

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

Building Science

Adventures In Building Science

www.buildingscience.com

Arrhenius Equation

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For Every 10 Degree K Rise
Activation Energy Doubles

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

Damage Functions

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...

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80 Percent of all Construction Problems are Related to Water

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Laws of Thermodynamics

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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

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

Rudolf Clausius

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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

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

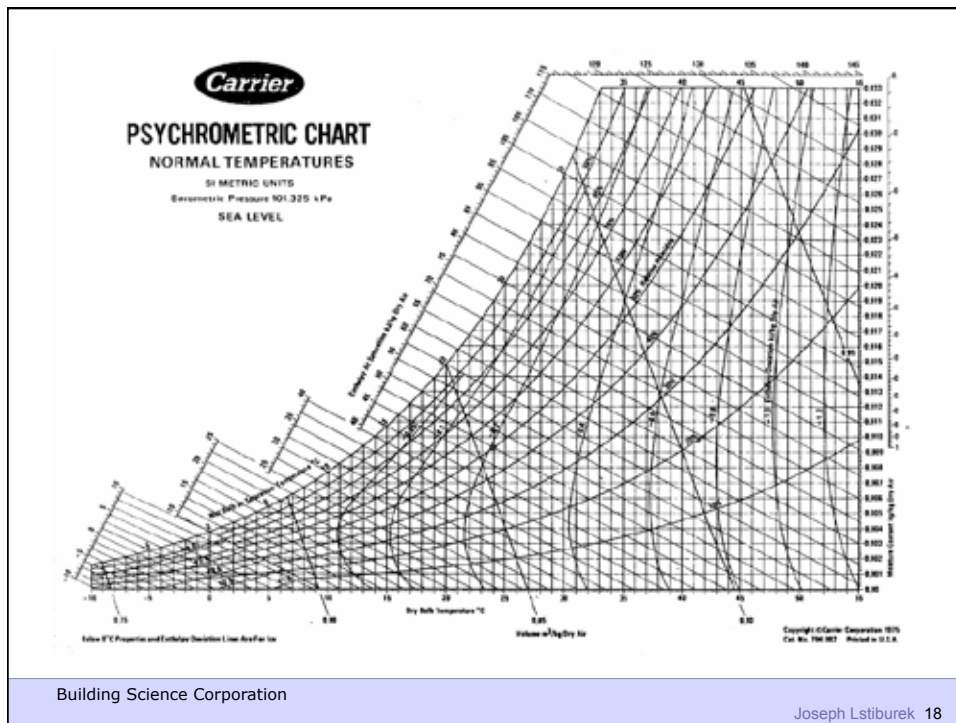
Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion

Thermodynamic Potential

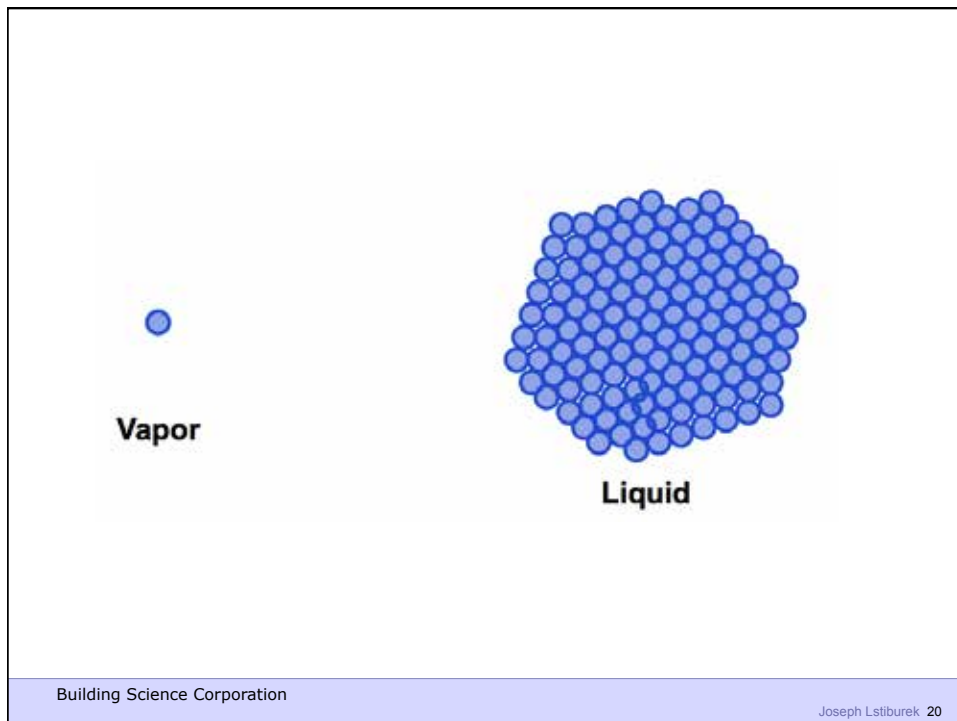
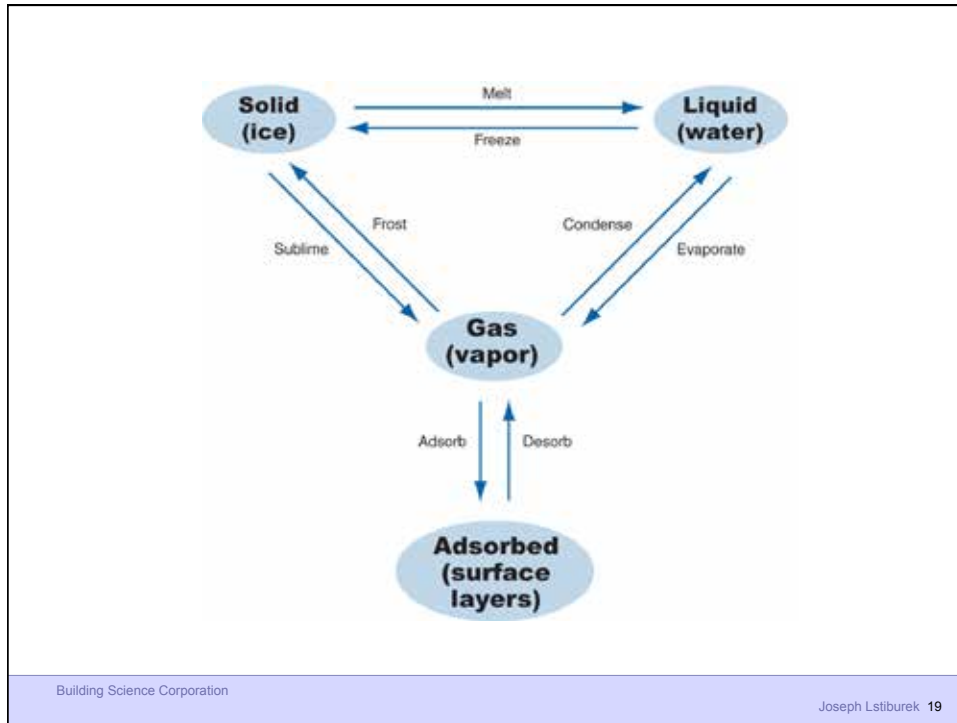
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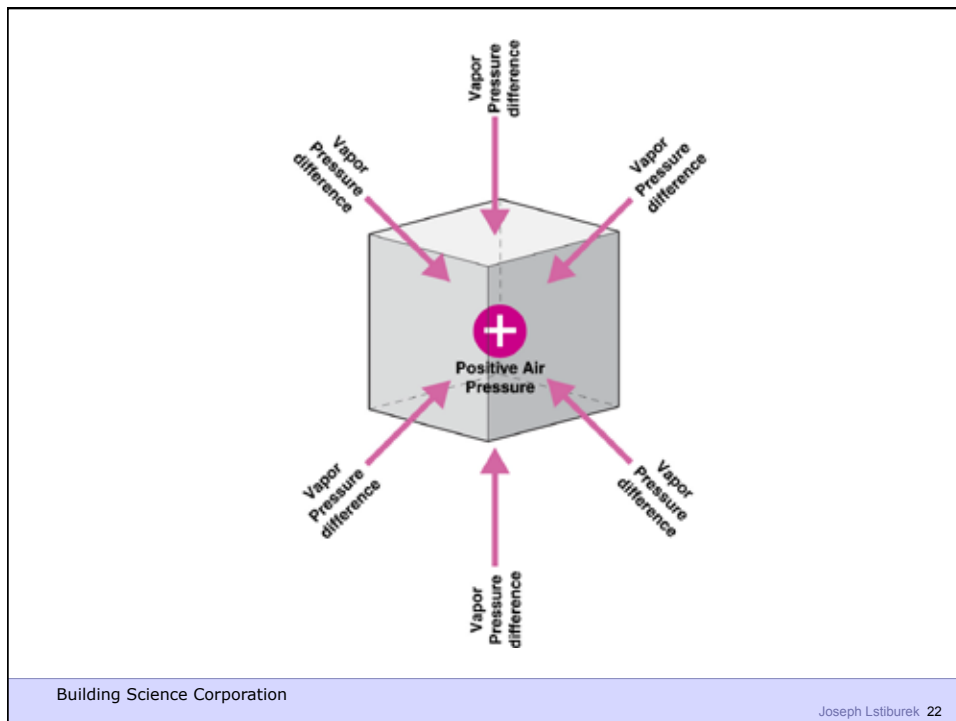
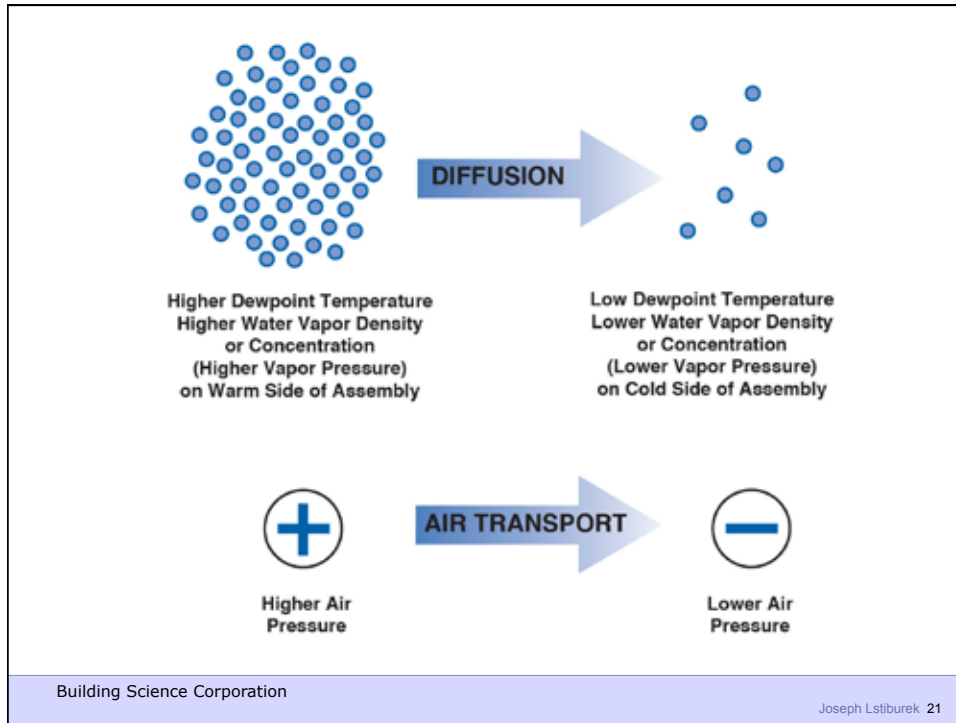
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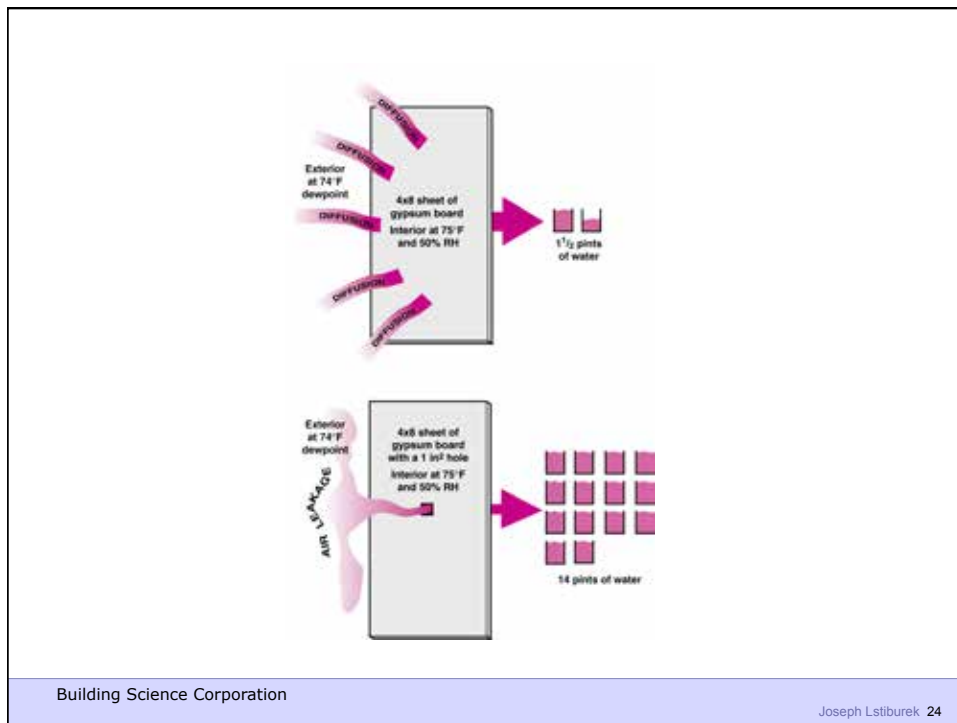
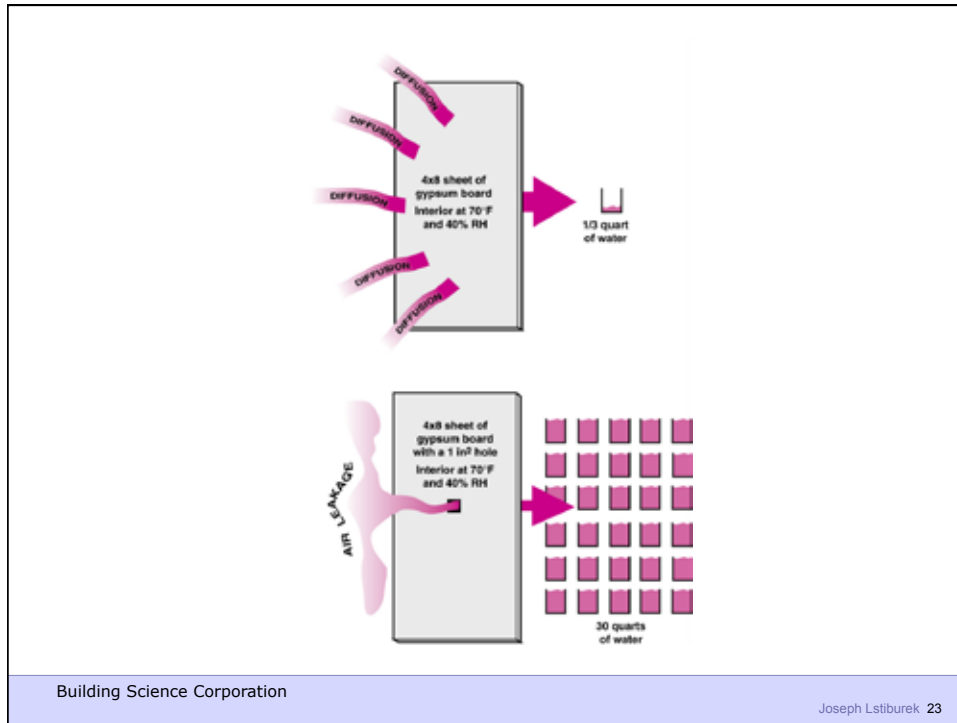


