

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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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

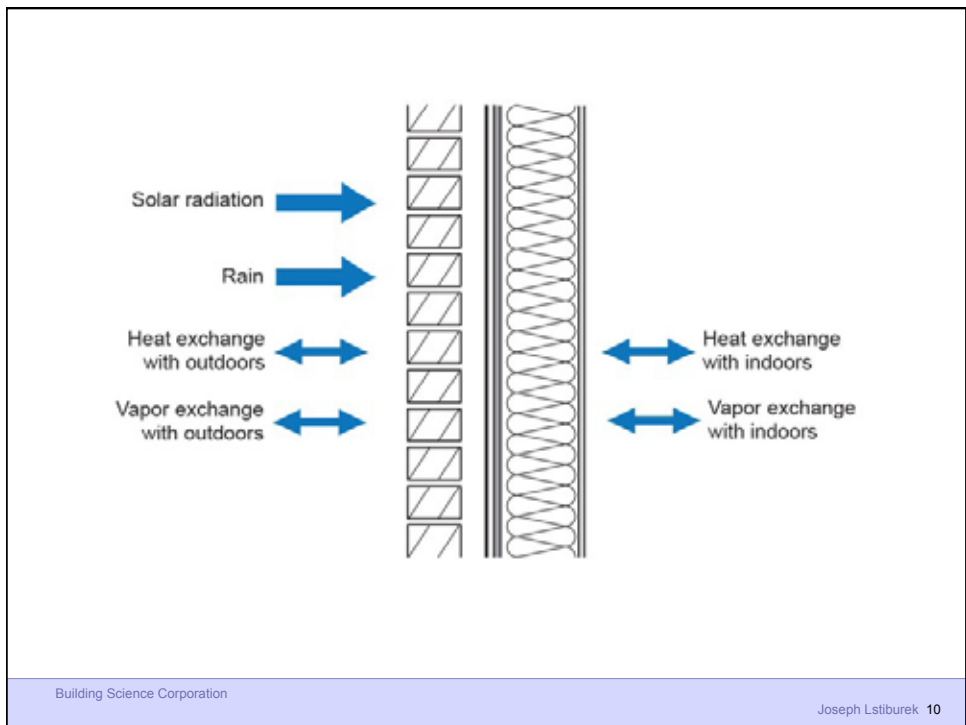
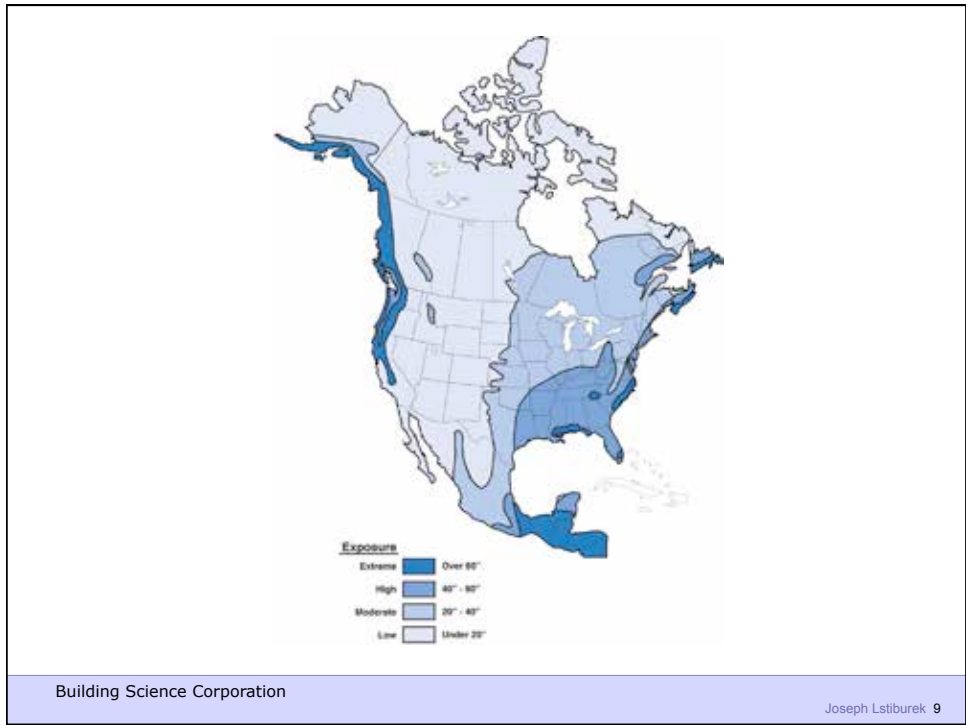
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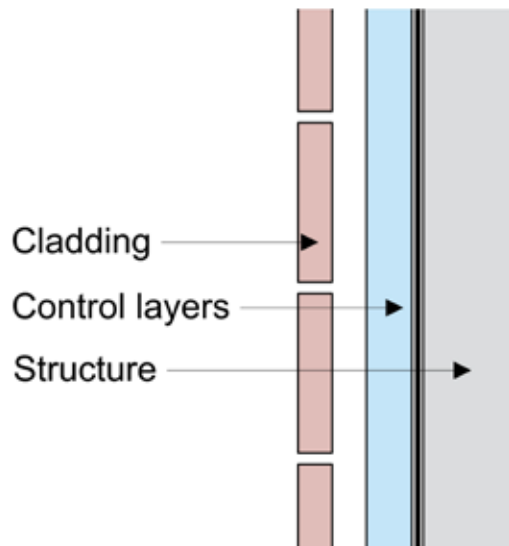


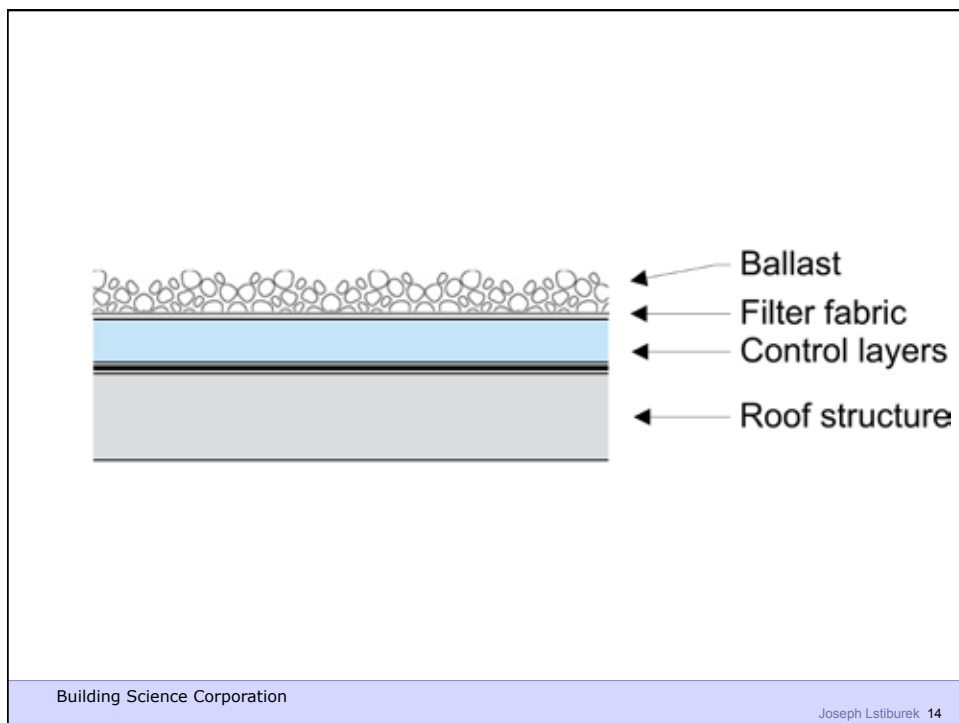
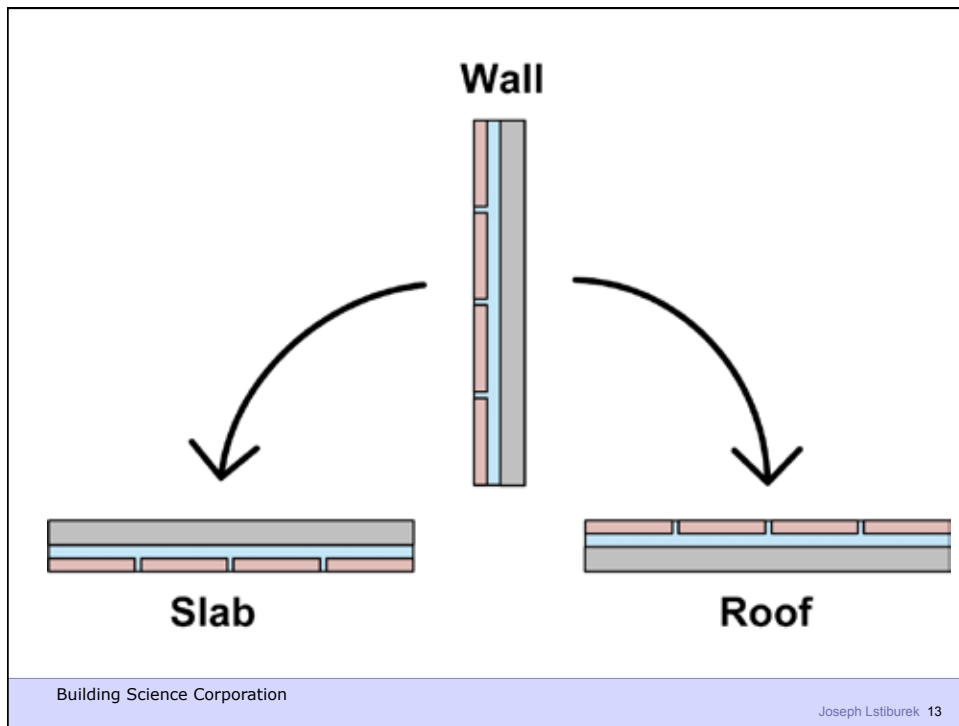
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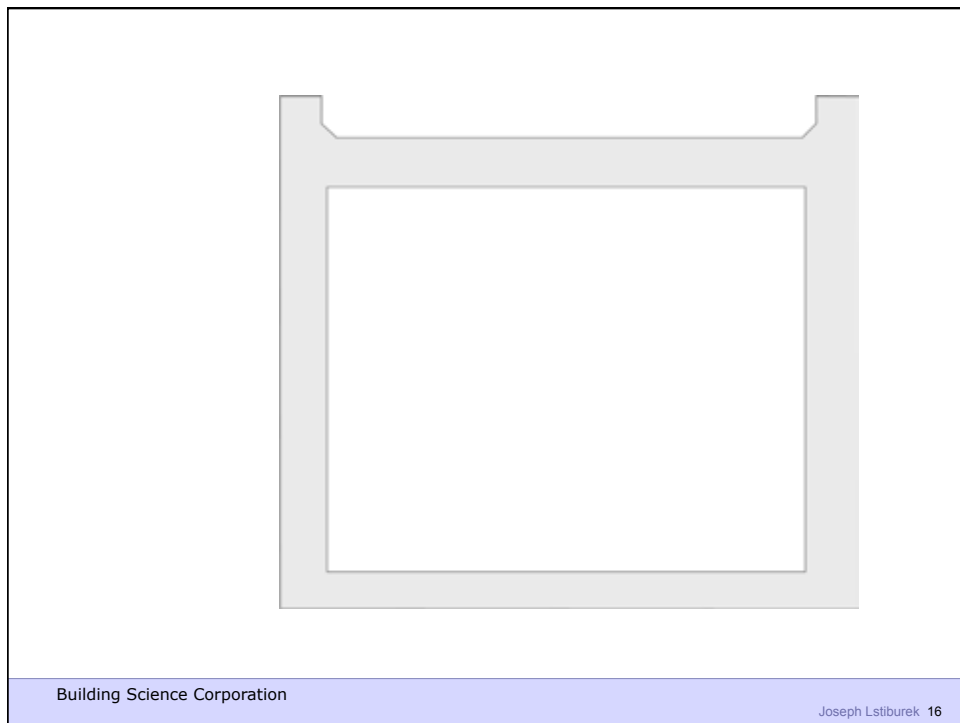
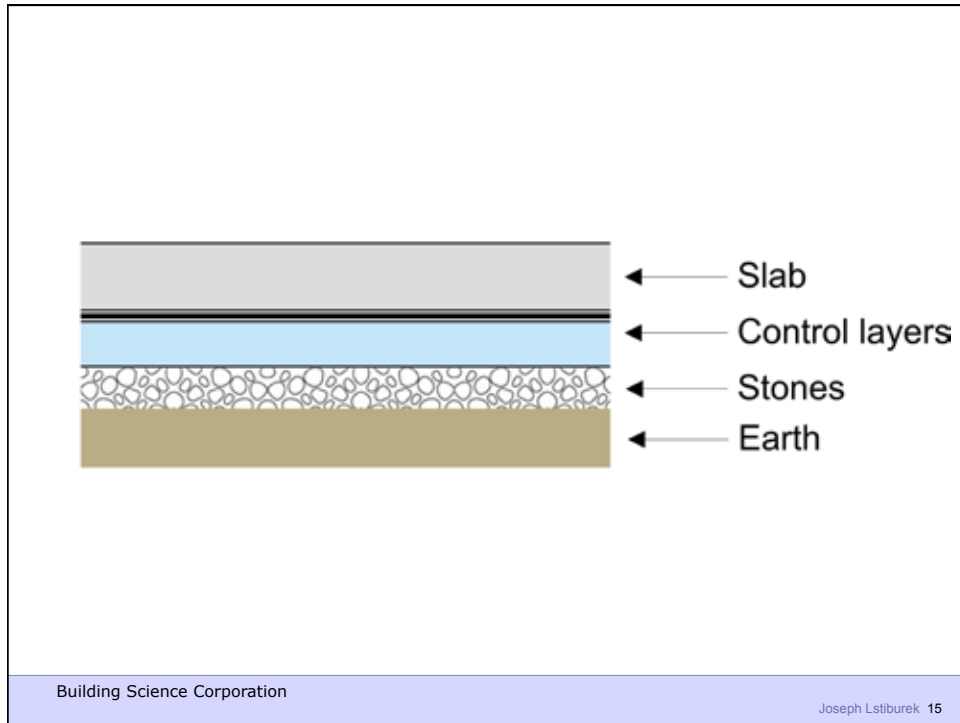
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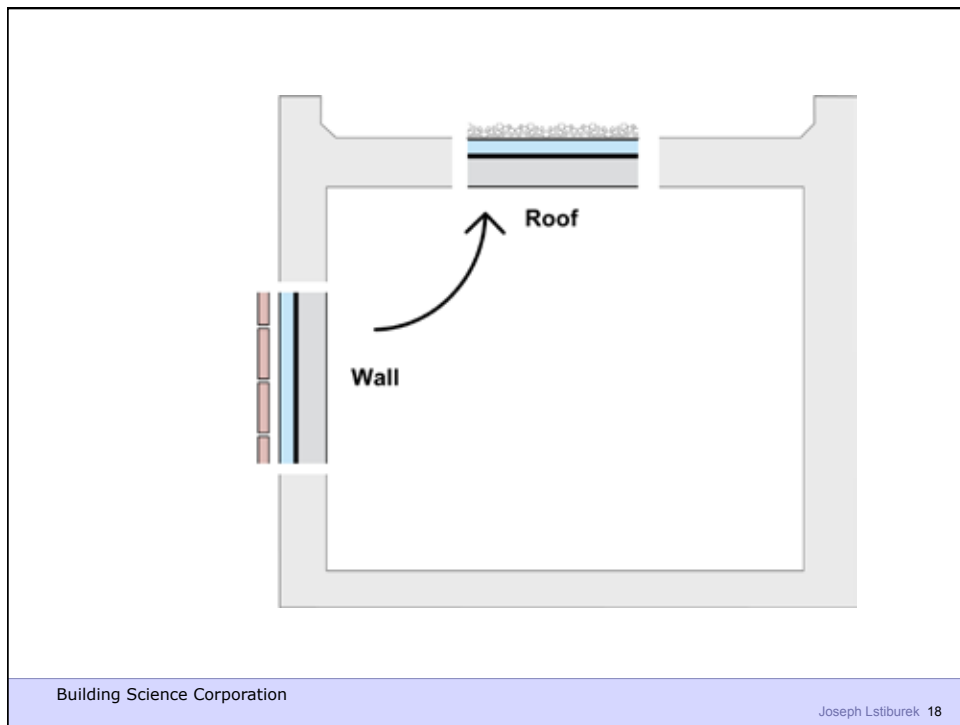
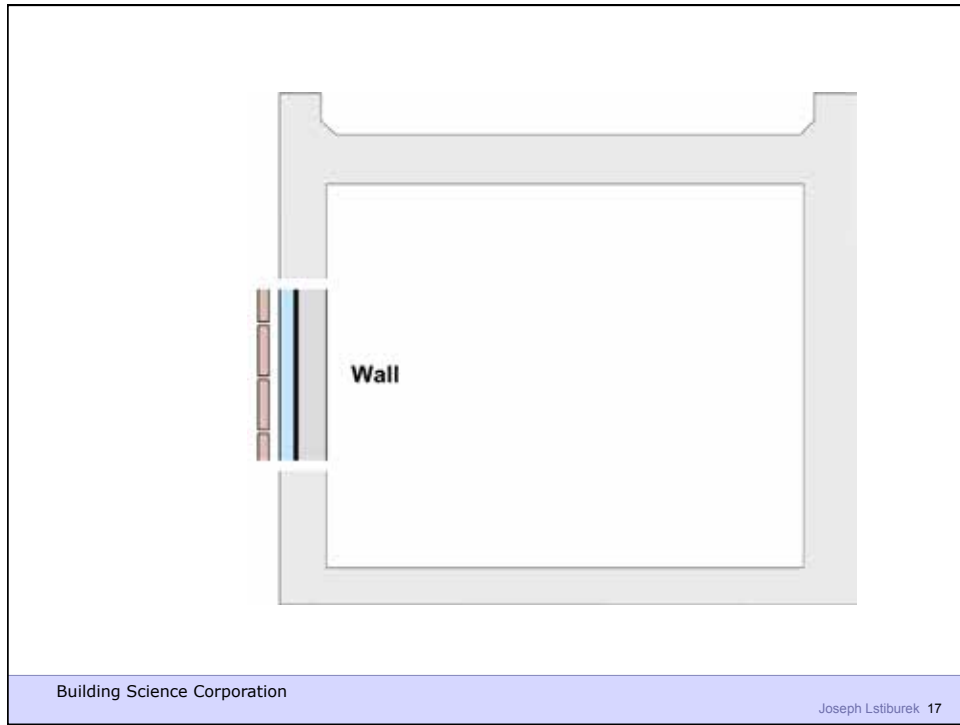


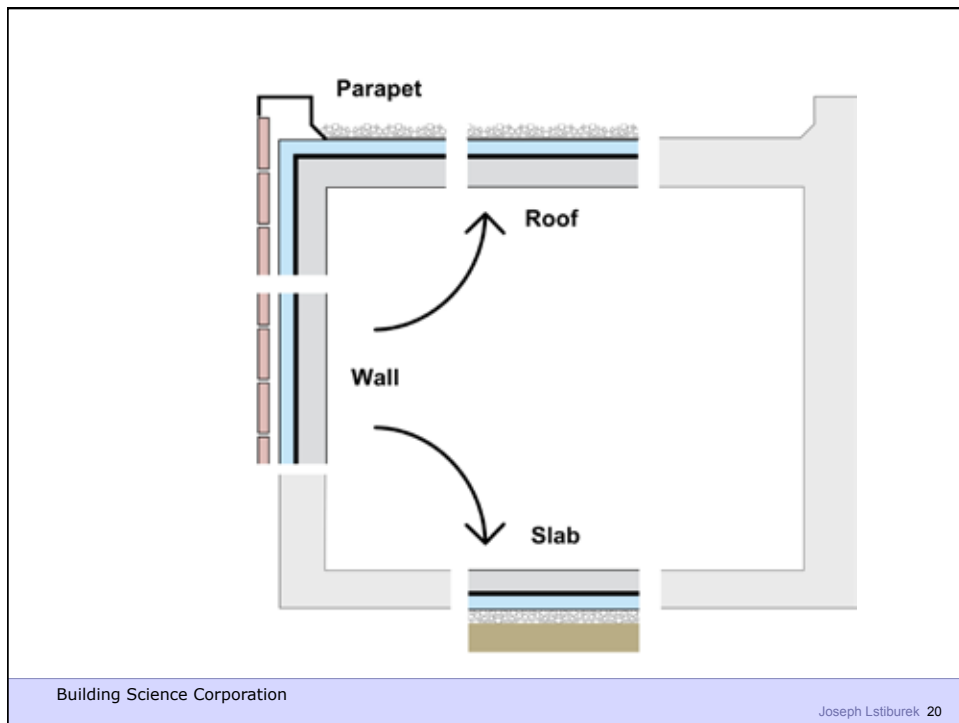
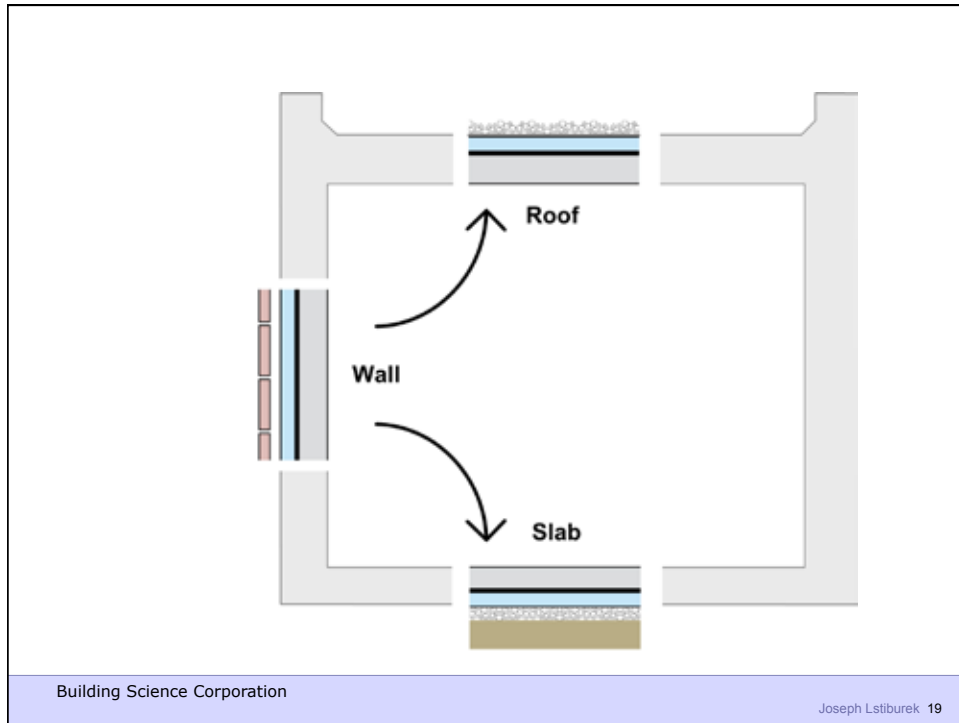
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

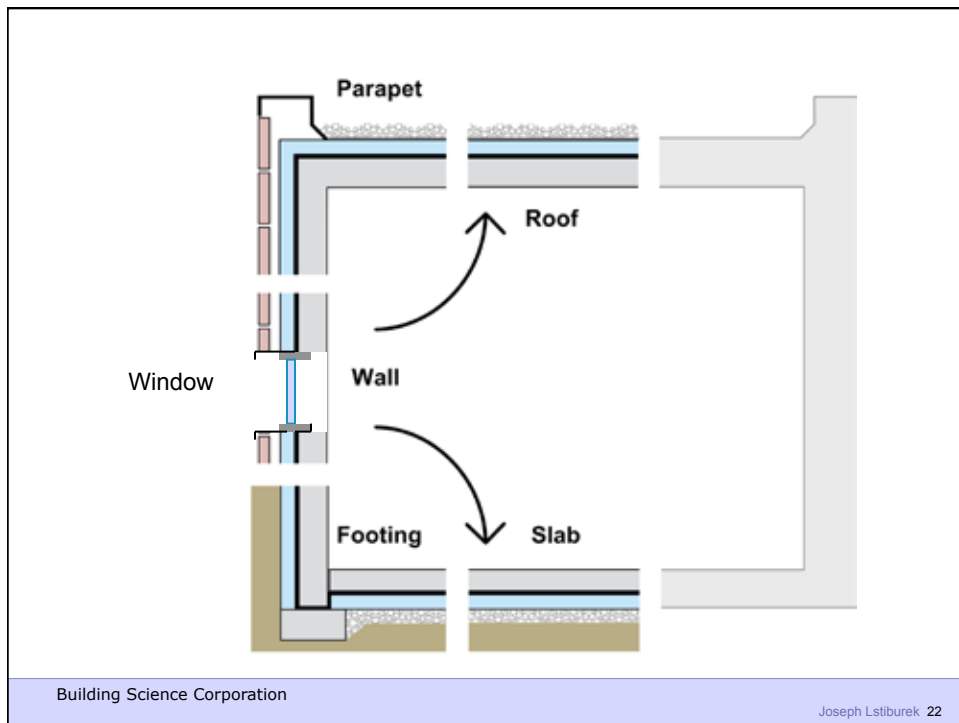
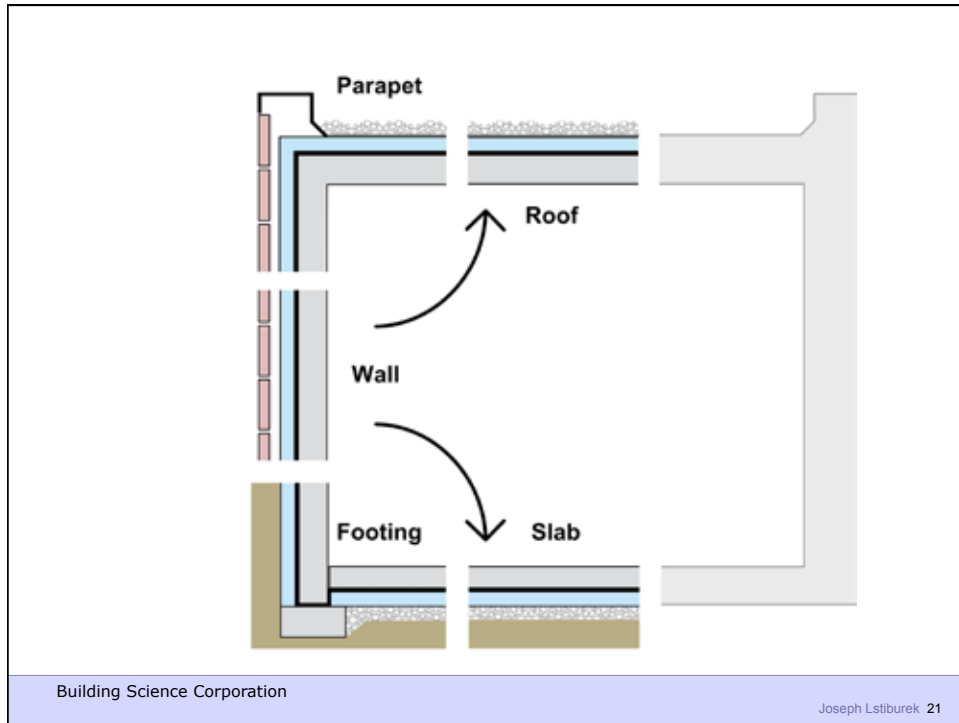


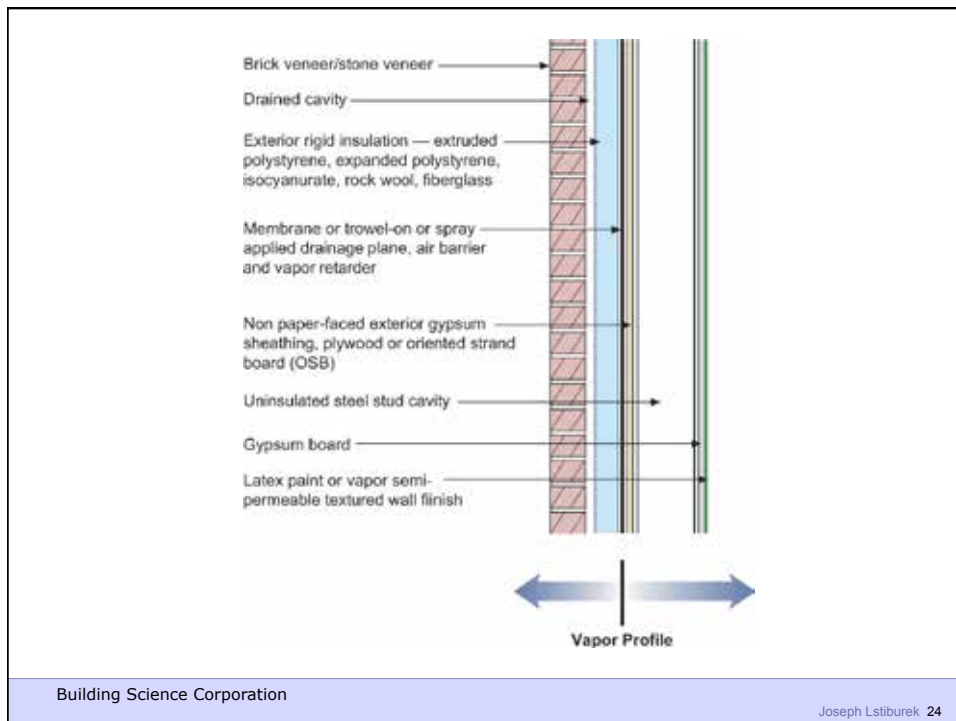
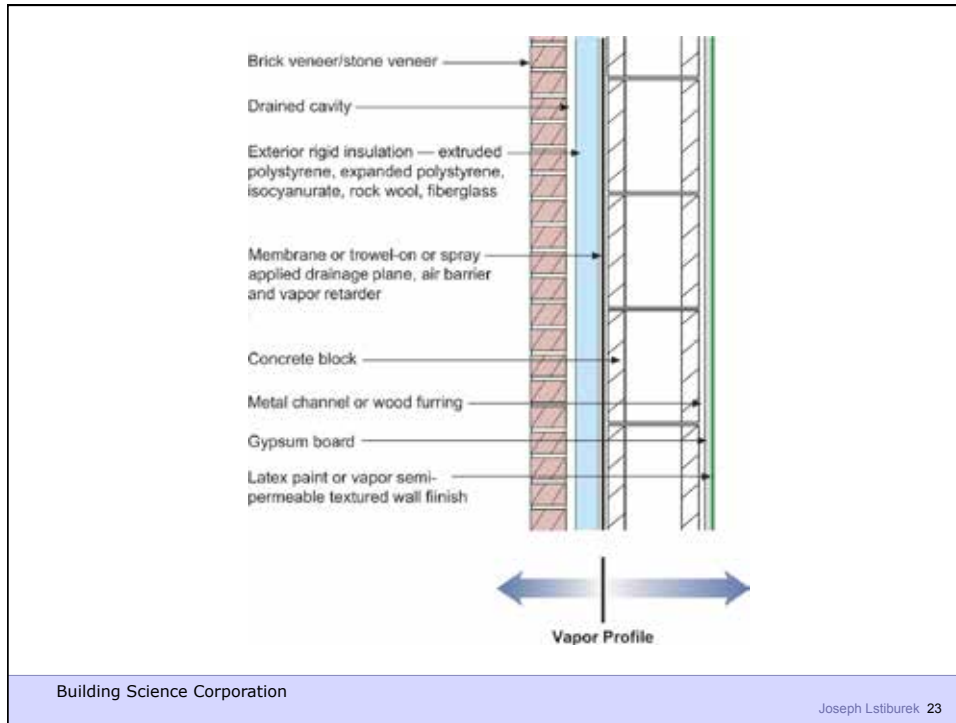


