

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

# Building Science

Adventures In Building Science

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## Order of Magnitude

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## Order of Magnitude

1 to 10

10 to 100

100 to 1000

1000 to 10000

First Order Effects, Second Order Effects....

## What is a Building?

## 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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First Law - Conservation of Energy  
Second Law - Entropy  
Third Law – Absolute Zero

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2<sup>nd</sup> 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

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

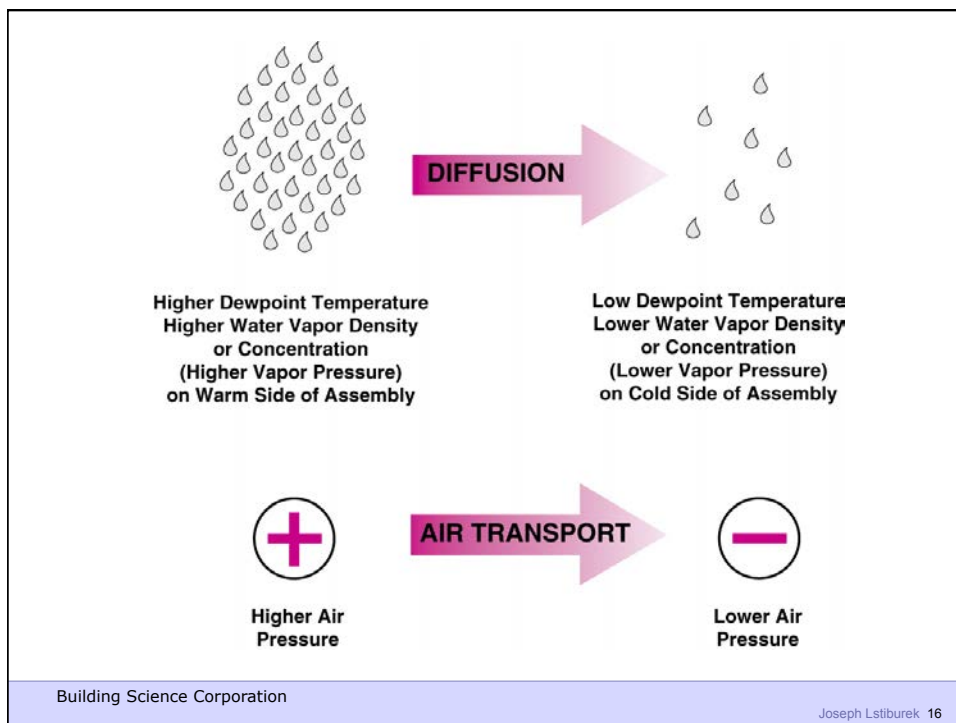
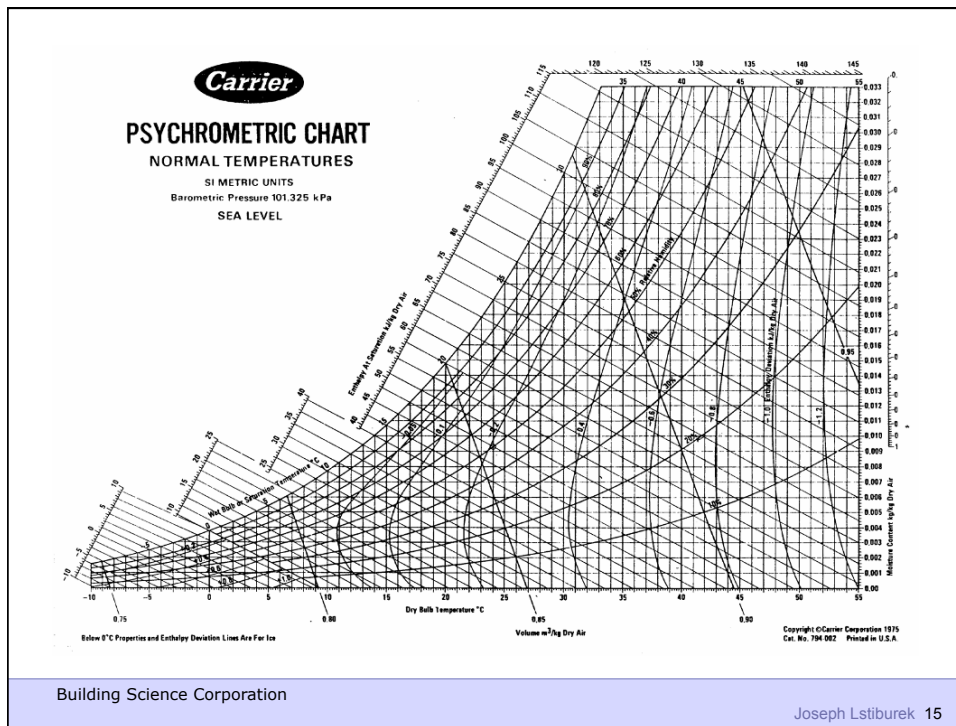
Thermal Gradient – Thermal Diffusion  
Concentration Gradient – Molecular Diffusion

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

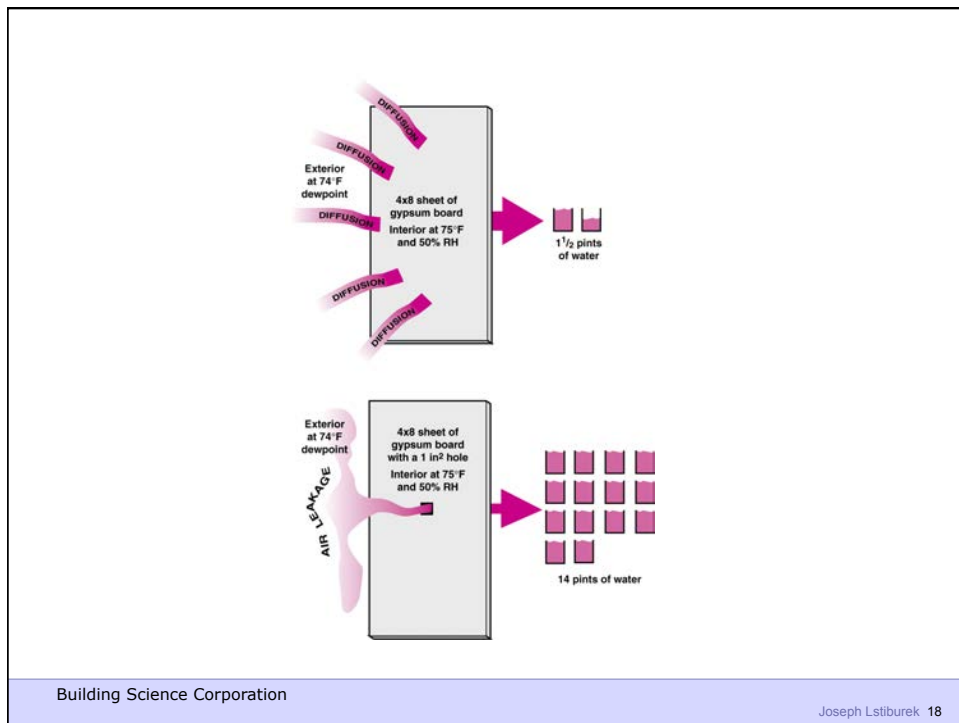
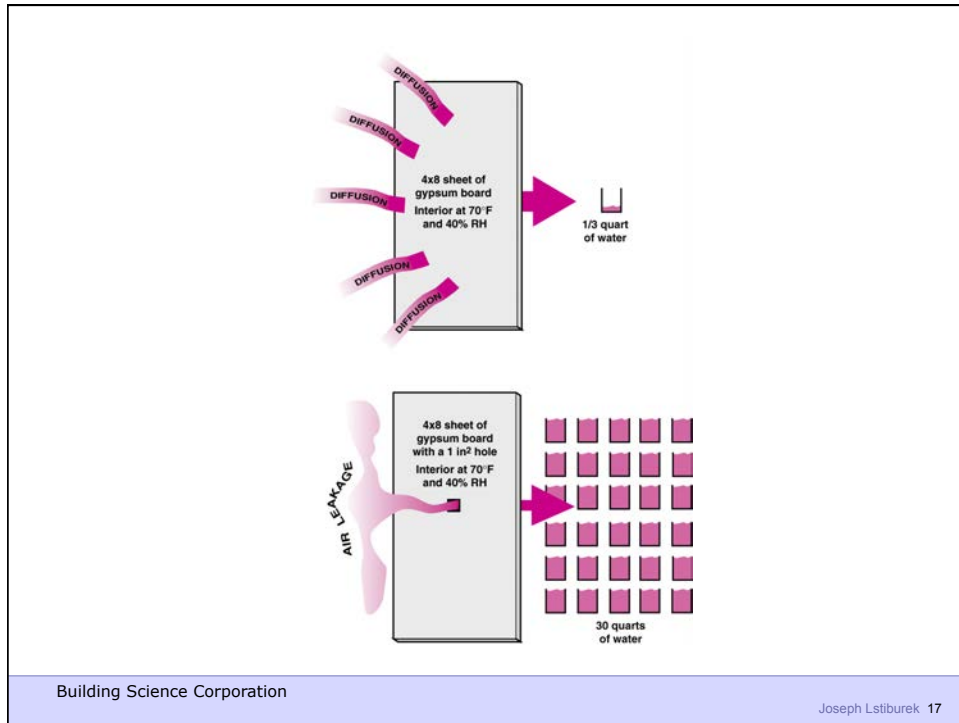
Thermal Gradient – Thermal Diffusion  
Concentration Gradient – Molecular Diffusion

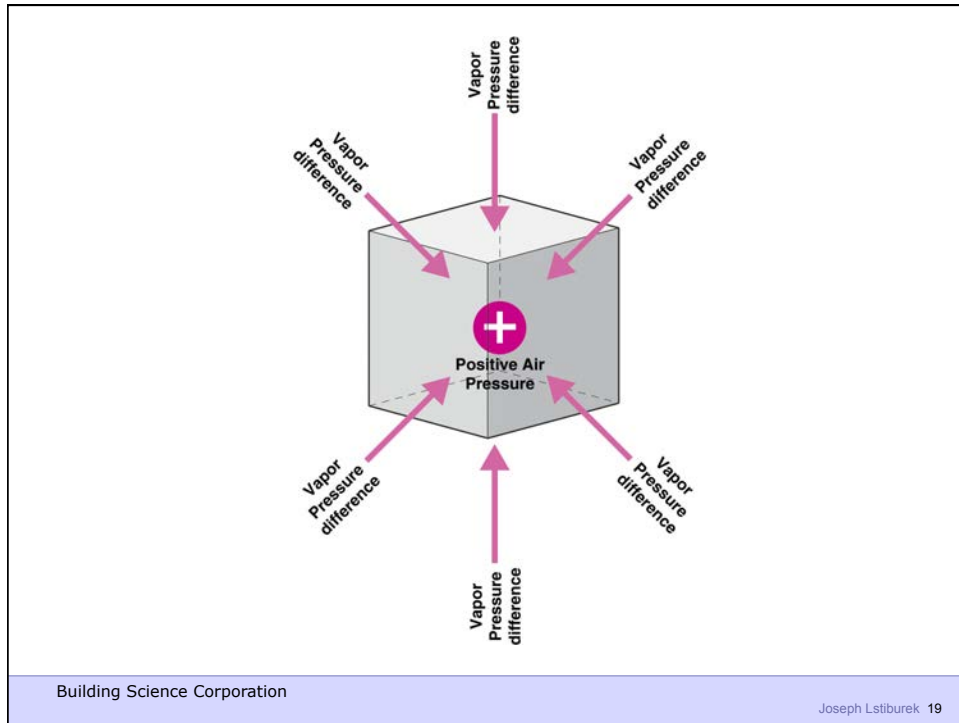
Vapor Diffusion

Thermodynamic Potential









Damage Functions

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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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Heat  
Air  
Moisture

HAM

## Hygrothermal Analysis

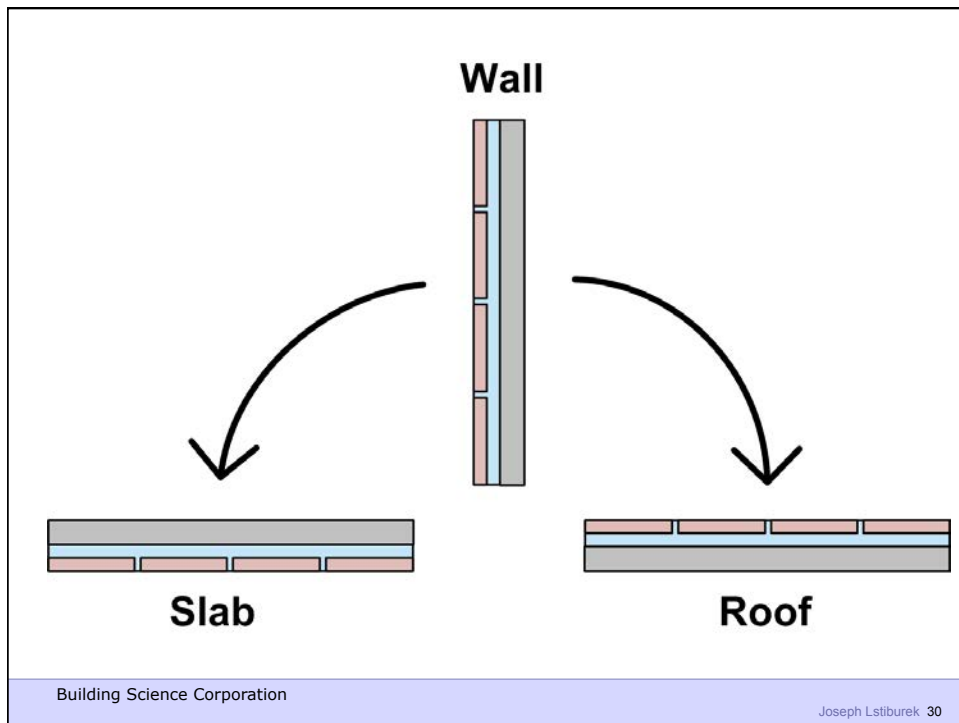
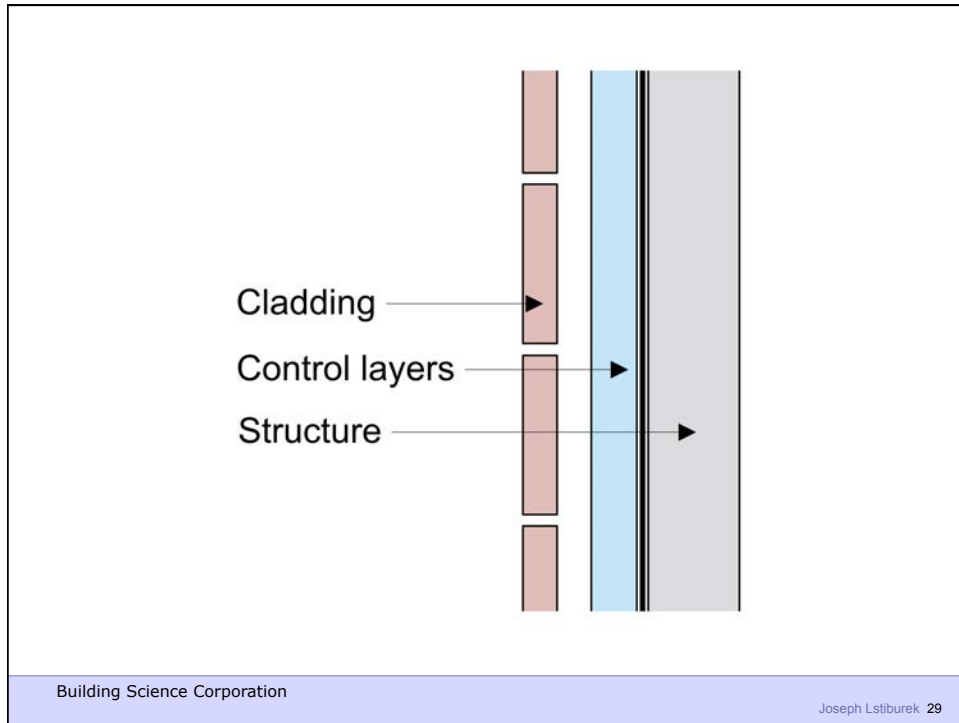
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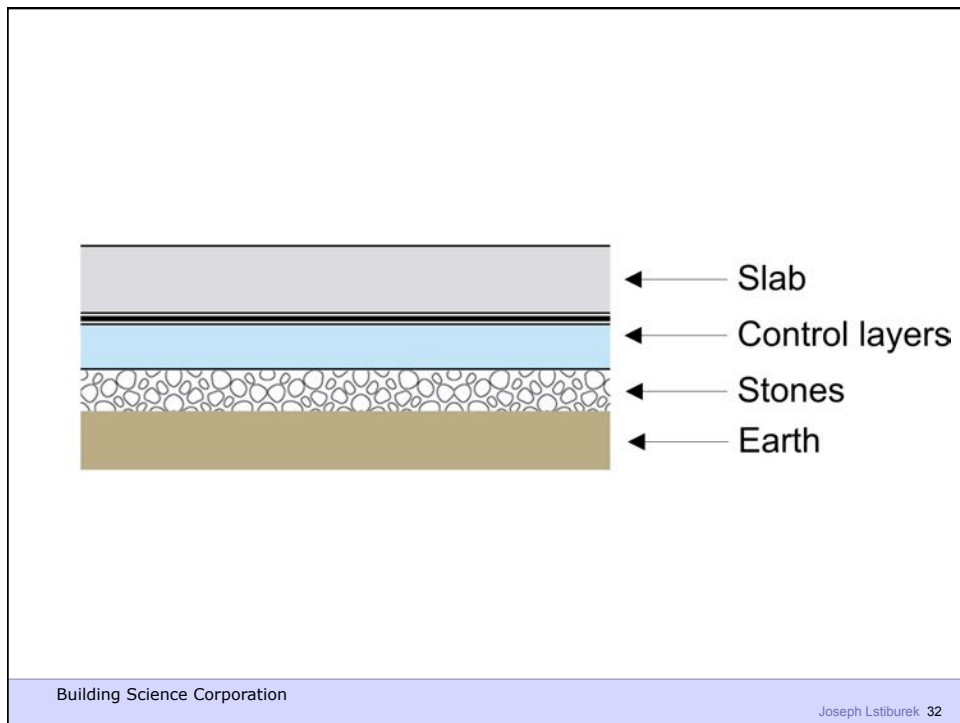
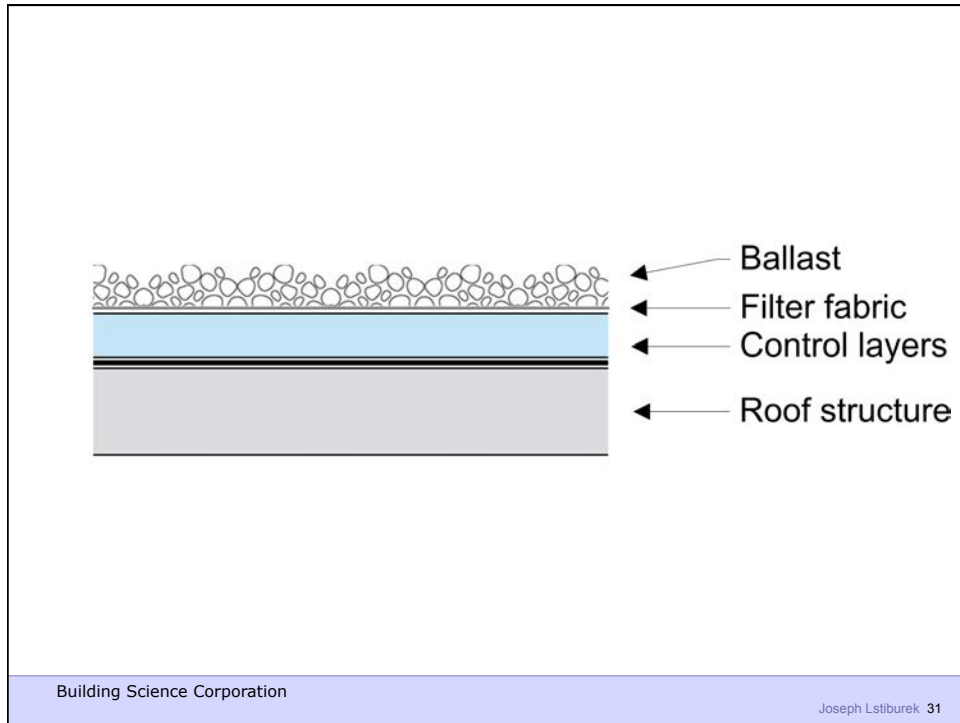
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Water Control Layer  
Air Control Layer  
Vapor Control Layer  
Thermal Control Layer