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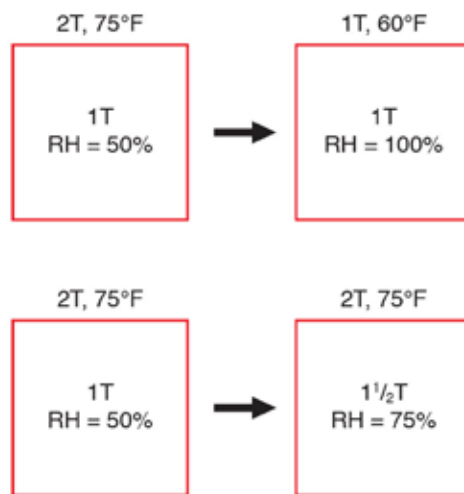




Vapor Pressure and Relative Humidity

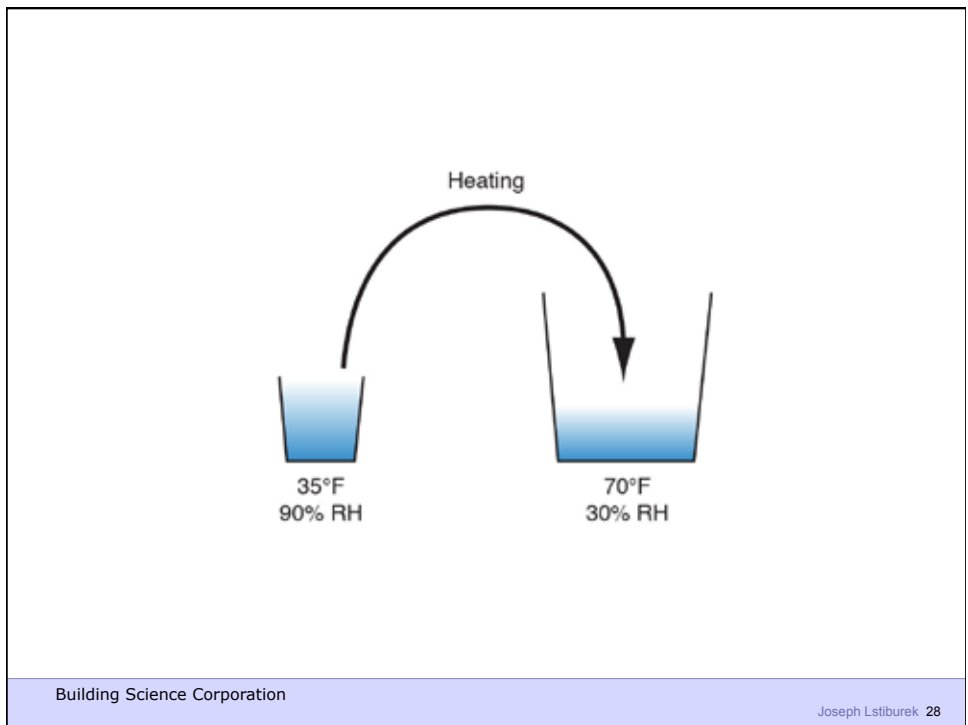
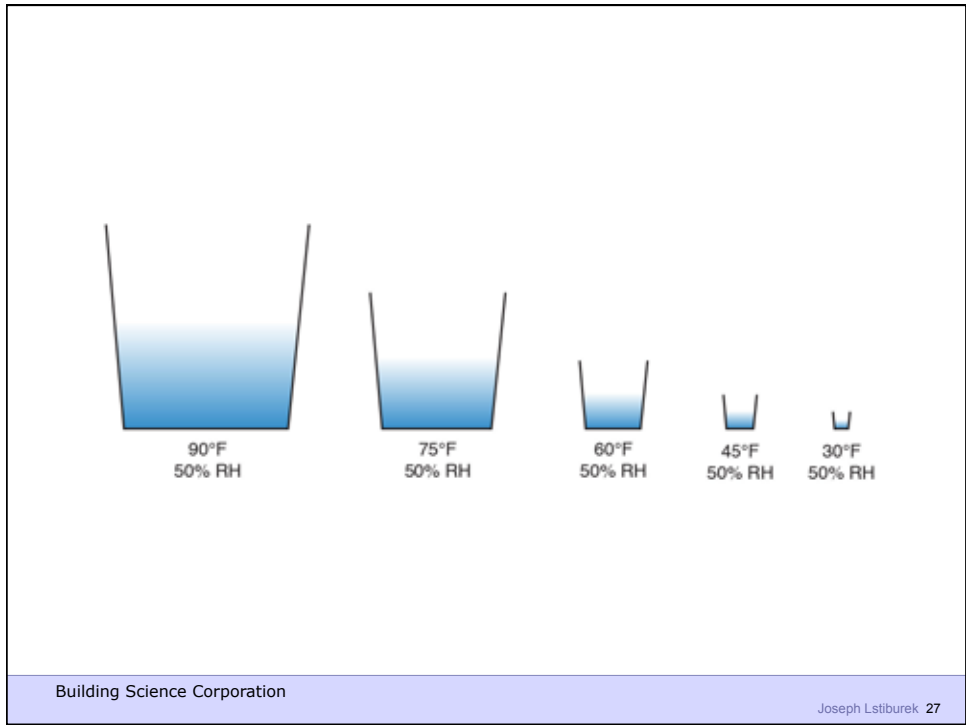
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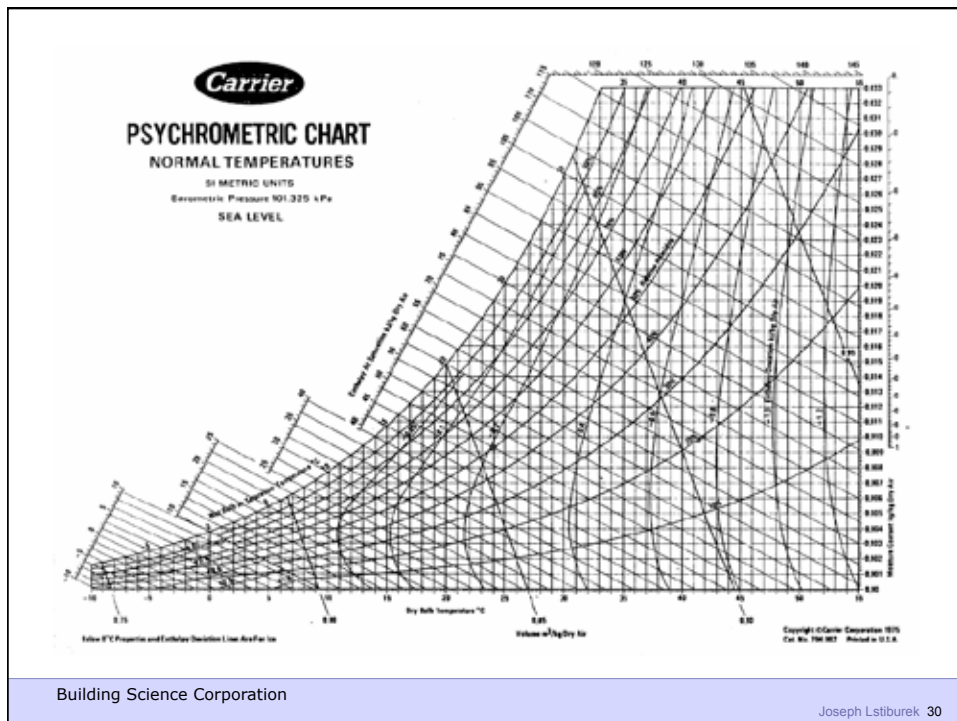
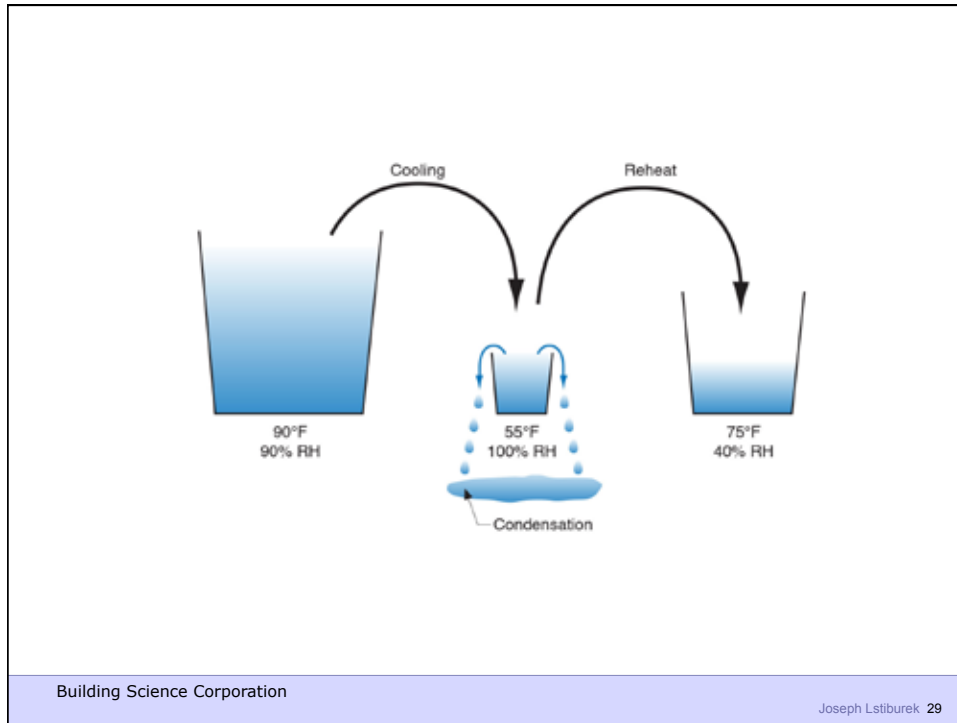
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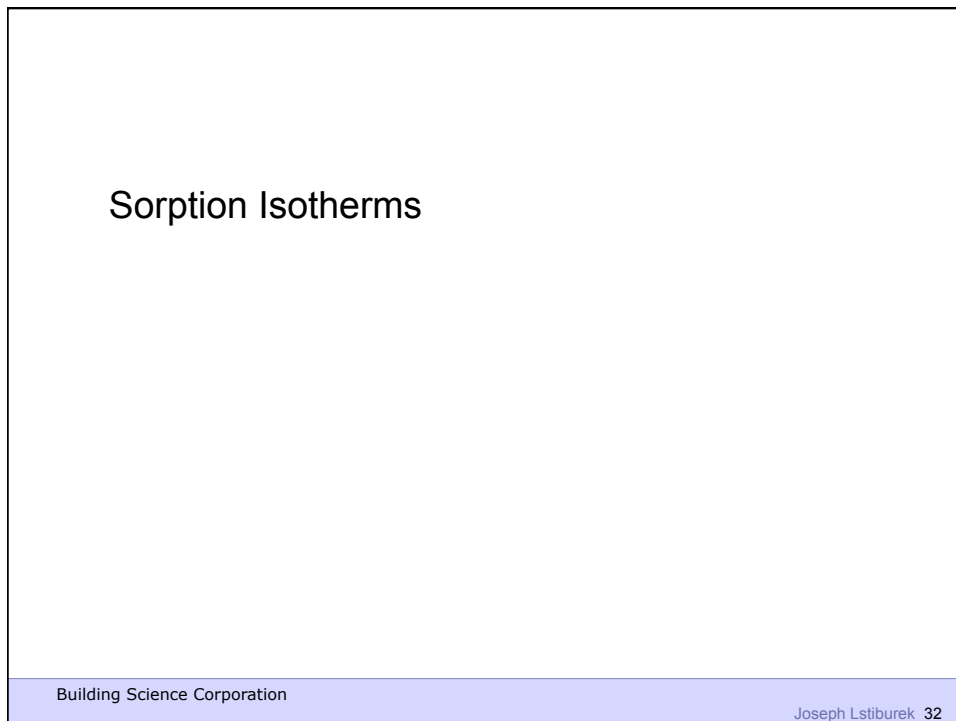
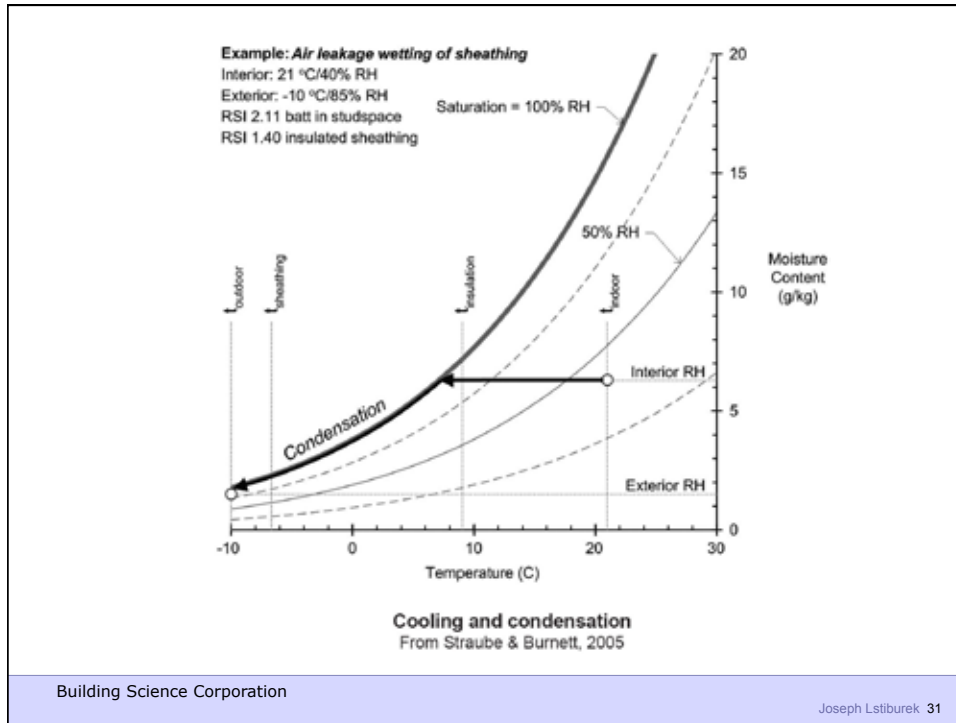