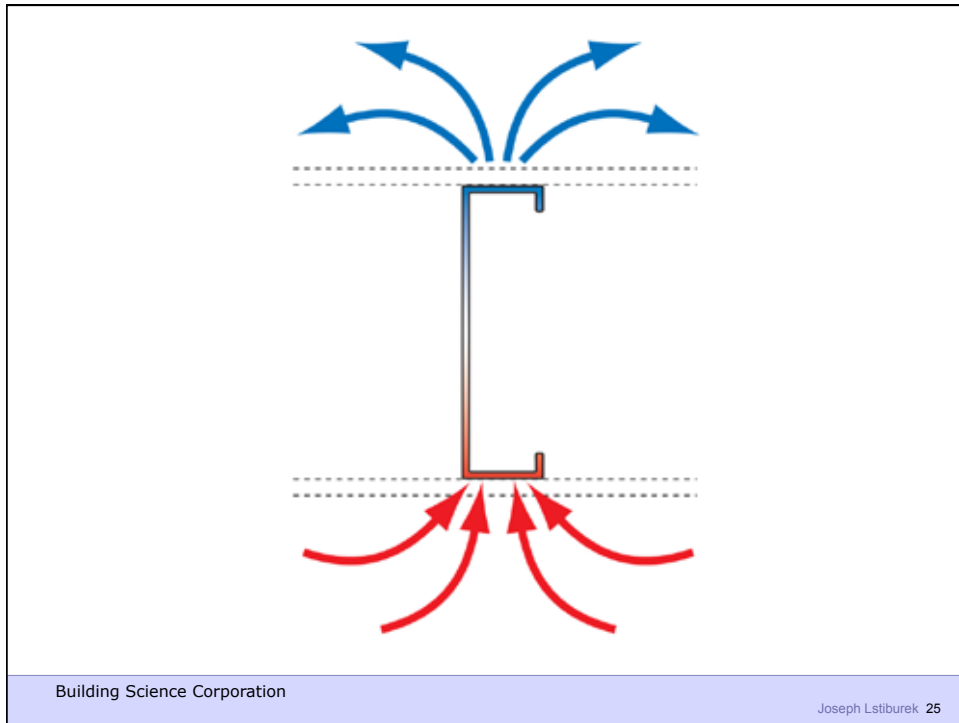


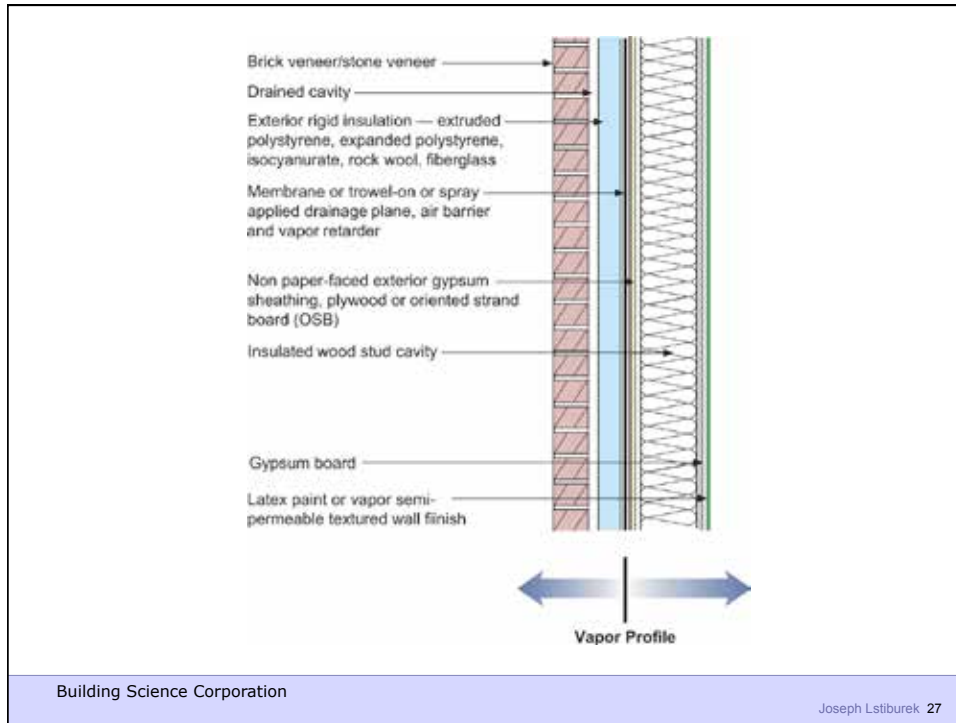








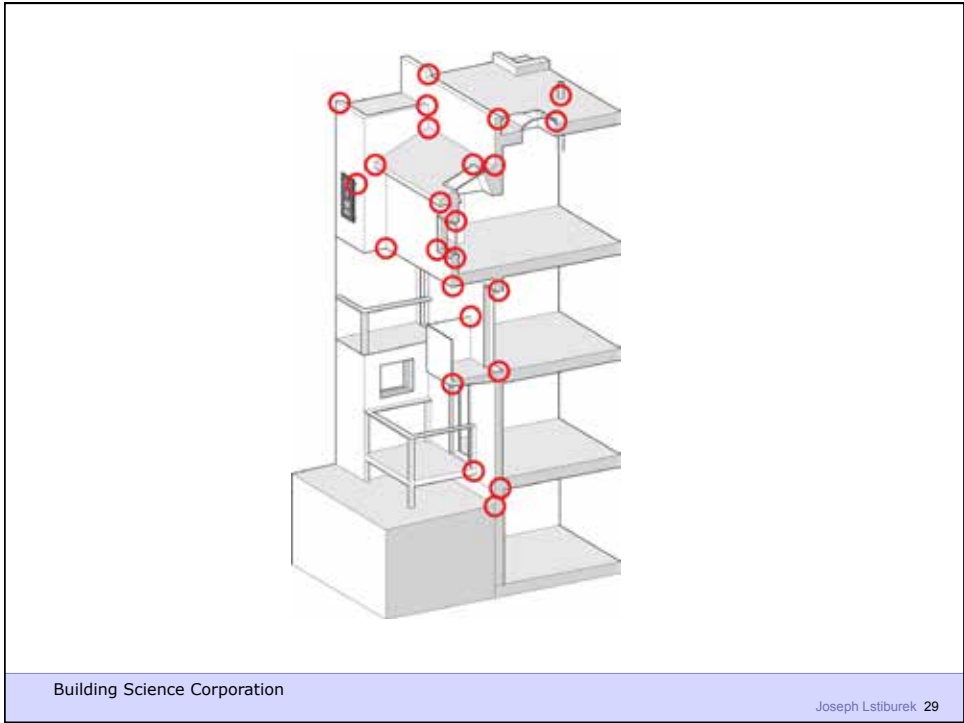




Commercial Enclosure: Simple Layers



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











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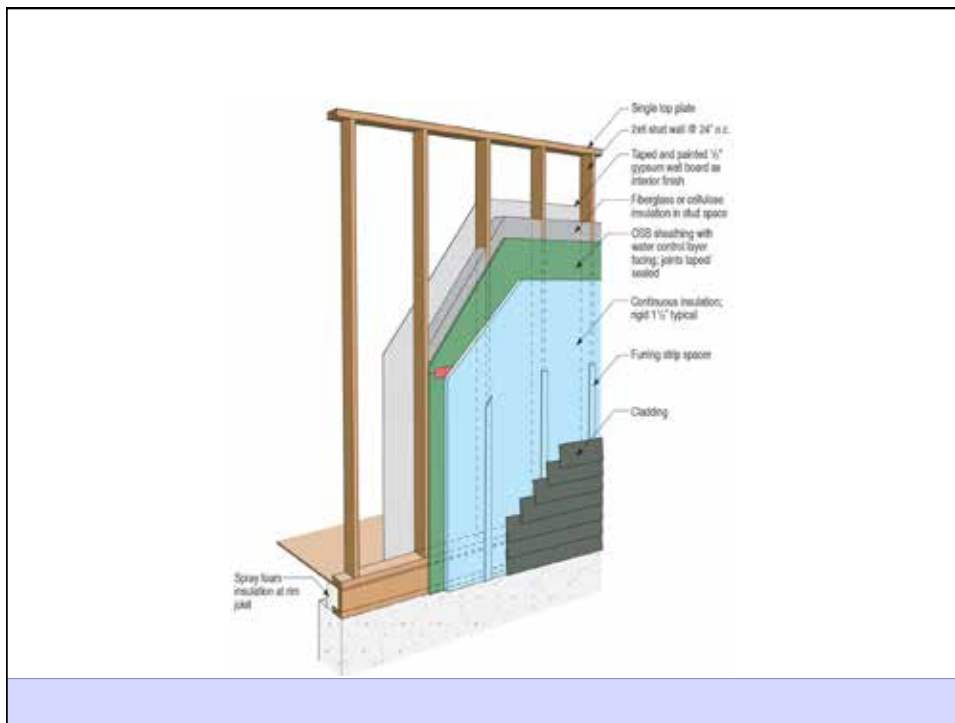
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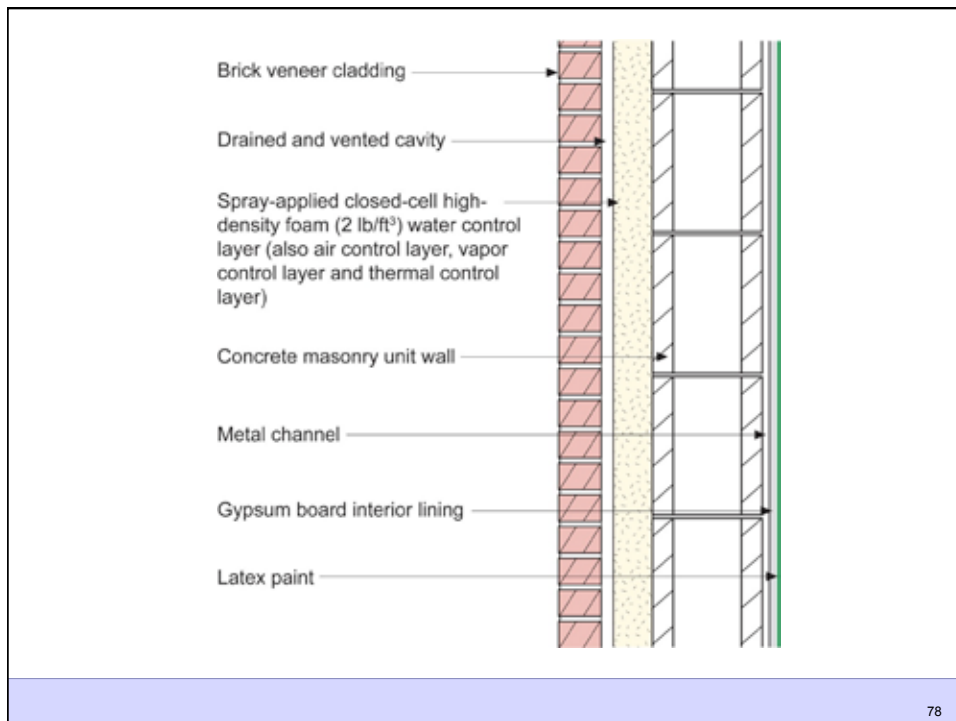
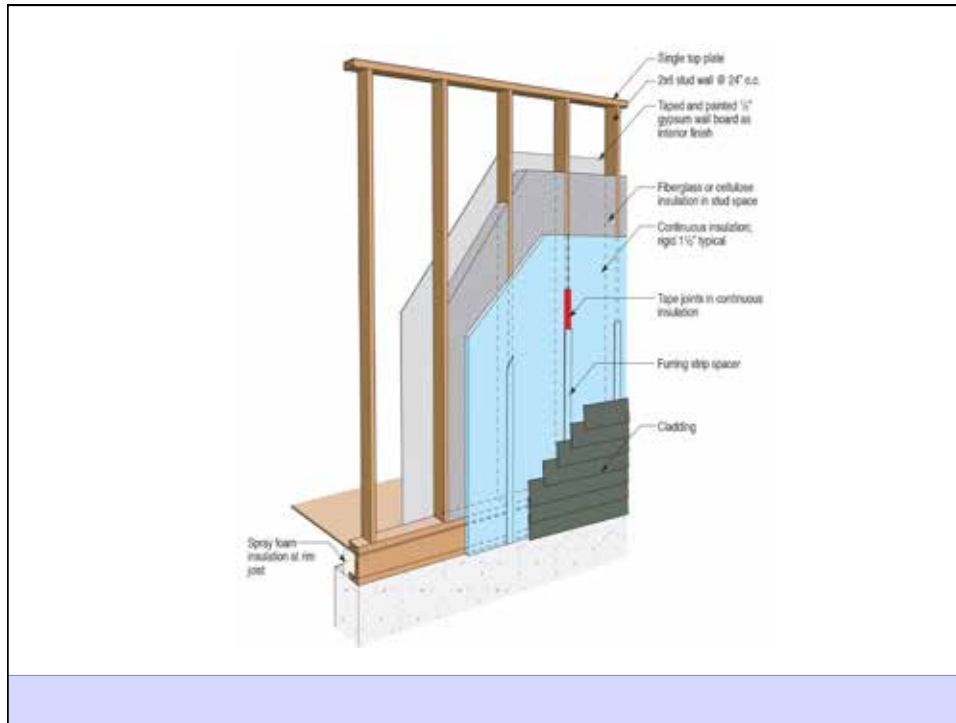
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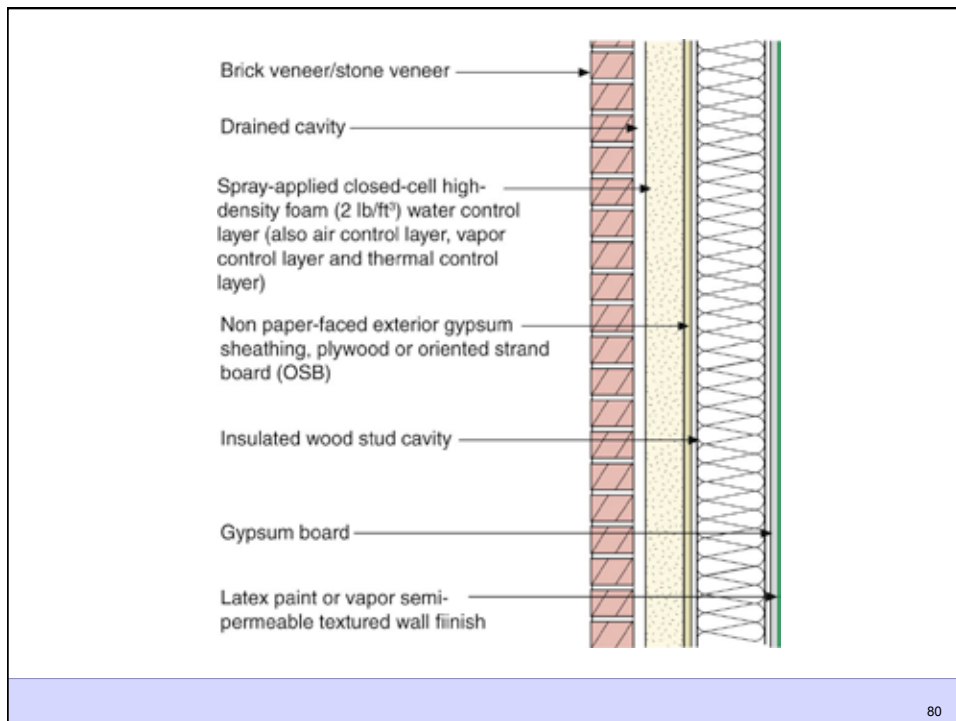
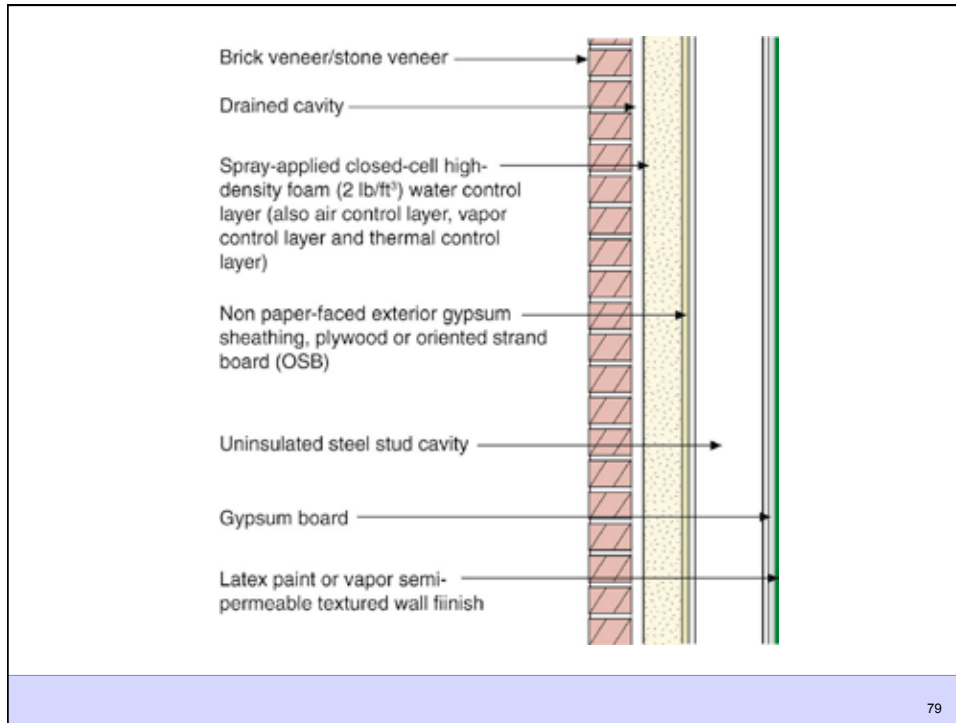


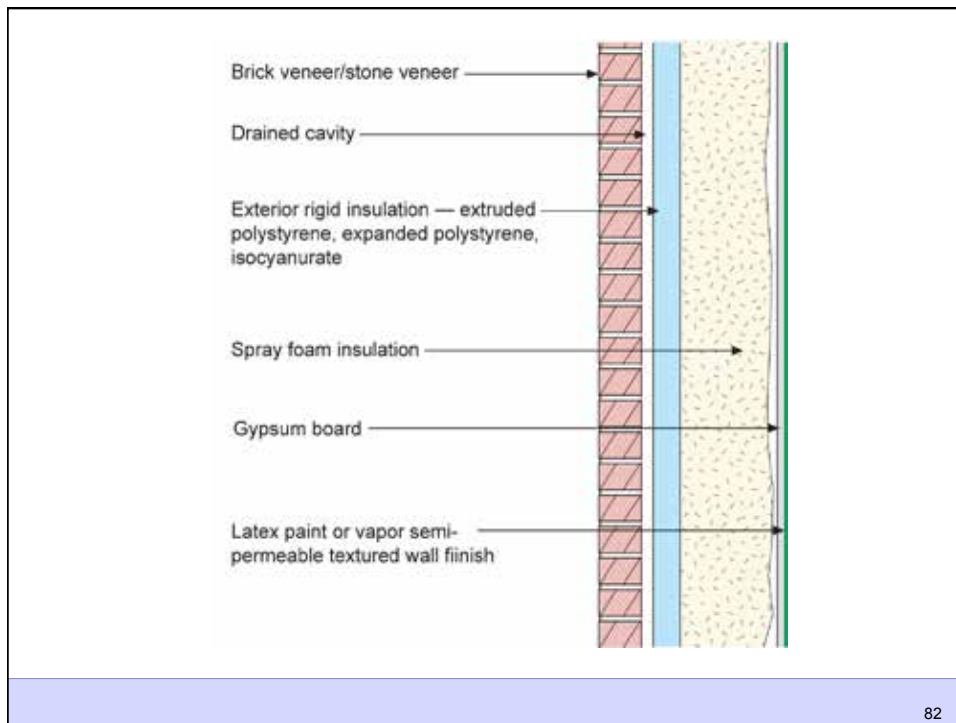
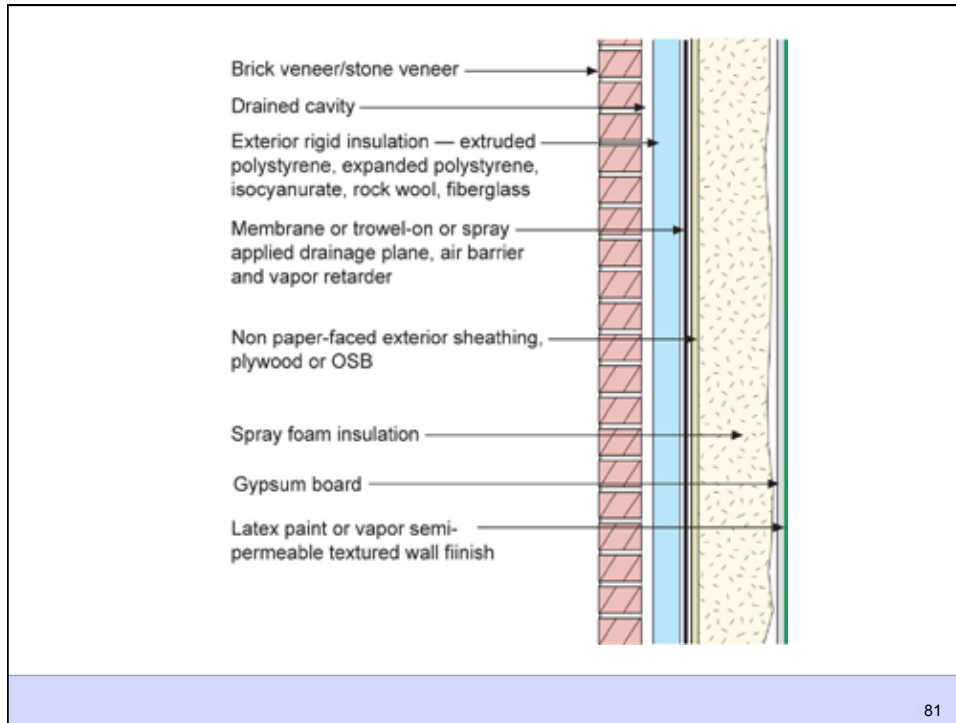
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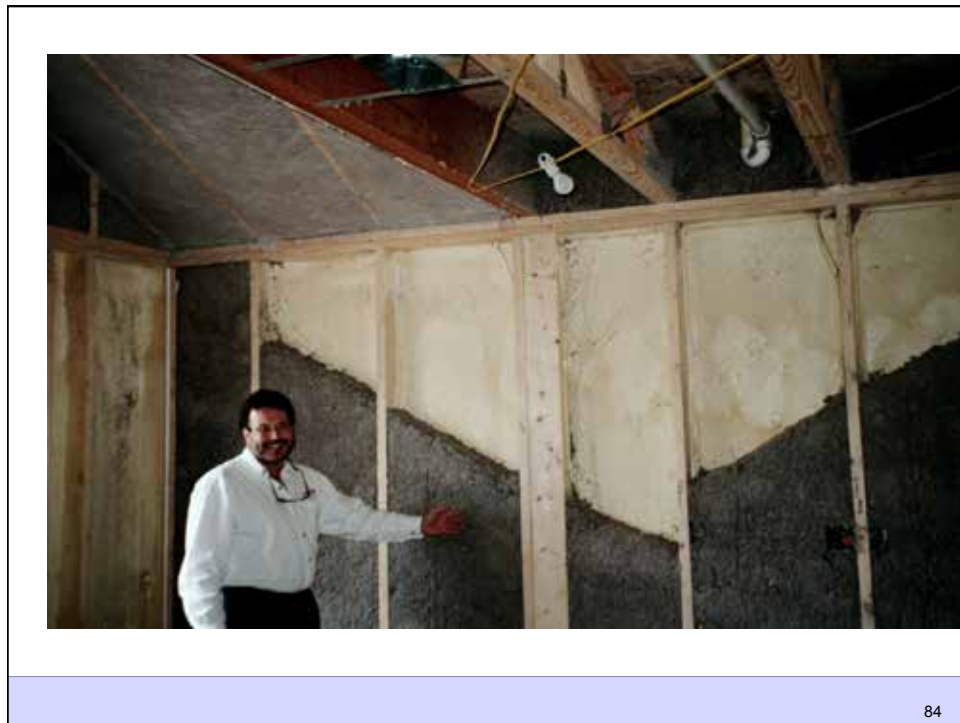
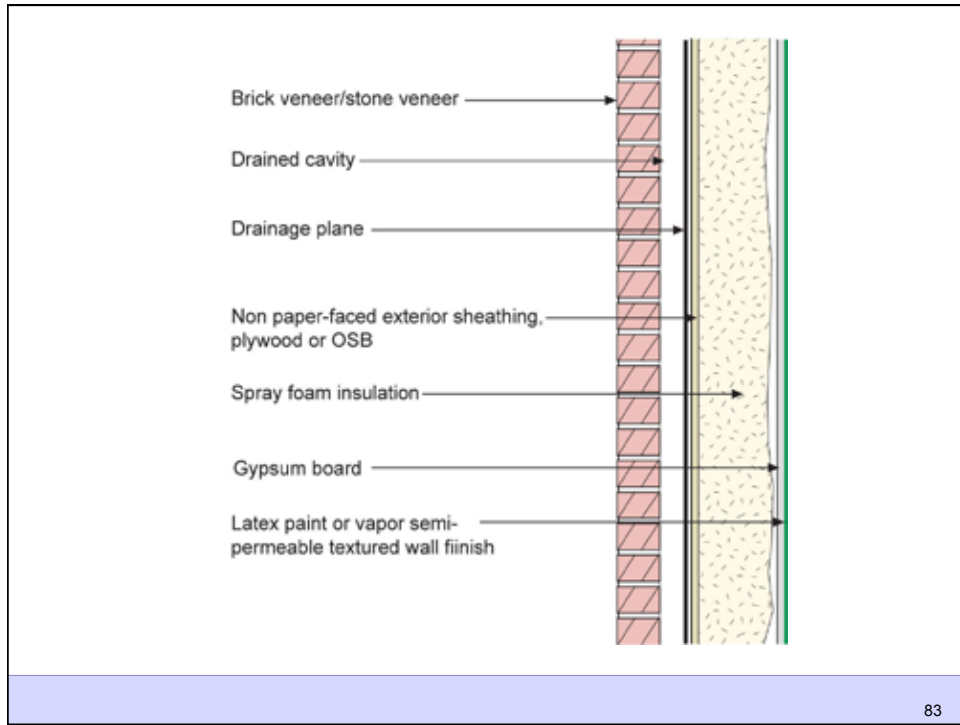
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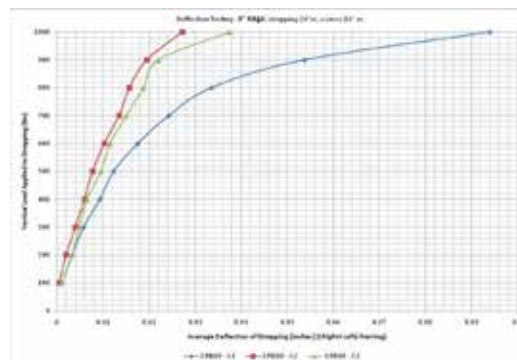






Rockwool

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



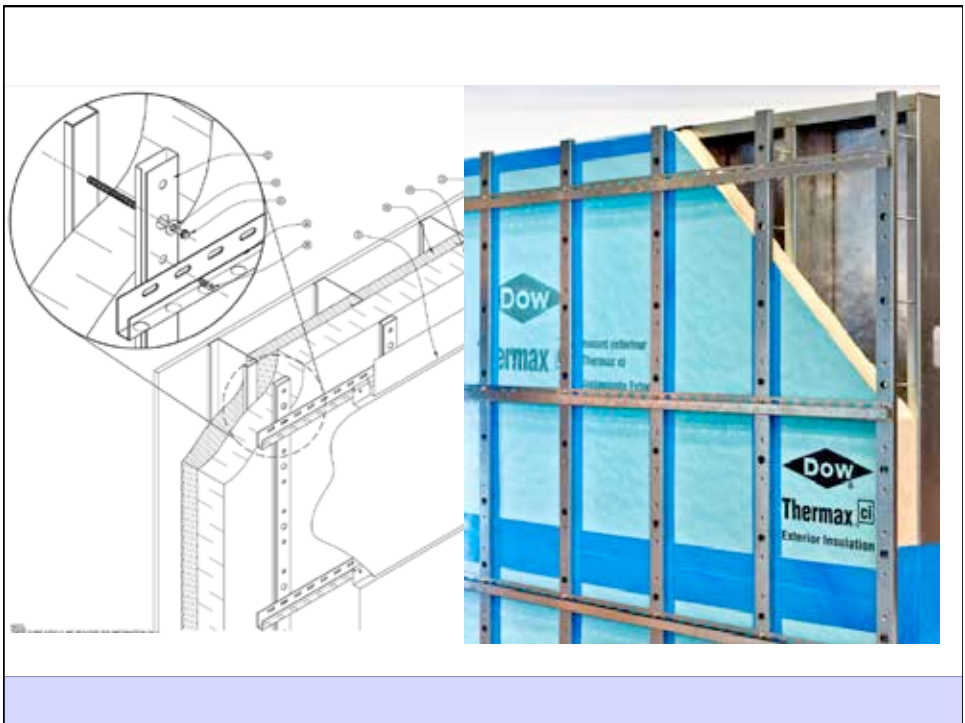
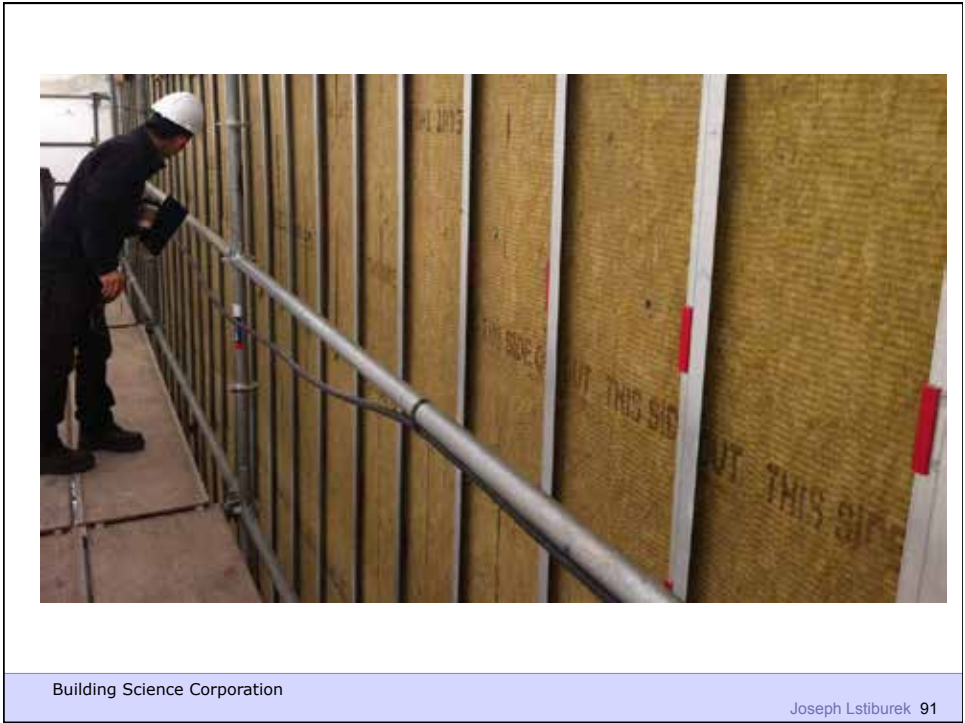


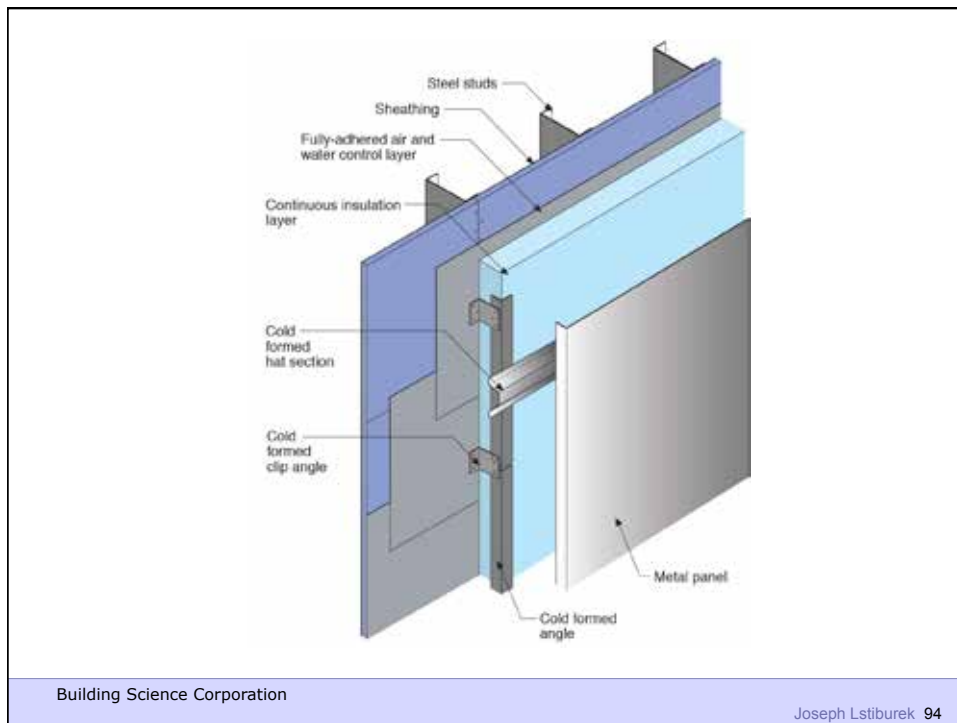
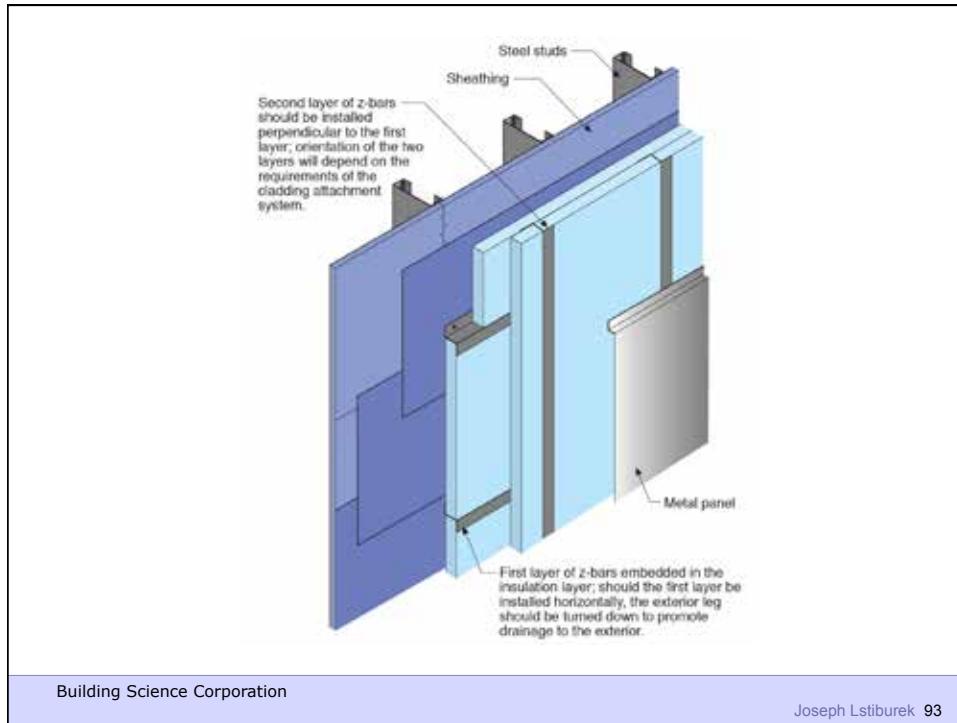
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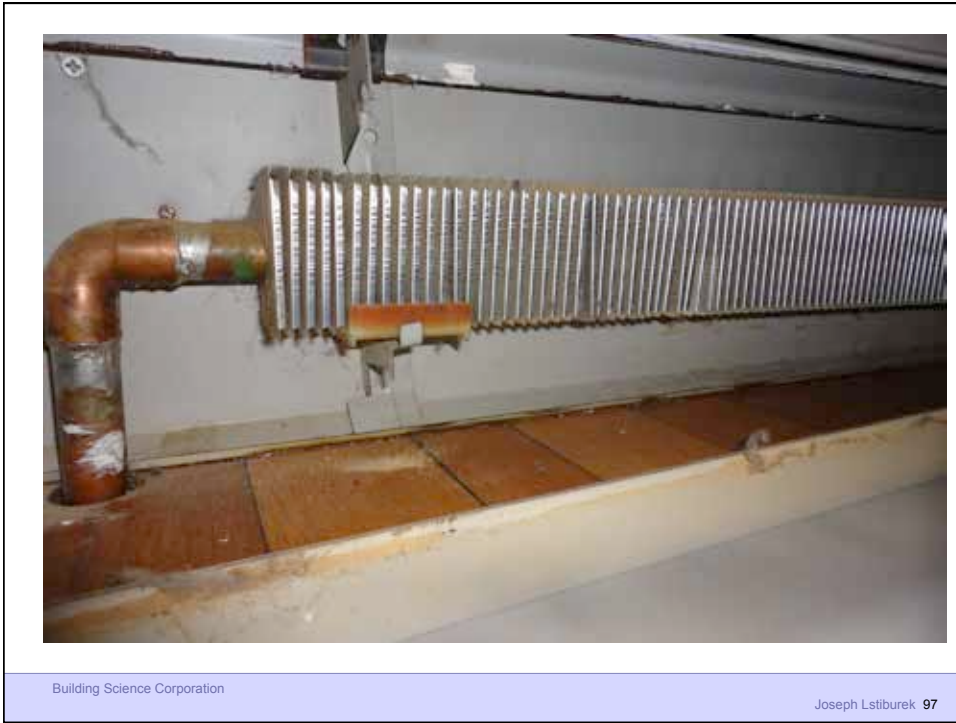


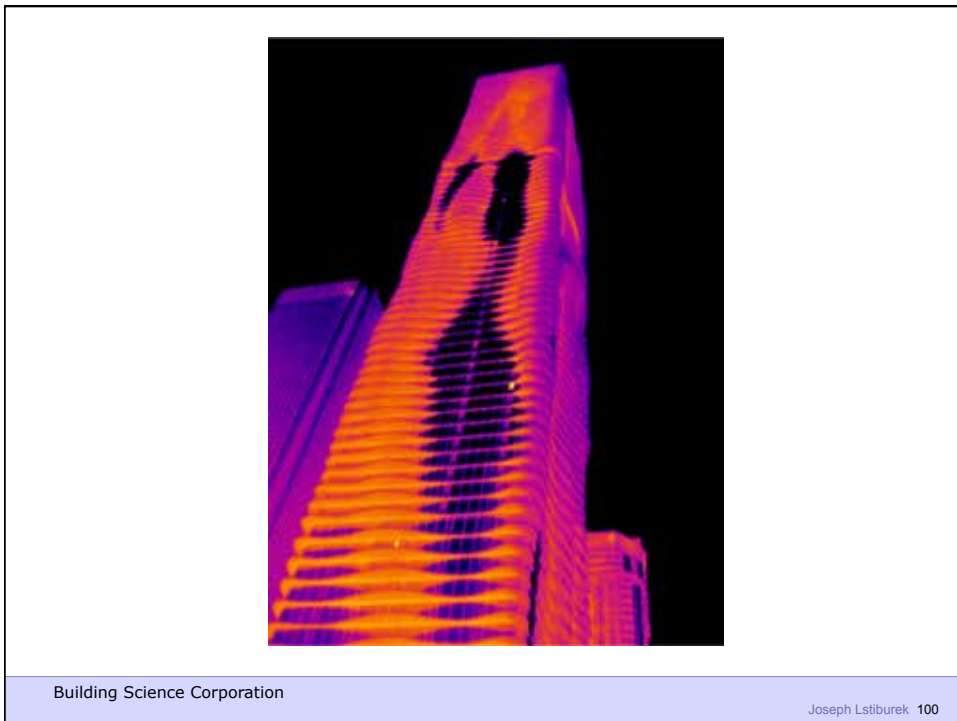
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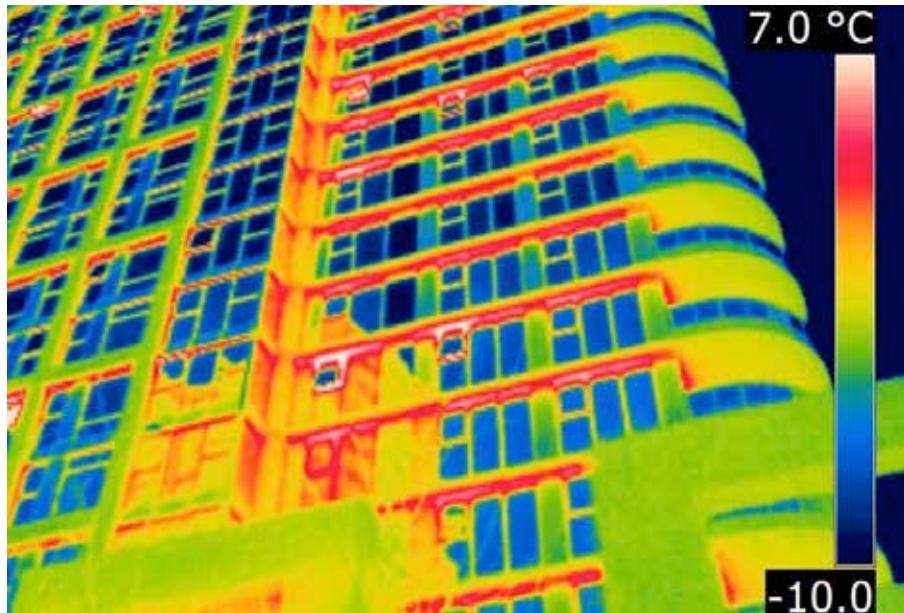






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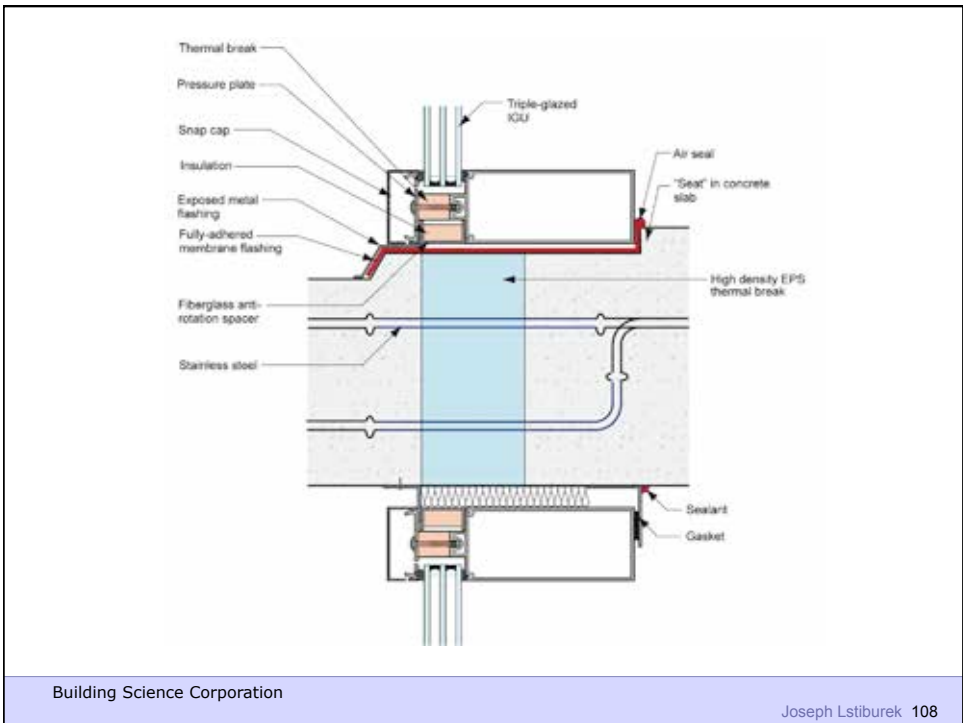
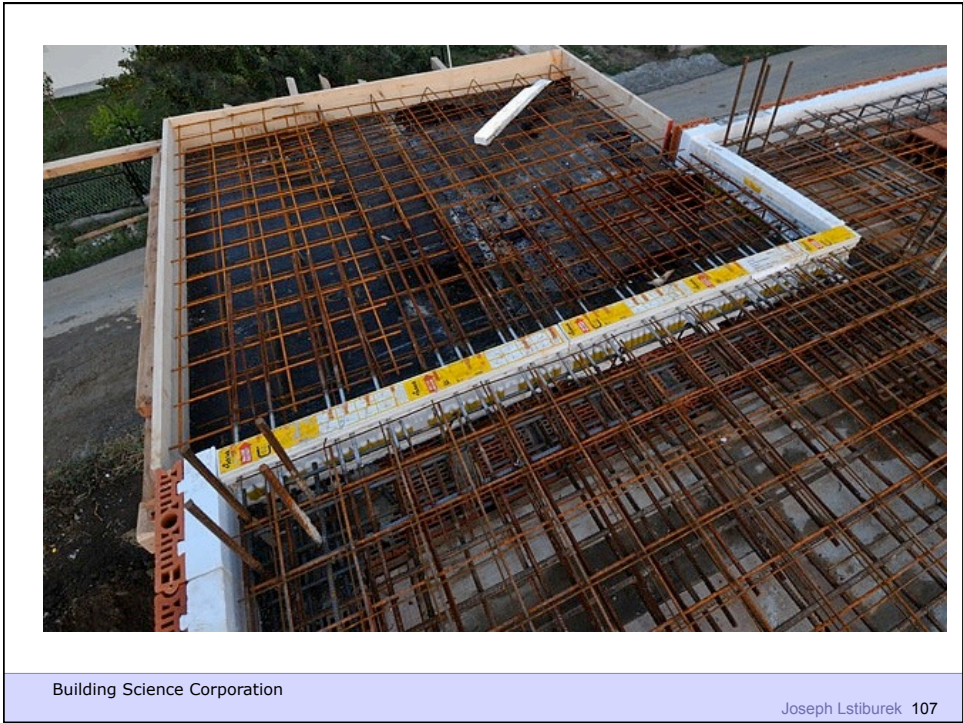
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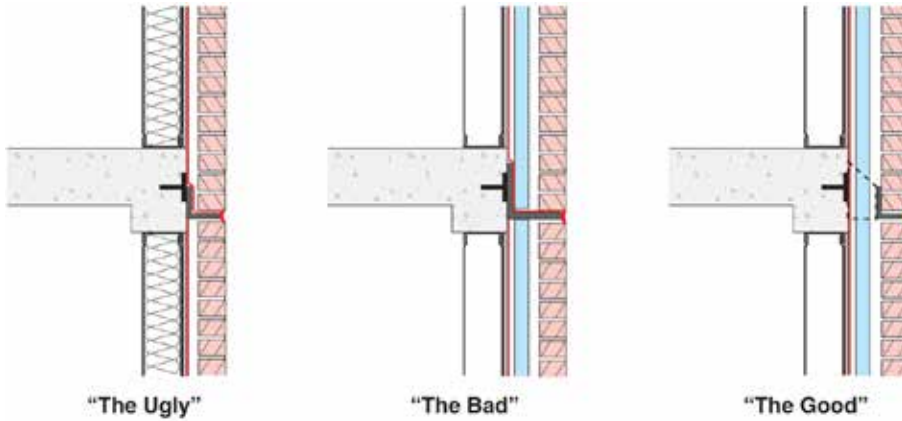
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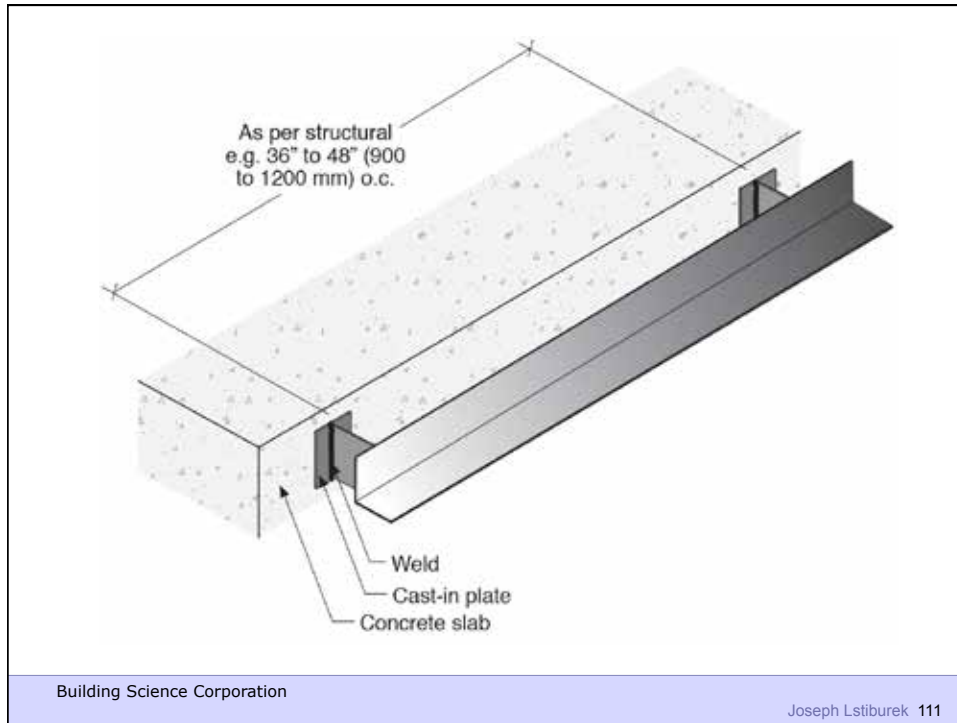
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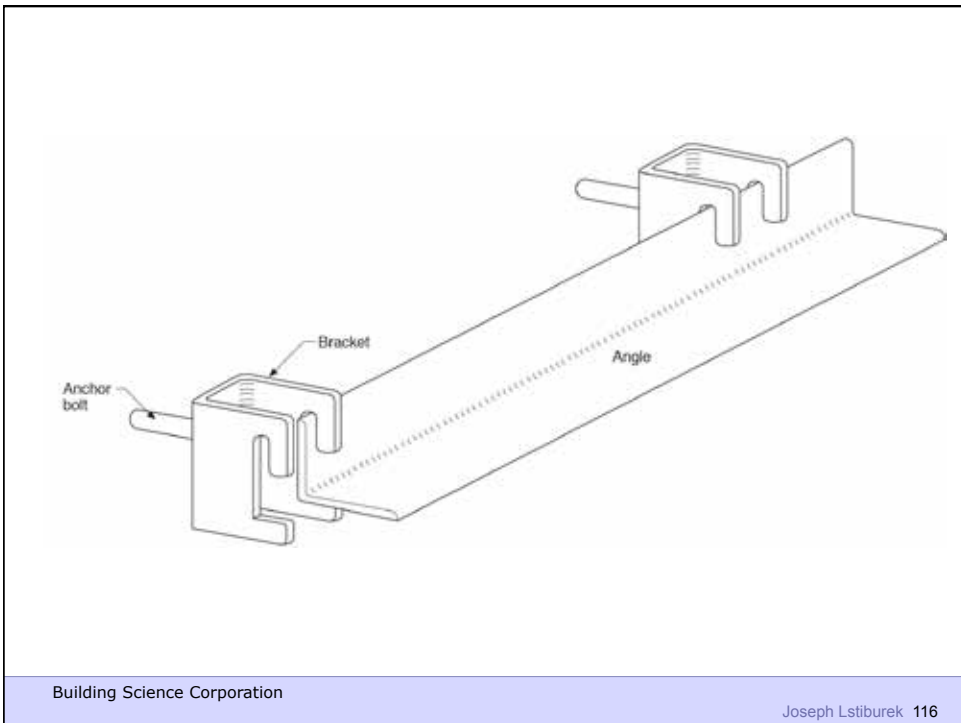


