

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

Building Science

Adventures In Building Science

www.buildingscience.com

"It isn't what we don't know that gives us trouble, it's what we know that ain't so"

Will Rogers

"There are known knowns. These are things we know. There are known unknowns. There are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.

Donald Rumsfeld

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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

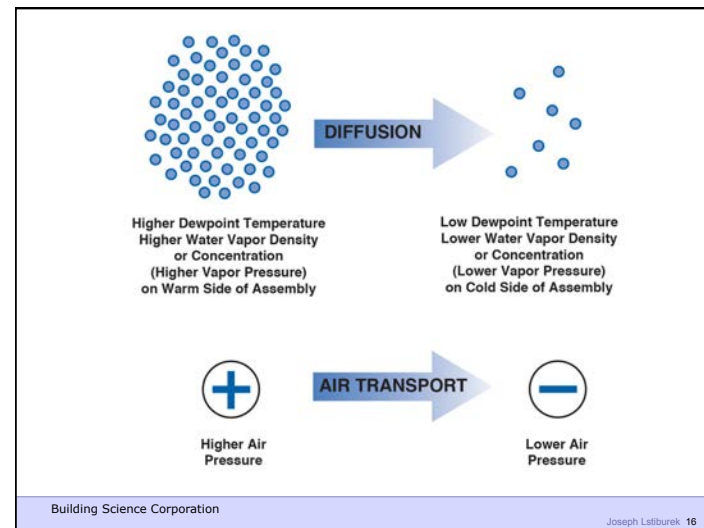
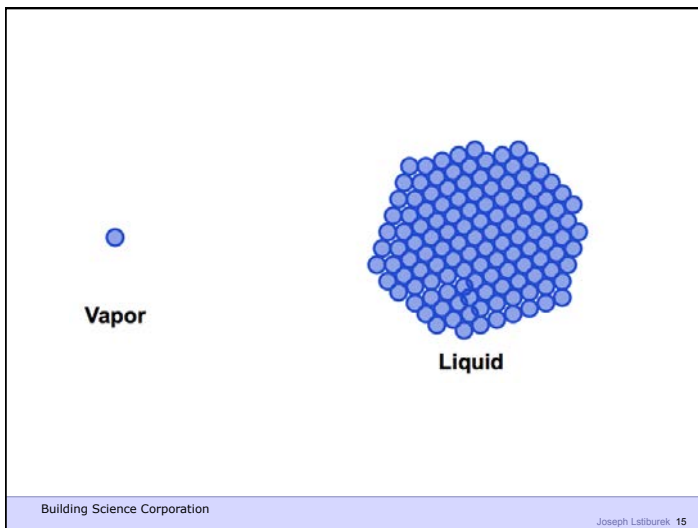
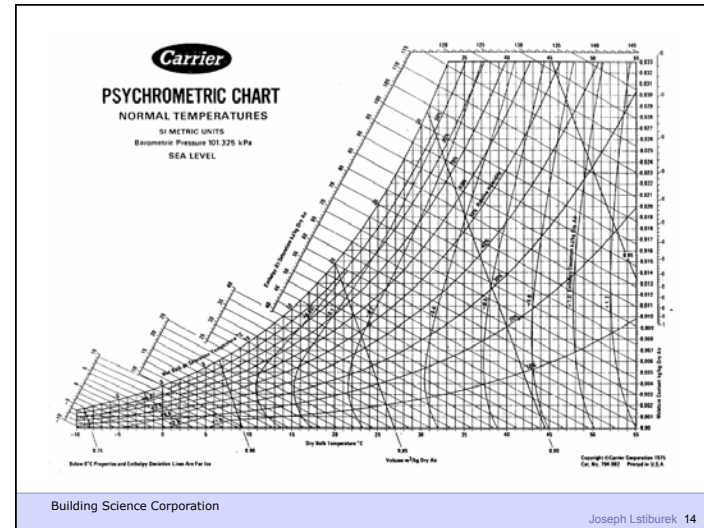
Vapor Diffusion

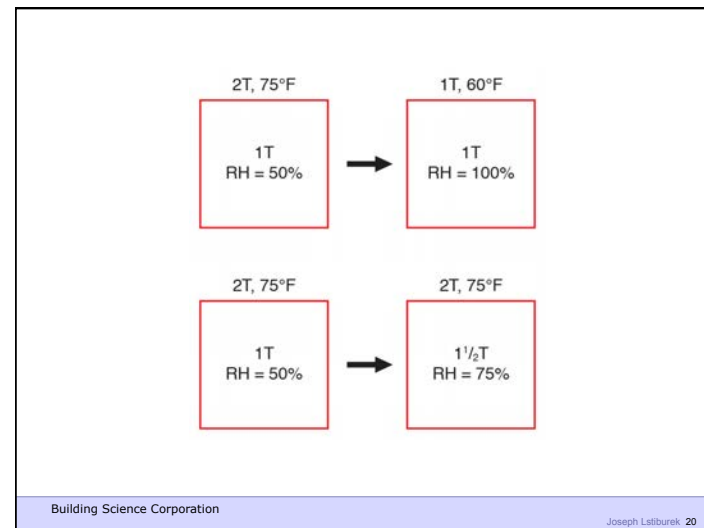
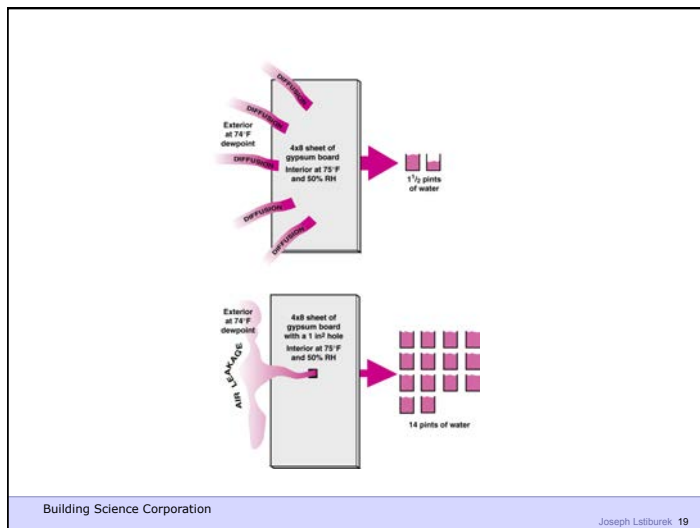
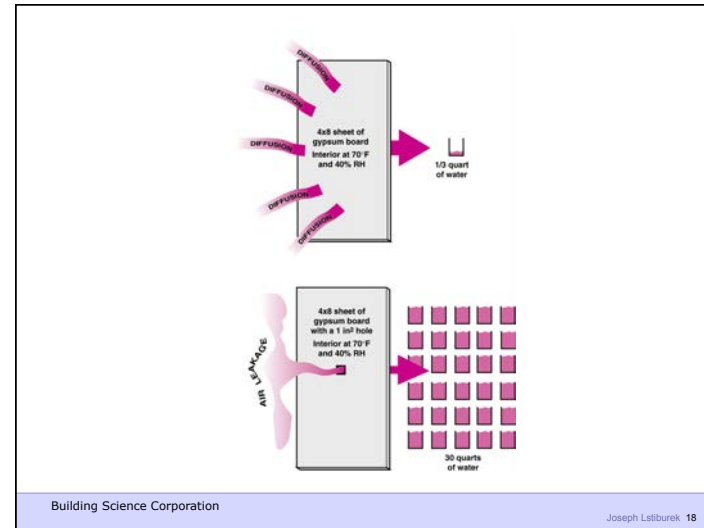
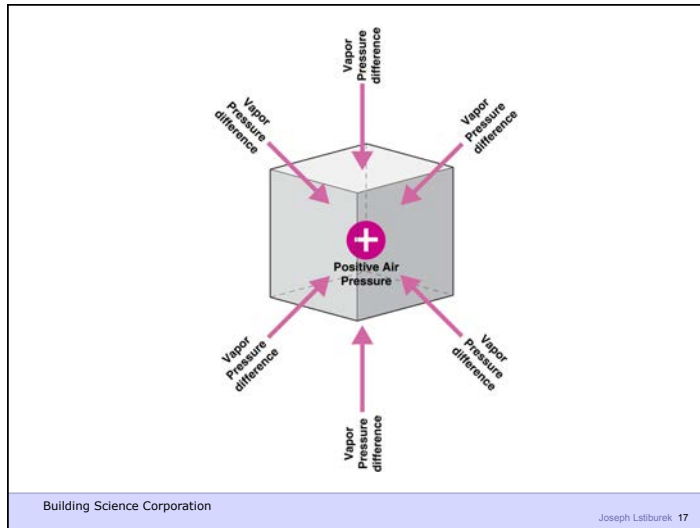
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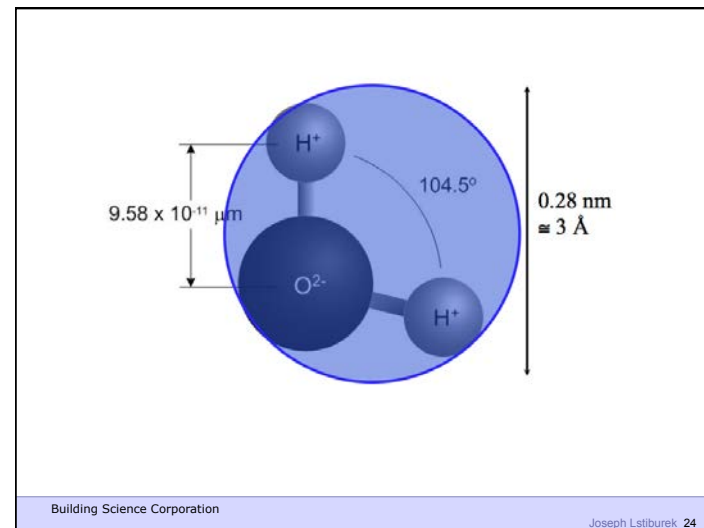
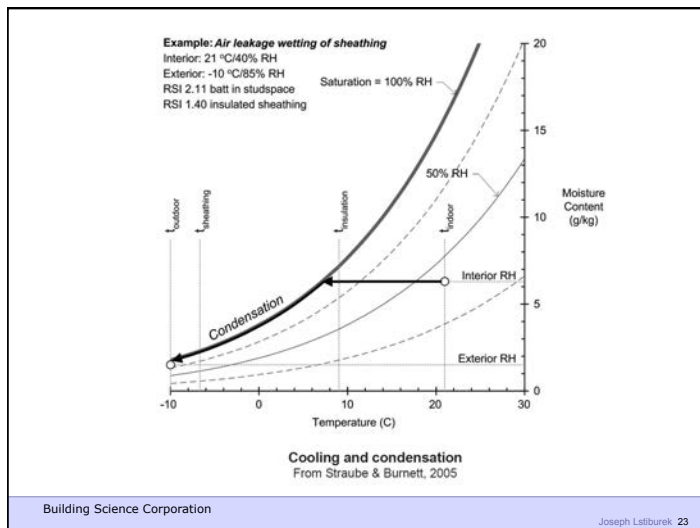
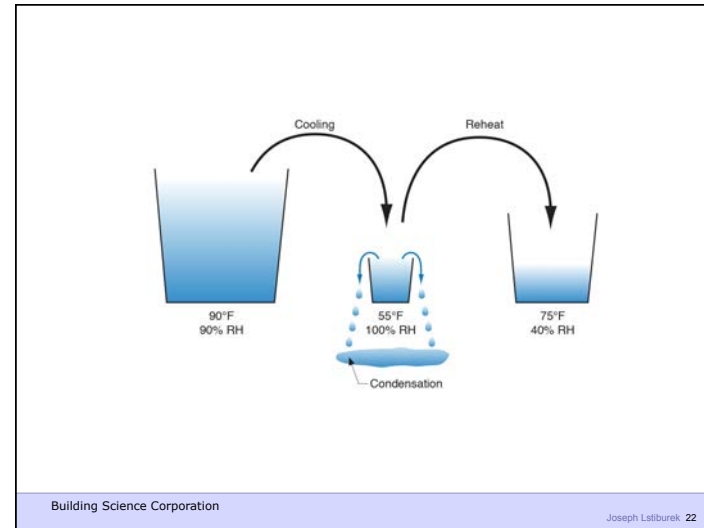
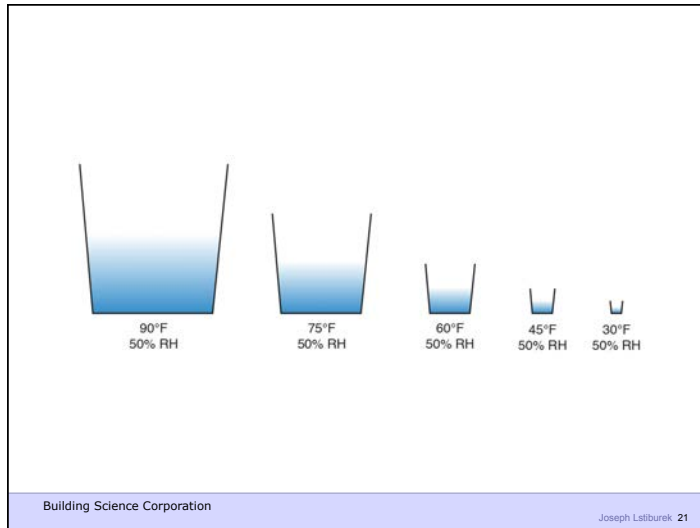
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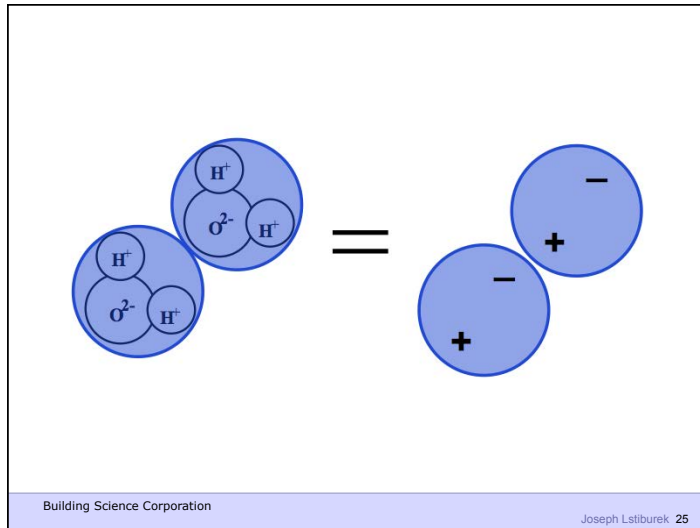
Thermodynamic Potential

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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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Heat
Air
Moisture

