

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

Building Science

Adventures In Building Science

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What is a Building?

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A Building is an Environmental Separator

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- 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

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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

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Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

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Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

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Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less

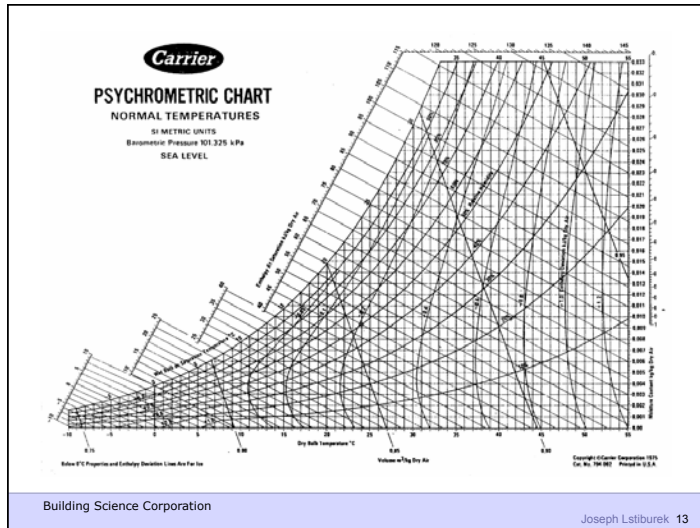
Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion

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Thermodynamic Potential

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Damage Functions

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Damage Functions
Water
Heat
Ultra Violet Radiation

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

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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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Heat
Air
Moisture

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HAM

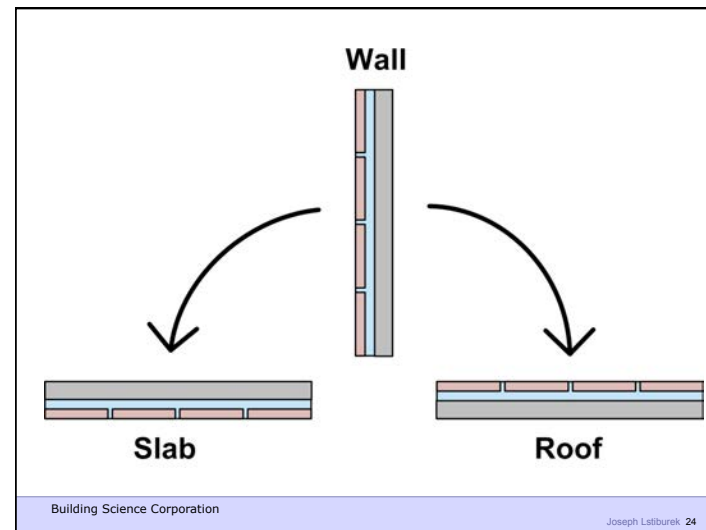
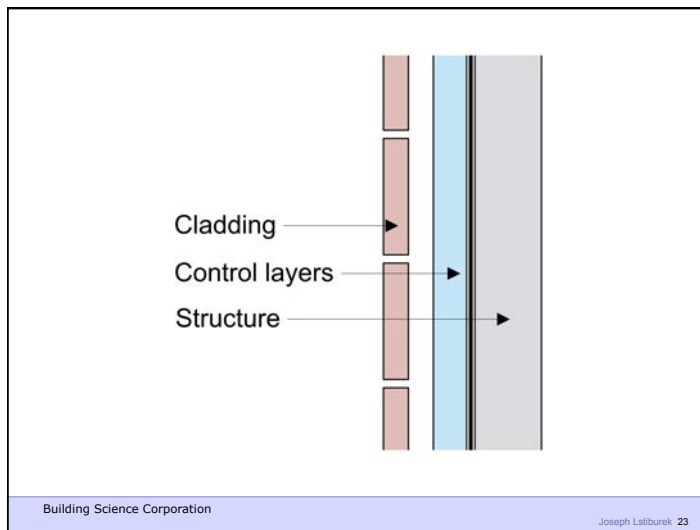
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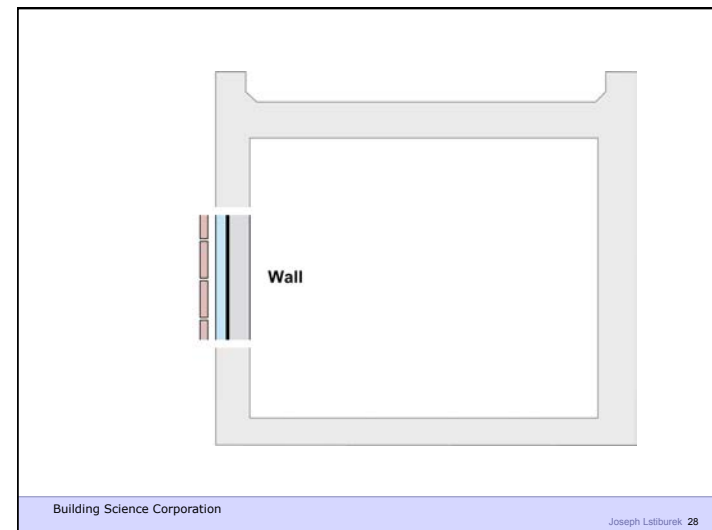
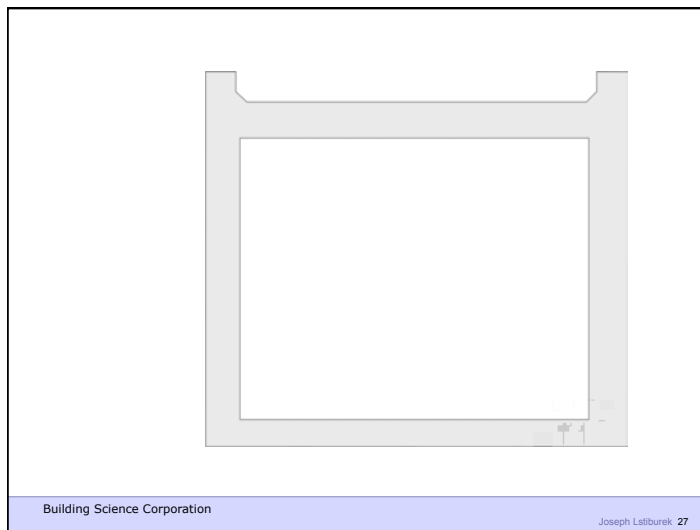
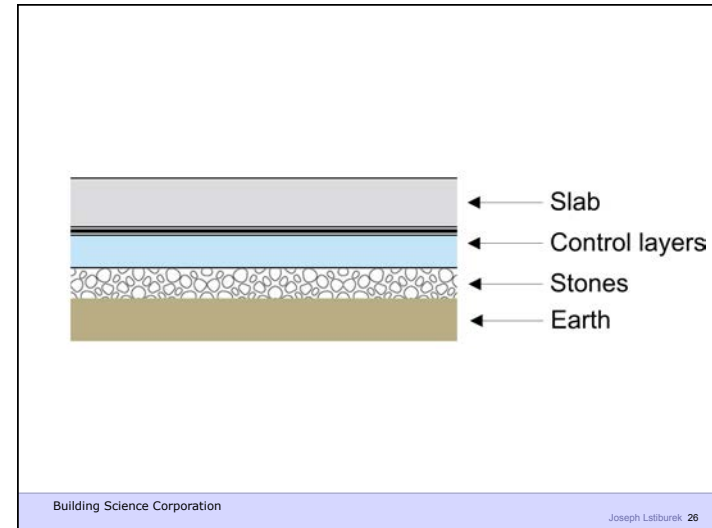
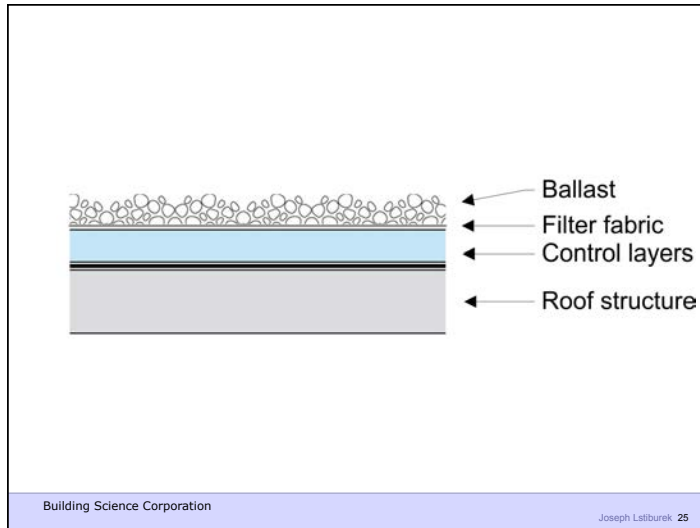
Hygrothermal Analysis