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2nd Law of Thermodynamics

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

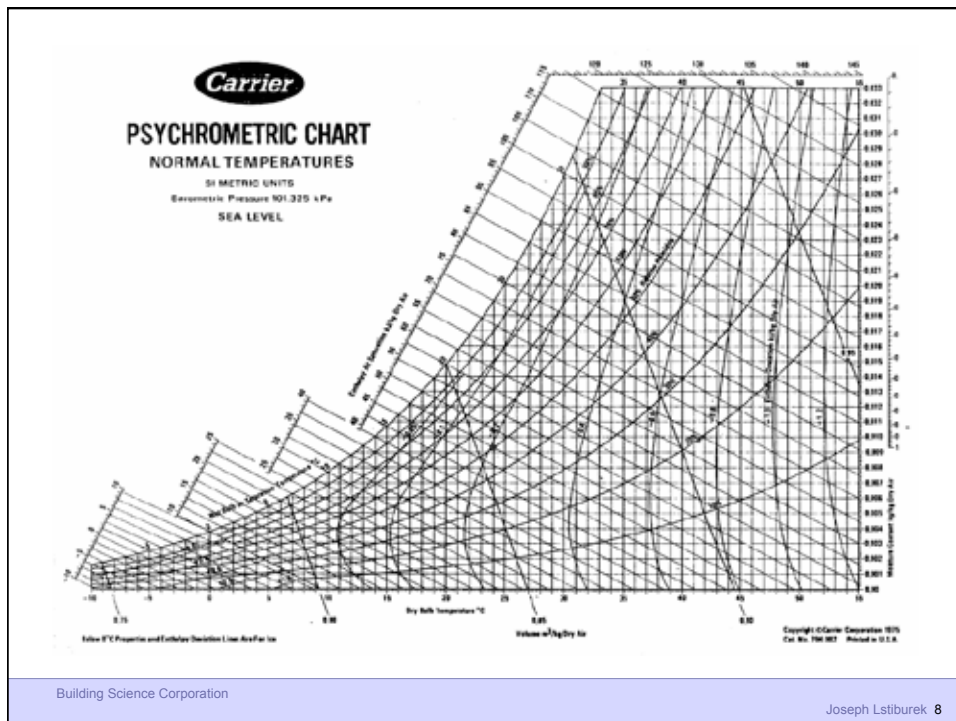
Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

Vapor Diffusion

Thermodynamic Potential

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Damage Functions

Damage Functions
Water
Heat
Ultra Violet Radiation

Damage Functions

Water

Heat

Ultra Violet Radiation

Oxidization (Ozone)

Fatigue (Creep)

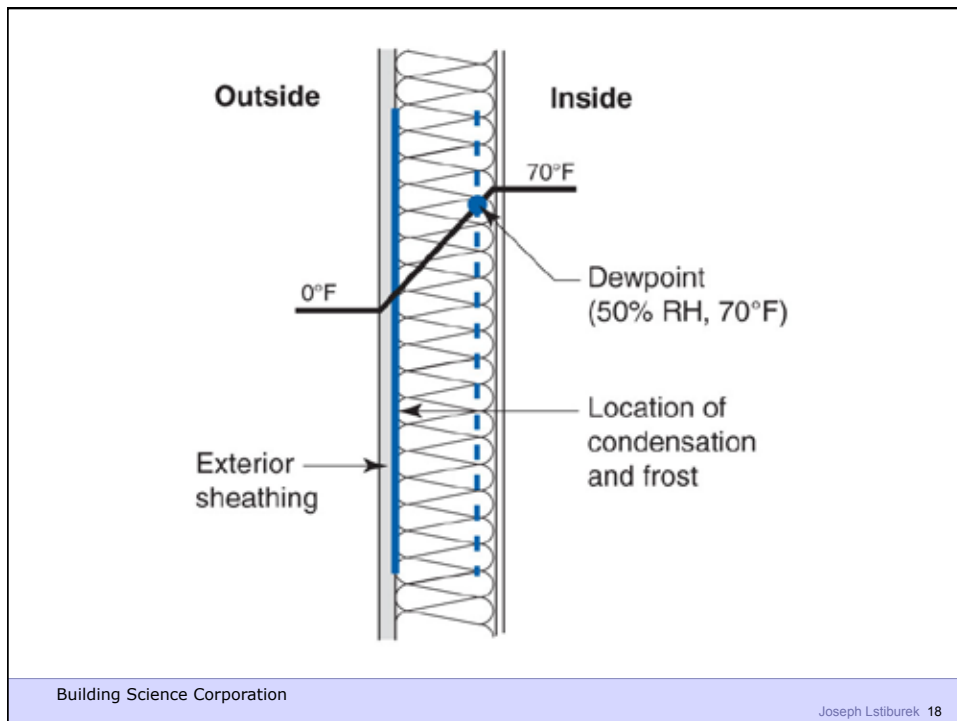
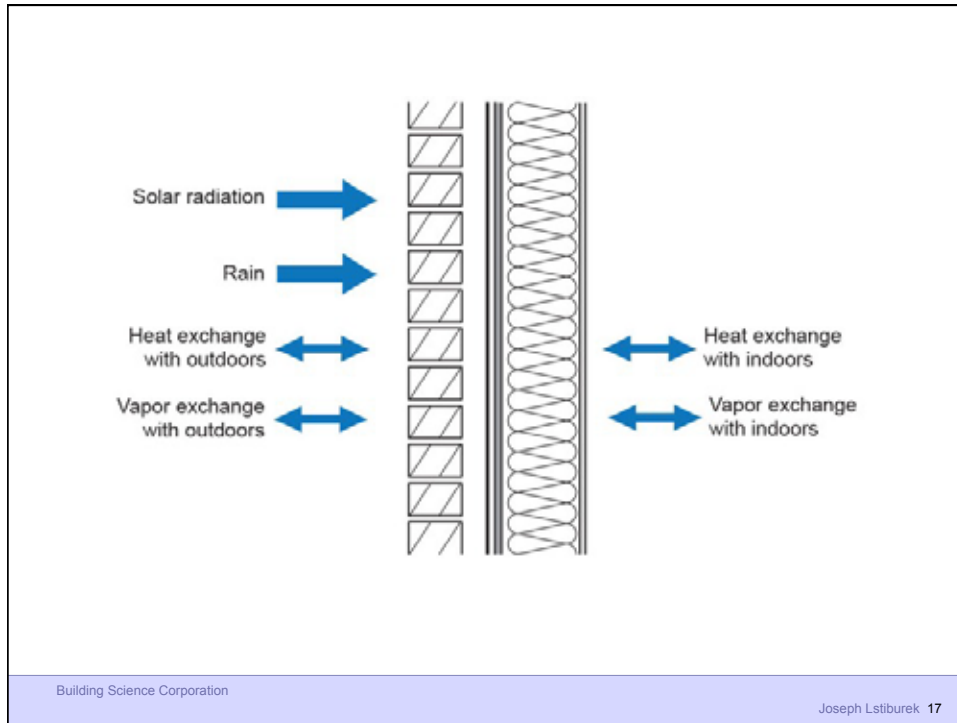
The Three Biggest Problems In Buildings Are
Water, Water and Water...

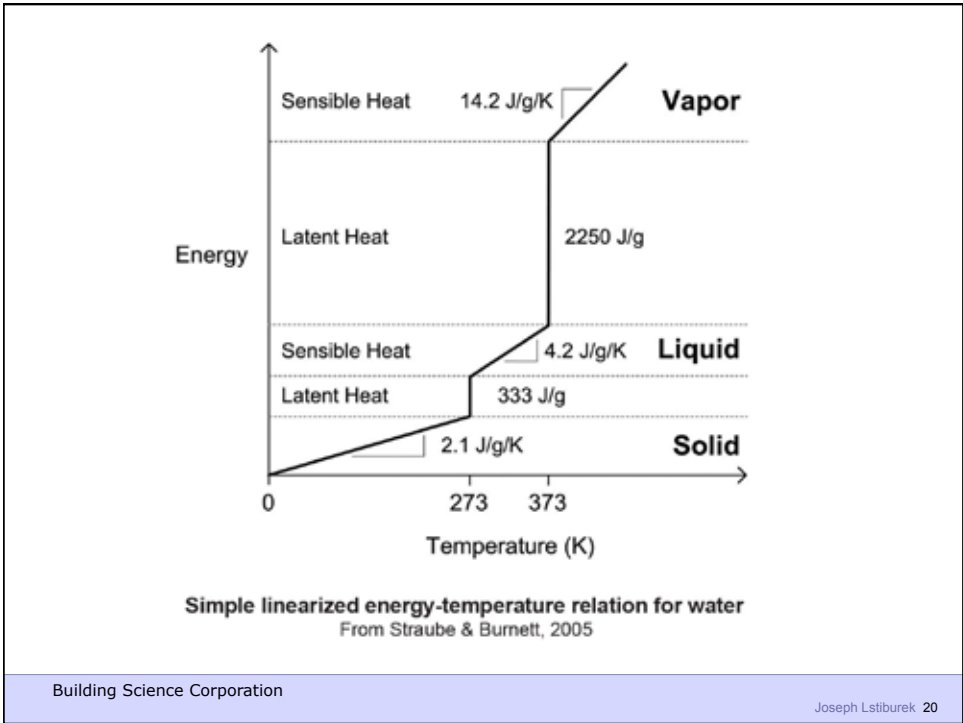
80 Percent of all Construction Problems are
Related to Water

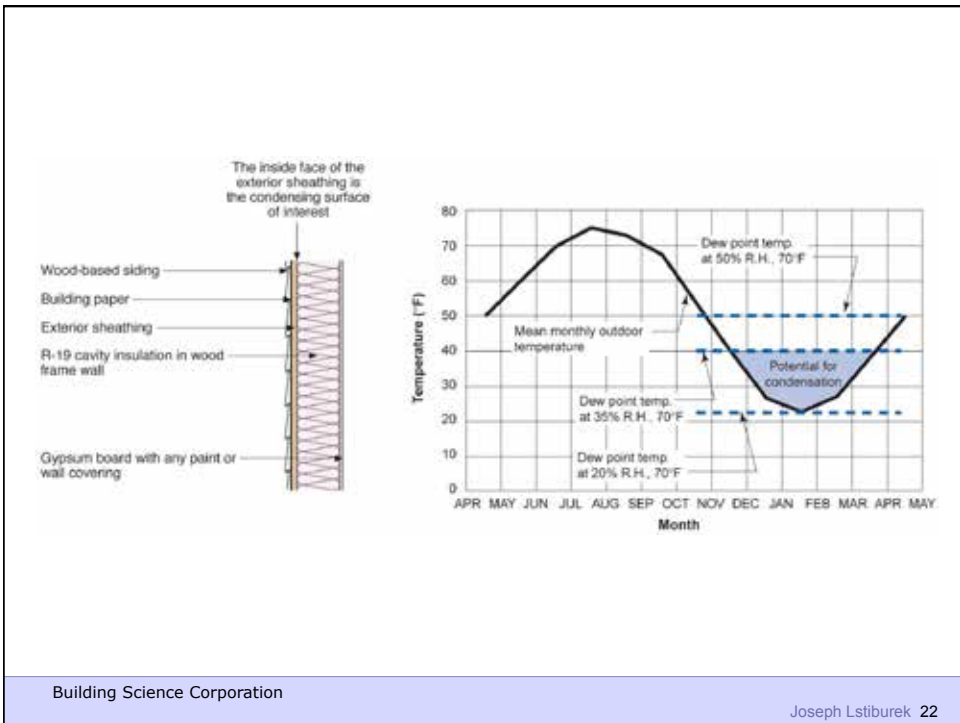
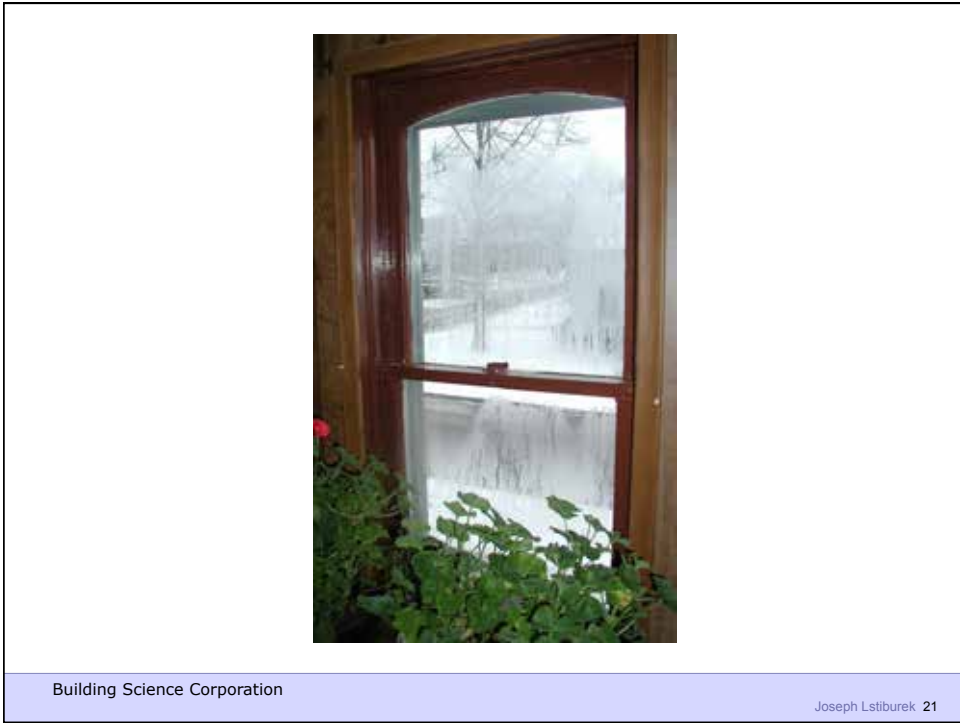
Heat
Air
Moisture

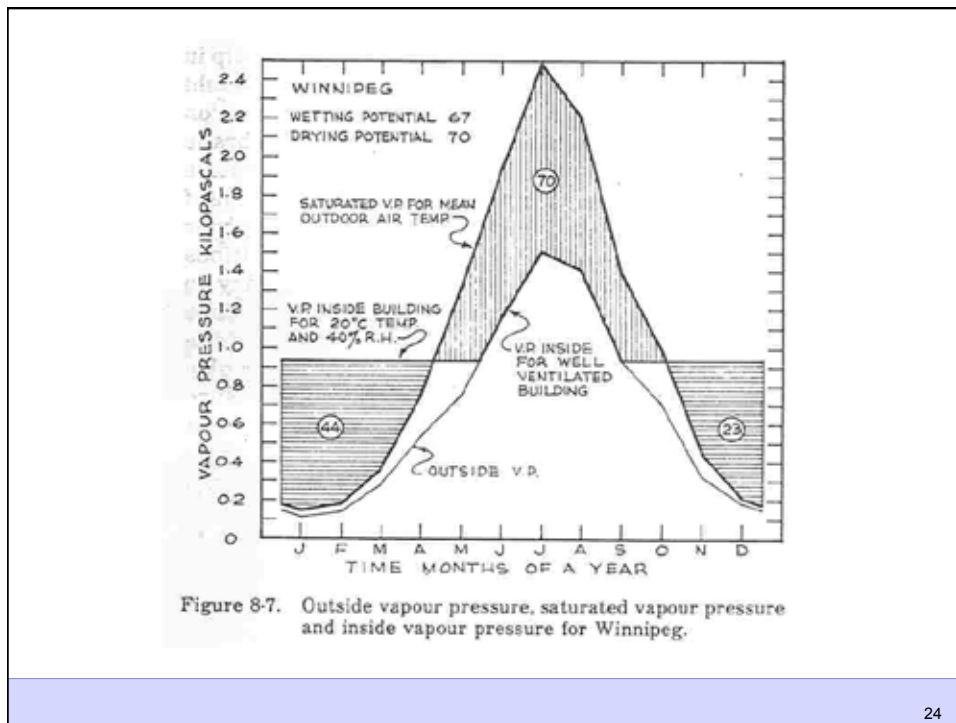
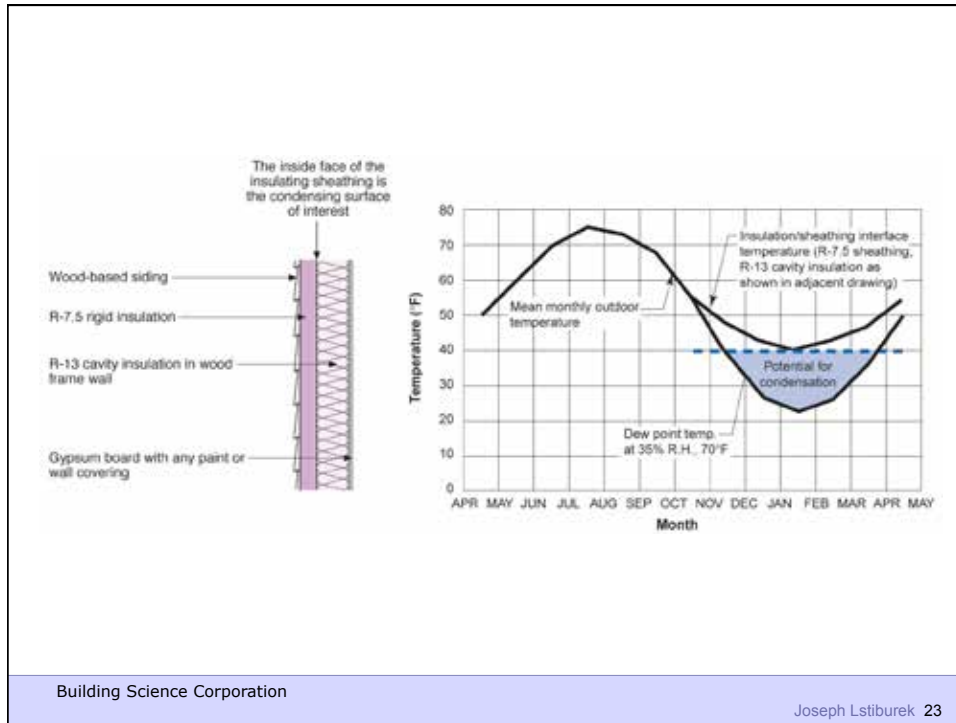
HAM

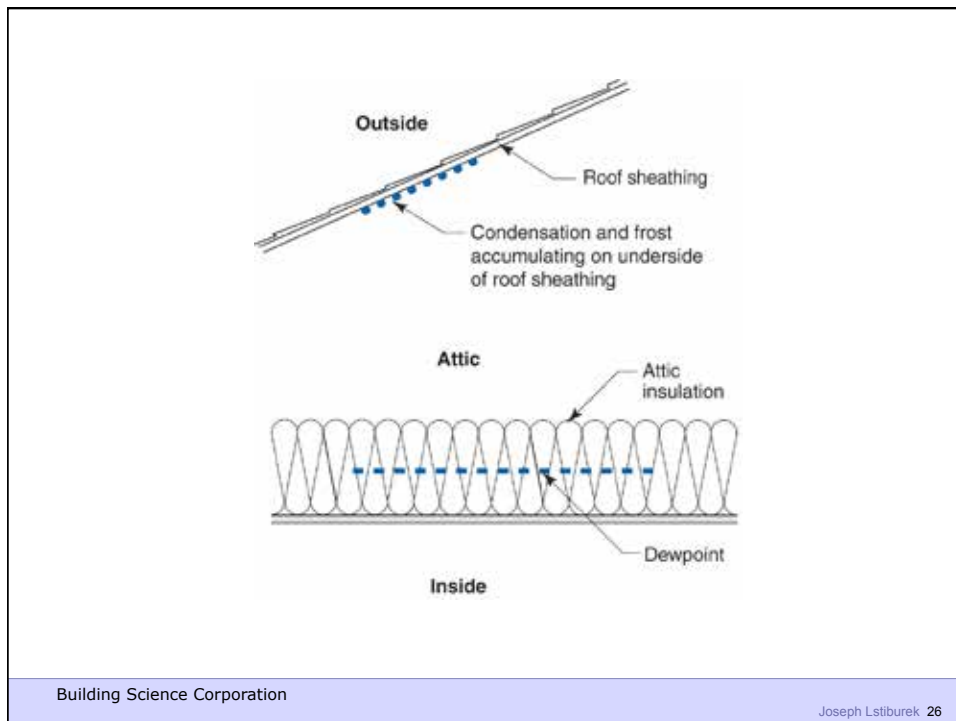
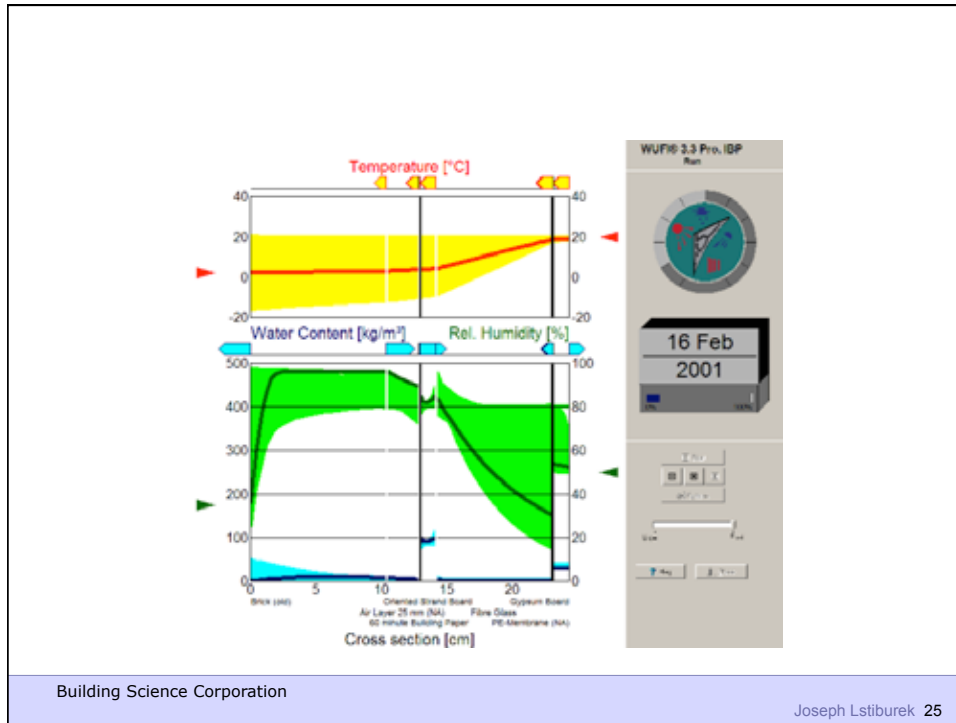
Hygrothermal Analysis







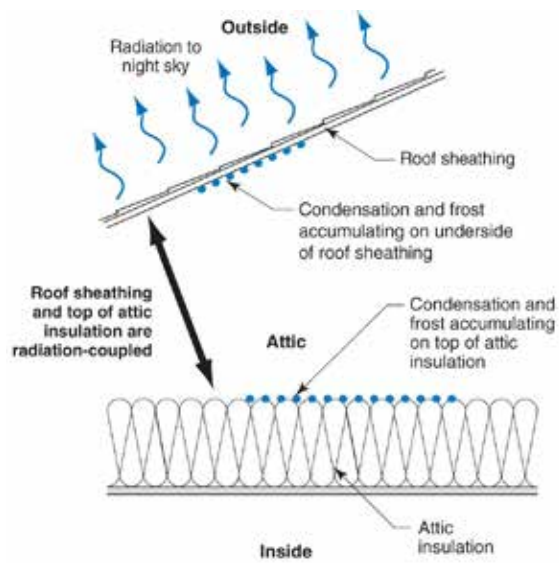






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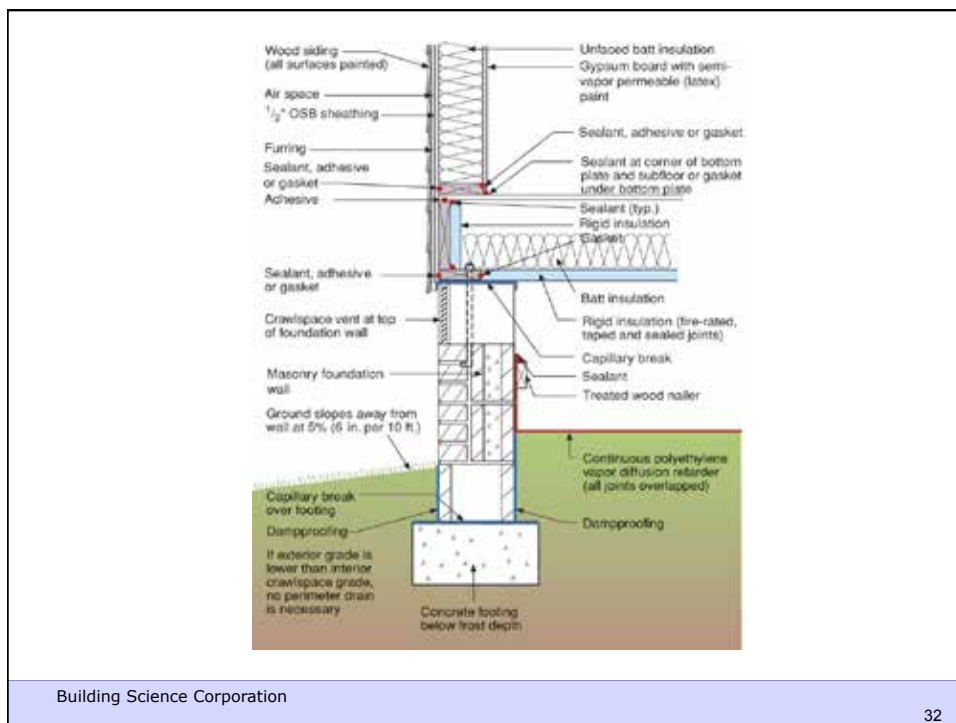
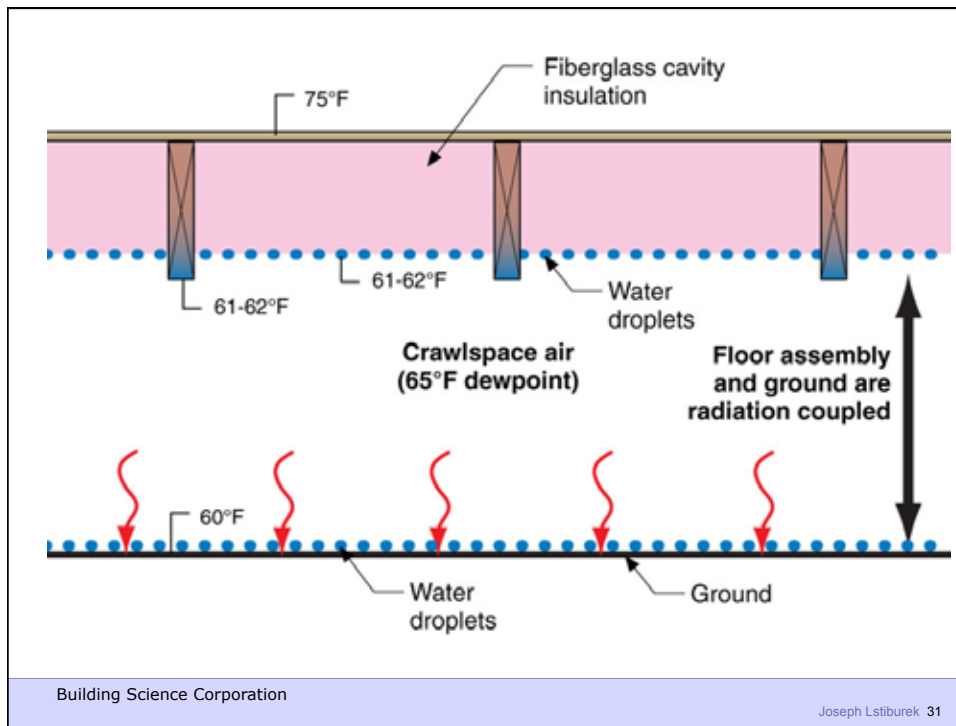
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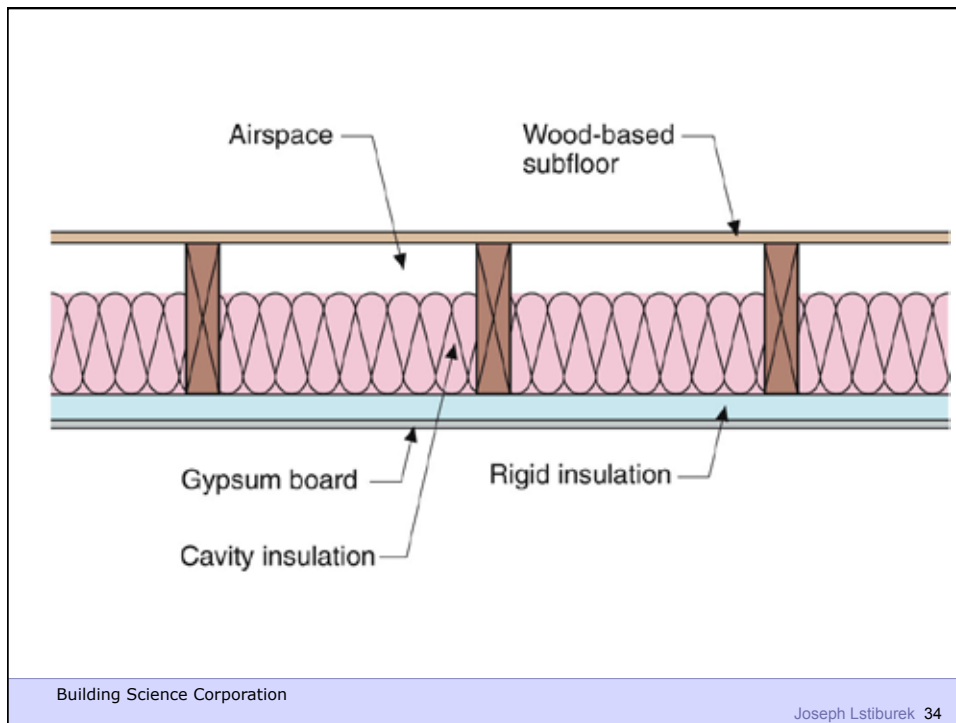
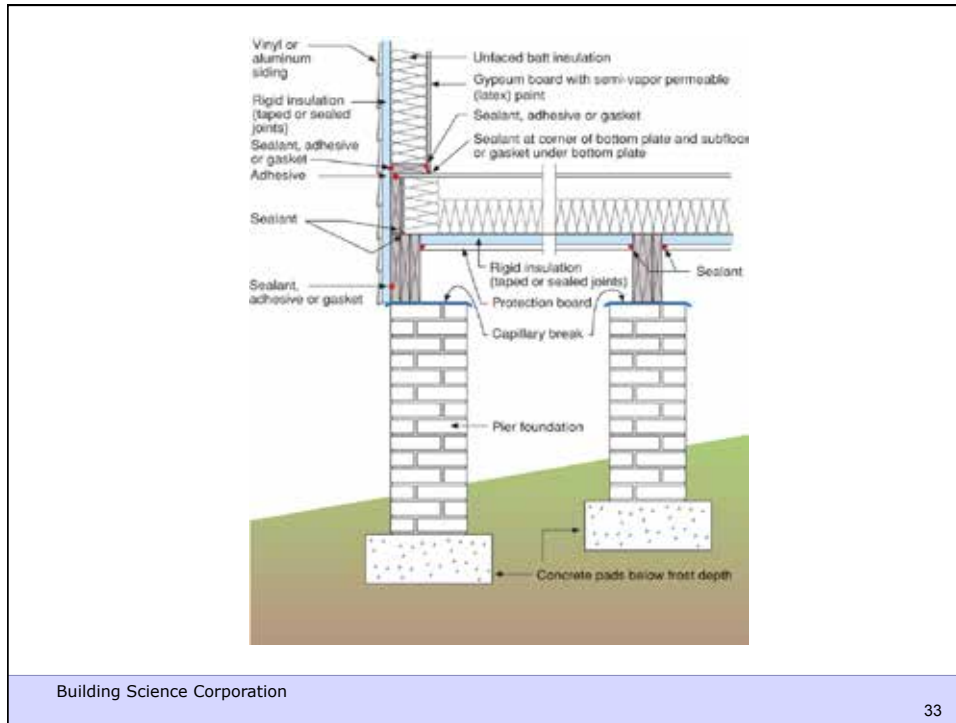
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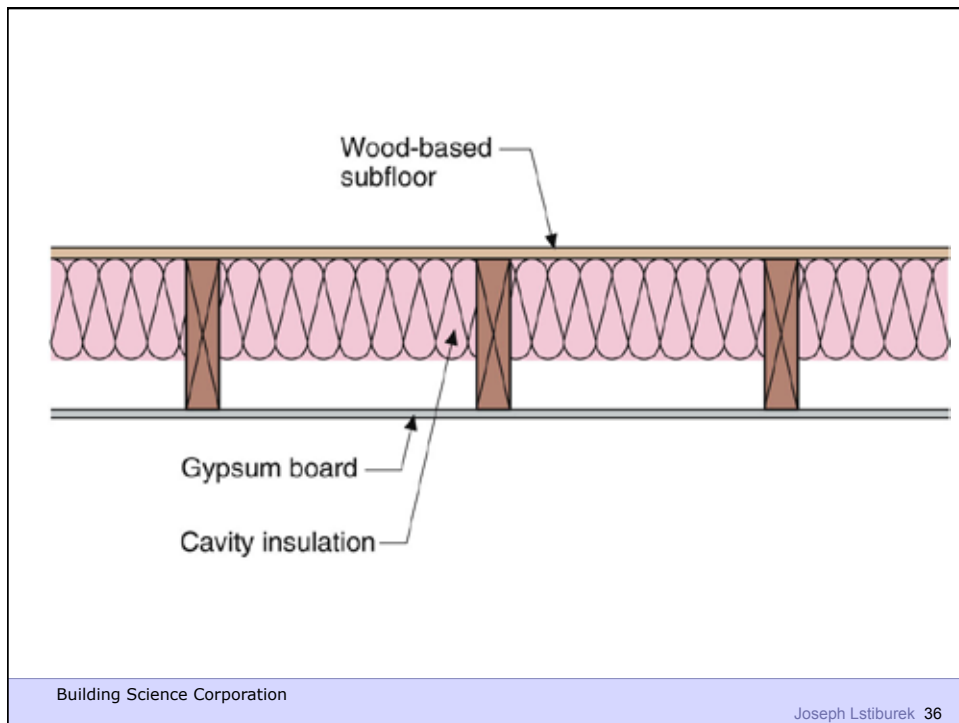
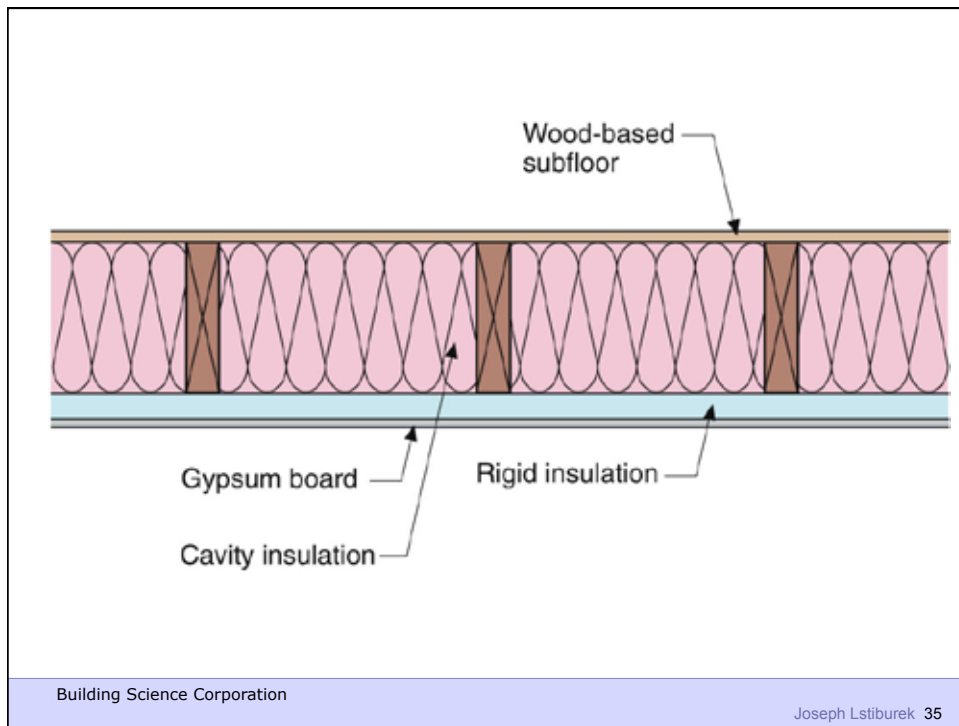