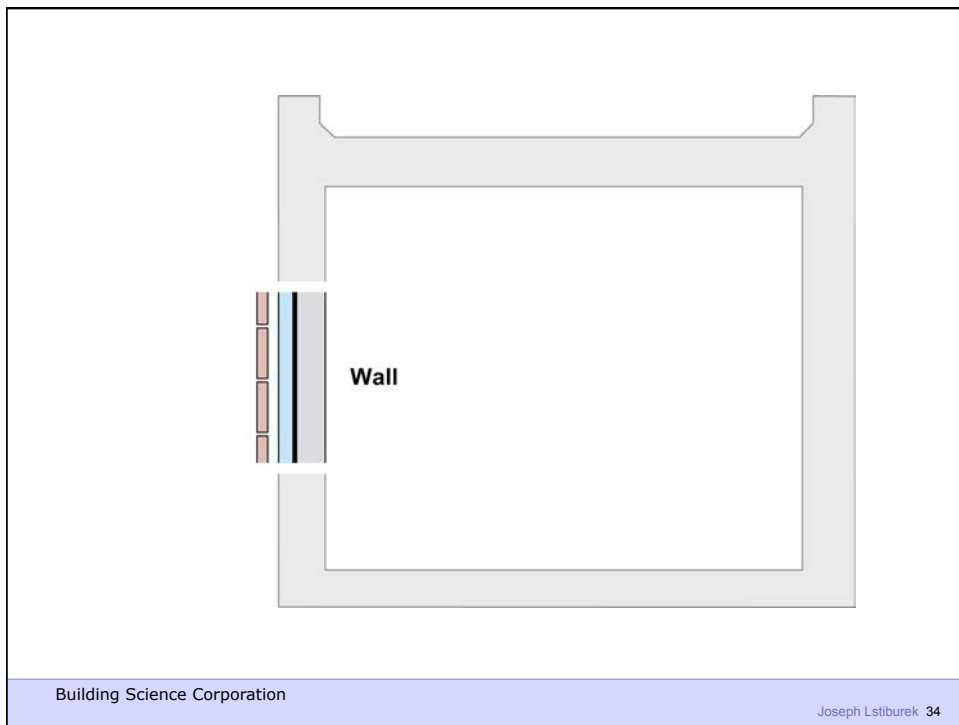
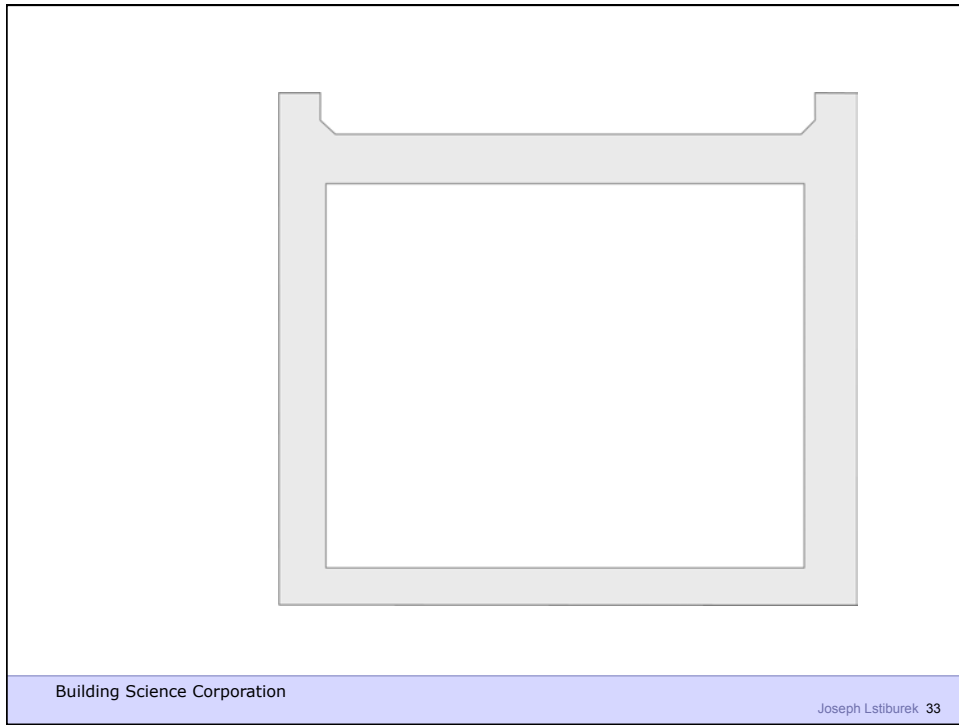
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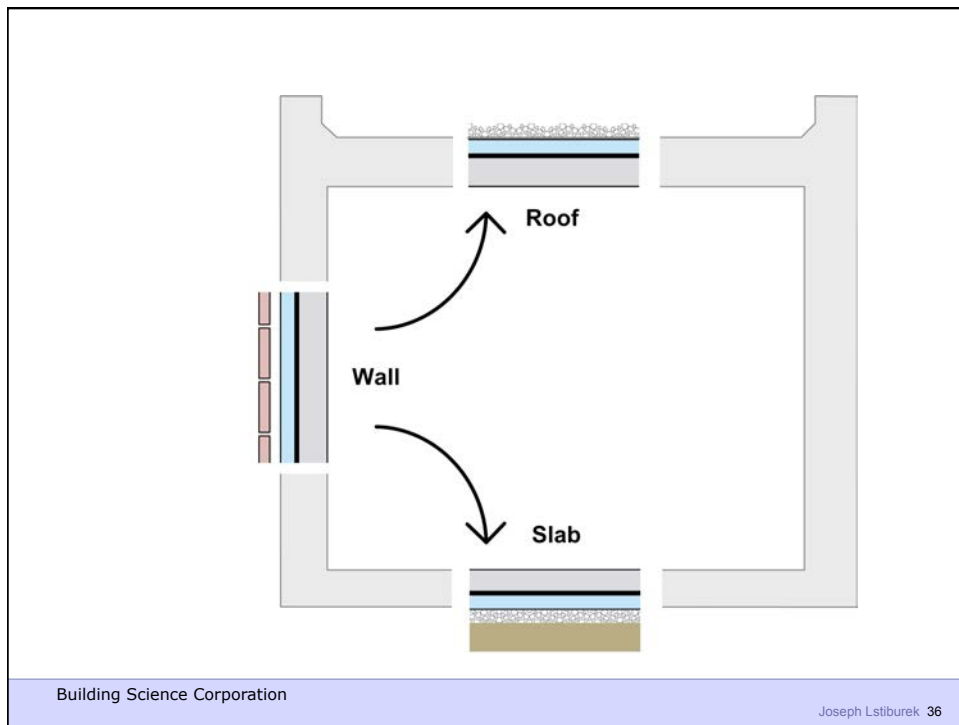
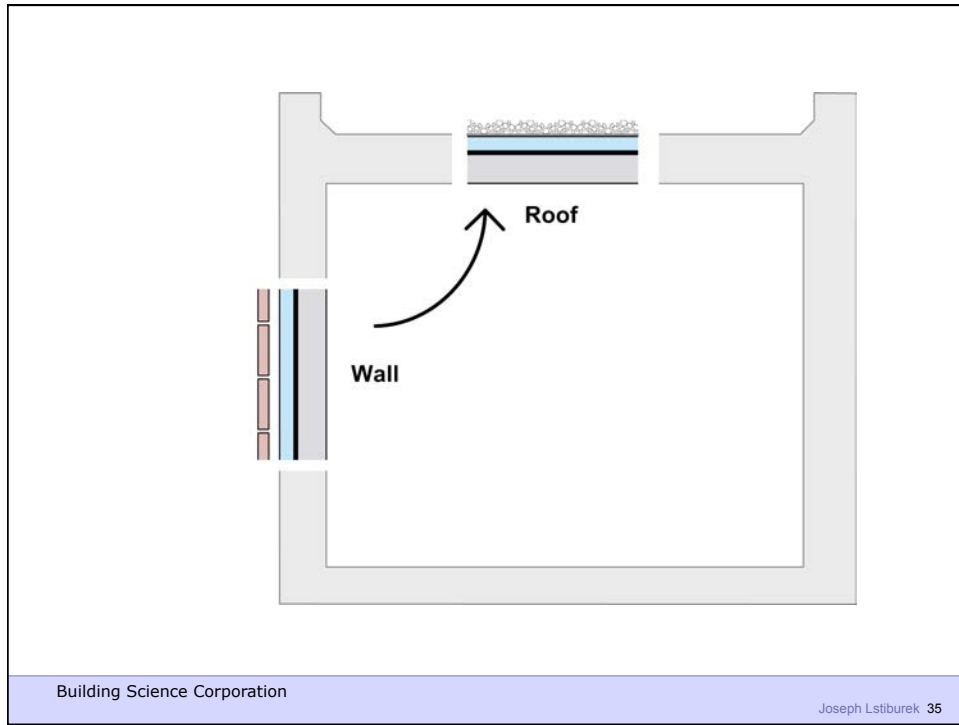
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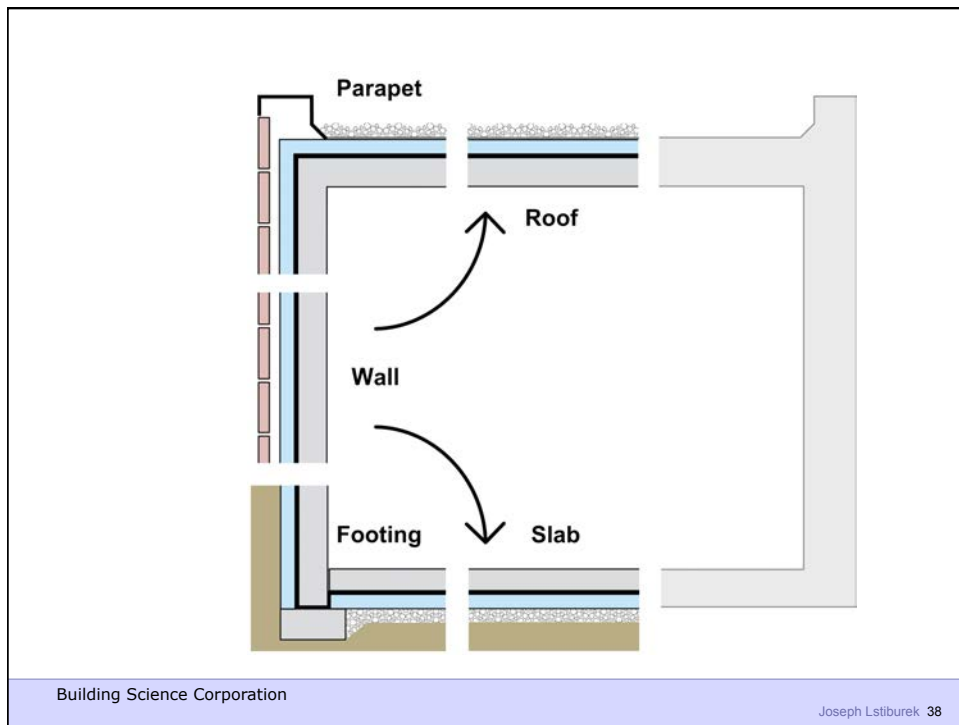
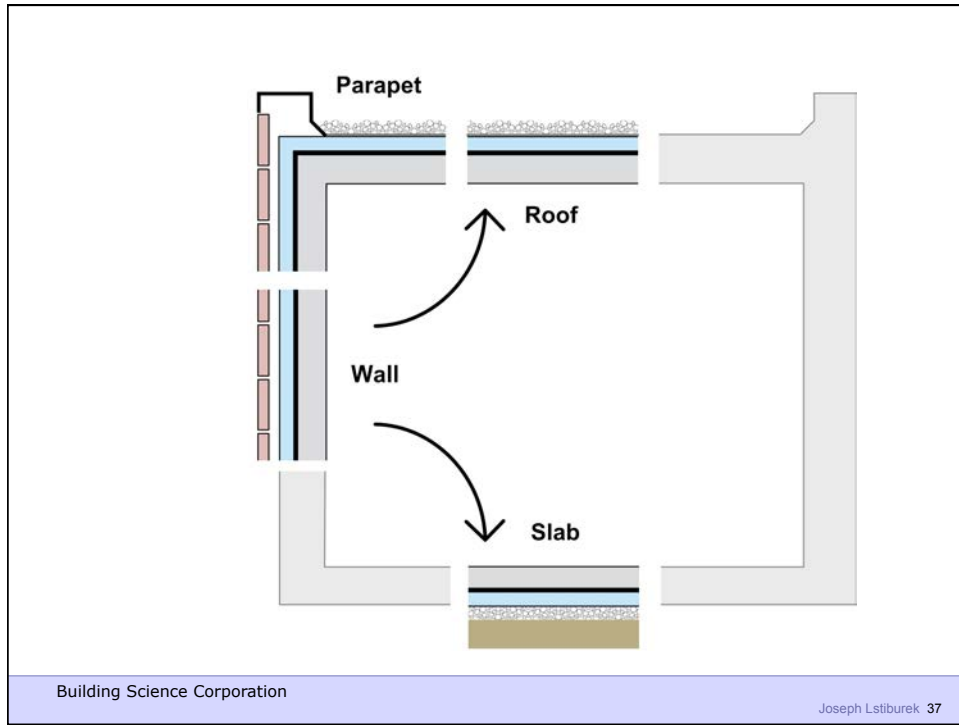


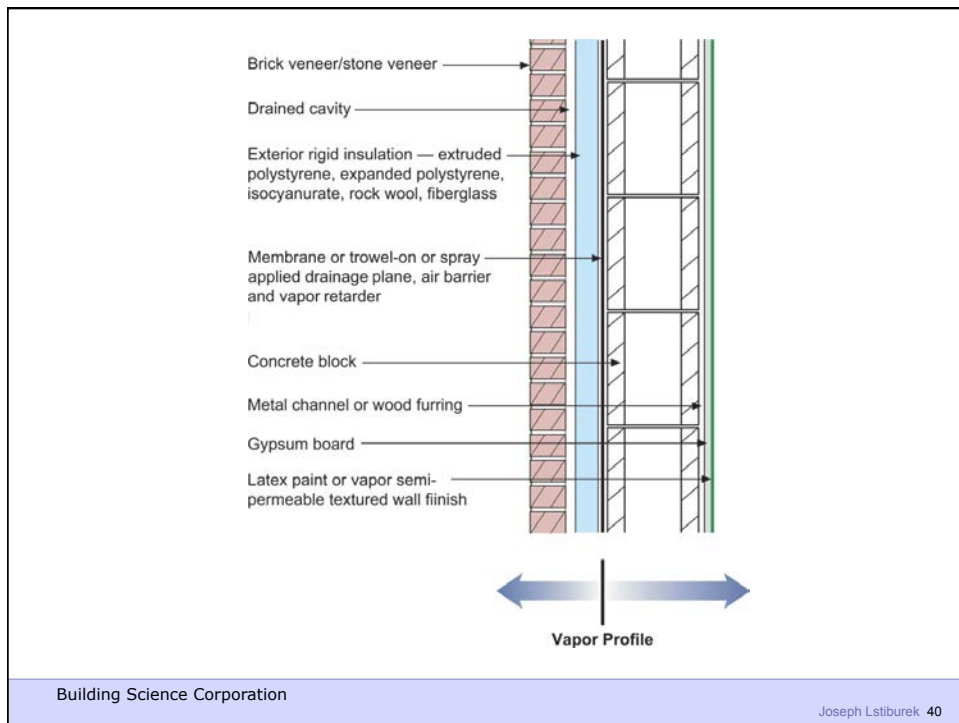
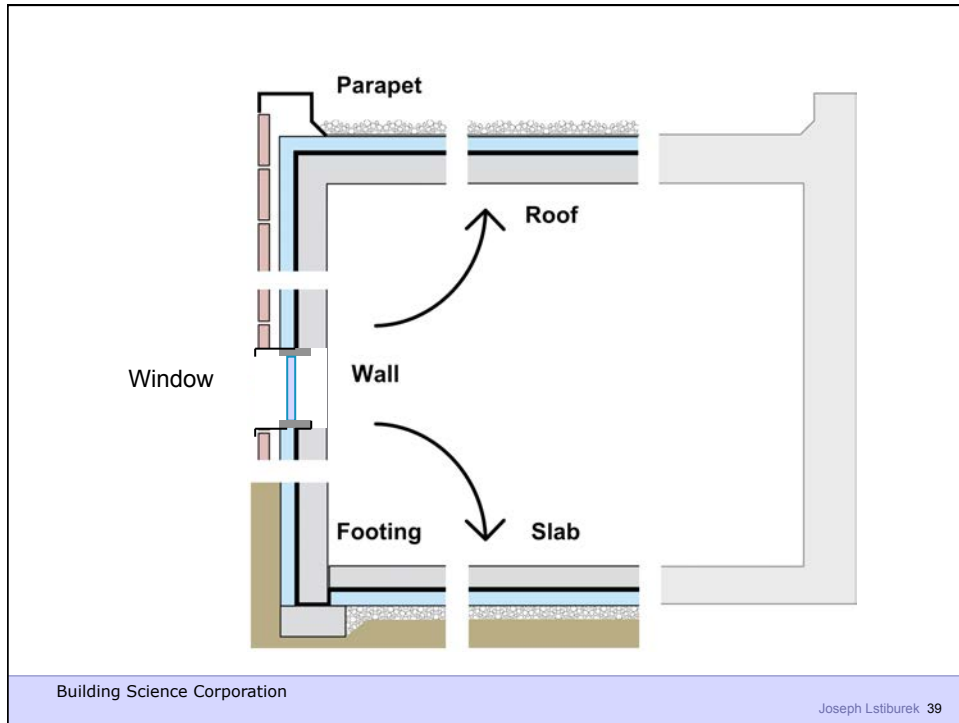


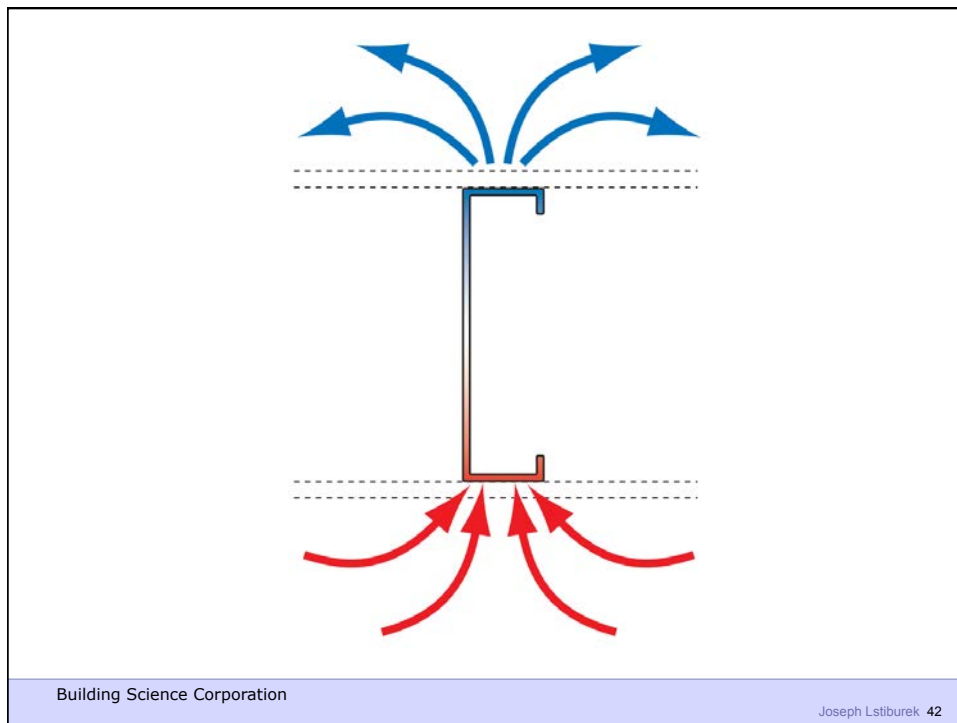
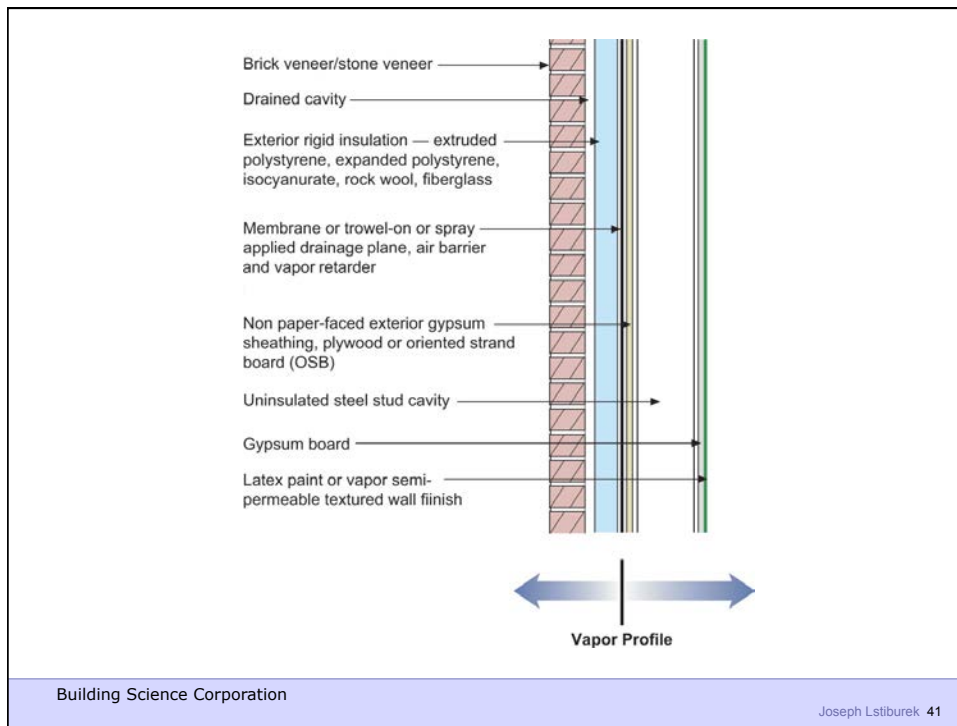


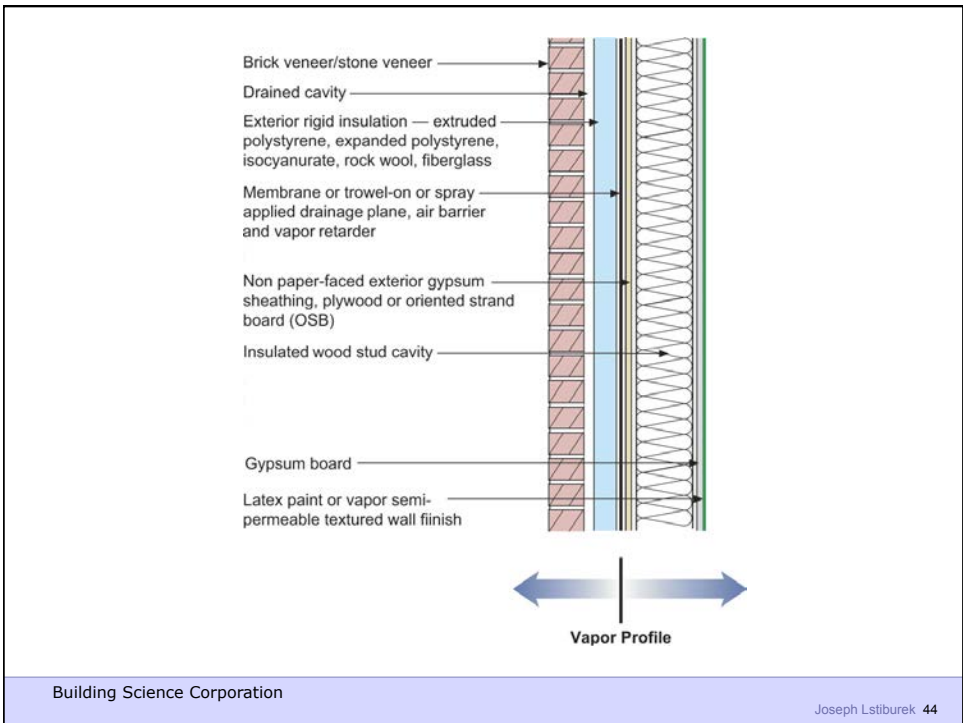




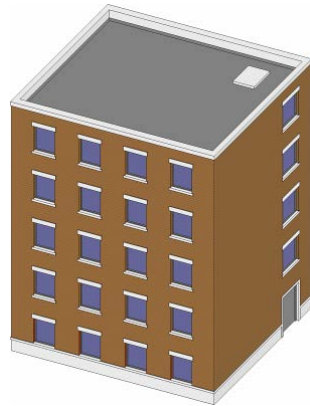








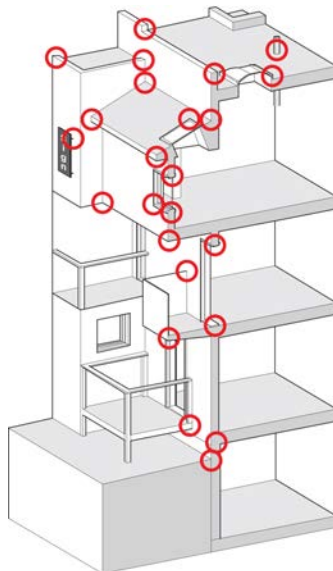
## Commercial Enclosure: Simple Layers



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

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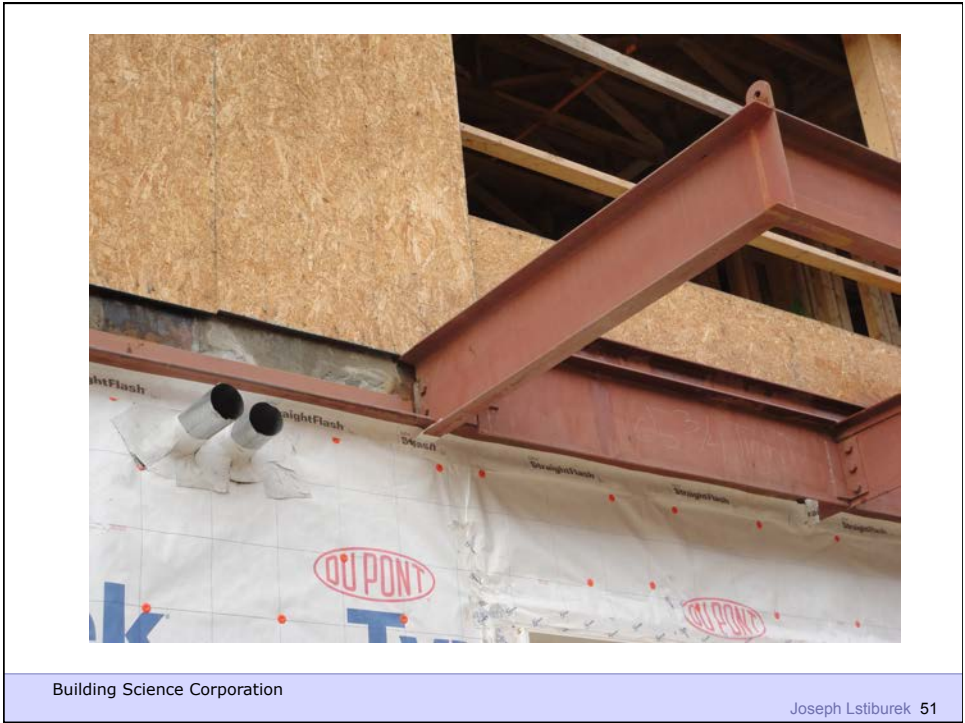
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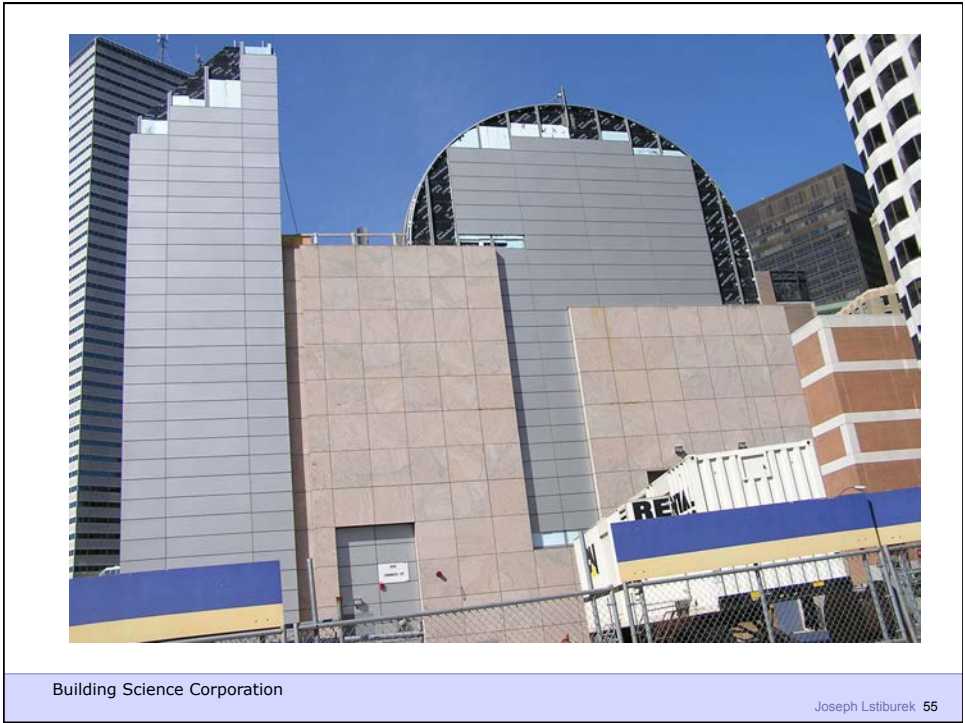
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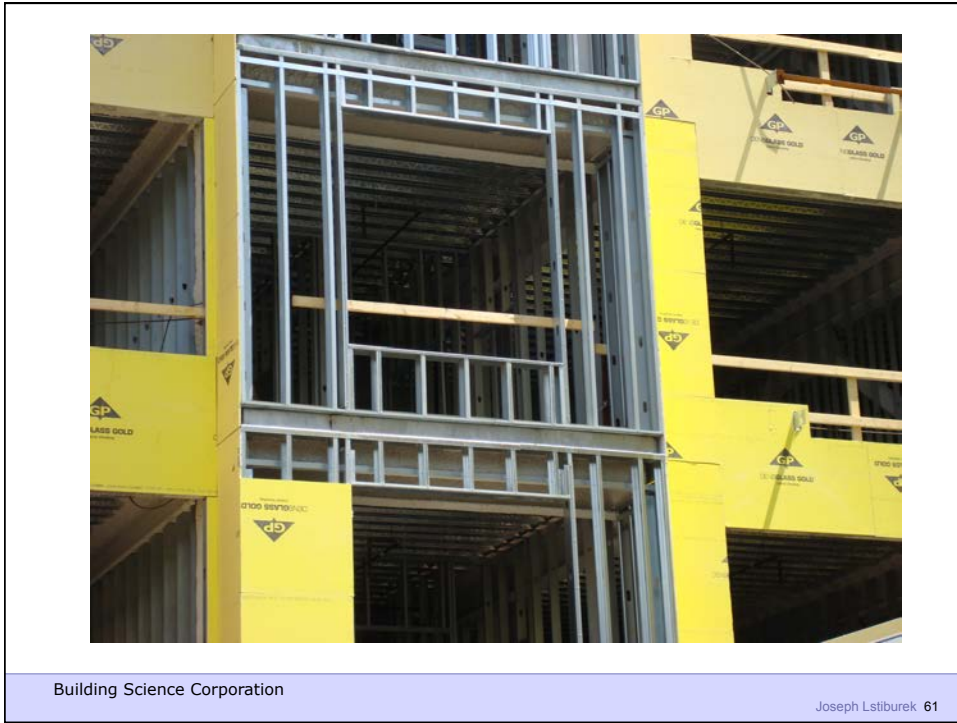


