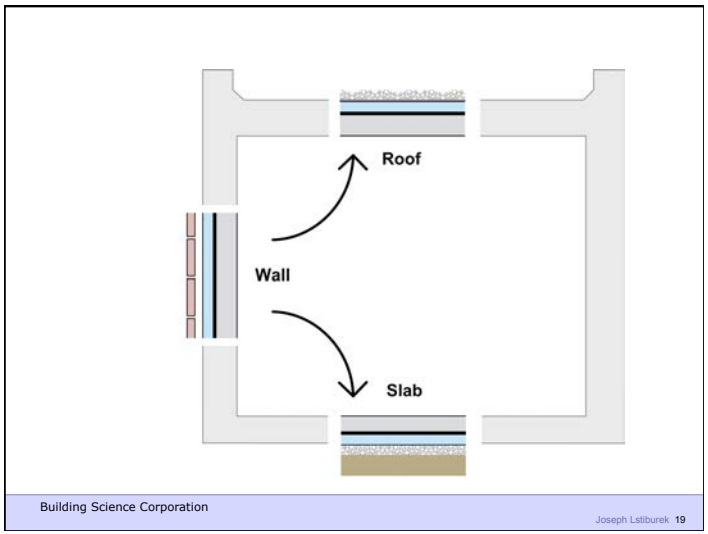
Roof
Wall
Slab
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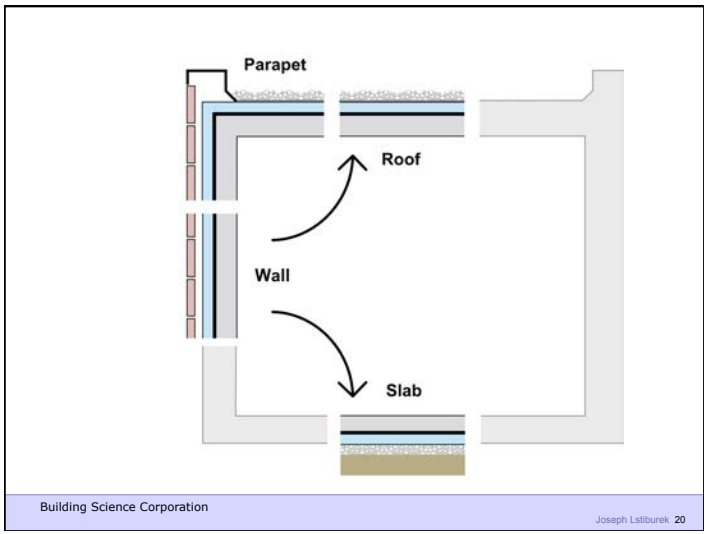
Parapet
Roof
Wall
Slab
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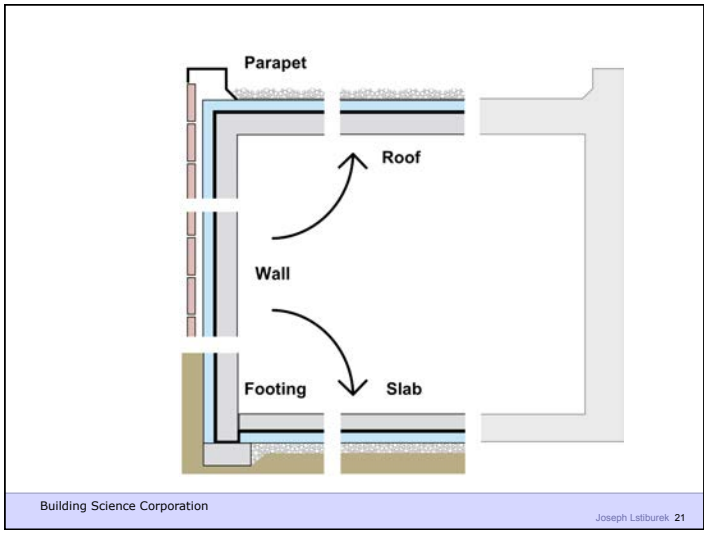
Parapet
Roof
Wall
Footing
Slab
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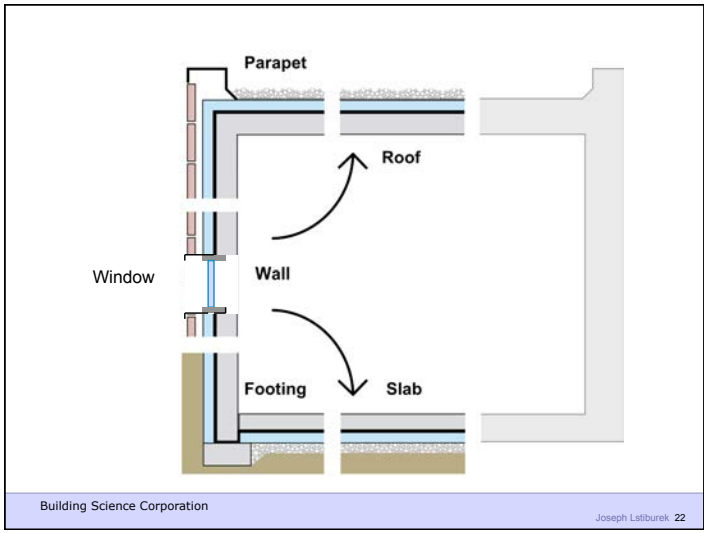
Parapet
Roof
Window
Wall
Footing
Slab
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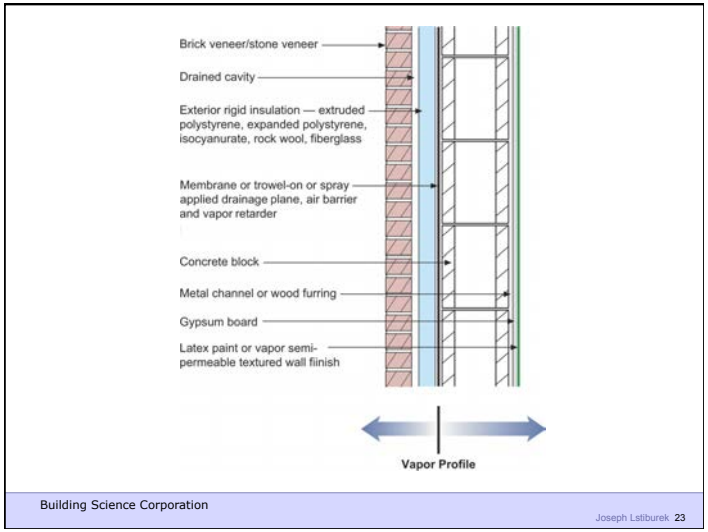
Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Concrete block
Metal channel or wood furring