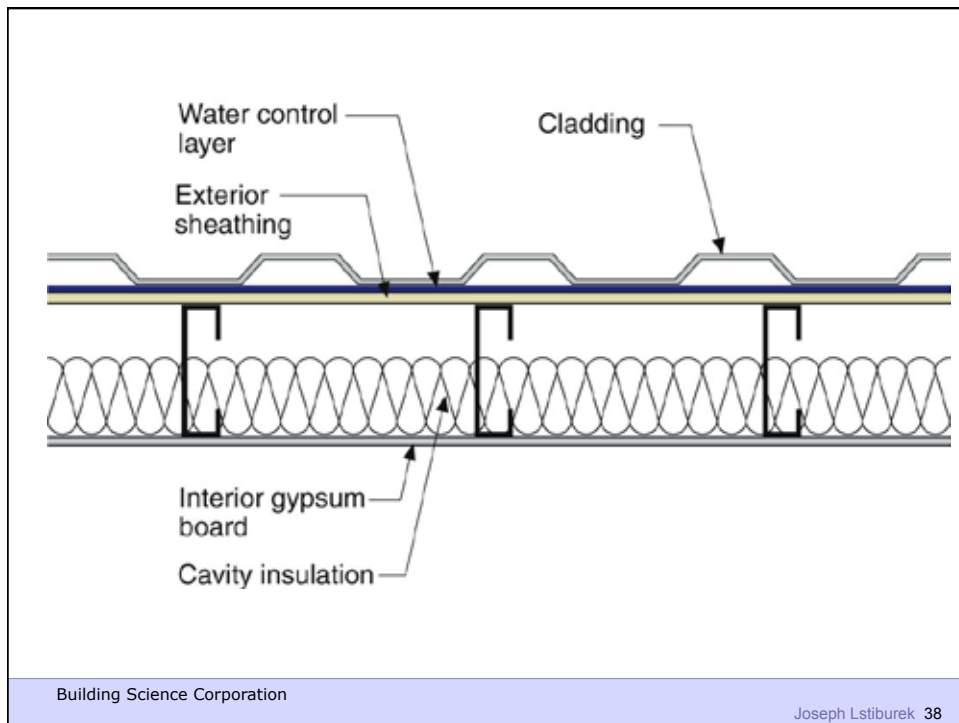
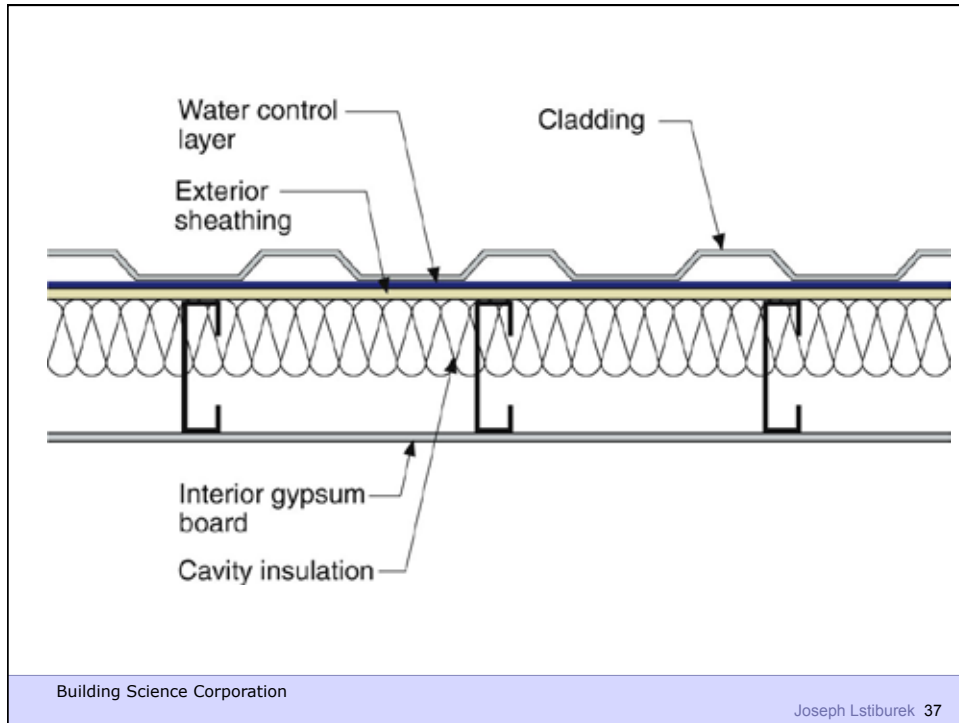
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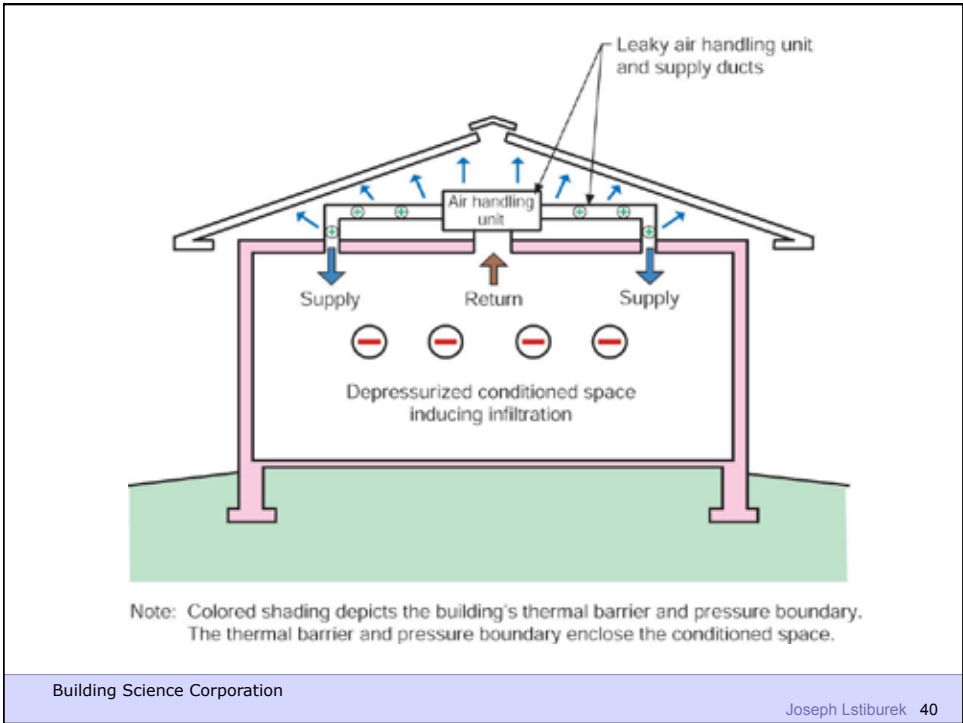
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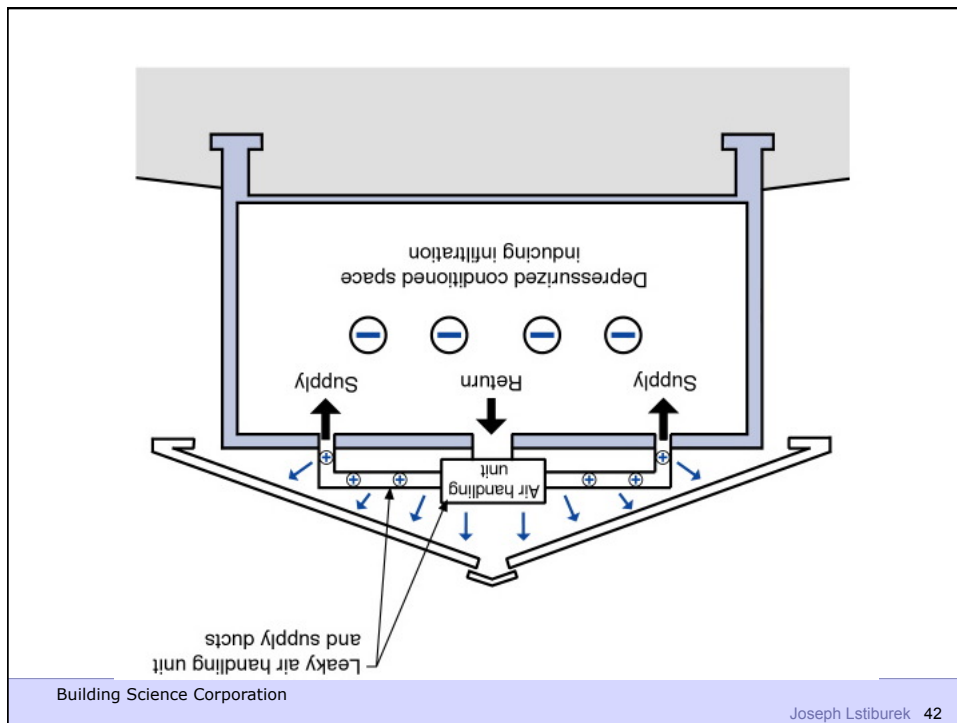
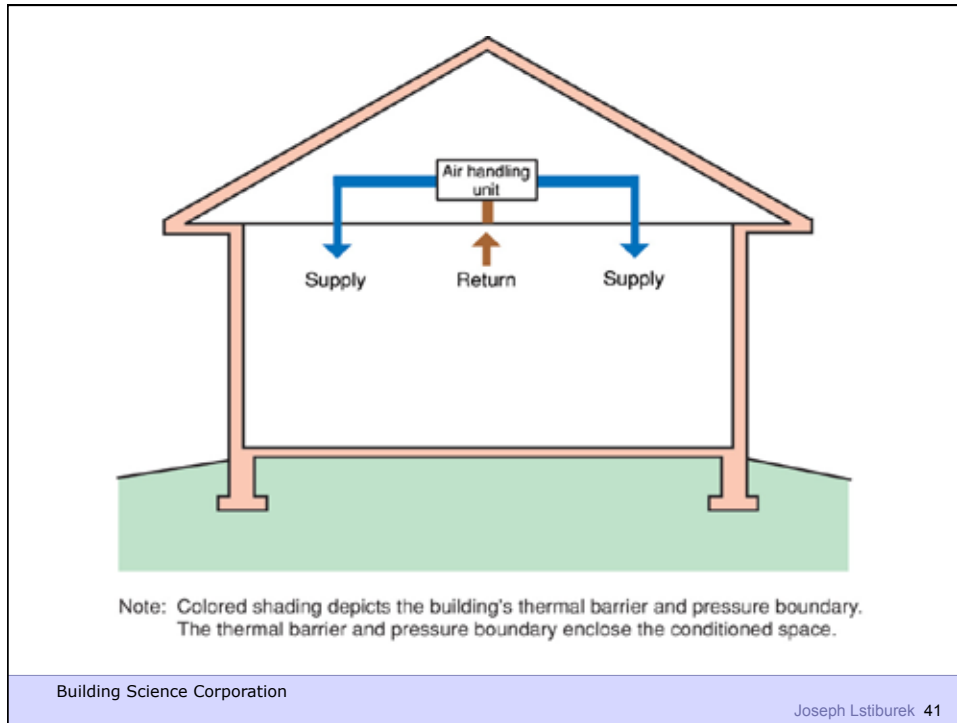


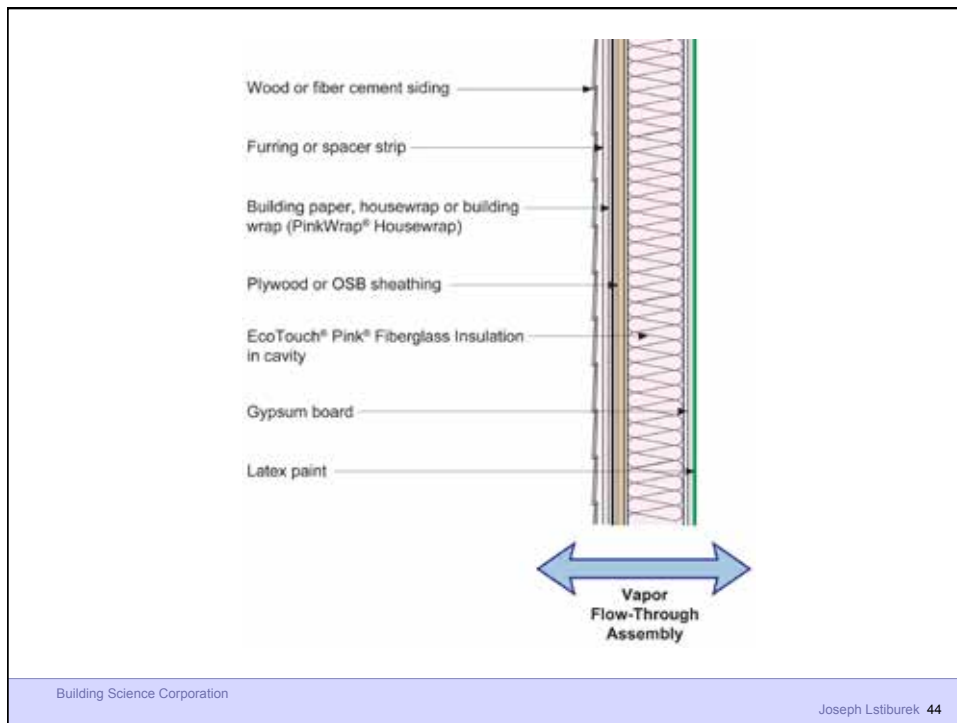
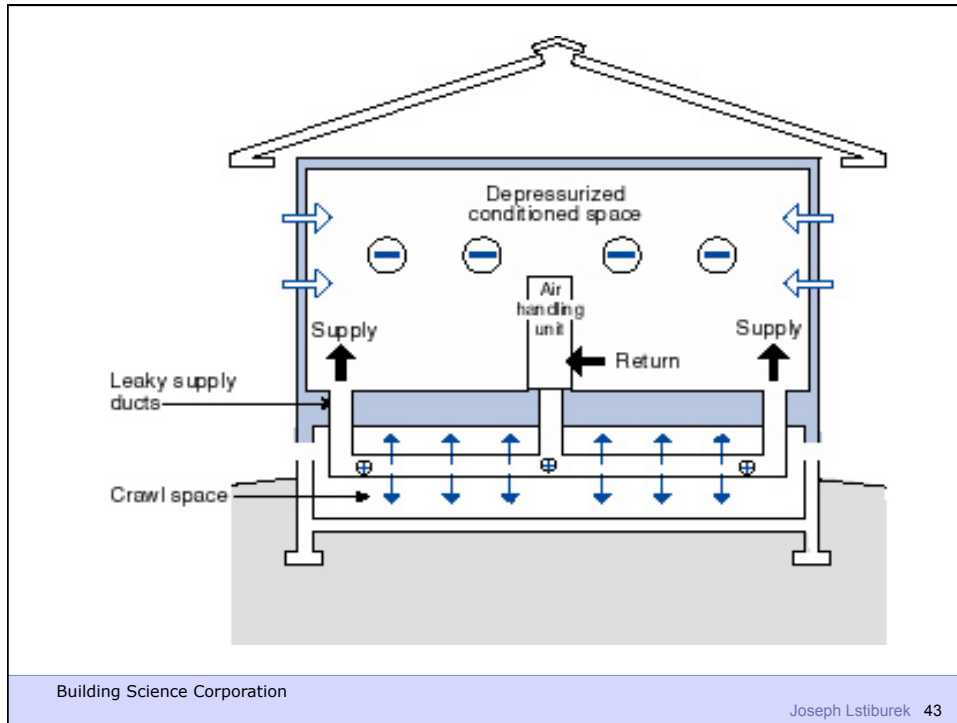


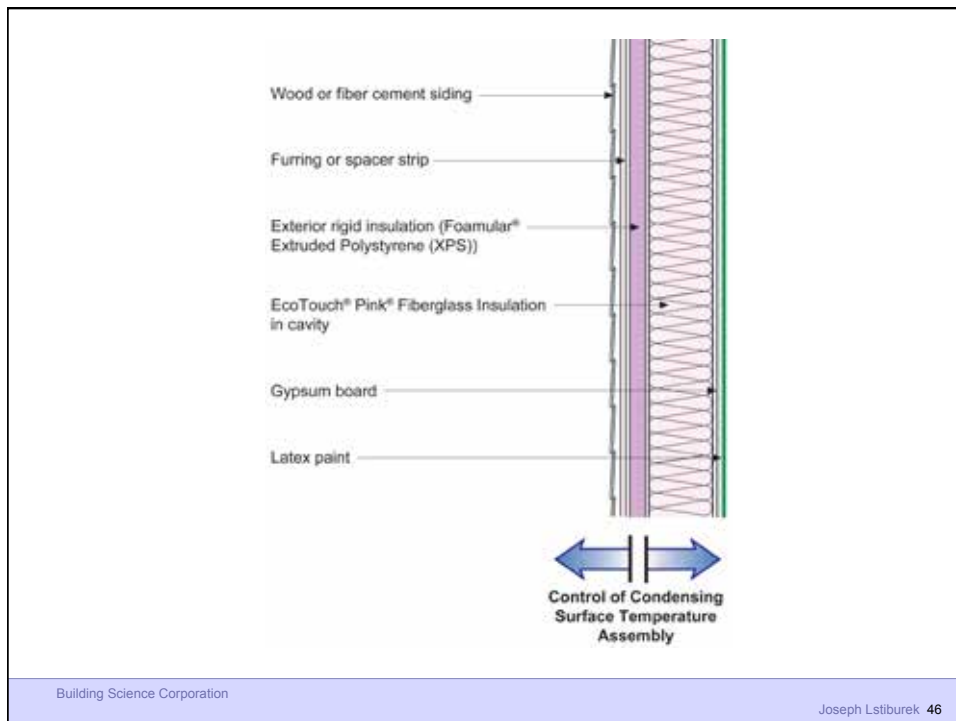
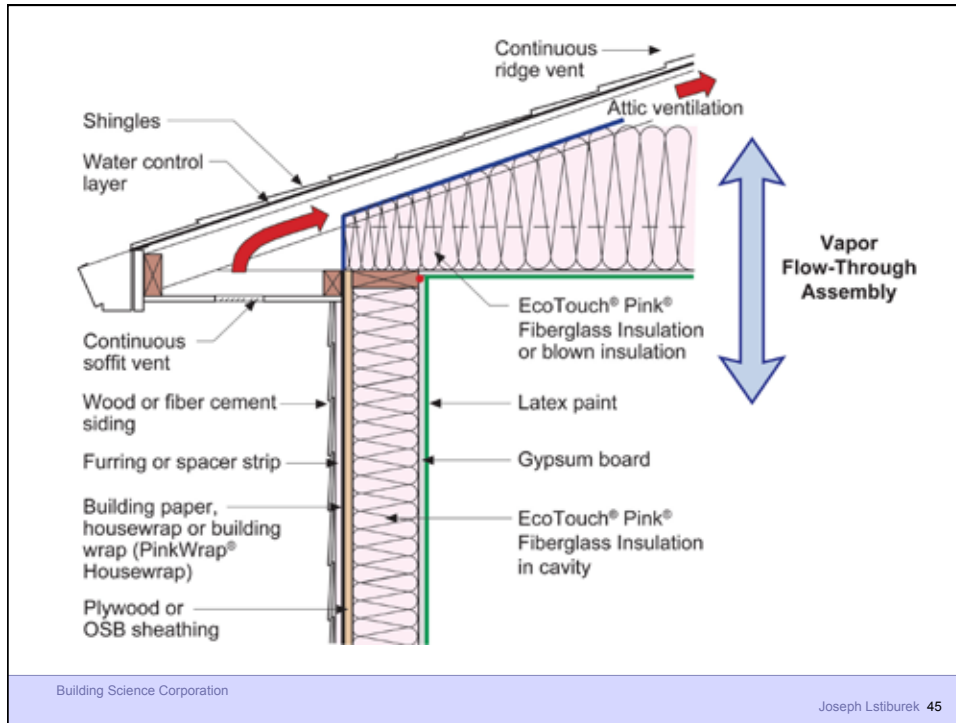


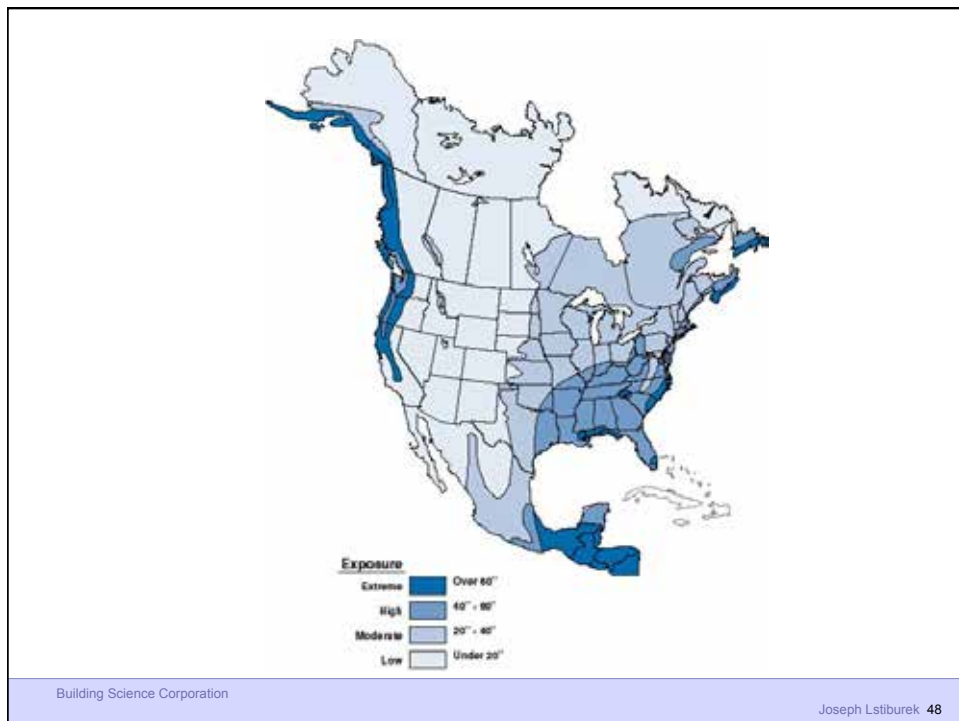
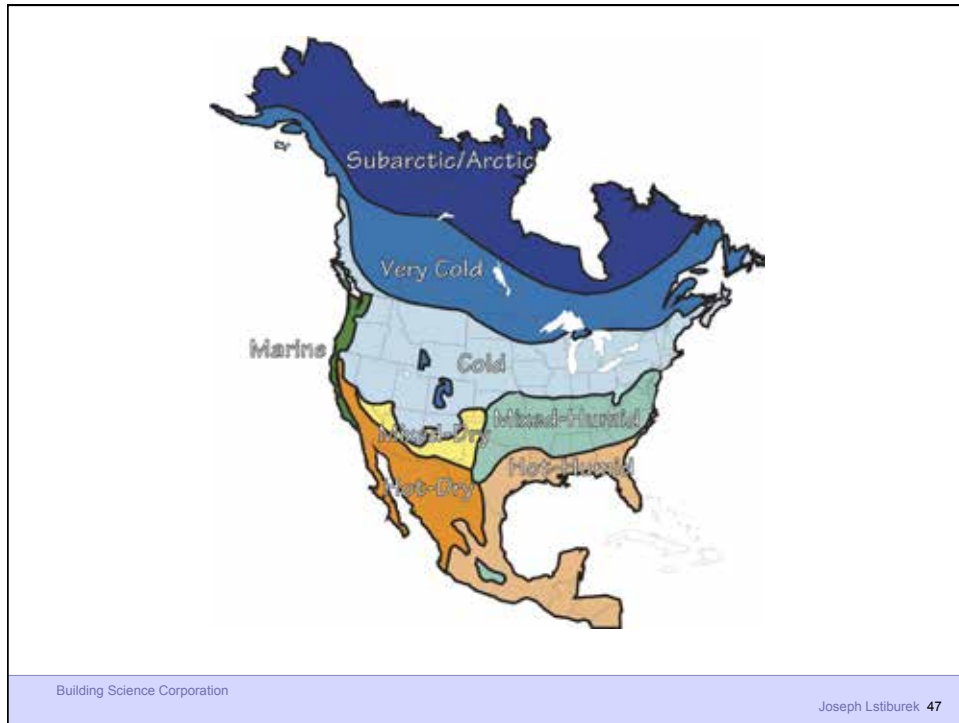


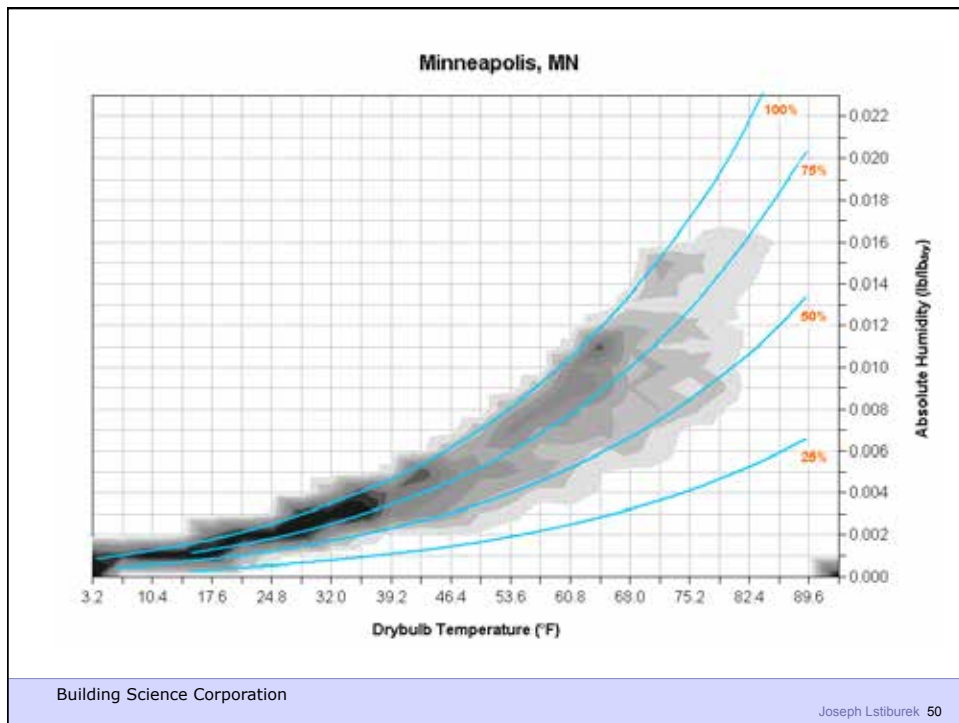
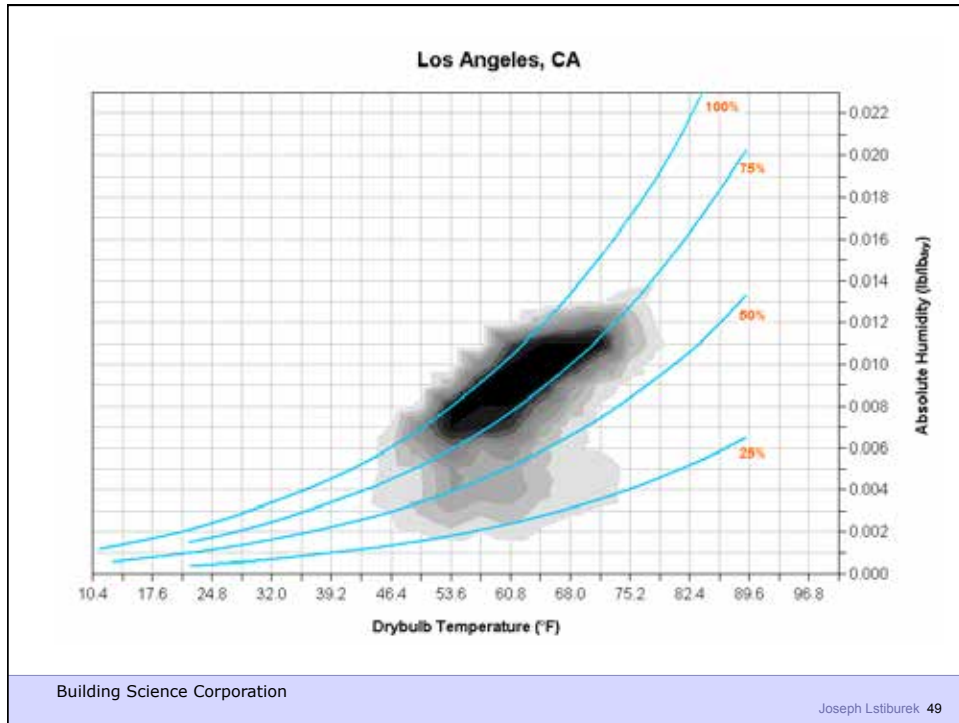


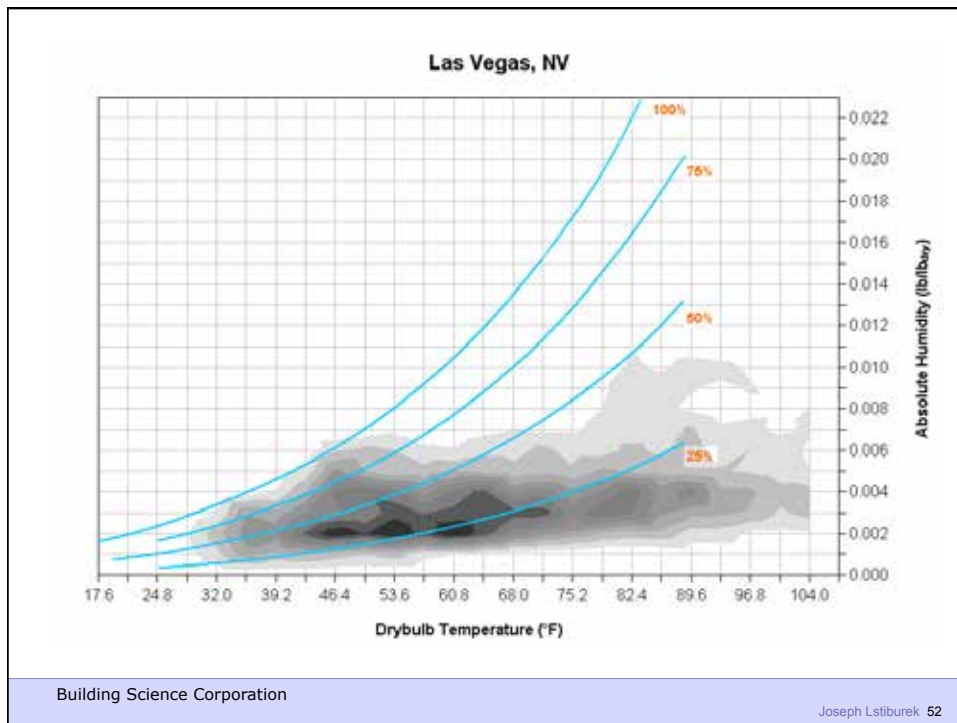
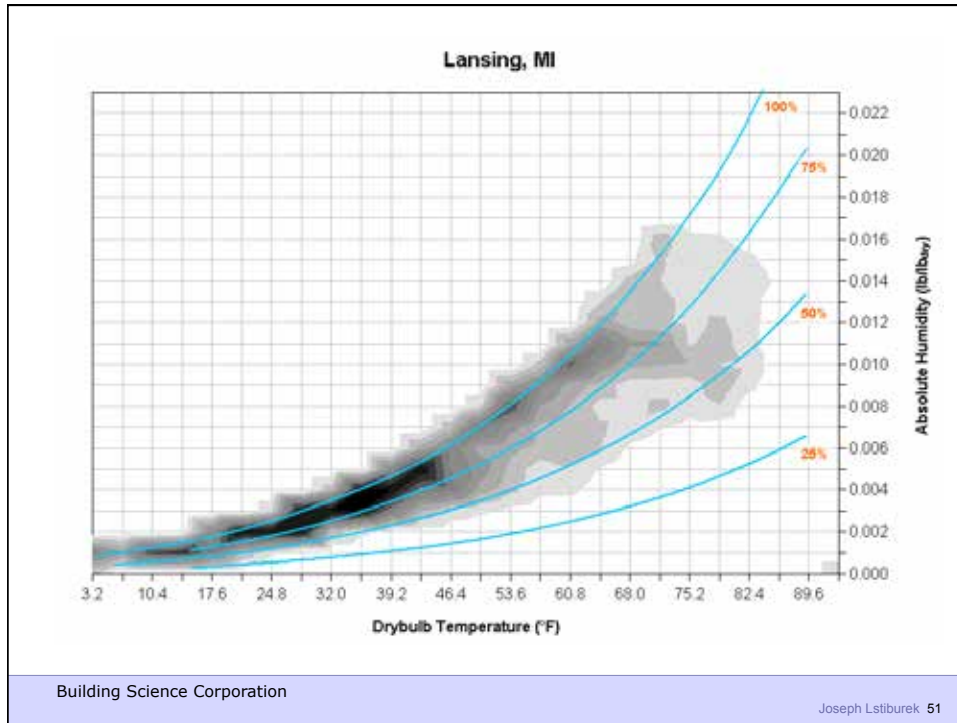


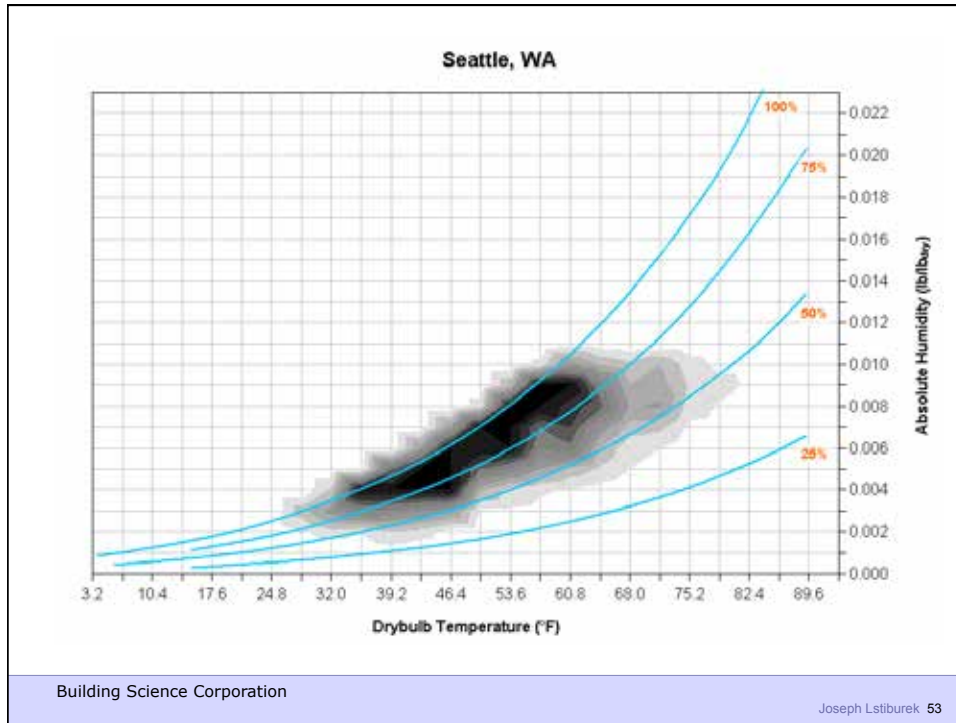










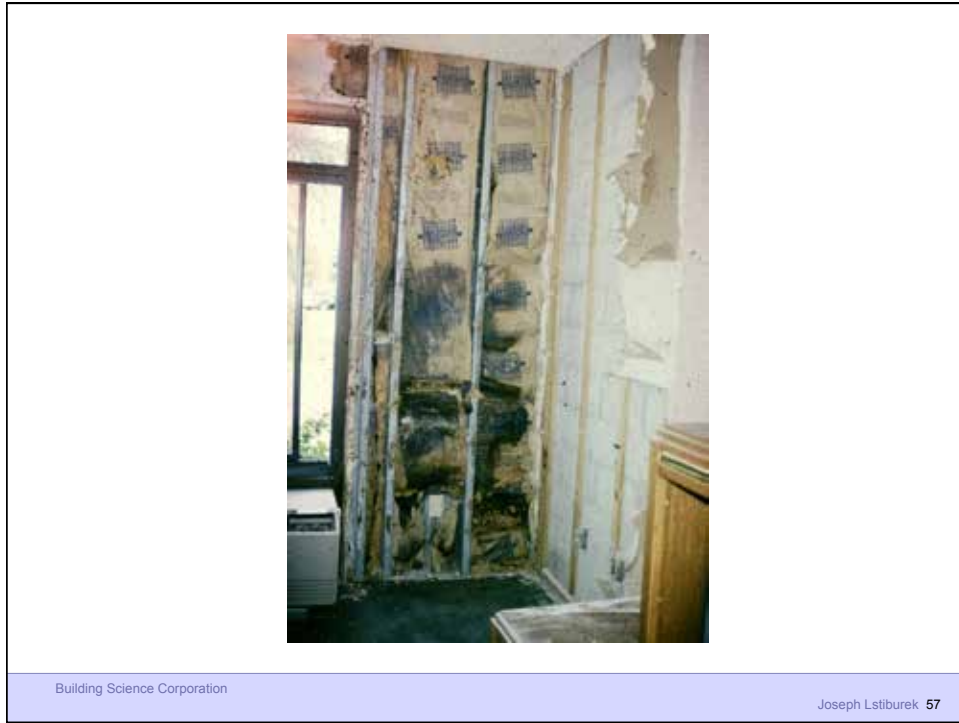


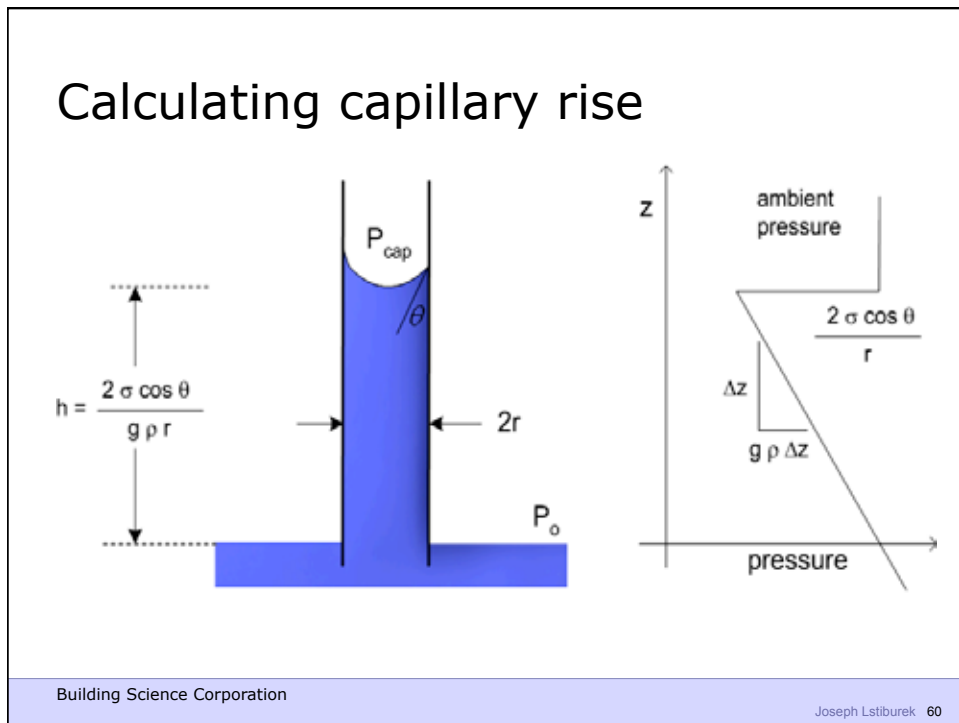
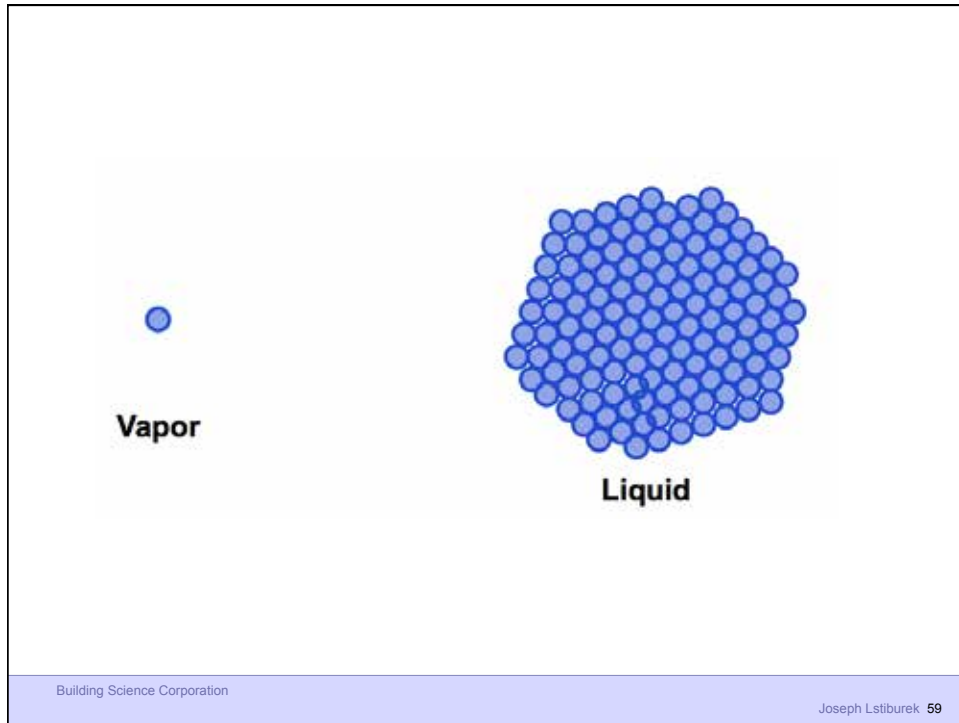
Don't Do Stupid Things