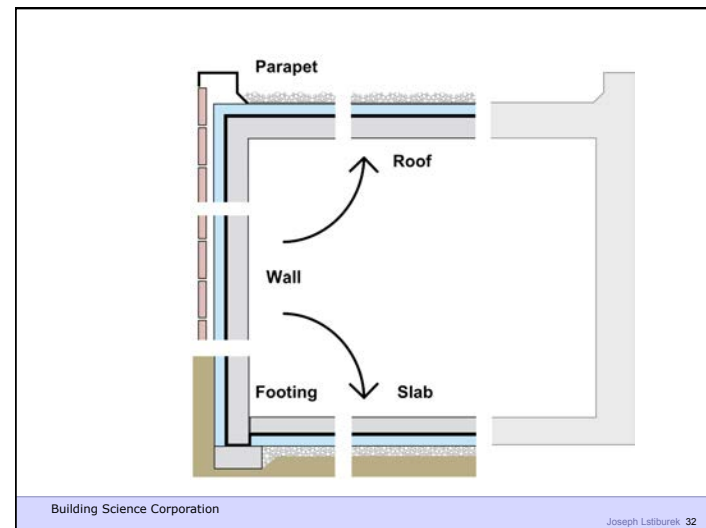
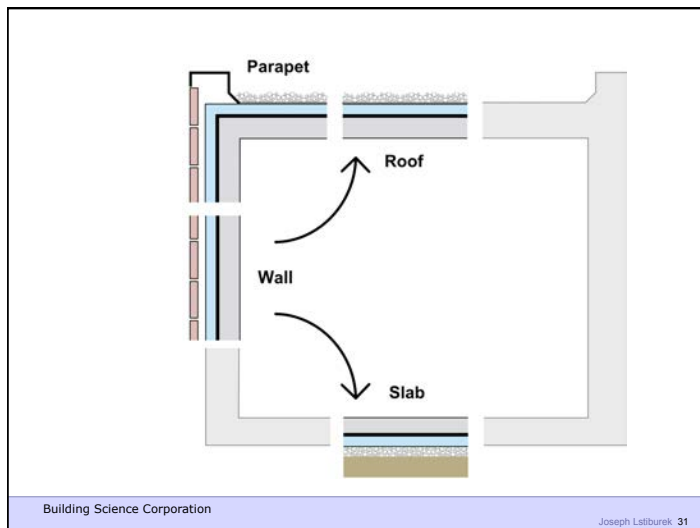
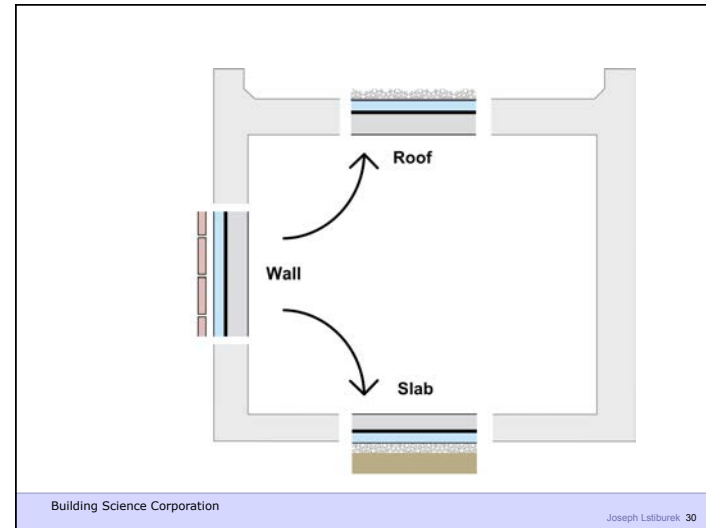
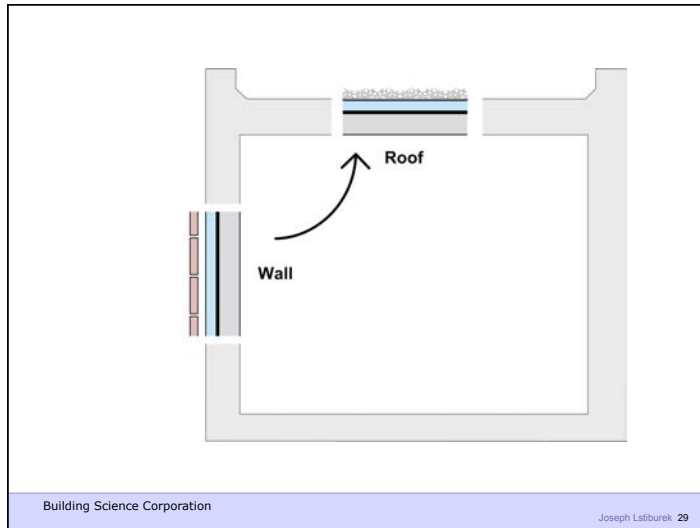
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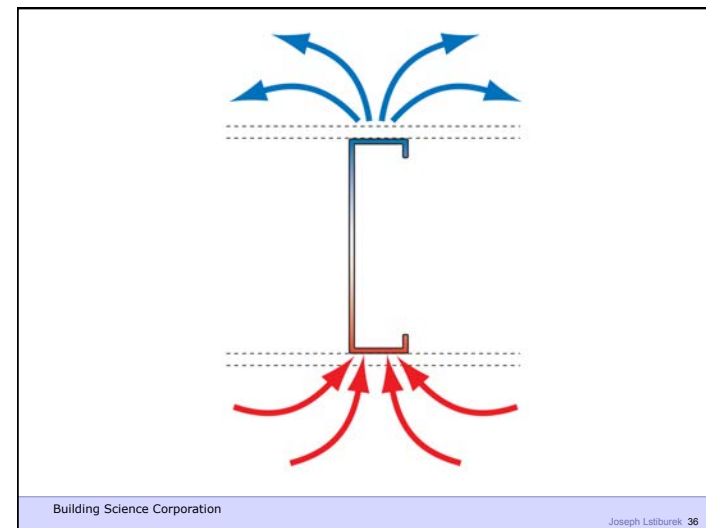
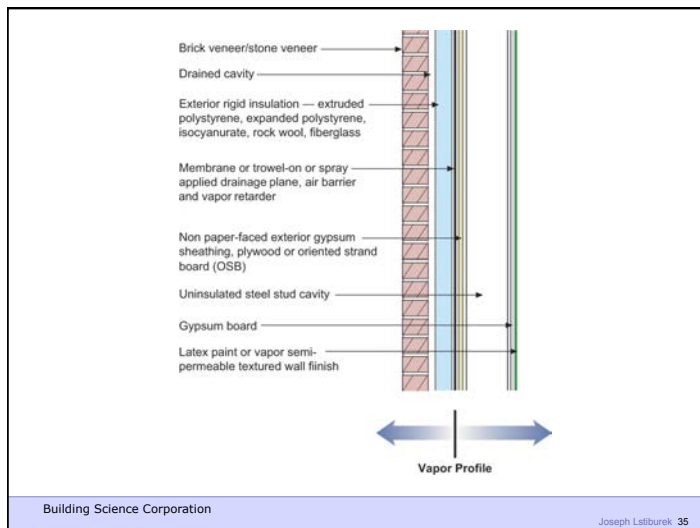
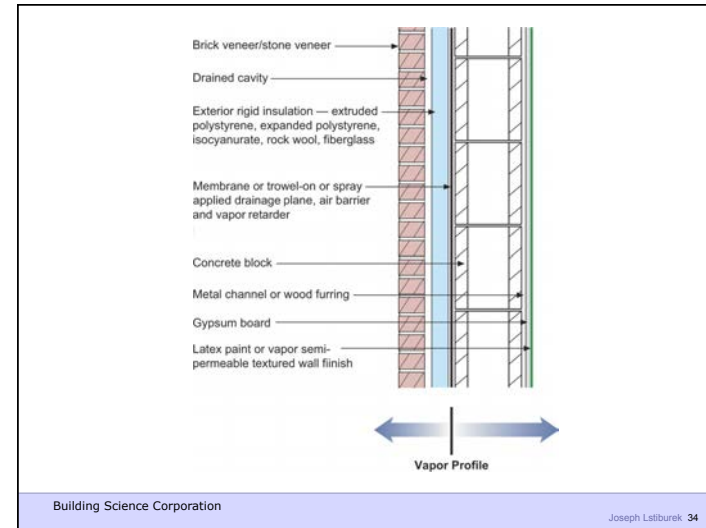
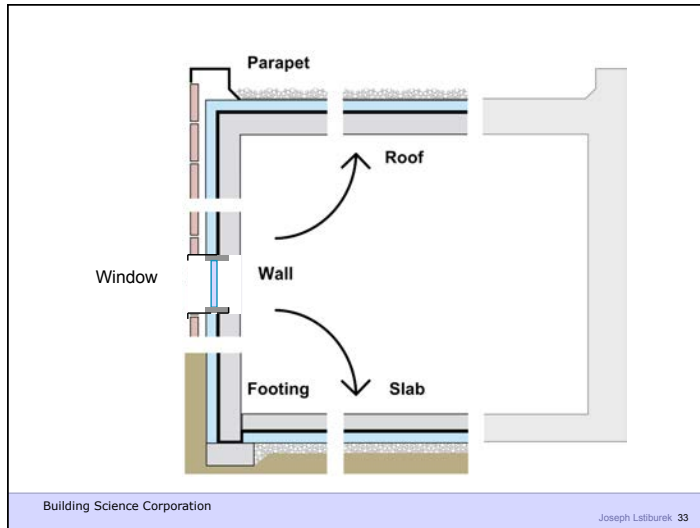
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

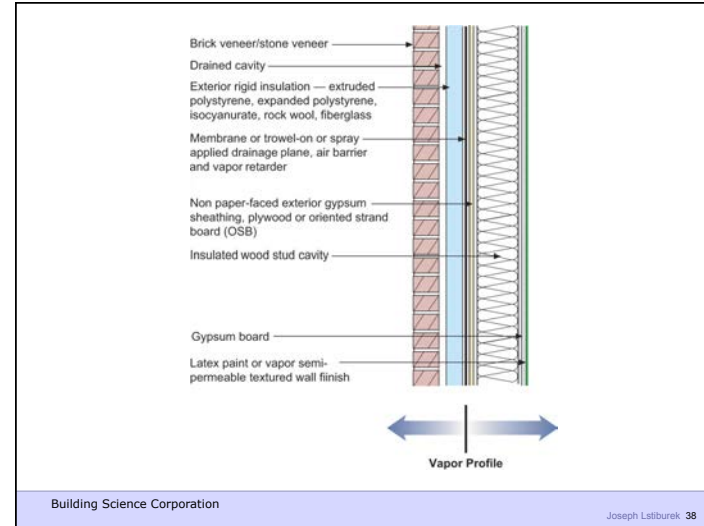
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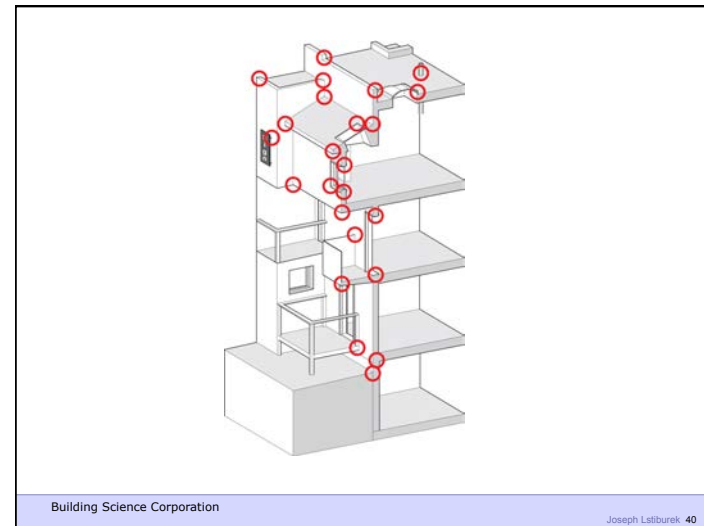


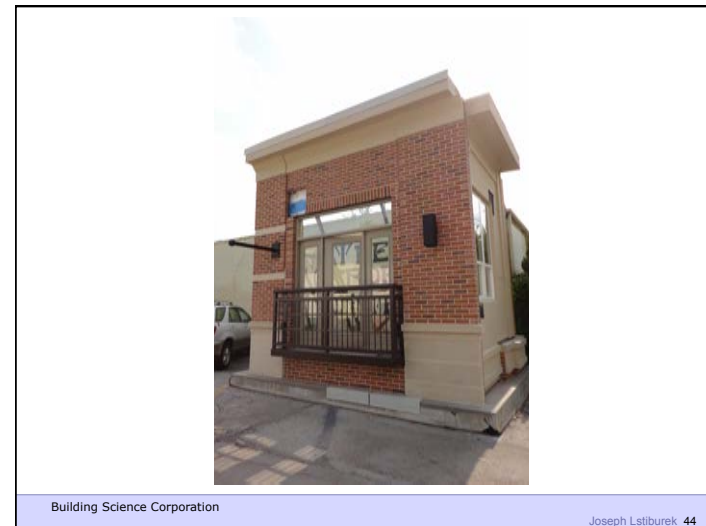
Commercial Enclosure: Simple Layers

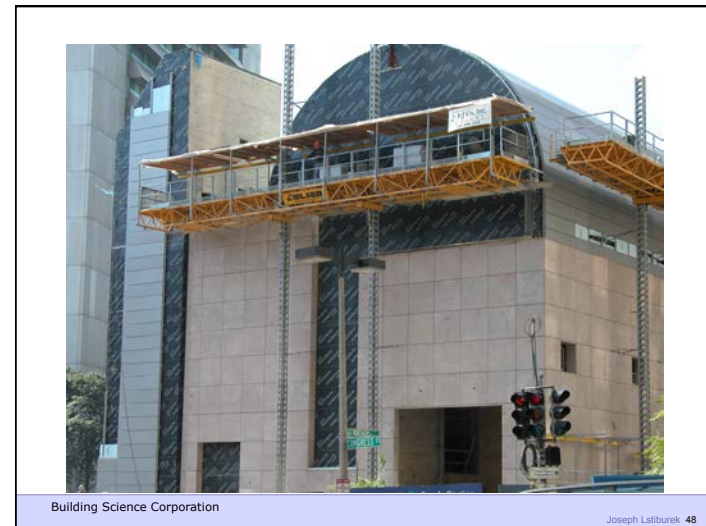
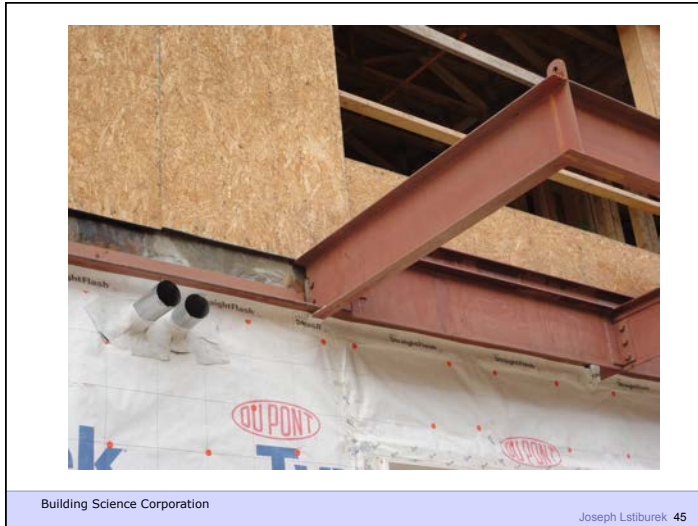
- Structure
- Rain/Air/Vapor
- Insulation
- Finish