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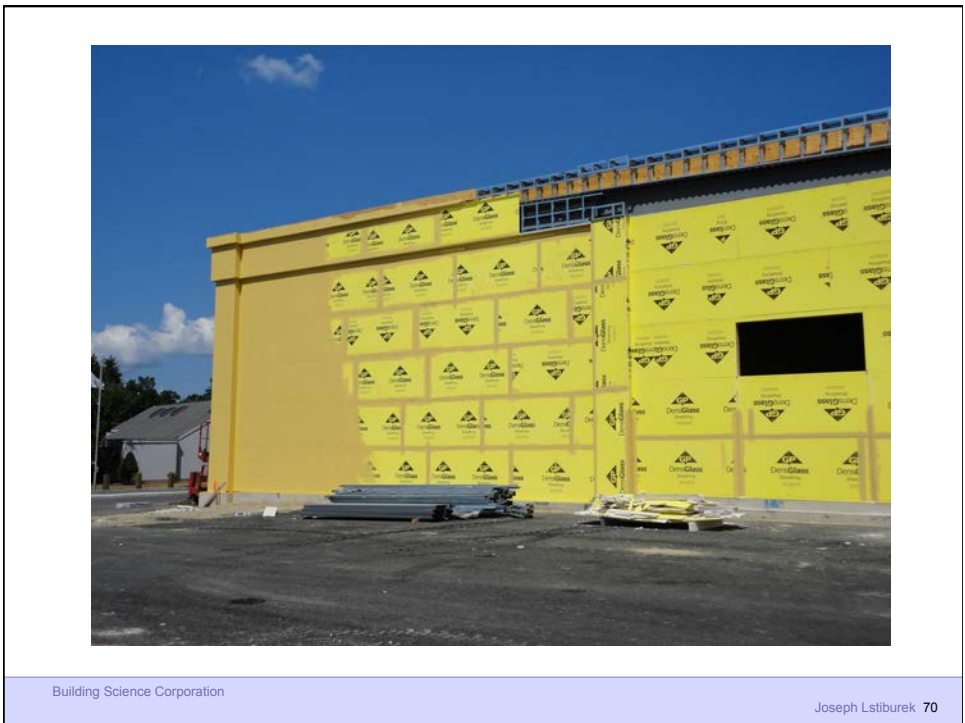
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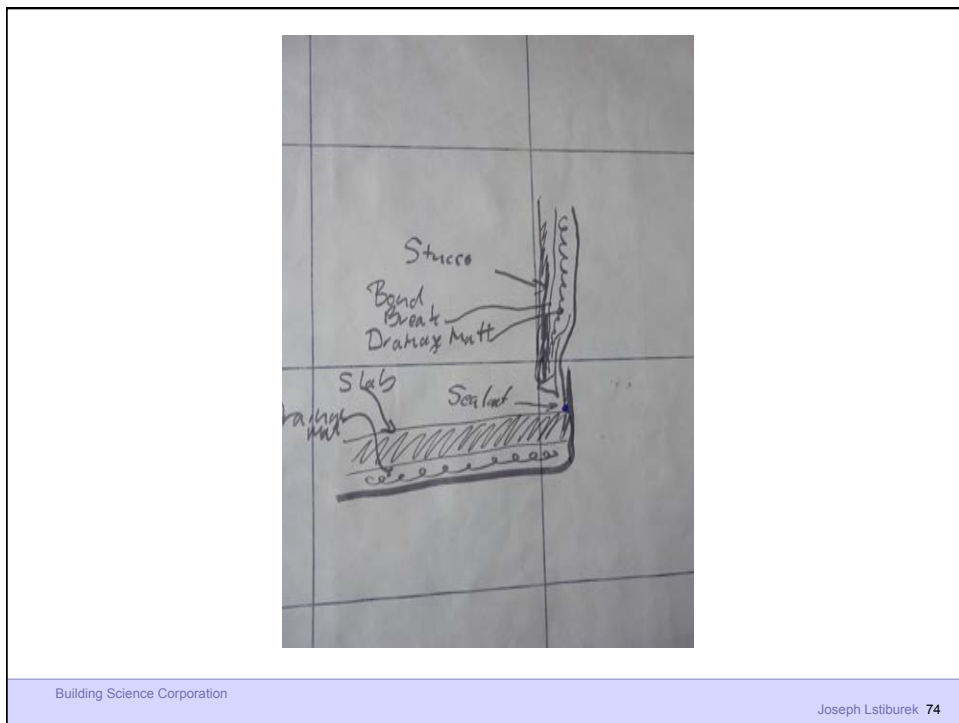
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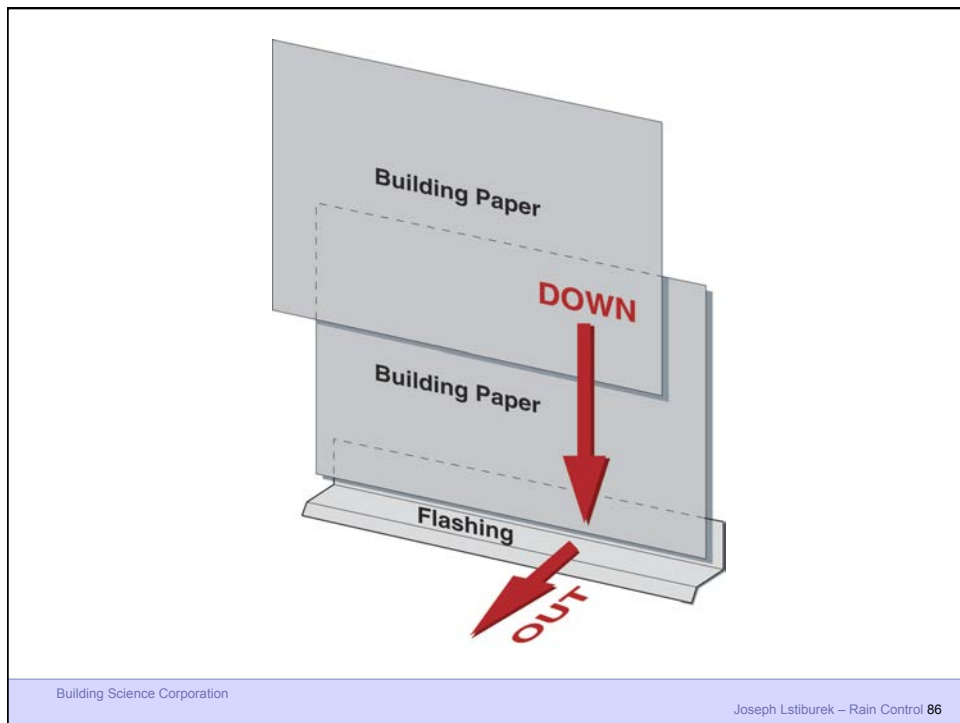
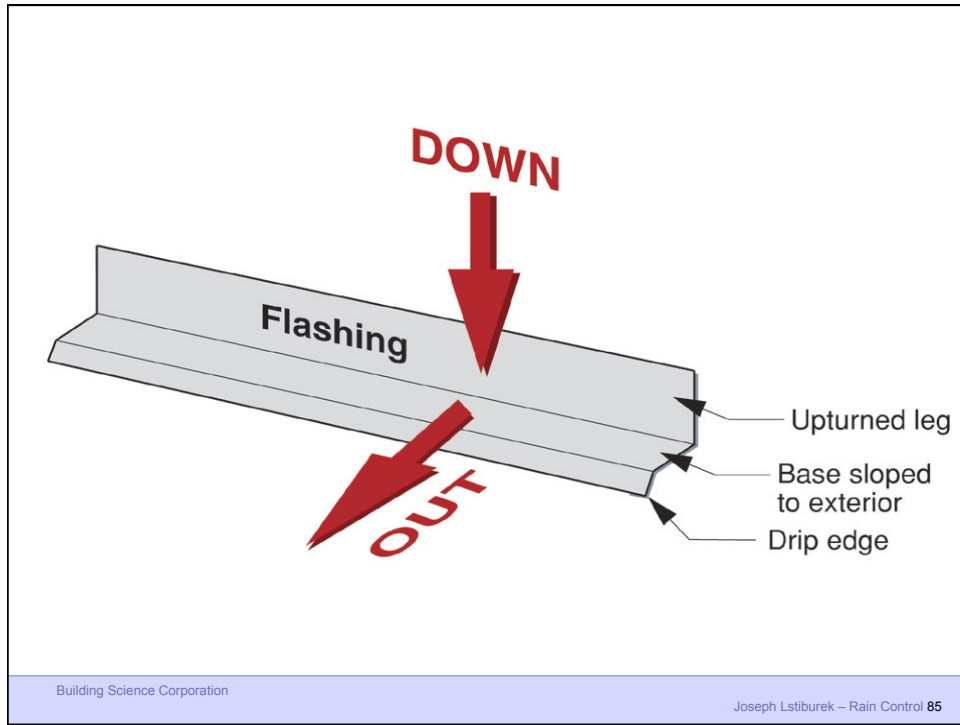
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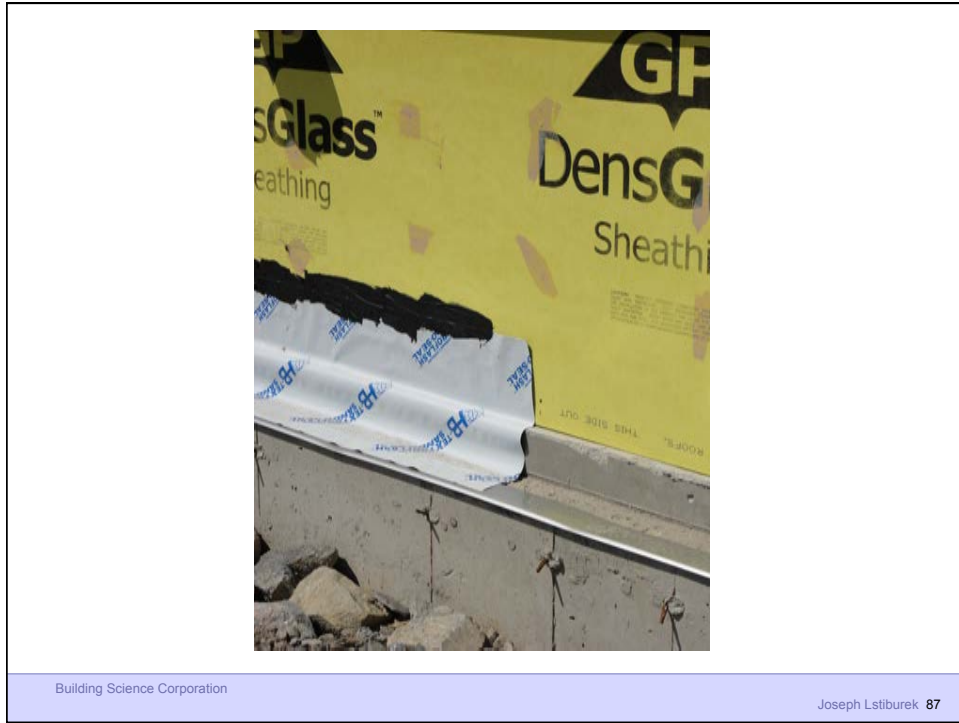
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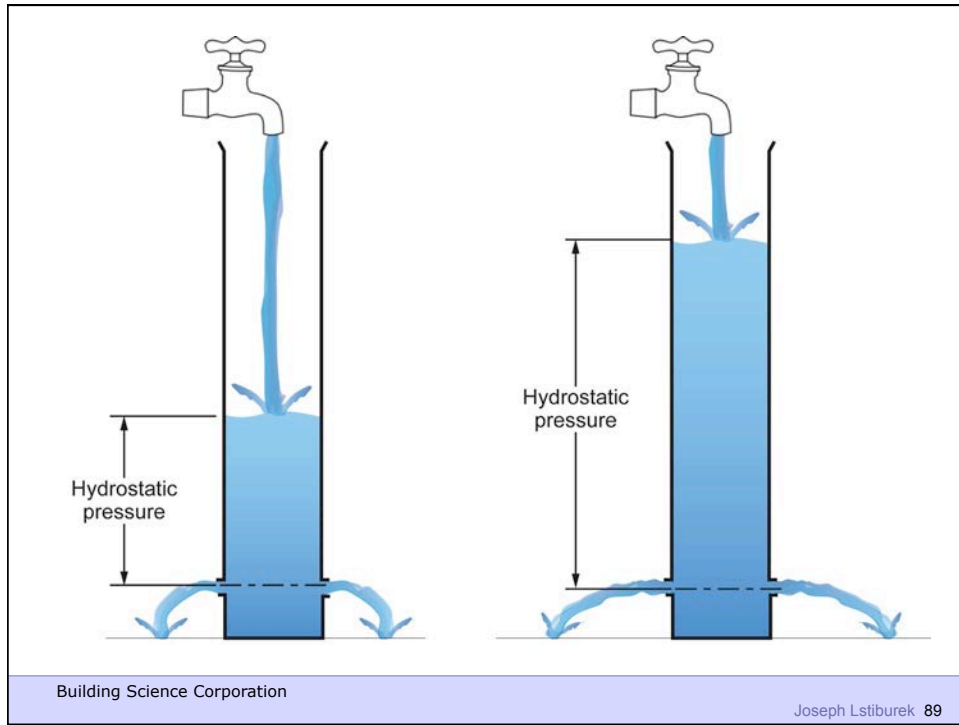


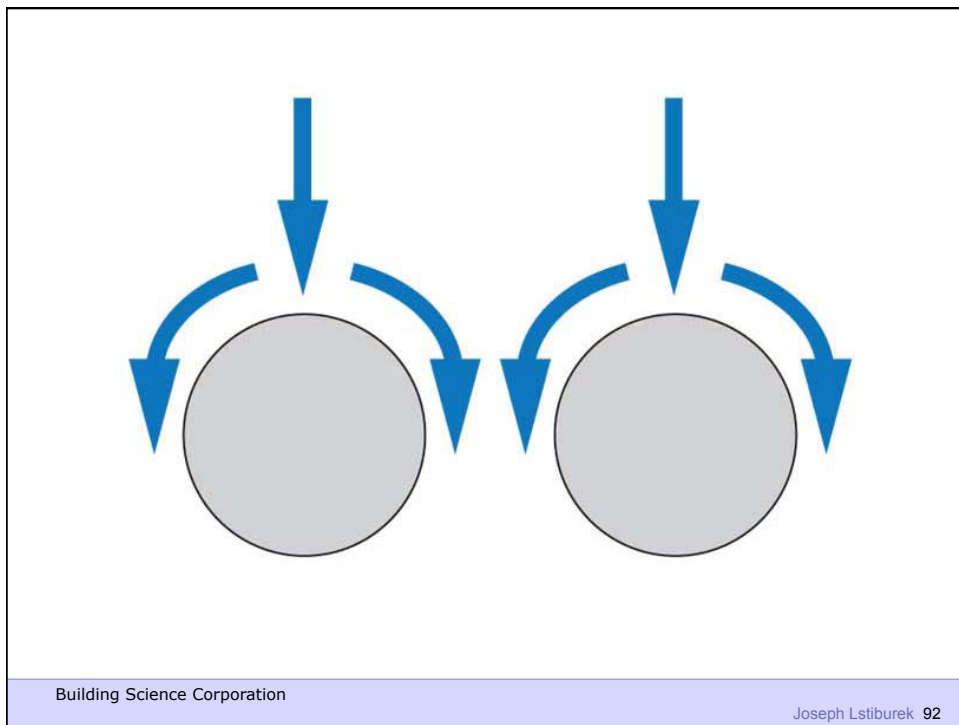
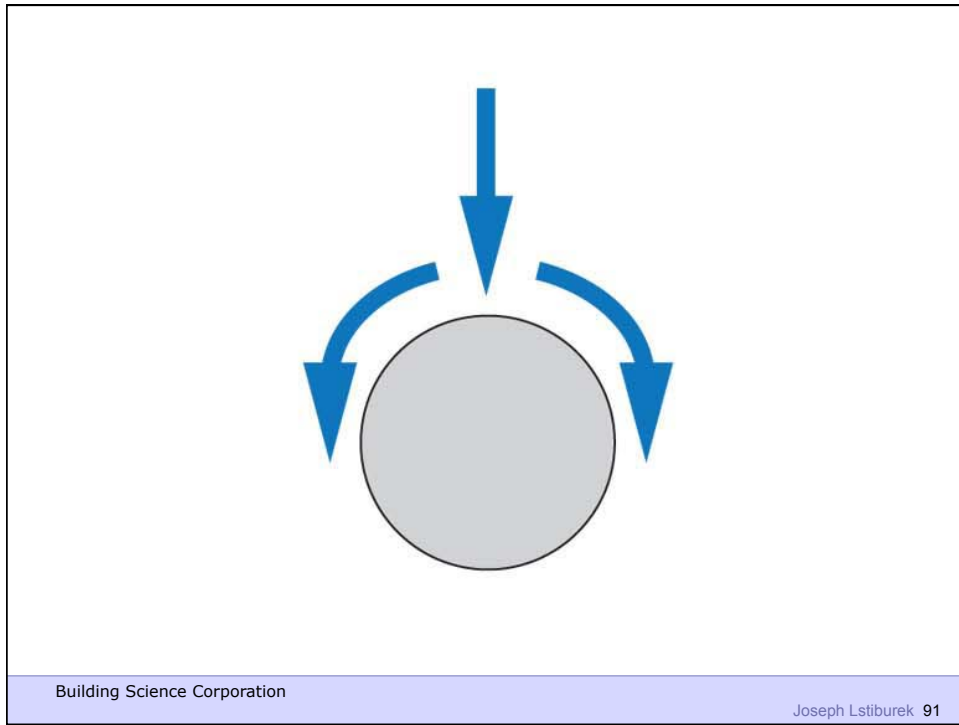
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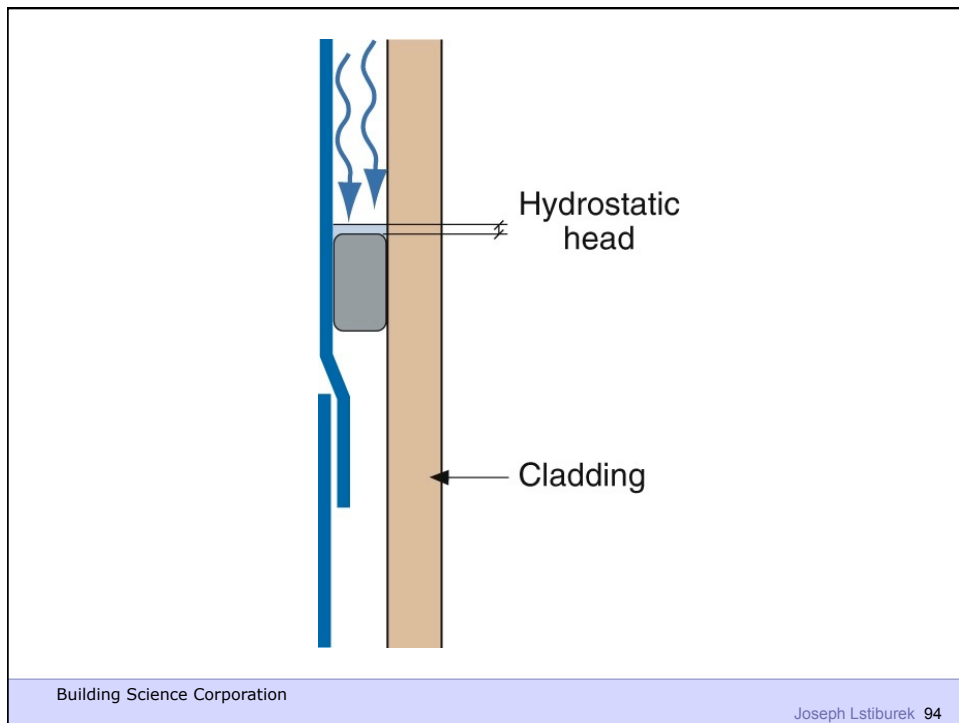
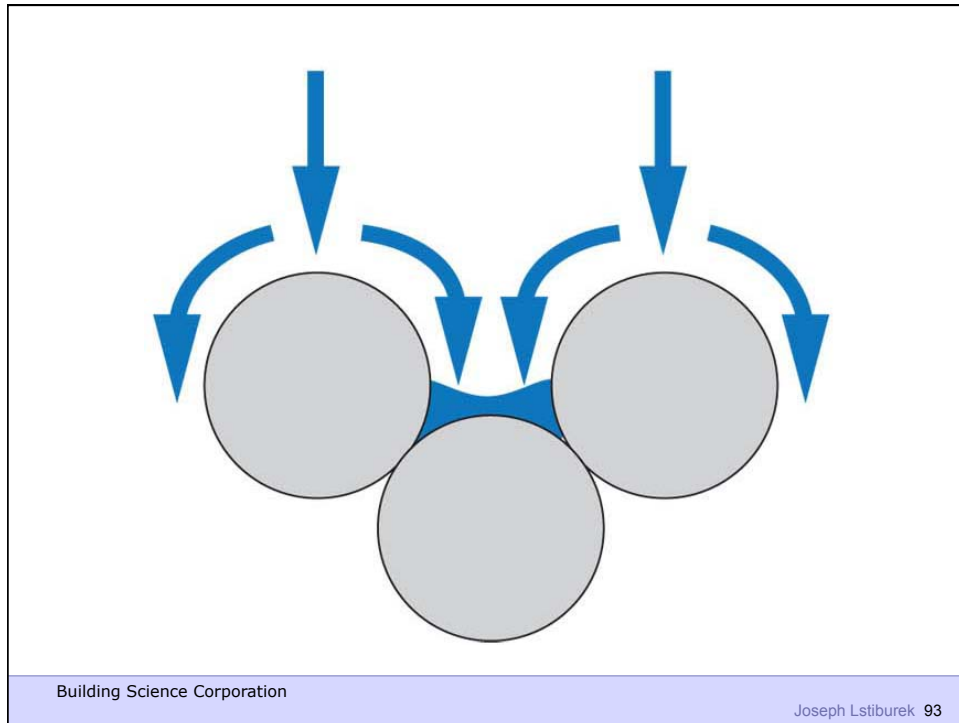
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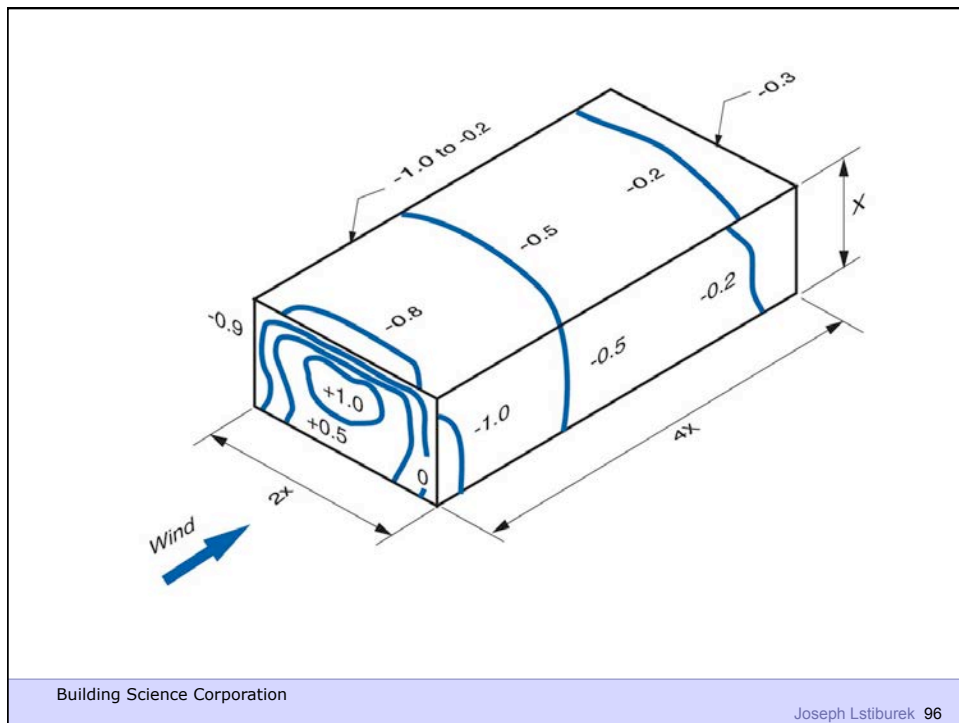
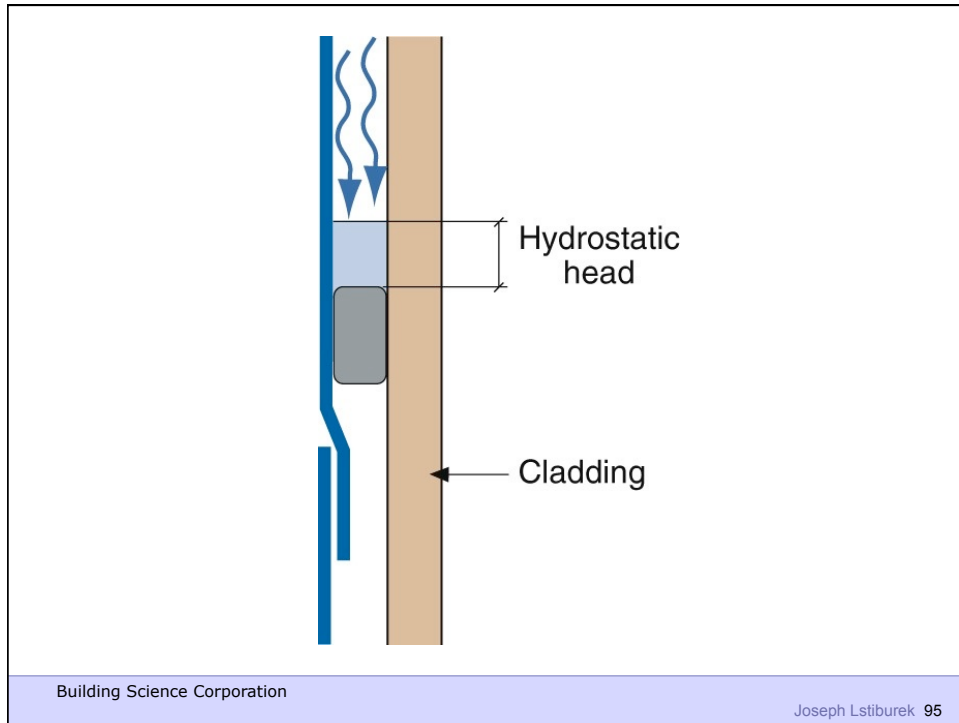