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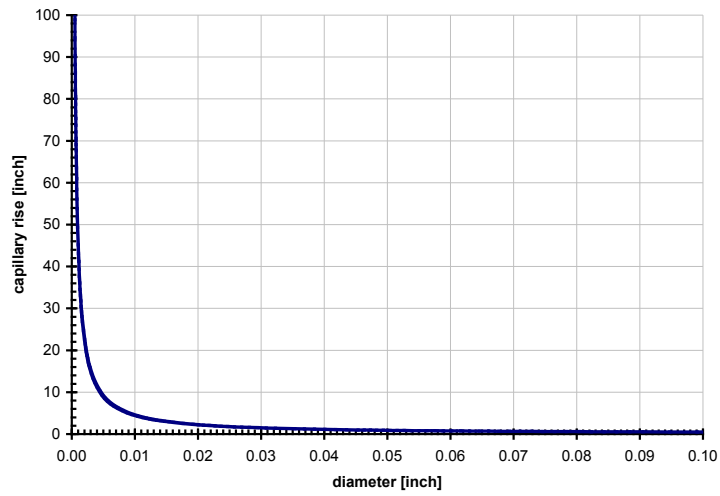
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Capillary rise versus diameter



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Capillary Flow

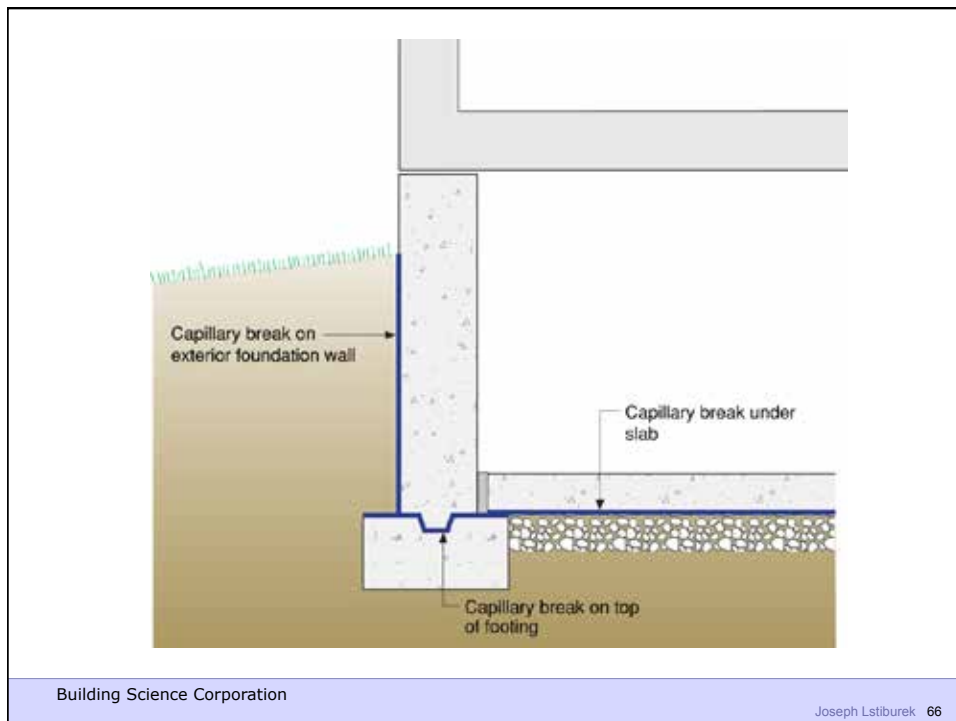
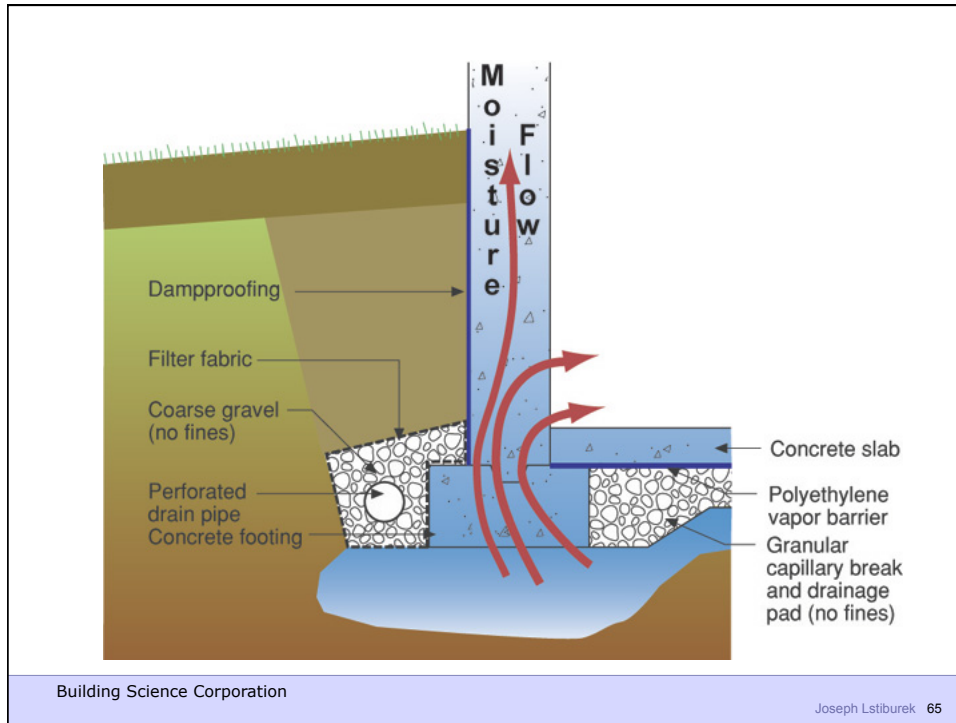
Siding laps

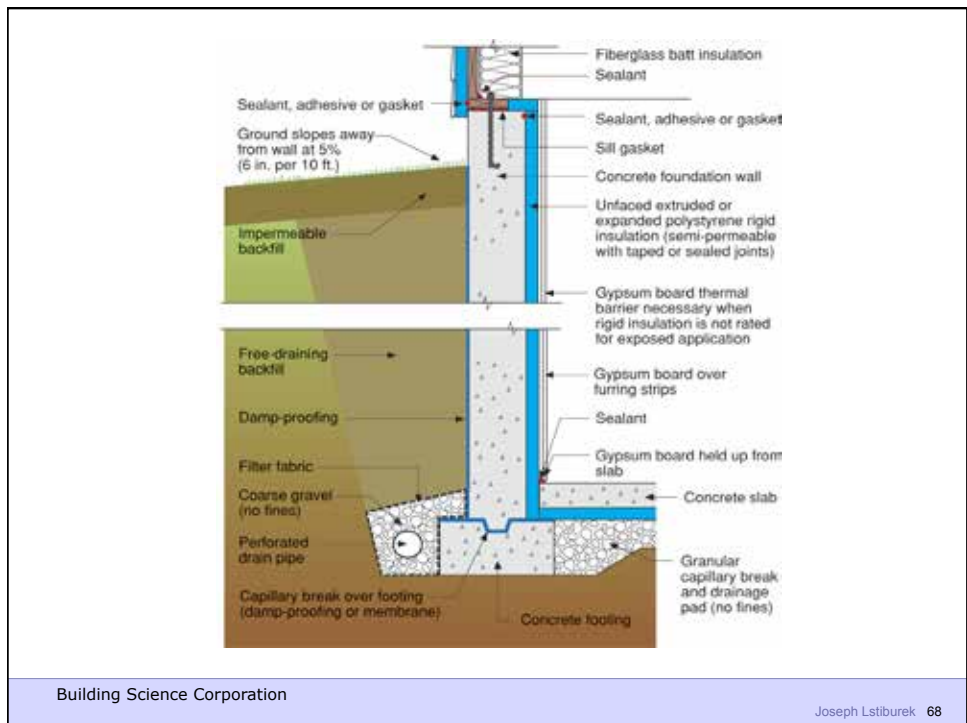
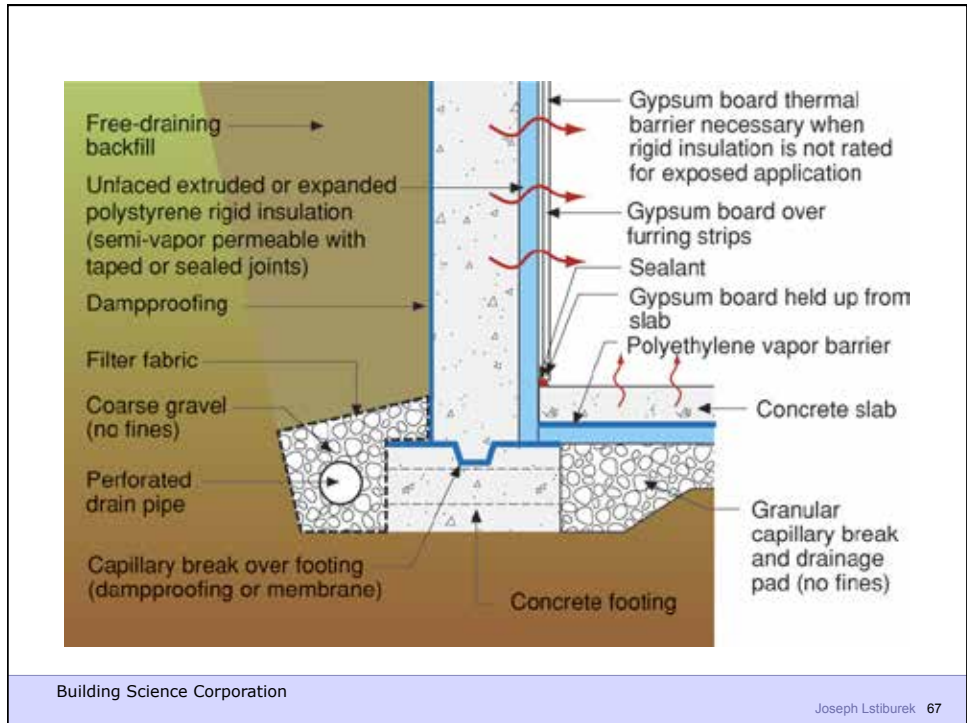


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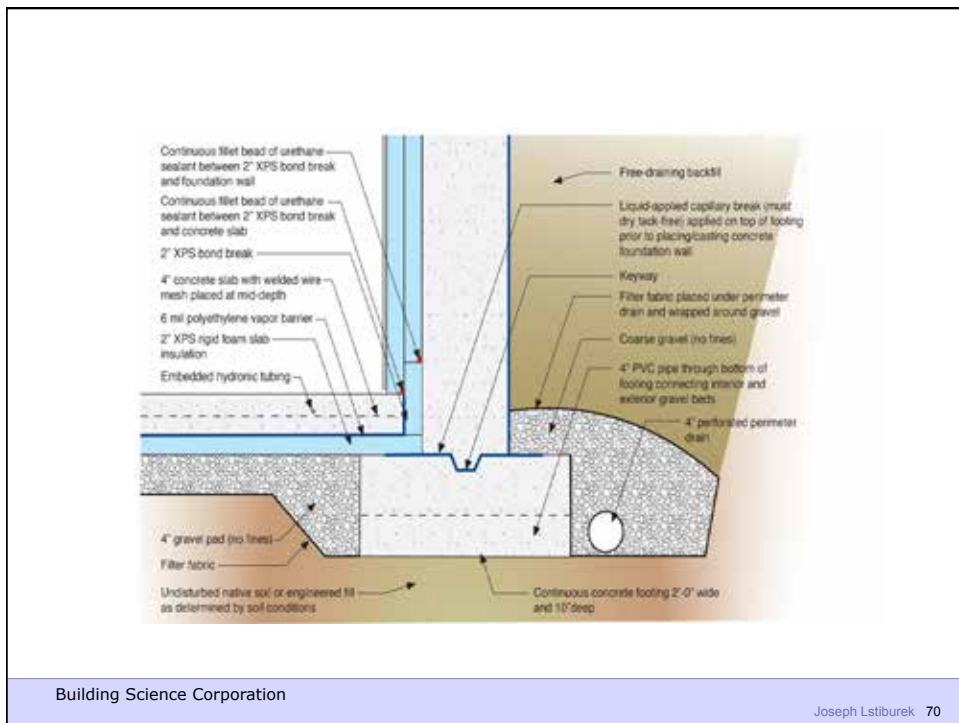






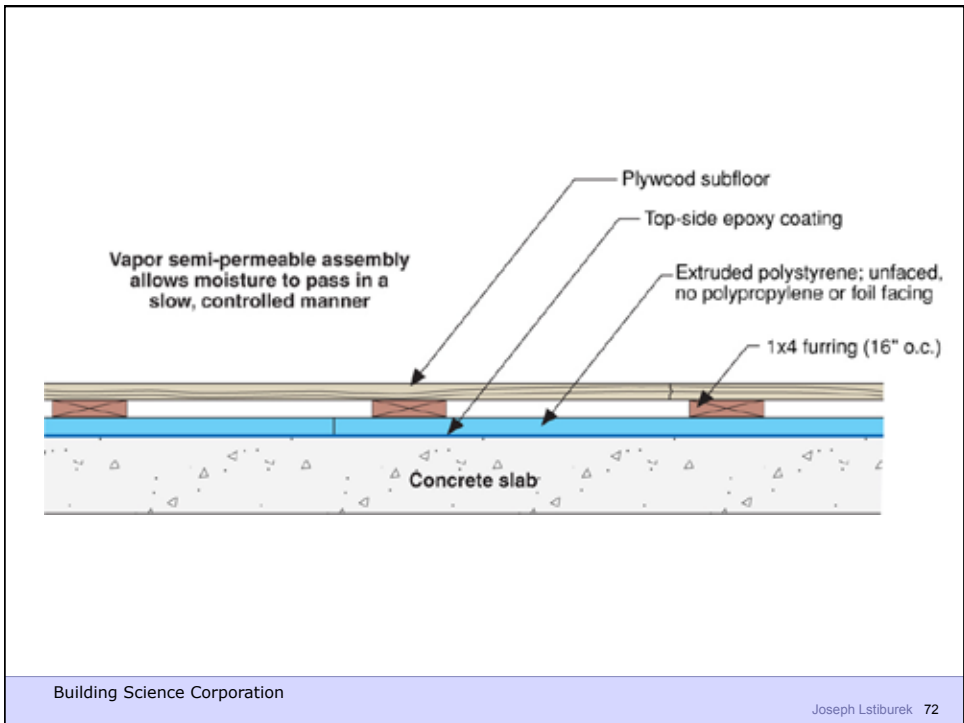
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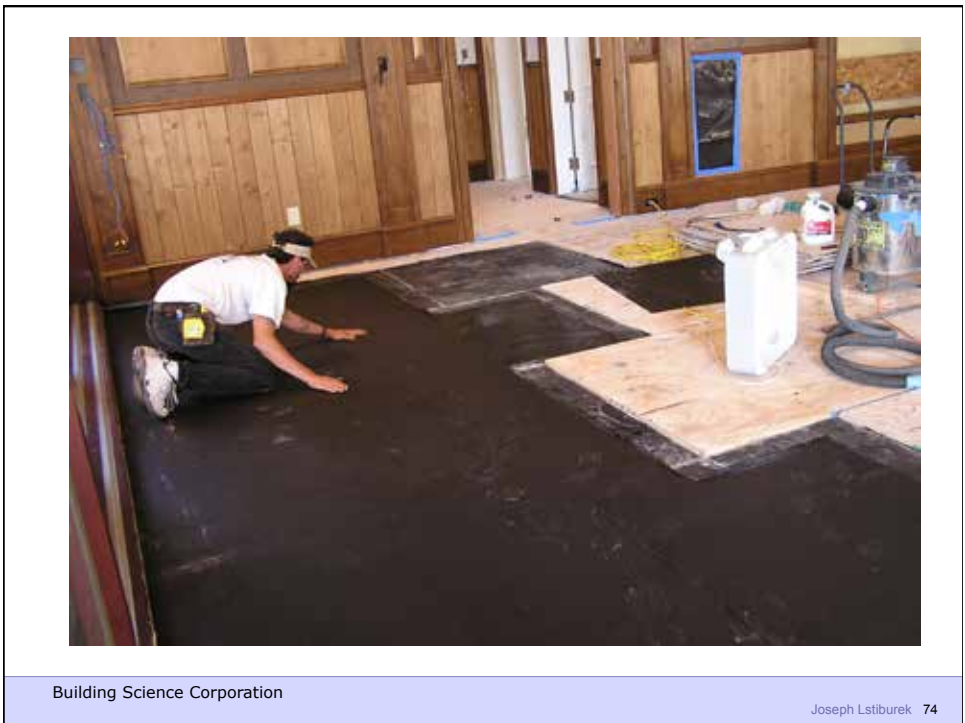
Joseph Lstiburek 69



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Joseph Lstiburek 70

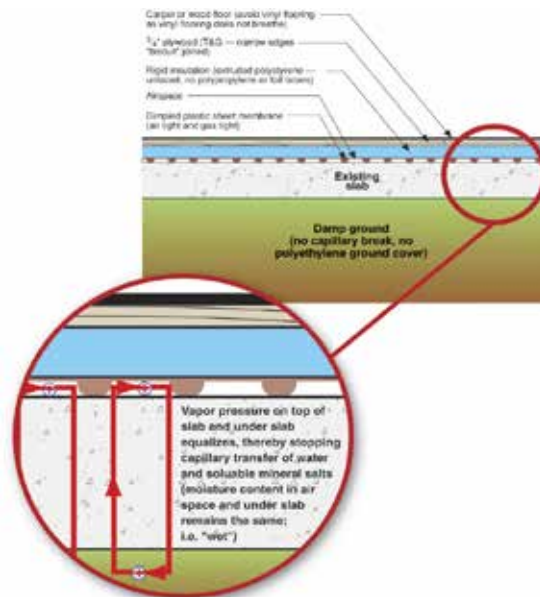






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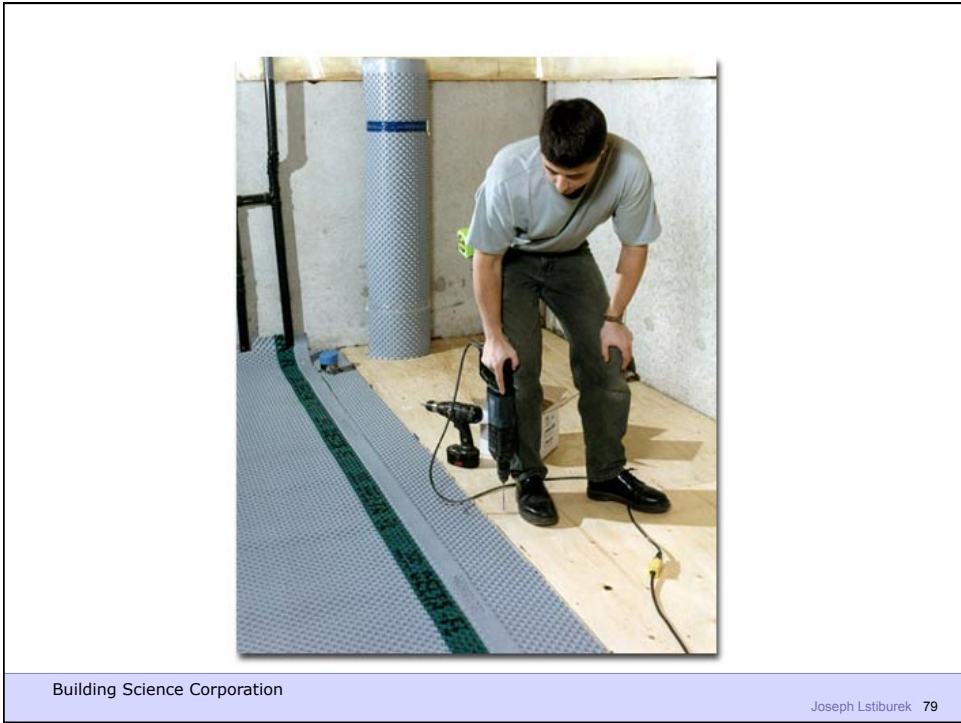
Joseph Lstiburek 75

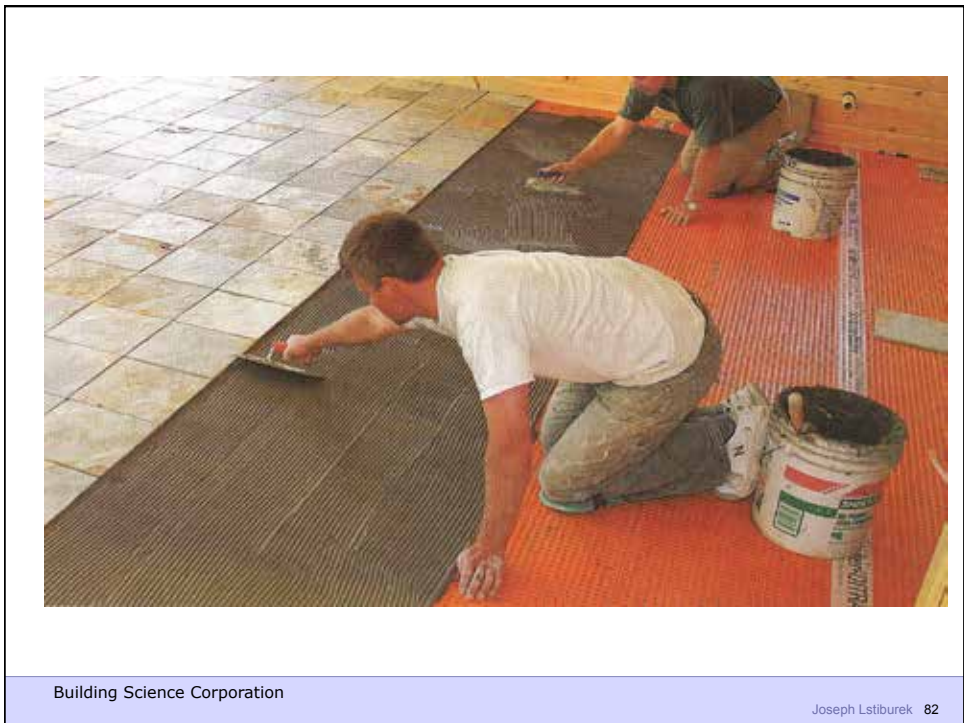


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Joseph Lstiburek 76



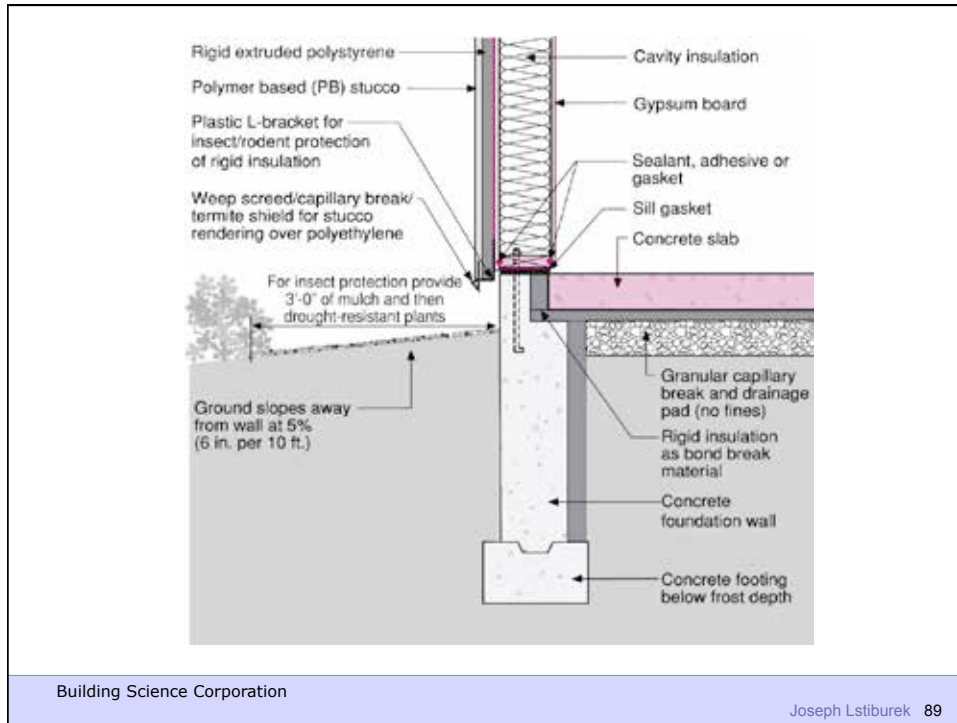




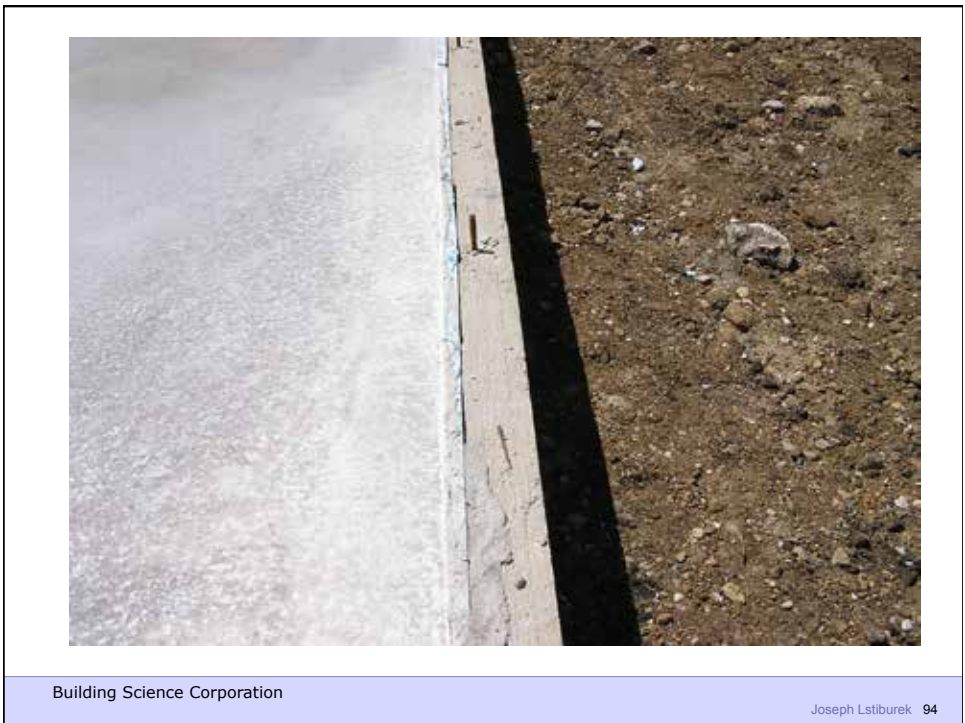










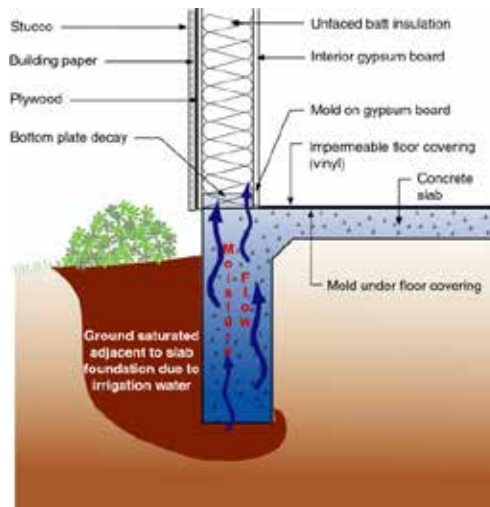




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Capillary Moisture Flow



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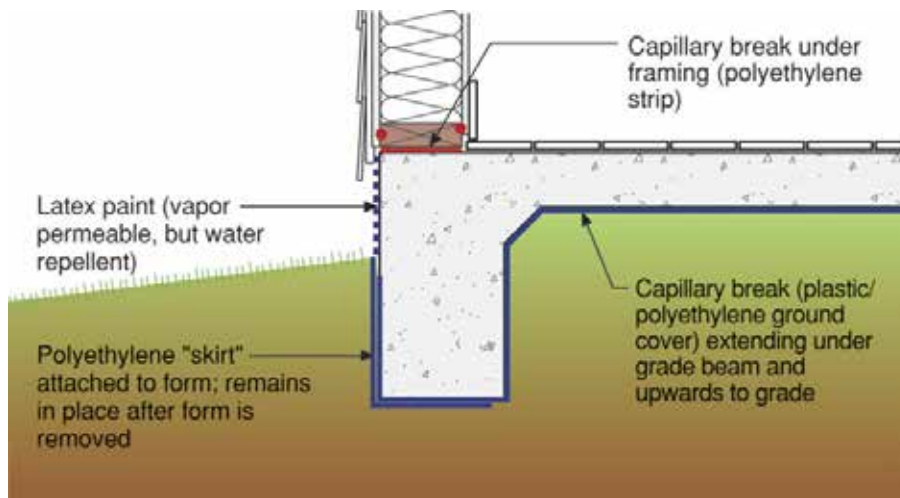






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Joseph Lstiburek 102



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Joseph Lstiburek 103



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Joseph Lstiburek 104



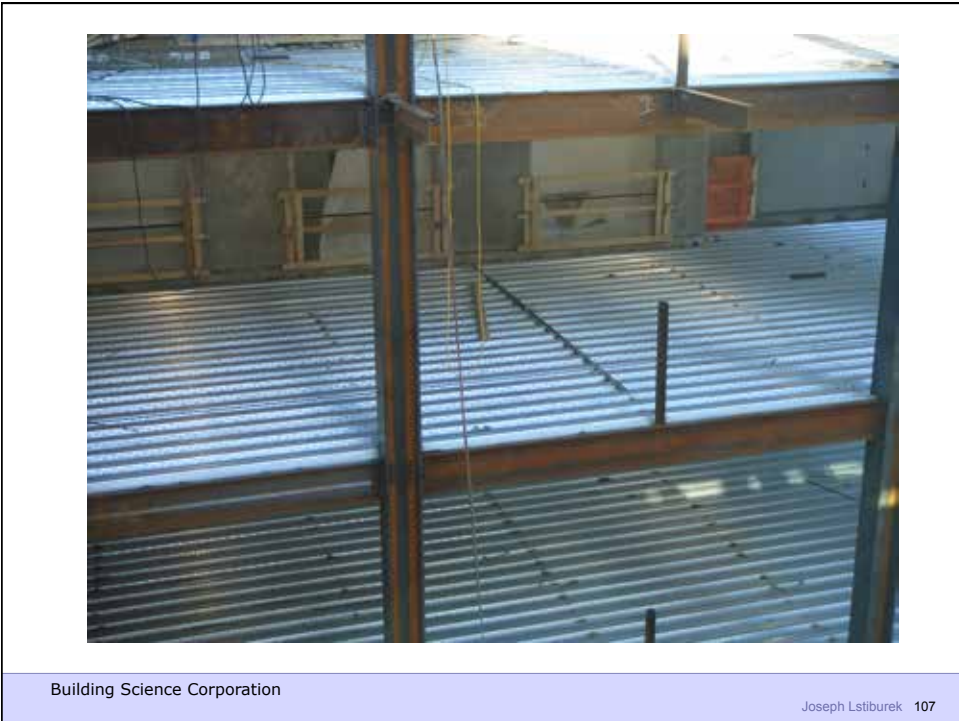
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Joseph Lstiburek 105



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Joseph Lstiburek 106

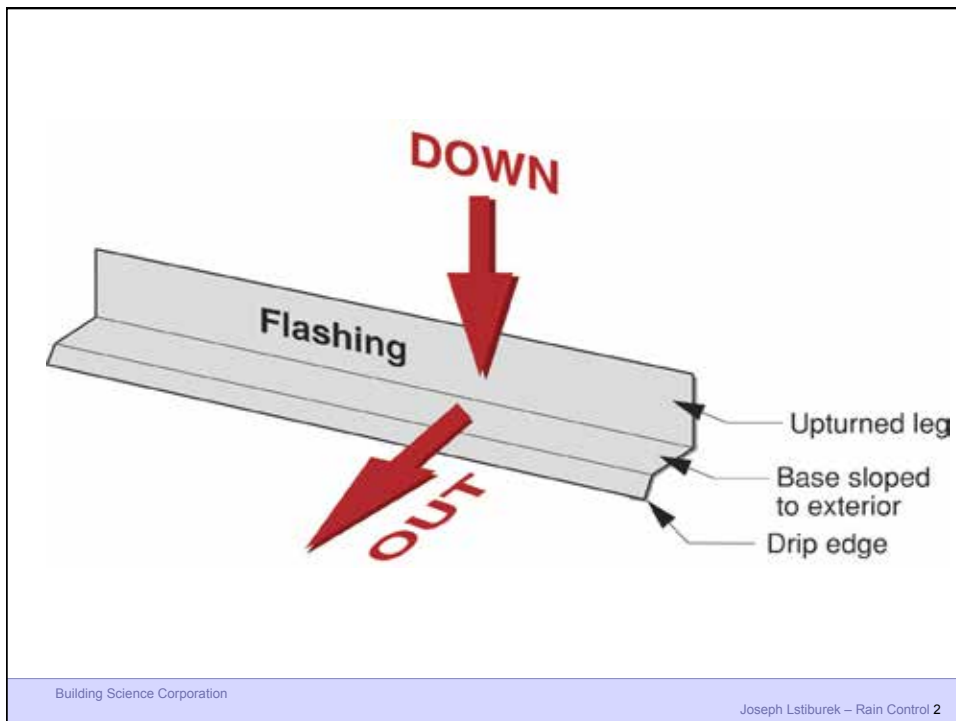


Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

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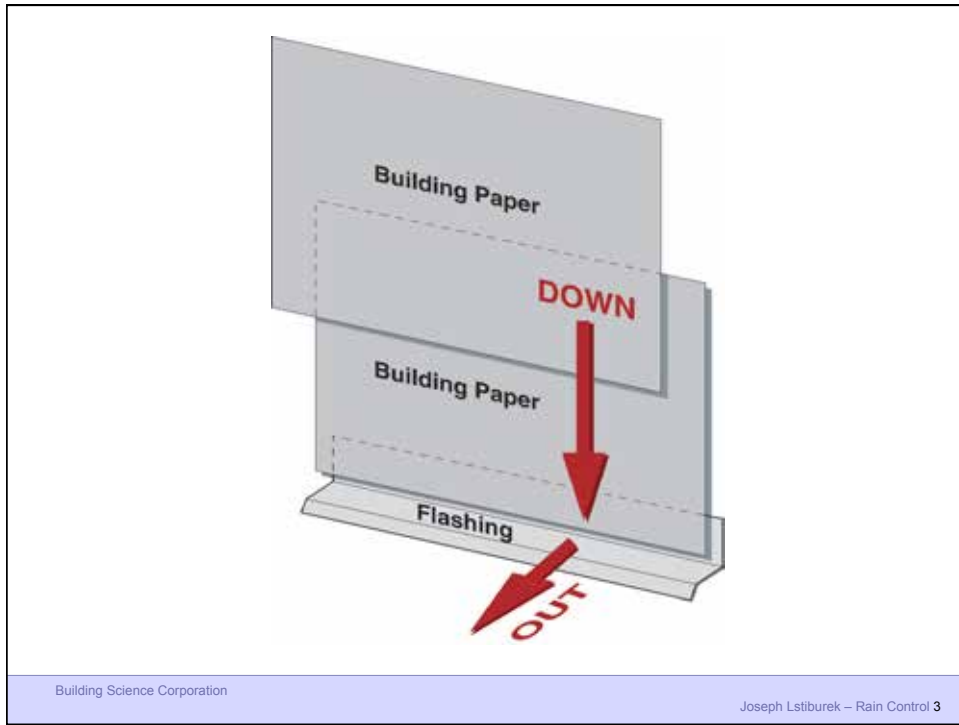
Adventures In Building Science