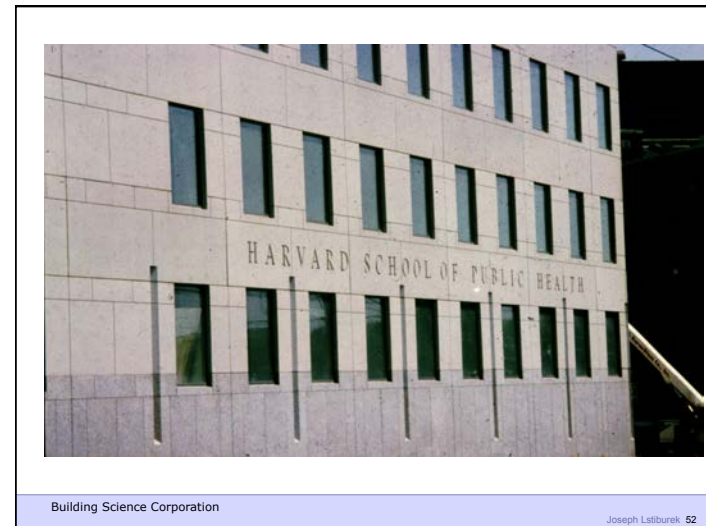
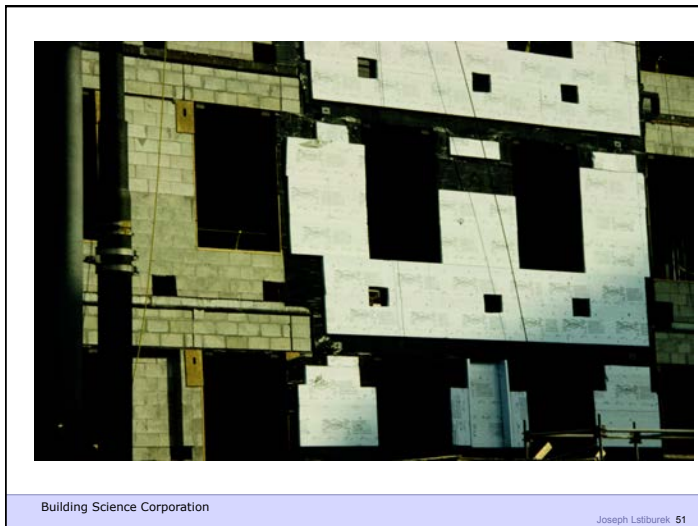
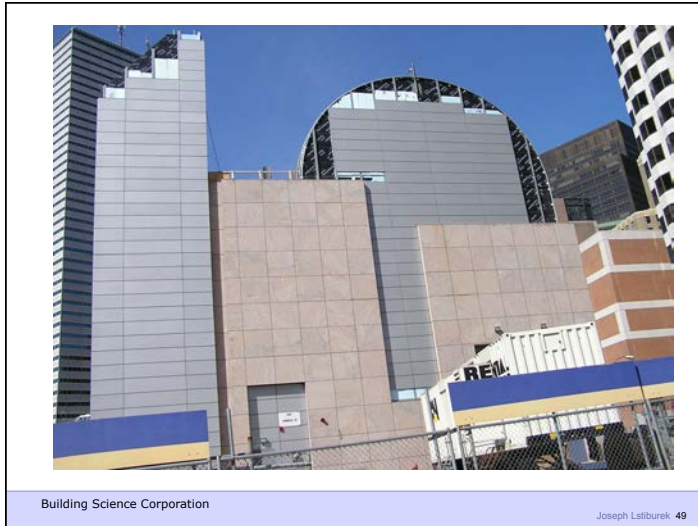
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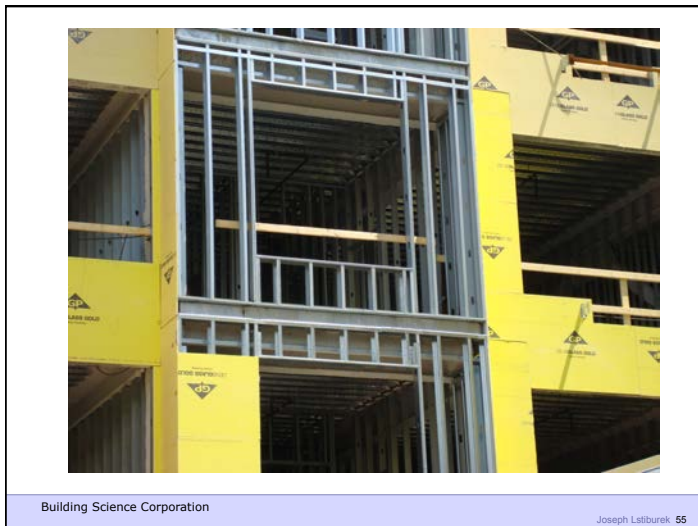
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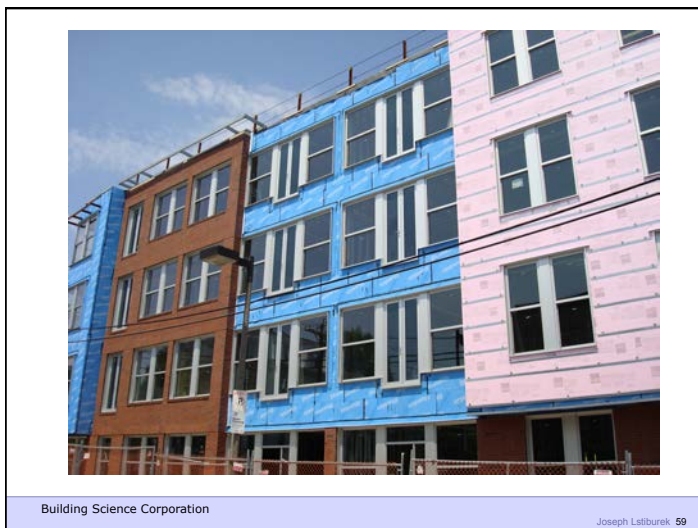
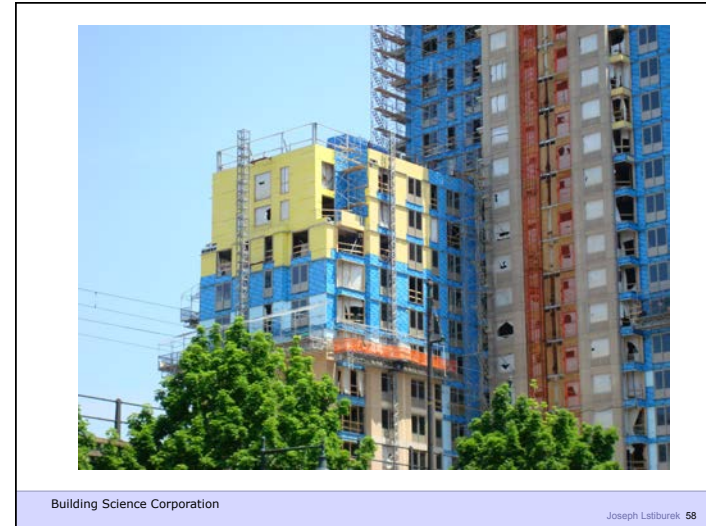






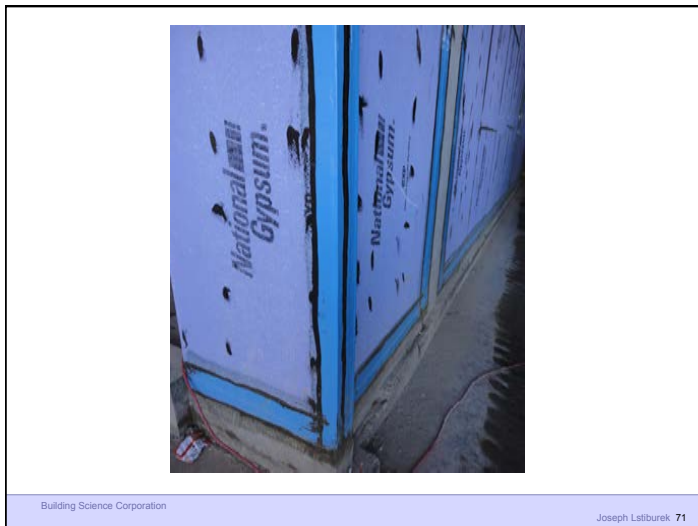




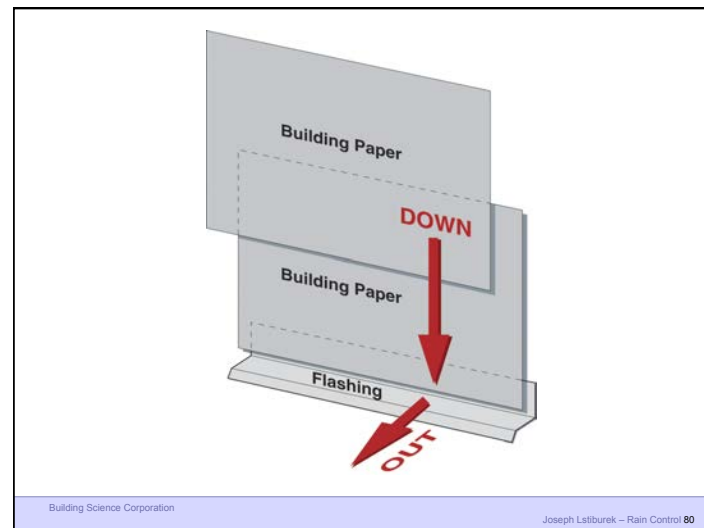
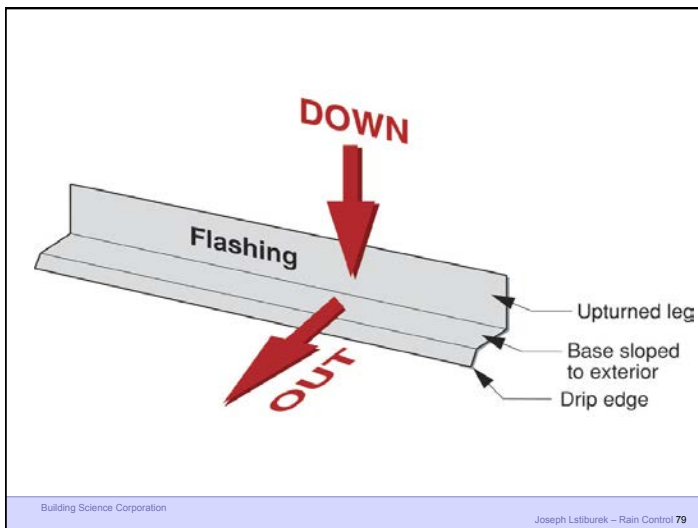
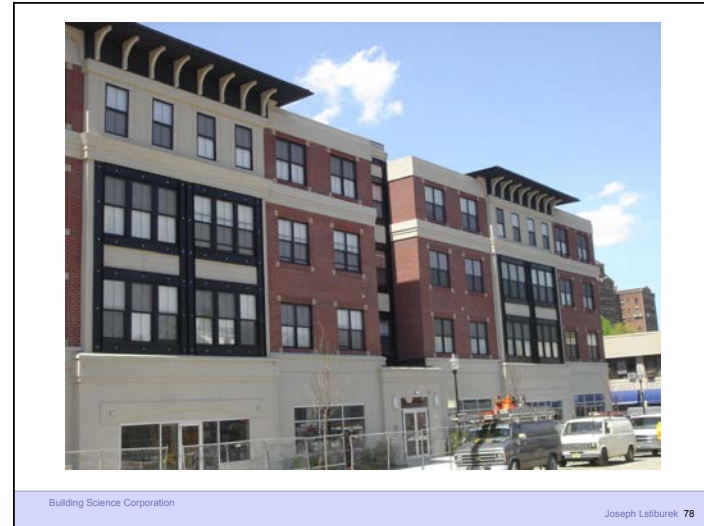
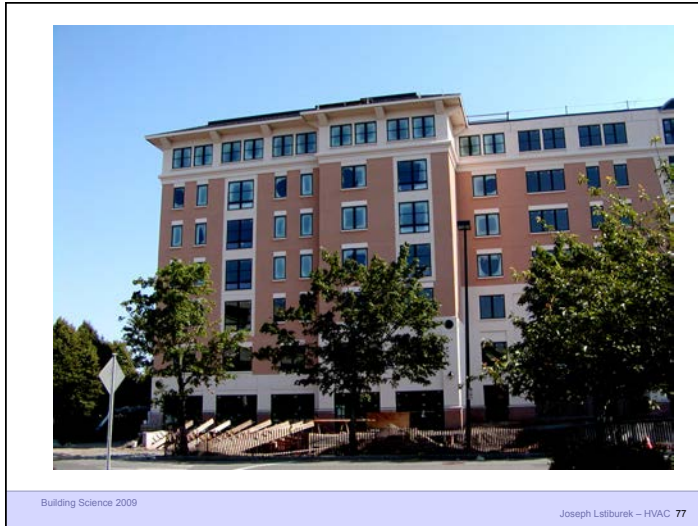