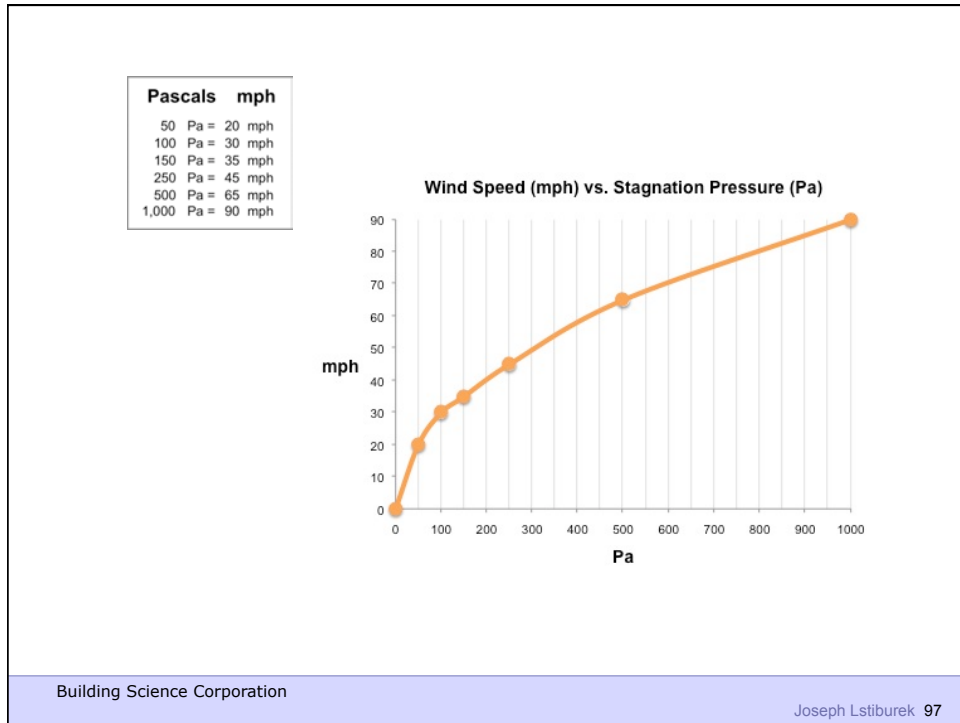














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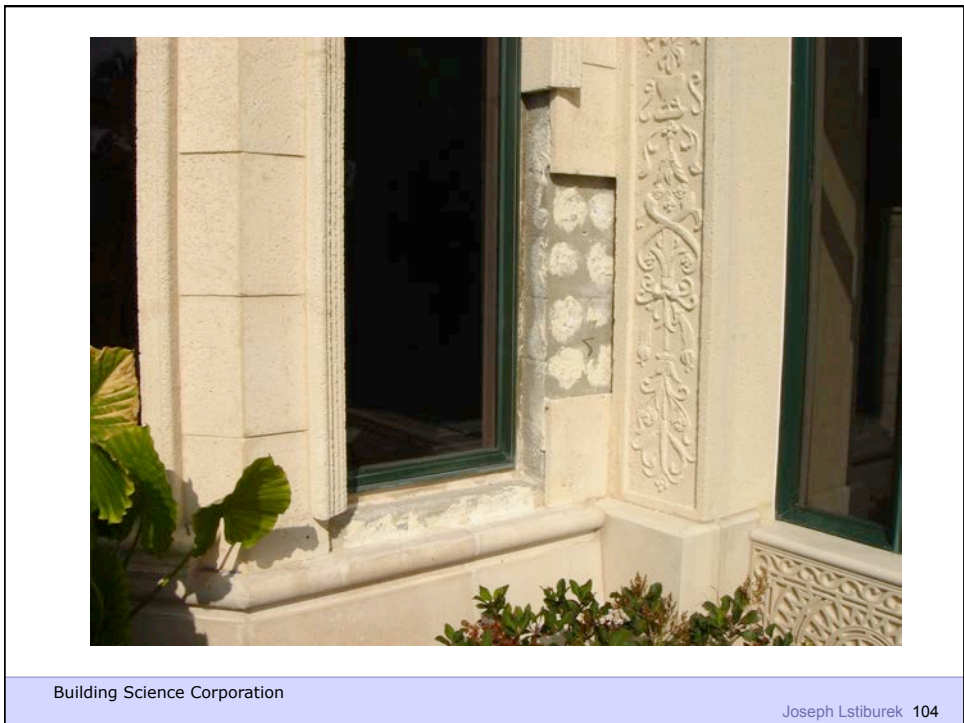
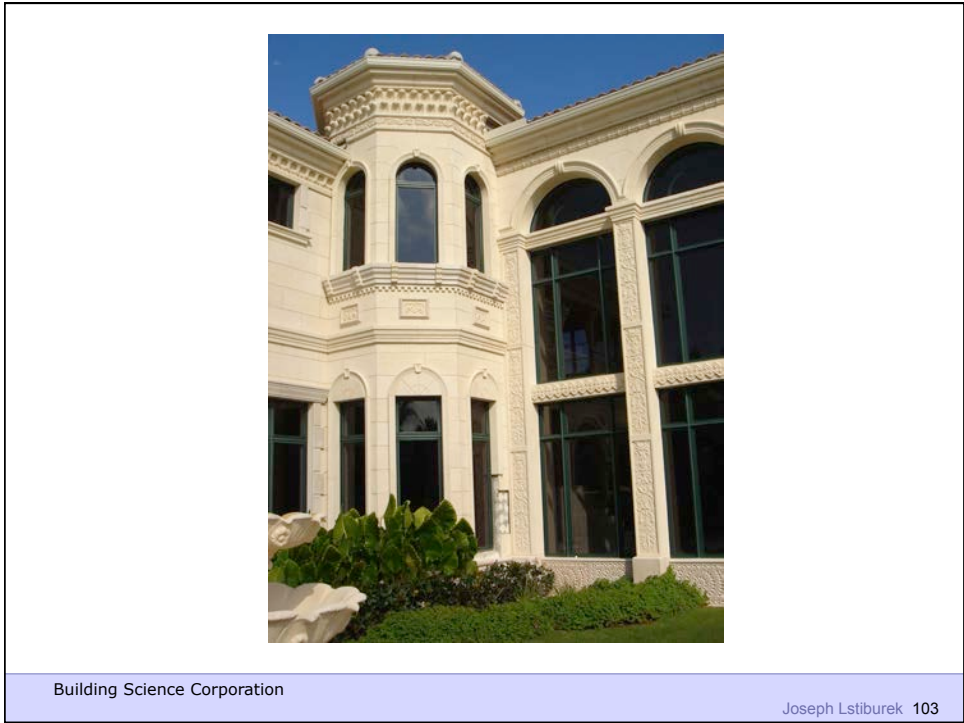
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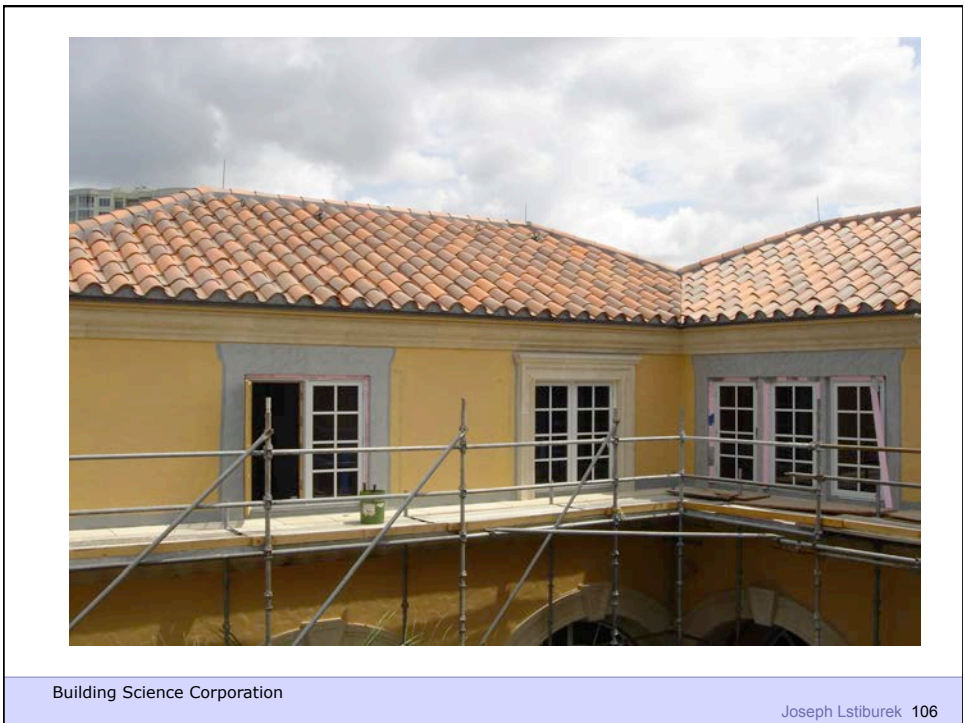
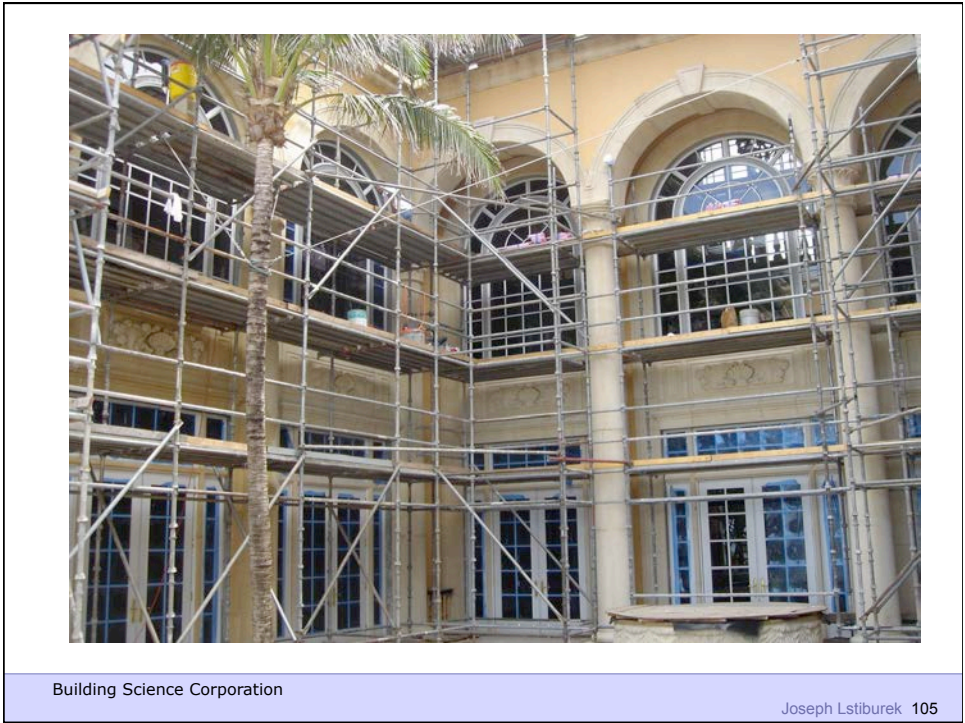


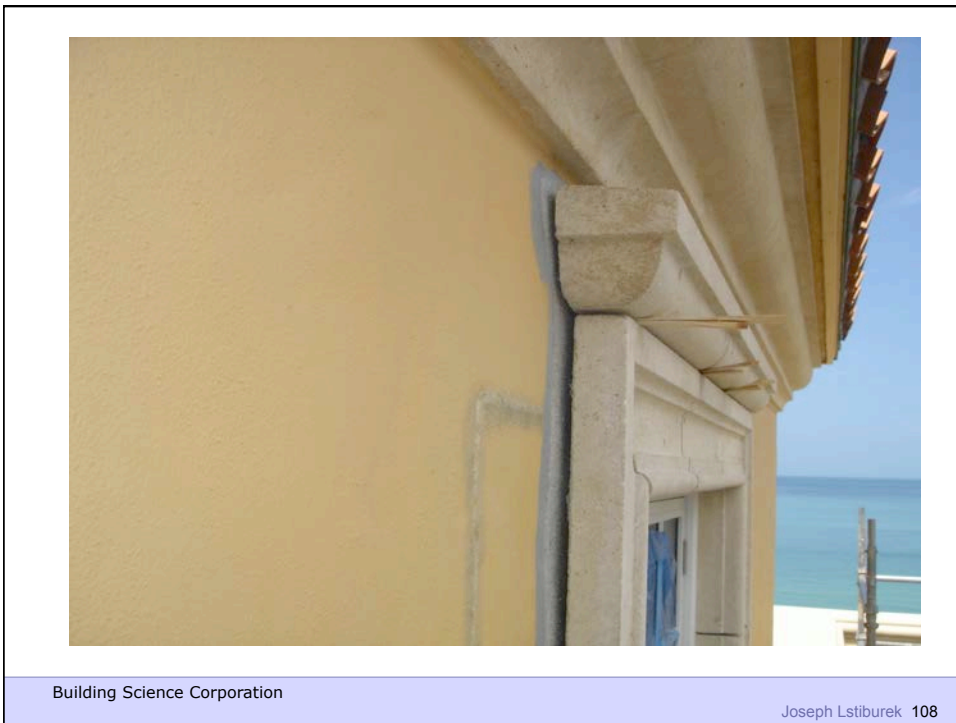
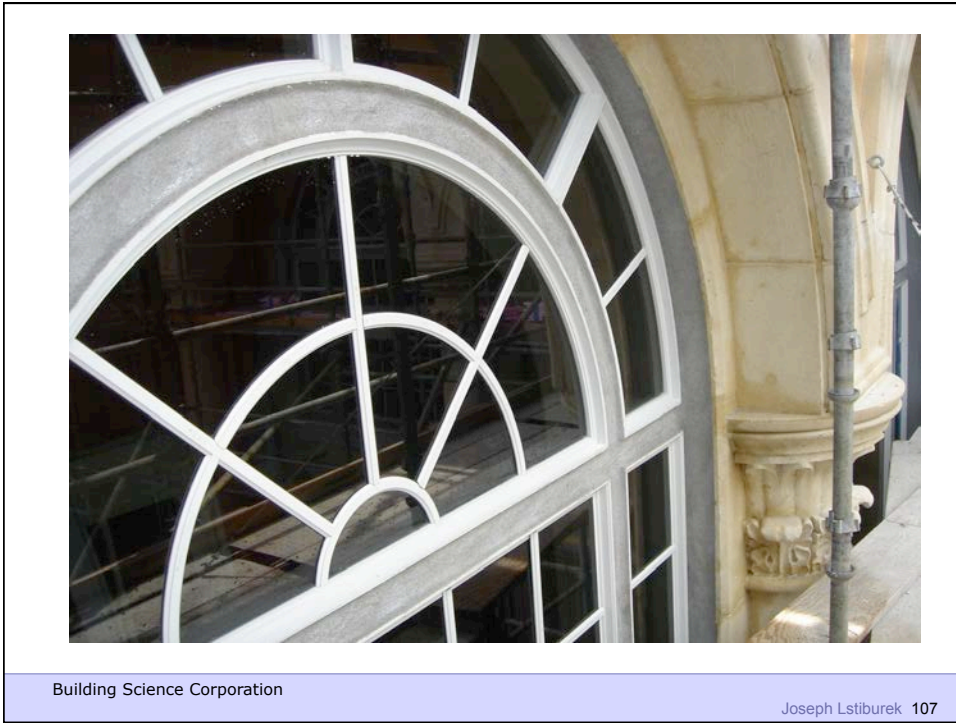
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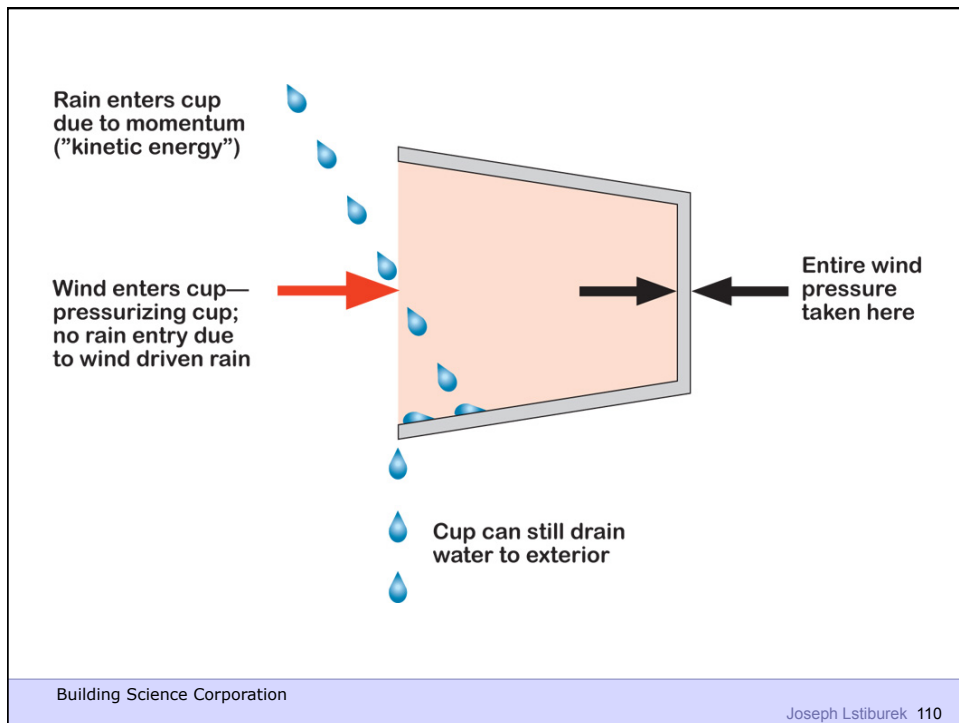
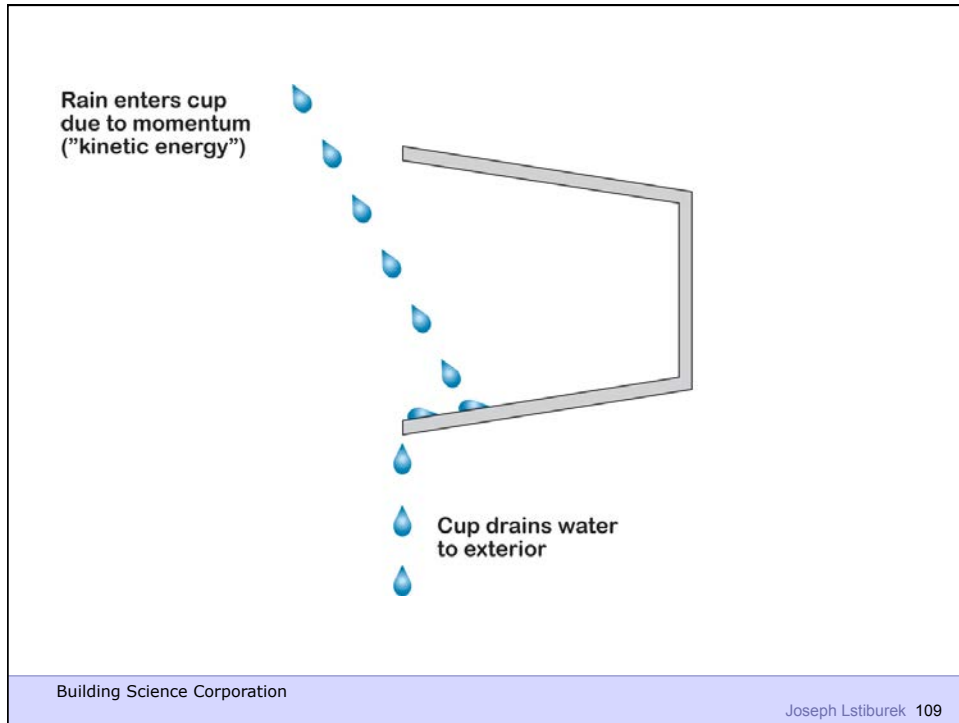
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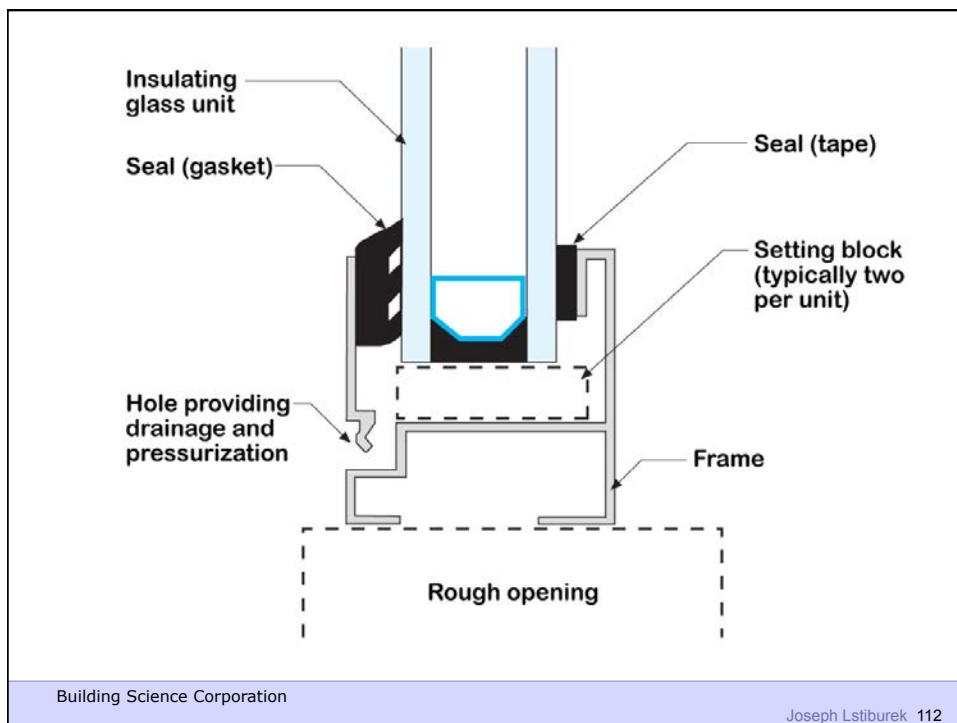
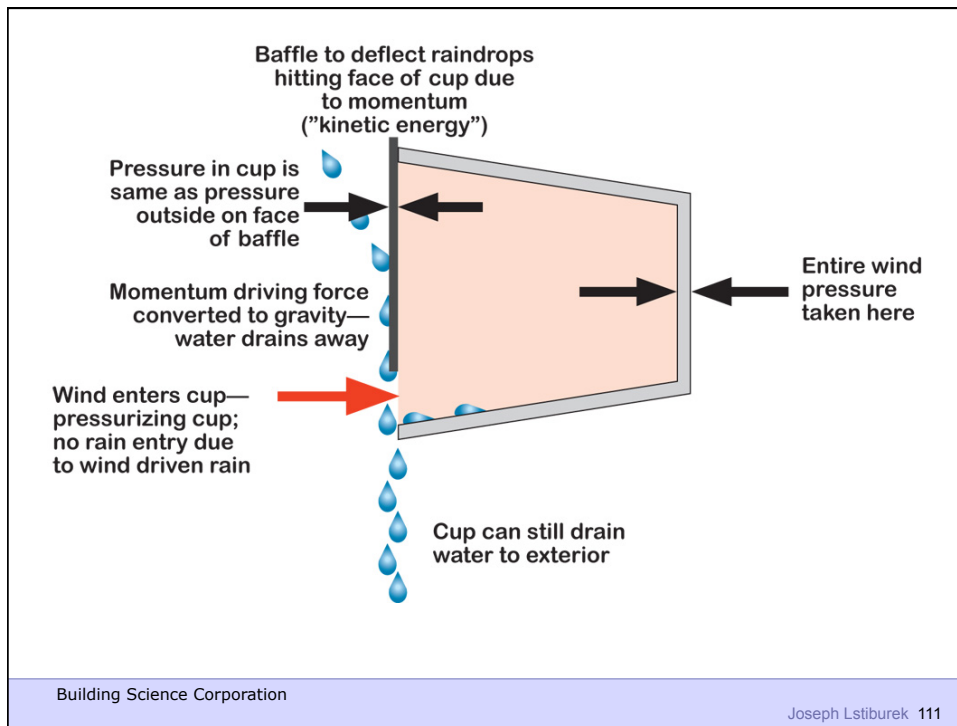




