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

\[ k = A e^{-E_a/(RT)} \]
Damage Functions
Water
Heat
Ultra-violet Radiation
2nd Law of Thermodynamics
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
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion
Thermodynamic Potential
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Configurations of the Perfect Wall
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 finish

Vapor Profile
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 finish

Vapor Profile
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)

Insulated wood stud cavity

Gypsum board

Latex paint or vapor semi-permeable textured wall finish

Vapor Profile
Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
Diagram of flashing with labels:
- Down
- Flashing
- Upturned leg
- Base sloped to exterior
- Drip edge
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

Entire wind pressure taken here
Baffle to deflect raindrops hitting face of cup due to momentum ("kinetic energy")

Pressure in cup is same as pressure outside on face of baffle

Momentum driving force converted to gravity—water drains away

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

Cup can still drain water to exterior

Entire wind pressure taken here
Outer seal sees water but not pressure; no pressure difference across this seal, therefore no rain entry.

Key seal is interior seal as it takes maximum wind load but it does not see water.

Pressure in chamber is same as pressure outside on face of assembly.

Air enters and pressurizes chamber.

Entire wind pressure taken here.

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

- Flashing tape
- Sealant “bedding” joint
- Building wrap “wrapped” into opening
Wind pressurizes chamber between inner and outer seal.
Inner, protected seal

Outer, exposed seal

Drain and vent opening
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)
Leaky air handling unit and supply ducts

Air handling unit

Supply

Return

Supply

Depressurized conditioned space inducing infiltration

Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.
Note: Colored shading depicts the building's thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.
Shingles

Roofing paper

Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered

Nail base for shingles (plywood or OSB) screwed through rigid insulation to wood decking or timber rafters

Air barrier membrane

Wood decking

Timber rafter or exposed joist
Minimum R-50 rigid insulation in two or more layers with horizontal and vertical joints staggered.

- Roof sheathing
- Roofing membrane
- Vented space

- Roof sheathing
- Roofing paper
- Shingles

- Air barrier membrane
- Wood decking
- Timber rafter or exposed joist
Roofing tile

Roofing paper

Netted cellulose insulation or batt insulation installed with wire stays or twine

Roof sheathing

Underside of roof sheathing is typically the “first” condensing surface

Stucco

Rigid insulation

Building paper drainage plane

Unfaced batt insulation

Gypsum board with vapor semi-permeable (latex) paint
In the diagram:

- **Metal cap**
- **18" wide membrane strip under parapet folded down over exterior OSB**
- **Coping wedge**
- **OSB**
- **Rubber roofing membrane**

**OSB sheathing**

**Scupper**

**Two layers OSB**

**High density spray foam insulation**

**Polymer modified (PM) or traditional cement stucco**

**Metal lath**

**Building paper bond break over drainage plane**

**Gypsum board with semi-permeable (latex) paint**

**Cavity insulation**

**Sealant, adhesive or gasket at top plate**

**Caulking or sealant**

**Cavity insulation**

**1/4" cant/ft**
Low density spray foam insulation

Asphalt shingles

Roofing paper

Roof sheathing

Raised heel truss

Rigid foam, or comparable, as backdamp

Soffit

Roof underlayment sealed to drip edge

Gypsum board with latex paint (acts as thermal barrier separating occupiable space from non-occupiable space)
Ballast (rock, pavers, earth)

Filter fabric

Extruded polystyrene insulation

Sloped concrete topping; slope minimum 2% to drains

Concrete structural deck

Drainage gap, i.e., drainage mat or grooved insulation

Fully-adhered roof membrane
Really Heavy Pink Stuff

Liquid Waterproofing over Concrete Deck
Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation (aka spray polyurethane foam)
Roof Sheathing

Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)

Shingles

Roofing paper

Roof Sheathing

Rigid Insulation

Air control layer (air barrier)
Shingles

Roofing paper

Roof Sheathing

Air impermeable insulation (aka spray polyurethane foam)

Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)
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<th>Climate Zone</th>
<th>Rigid Board or Air Impermeable Insulation</th>
<th>Total Cavity Insulation</th>
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*Adapted from Table R 702.1 2015 International Residential Code*
Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass)
Air permeable insulation (fiberglass batts, netted blown cellulose, netted blown fiberglass, spray applied fiberglass, stone wool / mineral wool batts)

Air impermeable insulation ("closed cell" spray polyurethane foam)

Gypsum board
<table>
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<tr>
<th>Climate Zone</th>
<th>Rigid Board Insulation</th>
<th>Code Required R-Value</th>
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*Adapted from Table R 806.5 2015 International Residential Code

Table 1