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HAM

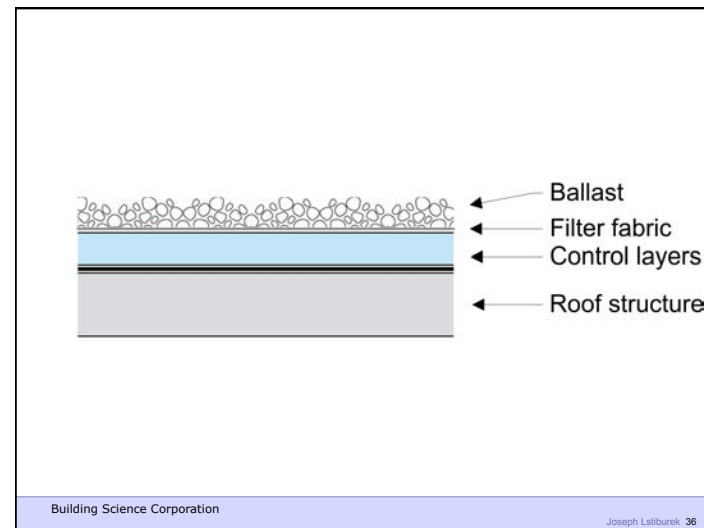
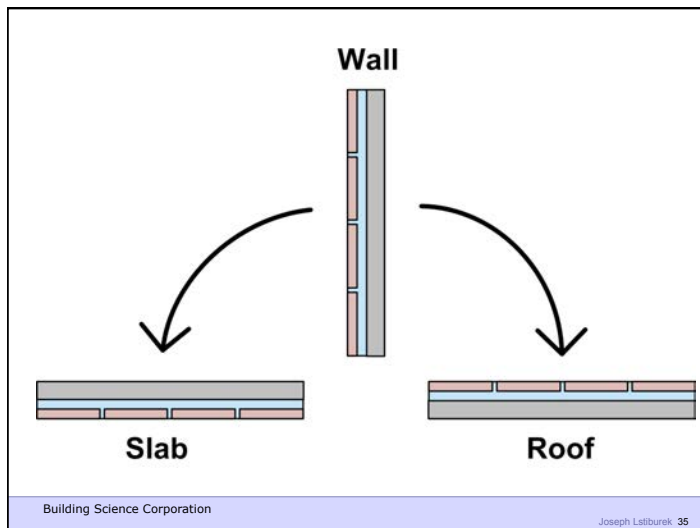
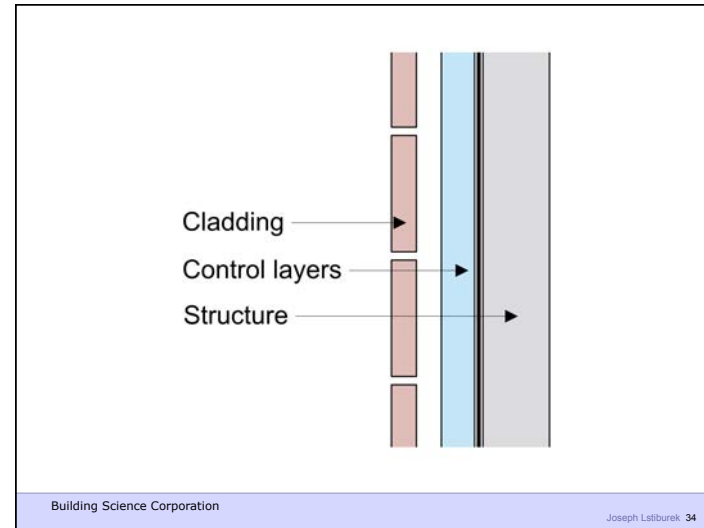
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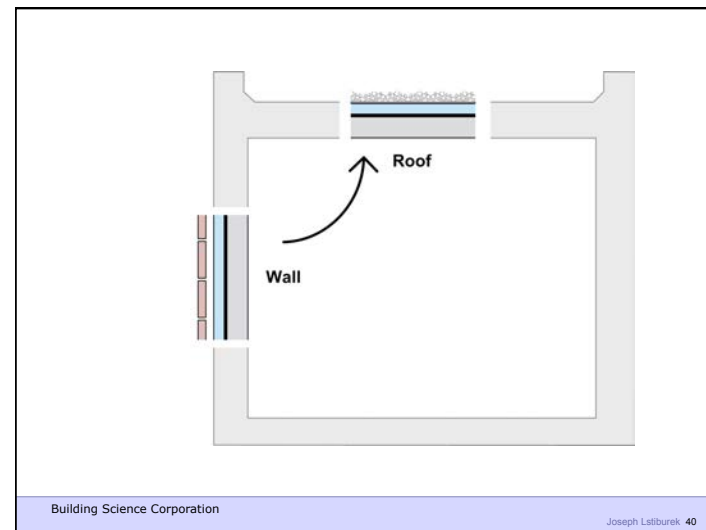
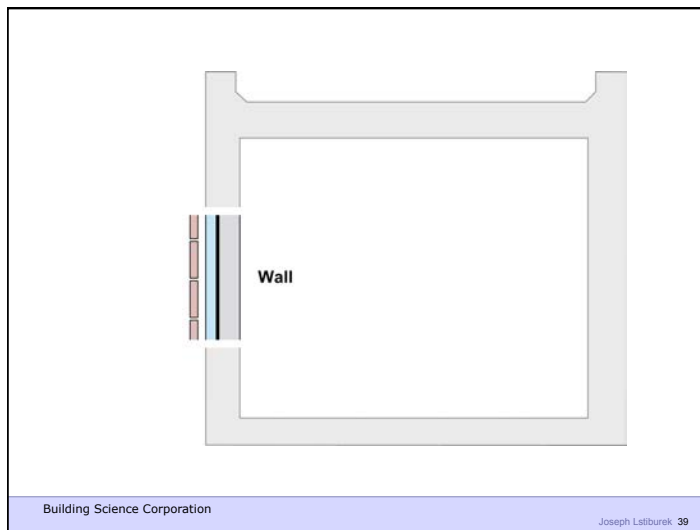
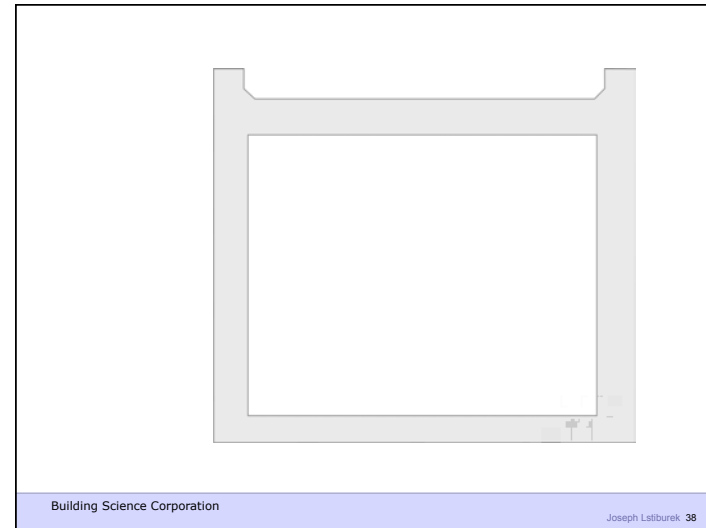
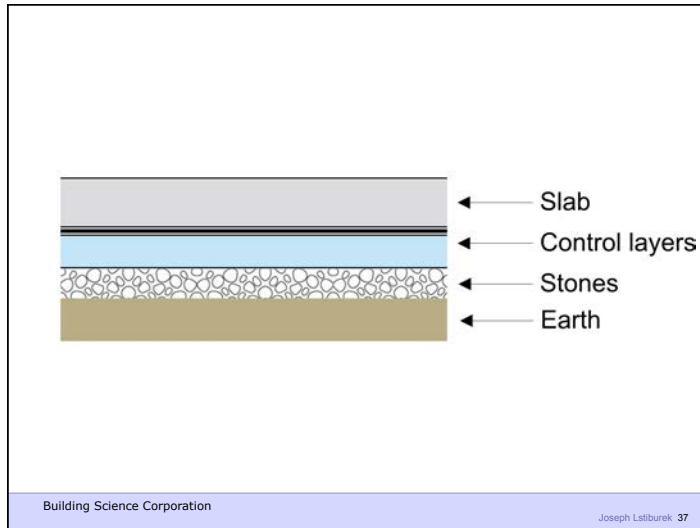
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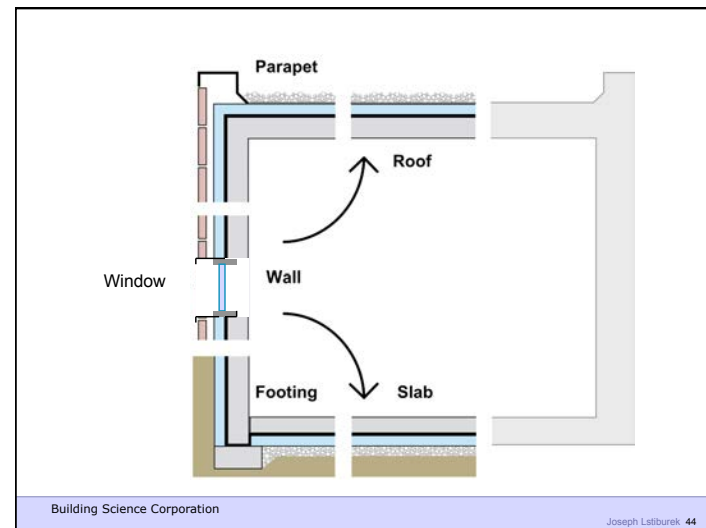
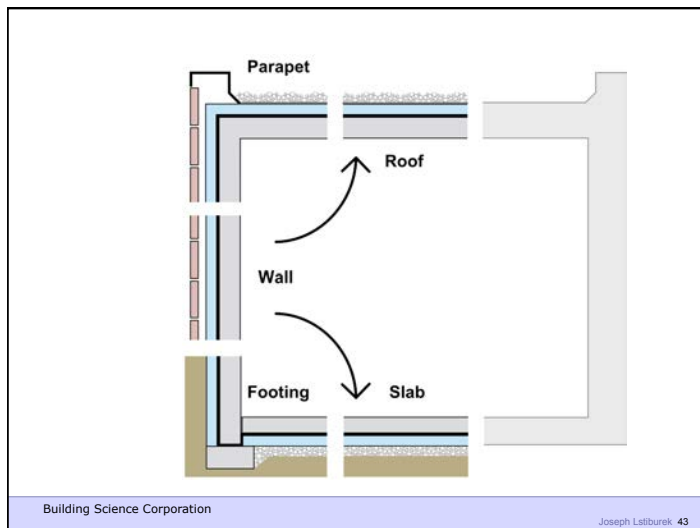
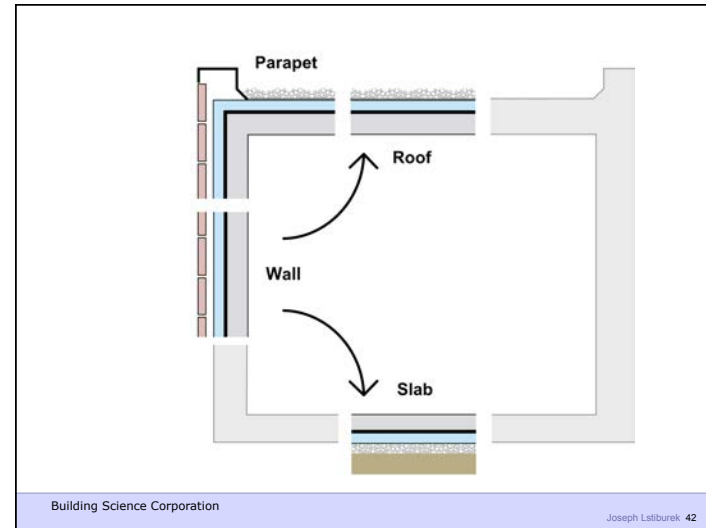
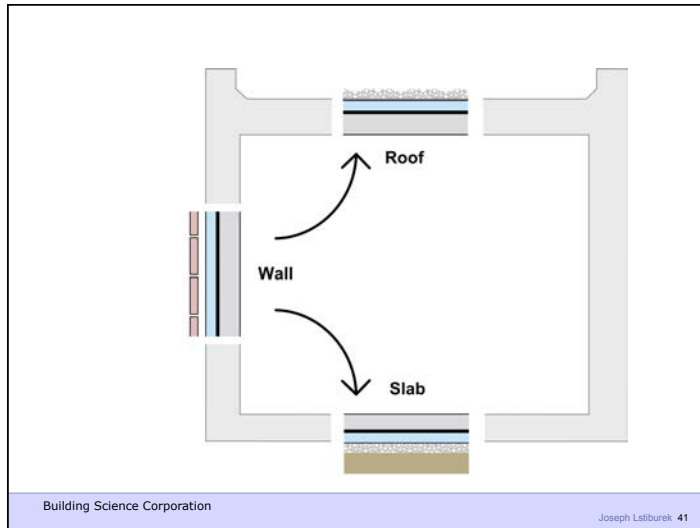
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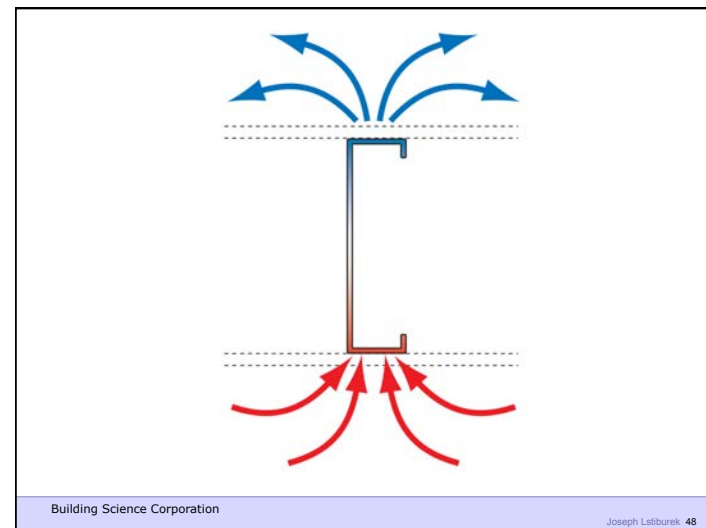
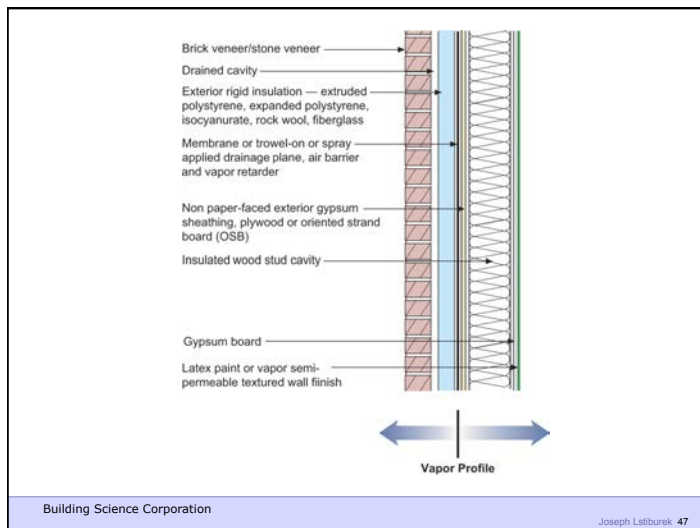
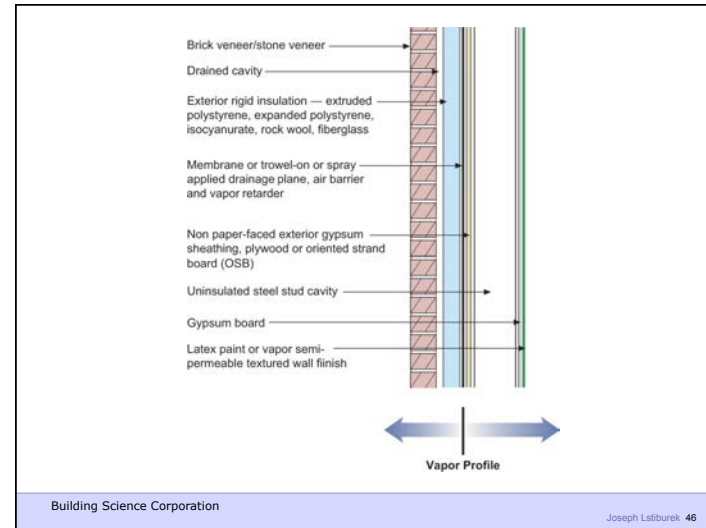
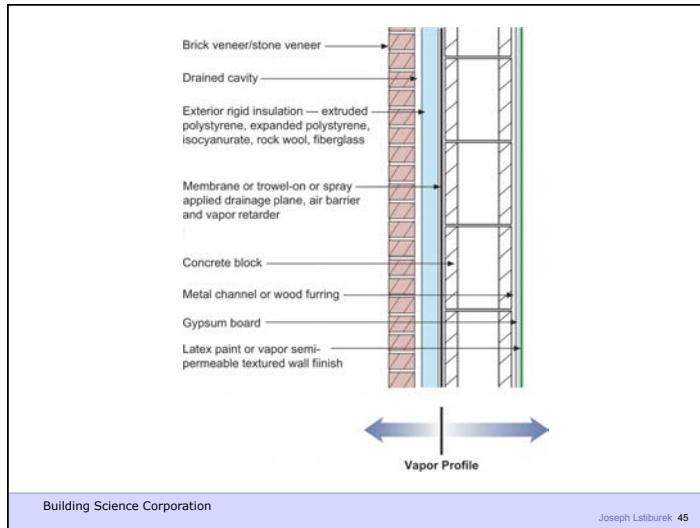
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