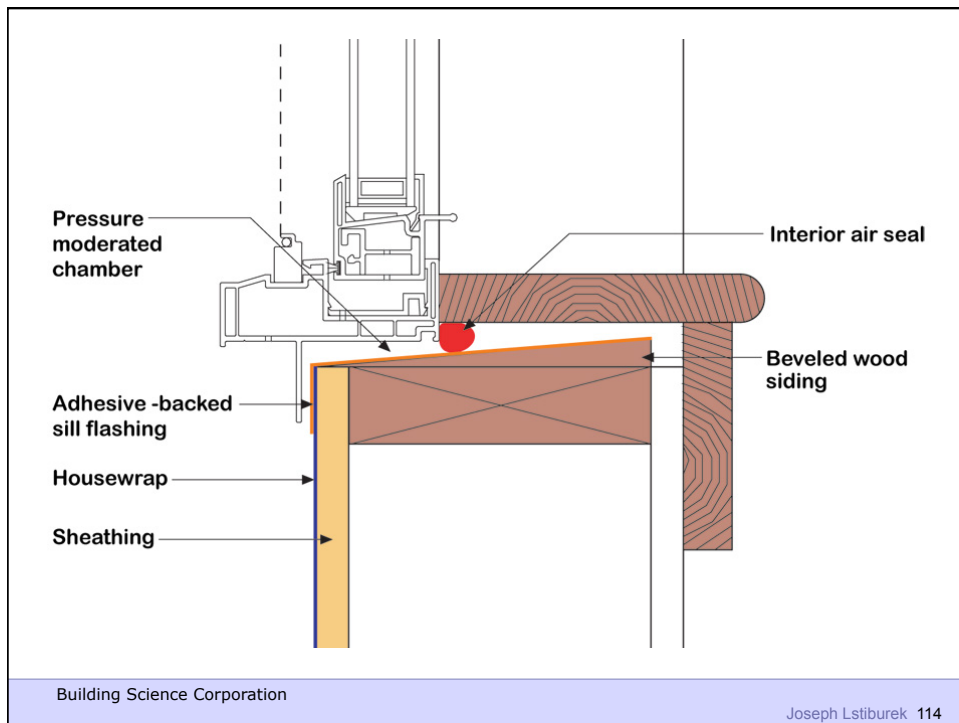
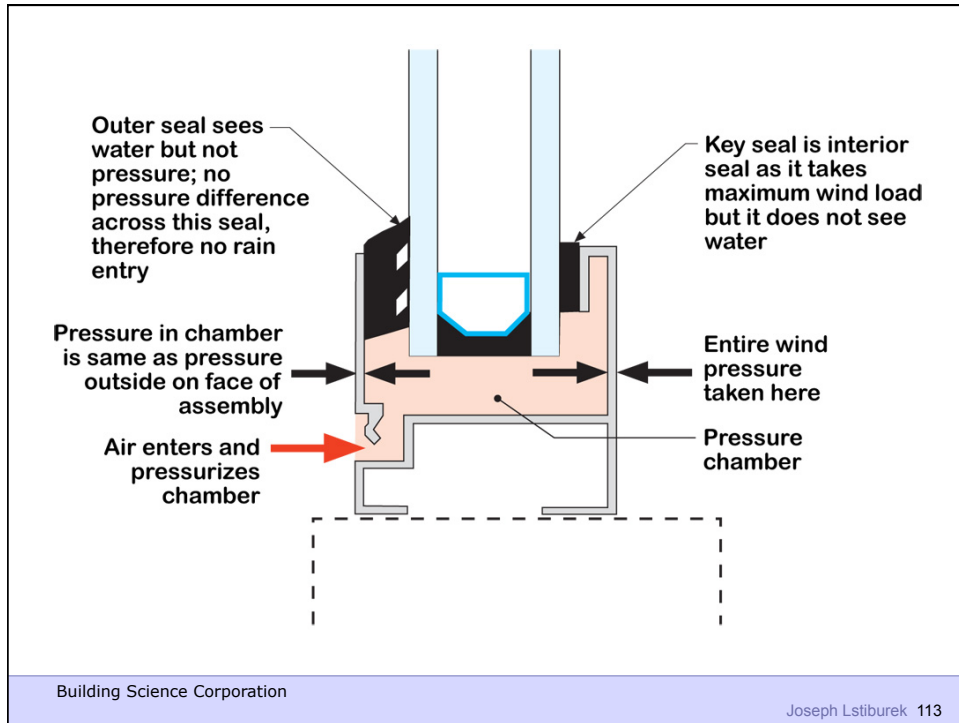


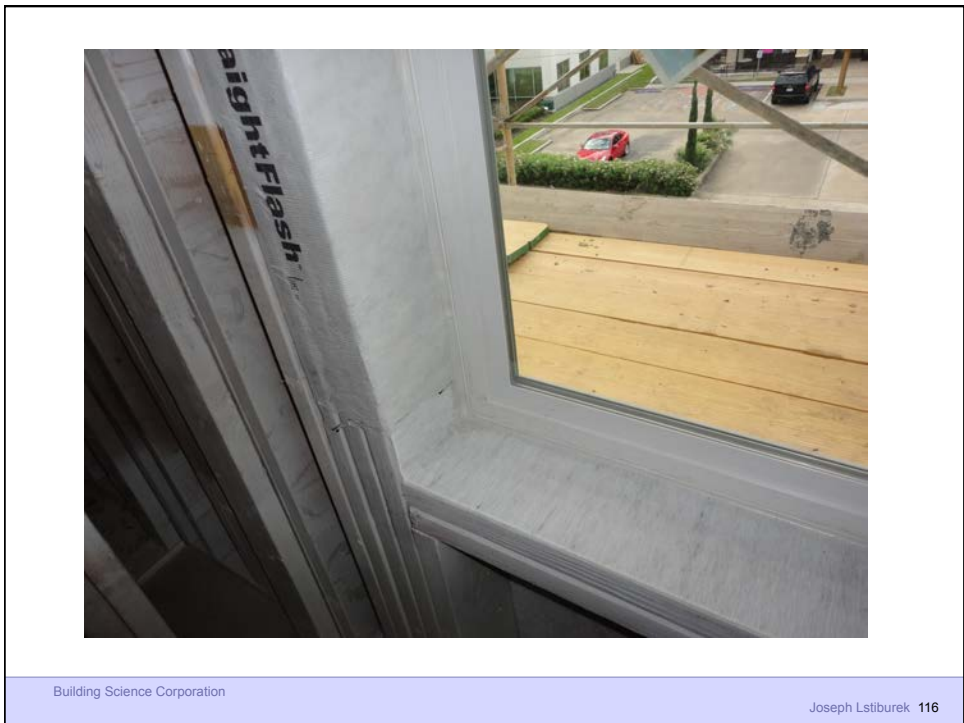
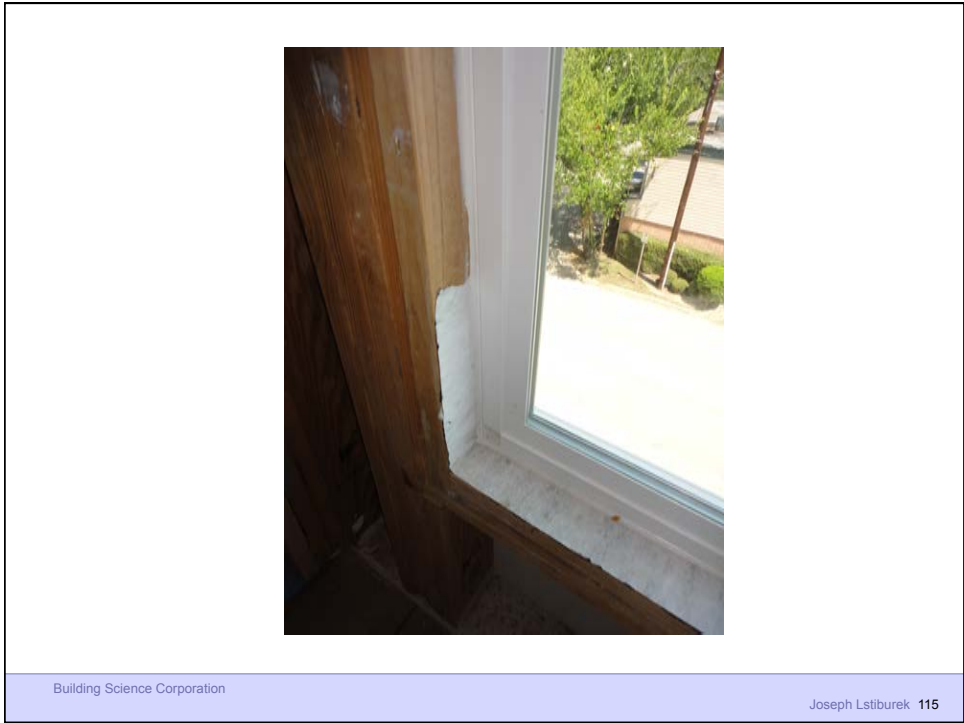


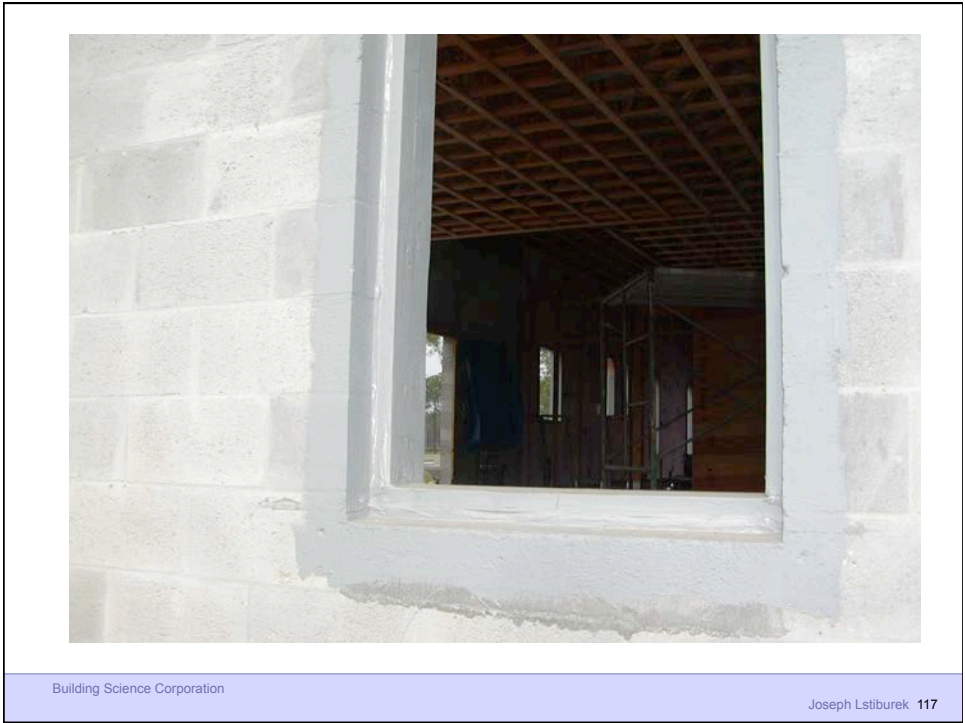








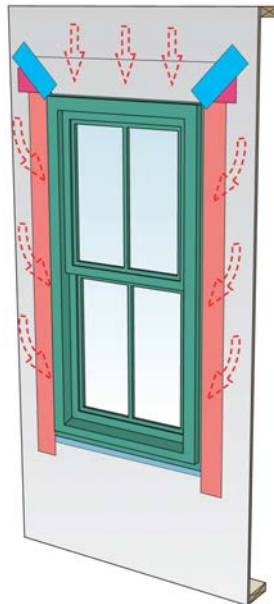






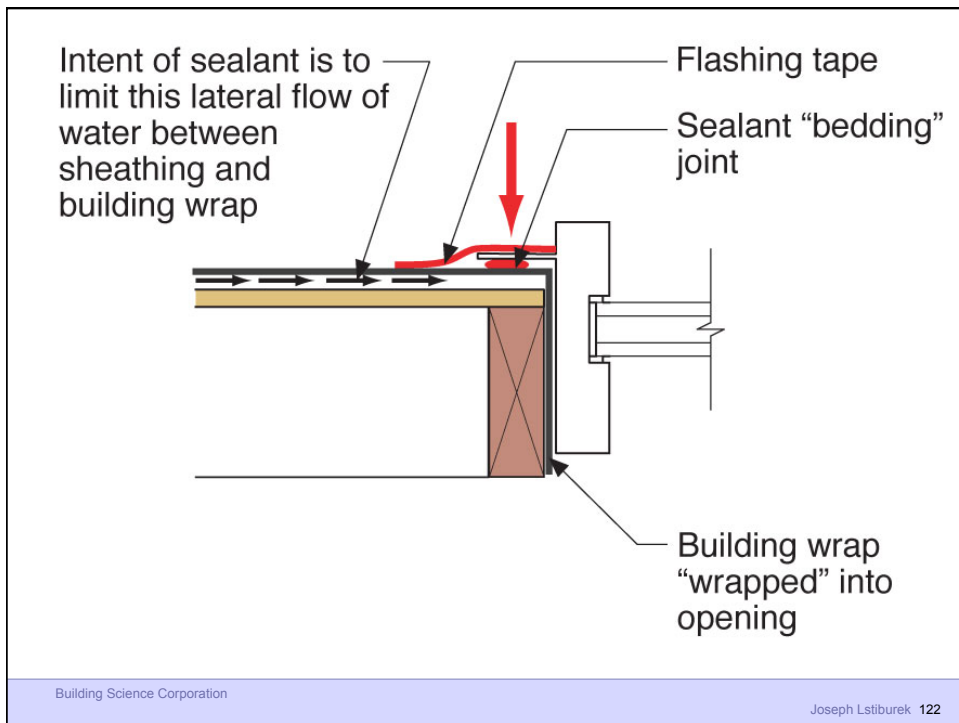
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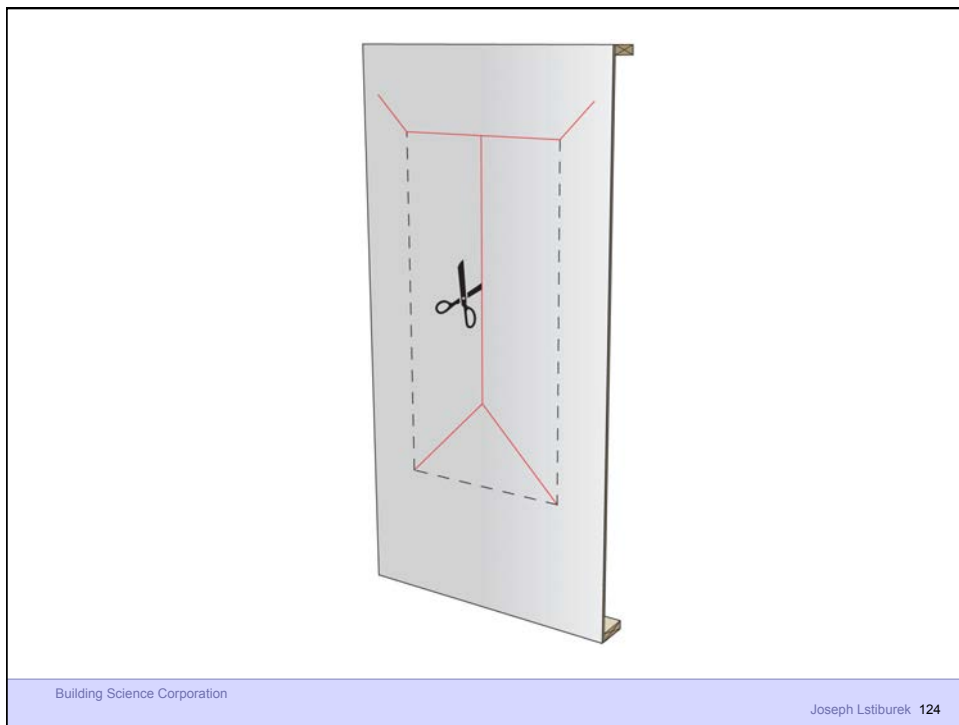
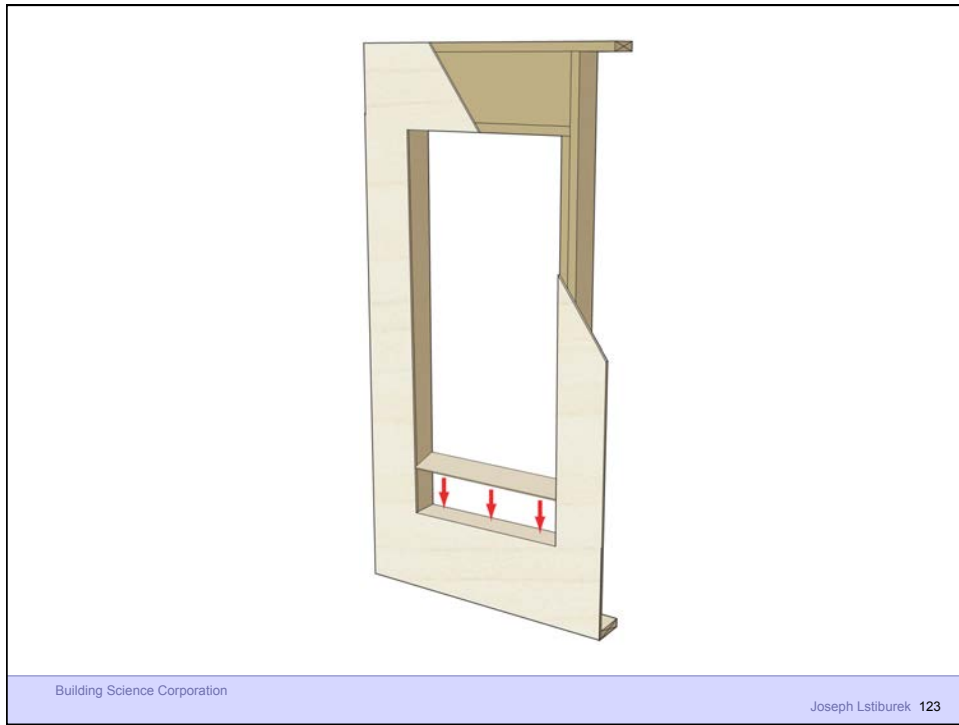
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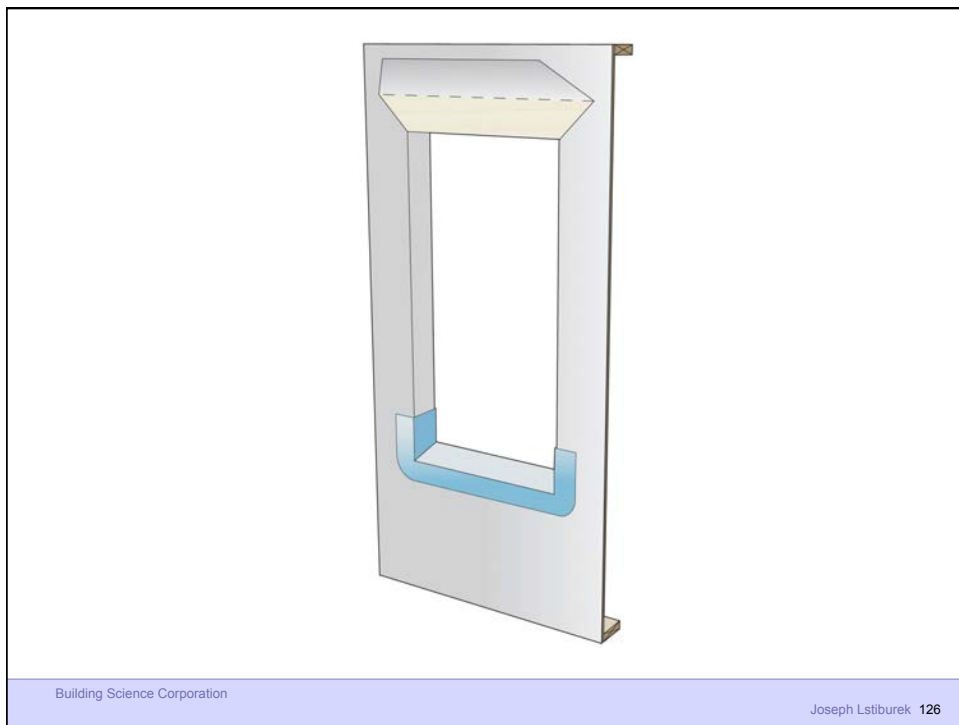
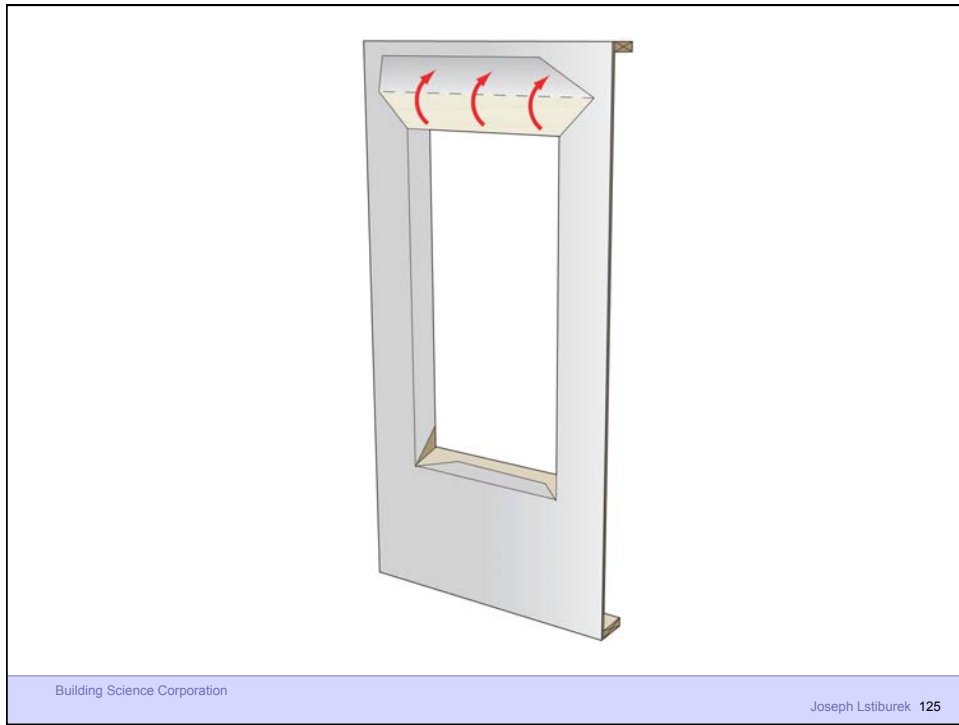