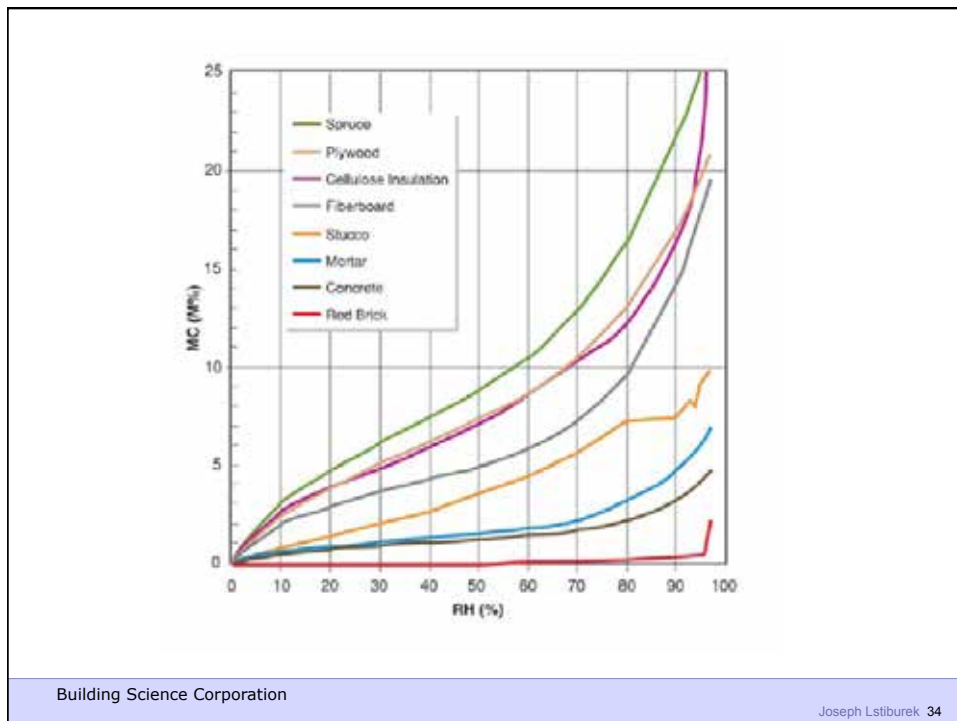
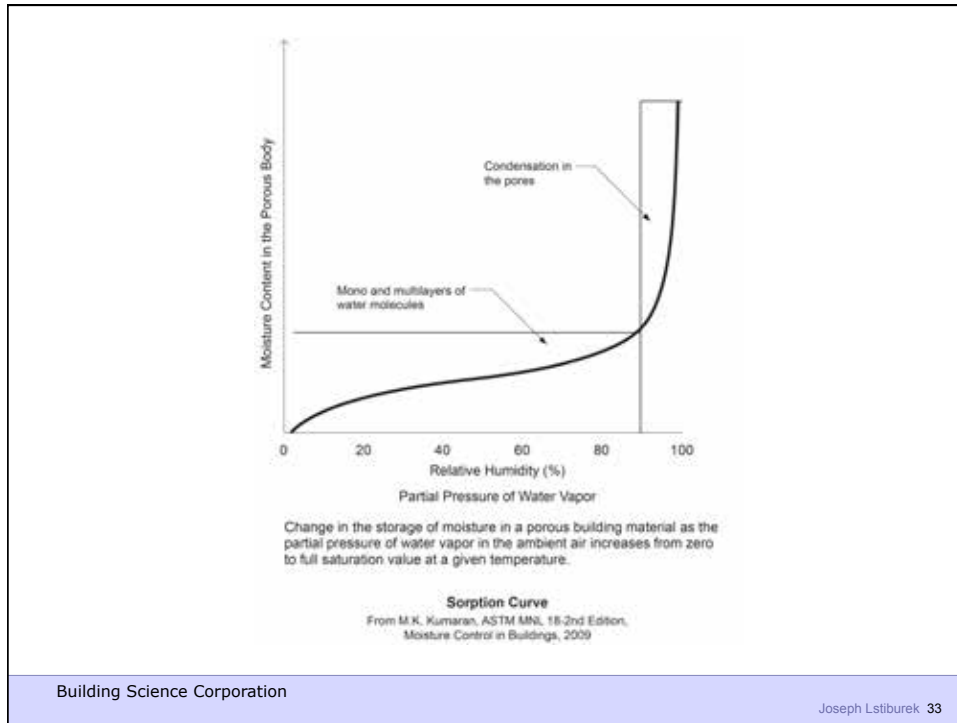
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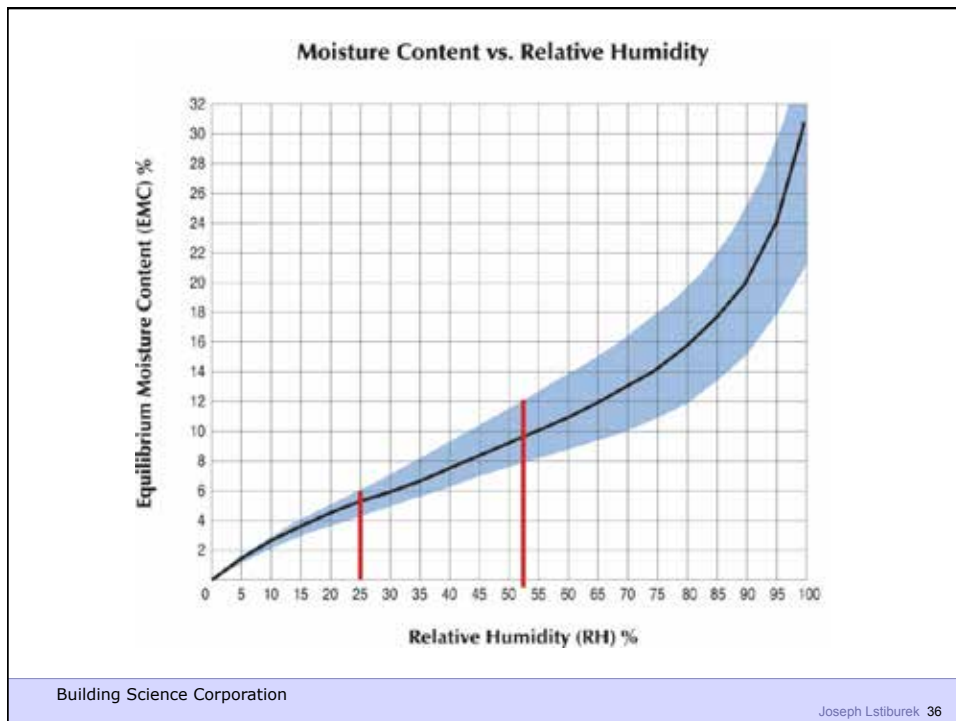
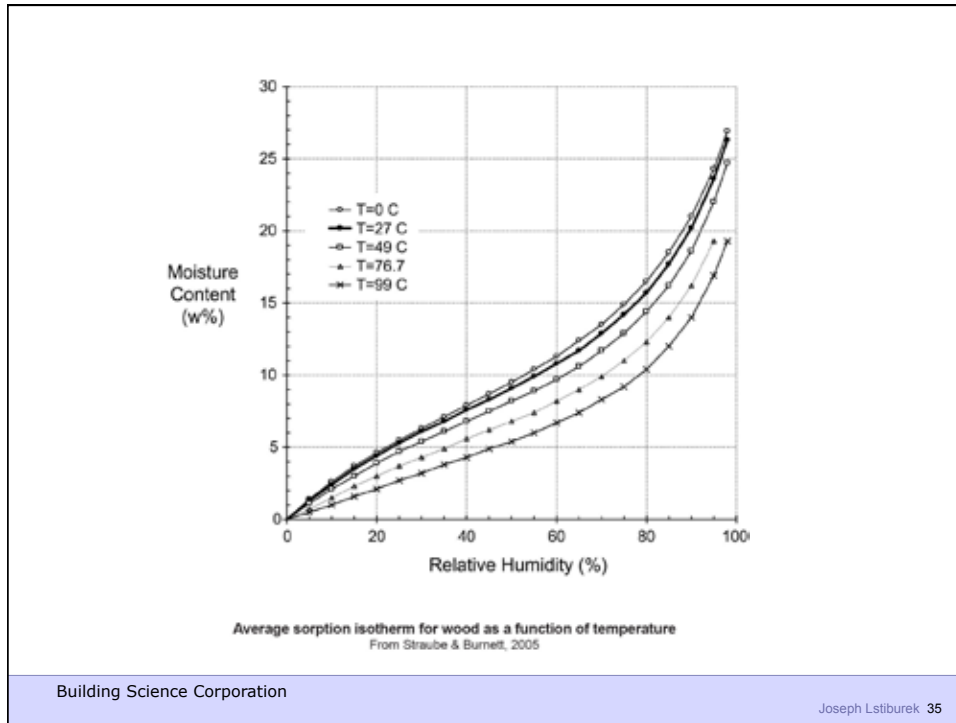
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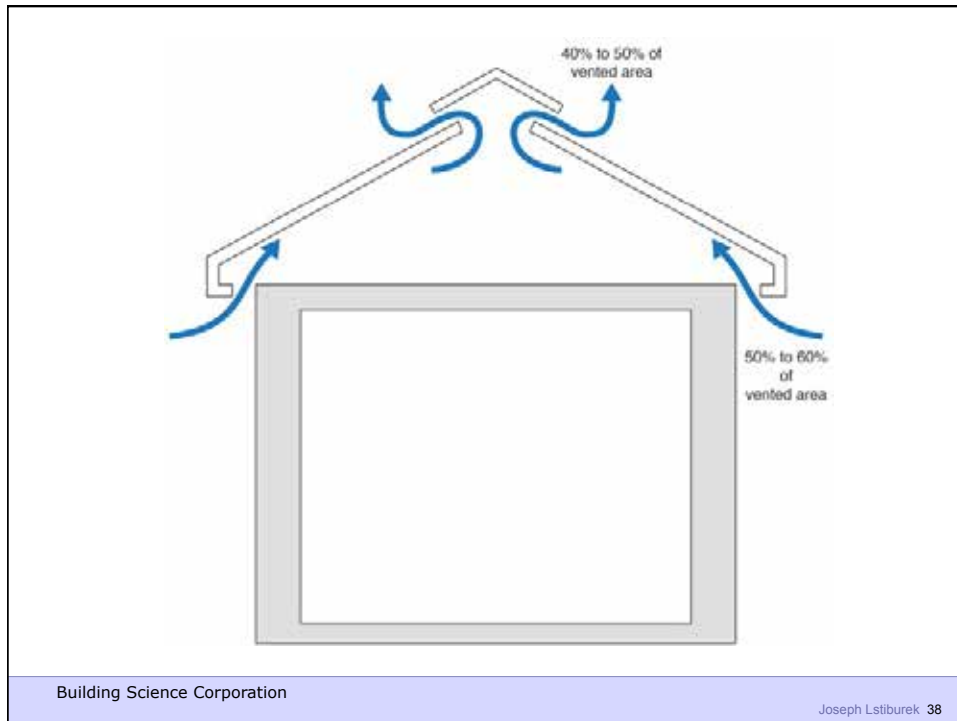


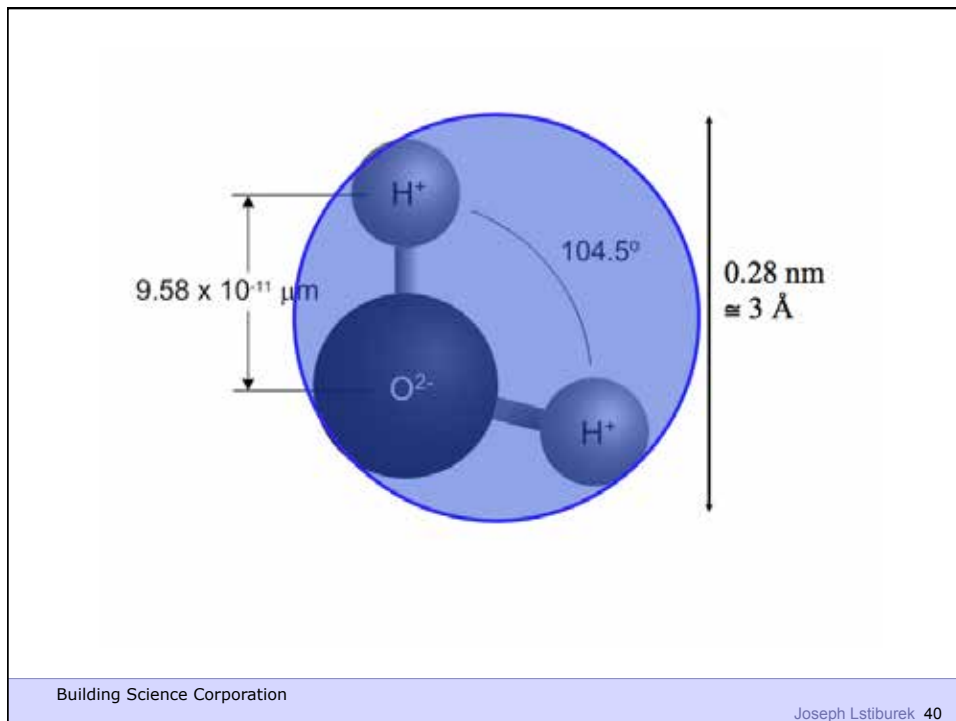
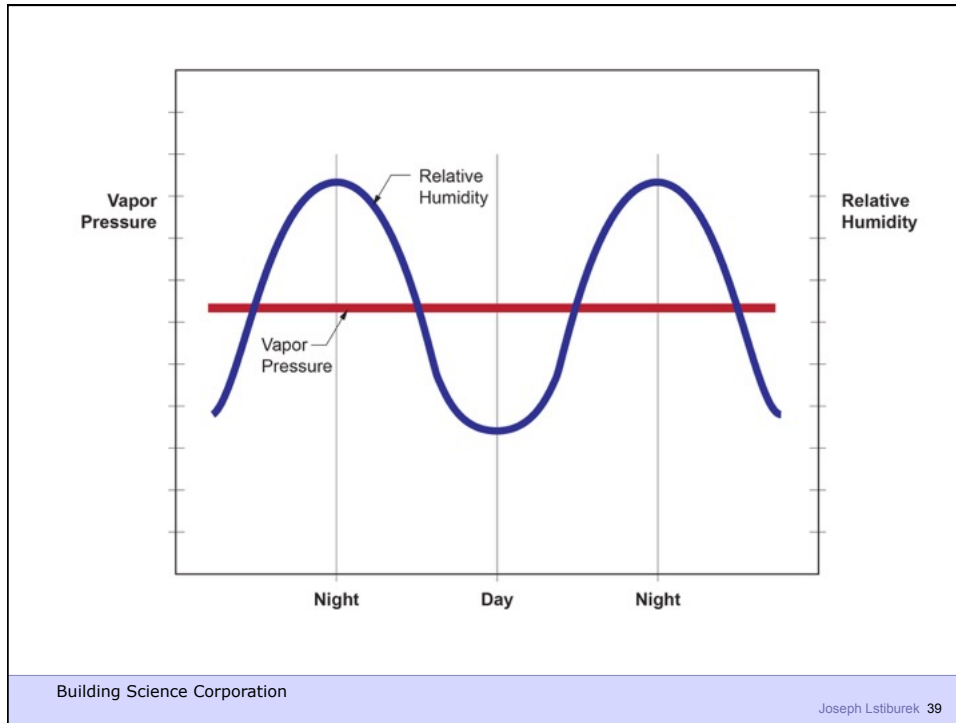