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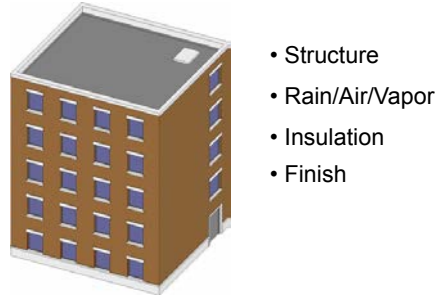








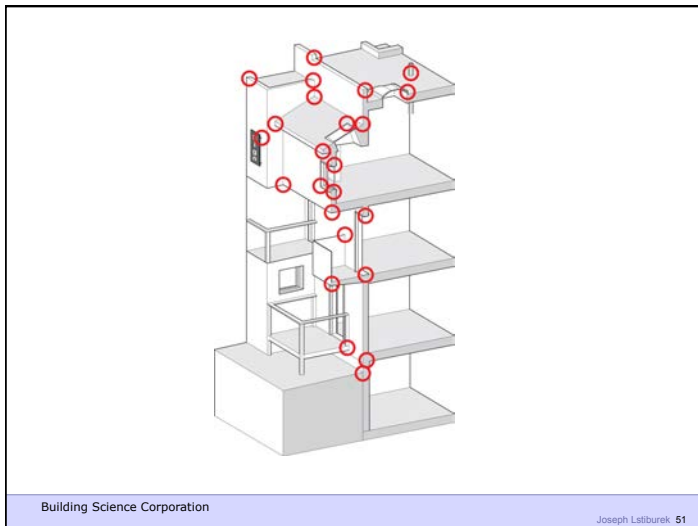
Commercial Enclosure: Simple Layers

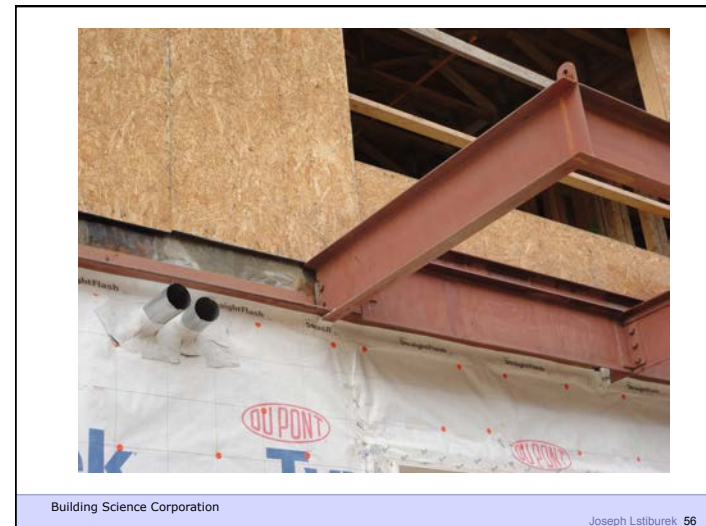
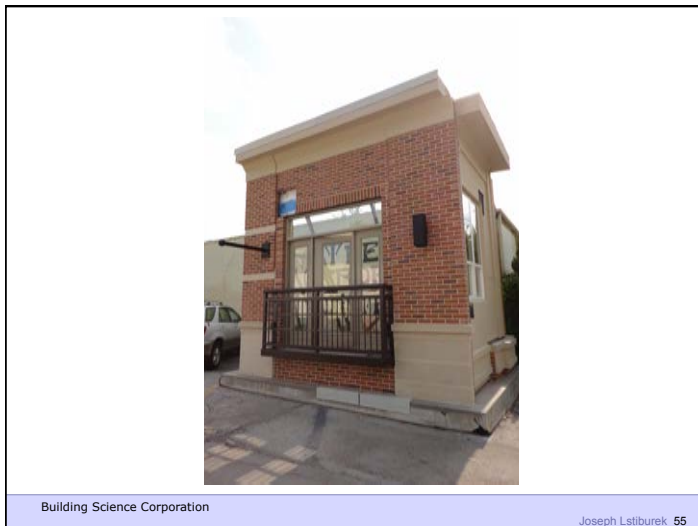


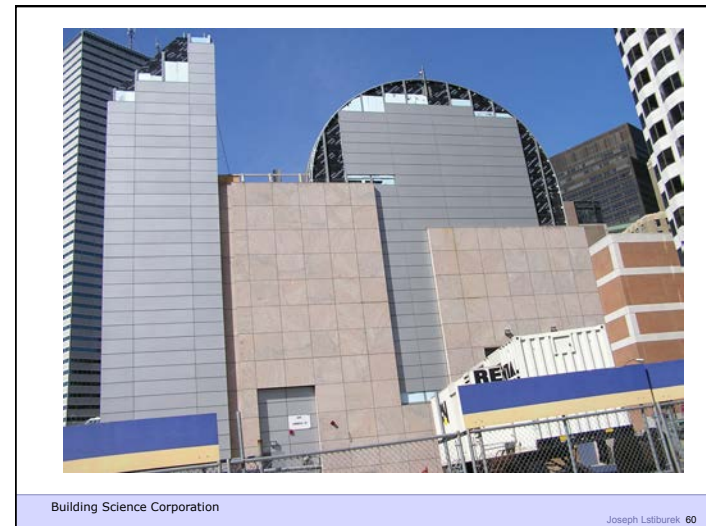
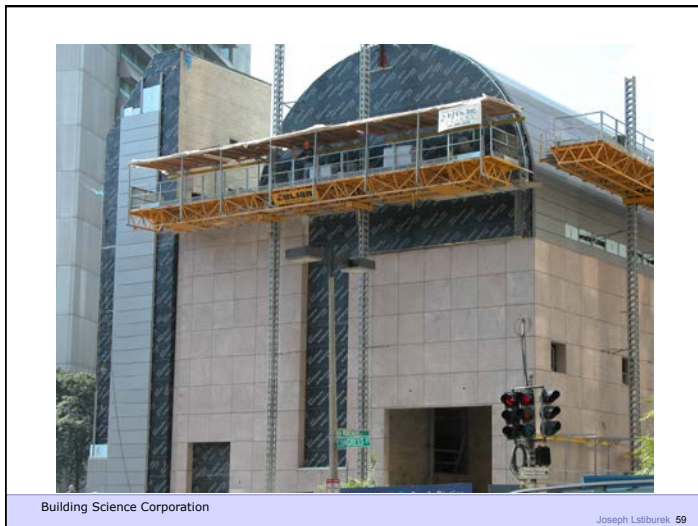
- Structure
- Rain/Air/Vapor
- Insulation
- Finish

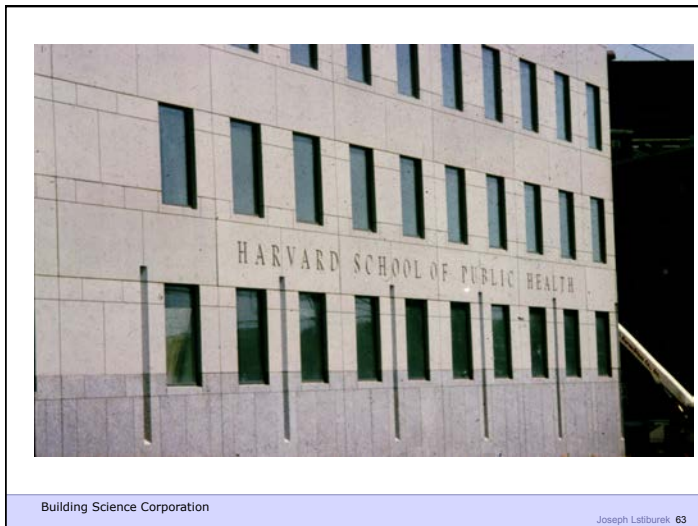
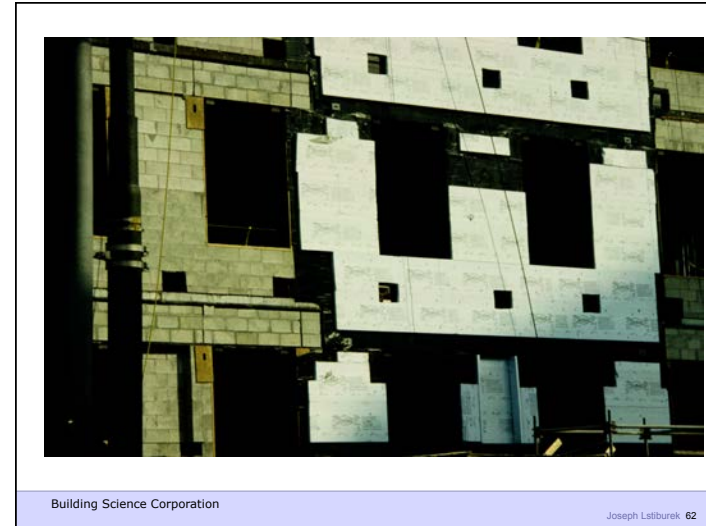
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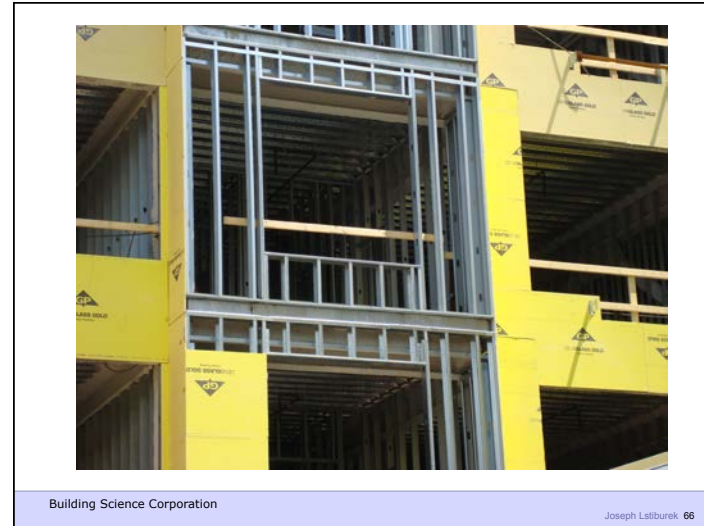
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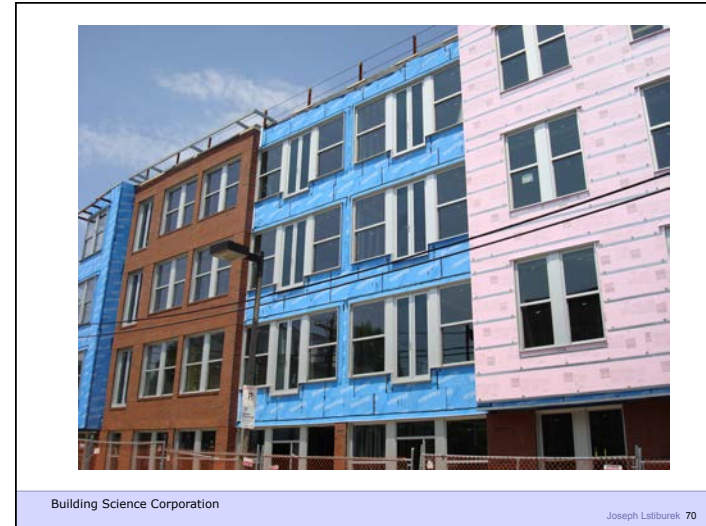
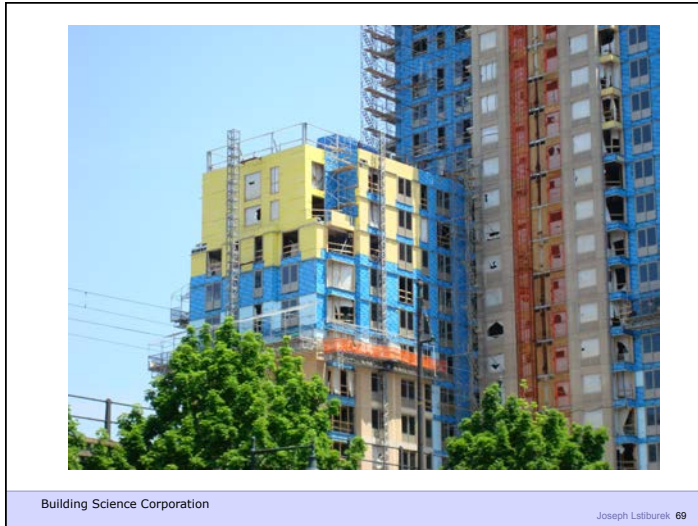