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile
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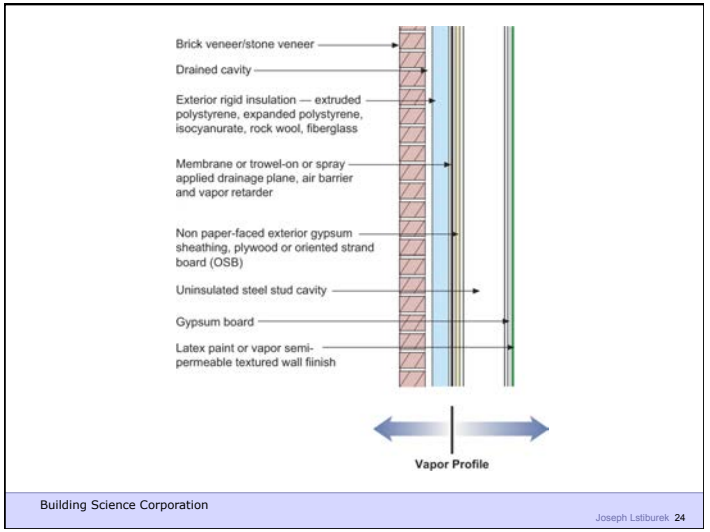
Brick veneer/stone veneer
Drained cavity
Exterior rigid insulation — extruded polystyrene, expanded polystyrene, isocyanurate, rock wool, fiberglass
Membrane or trowel-on or spray applied drainage plane, air barrier and vapor retarder
Non paper-faced exterior gypsum sheathing, plywood or oriented strand board (OSB)
Uninsulated steel stud cavity
Gypsum board
Latex paint or vapor semi-permeable textured wall fiinish
Vapor Profile
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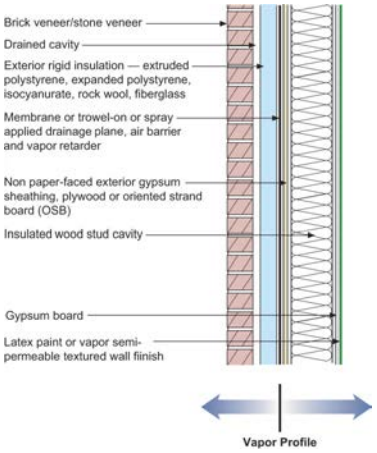