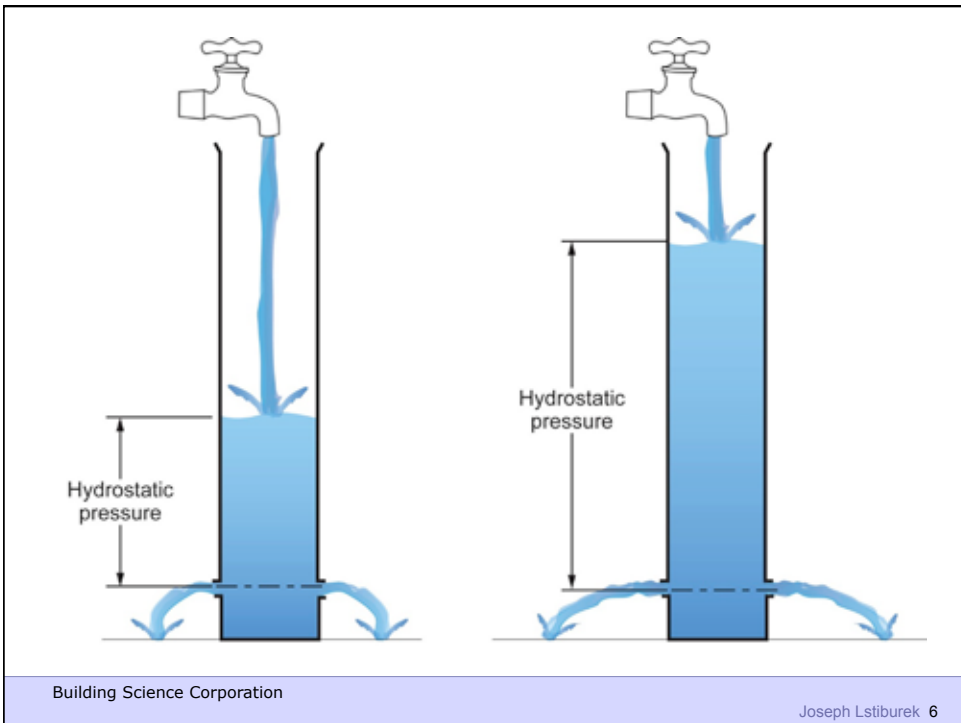
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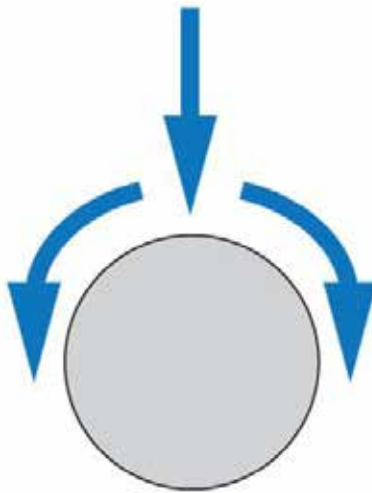






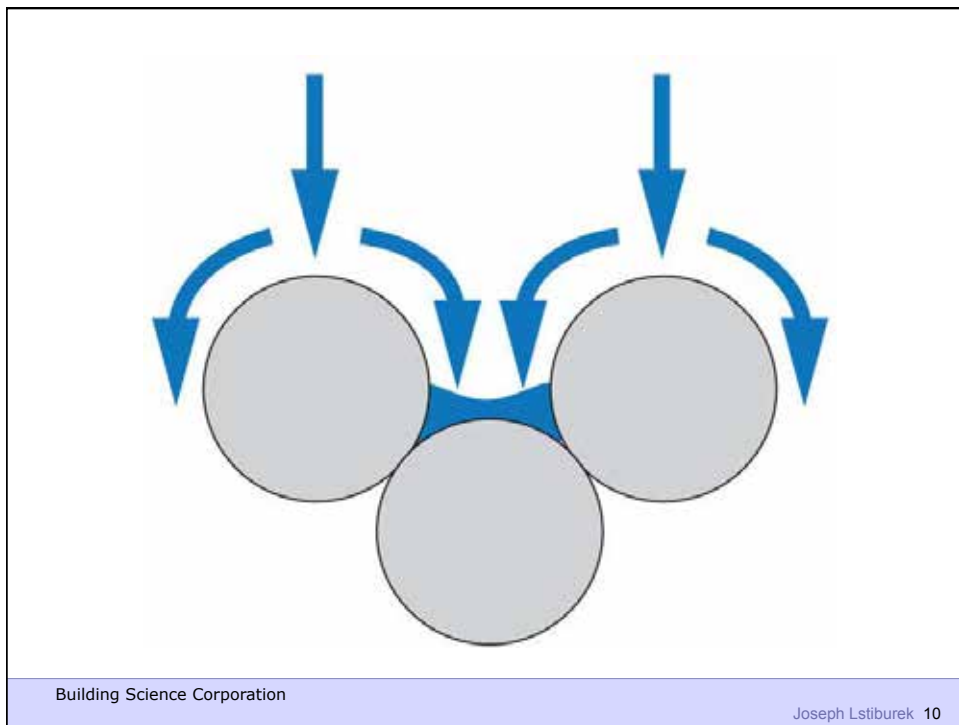
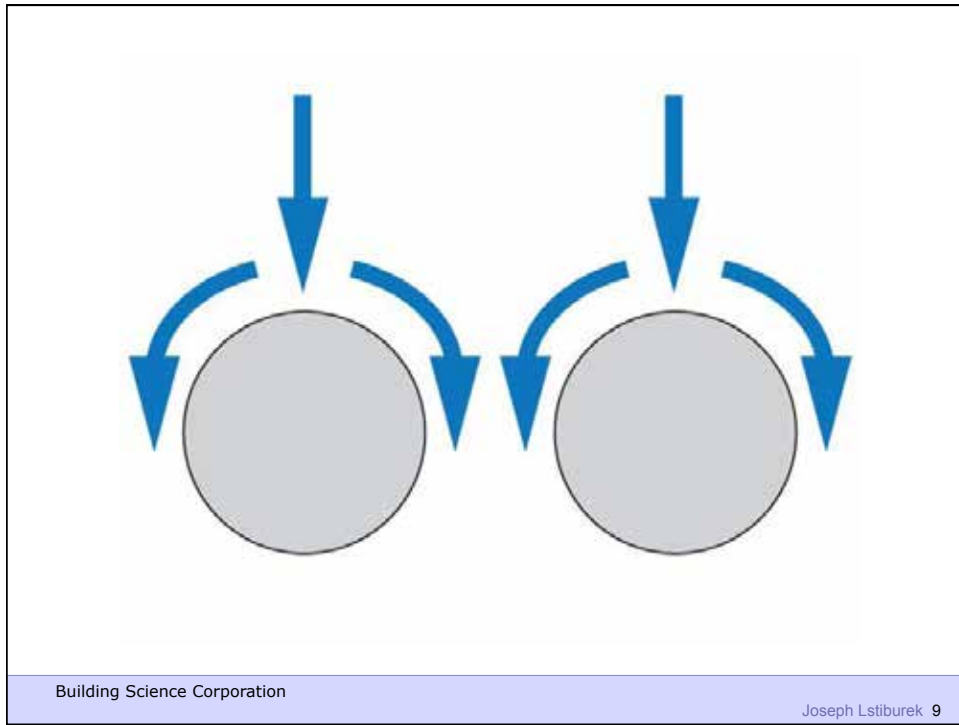
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Joseph Lstiburek 7



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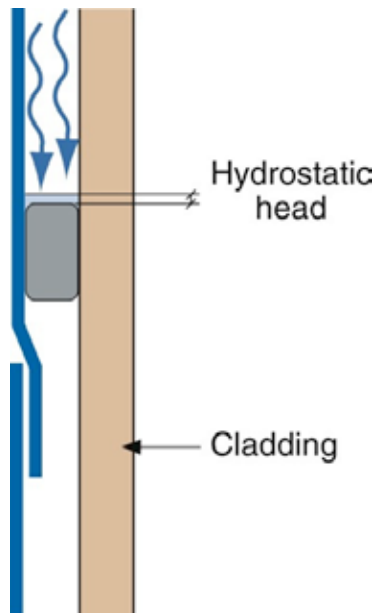
Joseph Lstiburek 8





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Joseph Lstiburek 11

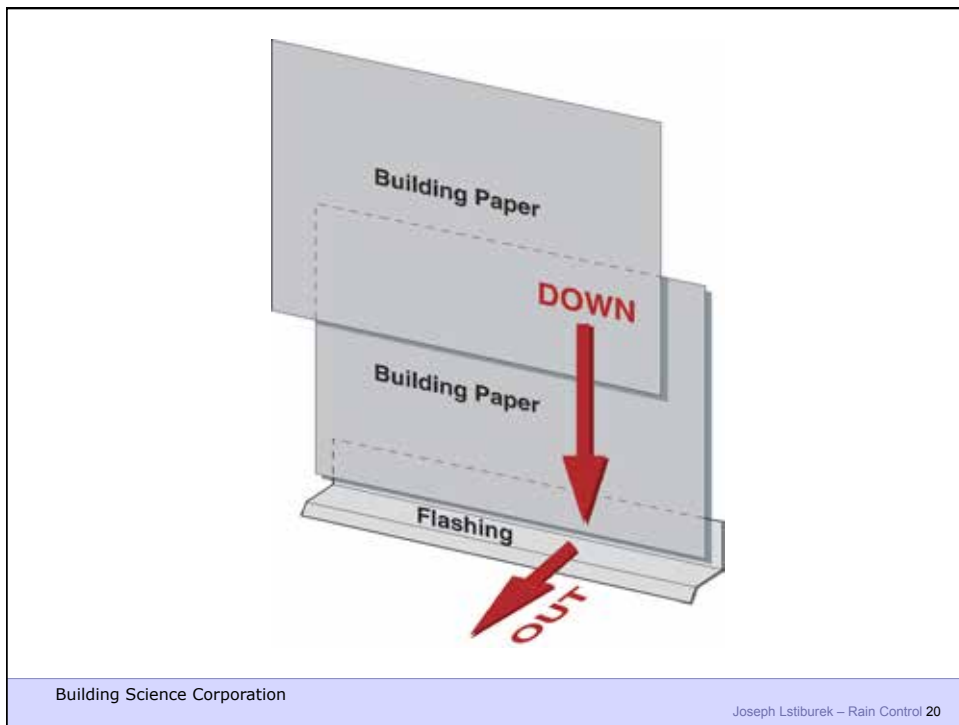
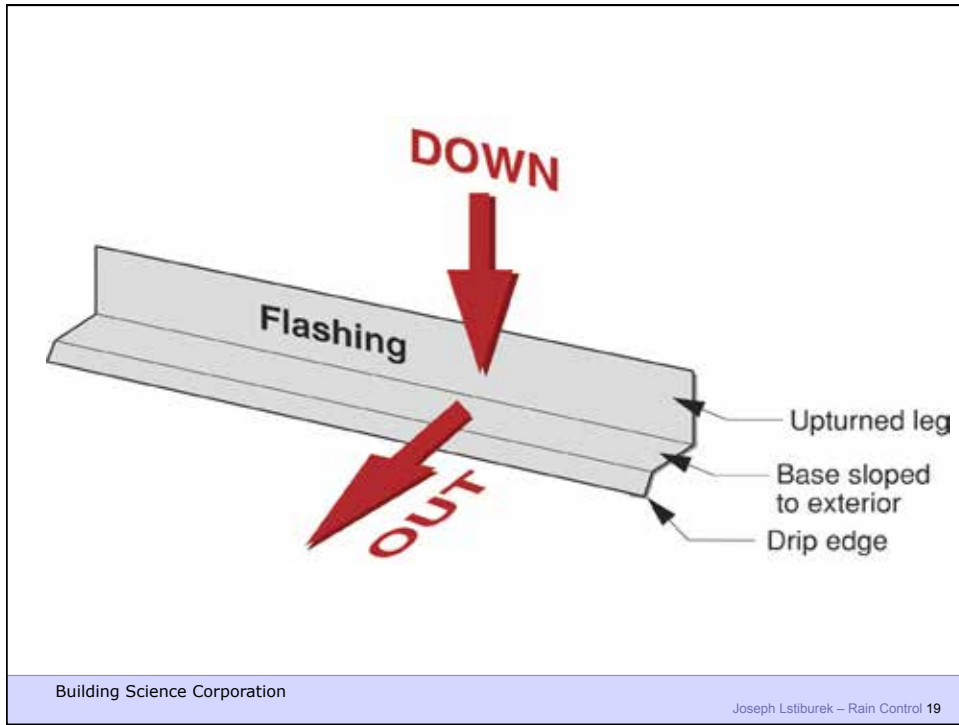


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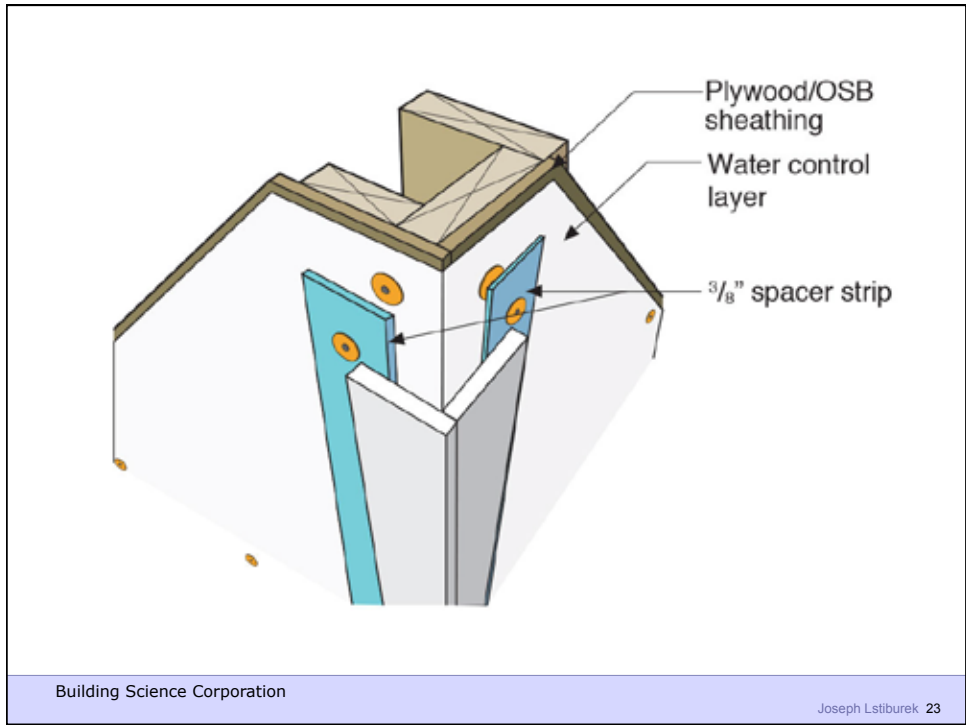
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Joseph Lstiburek 25



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Joseph Lstiburek 26

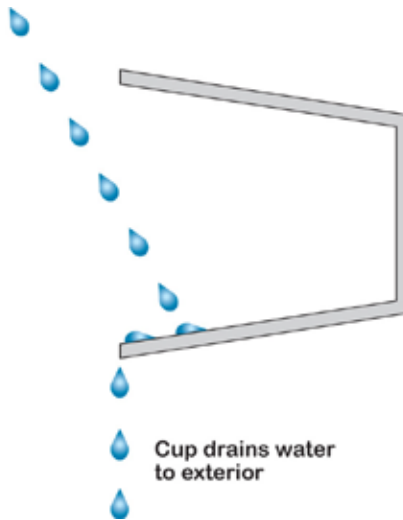




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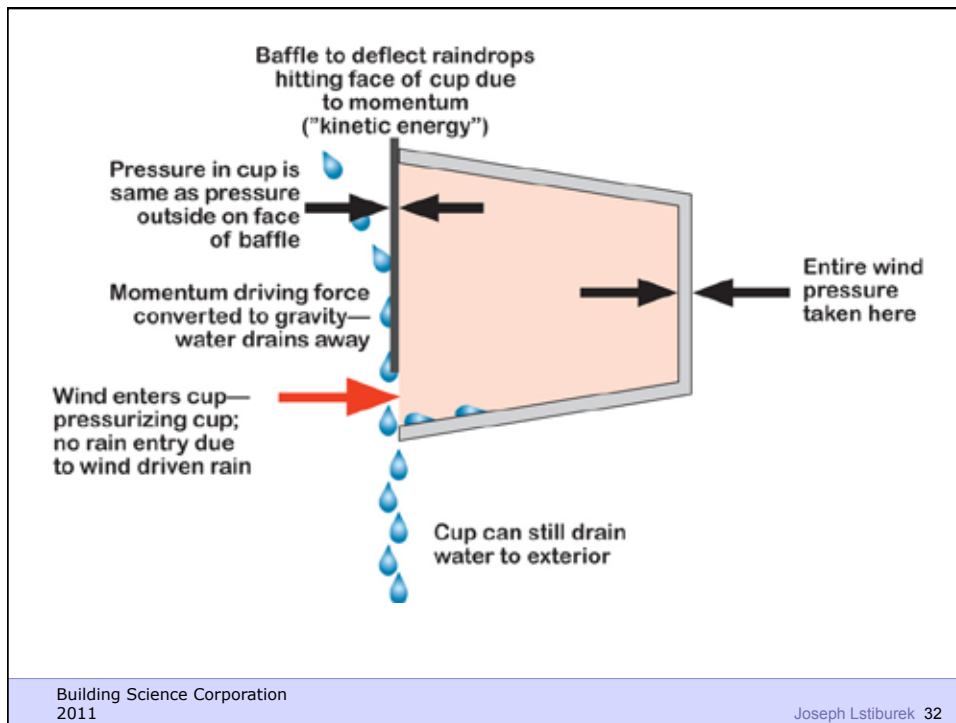
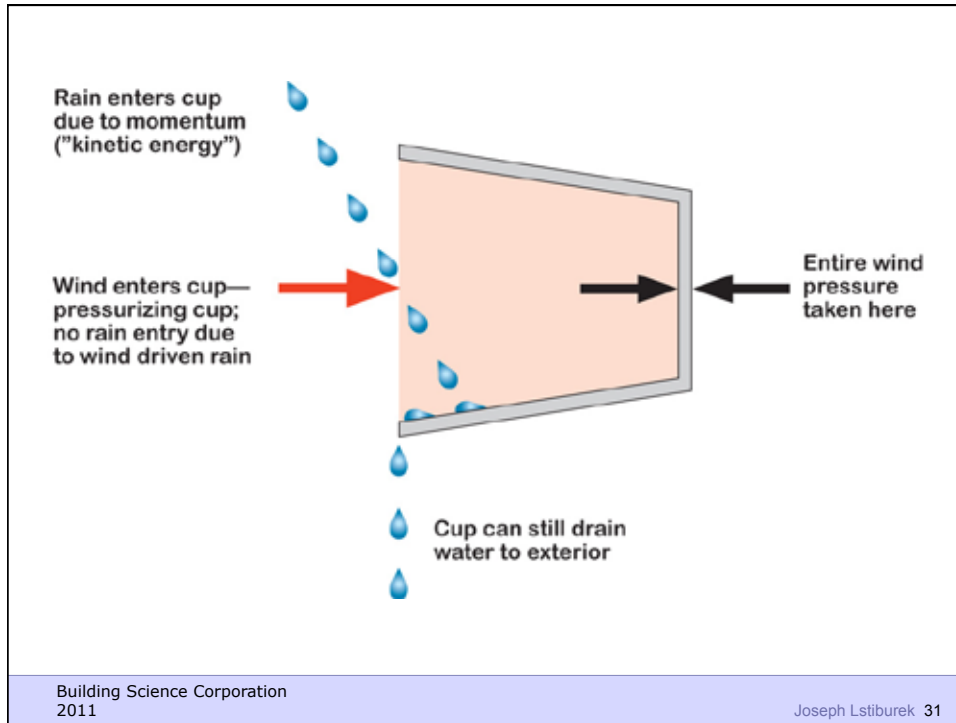
Rain enters cup
due to momentum
("kinetic energy")

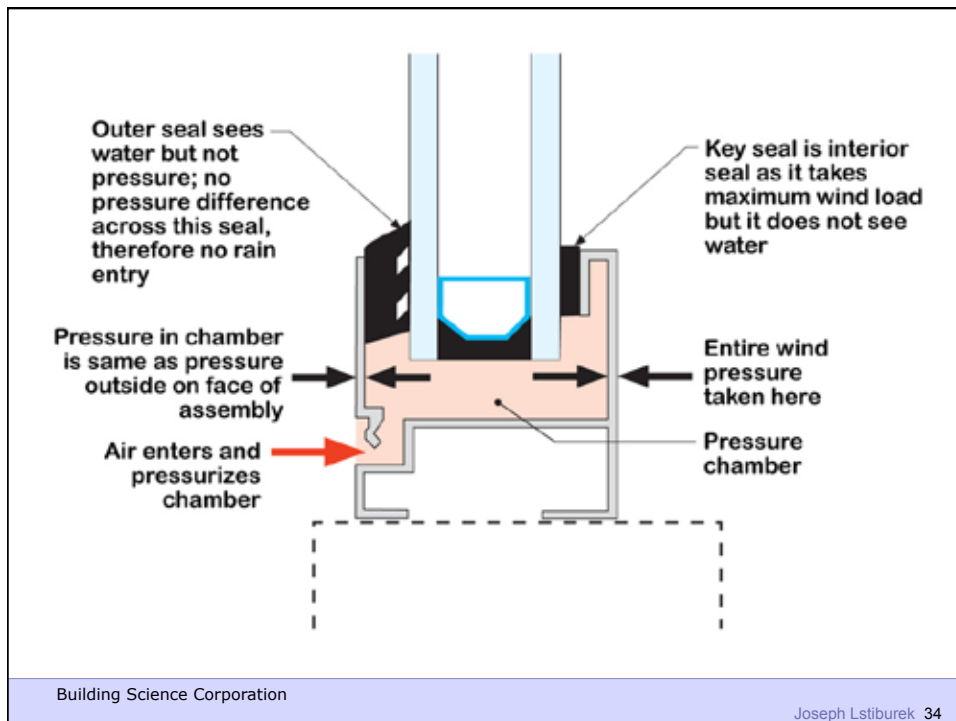
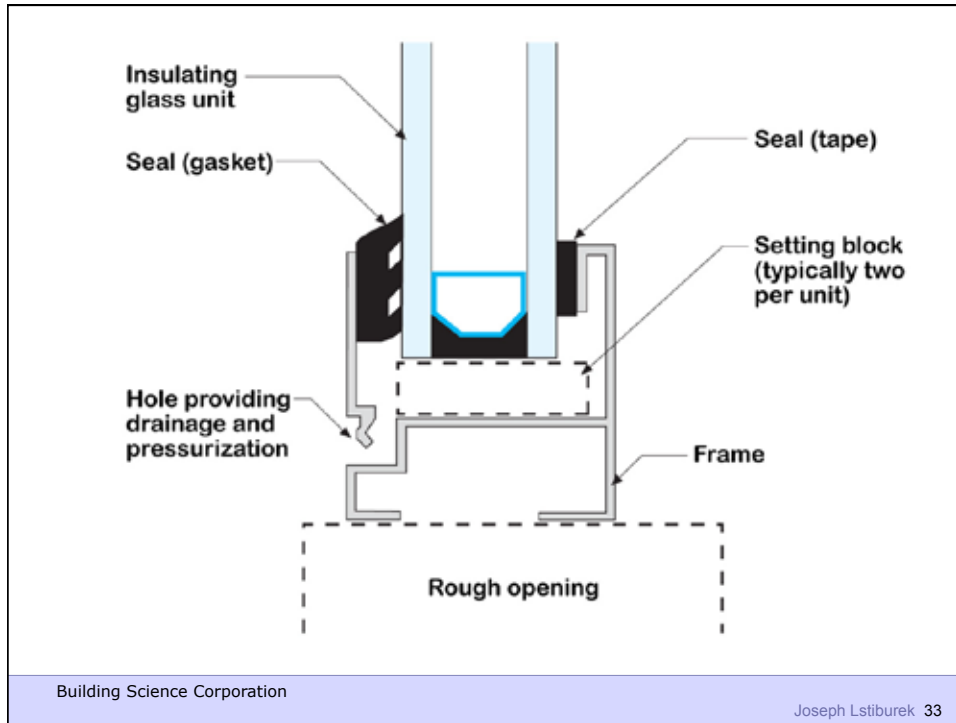


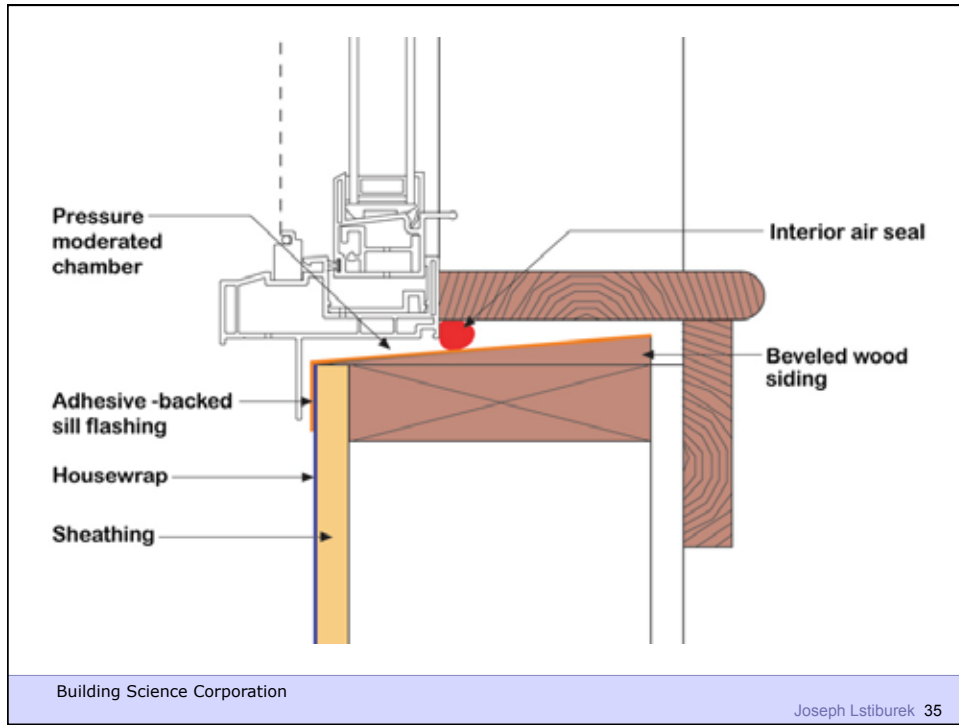
Cup drains water
to exterior

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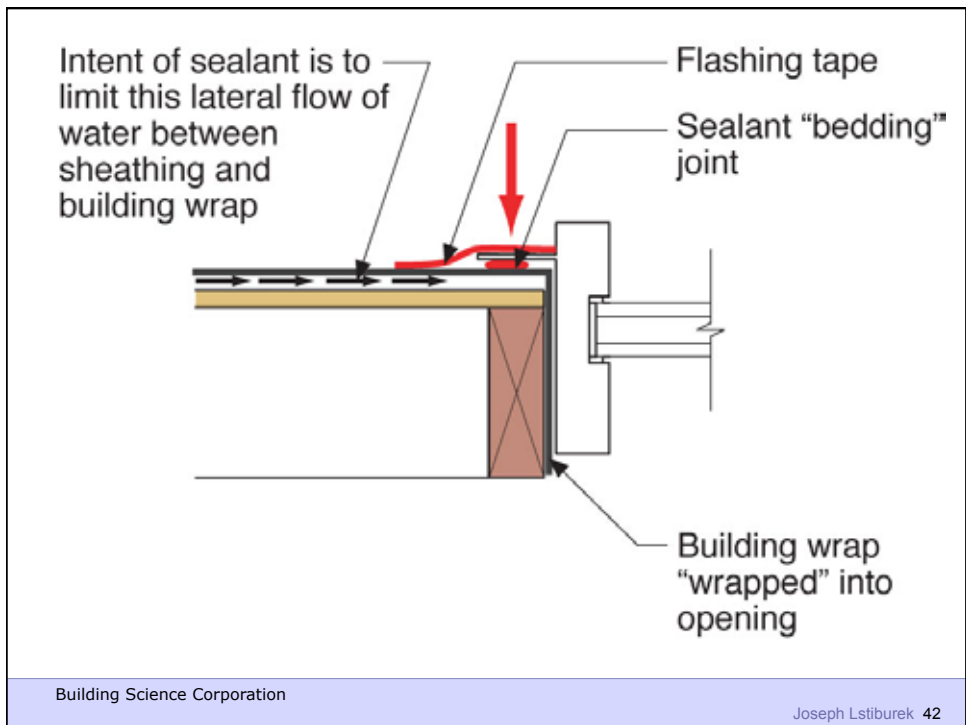


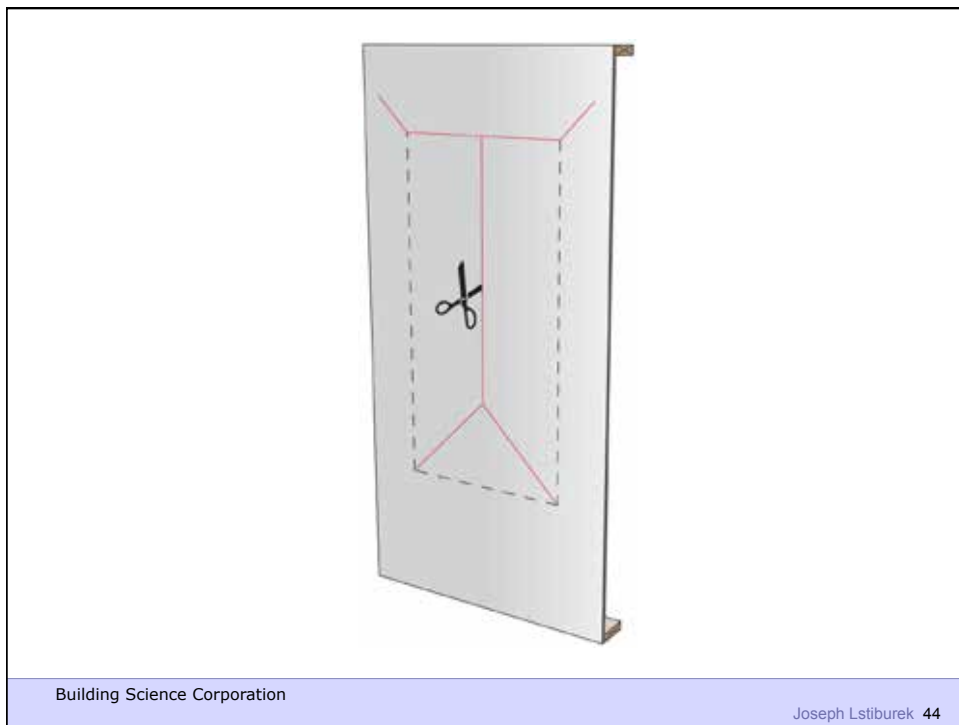
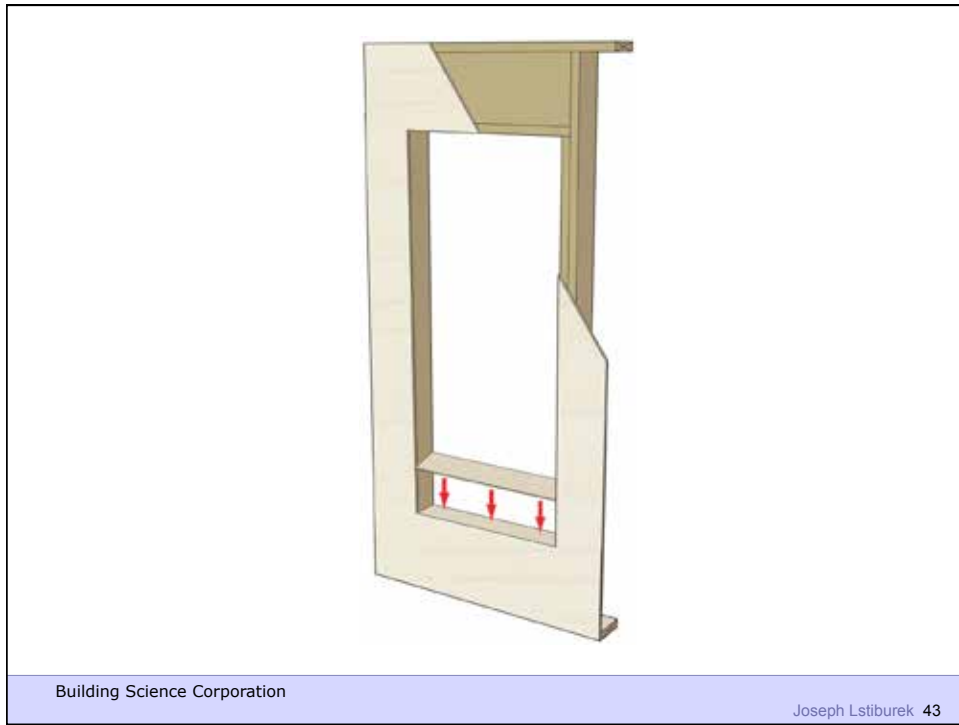


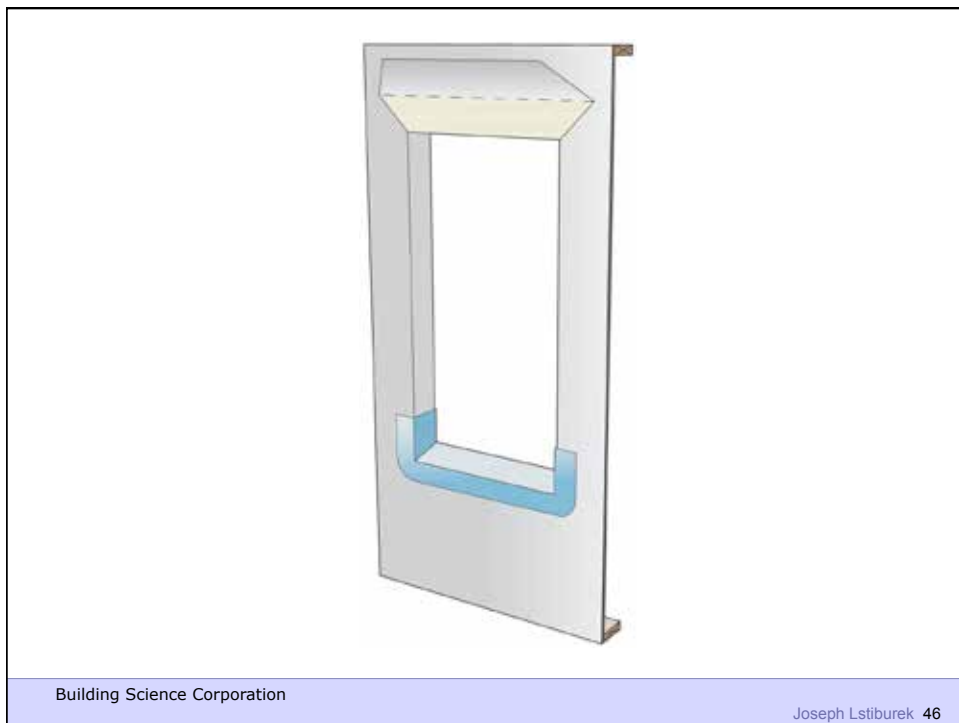
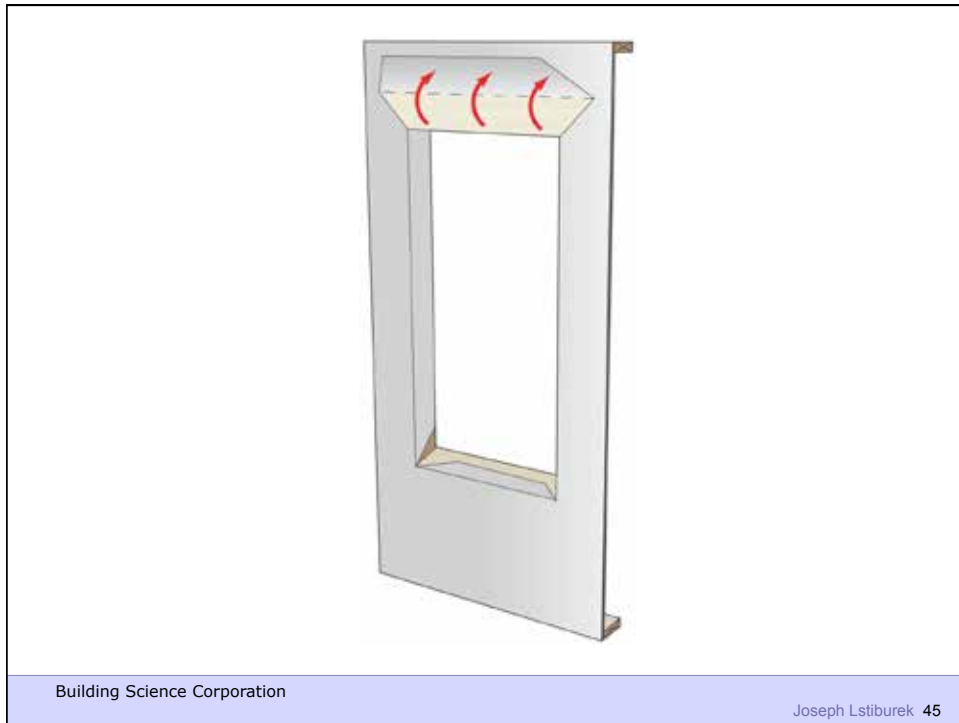
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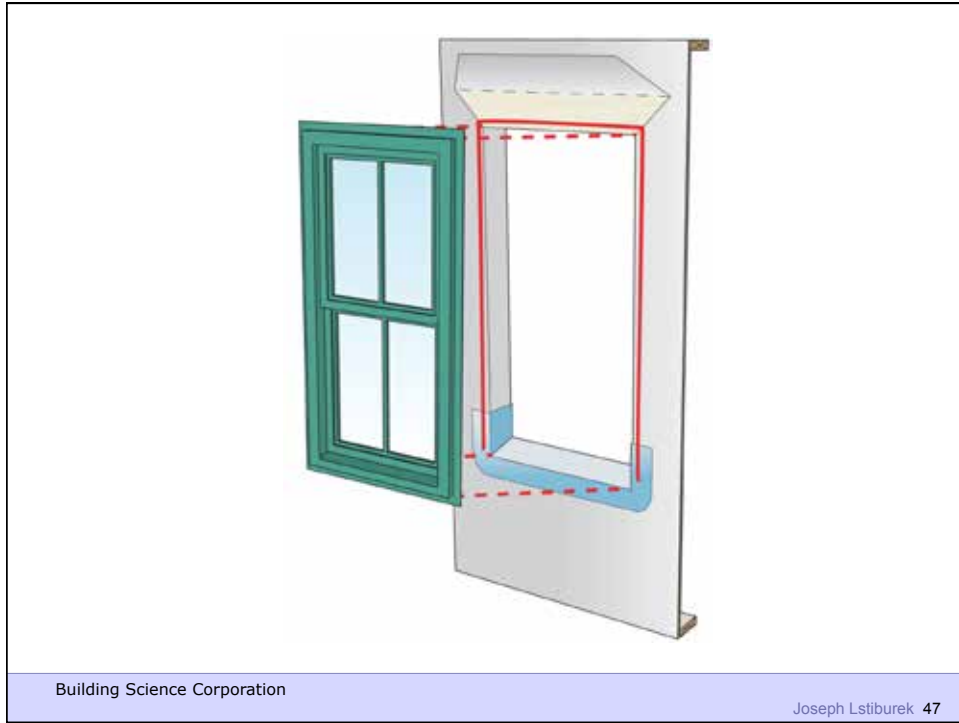