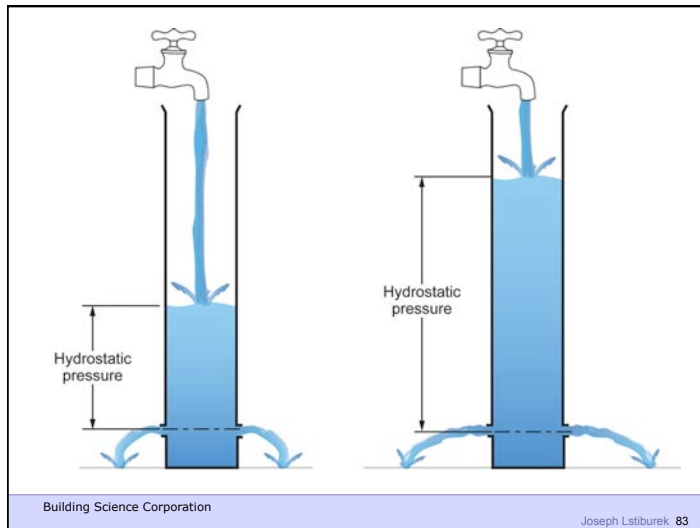


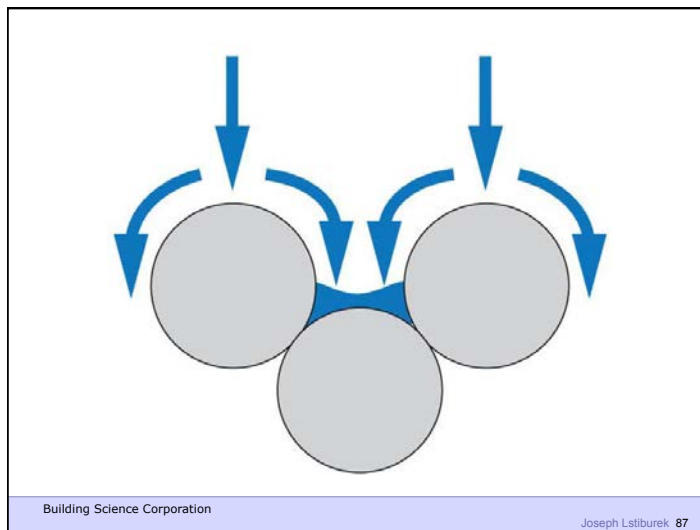
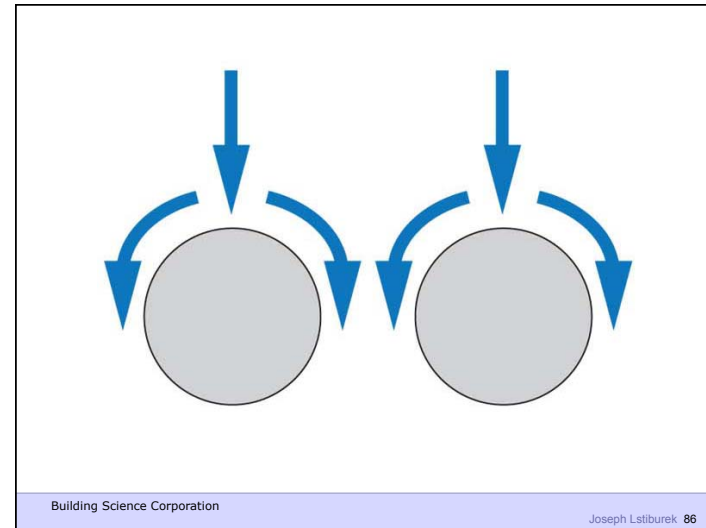
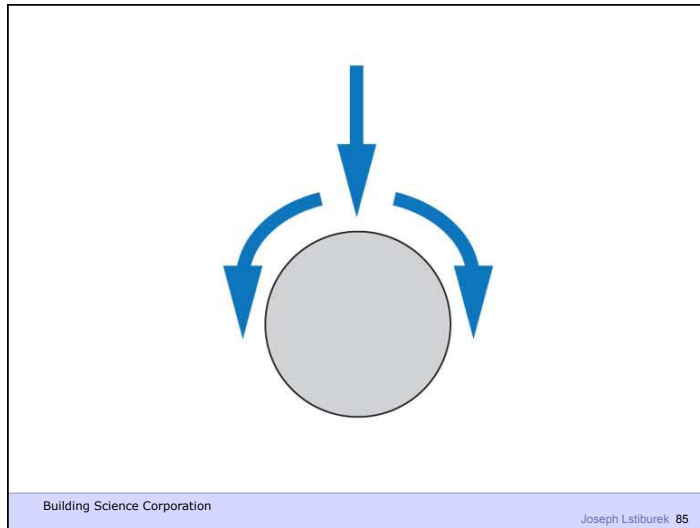


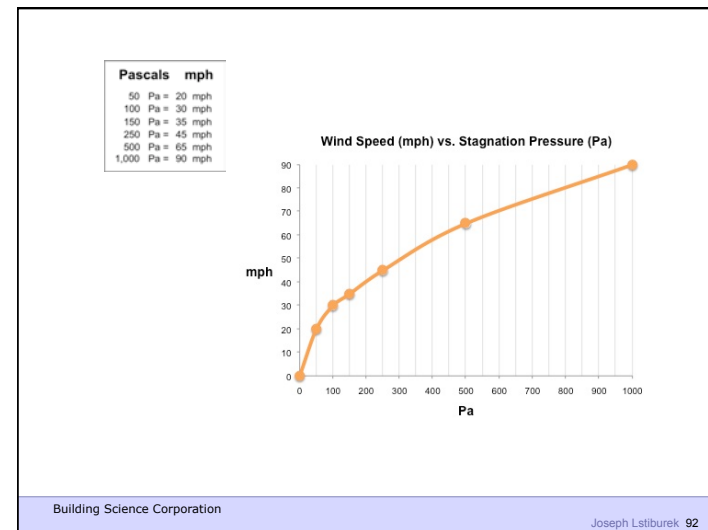
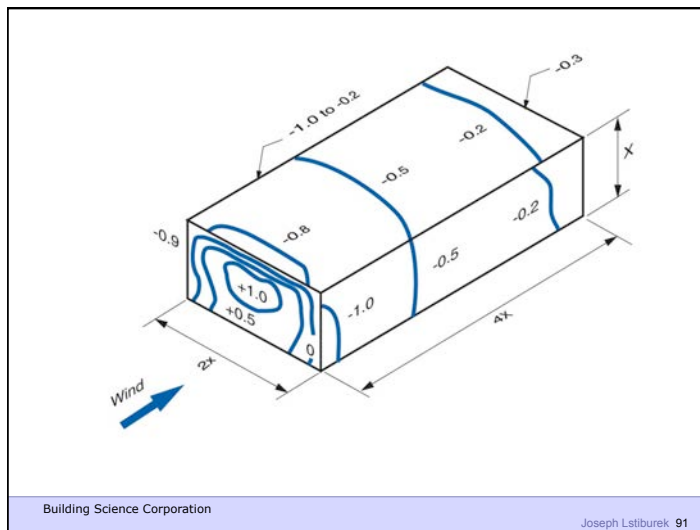
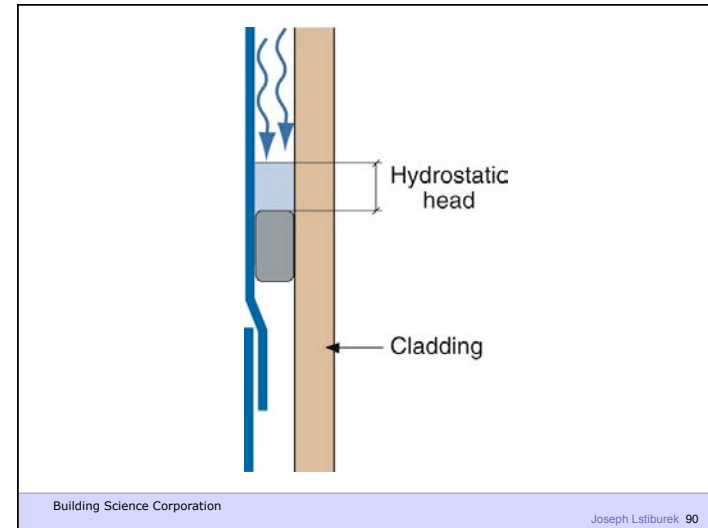
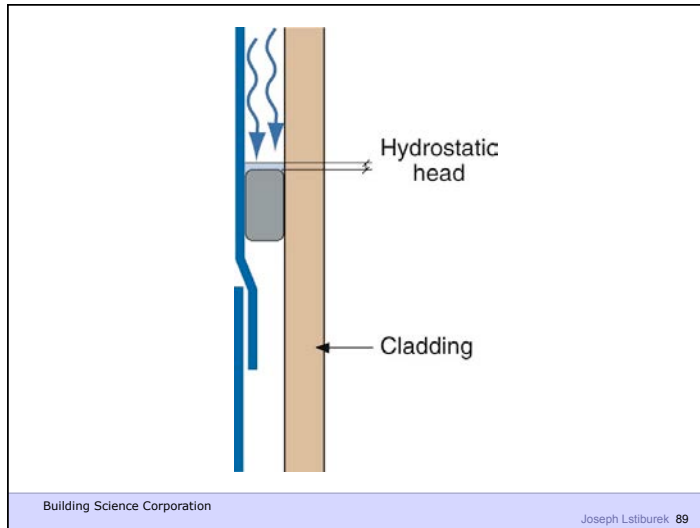