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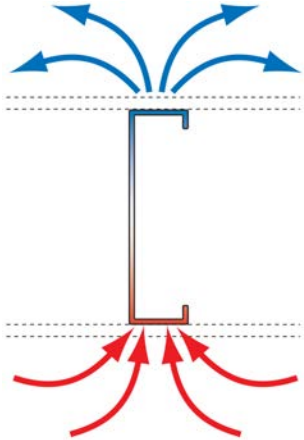

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Commercial Enclosure: Simple Layers

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

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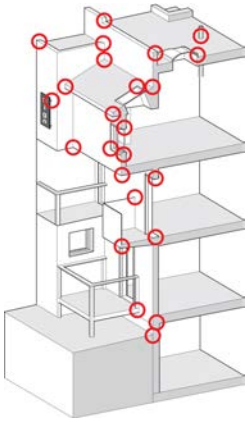

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Building Science Corporation Joseph Lstiburek 30

Building Science Corporation Joseph Lstiburek 31

Building Science Corporation Joseph Lstiburek 32

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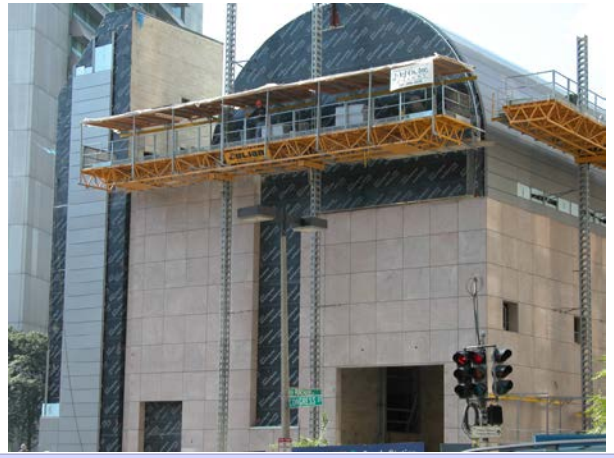
Building Science Corporation Joseph Lstiburek 35

Building Science Corporation Joseph Lstiburek 36



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Building Science Corporation Joseph Lstiburek 40

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Building Science Corporation Joseph Lstiburek 42

Building Science Corporation Joseph Lstiburek 43

Building Science Corporation Joseph Lstiburek 44

Building Science Corporation Joseph Lstiburek 45

Building Science Corporation Joseph Lstiburek 46

Building Science Corporation Joseph Lstiburek 47

Building Science Corporation Joseph Lstiburek 48

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Joseph Lstiburek 49

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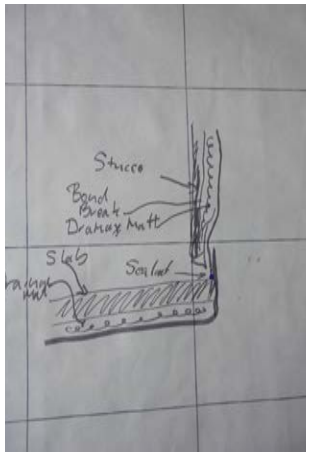
Building Science Corporation Joseph Lstiburek 55

Building Science Corporation Joseph Lstiburek 56


Stucco
Bond Break
Drainage Mat
Slab
Scratch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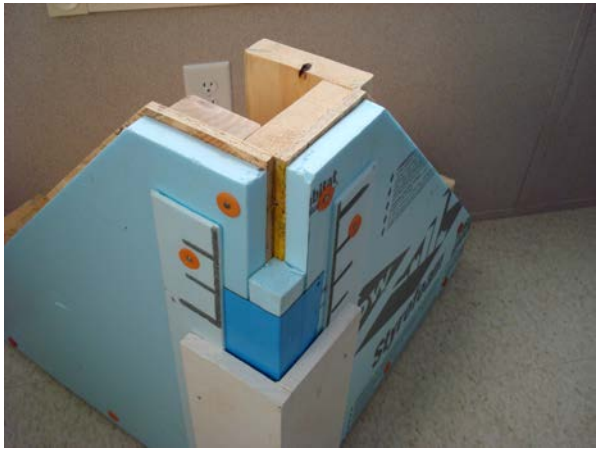