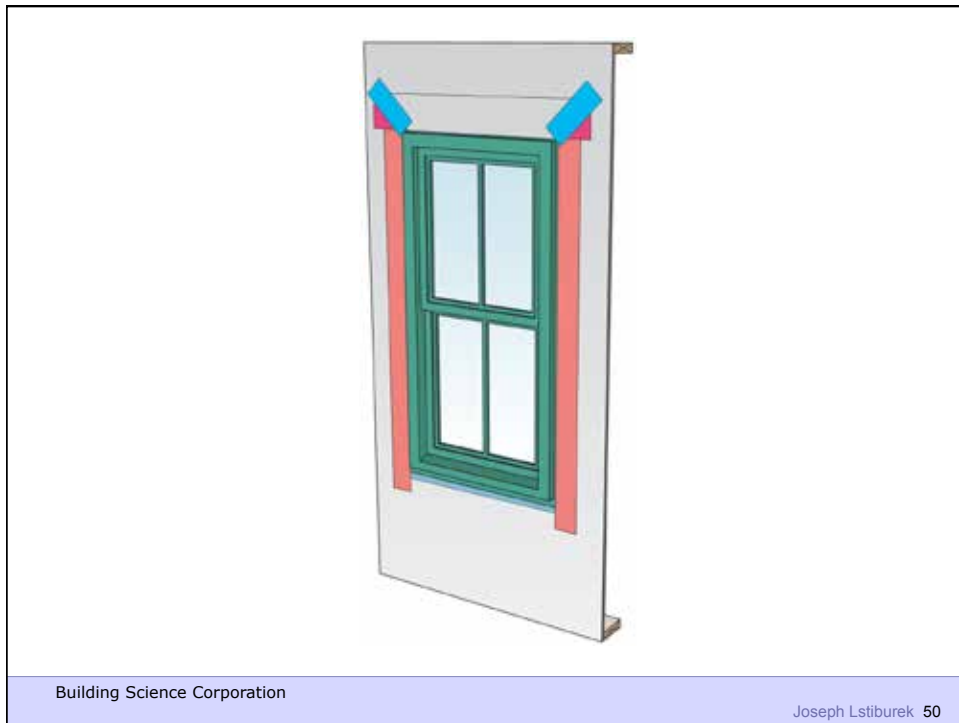
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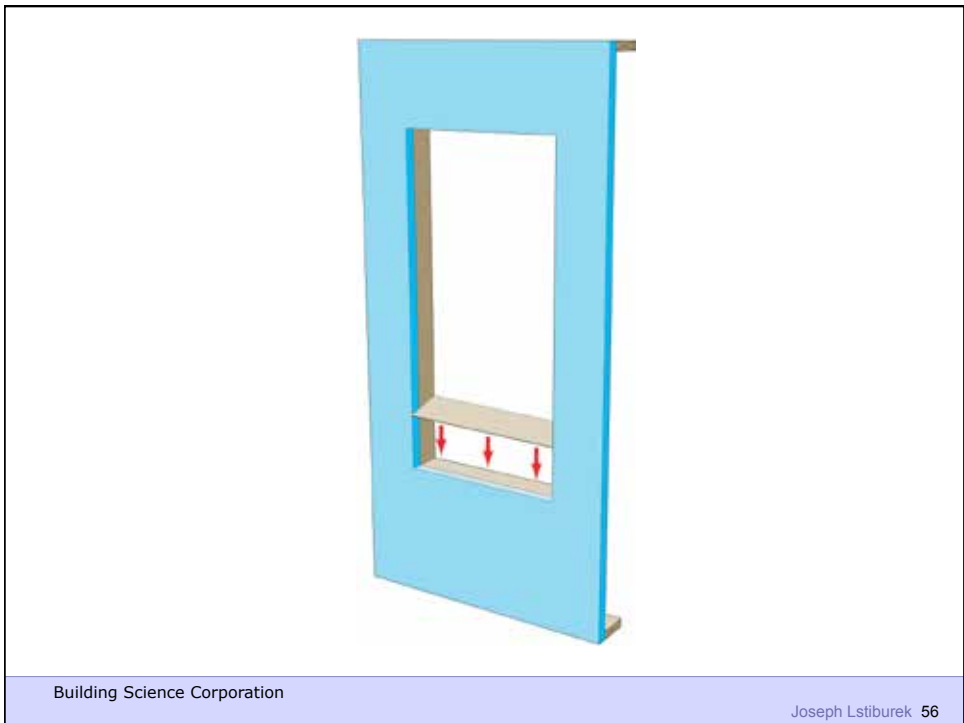
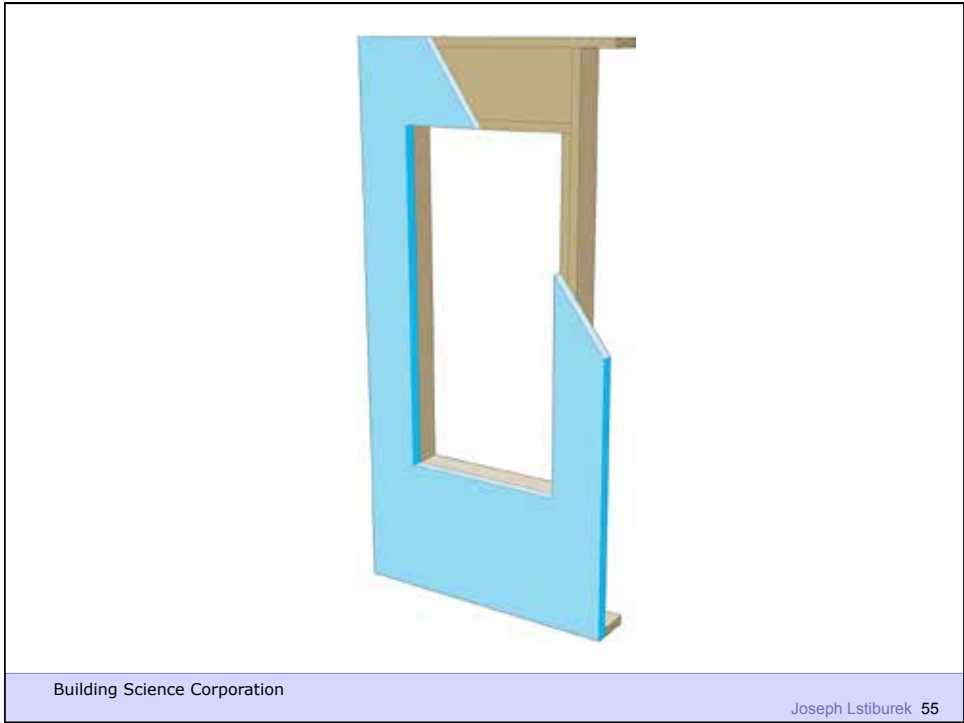


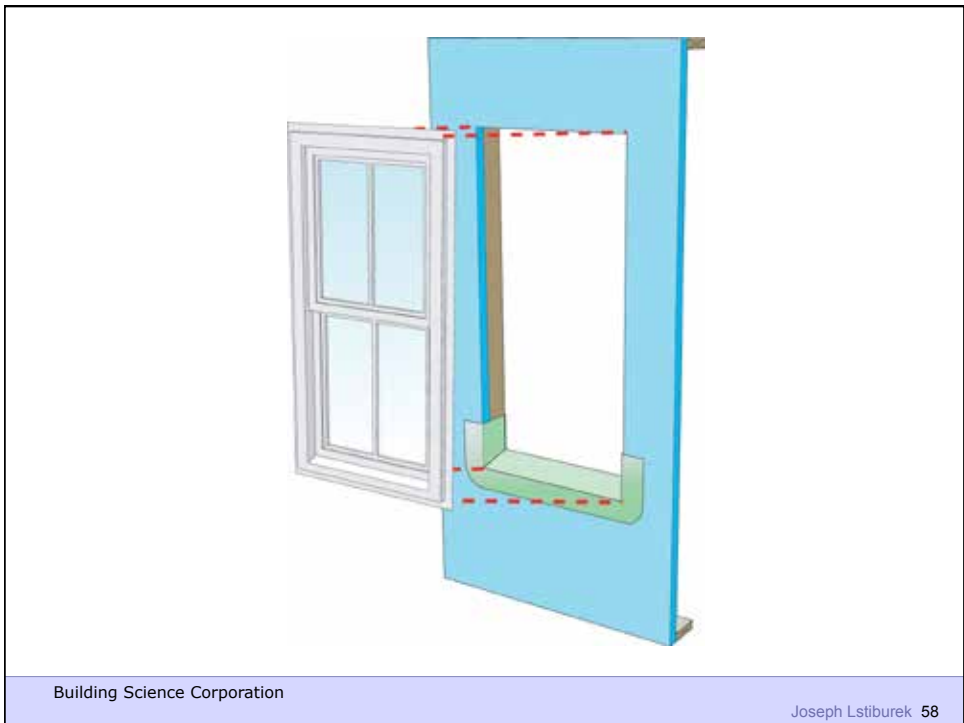
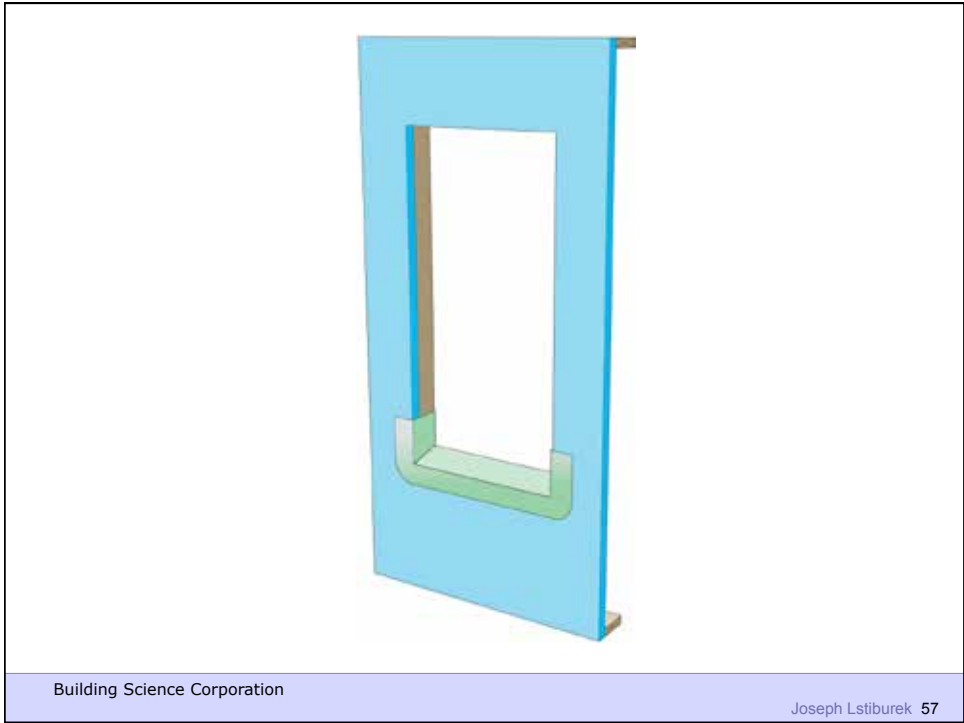




















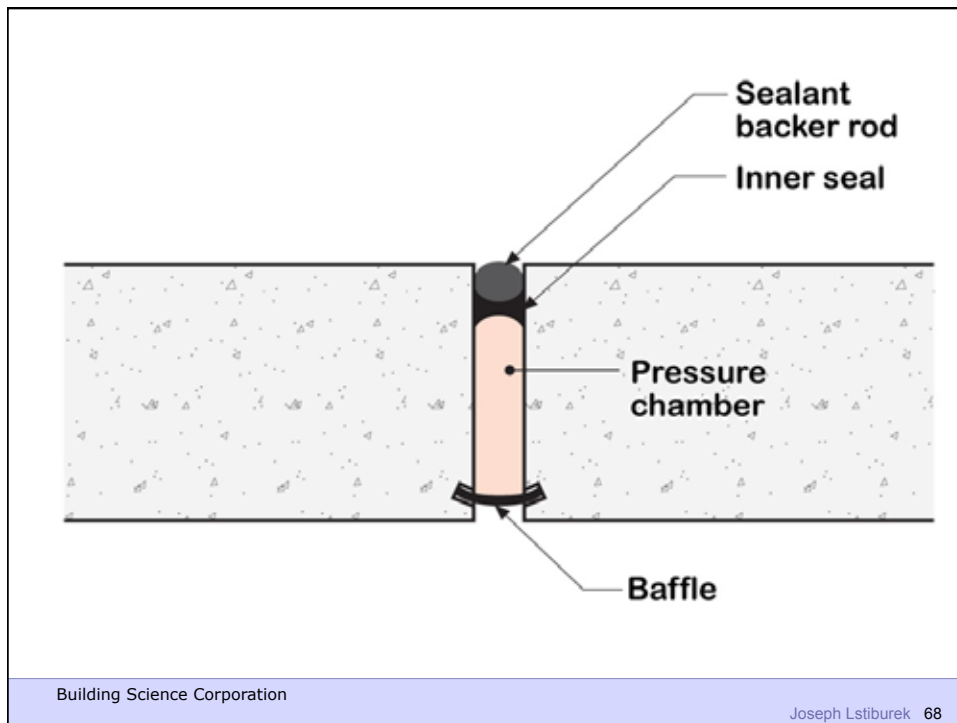
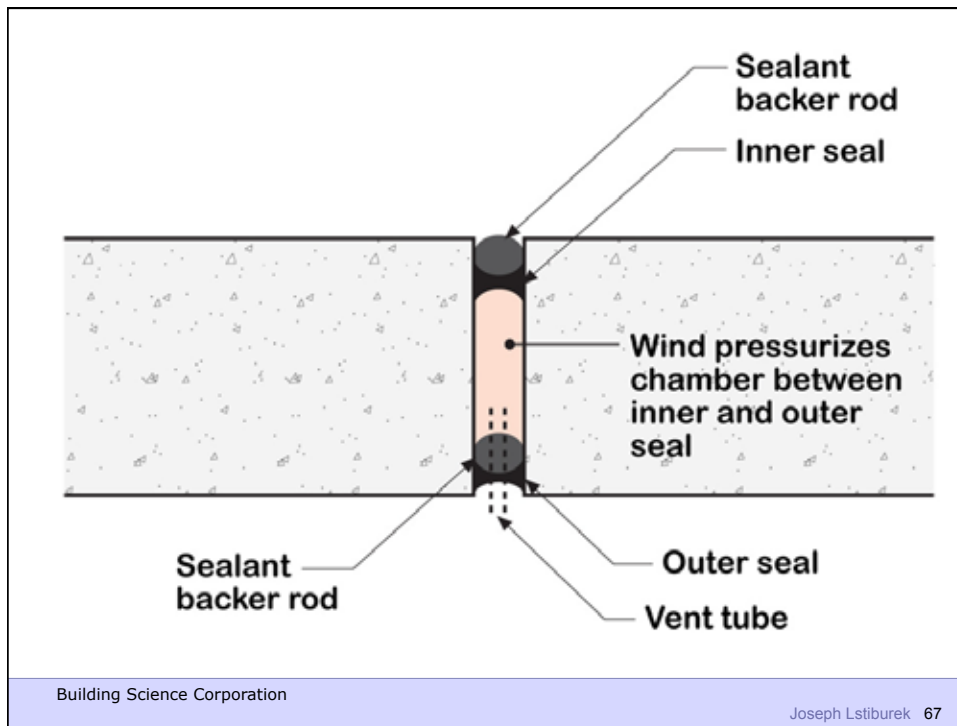
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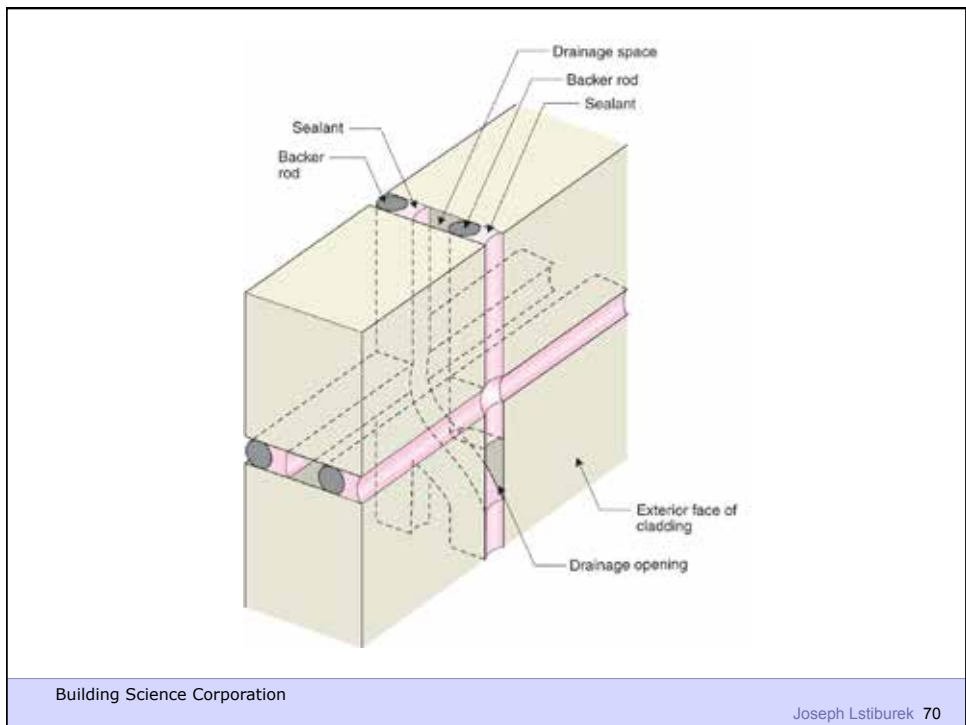
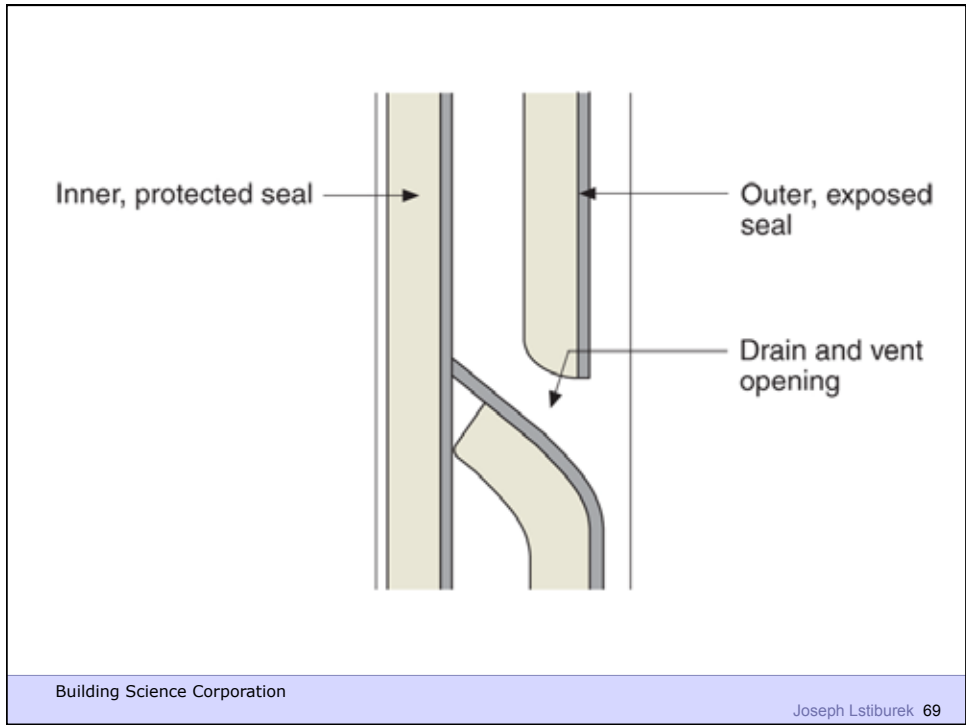
Joseph Lstiburek 65



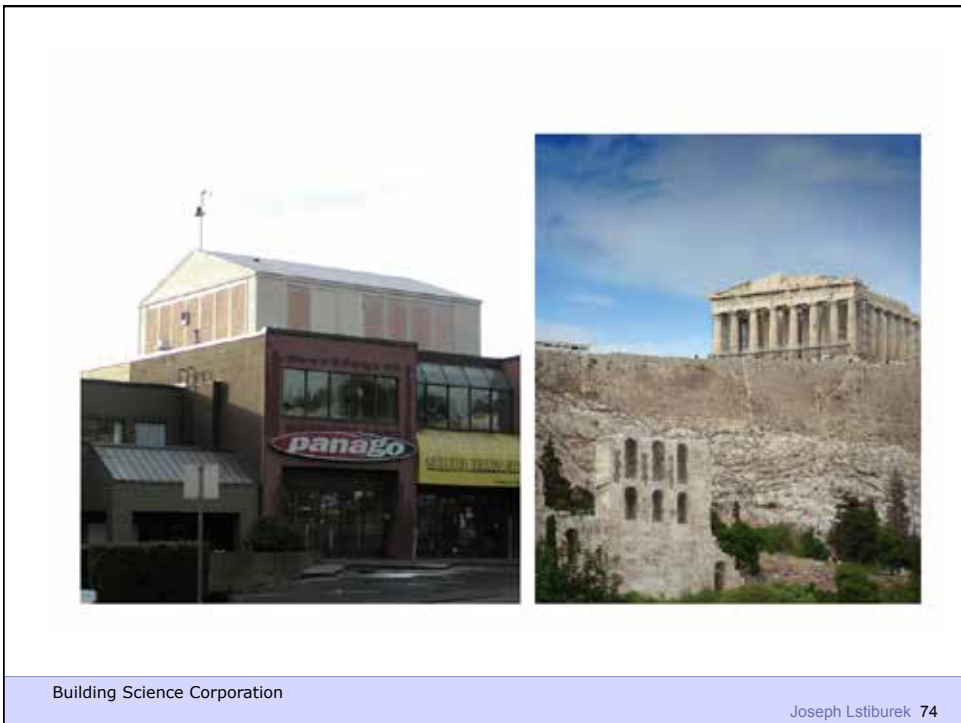
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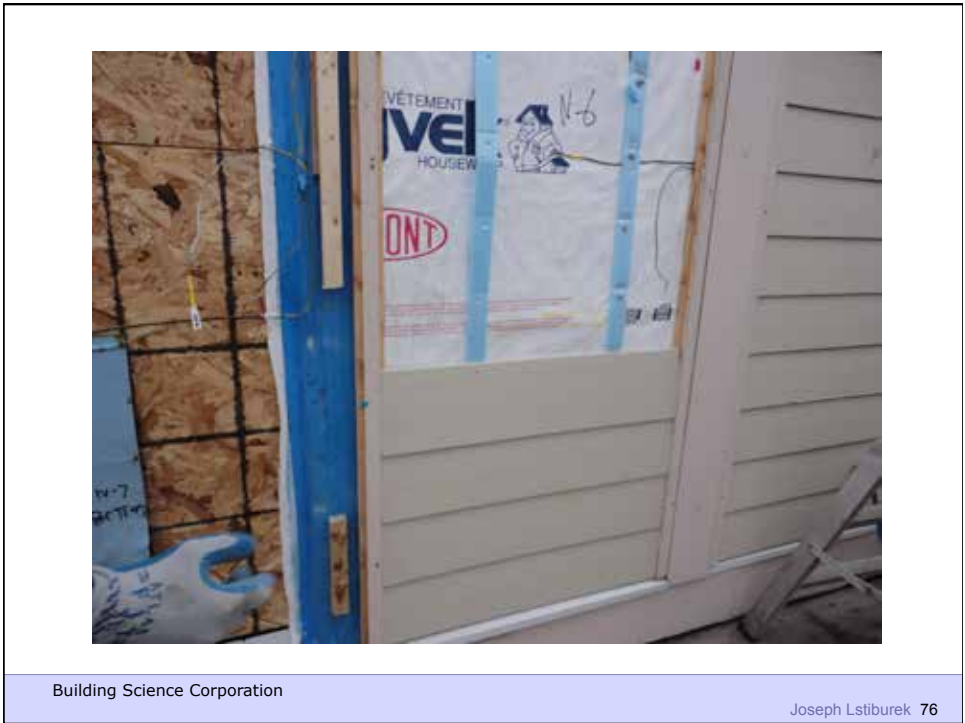
Joseph Lstiburek 66













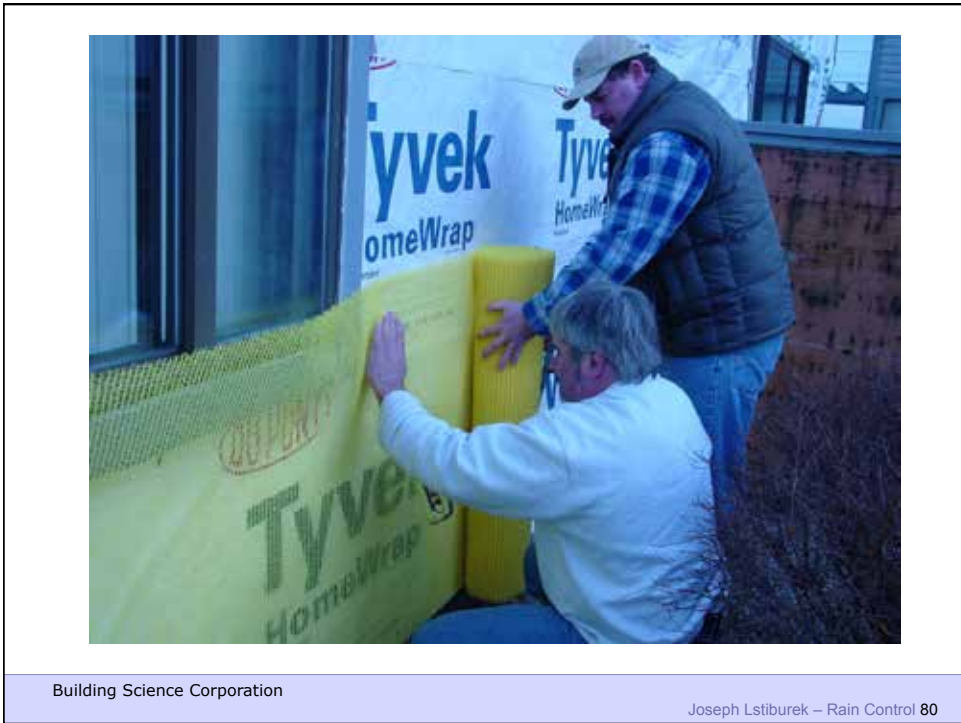
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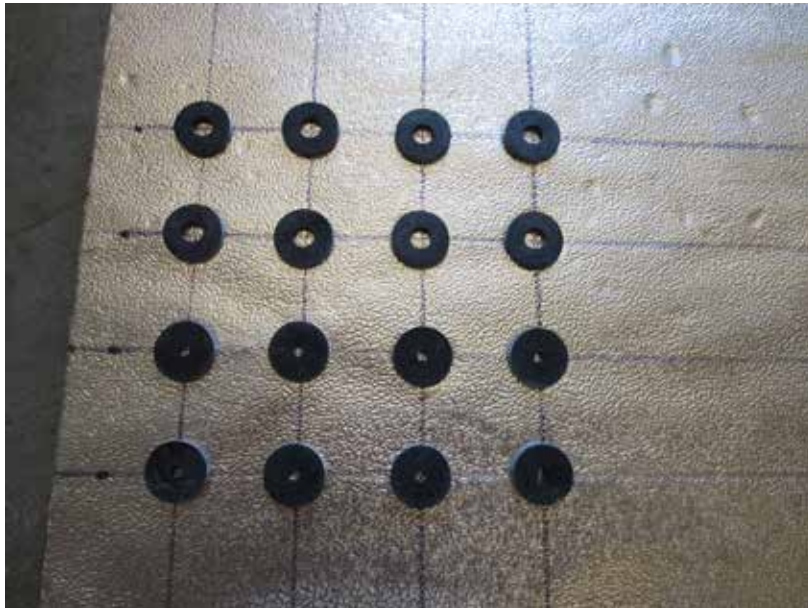
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Rain Screen

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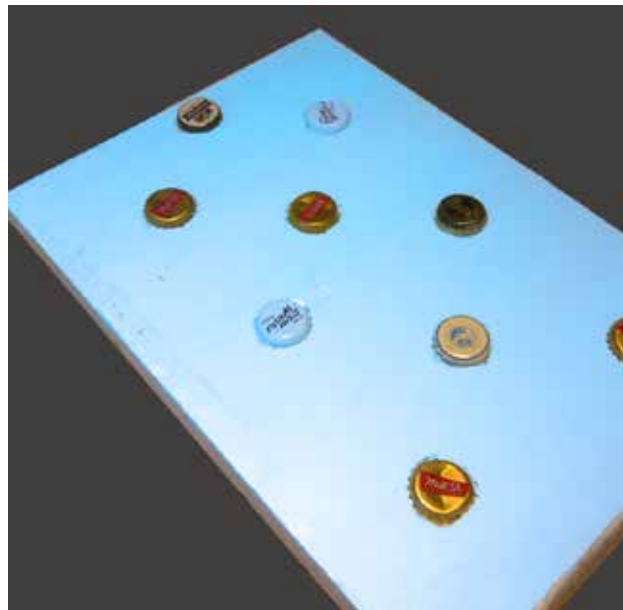
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Beer Screen?

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Joseph Lstiburek – Rain Control 85



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Joseph Lstiburek – Rain Control 86



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Joseph Lstiburek – Rain Control 87



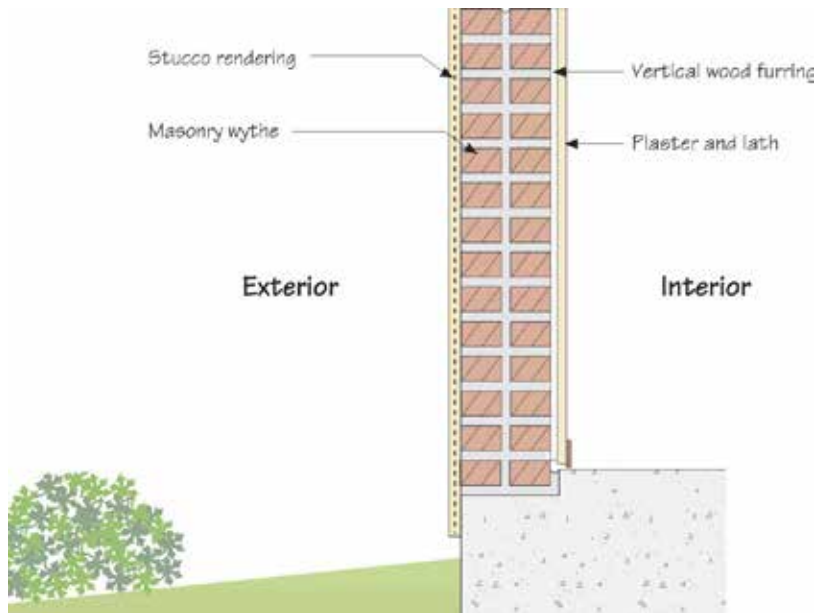
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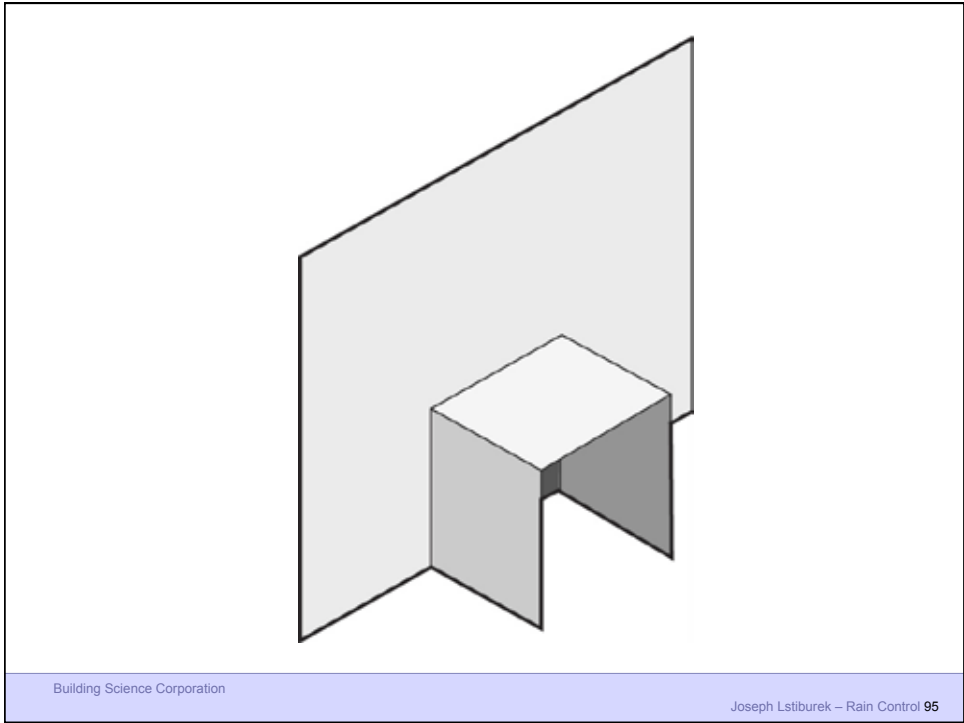


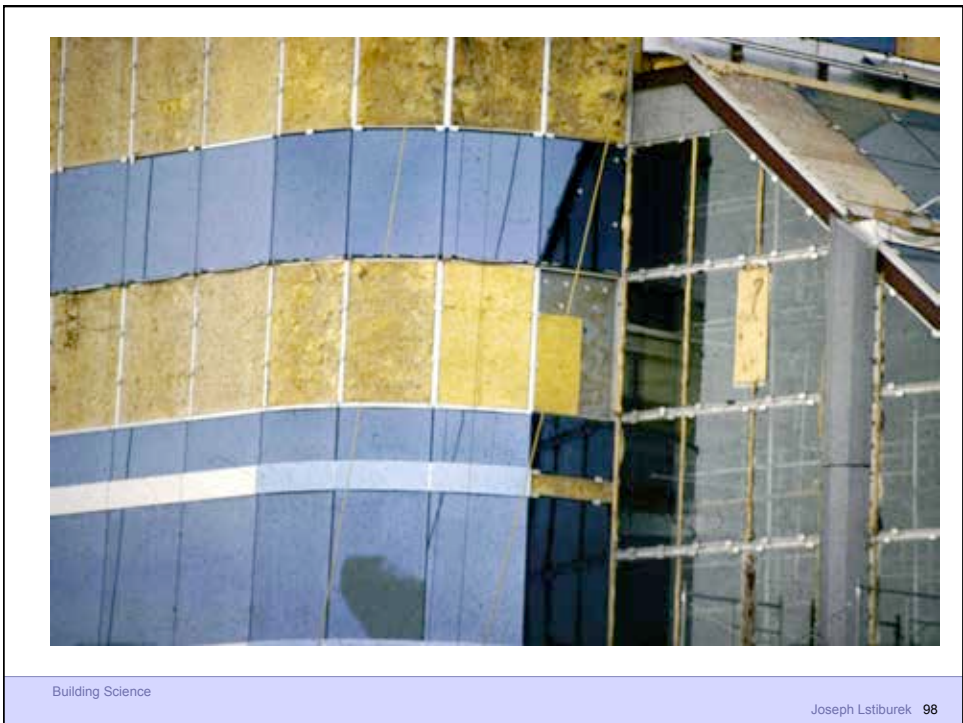
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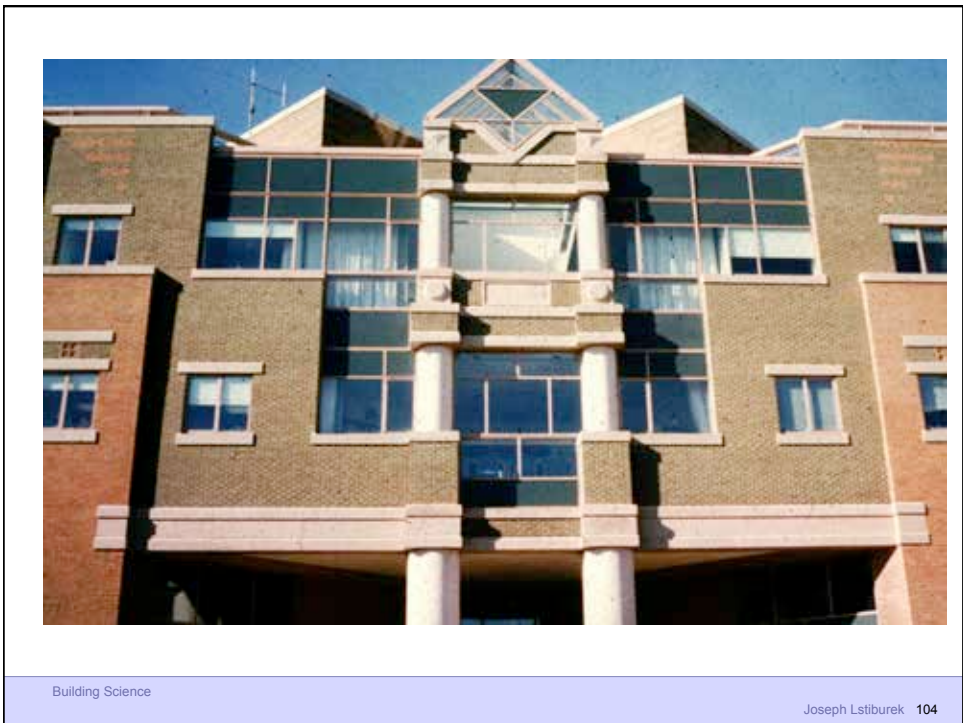
Joseph Lstiburek 99