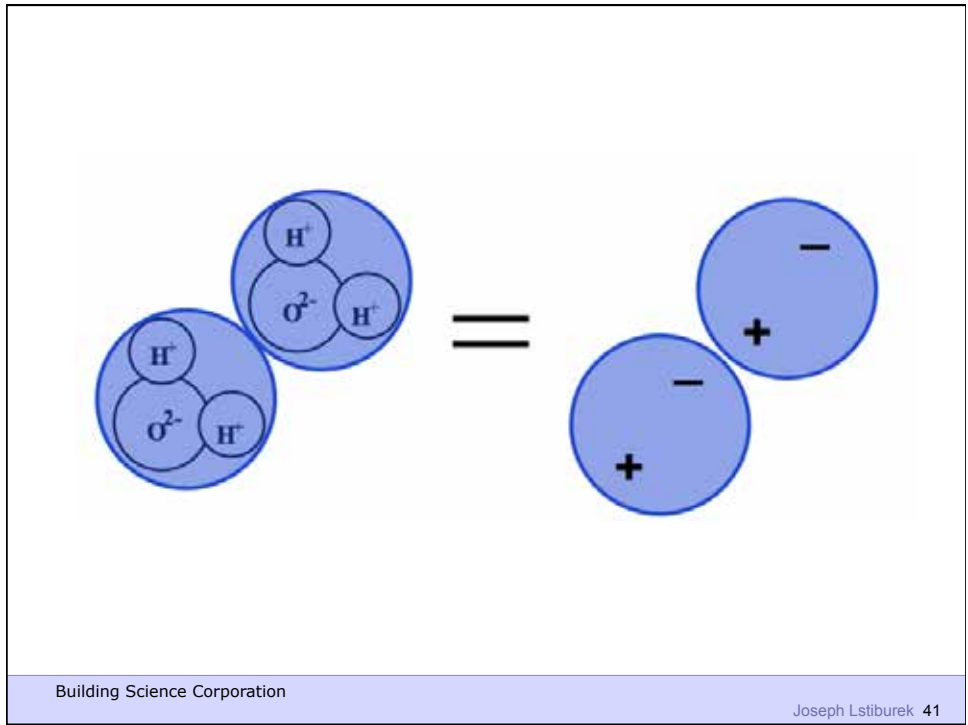
Quick Aside - Vented Attics

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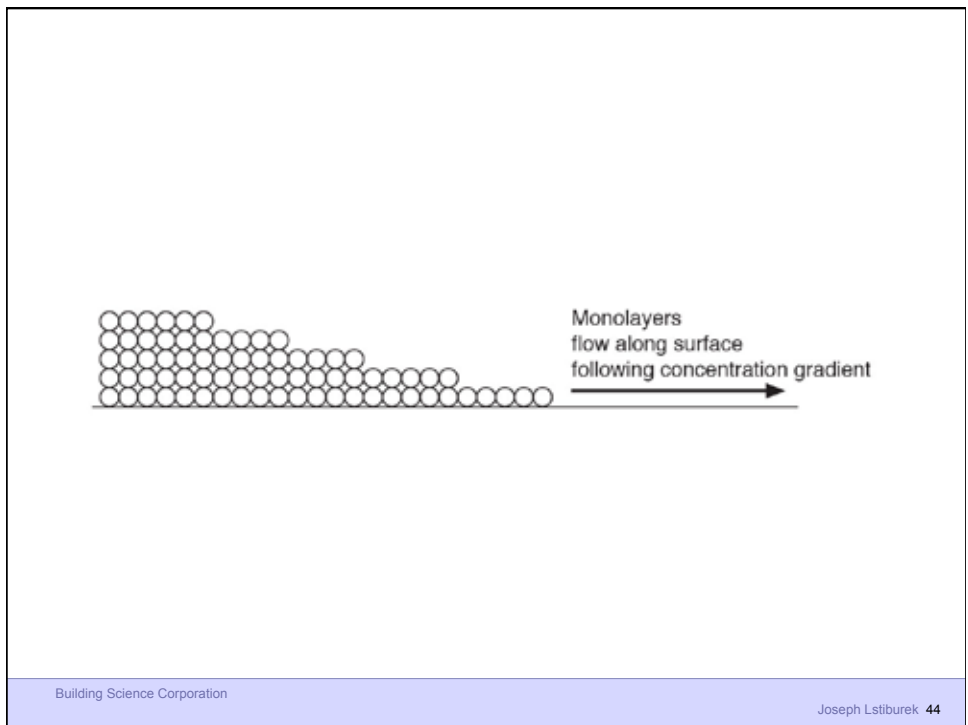
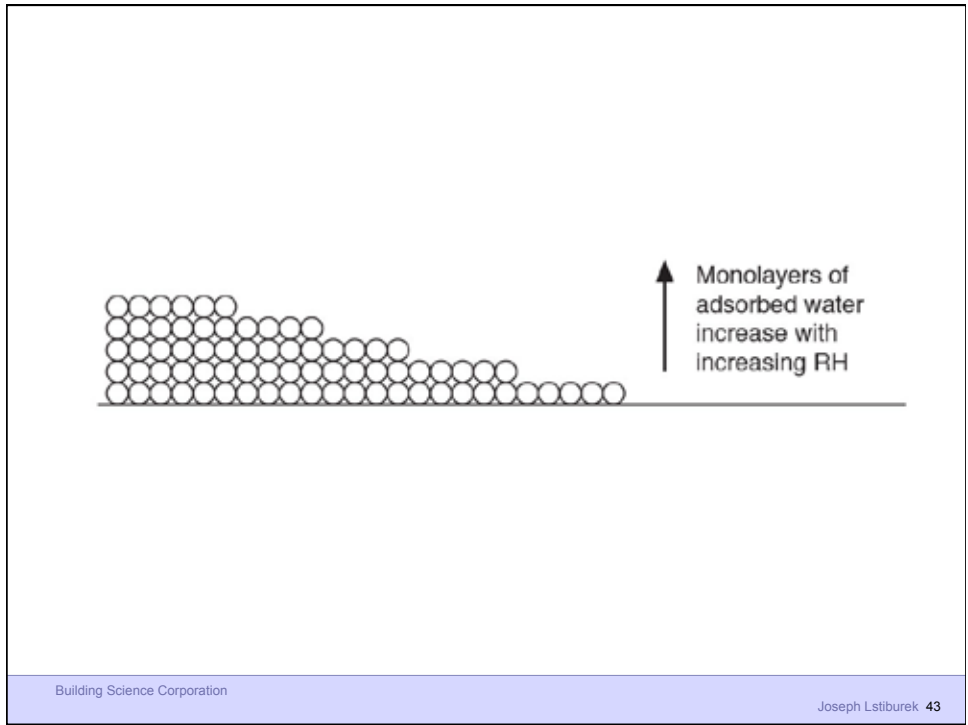


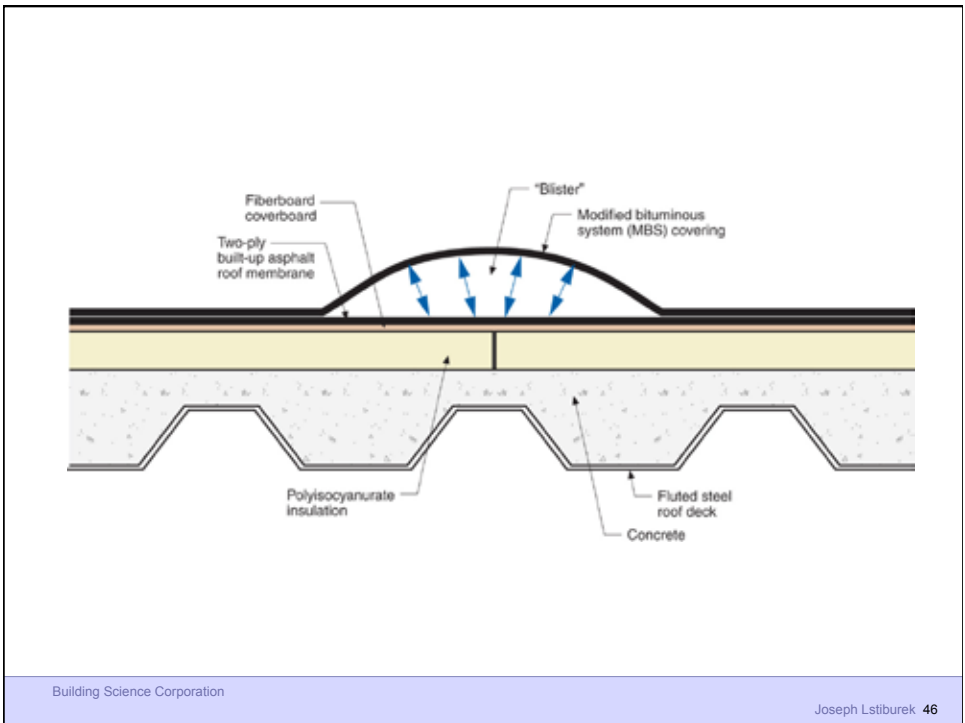


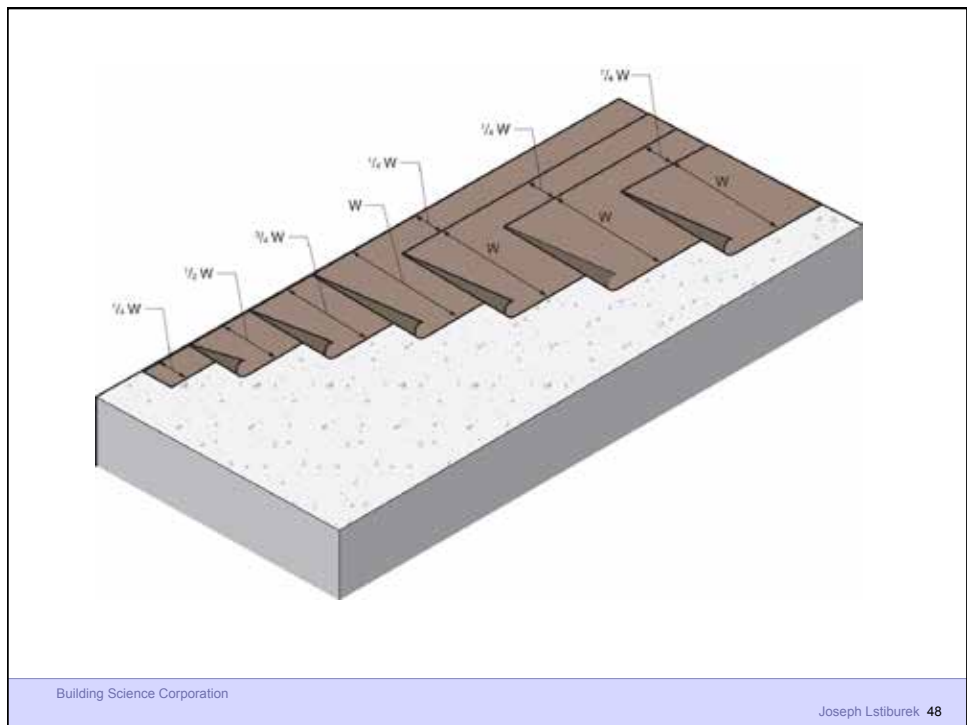
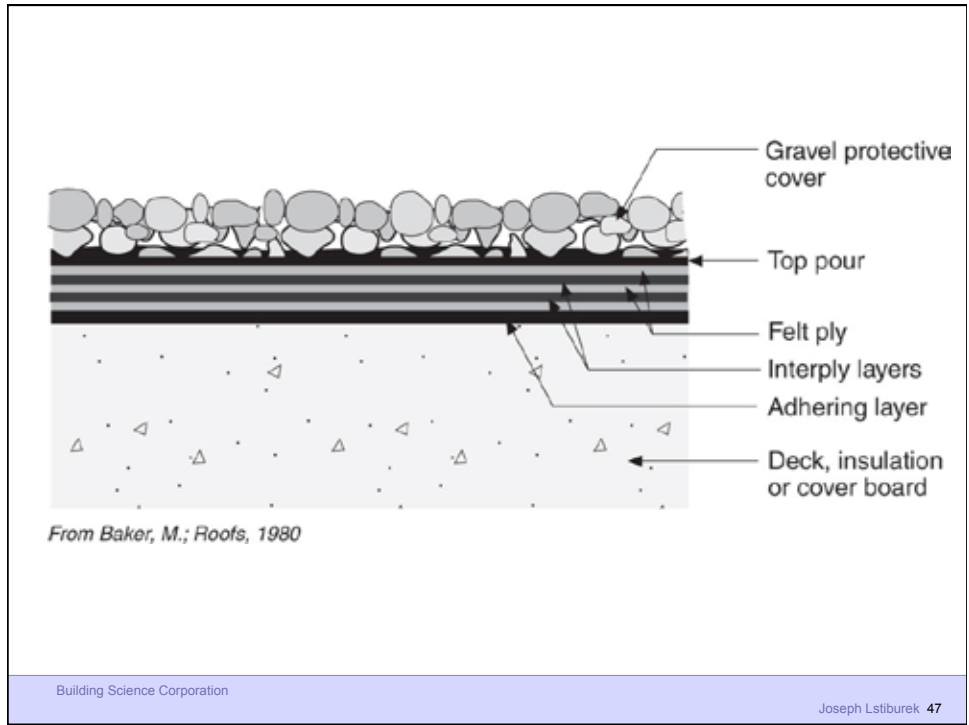
Vapor	Diffusion Convective Flow	Vapor Concentration Air Pressure
Adsorbate	Surface Diffusion	Concentration

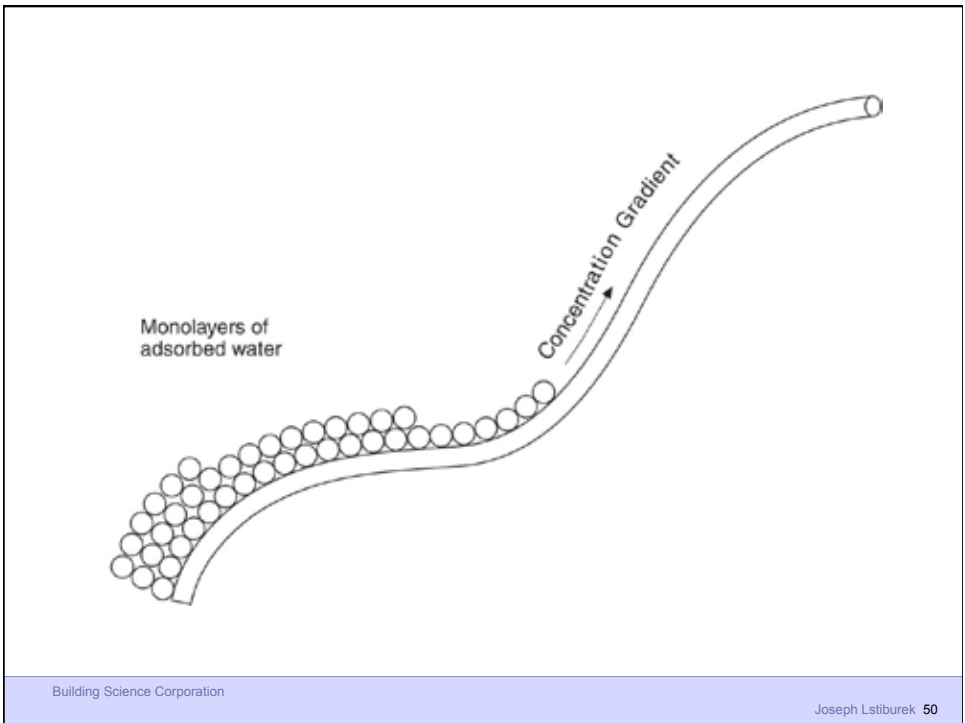
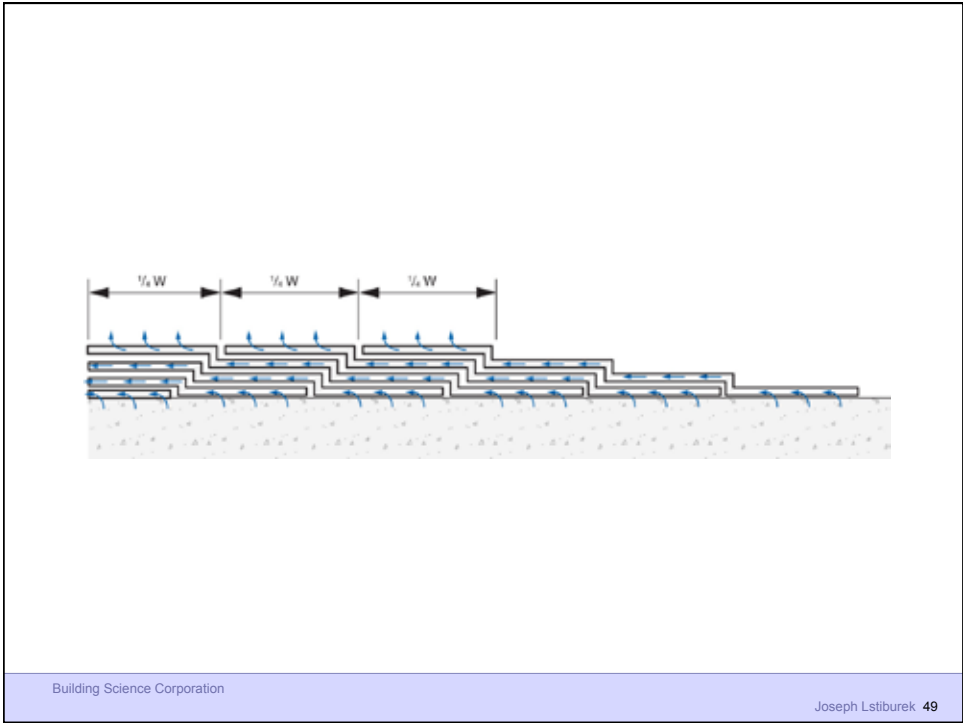
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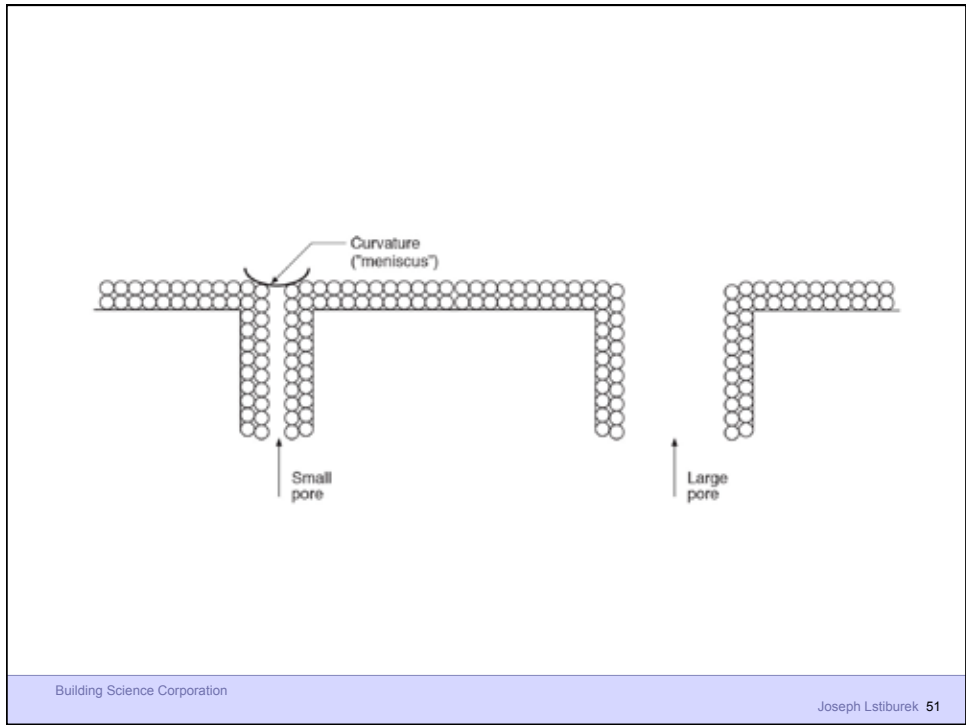
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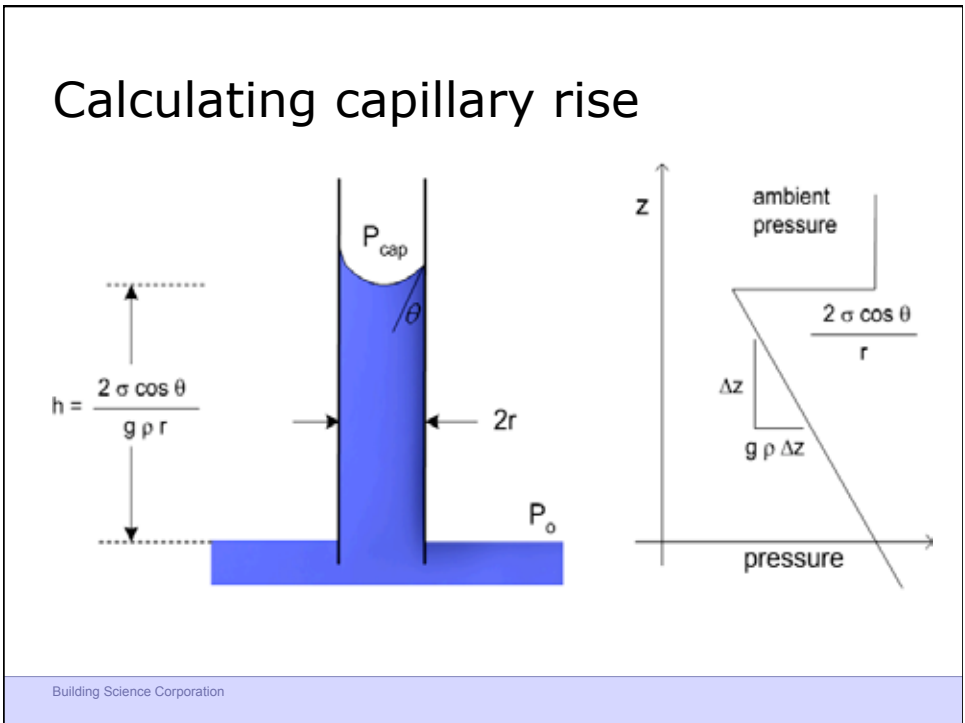