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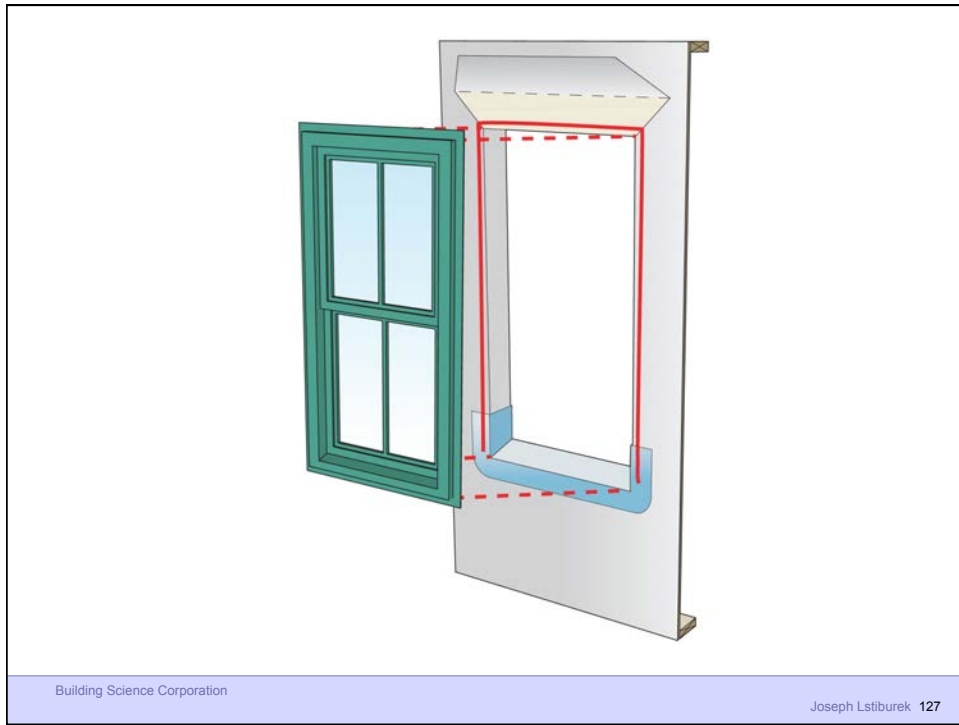
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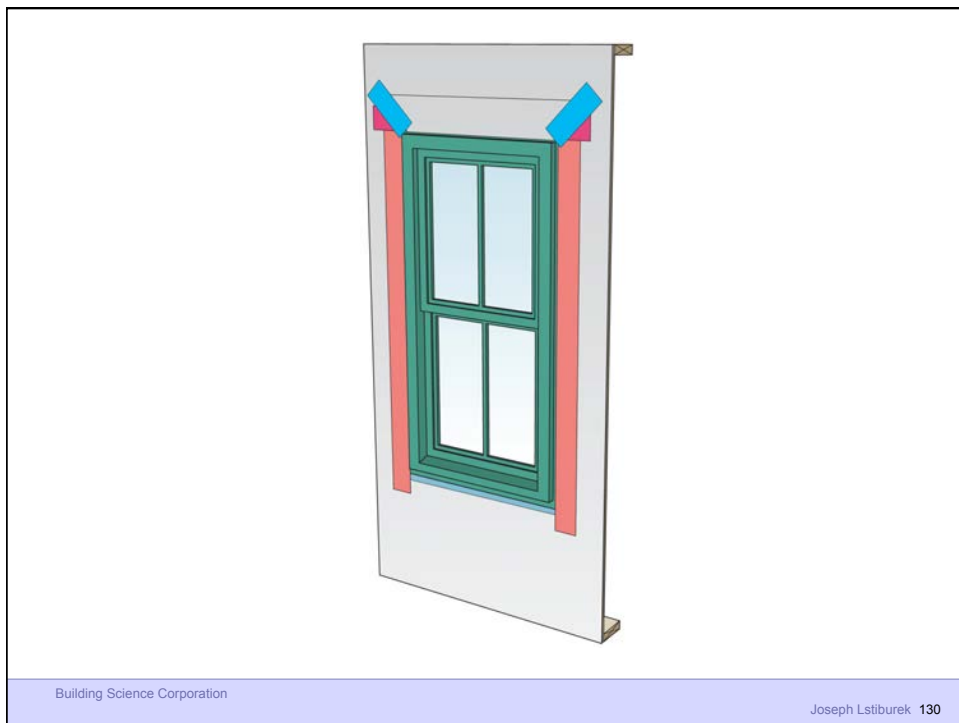


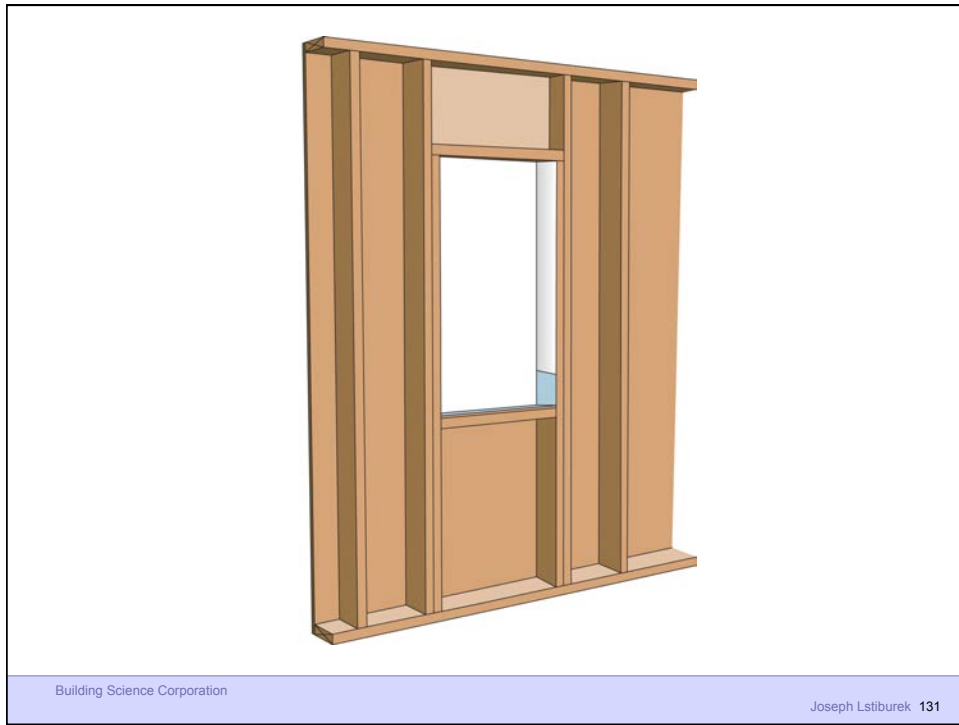


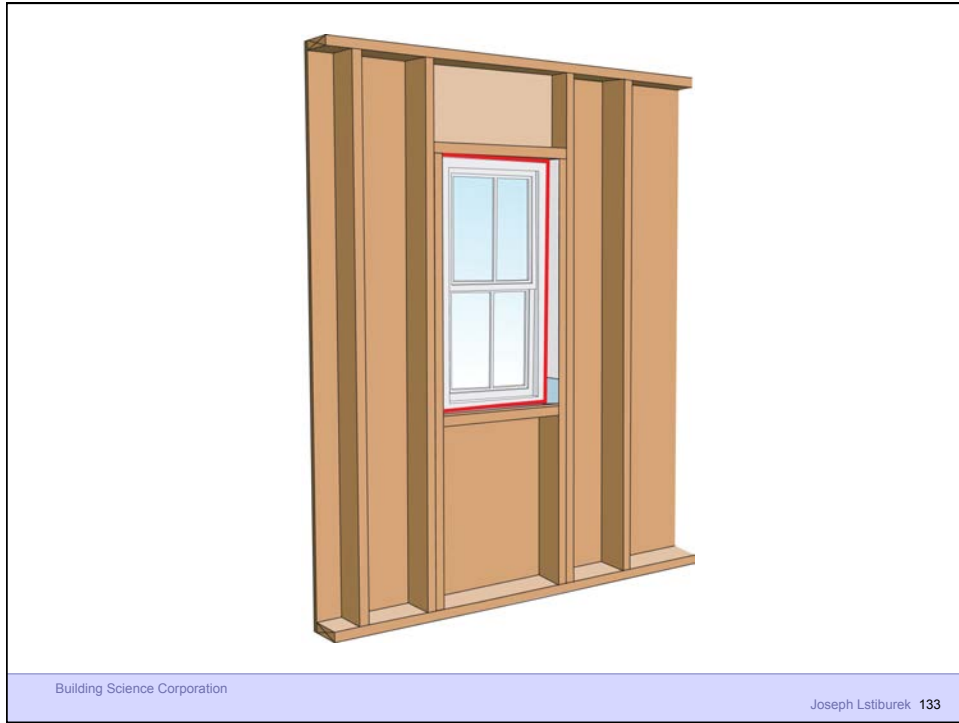


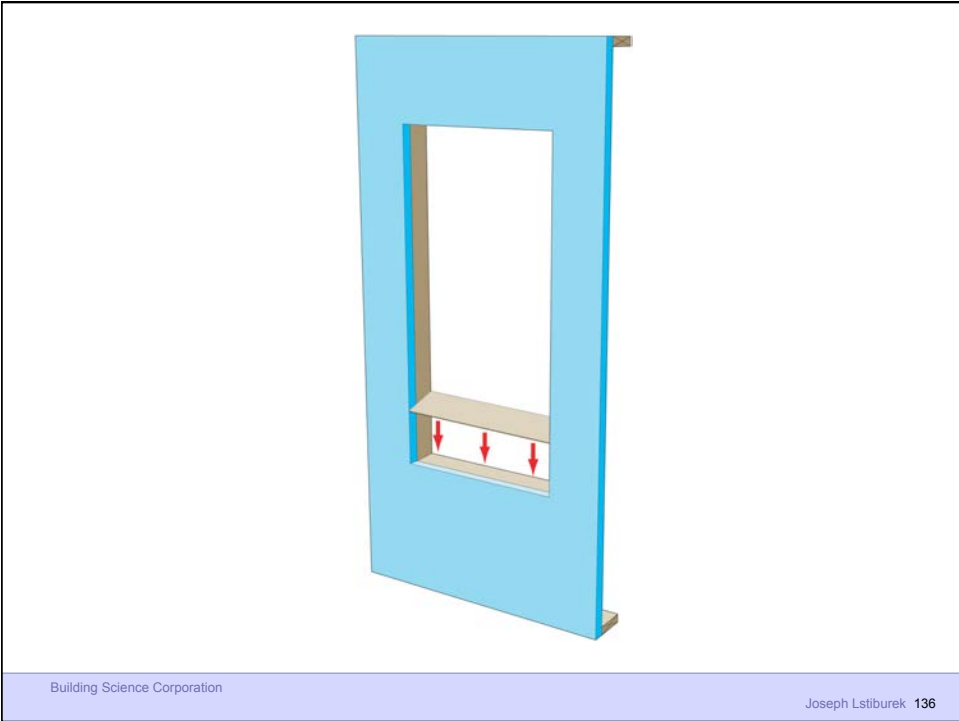
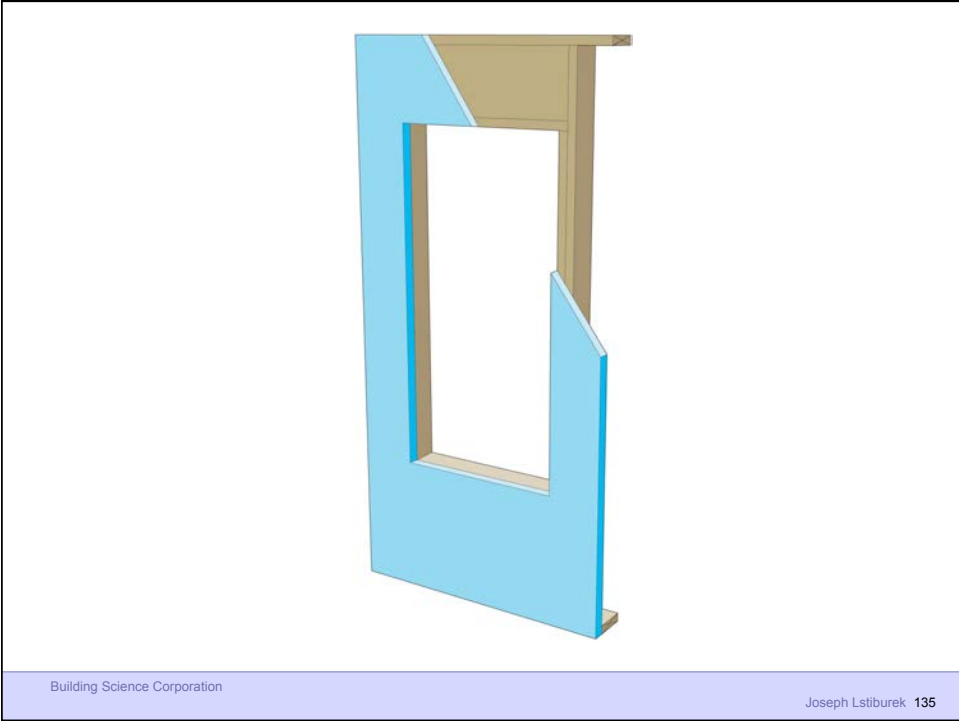


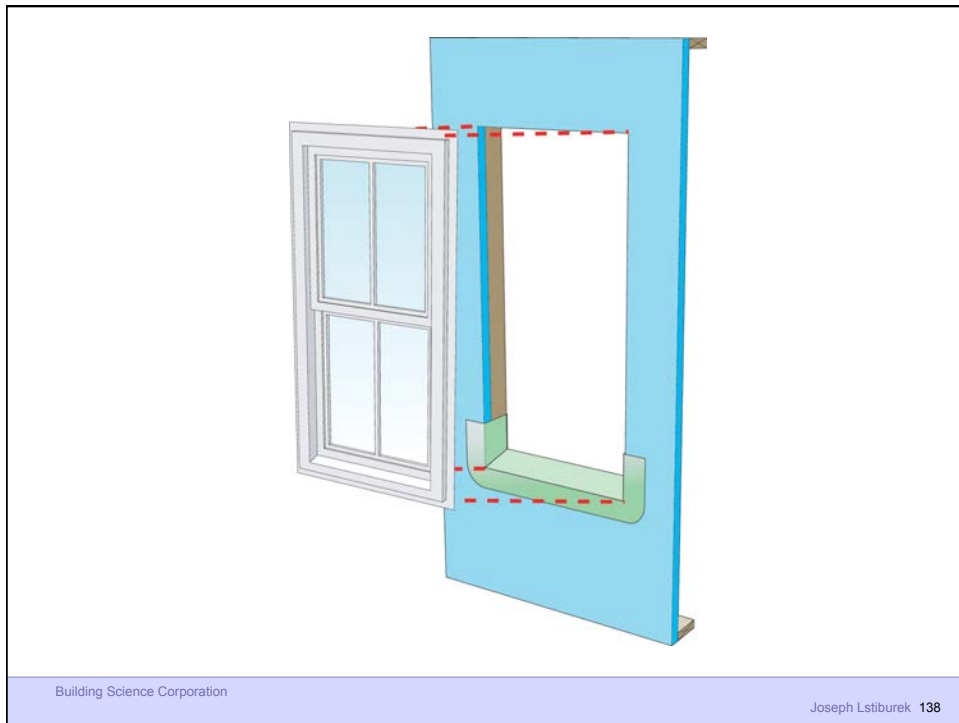






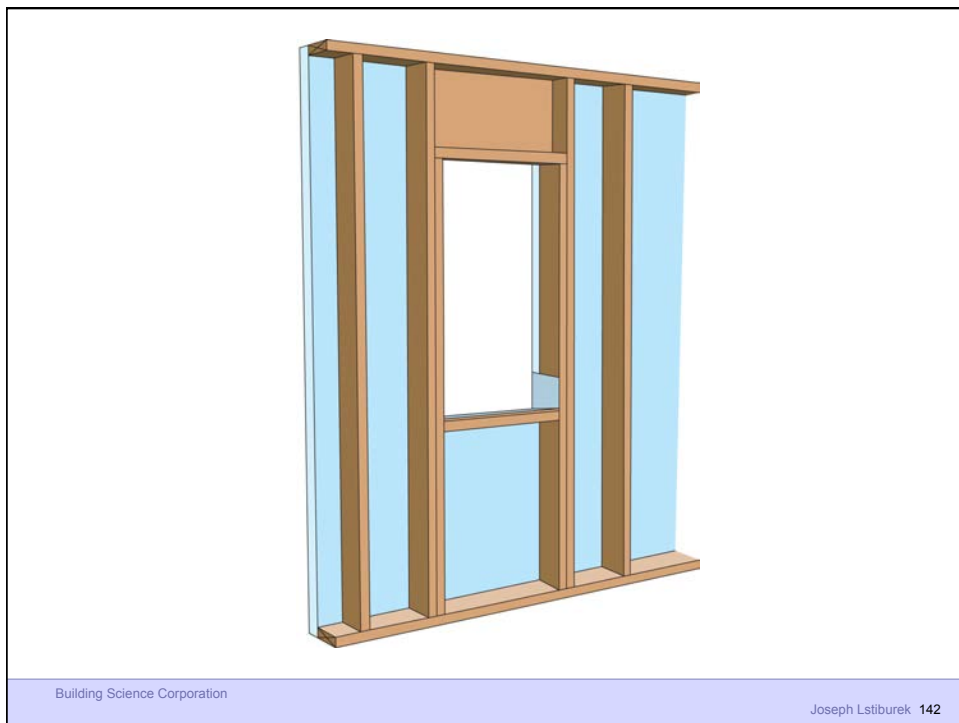
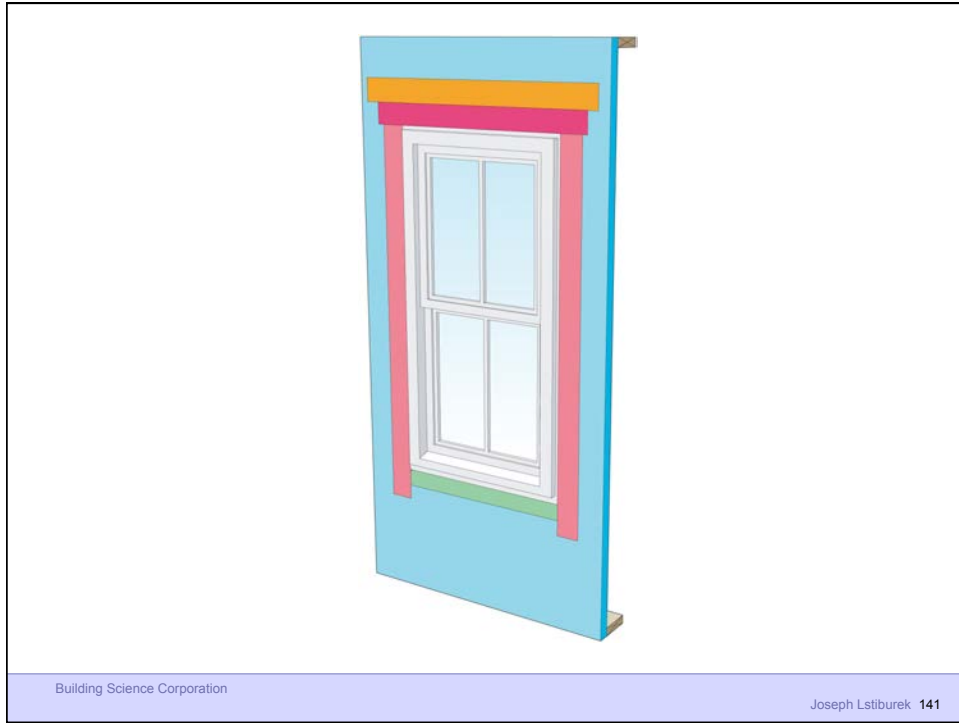










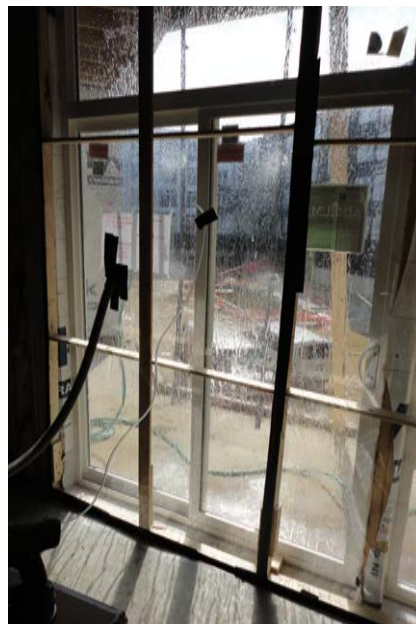






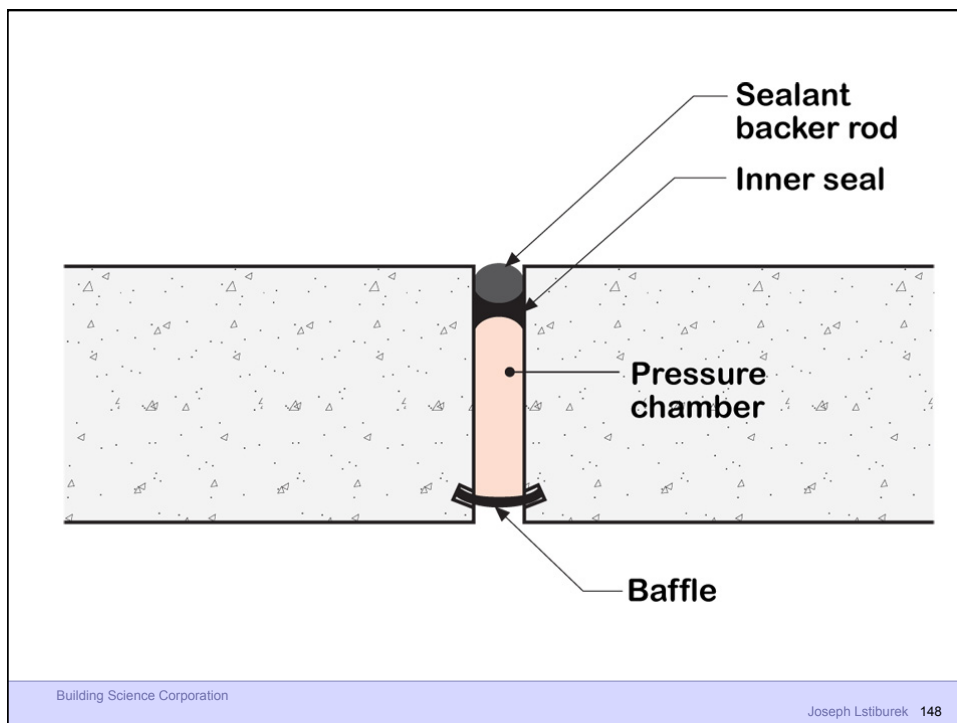
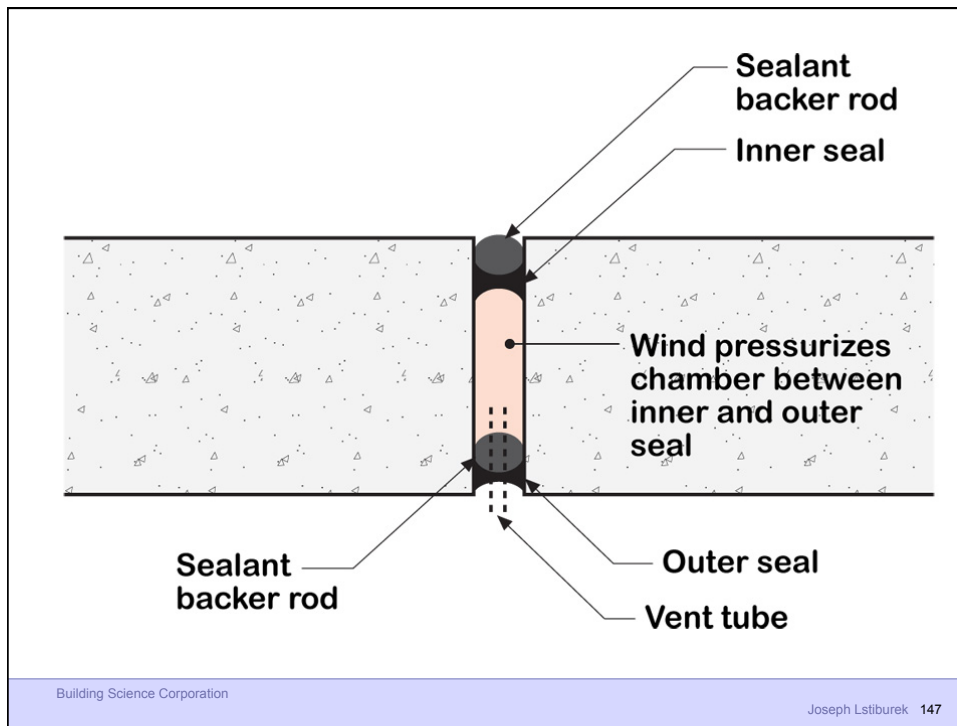
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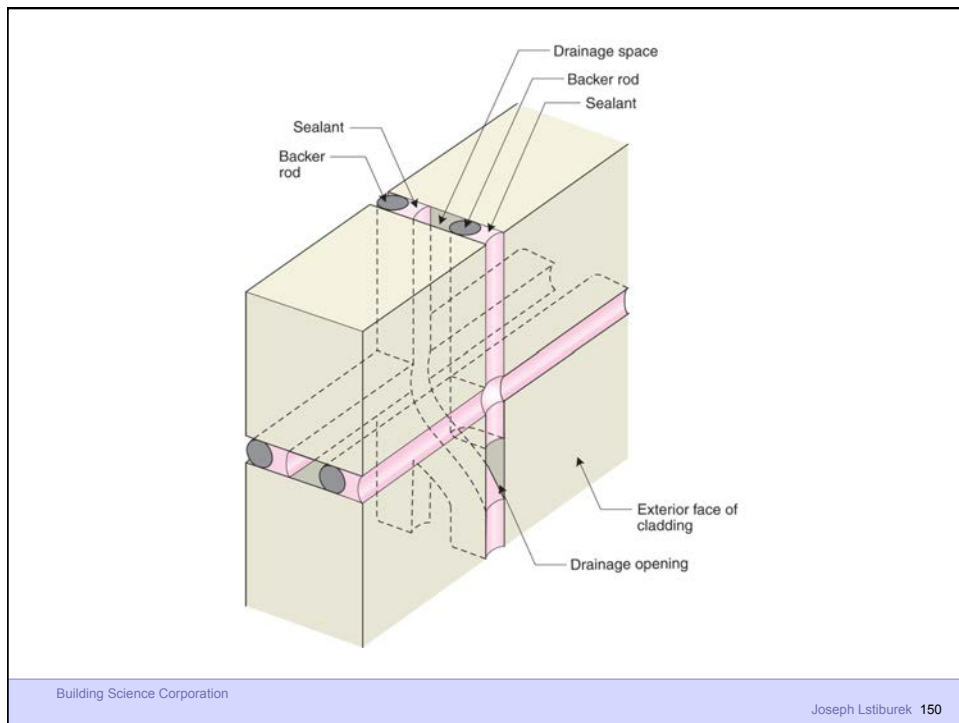
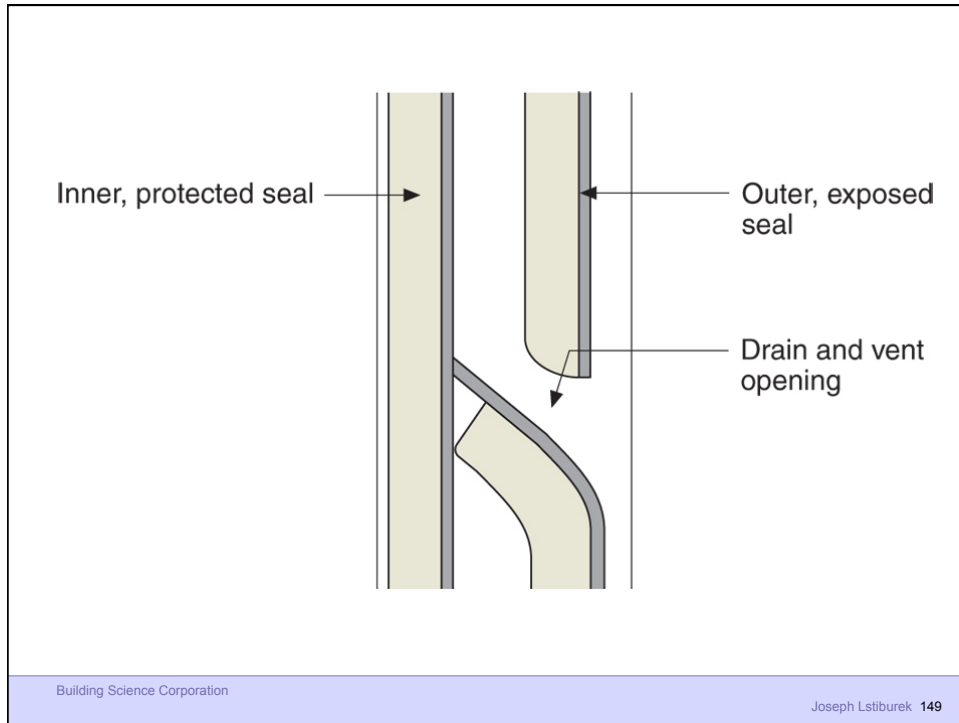
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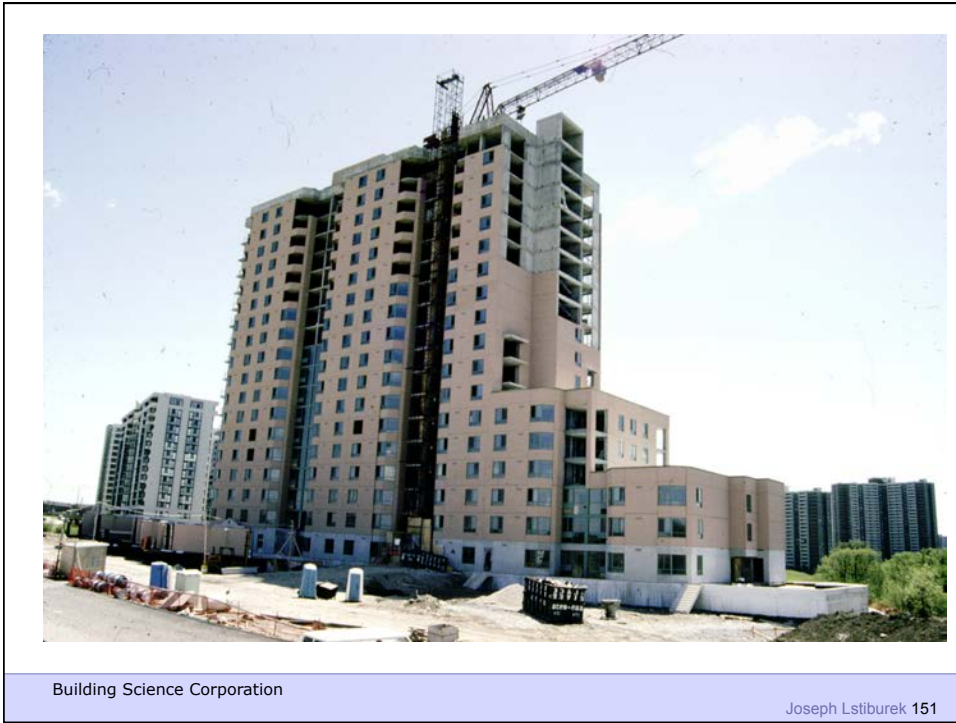
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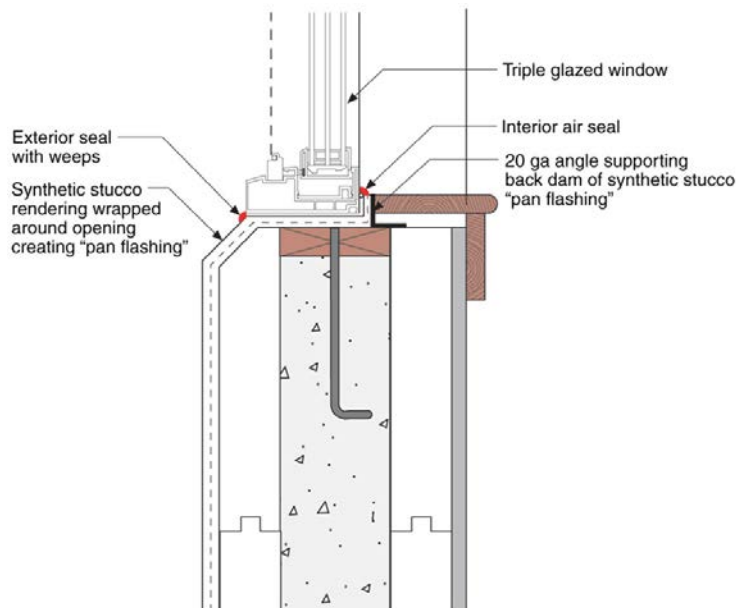