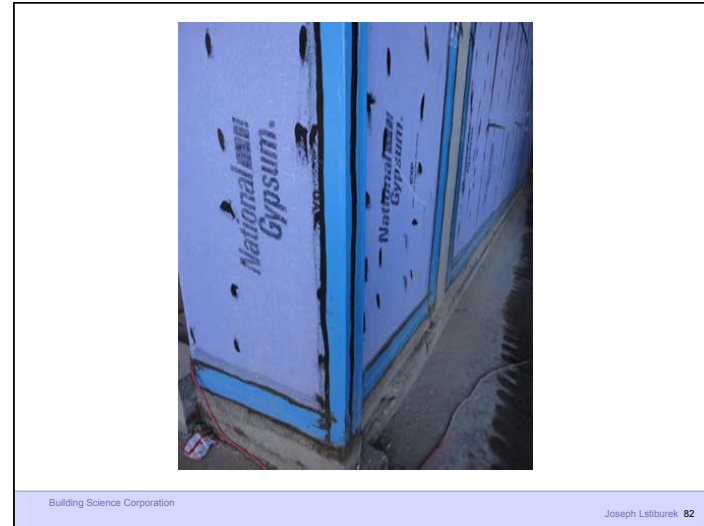


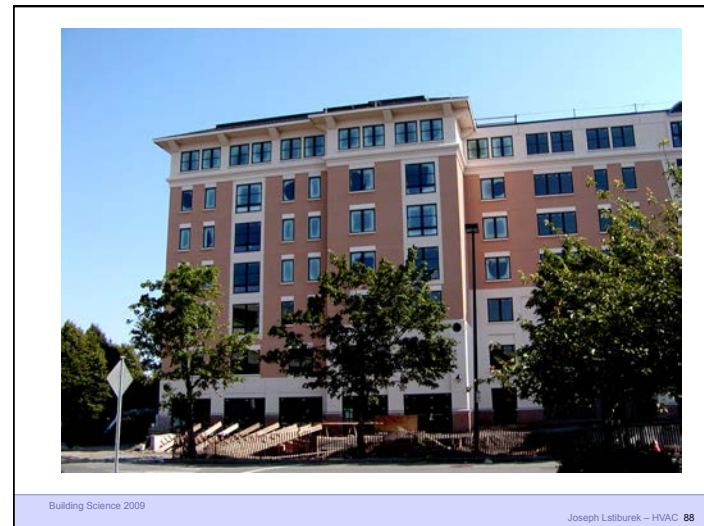
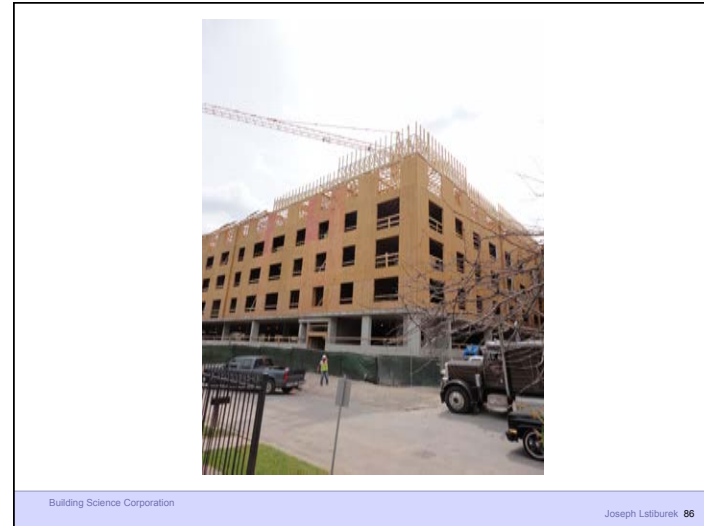


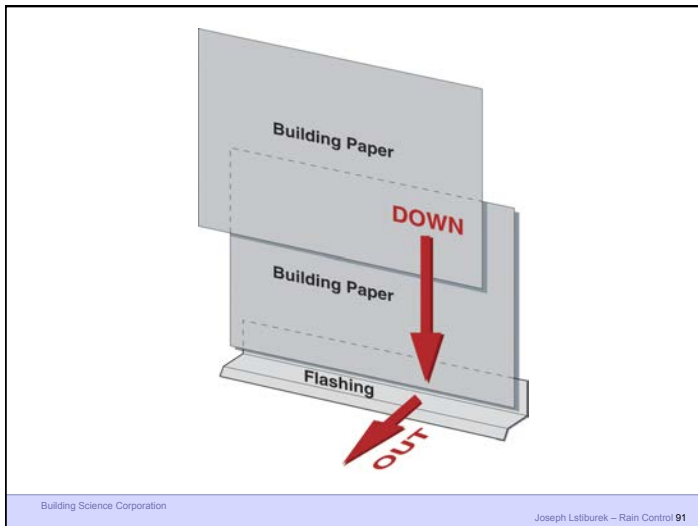
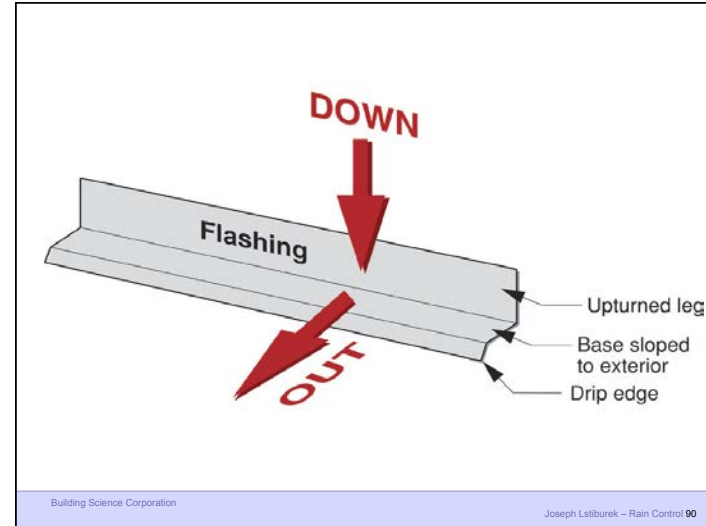


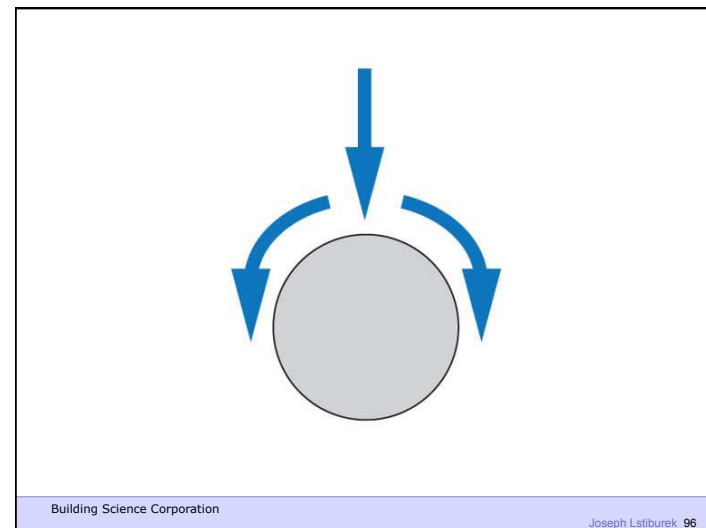
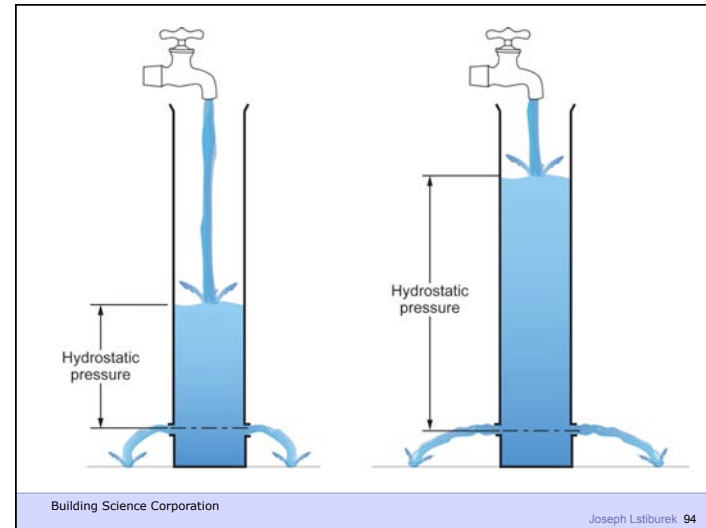


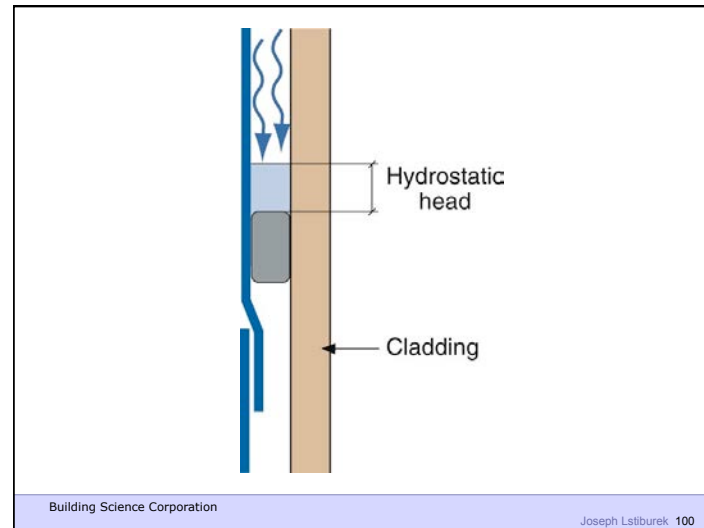
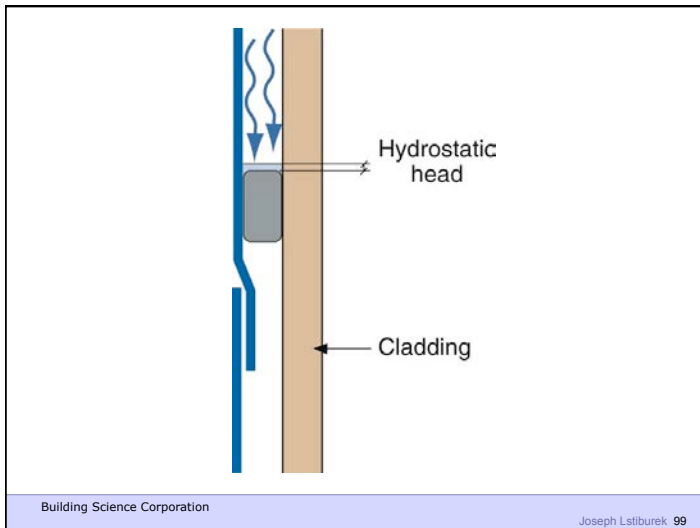
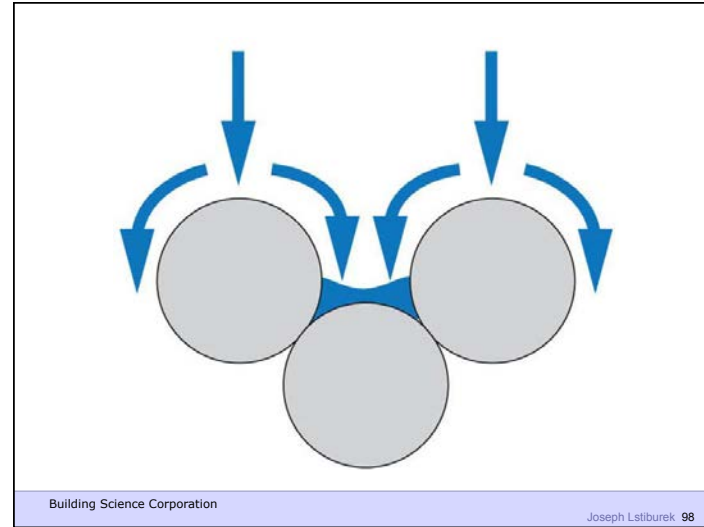
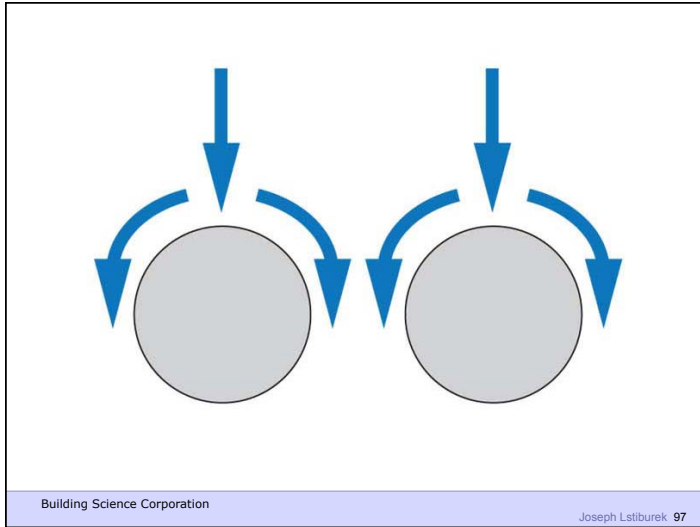


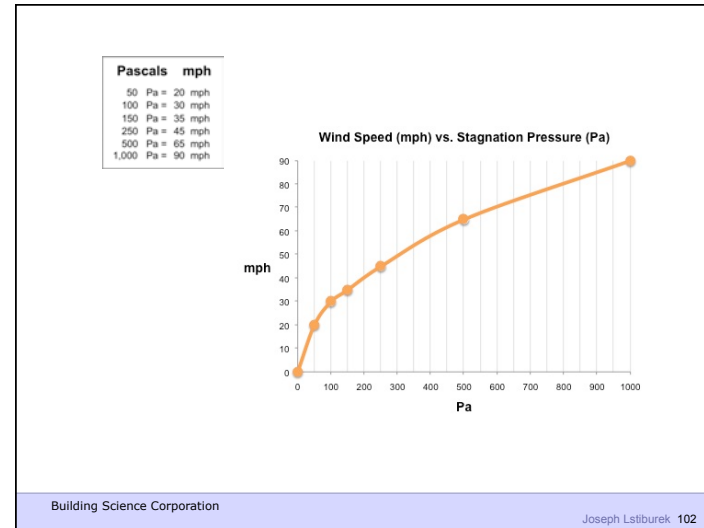
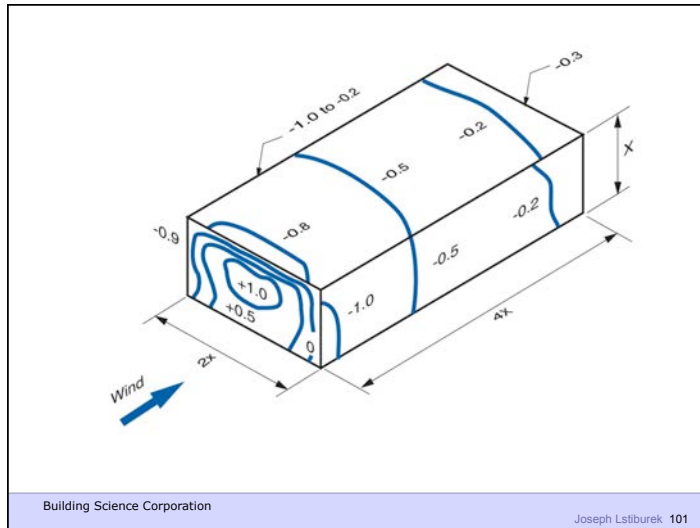