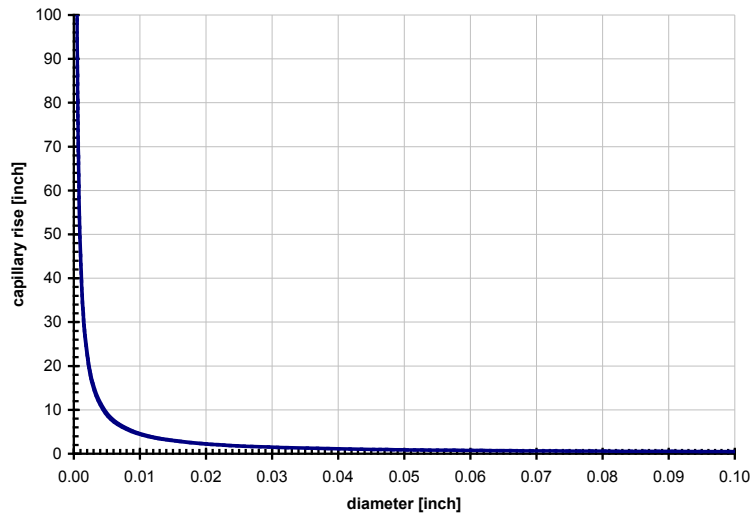


Vapor	Diffusion Convective Flow	Vapor Concentration Air Pressure
Adsorbate	Surface Diffusion	Concentration
Liquid	Capillary Flow	Suction Pressure

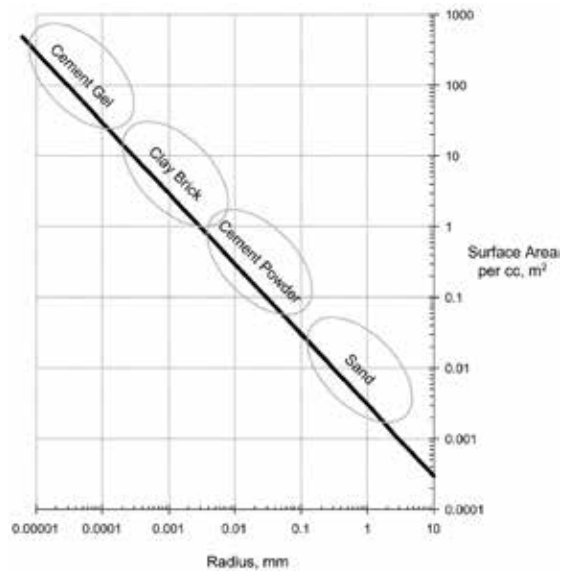
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Capillary rise versus diameter



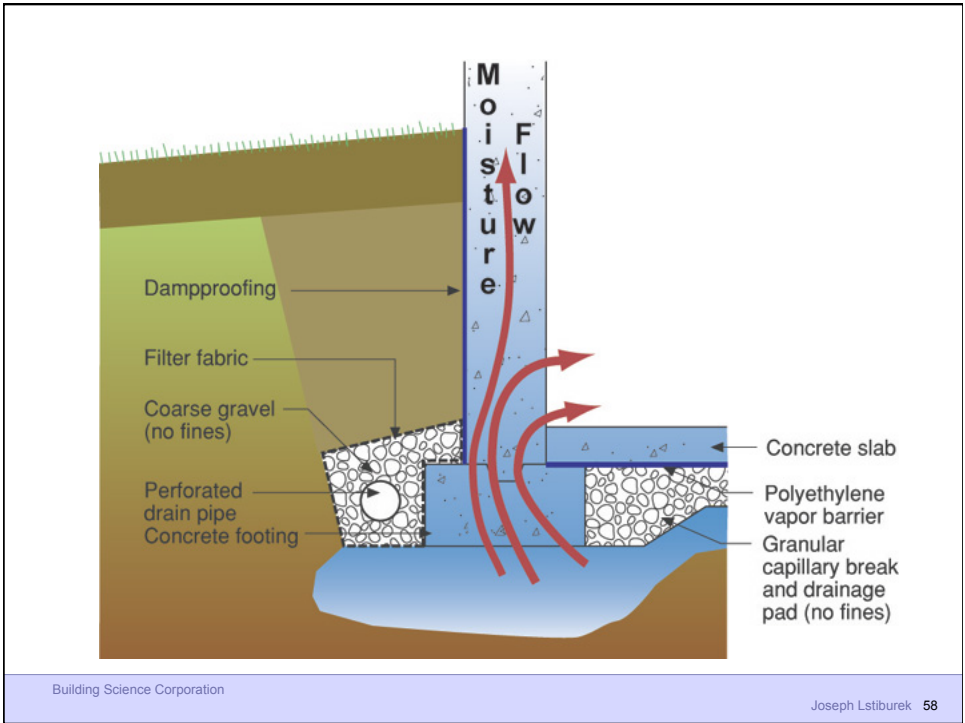
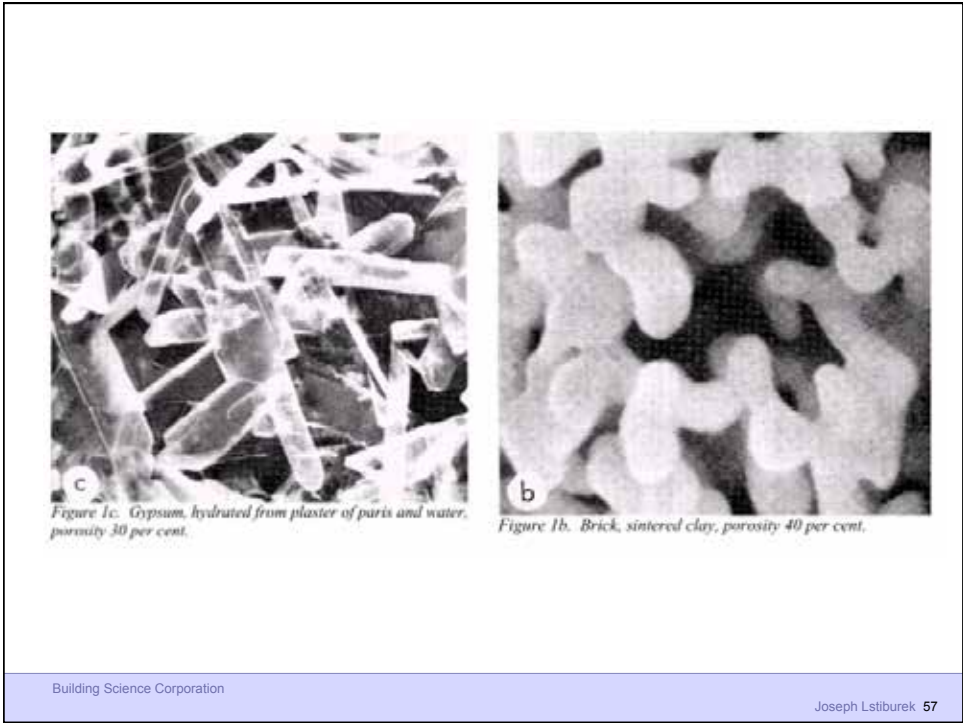
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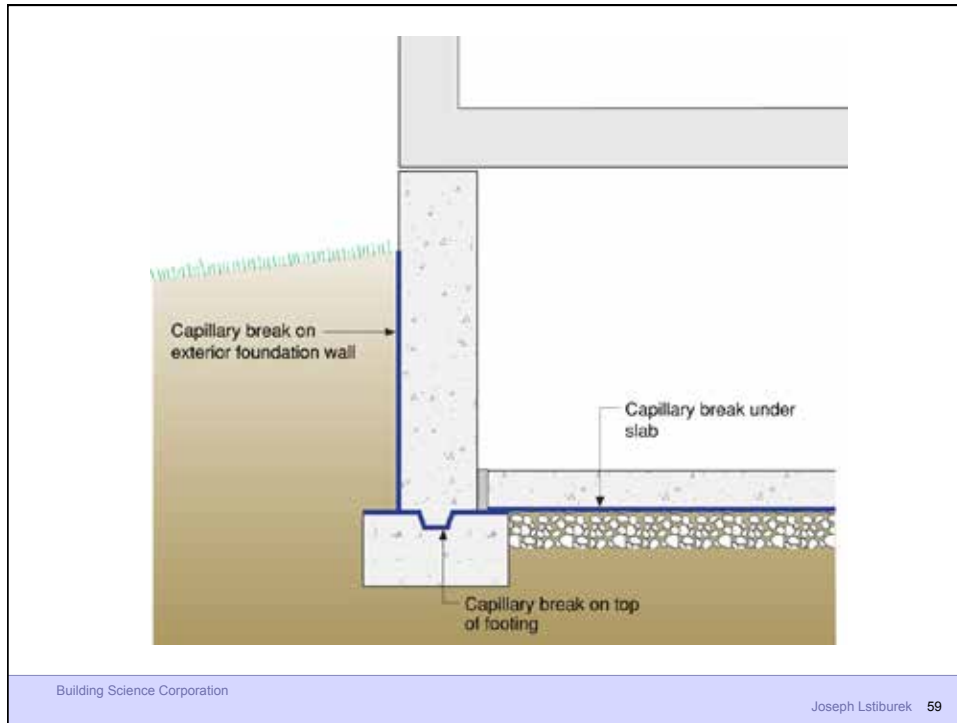