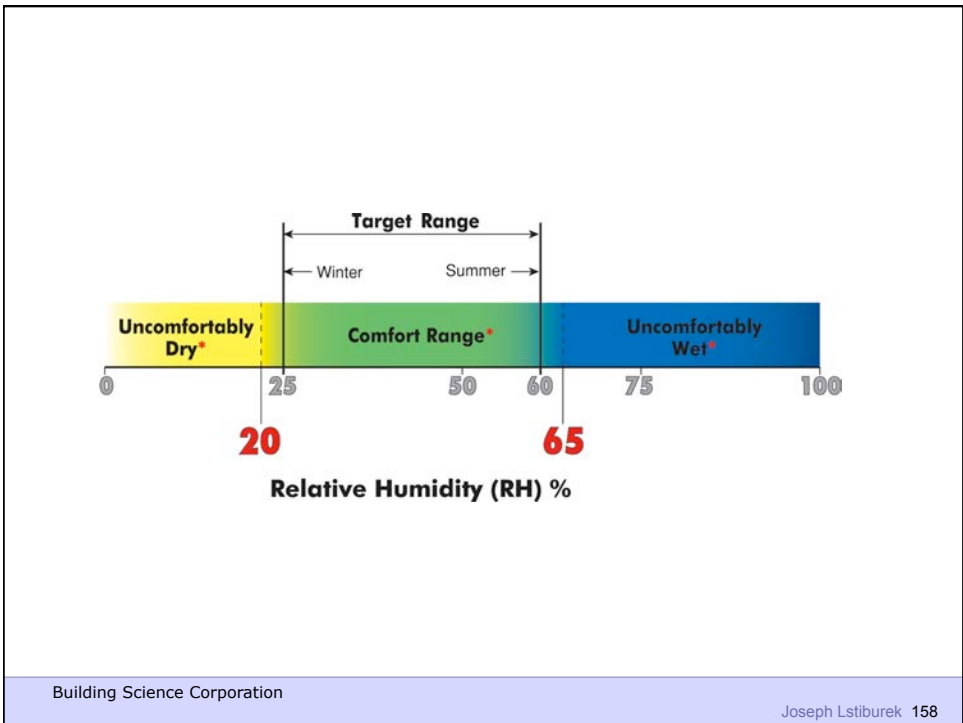
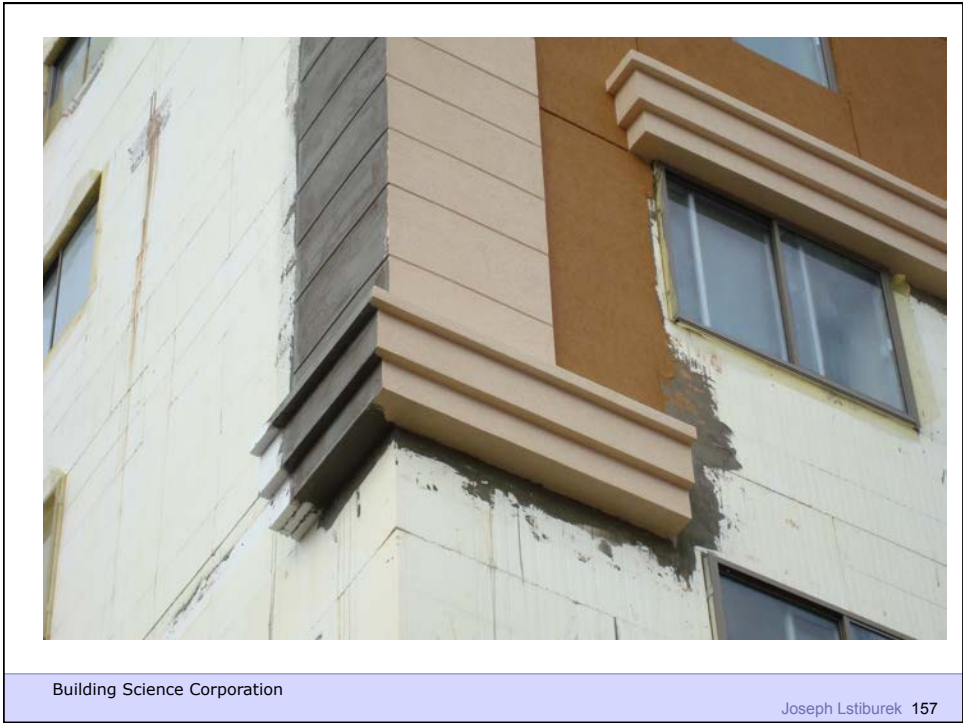
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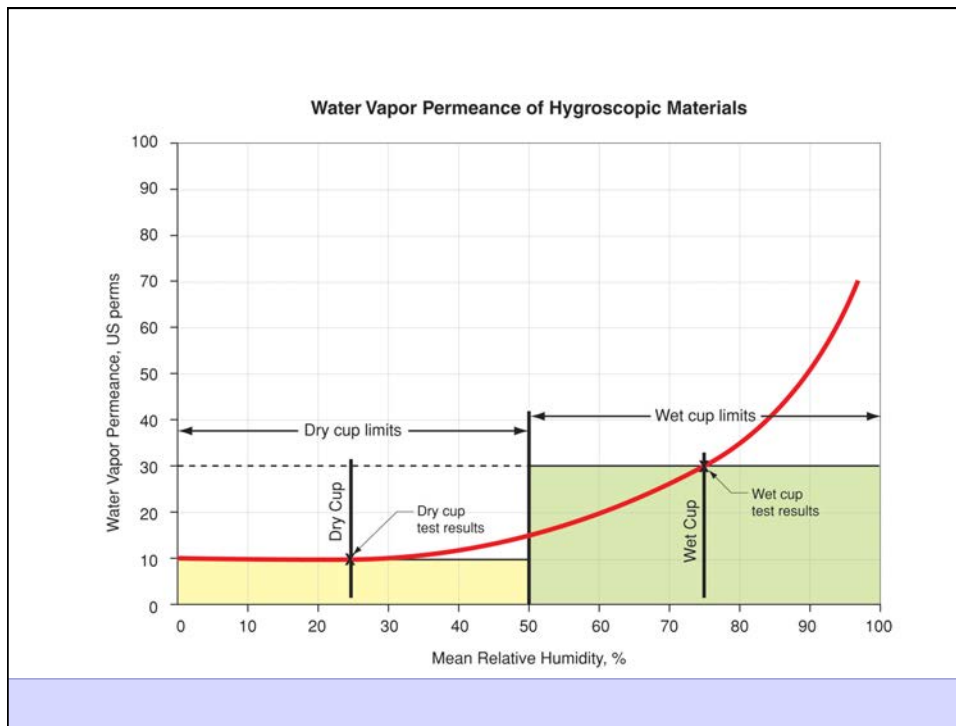
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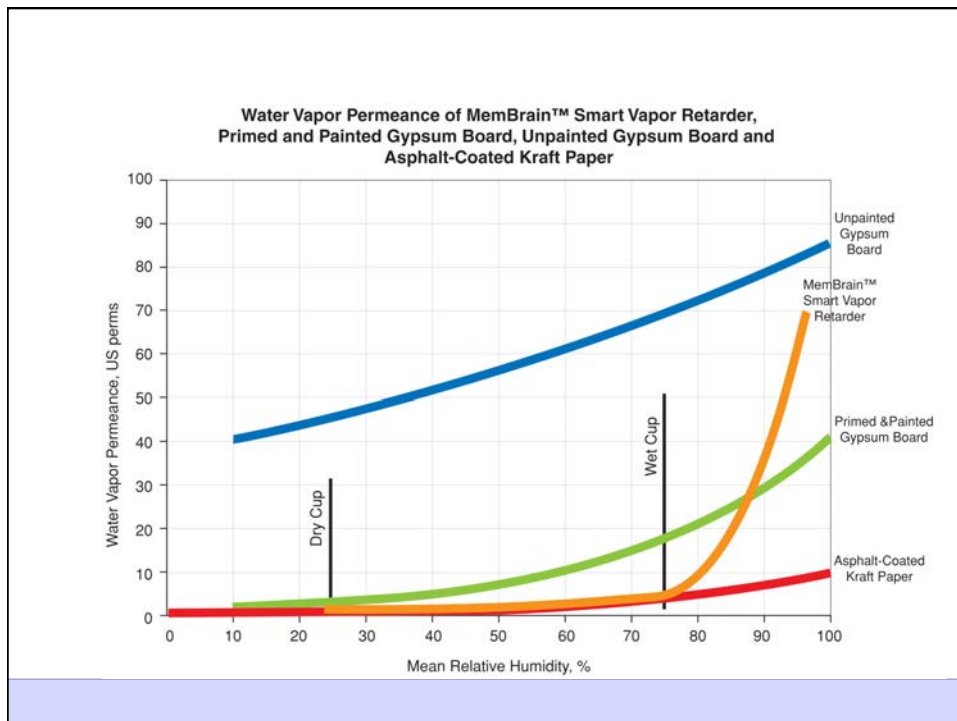
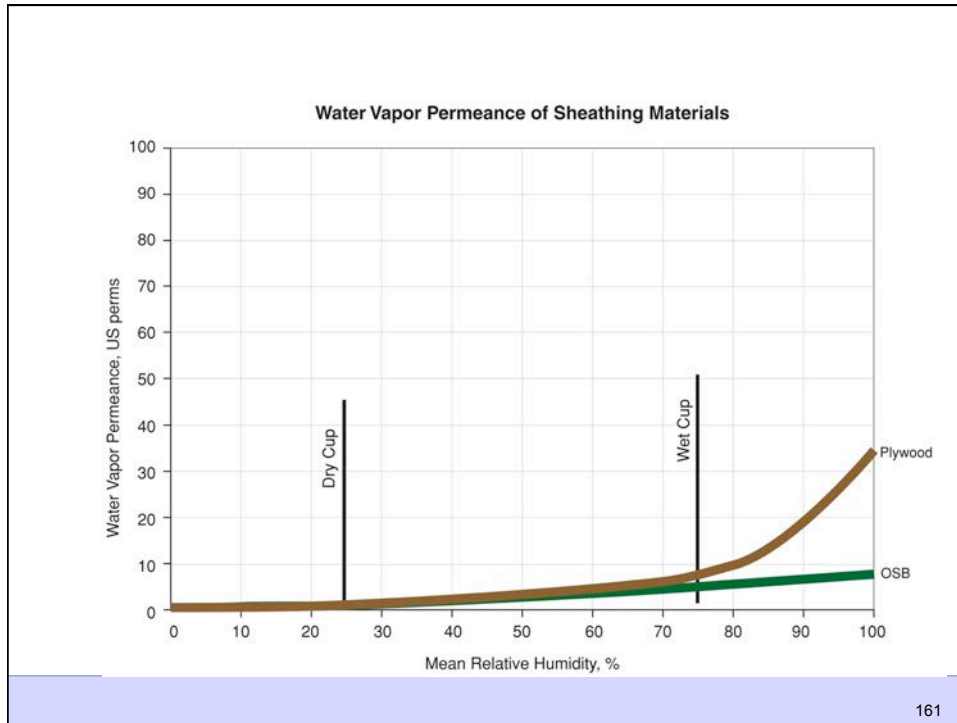
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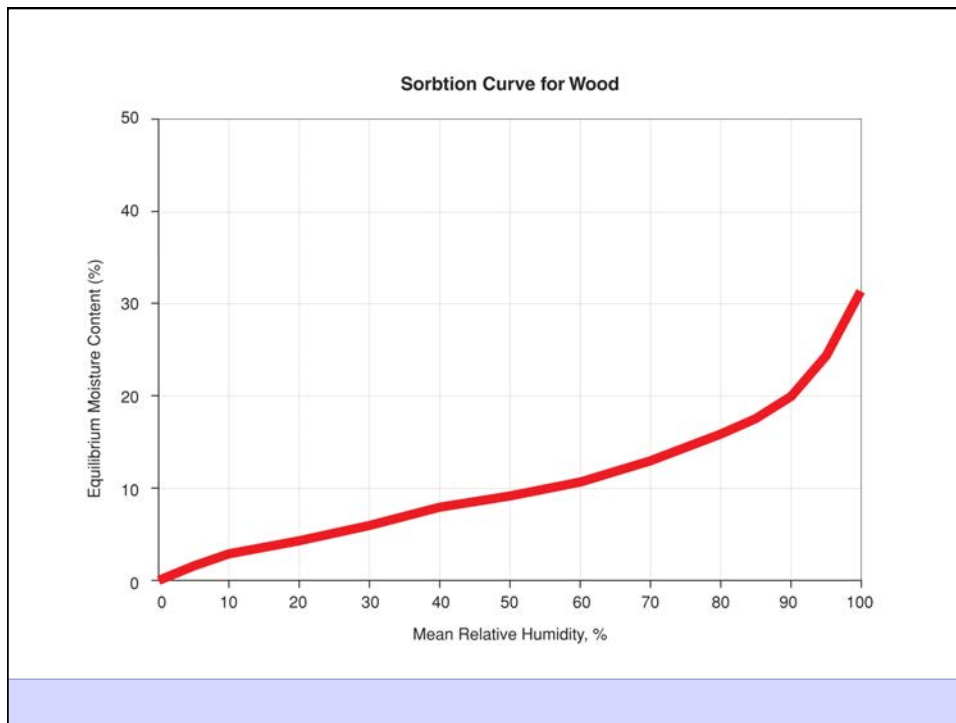
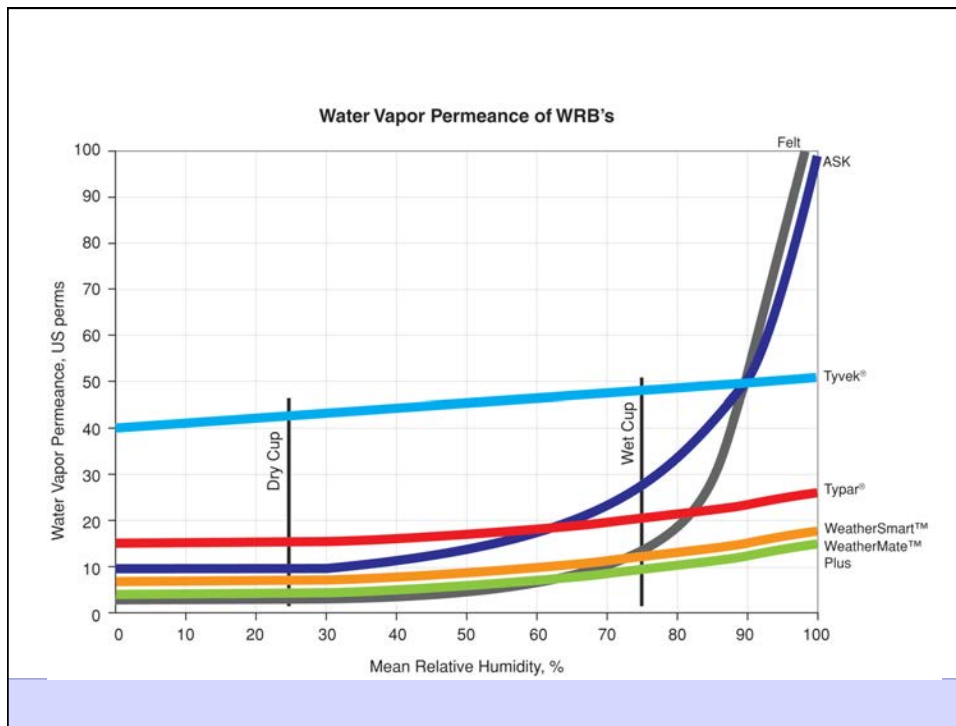
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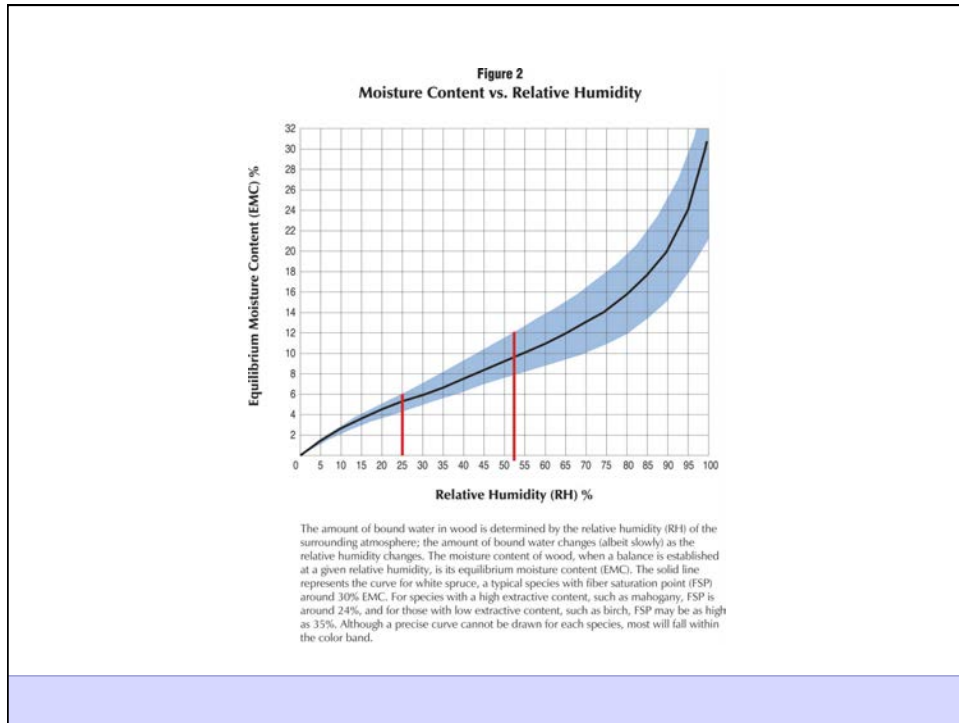


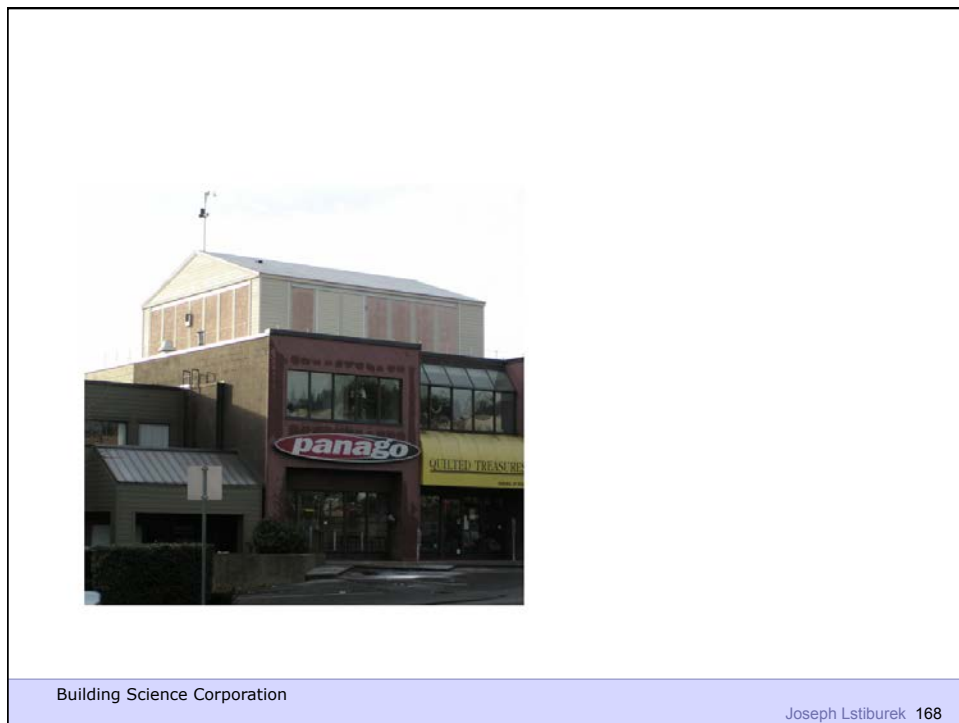
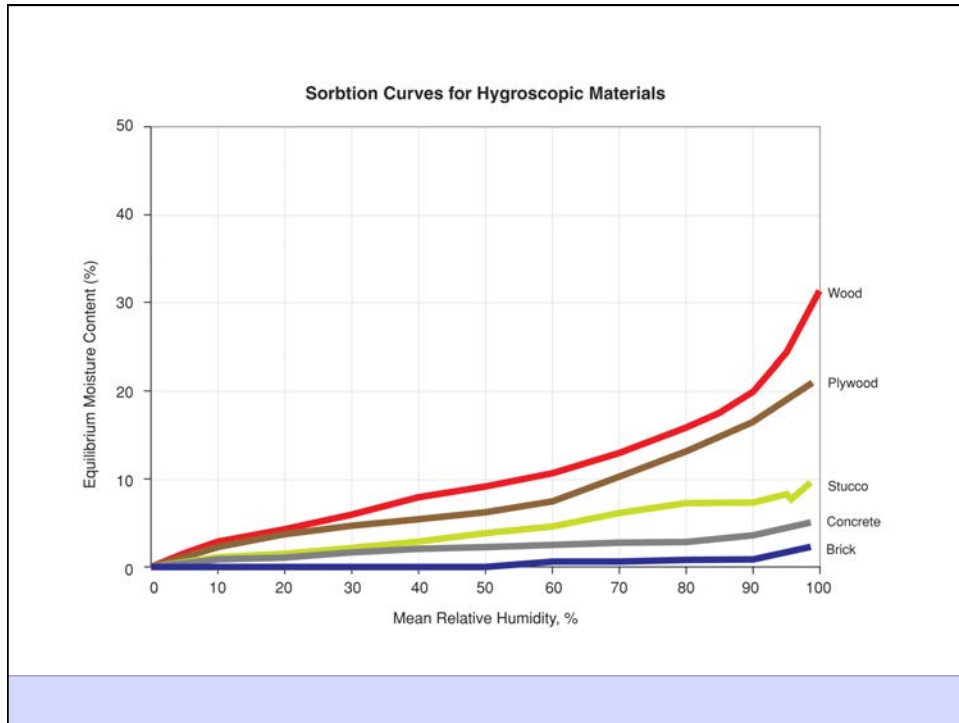