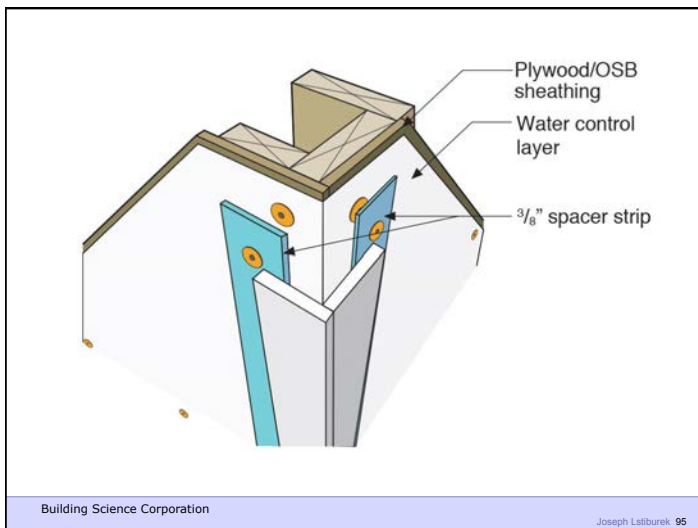


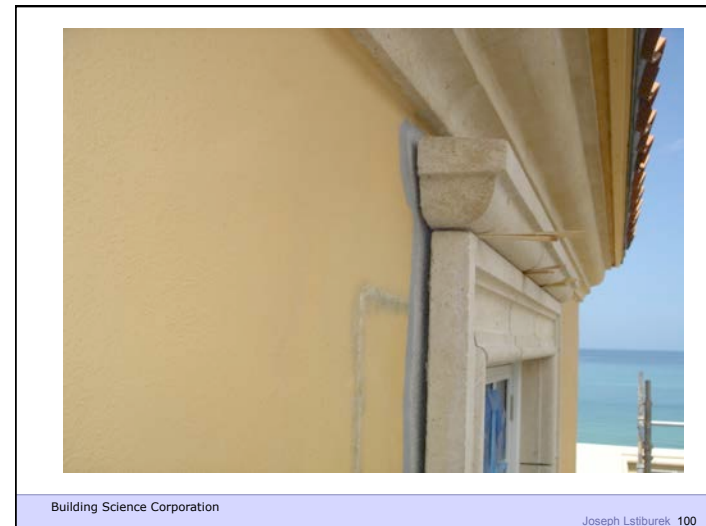
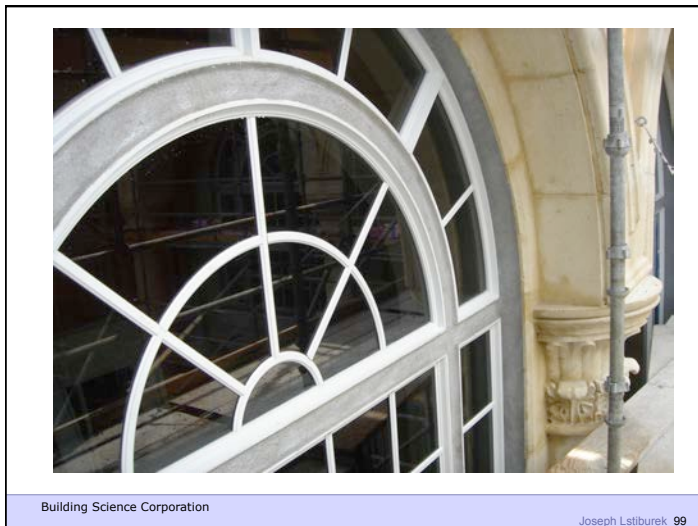


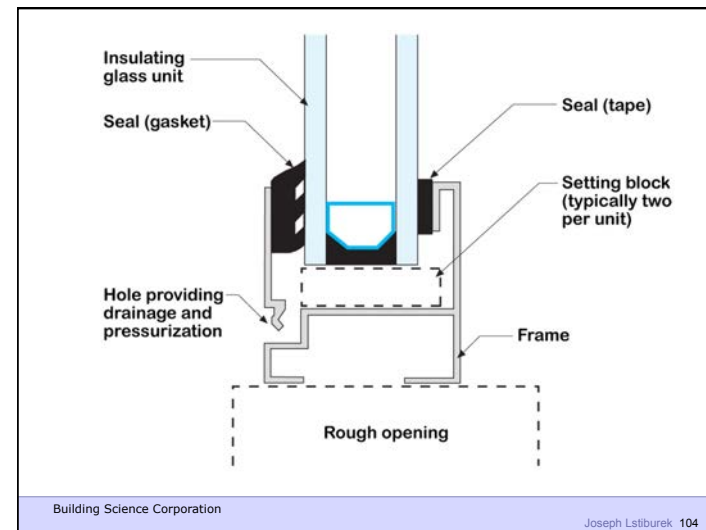
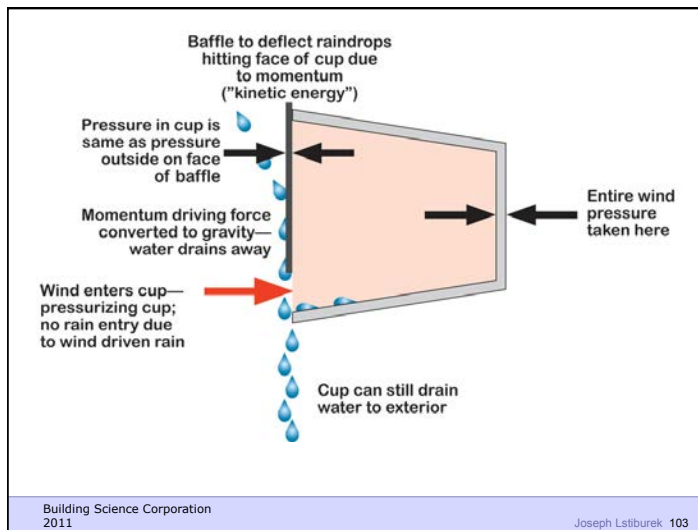
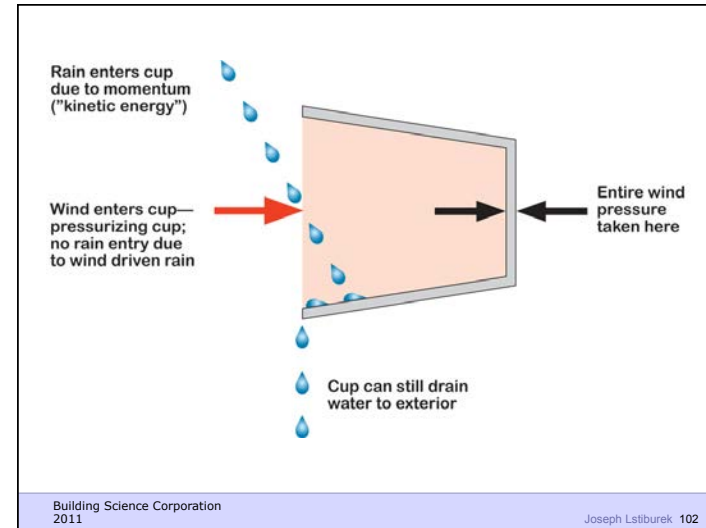
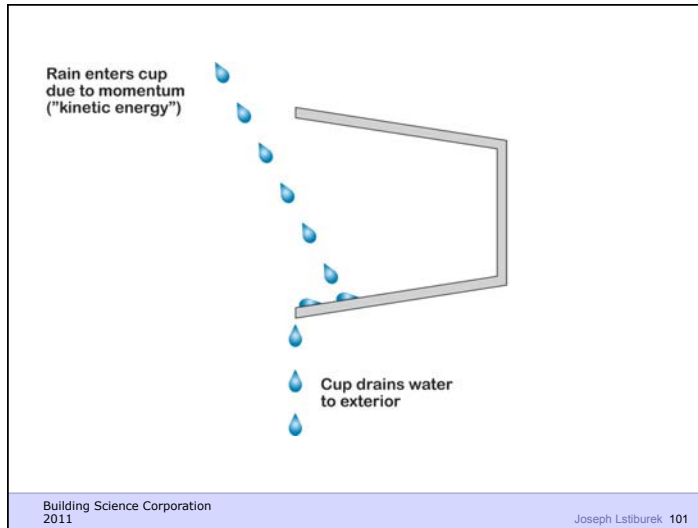


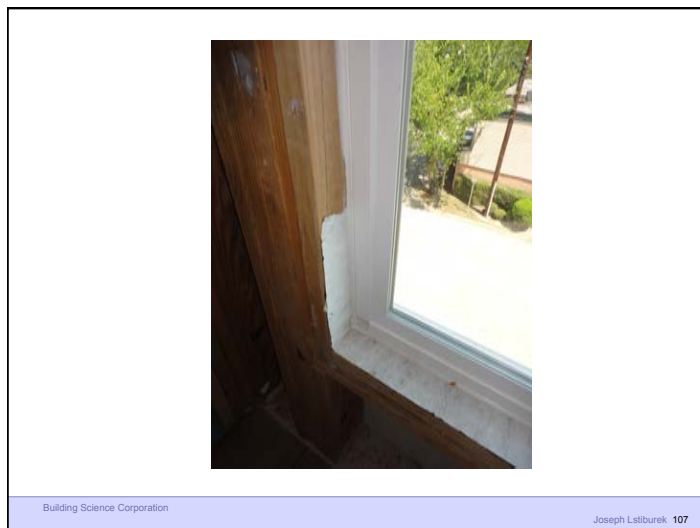
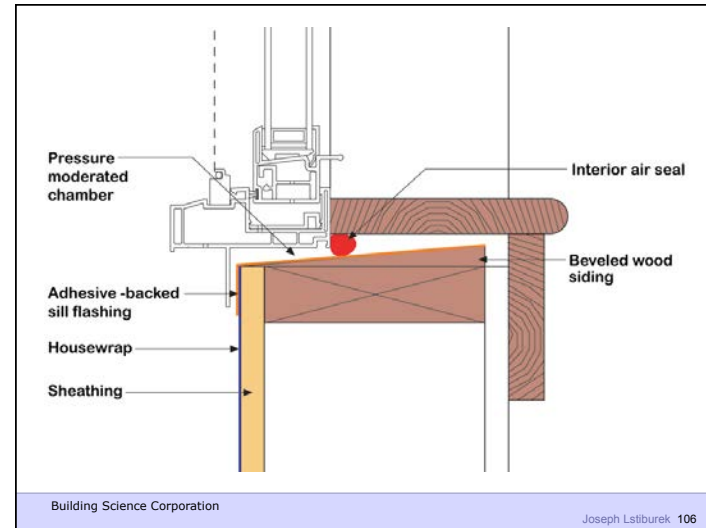
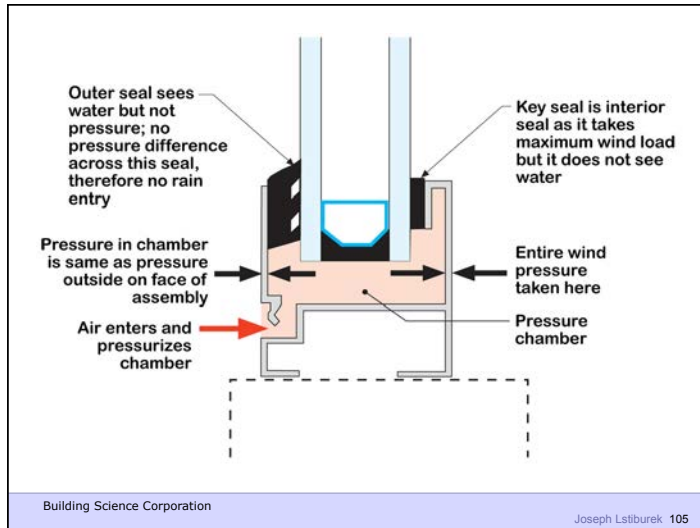