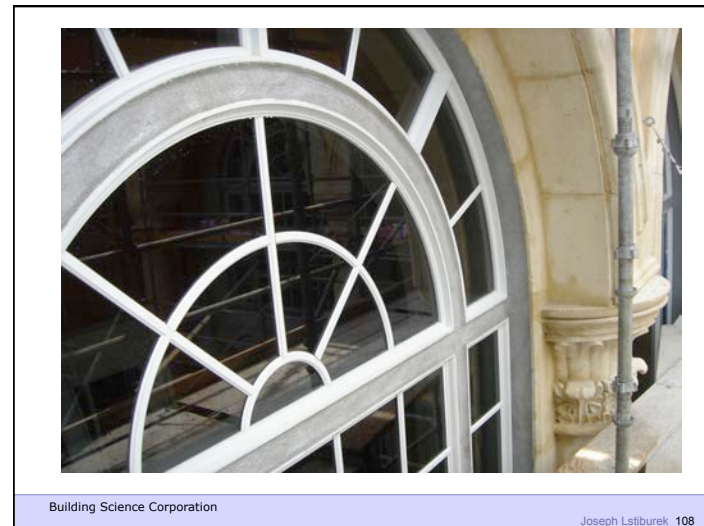


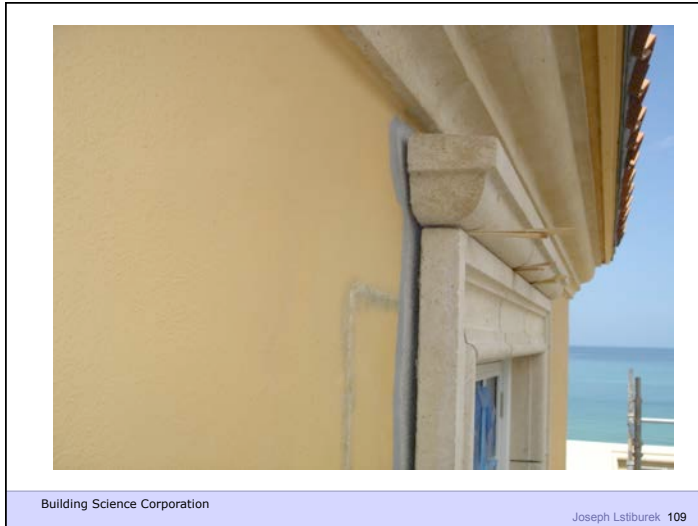






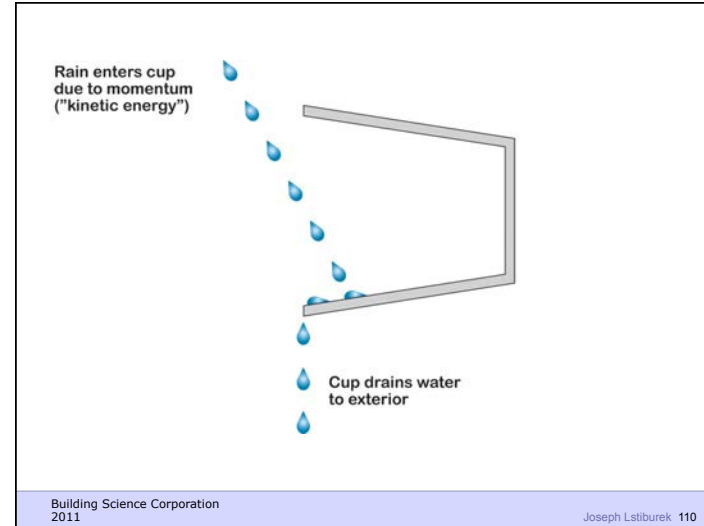






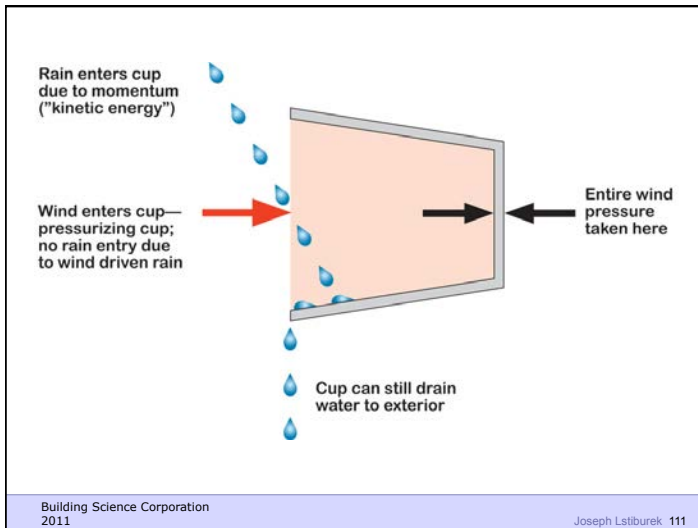
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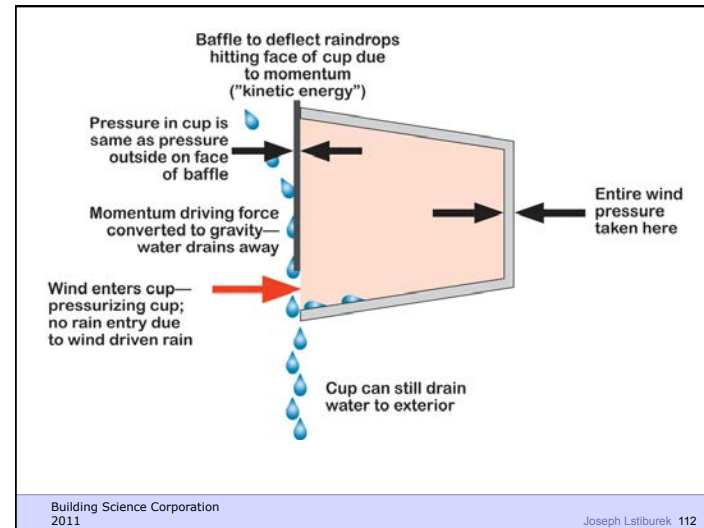
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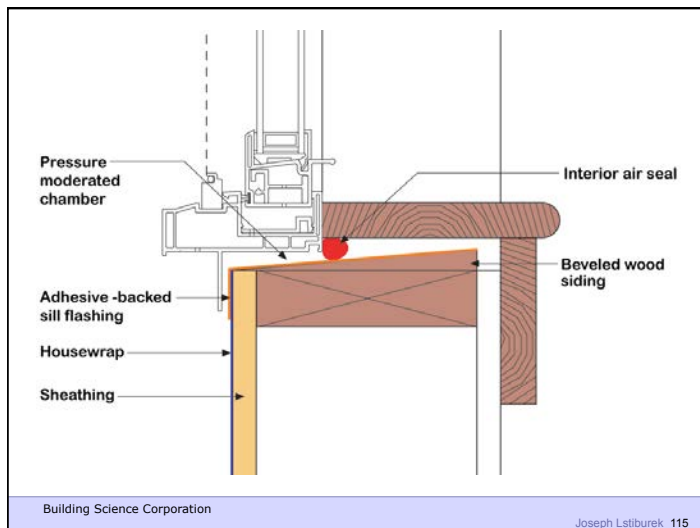
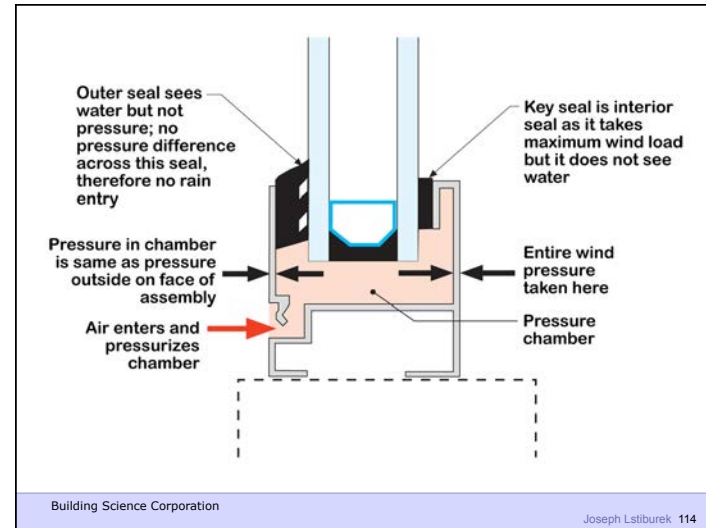
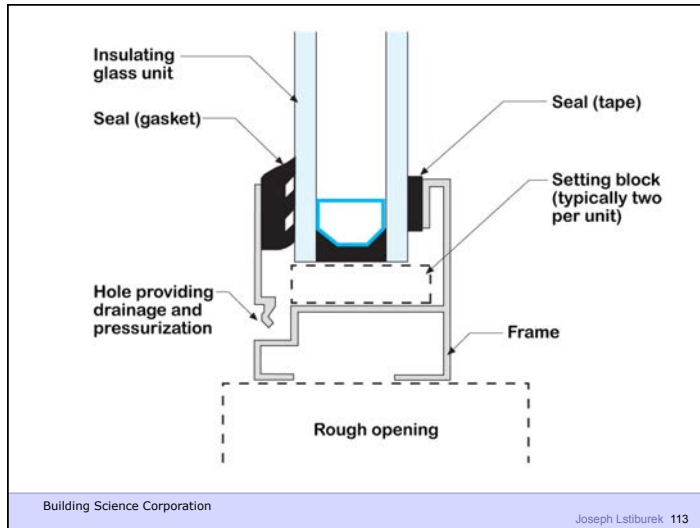
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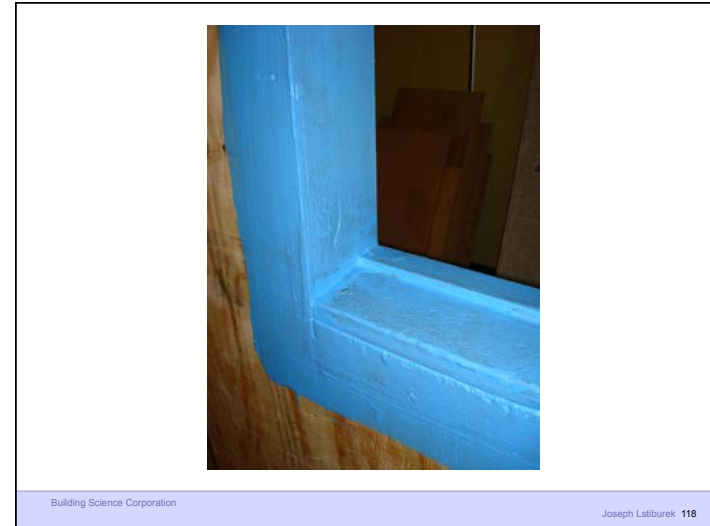
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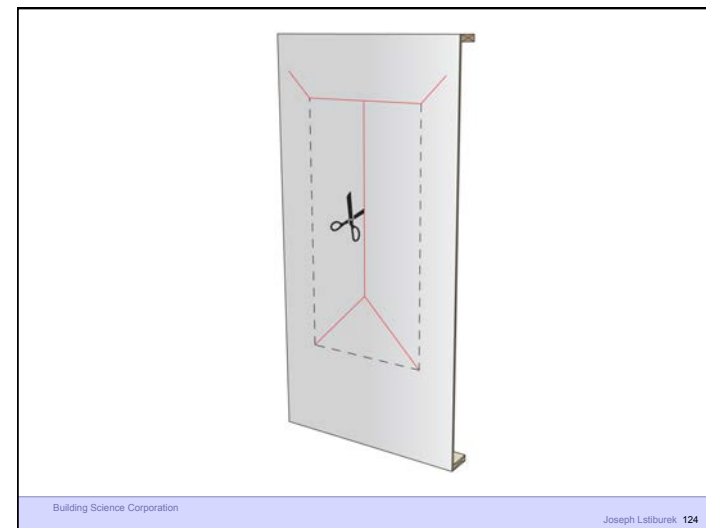
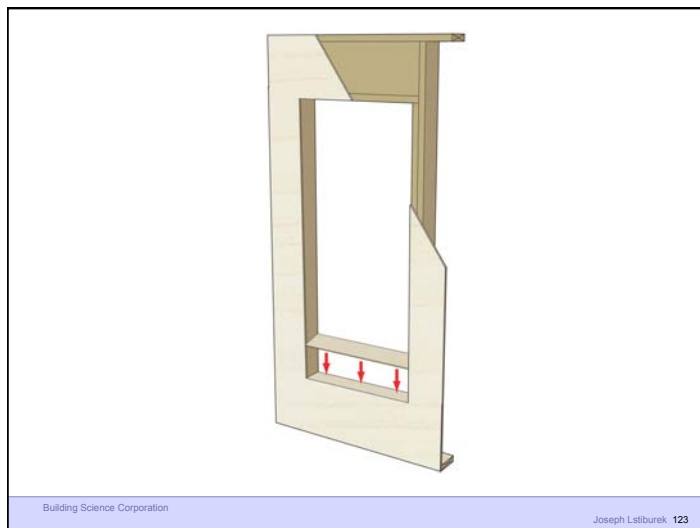
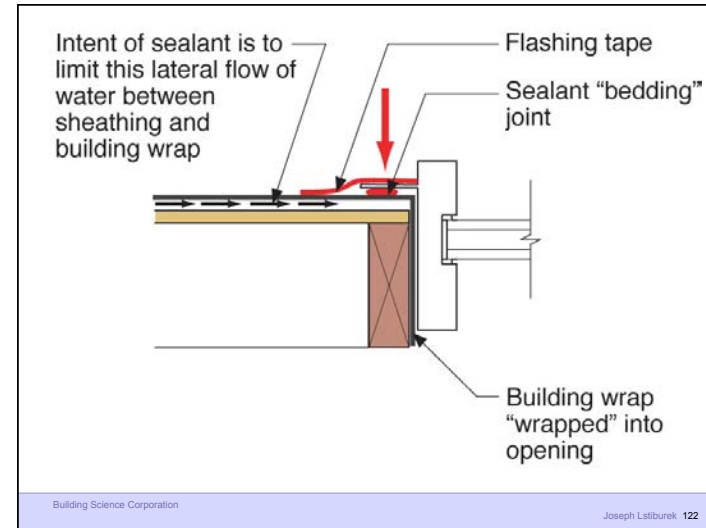