Surface area vs. particle size
From Straube & Burnett, 2005

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Heat
Air
Moisture

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HAM

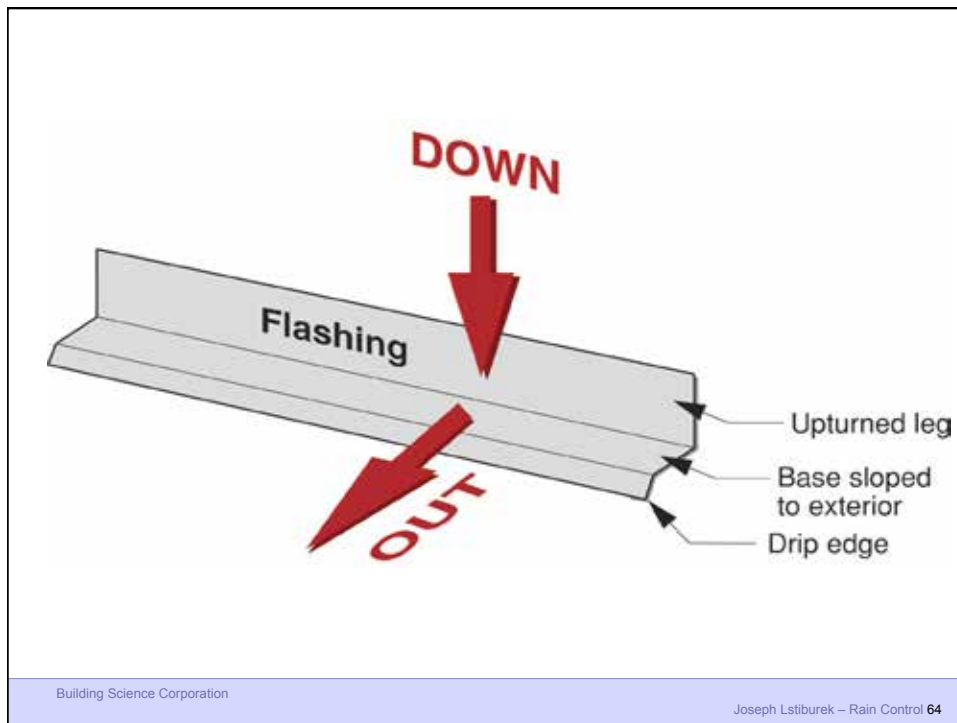
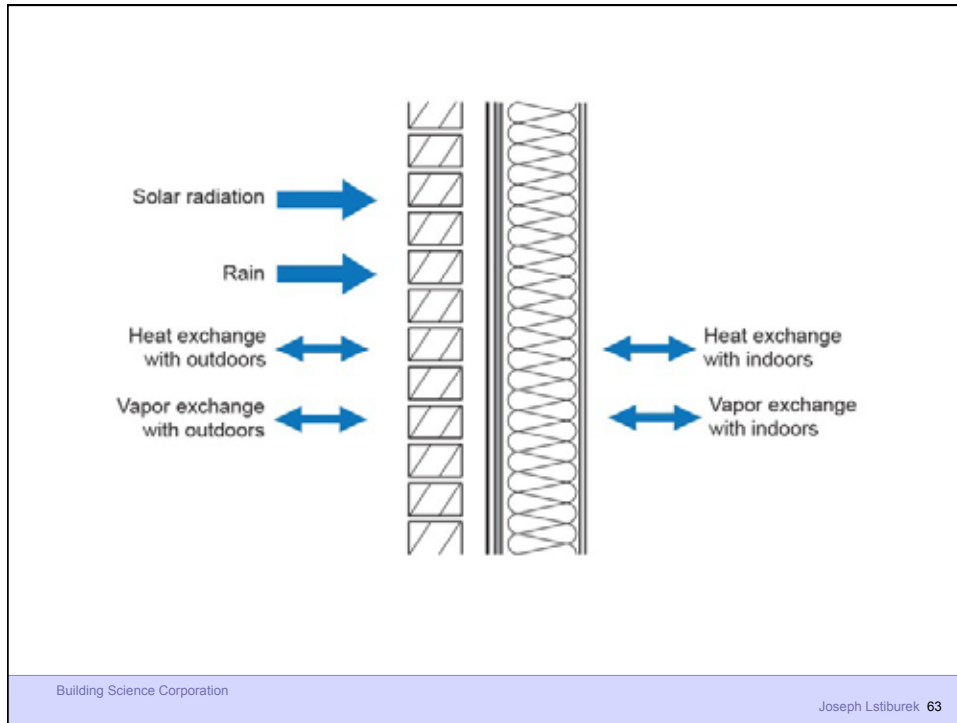
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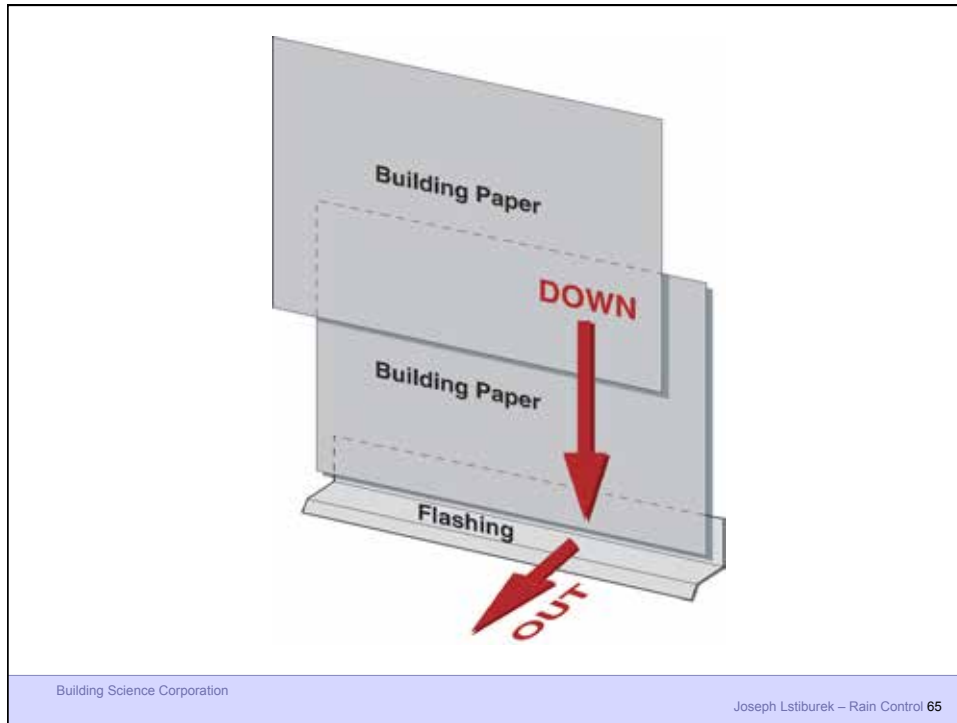
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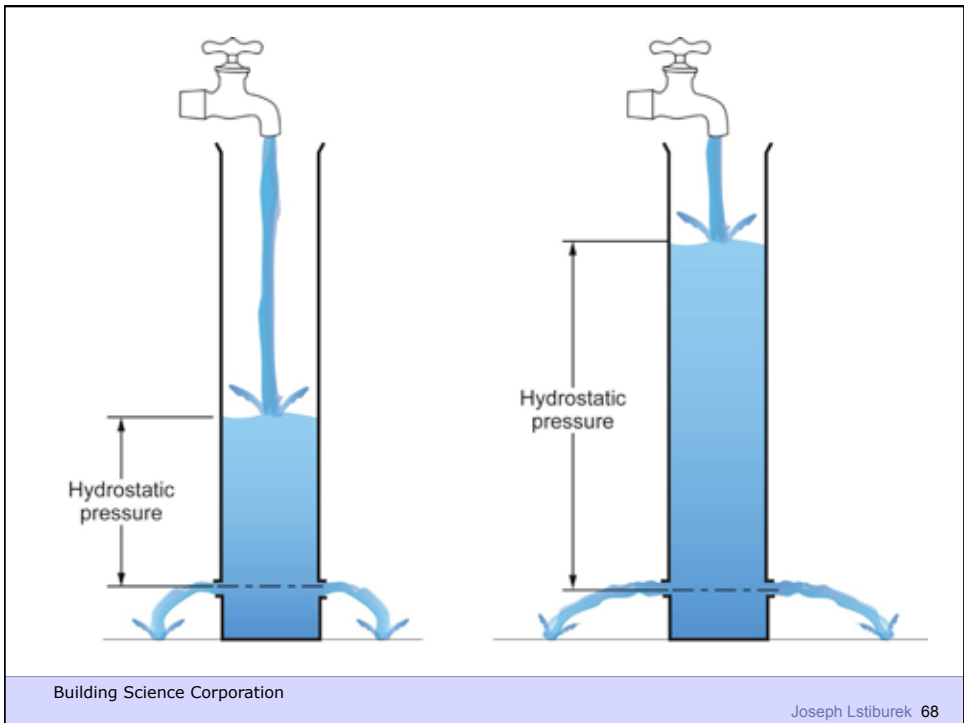
Hygrothermal Analysis

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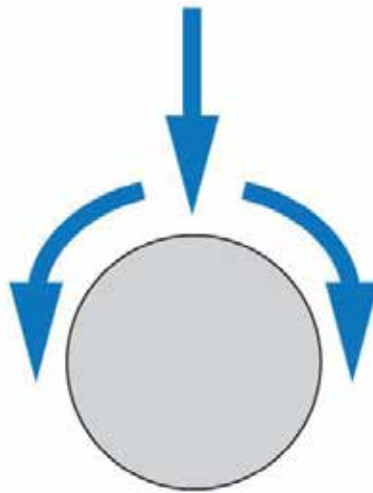






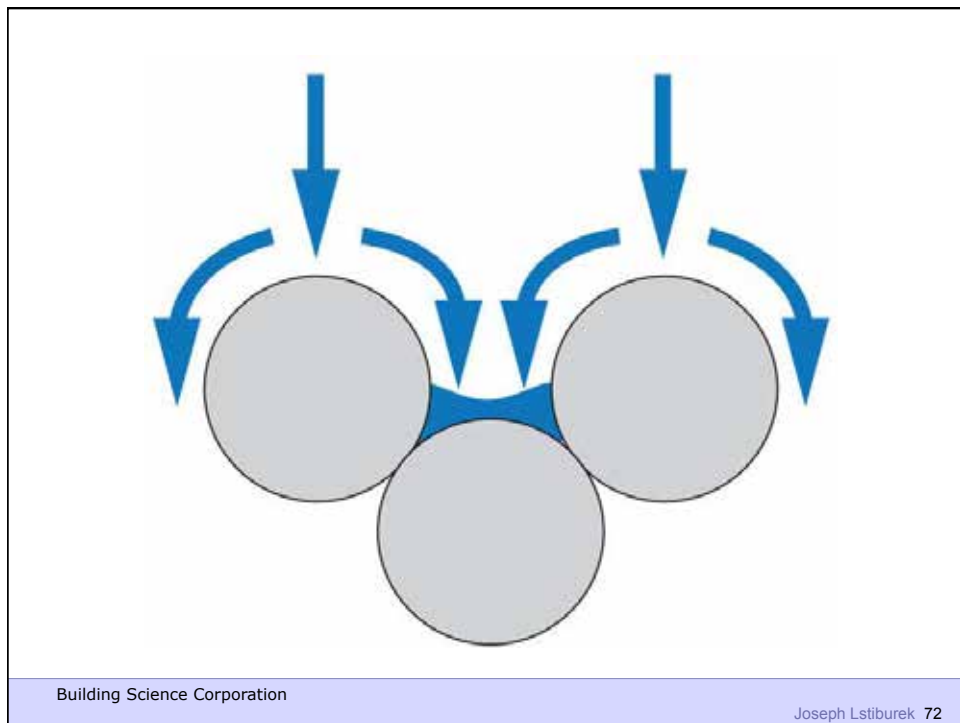
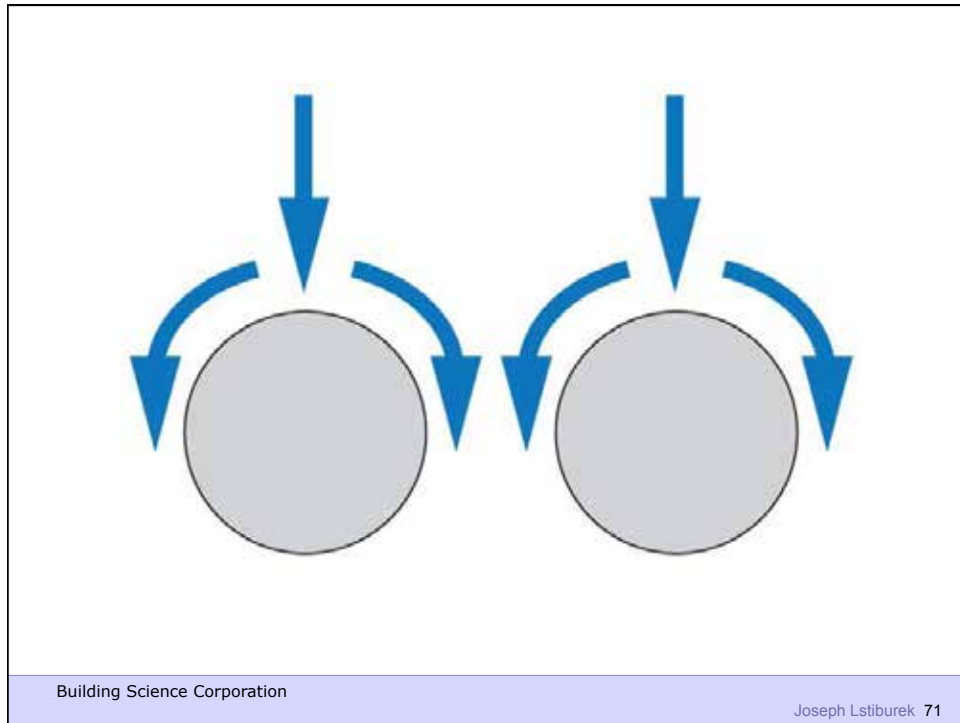
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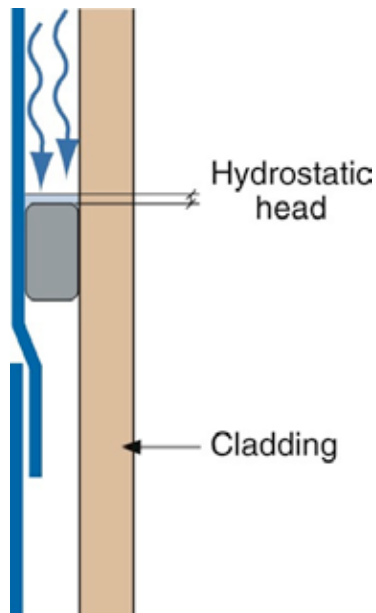
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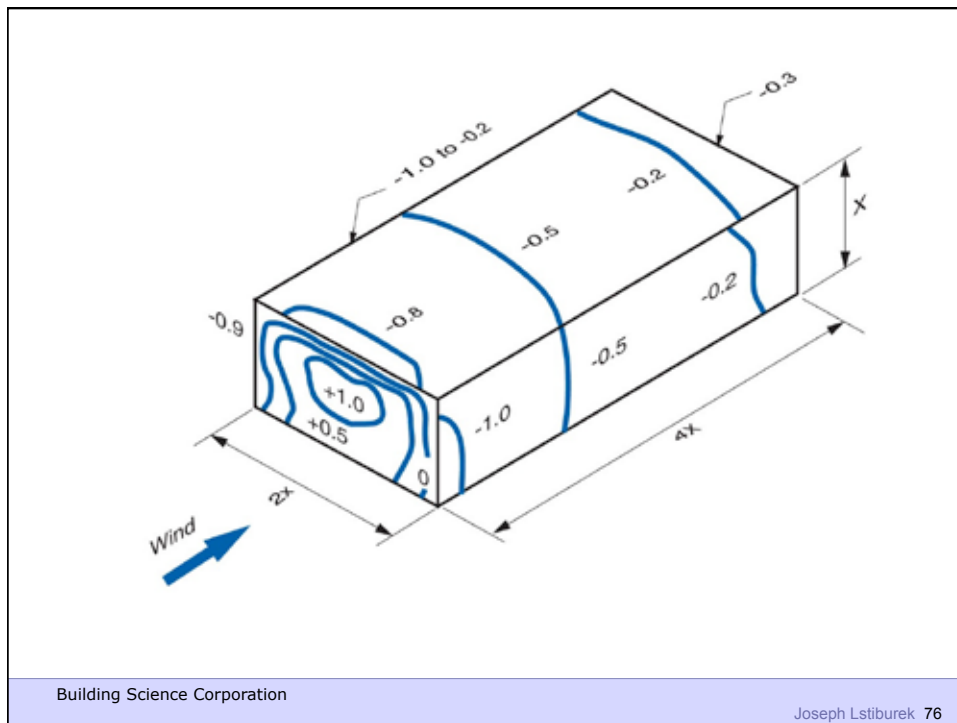
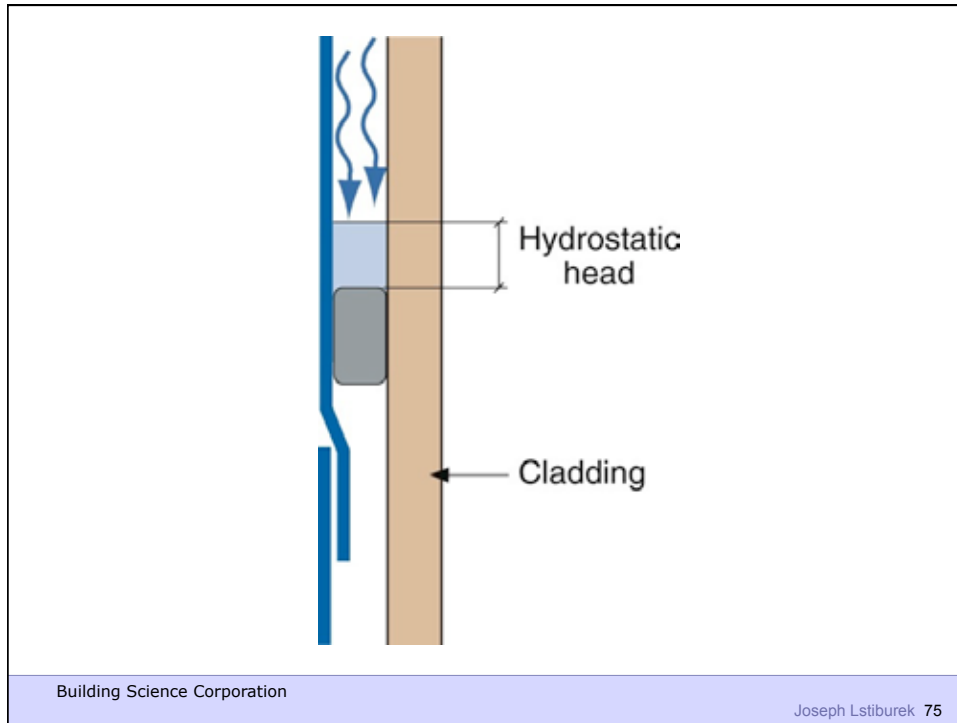
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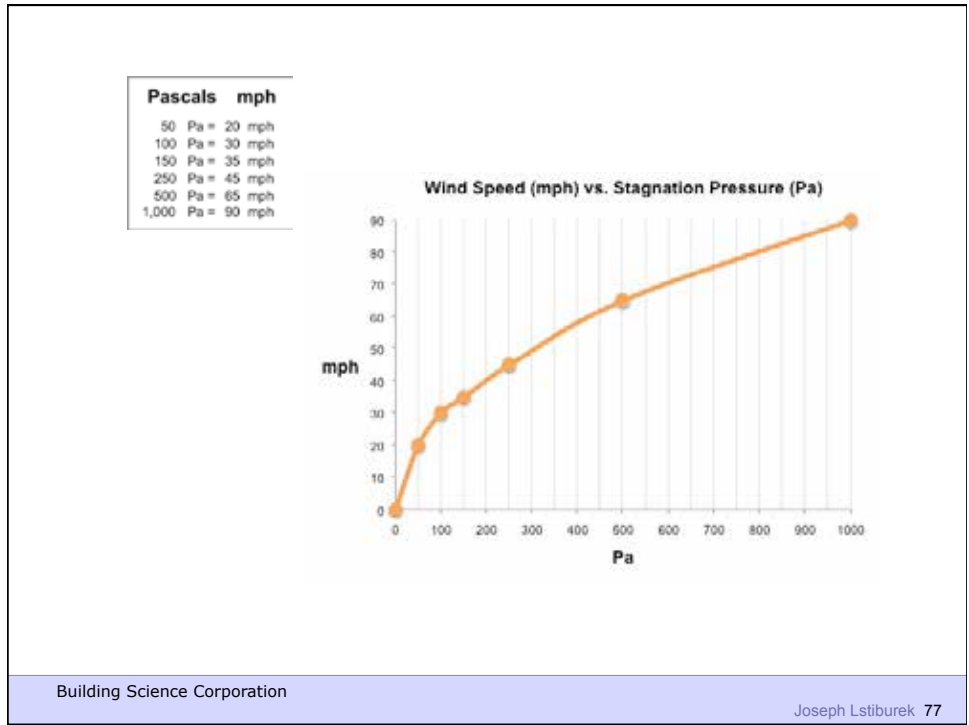
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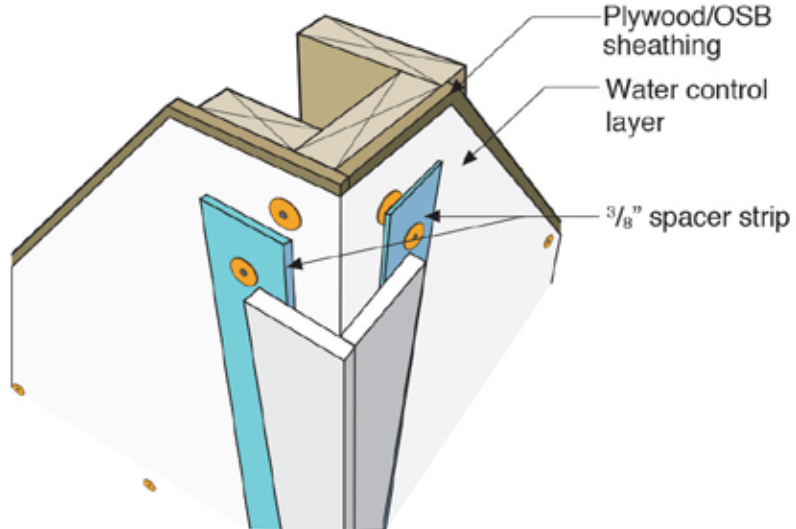