Air Barrier Metrics

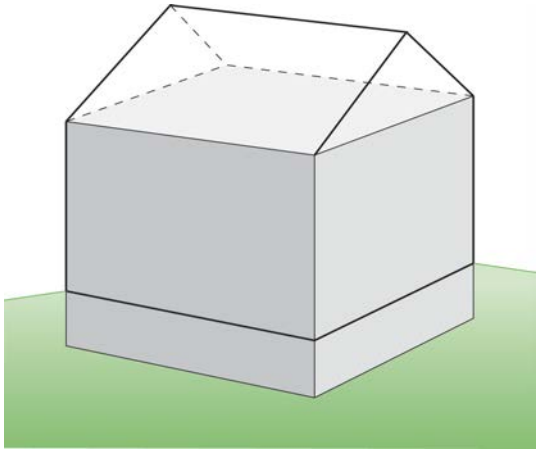
Material	0.02 l/(s-m2) @ 75 Pa
Assembly	0.20 l/(s-m2) @ 75 Pa
Enclosure	2.00 l/(s-m2) @ 75 Pa

Air Barrier Metrics

Material	0.02 l/(s-m2) @ 75 Pa
Assembly	0.20 l/(s-m2) @ 75 Pa
Enclosure	2.00 l/(s-m2) @ 75 Pa
	(3 ach@50 Pa)

Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

As Tight as Possible - with -
Balanced Ventilation
Distribution
Source Control - Spot exhaust ventilation
Filtration
Material selection
Energy Recovery



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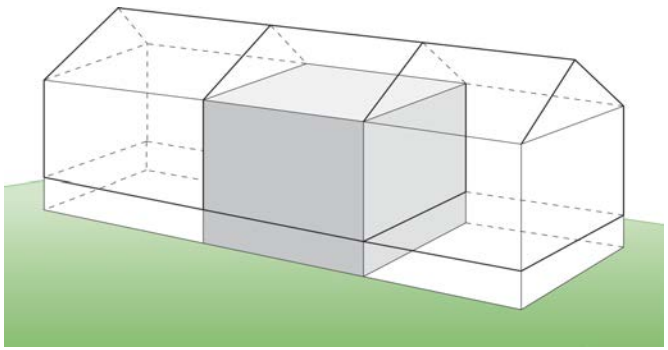

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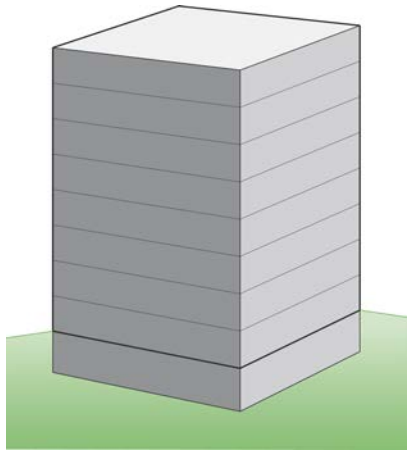

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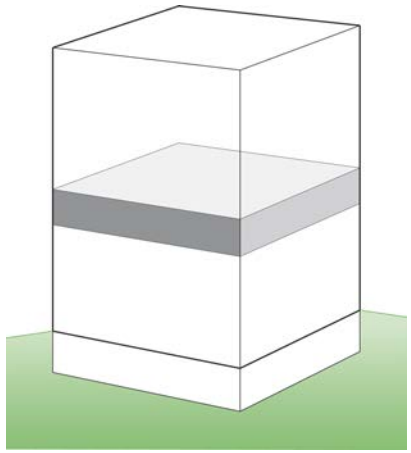

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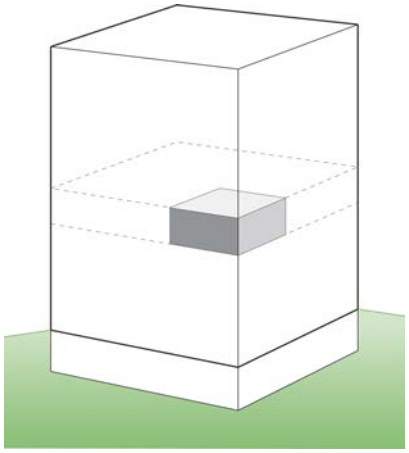