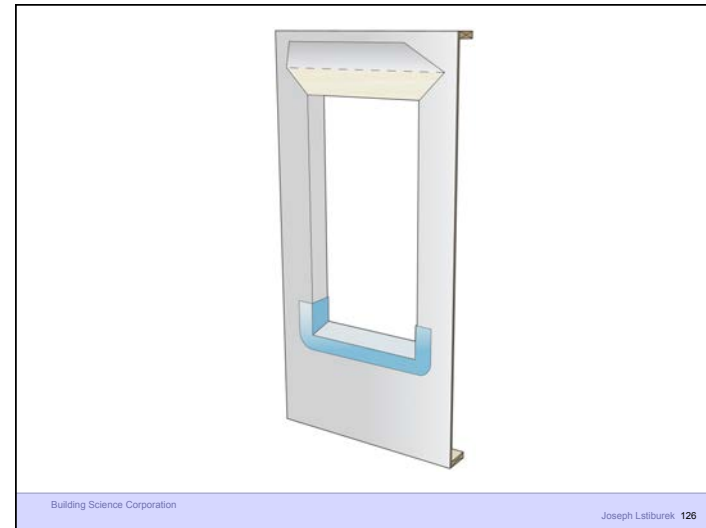
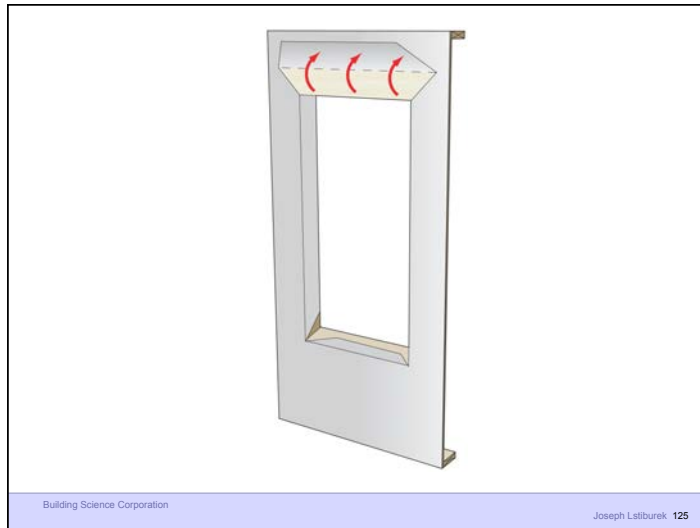
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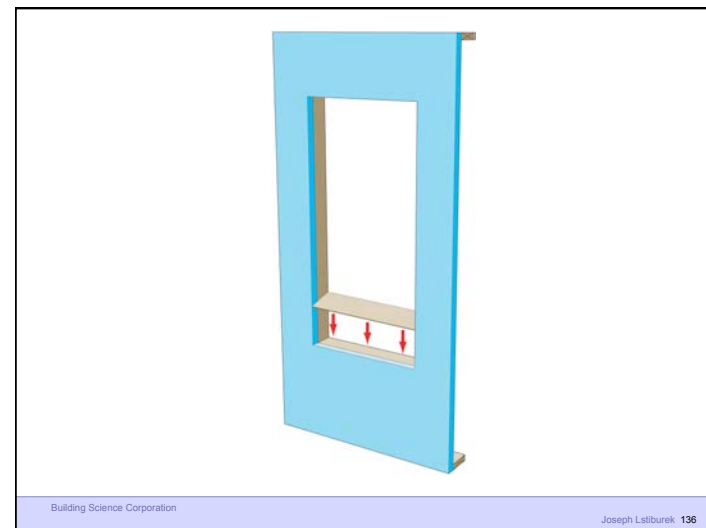
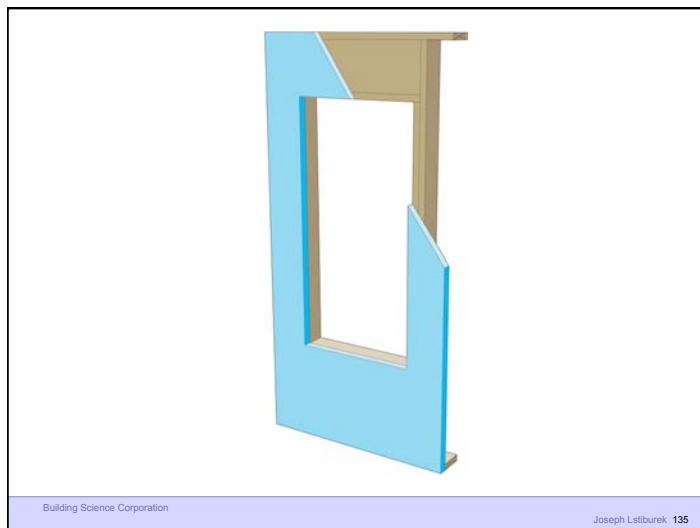
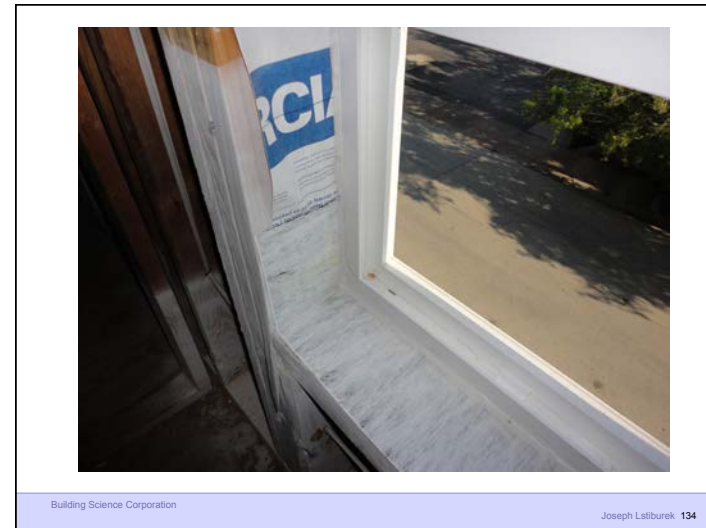


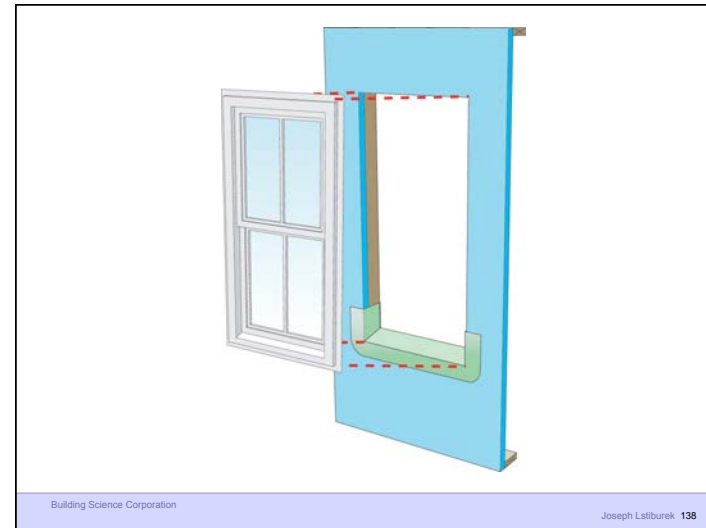
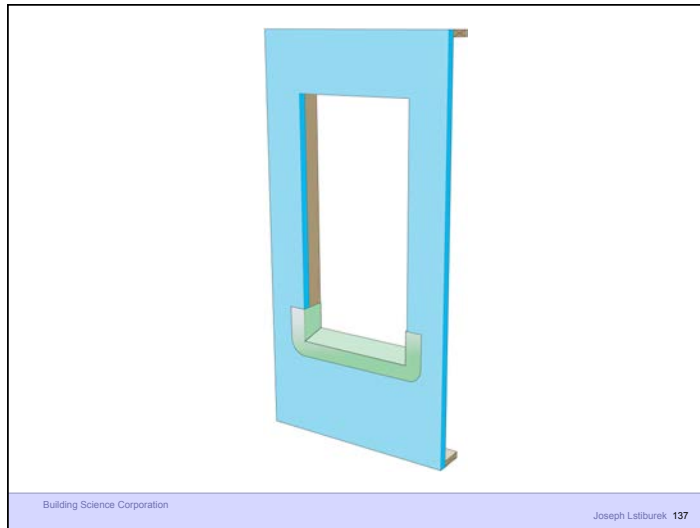




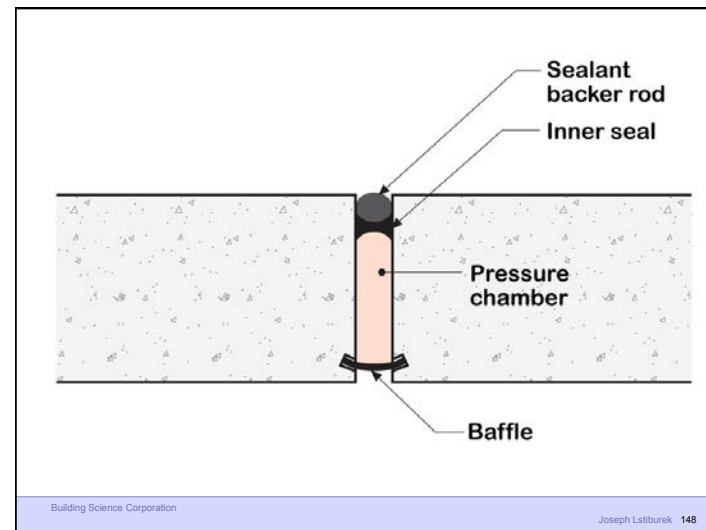
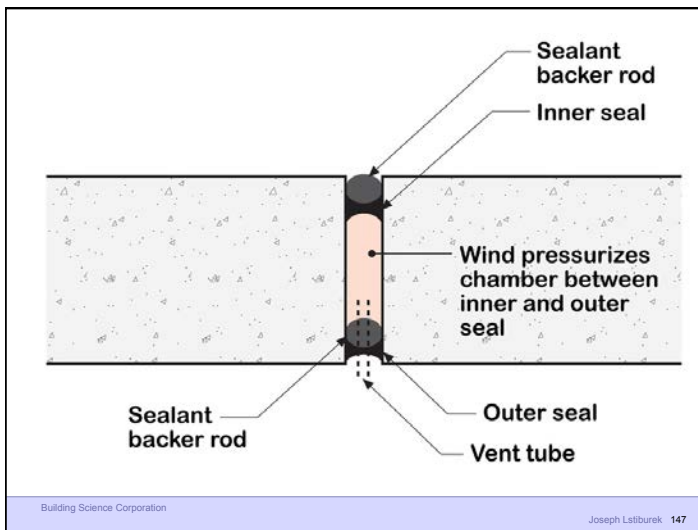
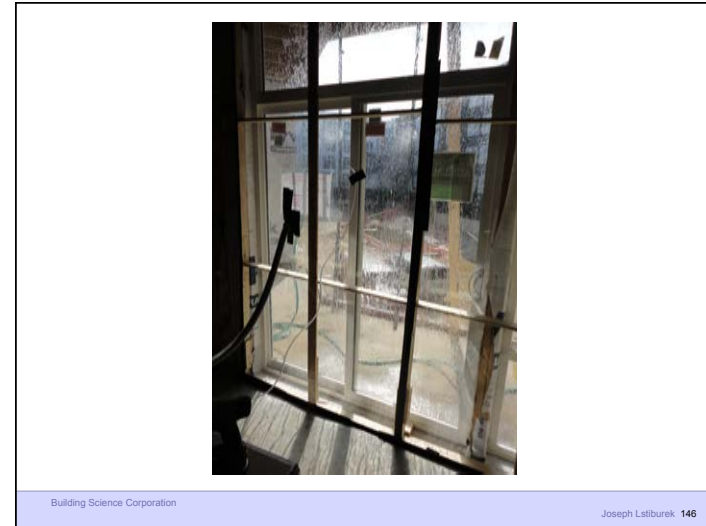


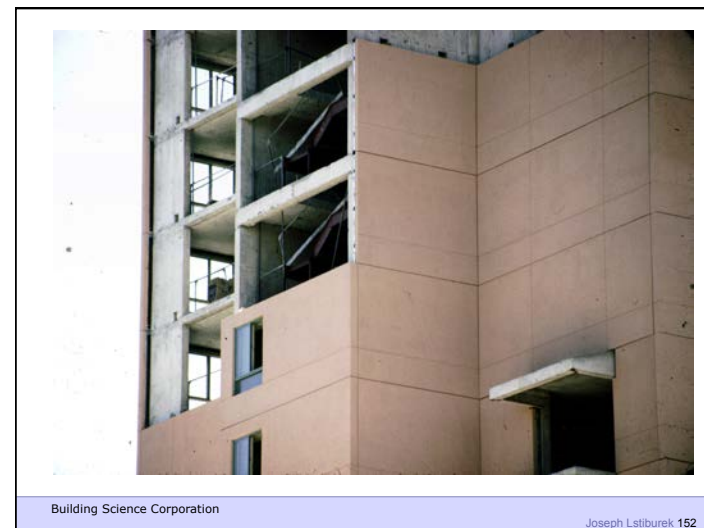
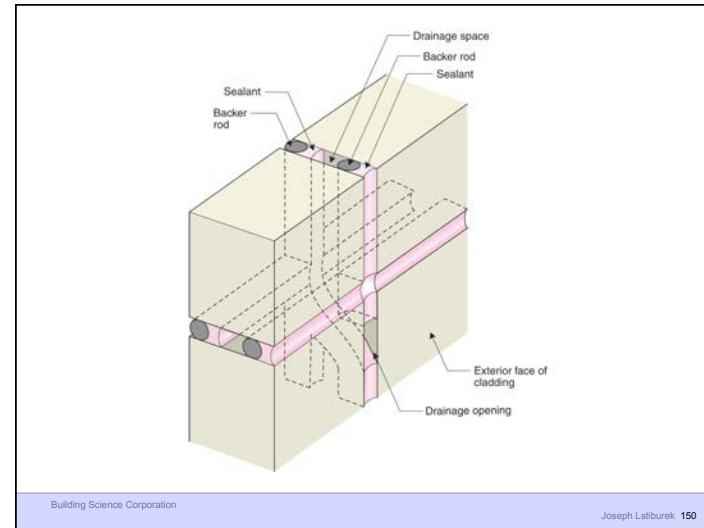
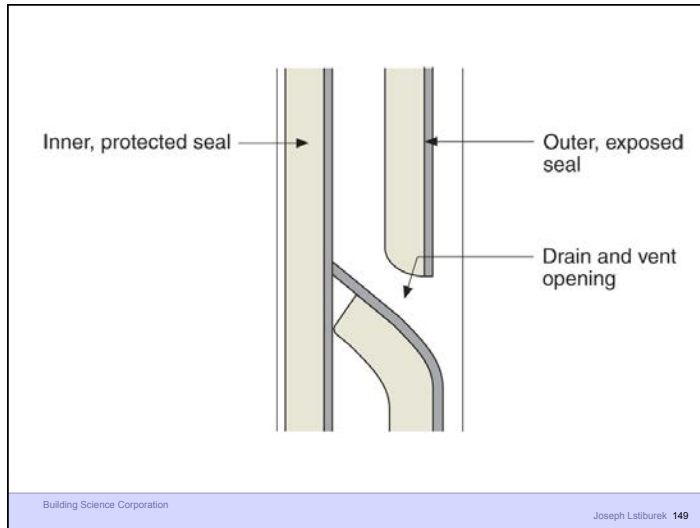


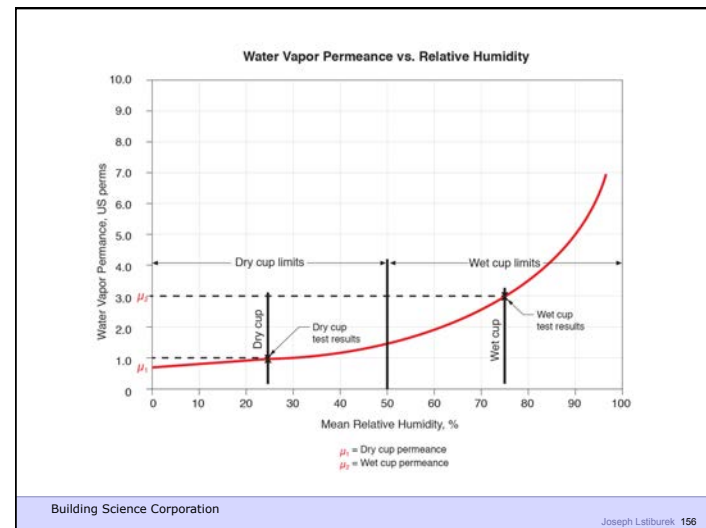
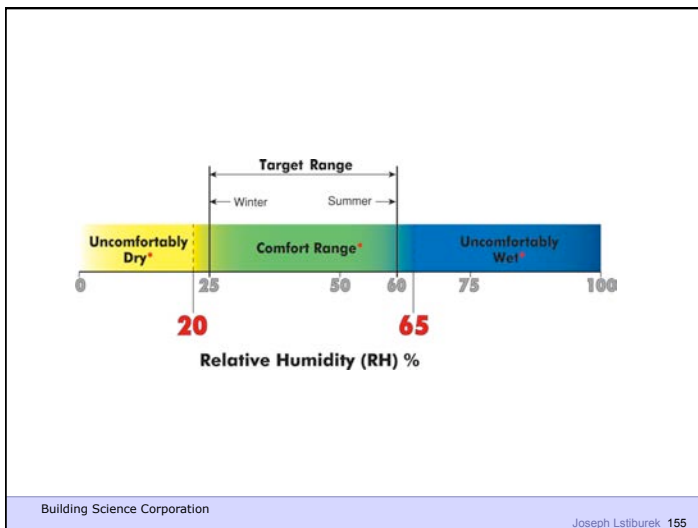