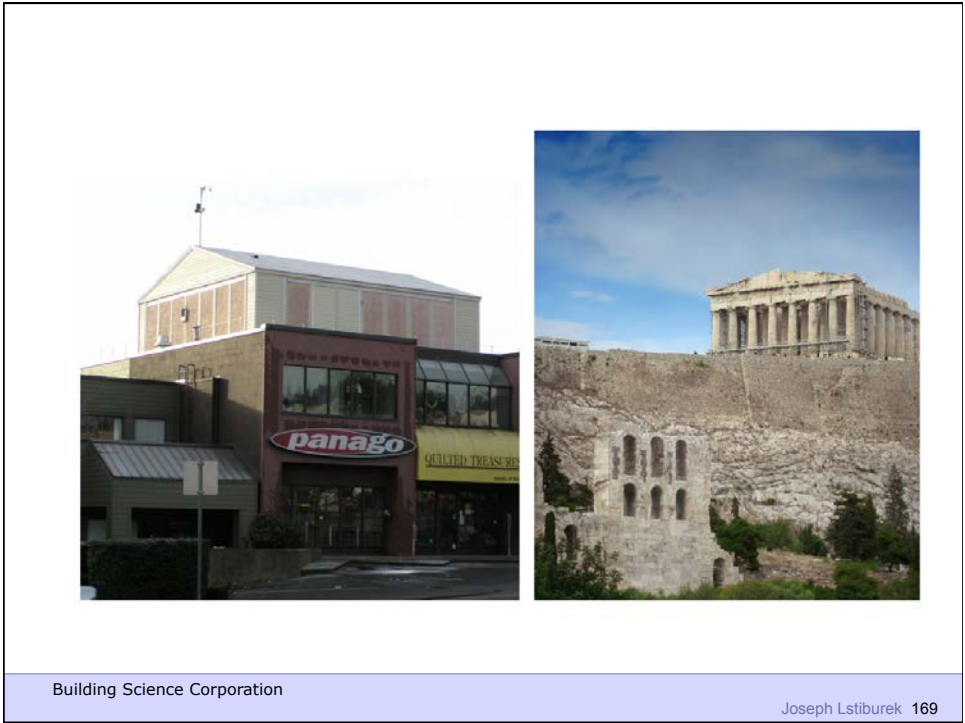






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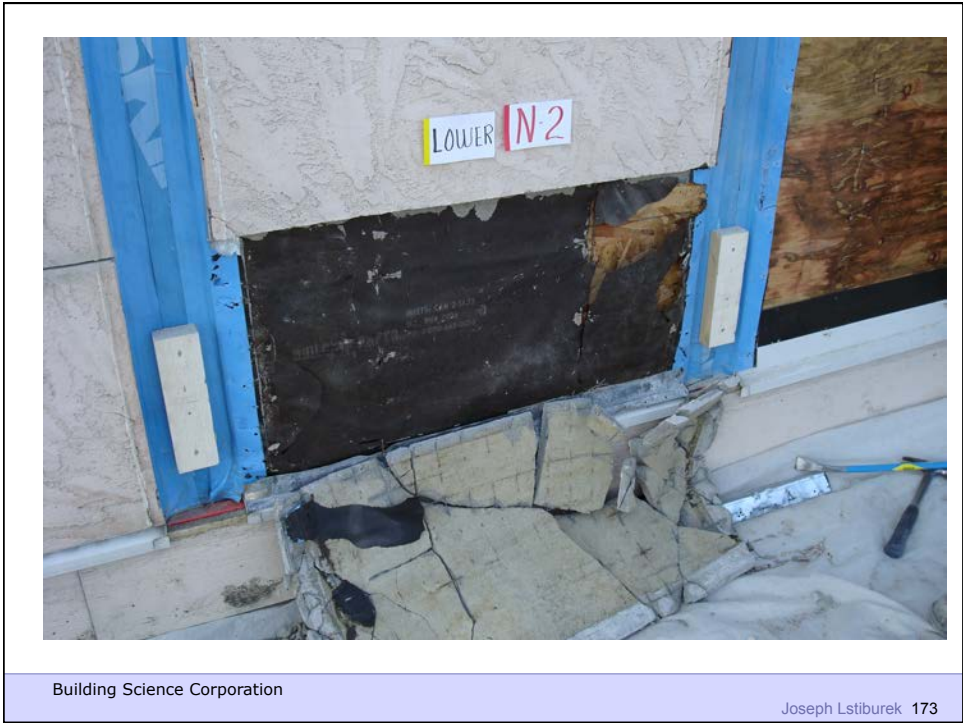
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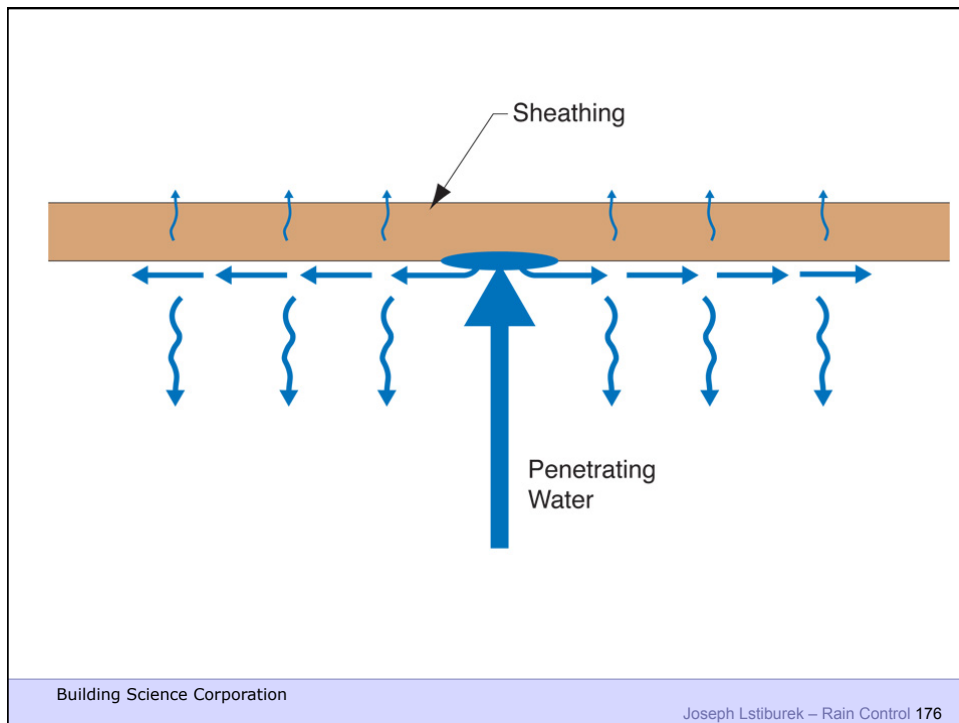
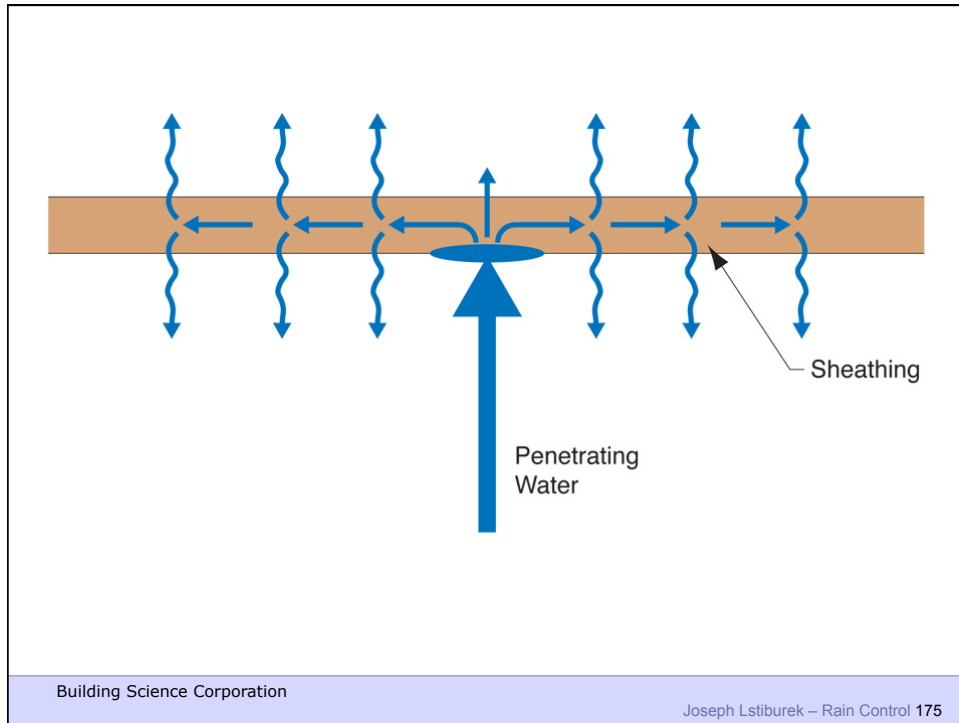


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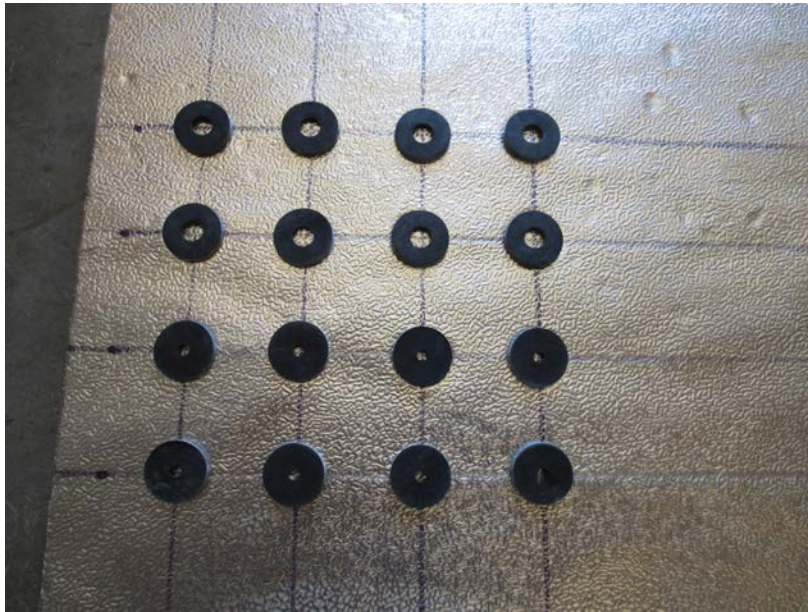
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## Rain Screen

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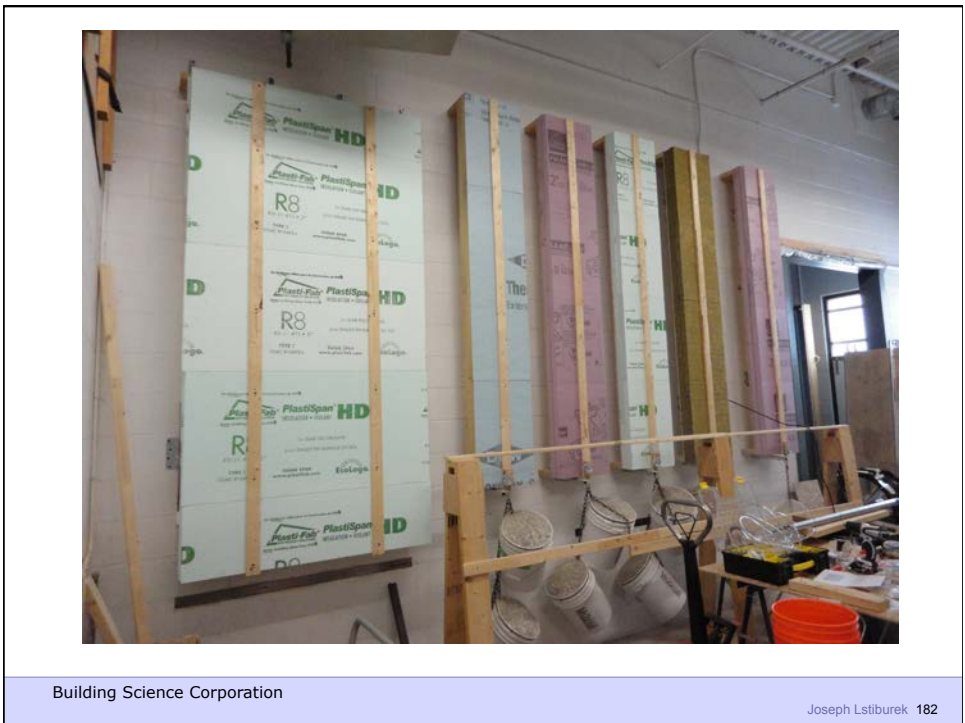
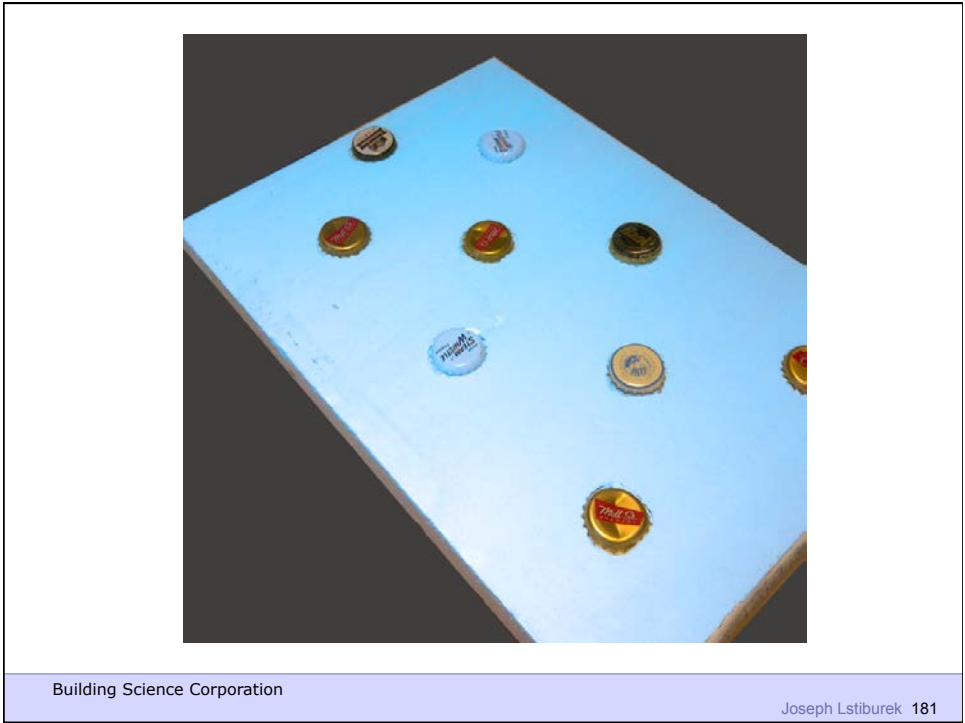
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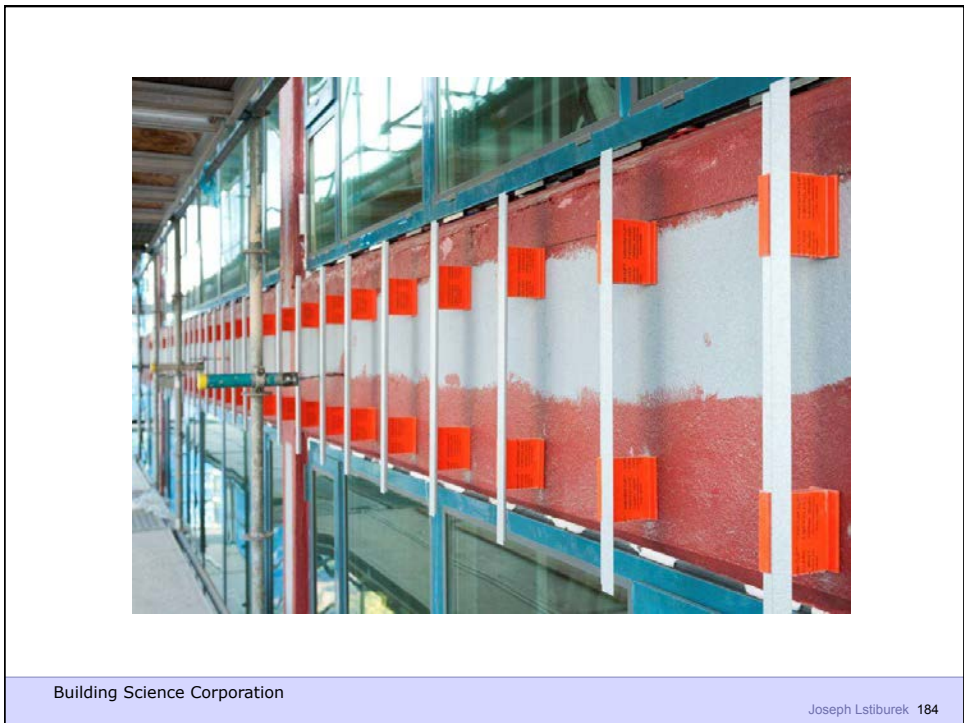
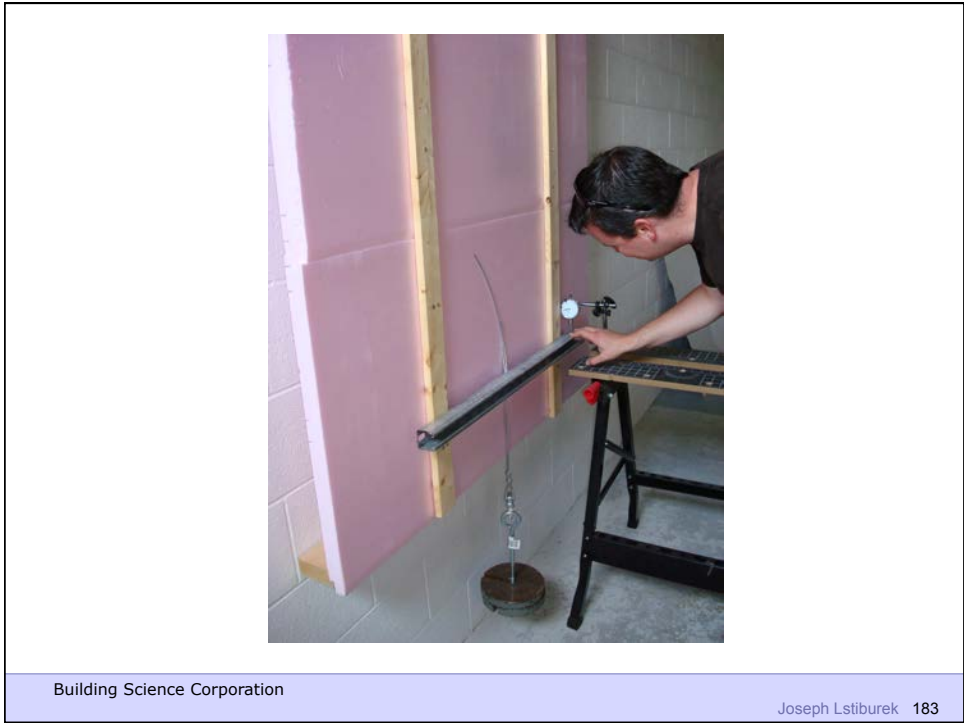
Joseph Lstiburek 179

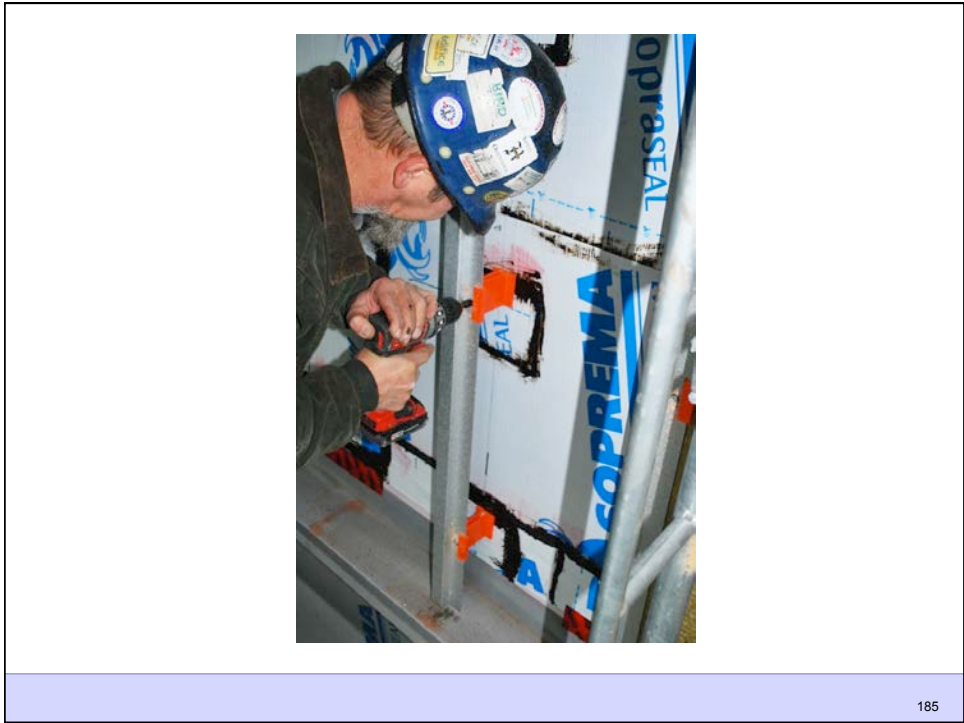
Beer Screen?

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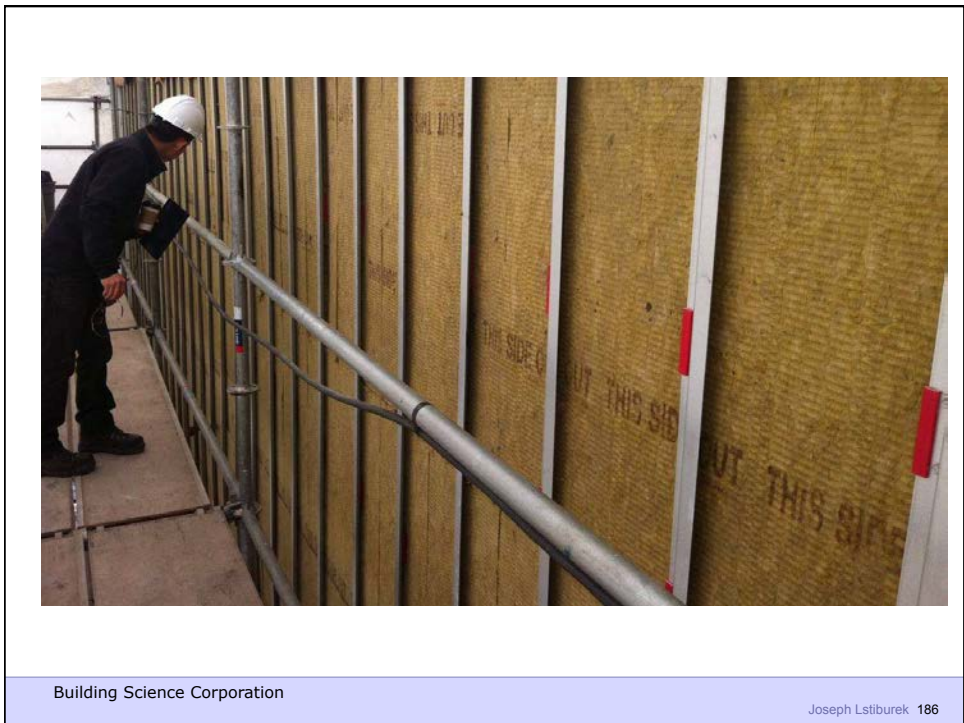
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