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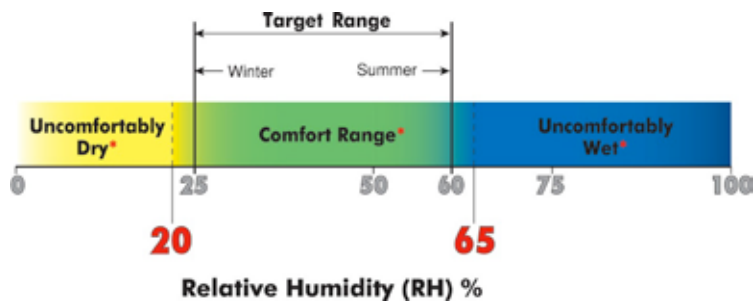


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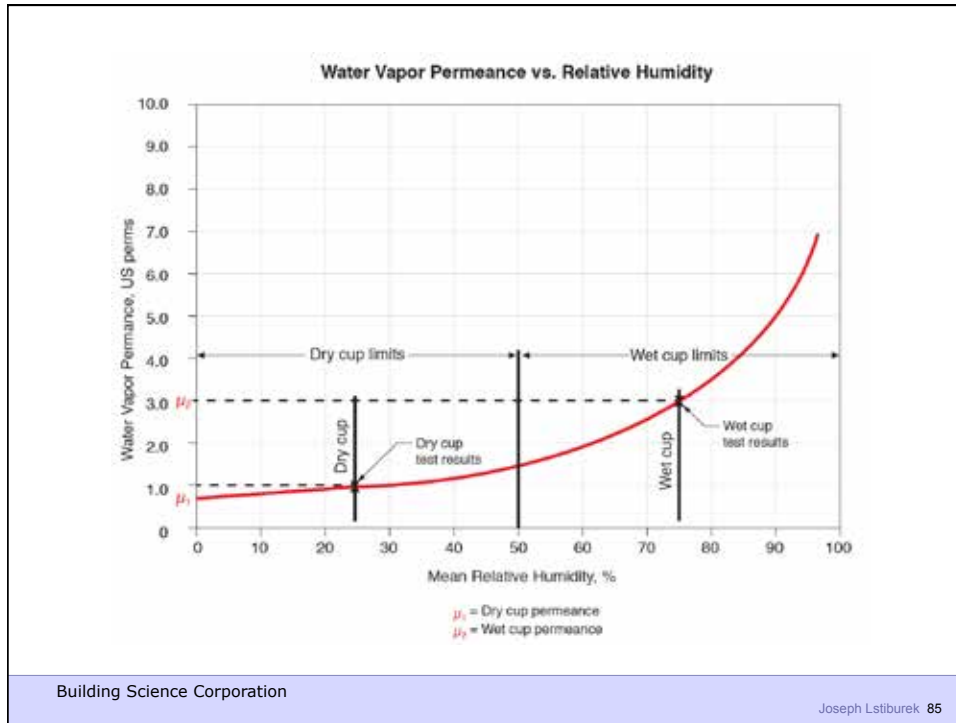
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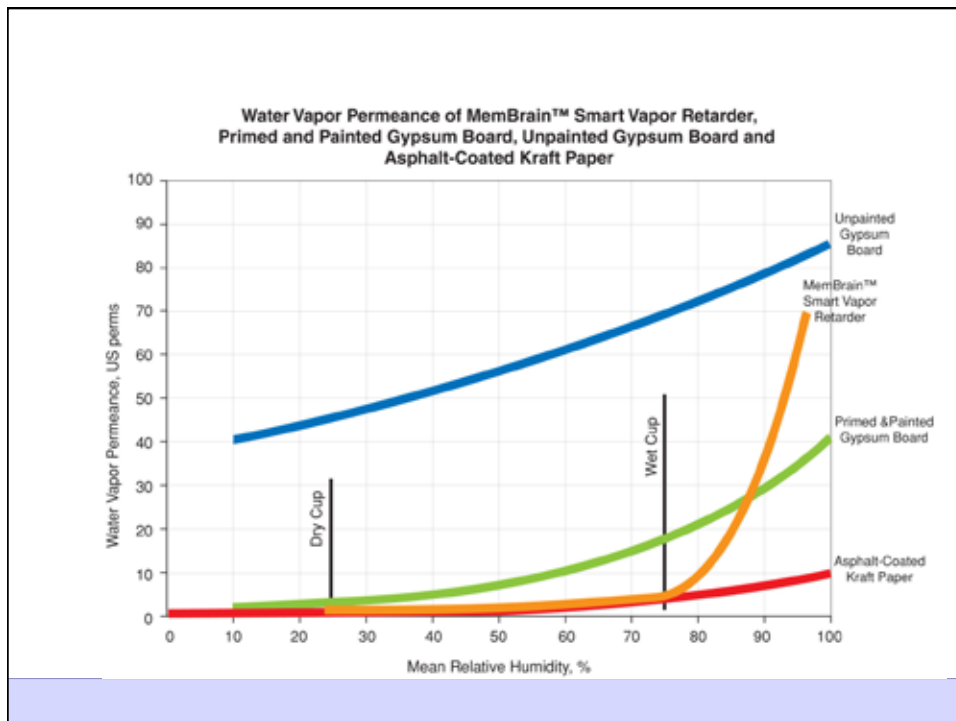
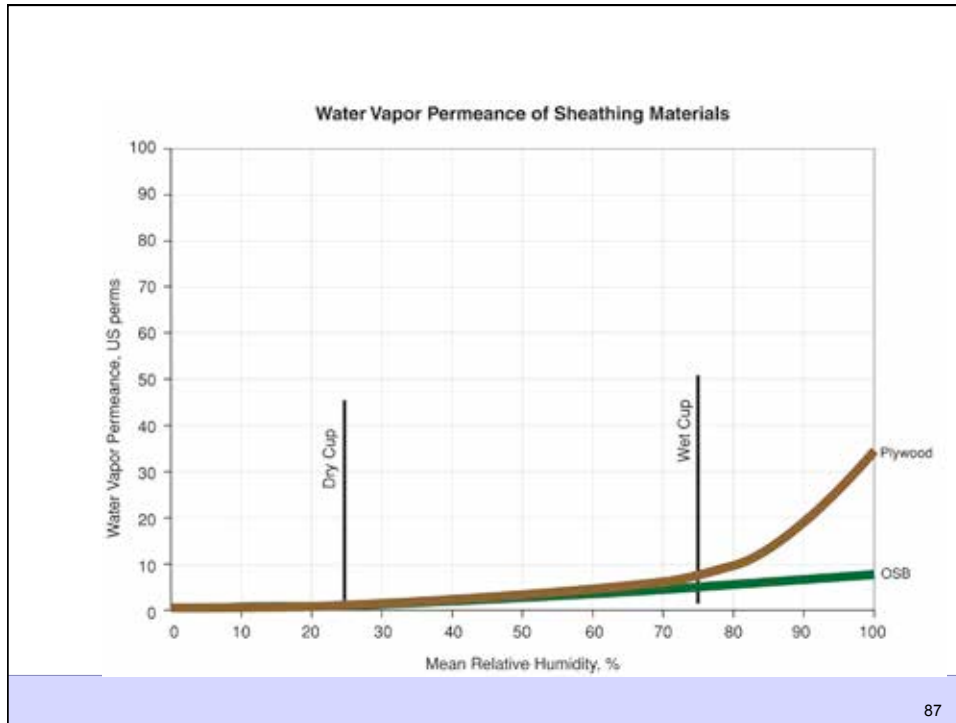
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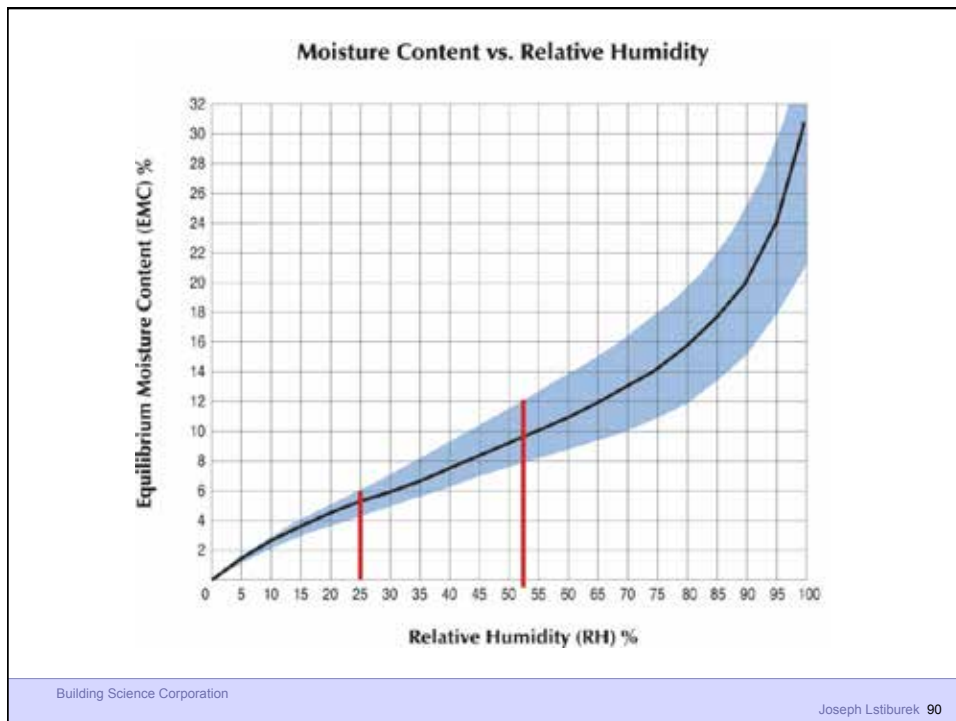
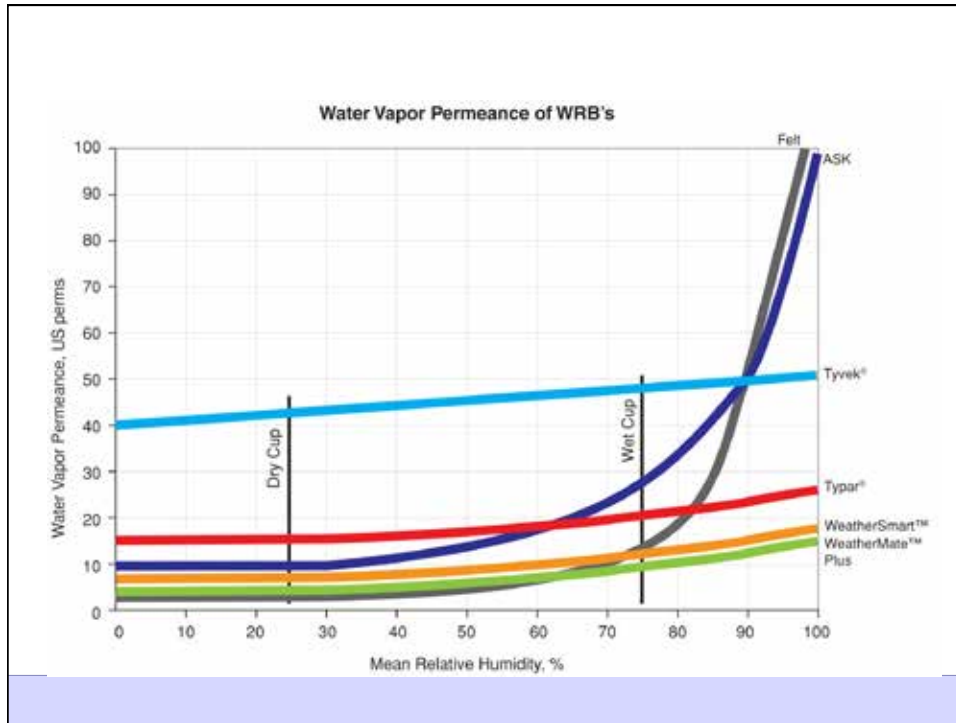


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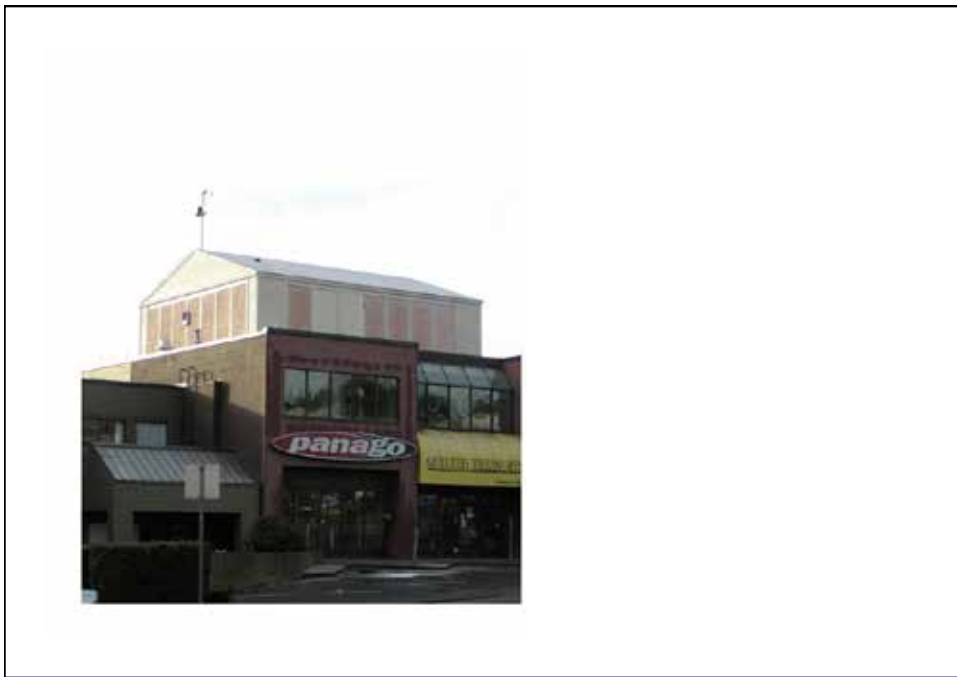