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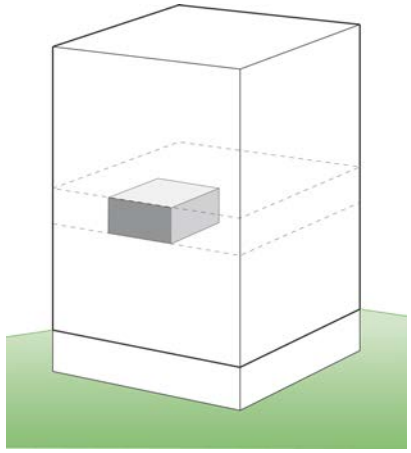

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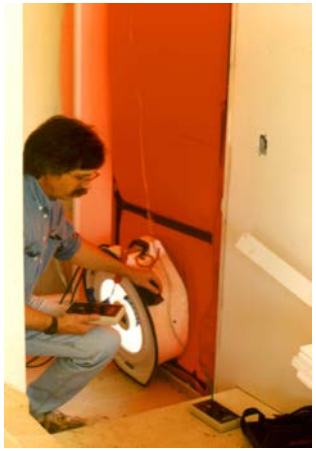

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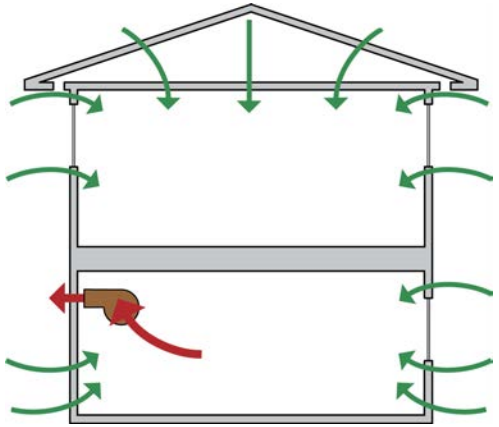

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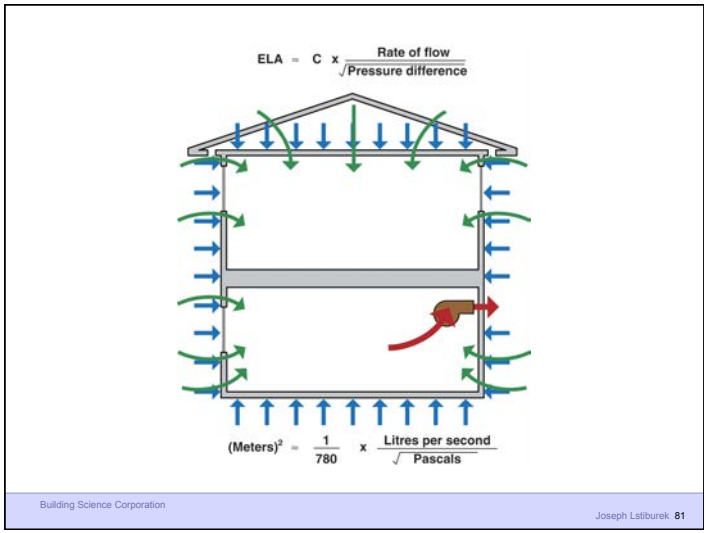

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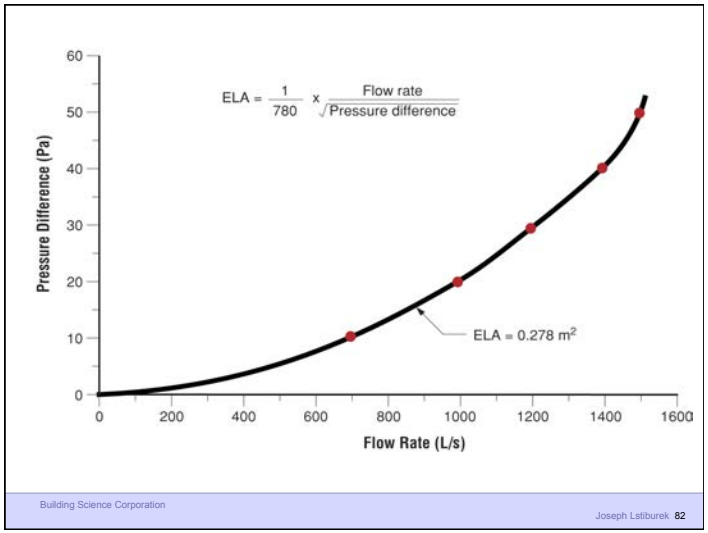