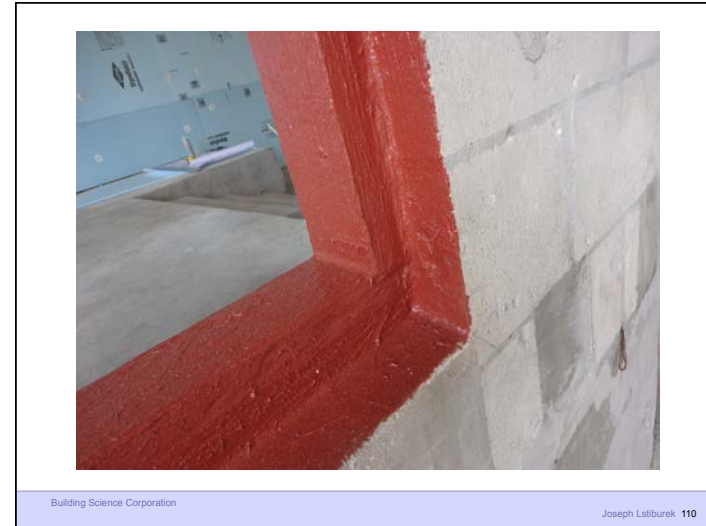


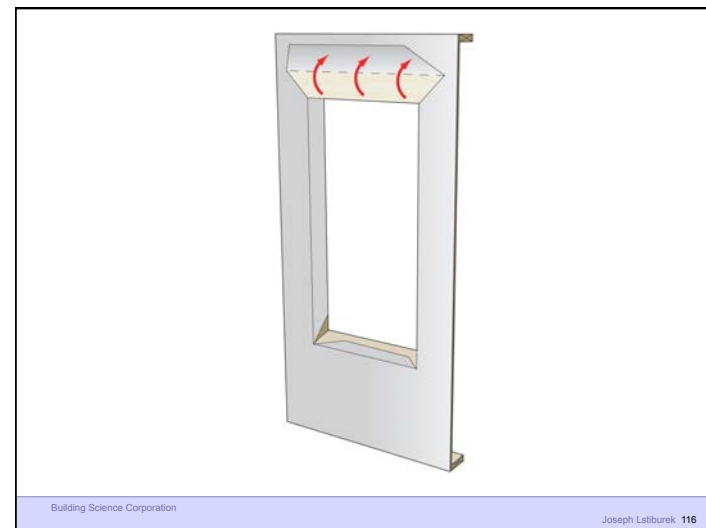
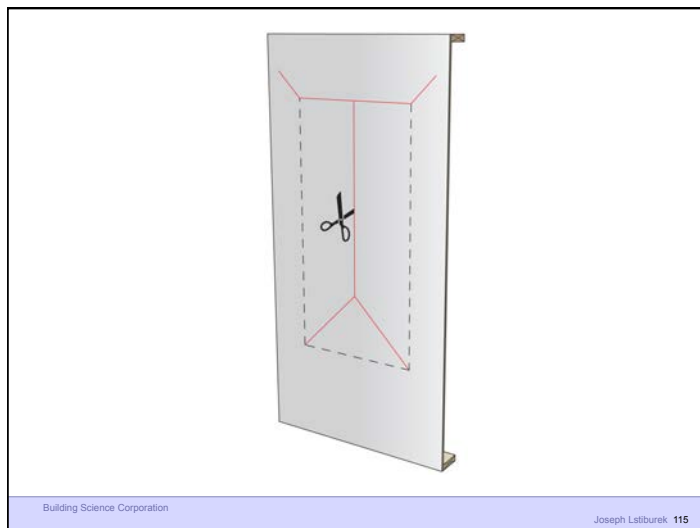
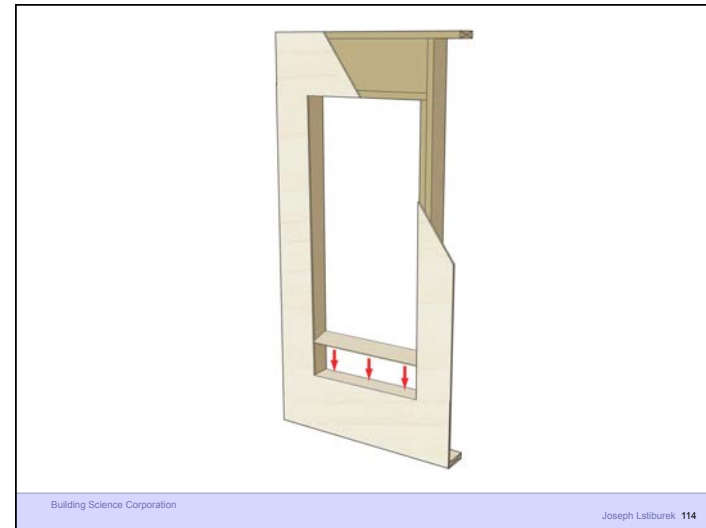
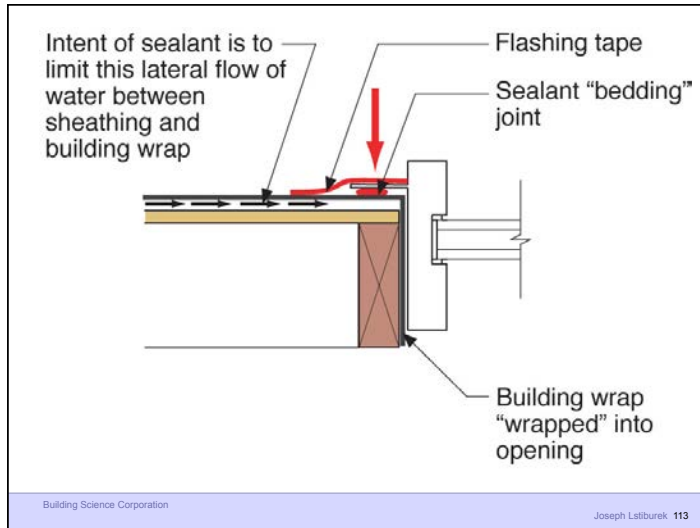


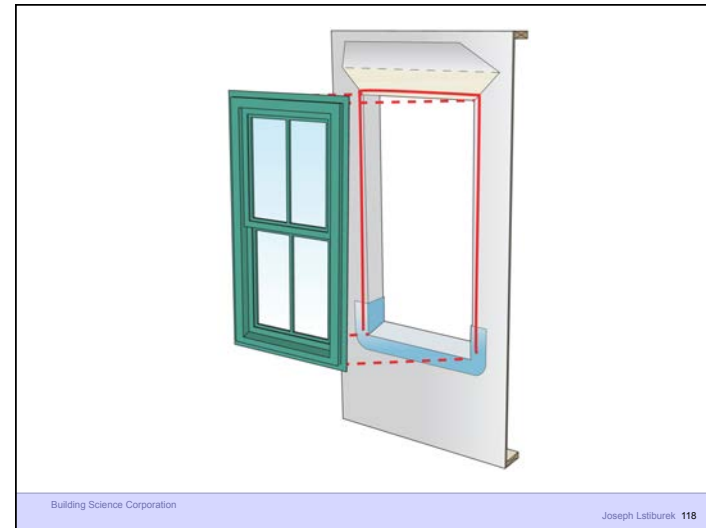
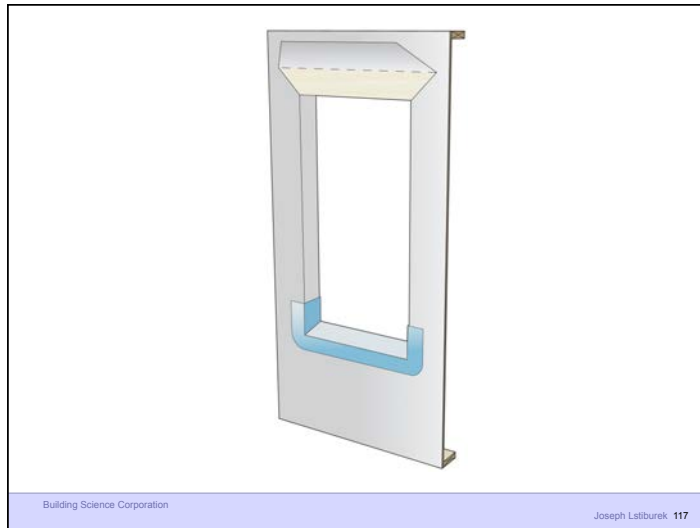




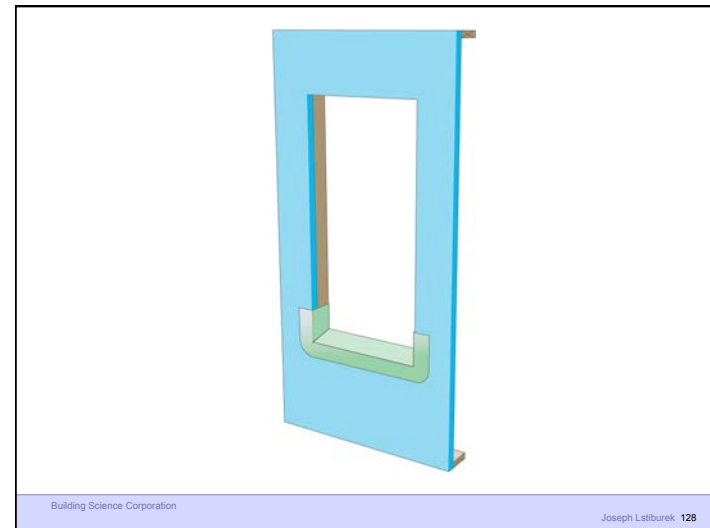
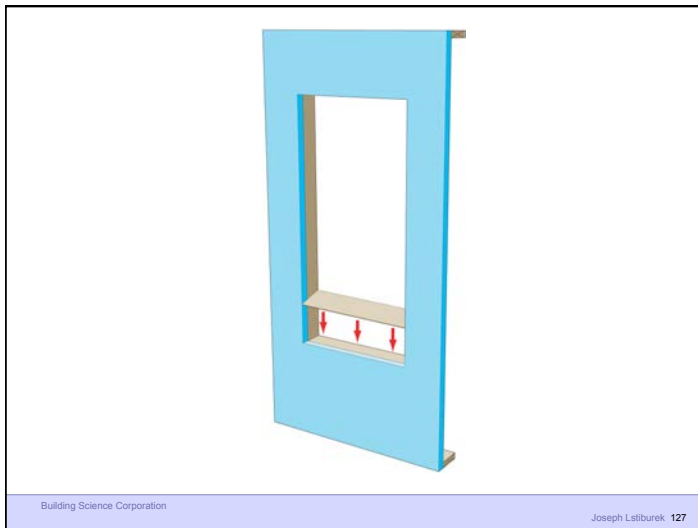
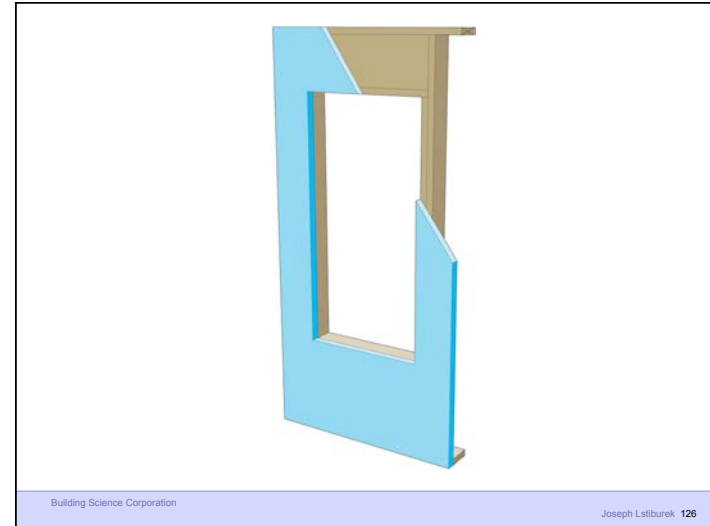


