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

Wall

Roof

Ballast
Filter fabric
Control layers
Roof structure

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Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
Brick veneer/stone veneer
Drained cavity
Drainage plane
Non paper-faced exterior sheathing, plywood or OSB
Spray foam insulation
Gypsum board
Latex paint or vapor semi-permeable textured wall finish
Rockwool

1x3 furring @ 24” o.c.
#10 screws @ 16” o.c. vertically
Result: 20 psf cladding weight
with < 2/100” deflection
Second layer of z-bars should be installed perpendicular to the first layer; orientation of the two layers will depend on the requirements of the cladding attachment system.

First layer of z-bars embedded in the insulation layer should be installed horizontally, the exterior leg should be turned down to promote drainage to the exterior.
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Joseph Lstiburek  99

Environmental Separation

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50 of 59
“The Ugly”

“The Bad”

“The Good”
As per structural e.g. 36” to 48” (900 to 1200 mm) o.c.

- Weld
- Cast-in plate
- Concrete slab
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Adventures In Building Science

2nd Law of Thermodynamics
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Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion
Thermodynamic Potential
Damage Functions

Water
Heat
Ultra Violet Radiation
Damage Functions
Water
Heat
Ultra Violet Radiation
Oxidization (Ozone)
Fatigue (Creep)

The Three Biggest Problems In Buildings Are Water, Water and Water…
80 Percent of all Construction Problems are Related to Water

Heat
Air
Moisture
HAM

Hygrothermal Analysis
Solar radiation

Rain

Heat exchange with outdoors

Vapor exchange with outdoors

Heat exchange with indoors

Vapor exchange with indoors

Outside

Inside

70°F

0°F

Dewpoint (50% RH, 70°F)

Location of condensation and frost

Exterior sheathing
Simple linearized energy-temperature relation for water
From Straube & Burnett, 2005
The inside face of the insulating sheathing is the condensing surface of interest.

**Figure 8-1.** Outside vapour pressure, saturated vapour pressure and inside vapour pressure for Winnipeg.
Heat, Air and Moisture Movement

Cross section [cm]

Outside

Roof sheathing

Condensation and frost accumulating on underside of roof sheathing

Attic

Attic insulation

Inside

Dewpoint
Wood-based subfloor

Gypsum board

Rigid insulation

Cavity insulation
Note: Colored shading depicts the building’s thermal barrier and pressure boundary. The thermal barrier and pressure boundary enclose the conditioned space.
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Heat, Air and Moisture Movement

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Wood or fiber cement siding
Furring or spacer strip
Building paper, housewrap or building wrap (PinkWrap® Housewrap)
Plywood or OSB sheathing
EcoTouch® Pink® Fiberglass Insulation in cavity
Gypsum board
Latex paint

Vapor Floe-Through Assembly
Don’t Do Stupid Things
Calculating capillary rise

\[ h = \frac{2 \sigma \cos \theta}{g \rho f} \]

\[ P_{\text{cap}} = \frac{2 \sigma \cos \theta}{r} \]

\[ P_0 \]

ambient pressure

\[ \Delta z \]

\[ g \rho \Delta z \]

pressure
Capillary rise versus diameter

Capillary Flow

Siding laps
Vapor semi-permeable assembly allows moisture to pass in a slow, controlled manner.

- Plywood subfloor
- Top-side epoxy coating
- Extruded polyethylene; unfaced, no polyethylene or foil facing
- 1x4 "nailing (16" o.c.)
- Concrete slab
Capillary Moisture Flow
Capillary break under framing (polyethylene strip)

Latex paint (vapor permeable, but water repellent)

Polyethylene “skirt” attached to form; remains in place after form is removed

Capillary break (plastic/polyethylene ground cover) extending under grade beam and upwards to grade
Rain enters cup due to momentum ("kinetic energy")

Cup drains water to exterior
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
Rain Screen
Beer Screen?
Don’t Do Stupid Things