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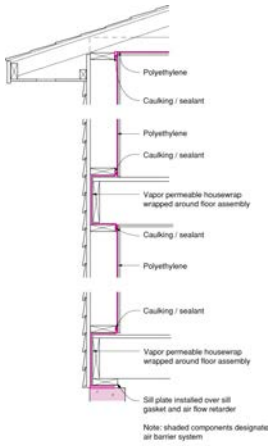

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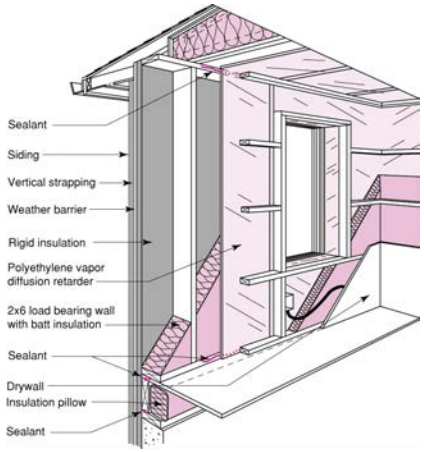

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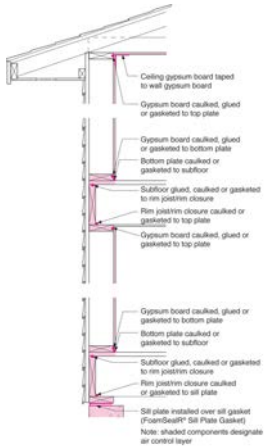

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Thermo
no
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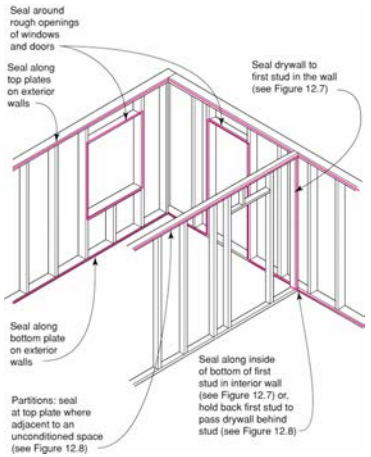
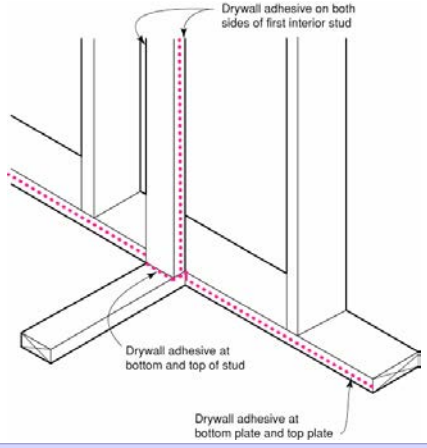
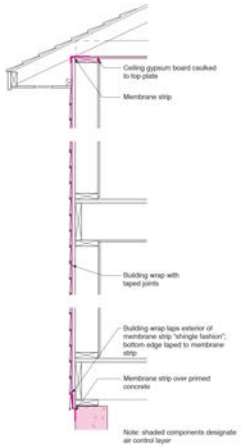

Seal around rough openings of windows and doors
Seal along top plates on exterior walls
Seal drywall to first stud in the wall (see Figure 12.7)
Seal along bottom plate on exterior walls
Seal along inside of bottom of first stud in interior wall (see Figure 12.7) or, hold back first stud to pass drywall behind stud (see Figure 12.8)
Partitions: seal at top plate where adjacent to an unconditioned space (see Figure 12.8)


Drywall adhesive on both sides of first interior stud
Drywall adhesive at bottom and top of stud
Drywall adhesive at bottom plate and top plate


Ceiling gypsum board caulked to top plate
Membrane strip
Building wrap with taped joints
Building wrap laps exterior of membrane strip "shingle fashion"; bottom edge taped to membrane strip
Membrane strip over primed concrete
Note: shaded components designate air control layer