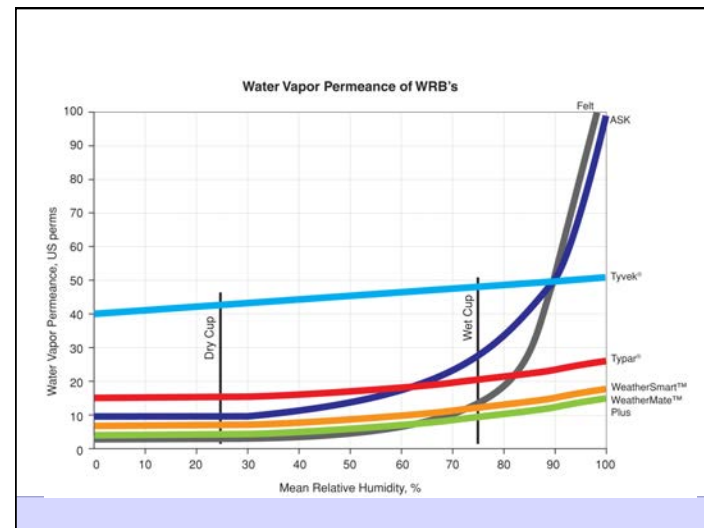
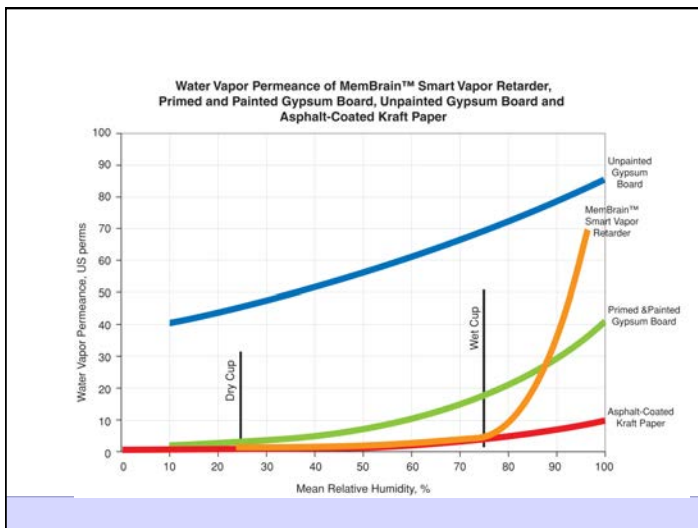
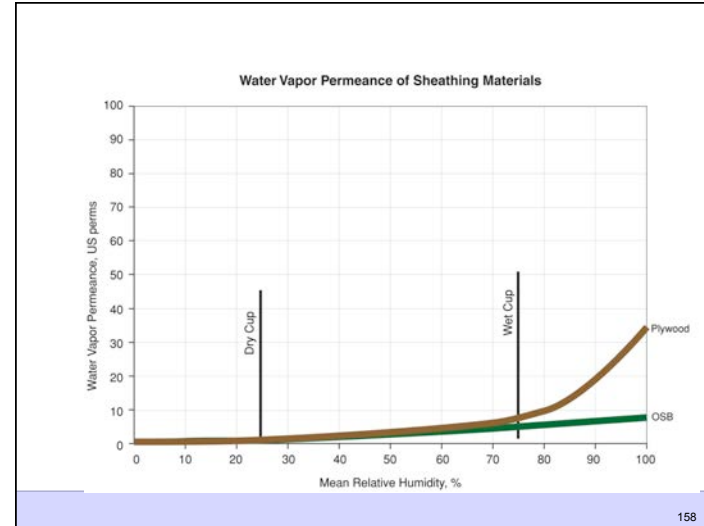


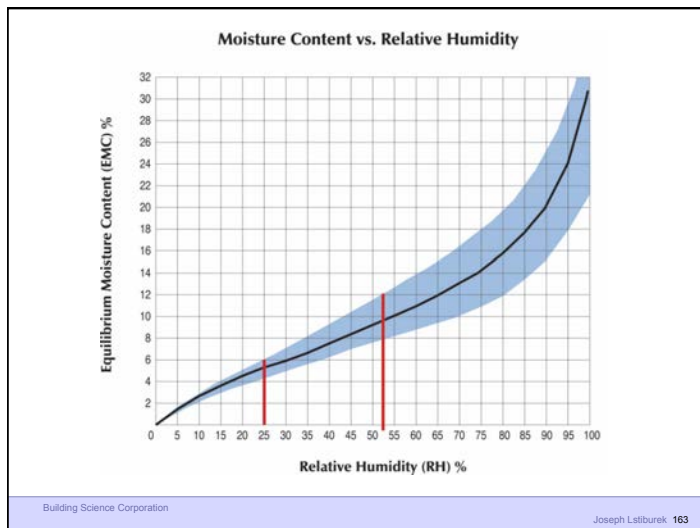
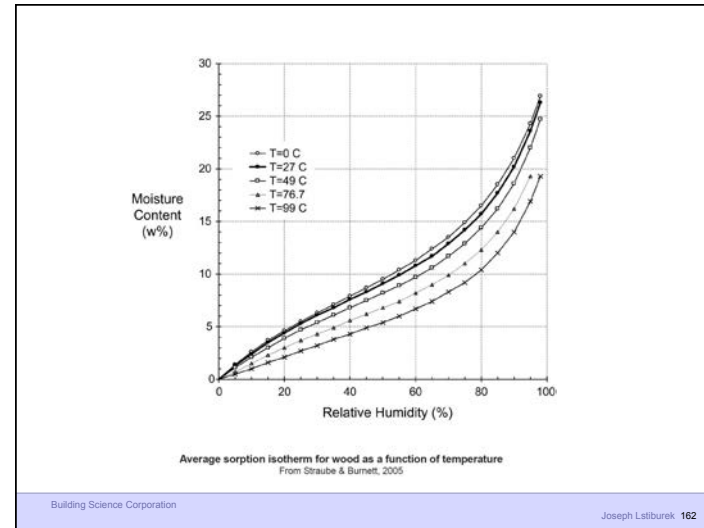
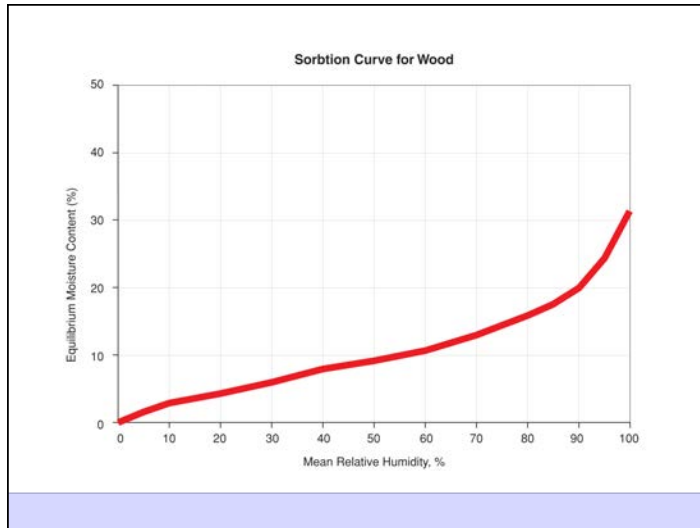


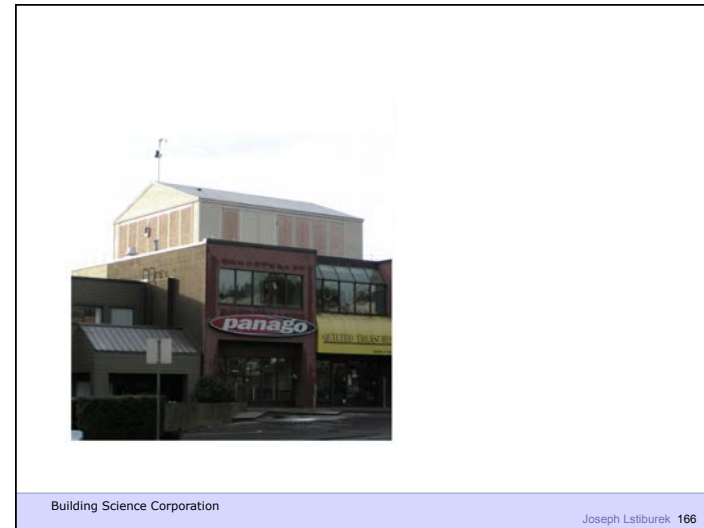
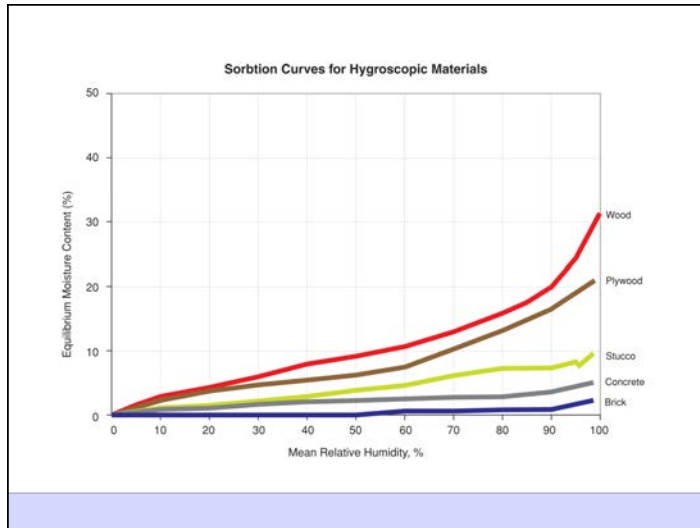




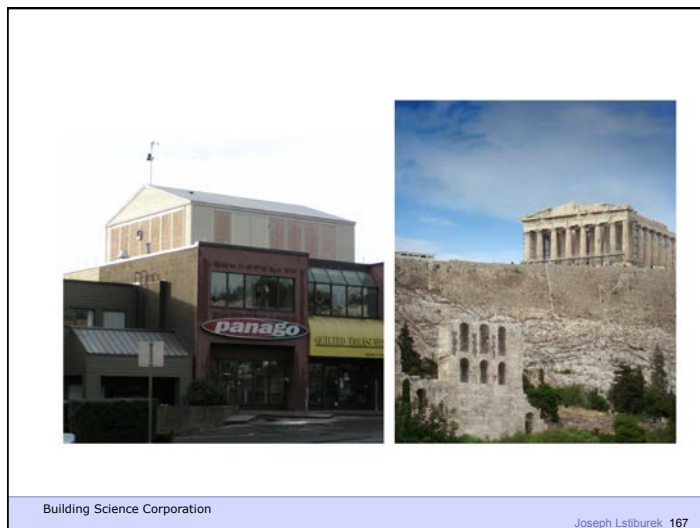








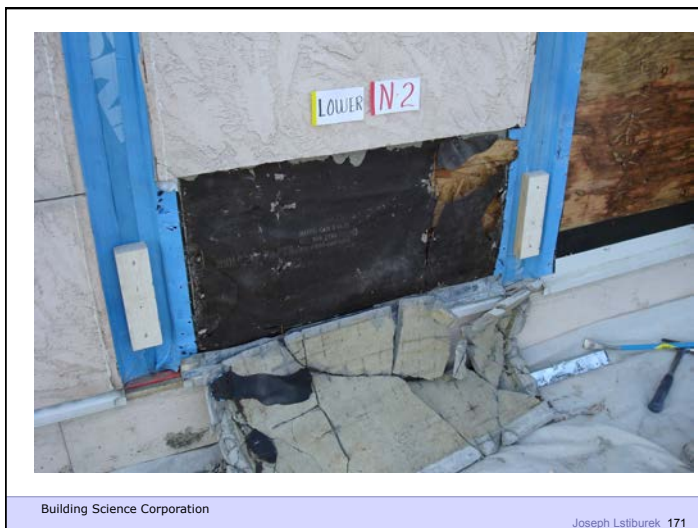
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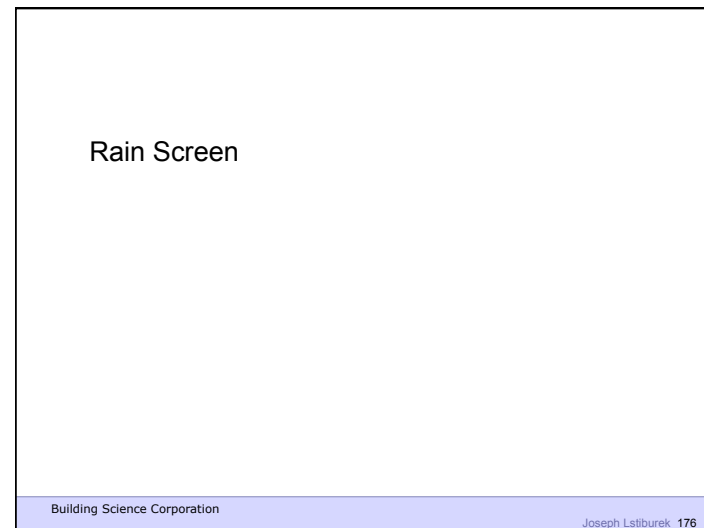
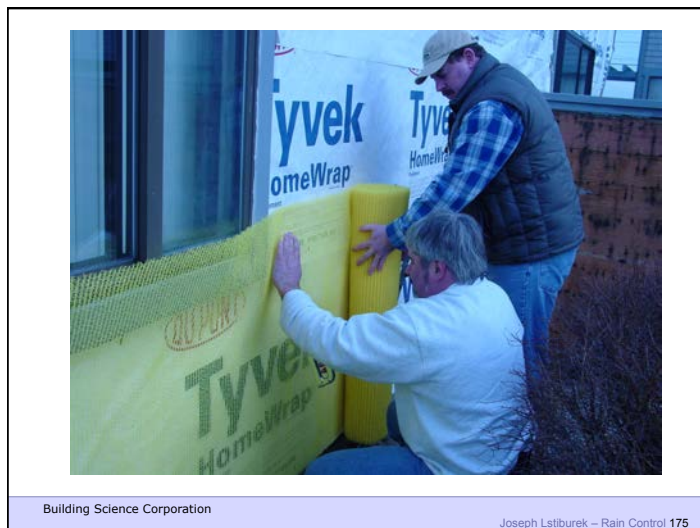
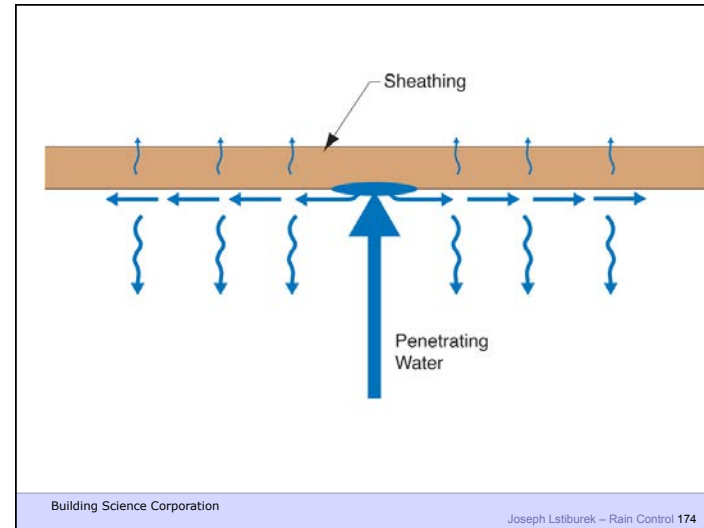
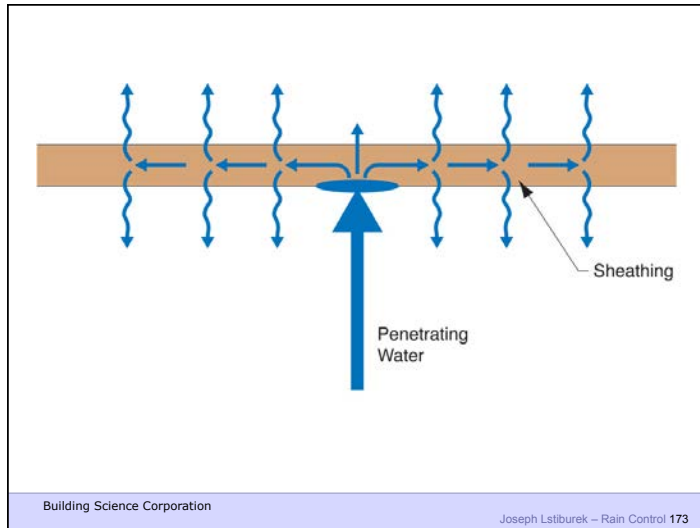


