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
Order of Magnitude

1 to 10
10 to 100
100 to 1000
1000 to 10000
First Order Effects, Second Order Effects….
Arrhenius Equation

For Every 10 Degree K Rise
Activation Energy Doubles

\[ k = A e^{-\frac{E_a}{RT}} \]
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

Laws of Thermodynamics
Zeroth Law – $A = B$ and $B = C$ therefore $A = C$
First Law - Conservation of Energy
Second Law - Entropy
Third Law – Absolute Zero

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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
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
### Moisture Transport in Porous Media

<table>
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<tr>
<th>Phase</th>
<th>Transport Process</th>
<th>Driving Potential</th>
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<tbody>
<tr>
<td>Vapor</td>
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### Moisture Transport in Assemblies

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<tr>
<td></td>
<td>Momentum</td>
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Vapor Pressure and Relative Humidity
Sorption Isotherms

Change in the storage of moisture in a porous building material as the partial pressure of water vapor in the ambient air increases from zero to full saturation value at a given temperature.

Sorption Curve

Average sorption isotherm for wood as a function of temperature
From Strube & Burnet, 2005
Quick Aside - Vented Attics
Heat
Air
Moisture
HAM

Hygrothermal Analysis
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer
Perfect Wall

Cladding

Control layers

Structure
Configurations of the Perfect Wall
Commercial Enclosure: Simple Layers

- Structure
- Rain/Air/Vapor
- Insulation
- Finish
Building Science Corporation

Joseph Lstiburek – Rain Control

RCI Western Chapter
Fundamentals
June 2, 2016

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60 of 85
Rain Screen
Beer Screen?
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-ties 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-ties embedded in the insulation layer should be oriented vertically. The exterior leg should be turned down to promote drainage to the exterior.