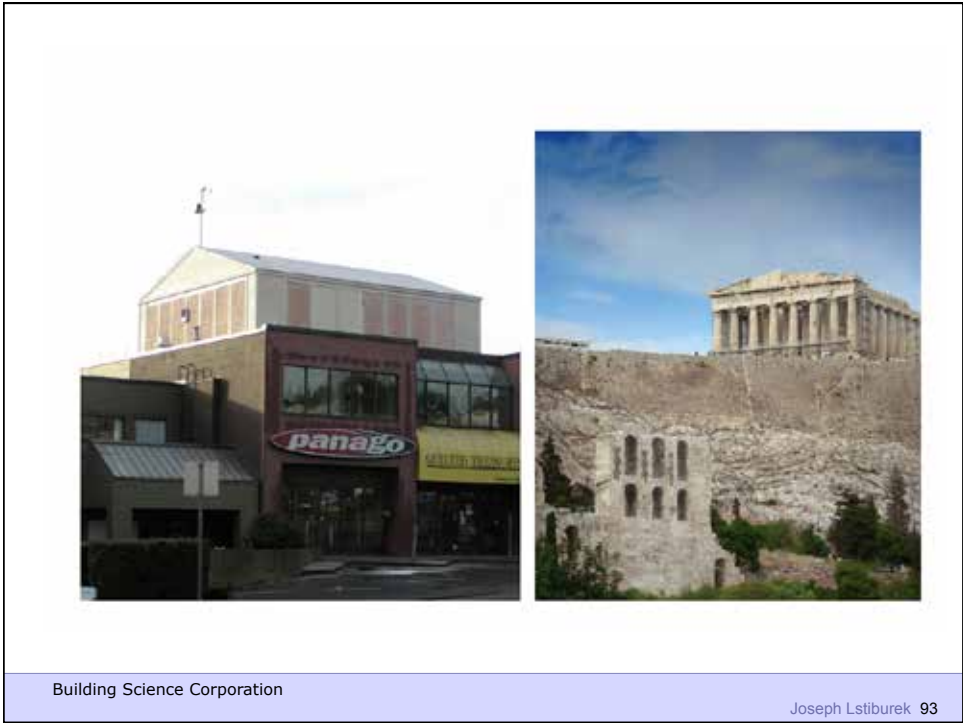
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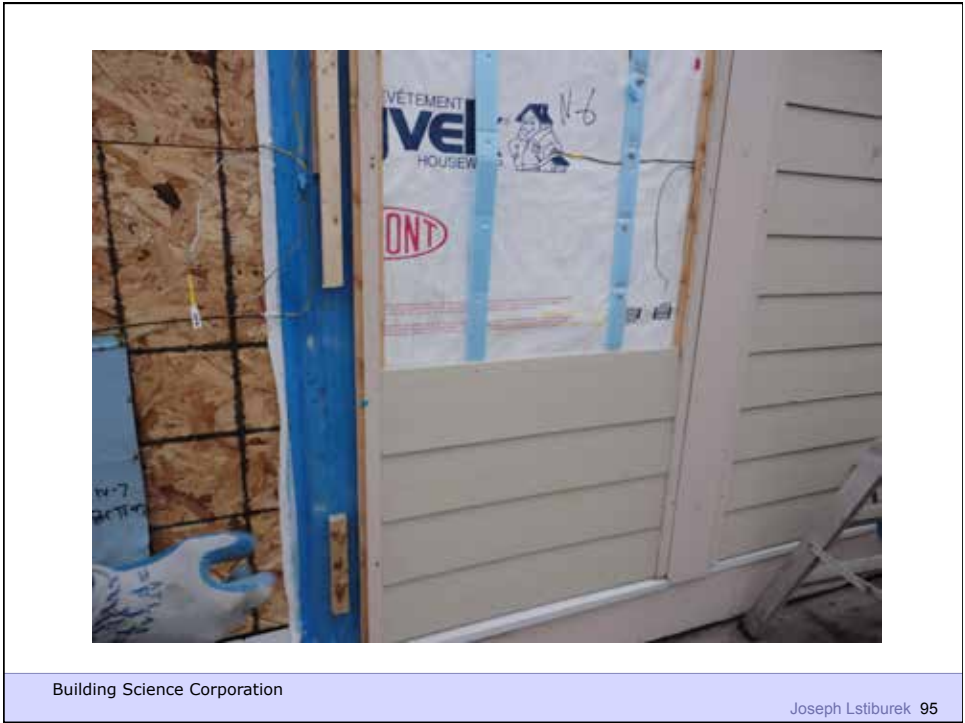
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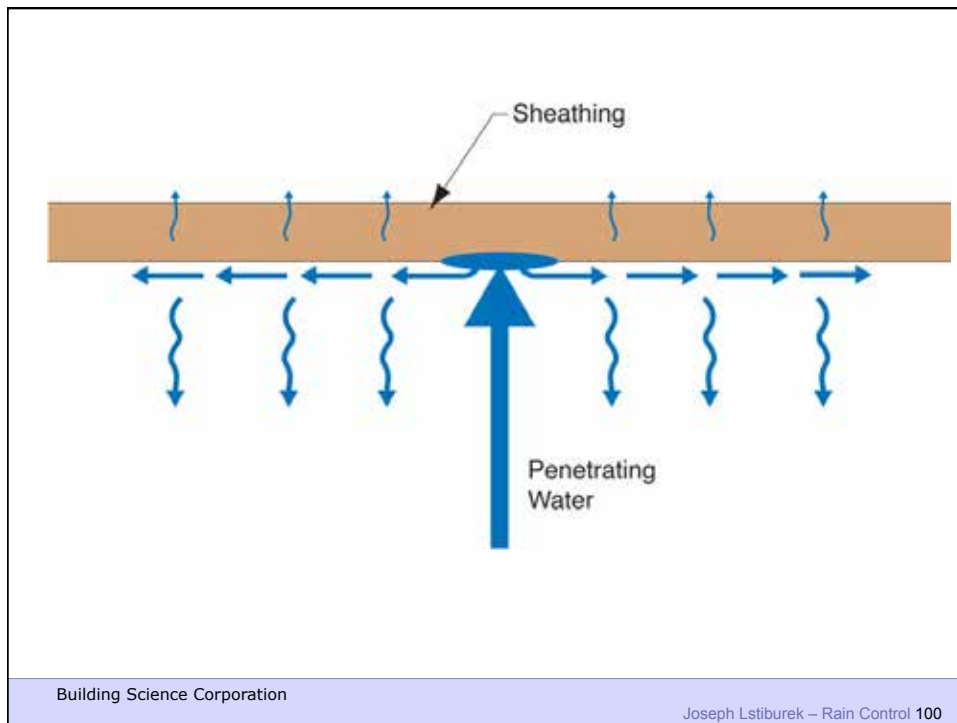
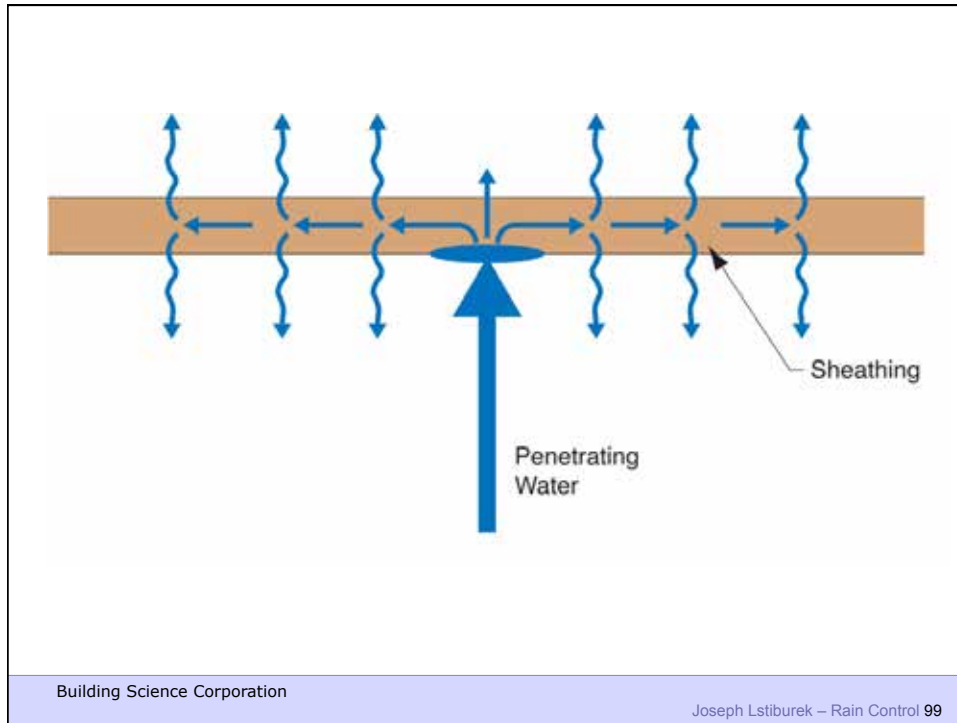
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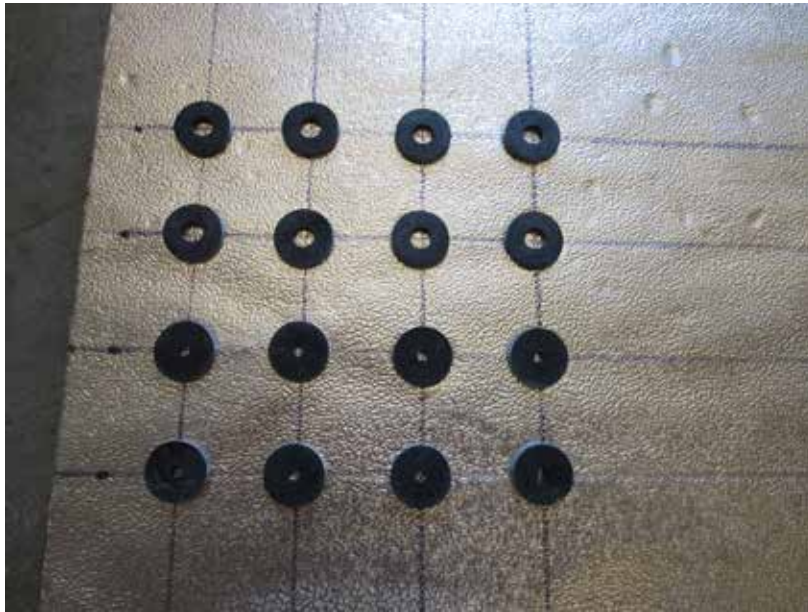
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Joseph Lstiburek – Rain Control 101

Rain Screen

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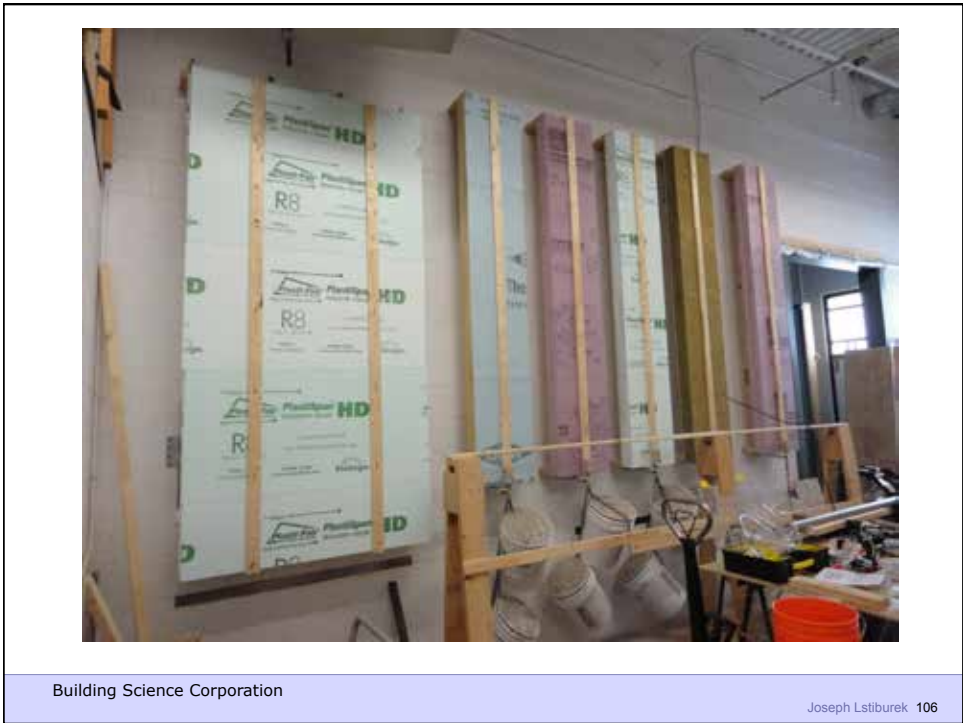
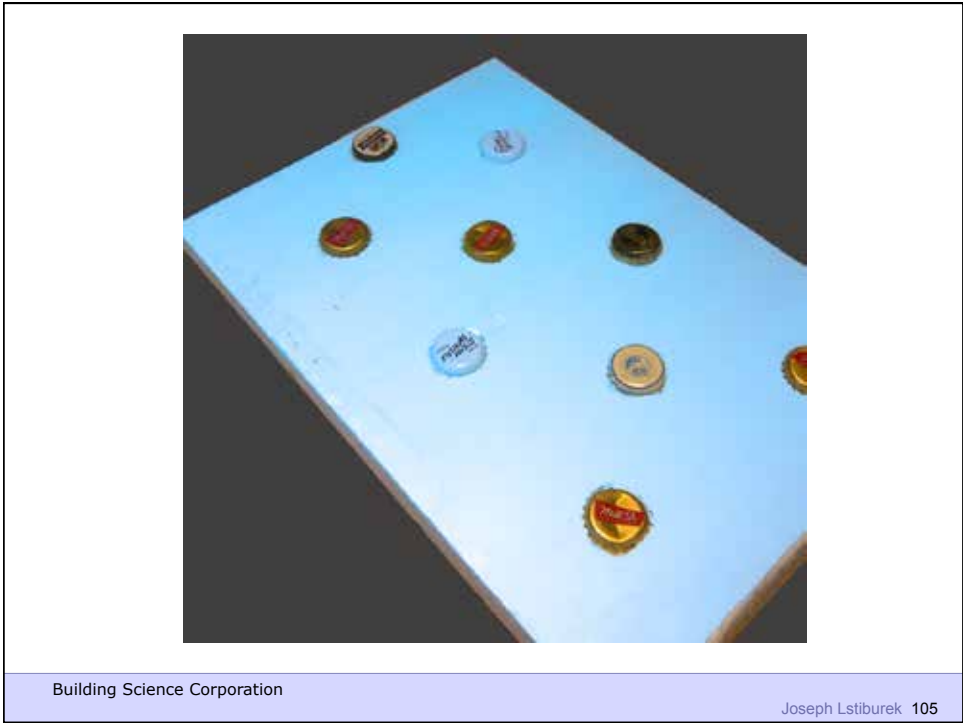
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Beer Screen?

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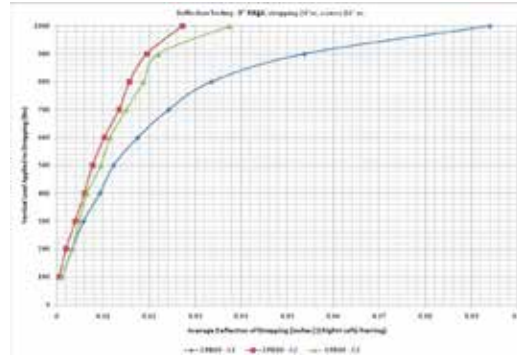






Rockwool

1x3 furring @ 24" o.c.
 #10 screws @ 16" o.c. vertically
 Result: 20 psf cladding weight
 with < 2/100" deflection



Myth of the Dew Point