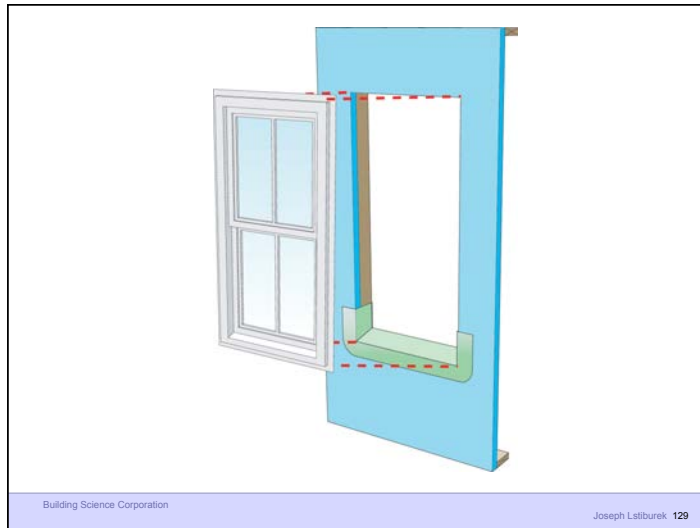




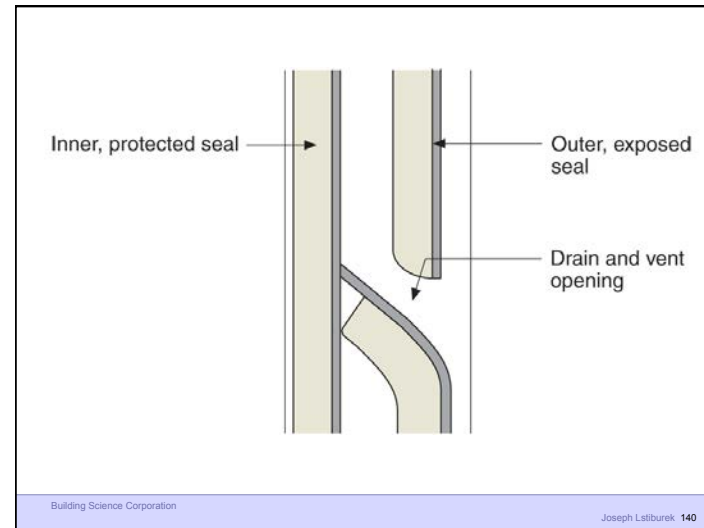
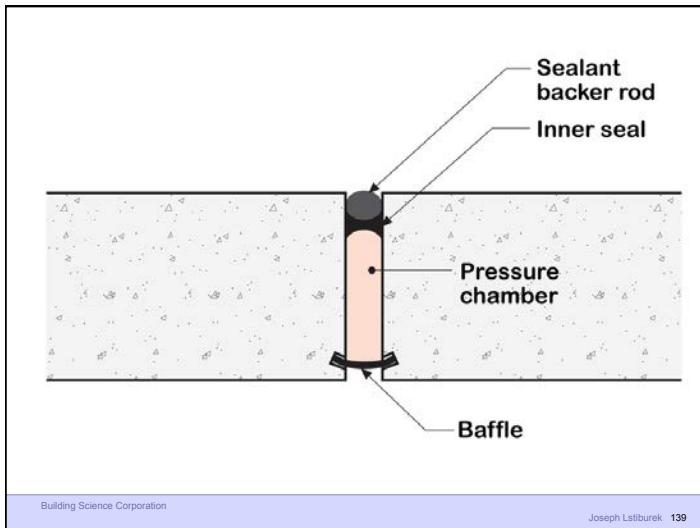
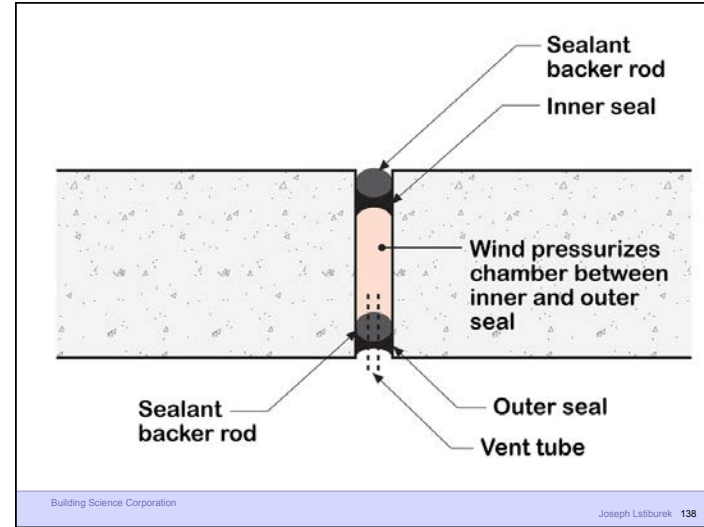


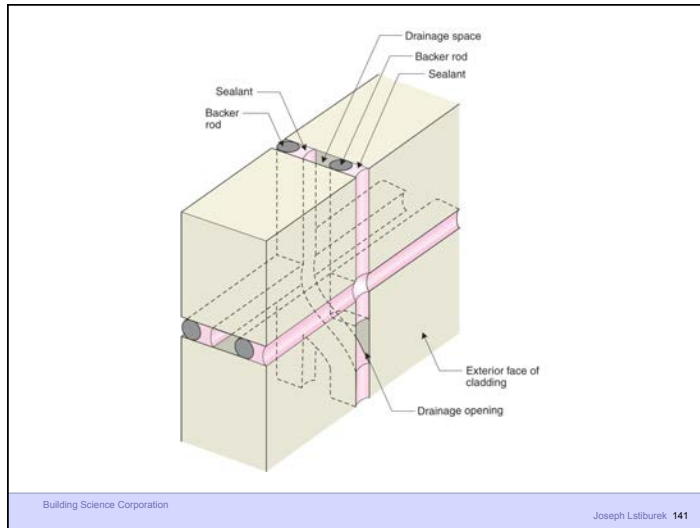


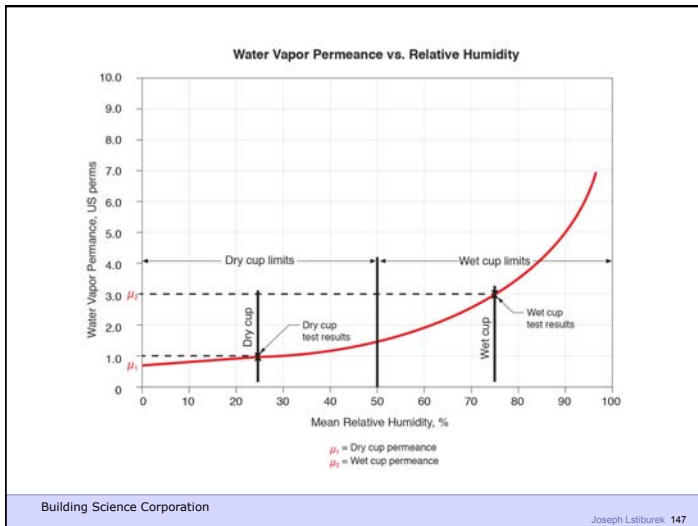
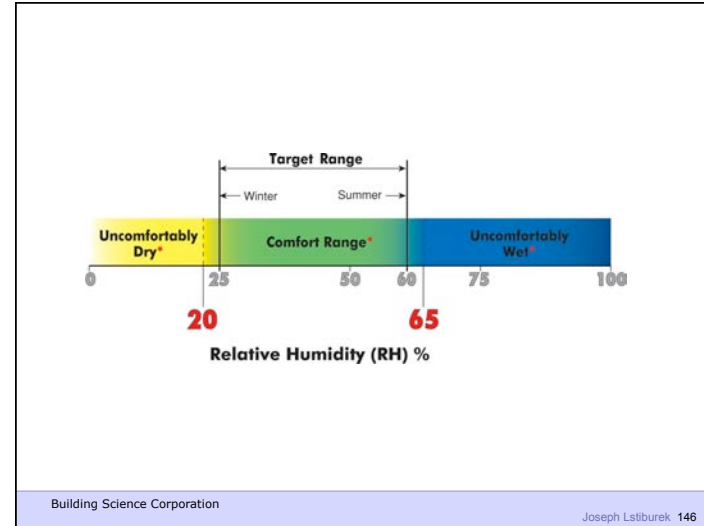


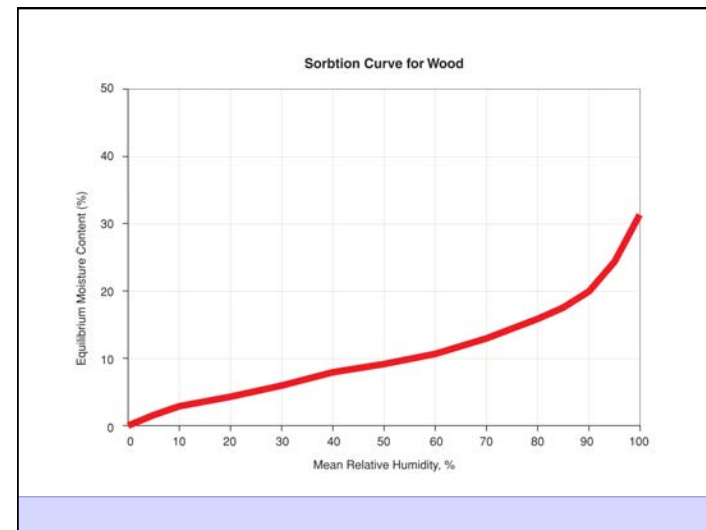
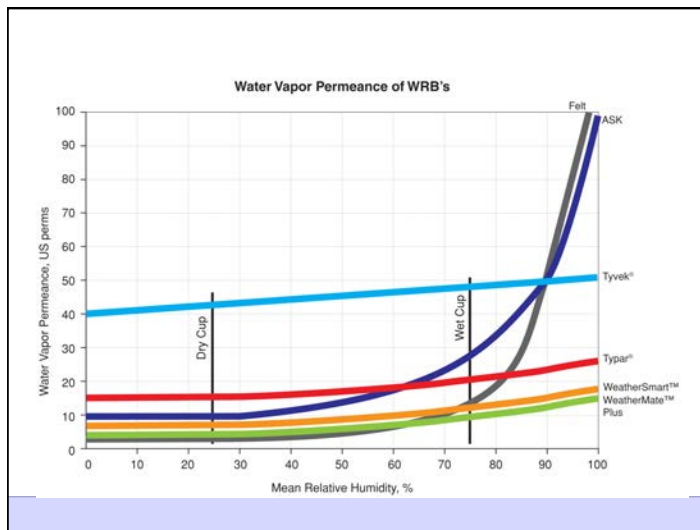
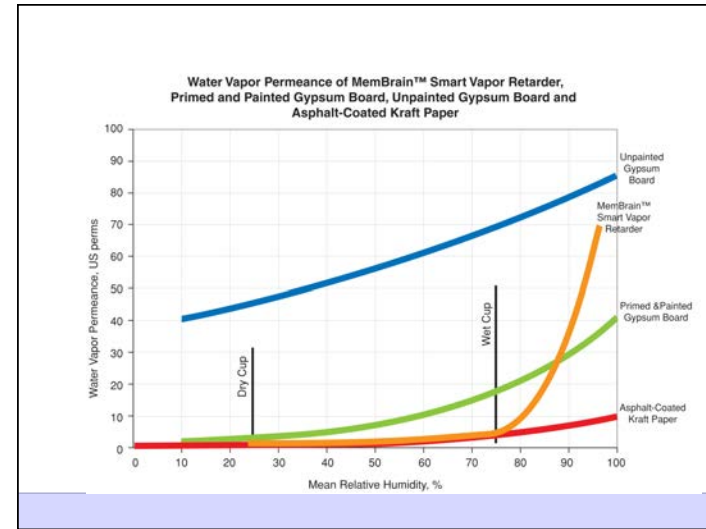
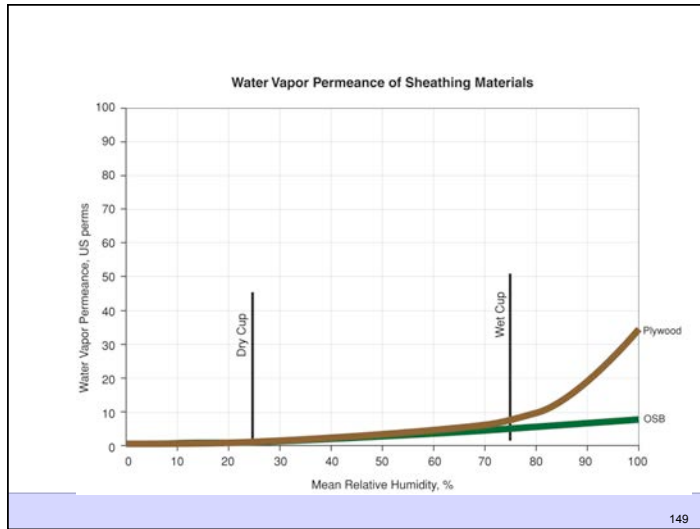