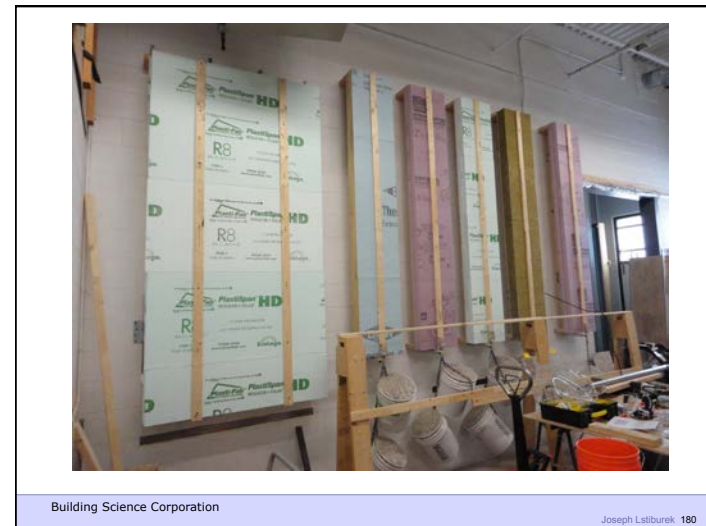
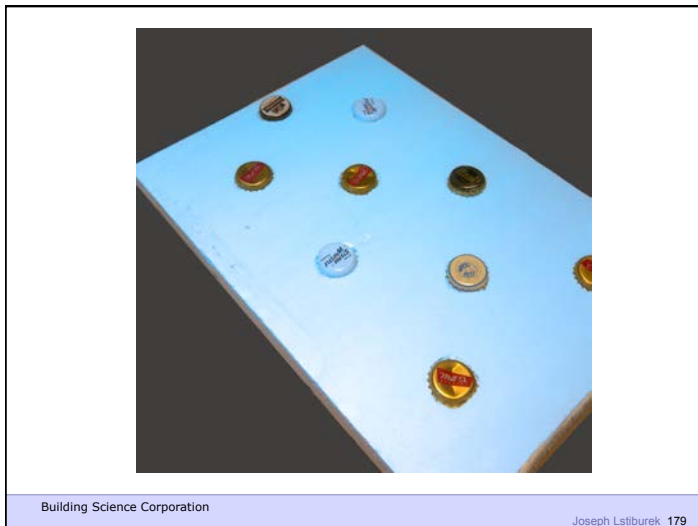
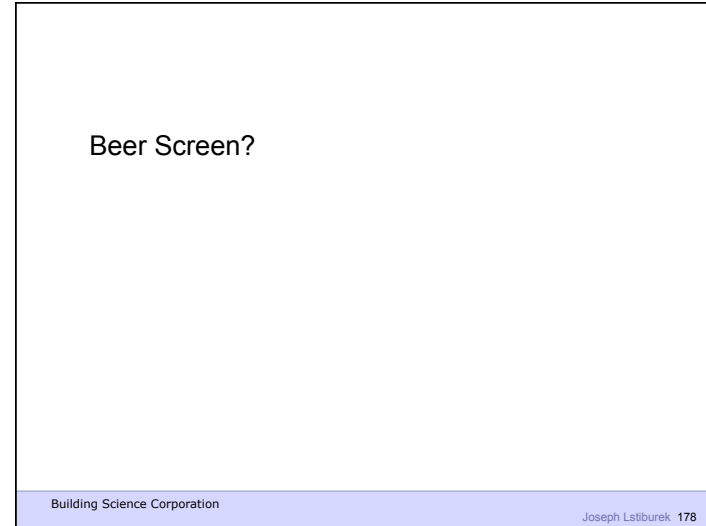
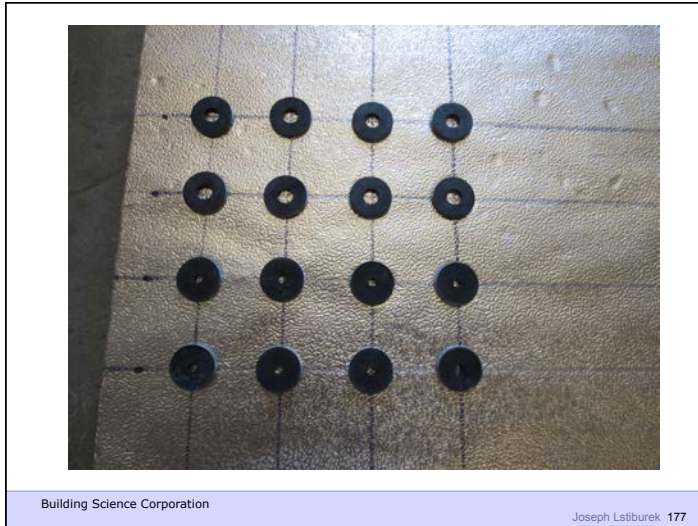
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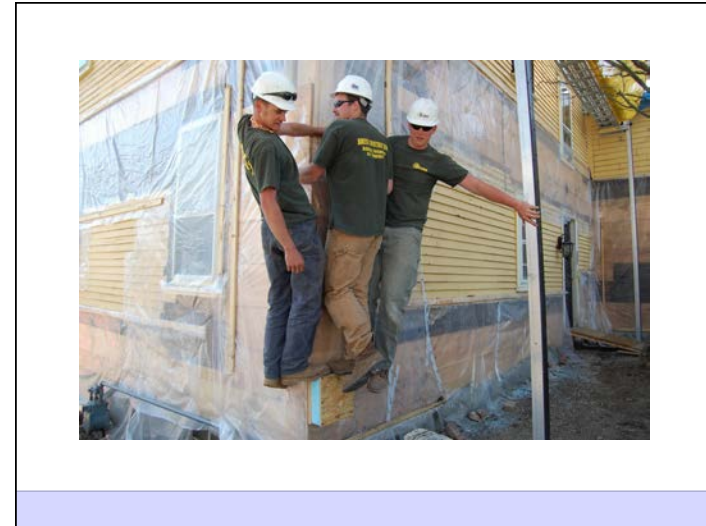


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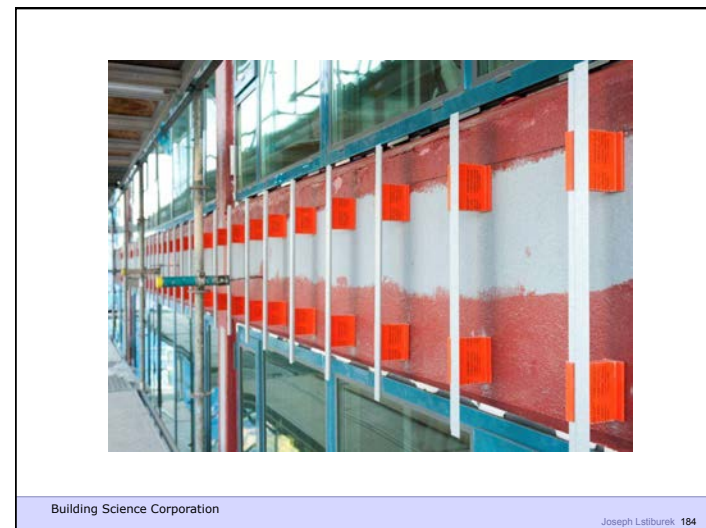


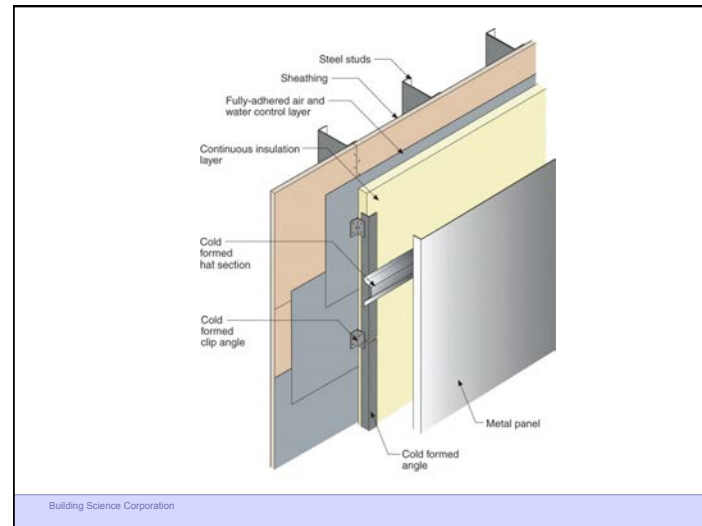
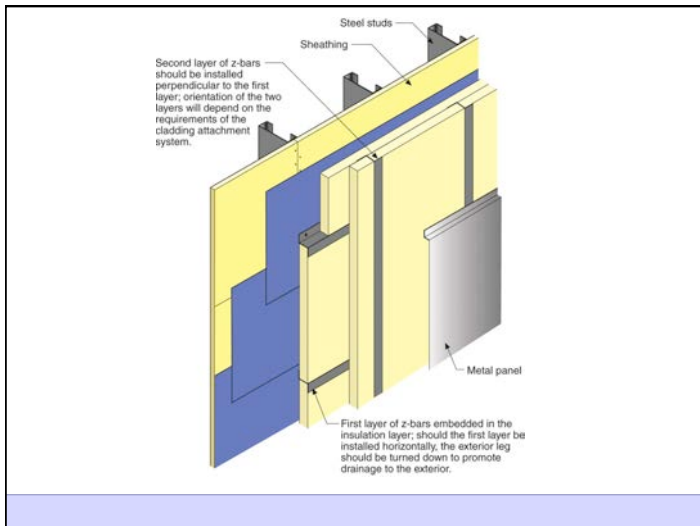
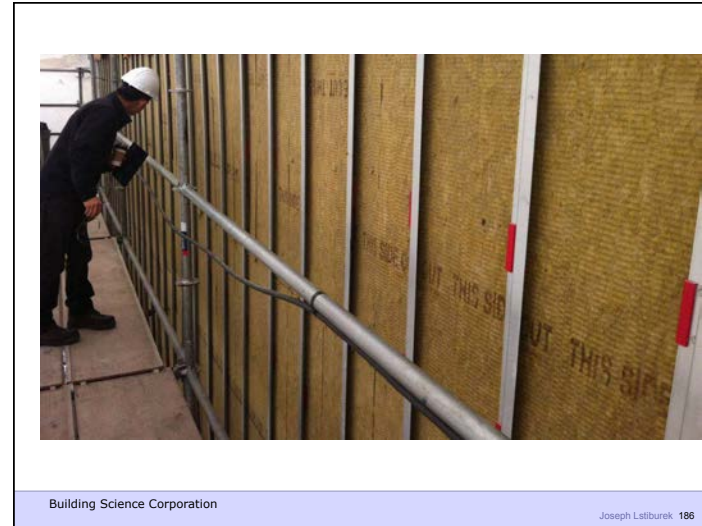
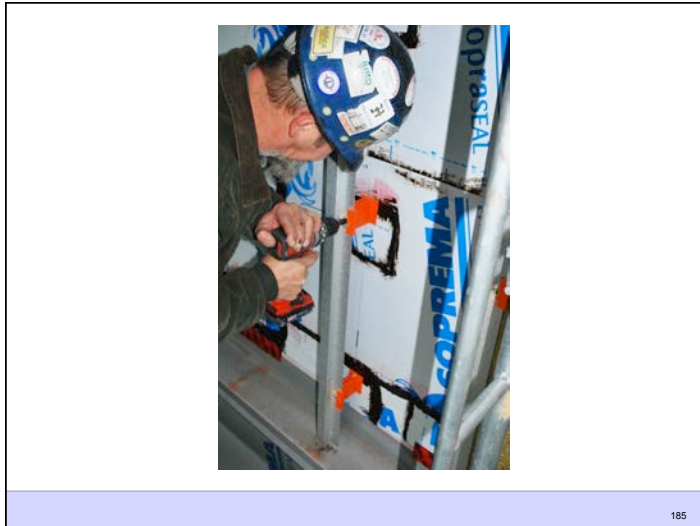


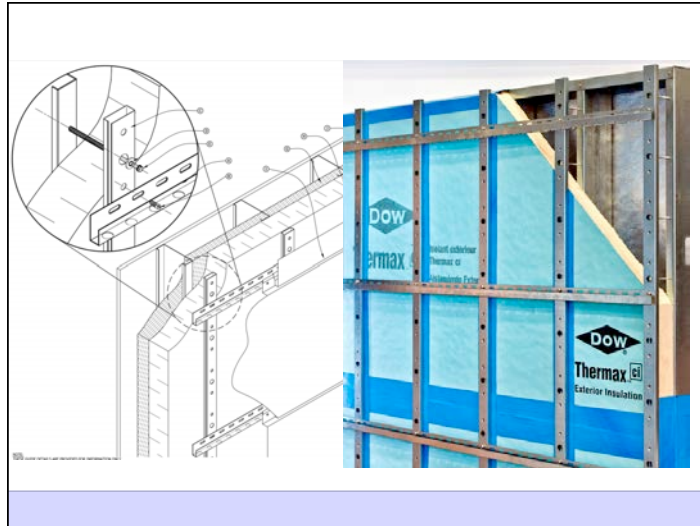


Rockwool

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







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Joseph Lstiburek – Rain Control 190



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