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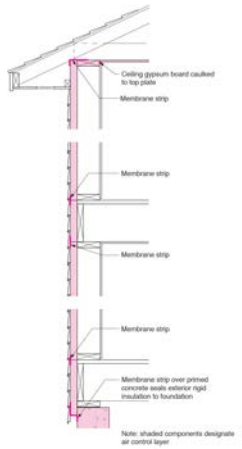

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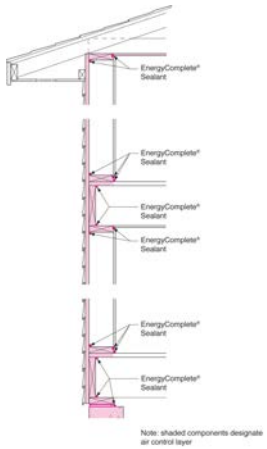
Joseph Lstiburek 95



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Building Science Corporation Joseph Lstiburek 98

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Building Science Corporation Joseph Lstiburek 101

Building Science Corporation Joseph Lstiburek 102

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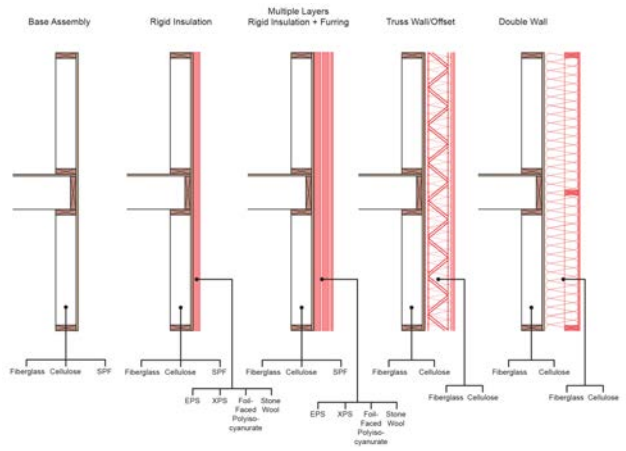
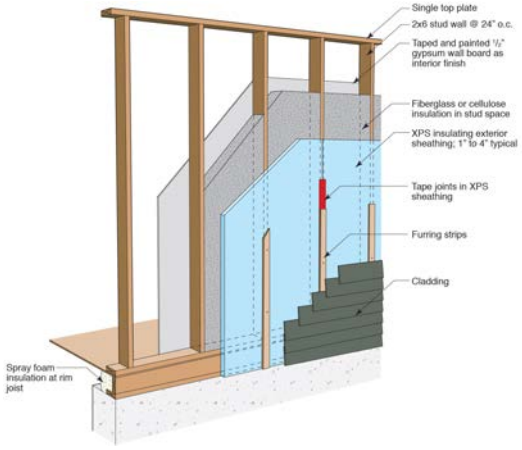
GRACE
Ice & Water Shield
RIPCORD


DOW
TUFF-R


Base Assembly
Rigid Insulation
Multiple Layers
Rigid Insulation + Furring
Truss Wall/Offset
Double Wall
Fiberglass
Cellulose
SPF
EPS
XPS
Foil-Faced Polyiso-cyanurate
Stone Wool



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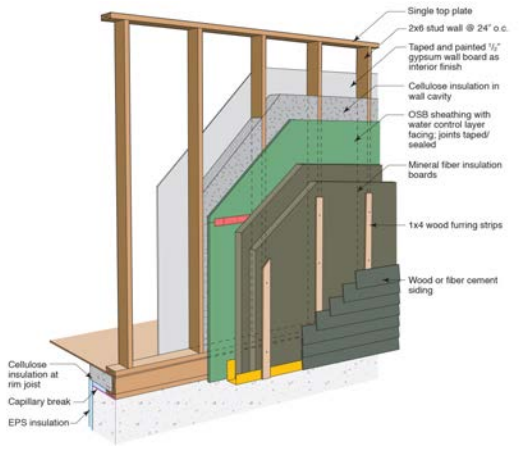

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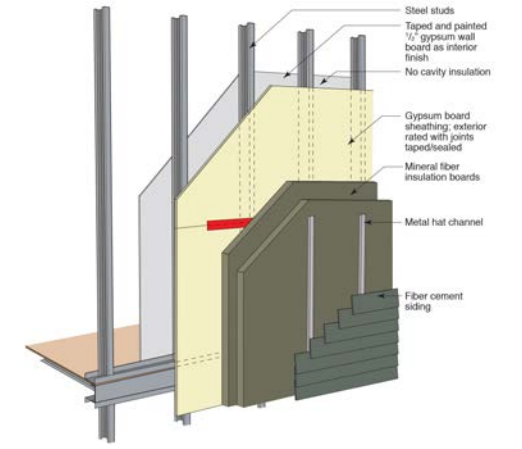