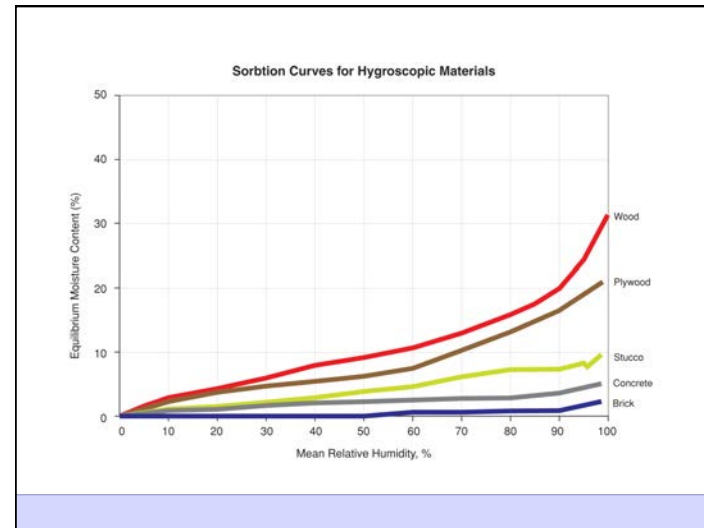
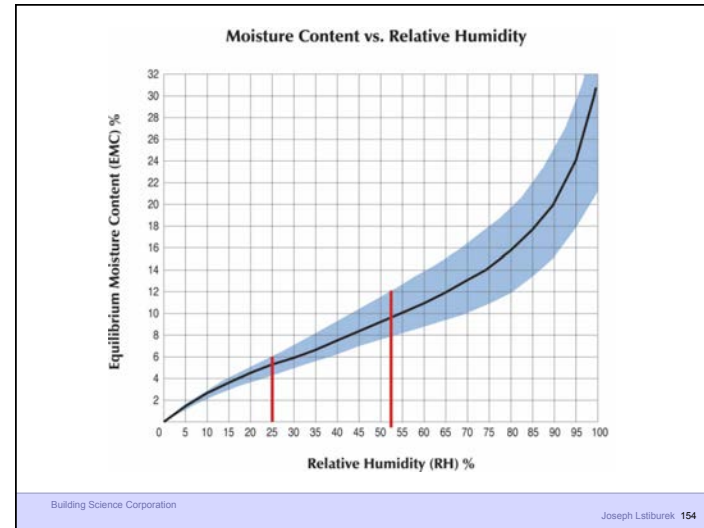
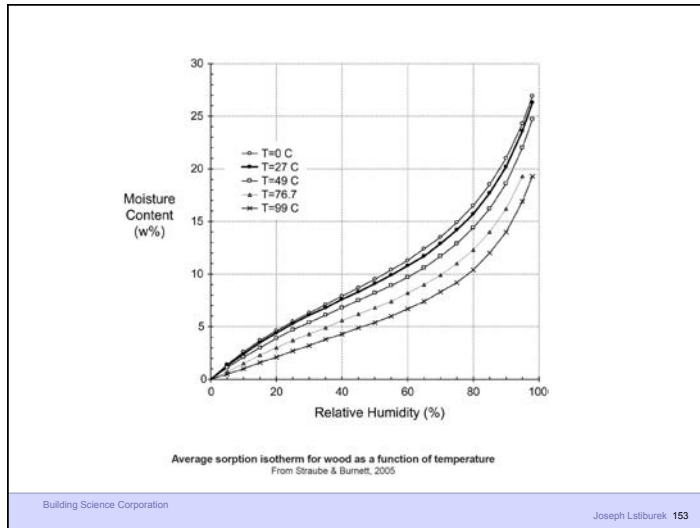


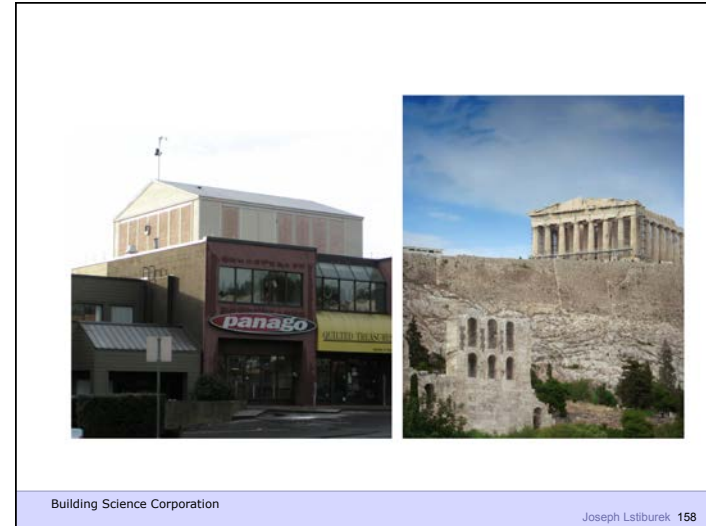
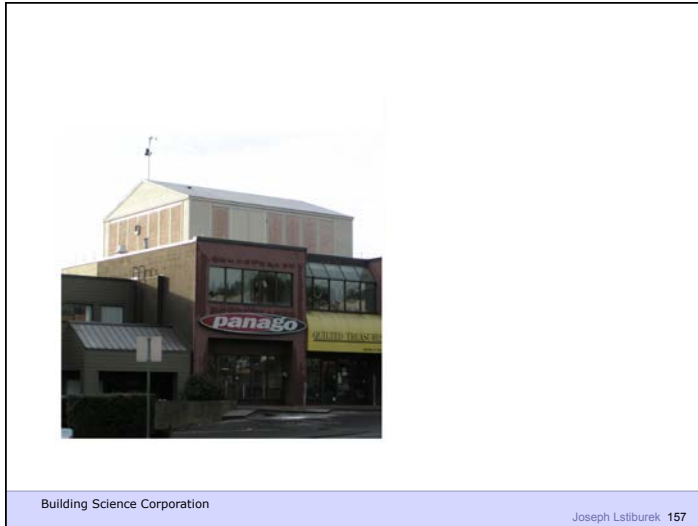


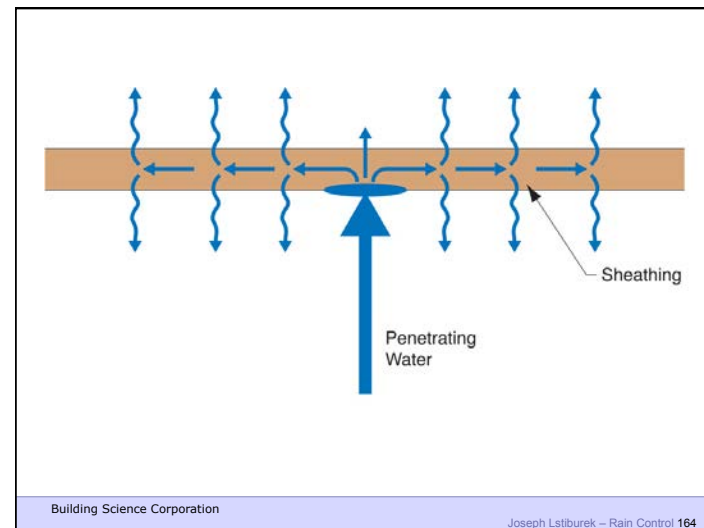
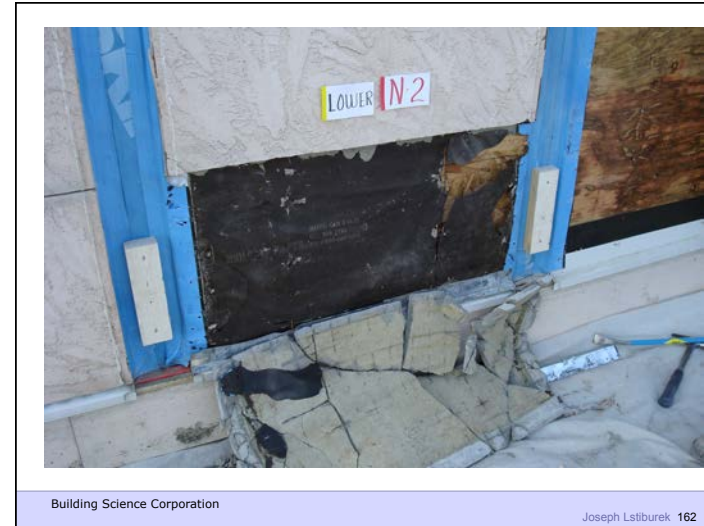


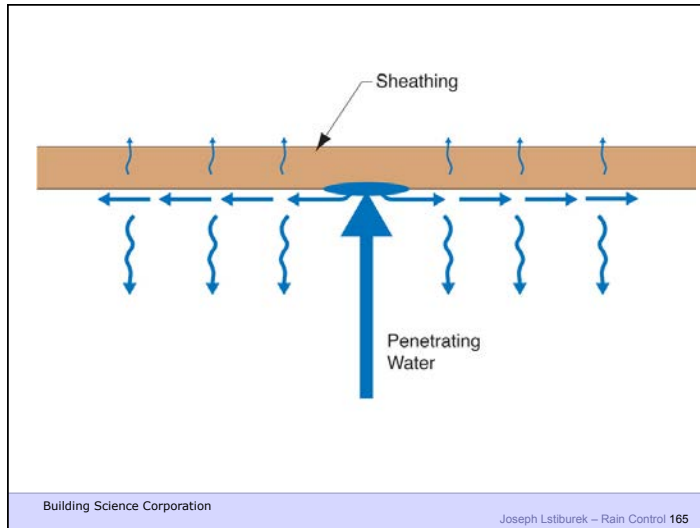






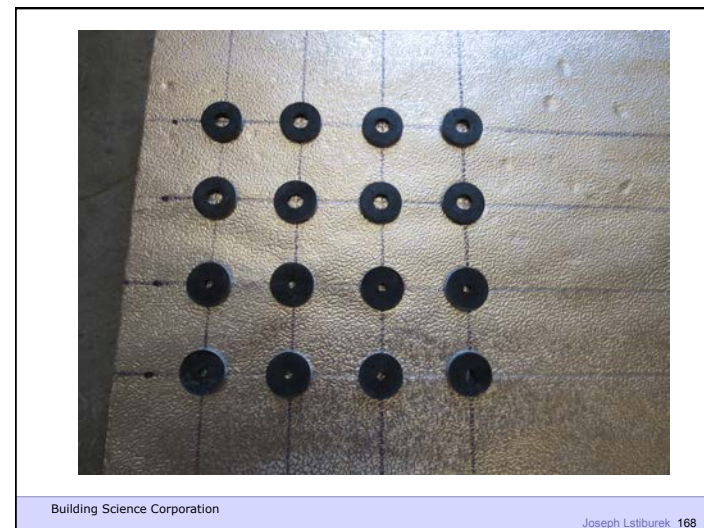






Rain Screen

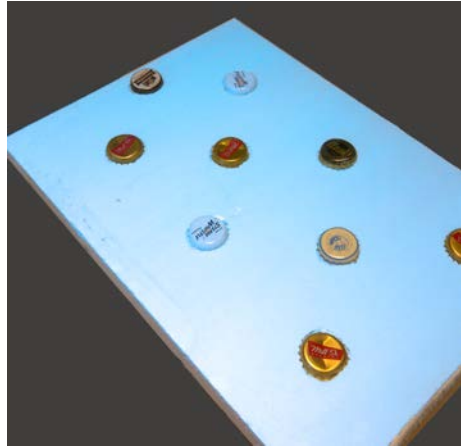
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Beer Screen?


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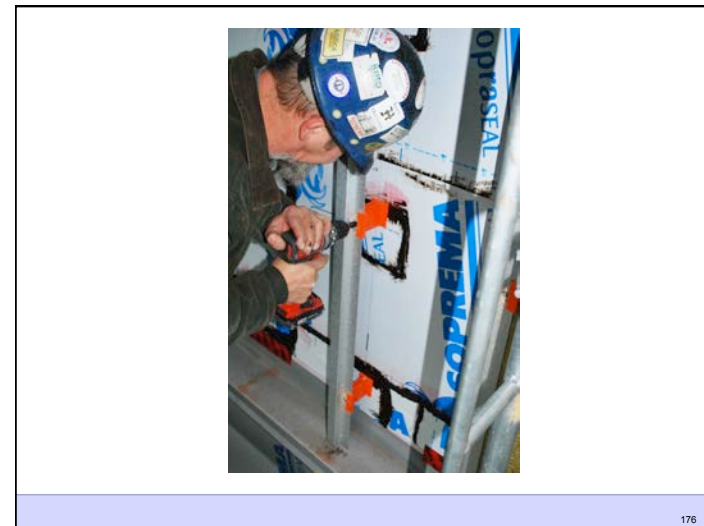
Rockwool

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



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