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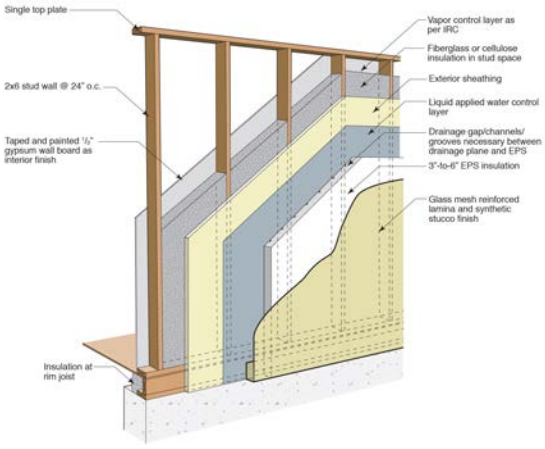

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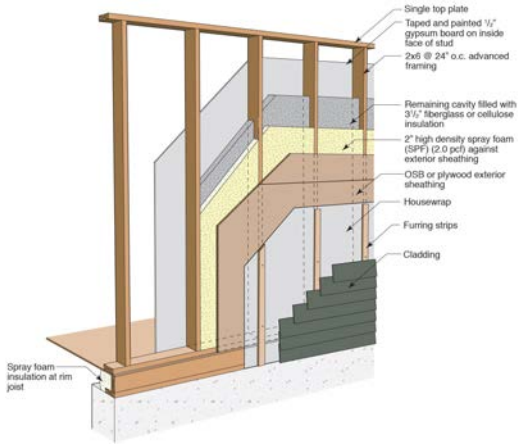

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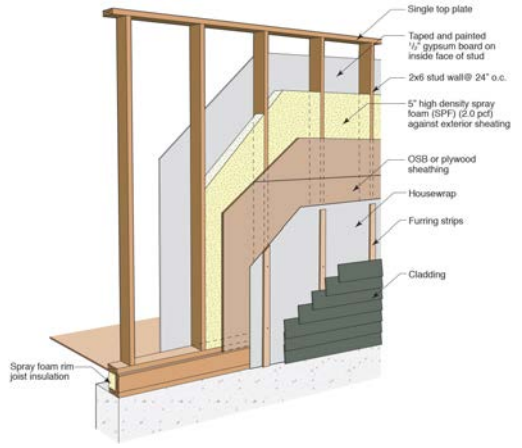

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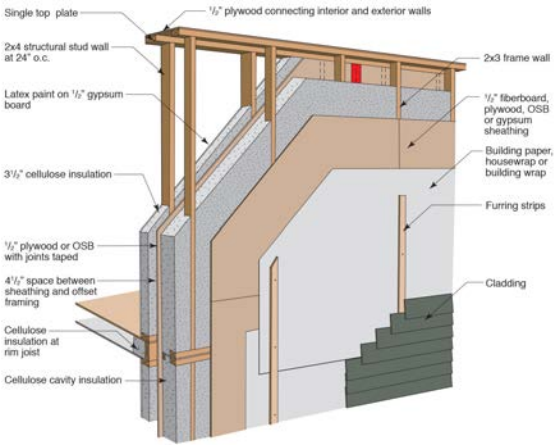

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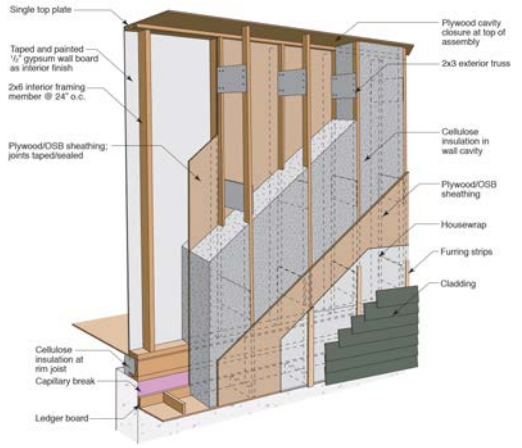

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