Don't Do Stupid Things

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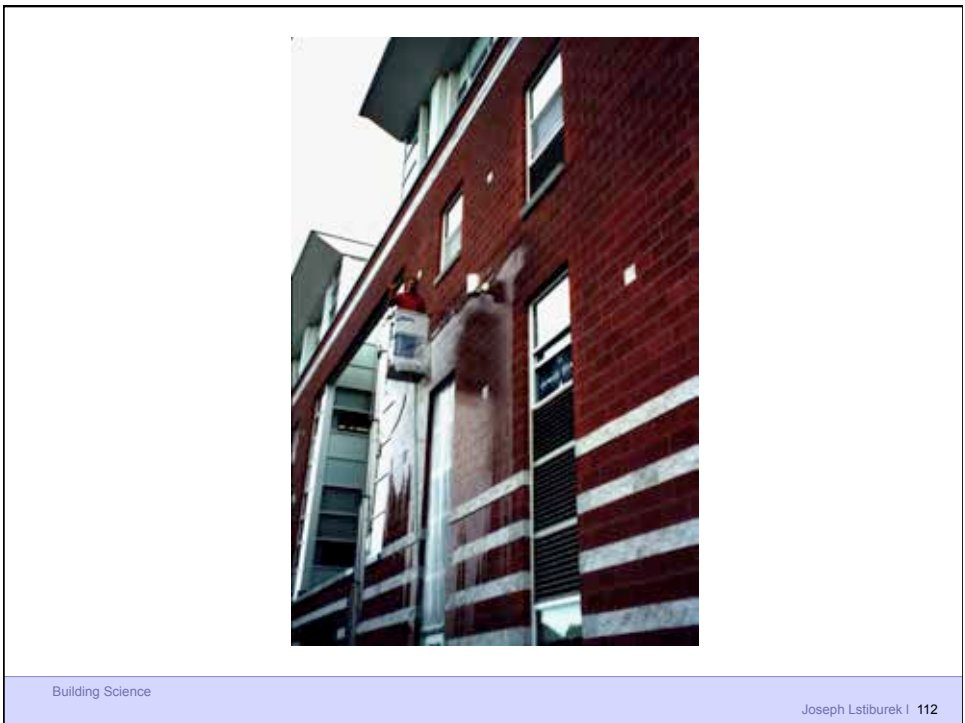
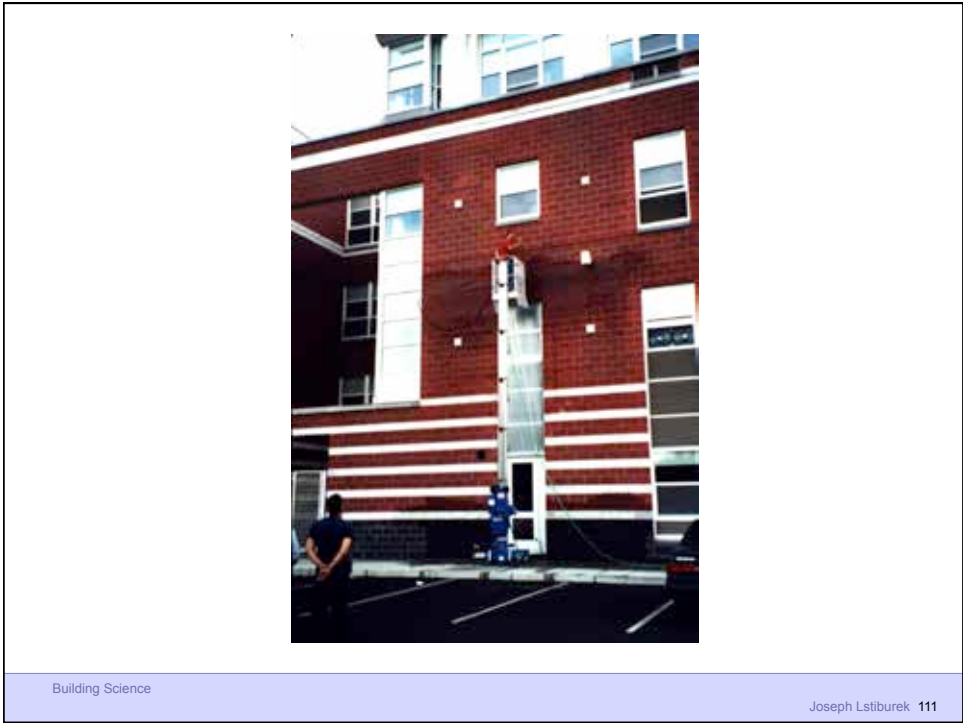
















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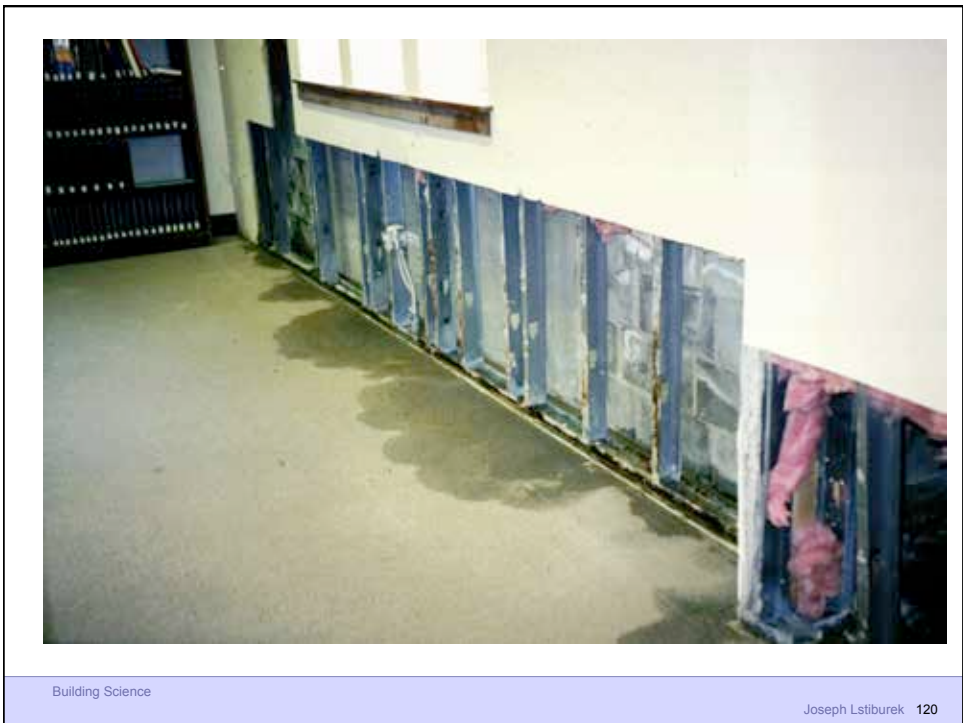
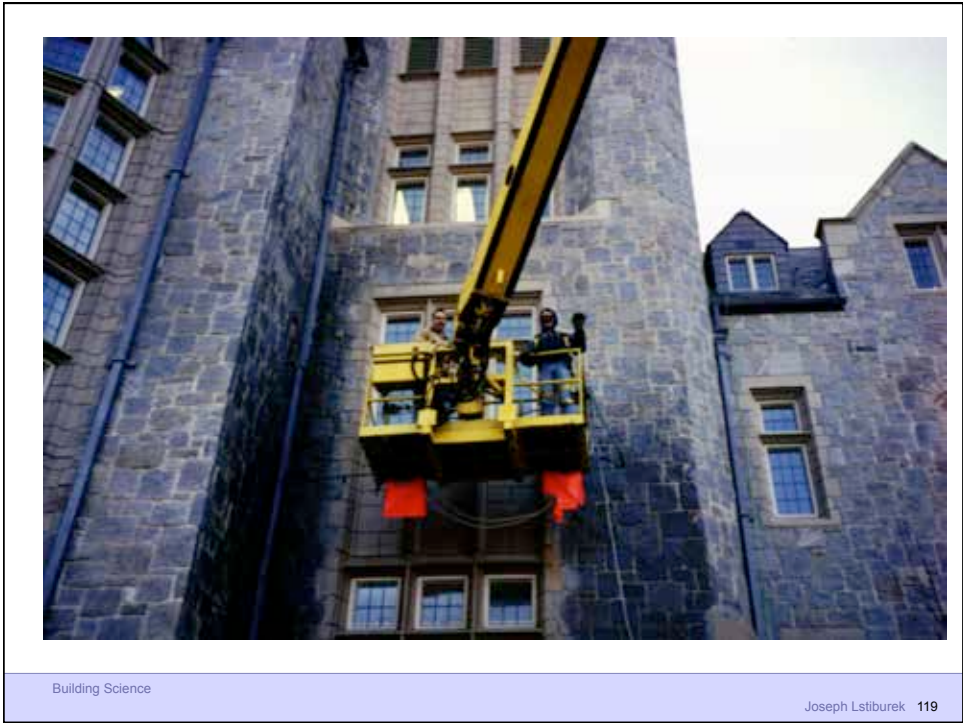
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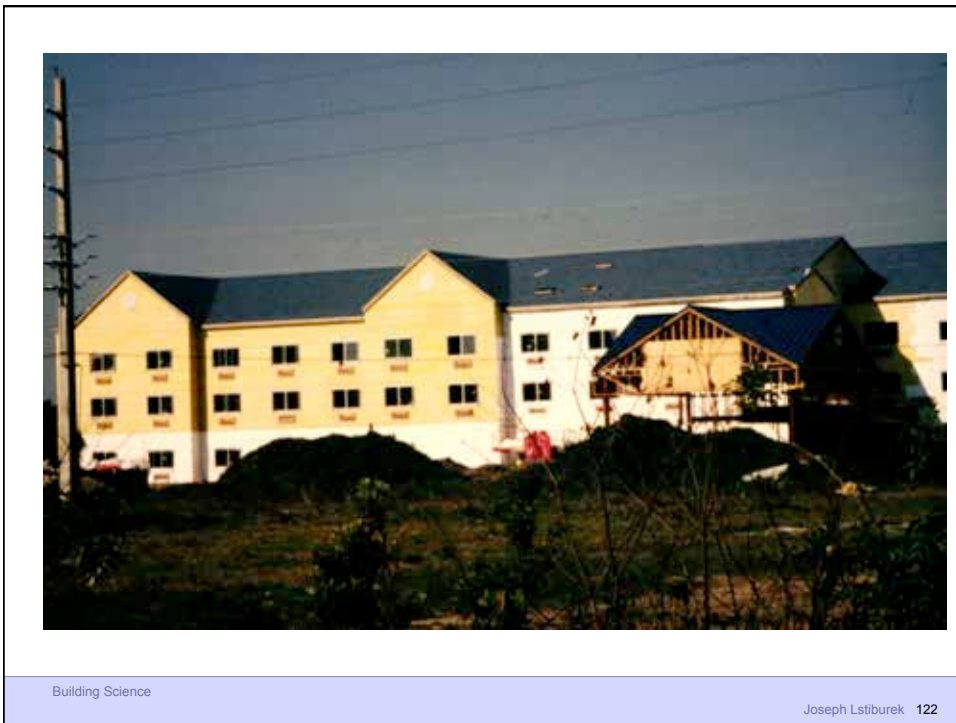
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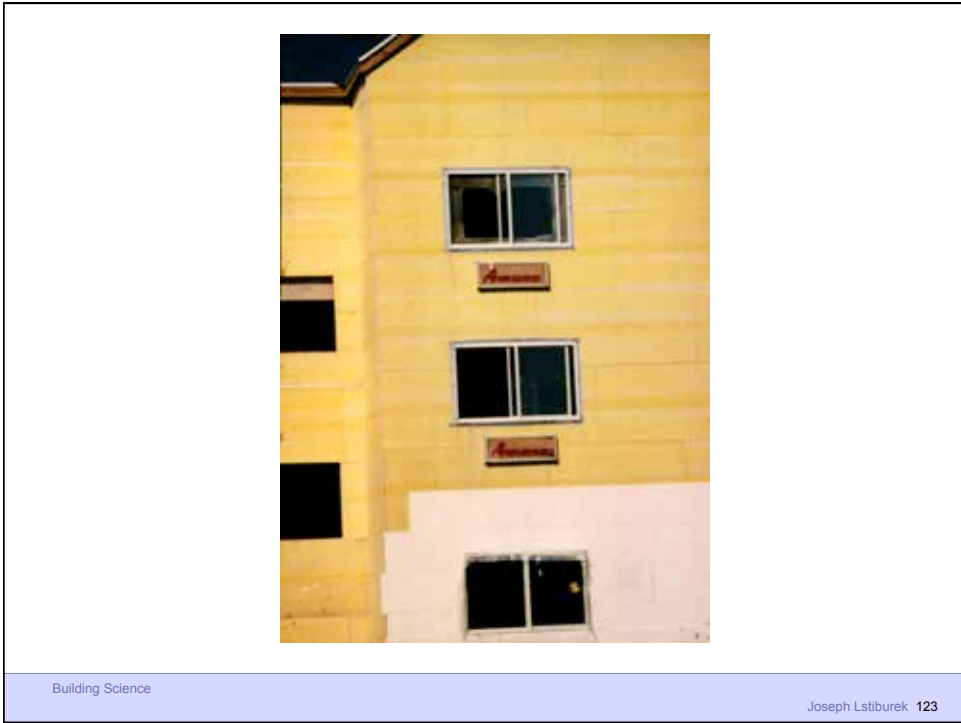


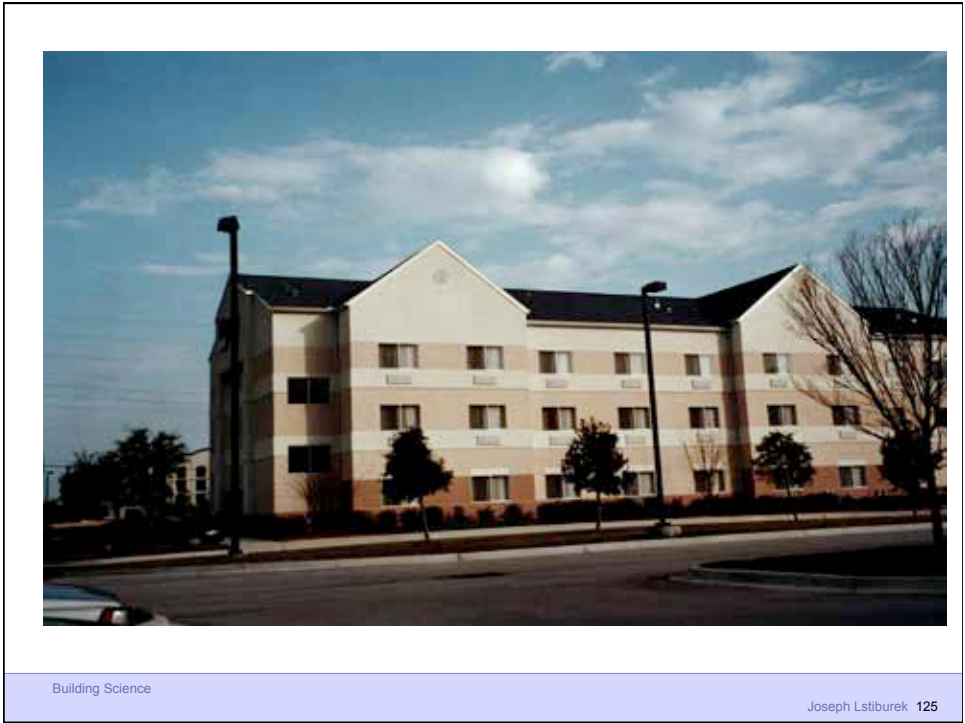
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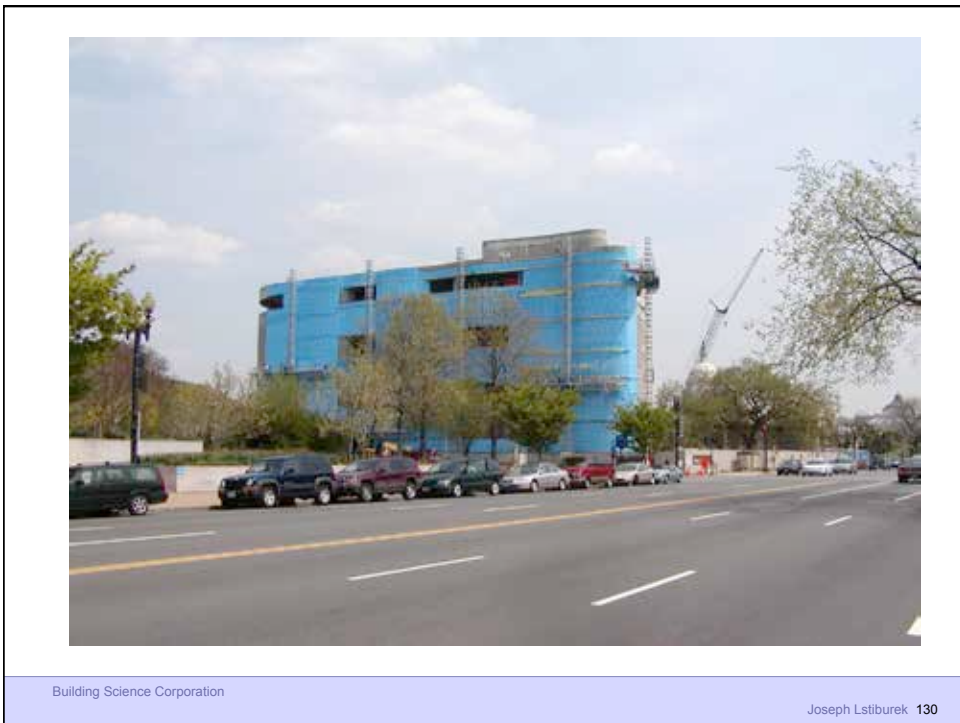


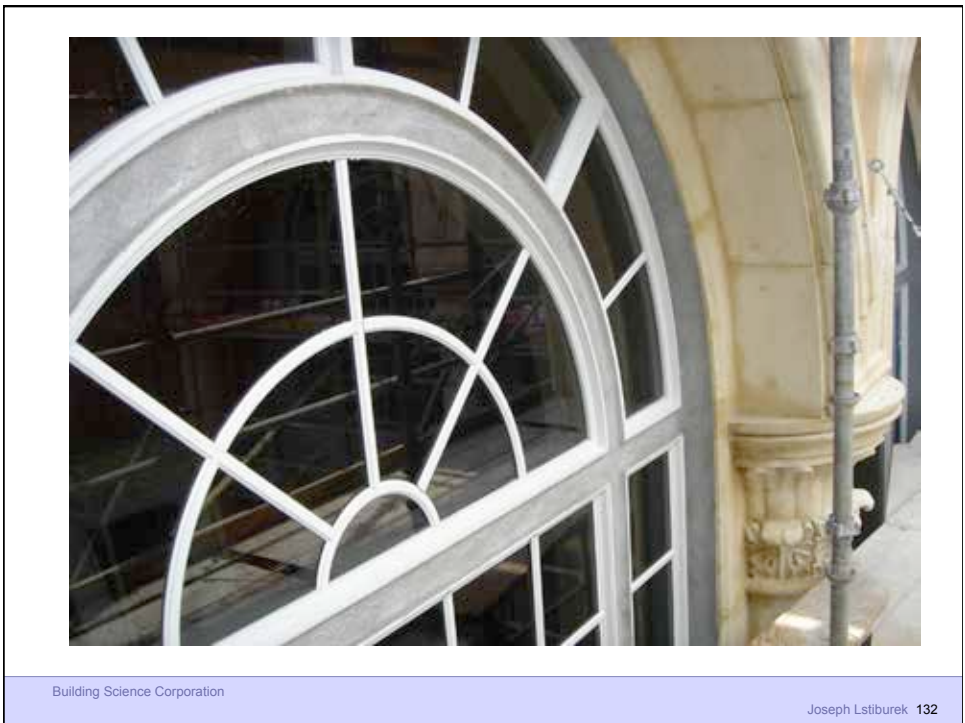














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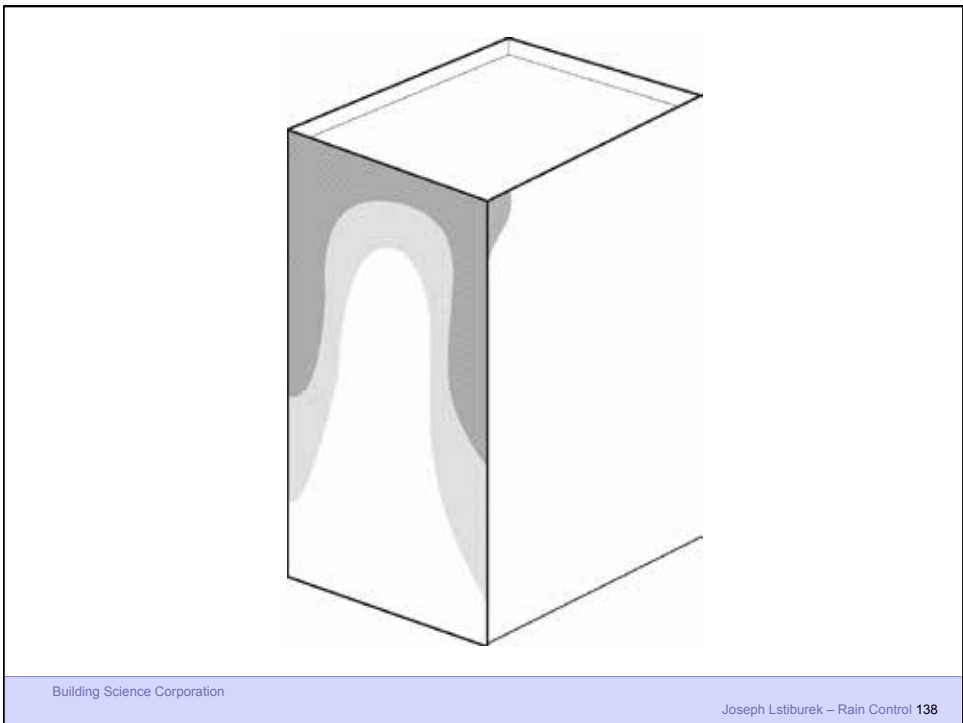
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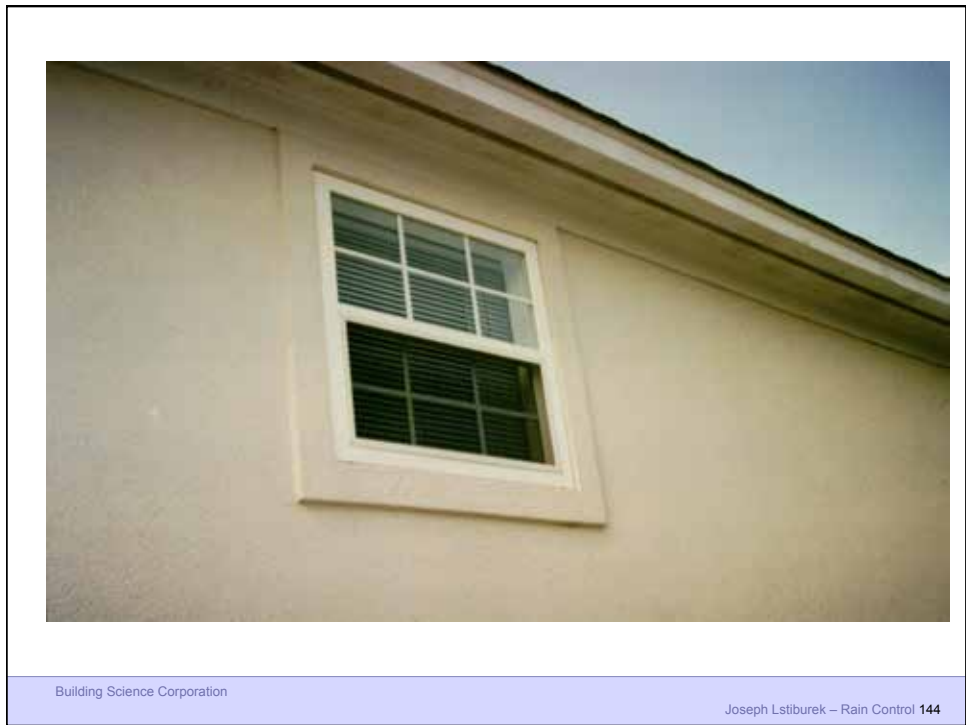
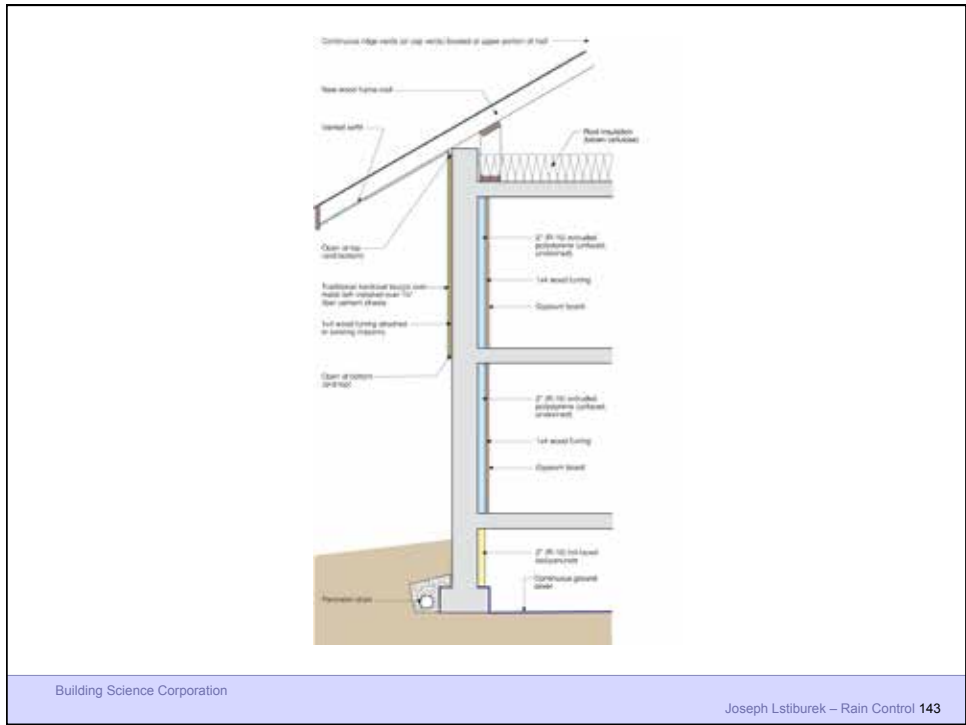
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Joseph Lstiburek – Rain Control 141

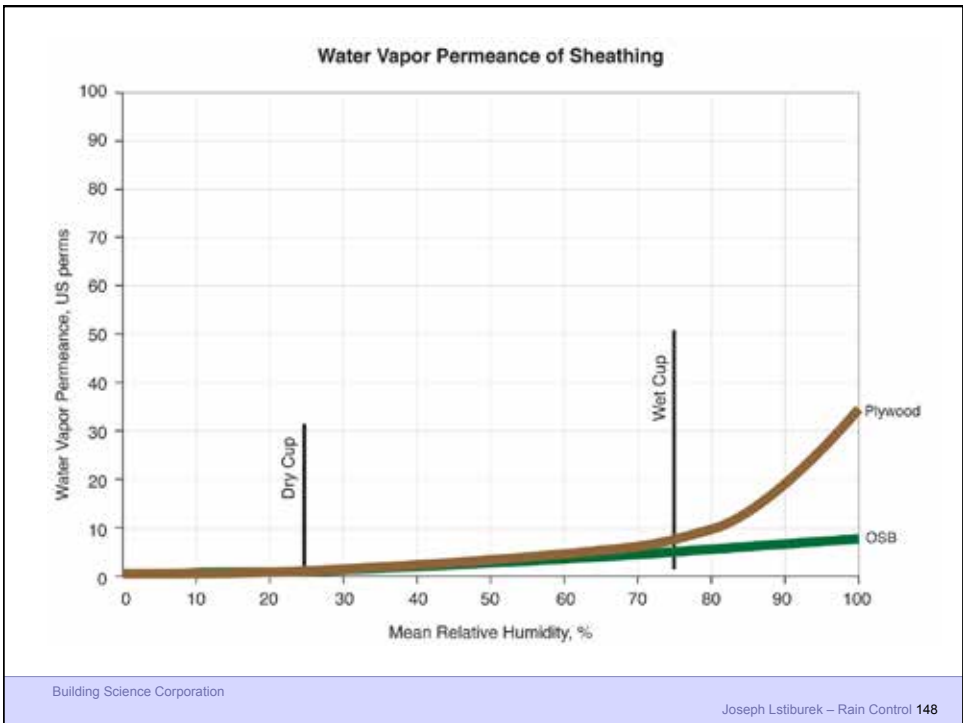


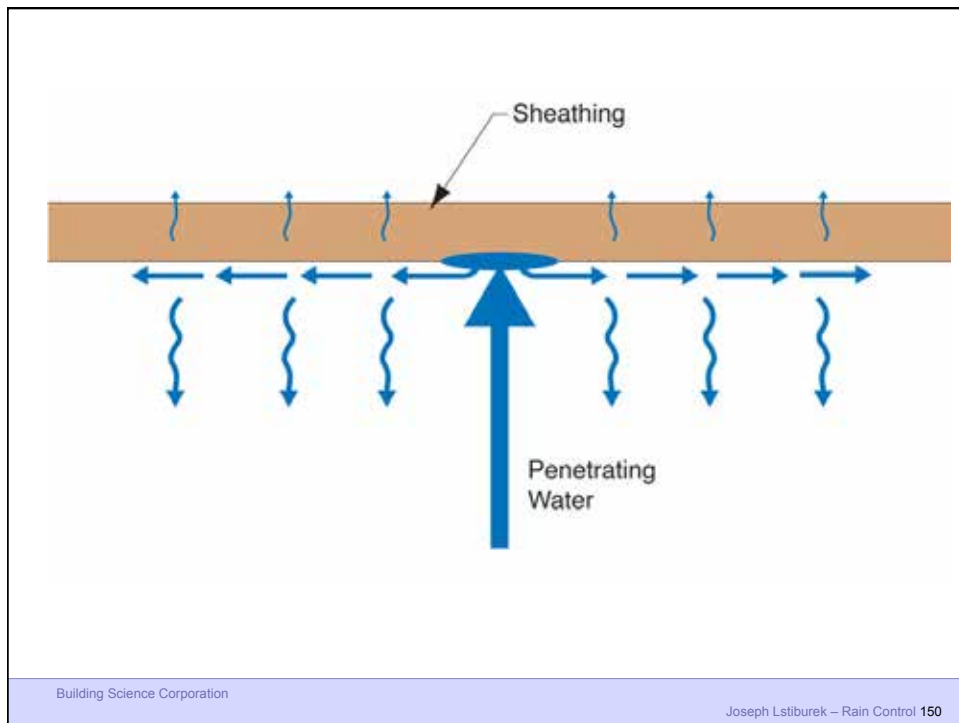
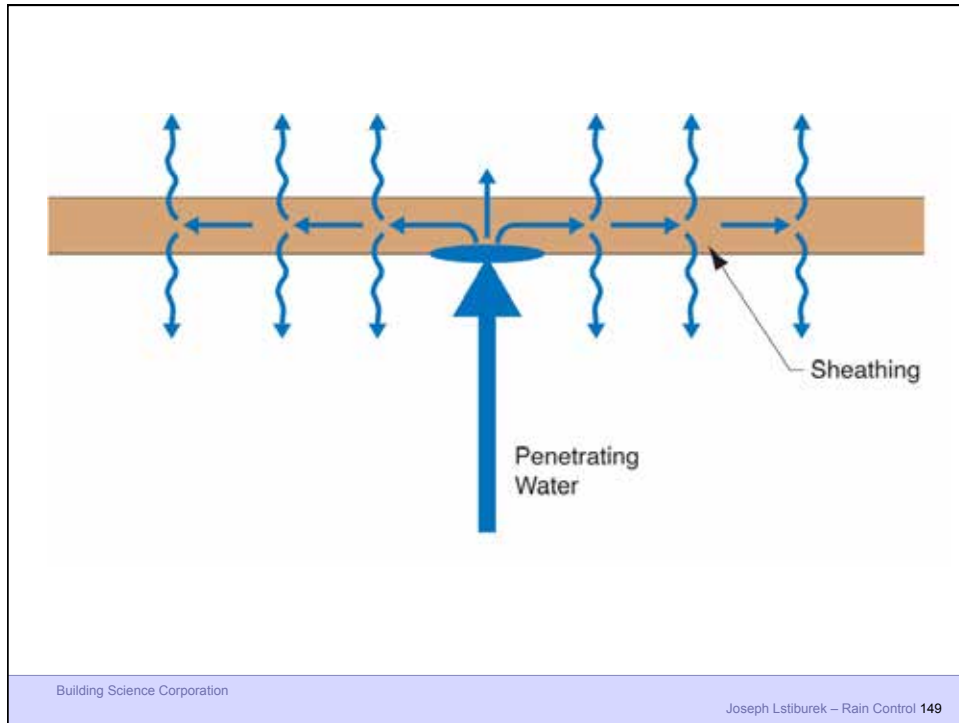
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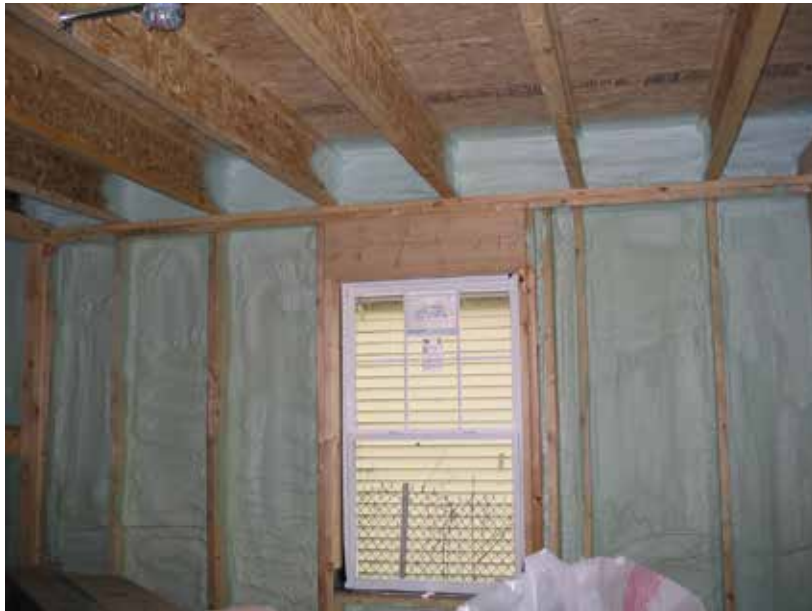






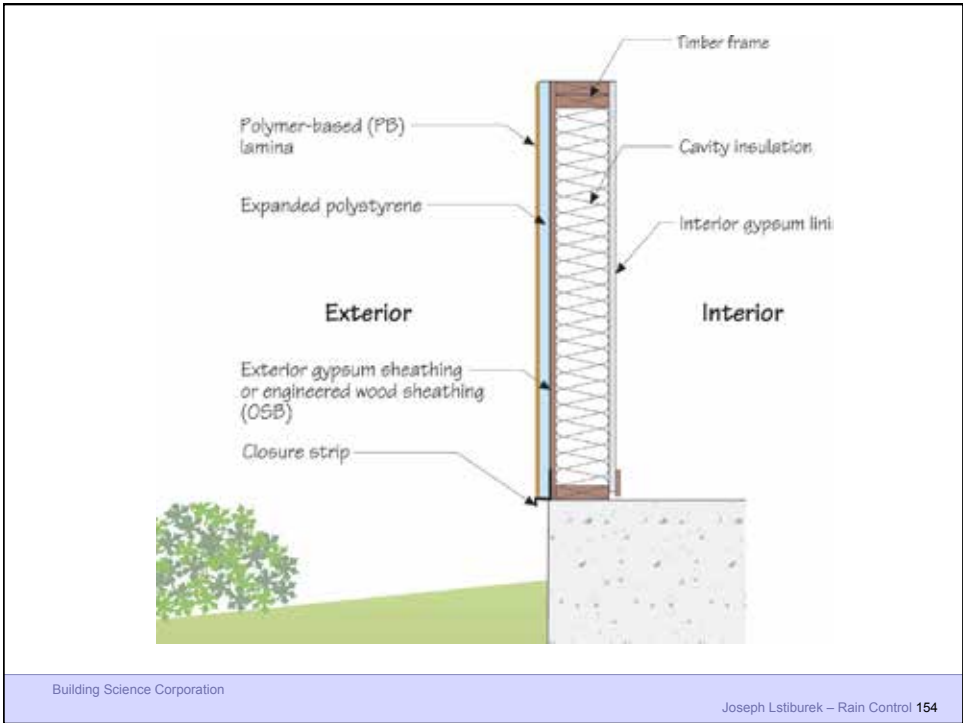
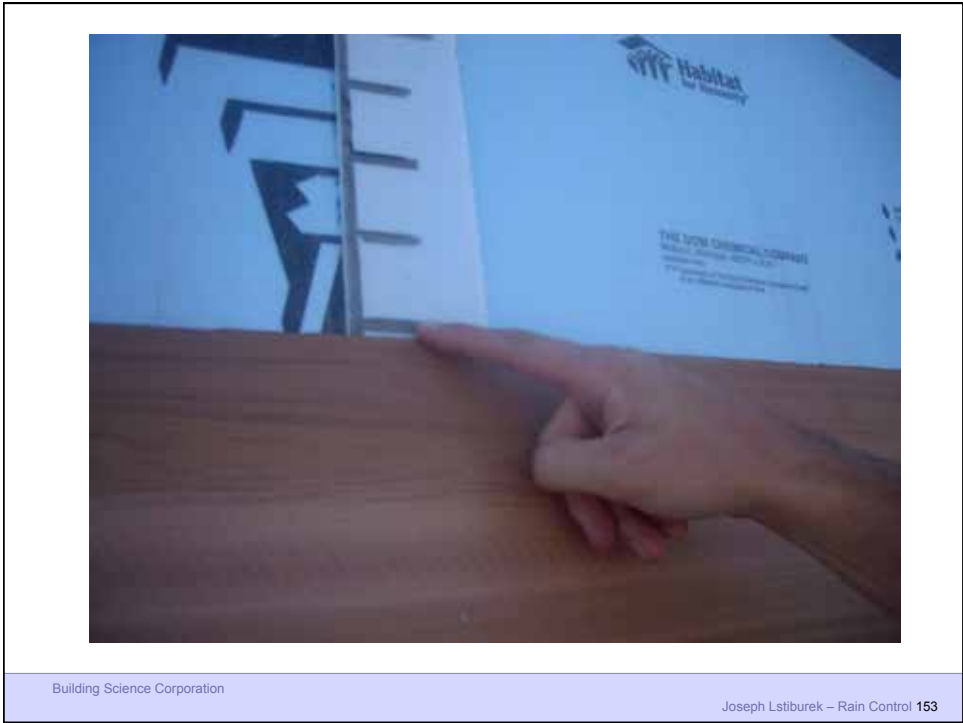
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Joseph Lstiburek – Rain Control 158













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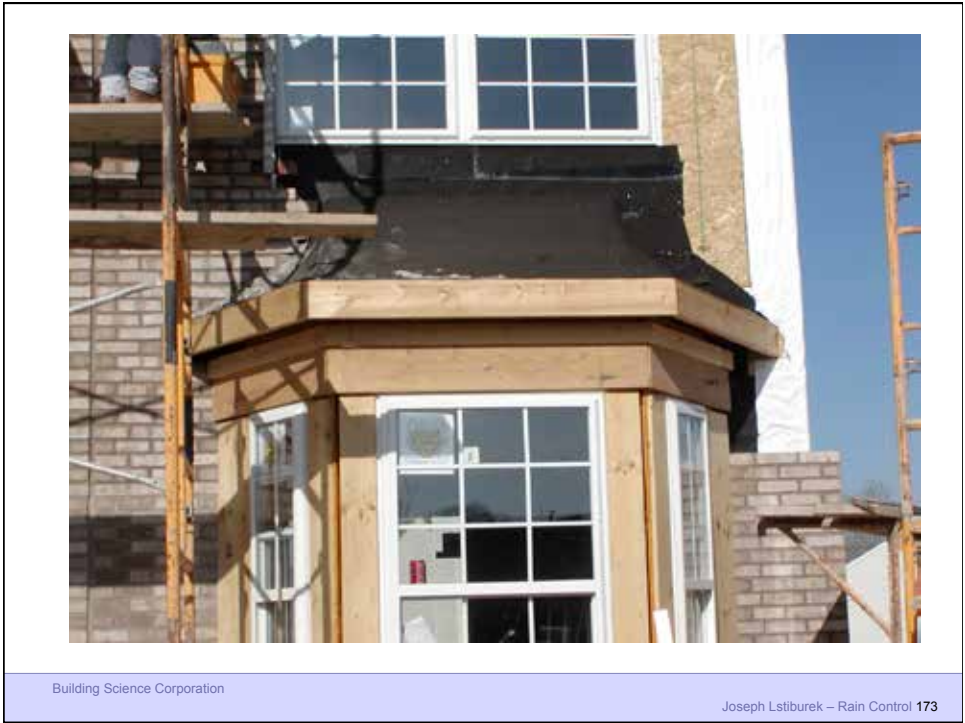
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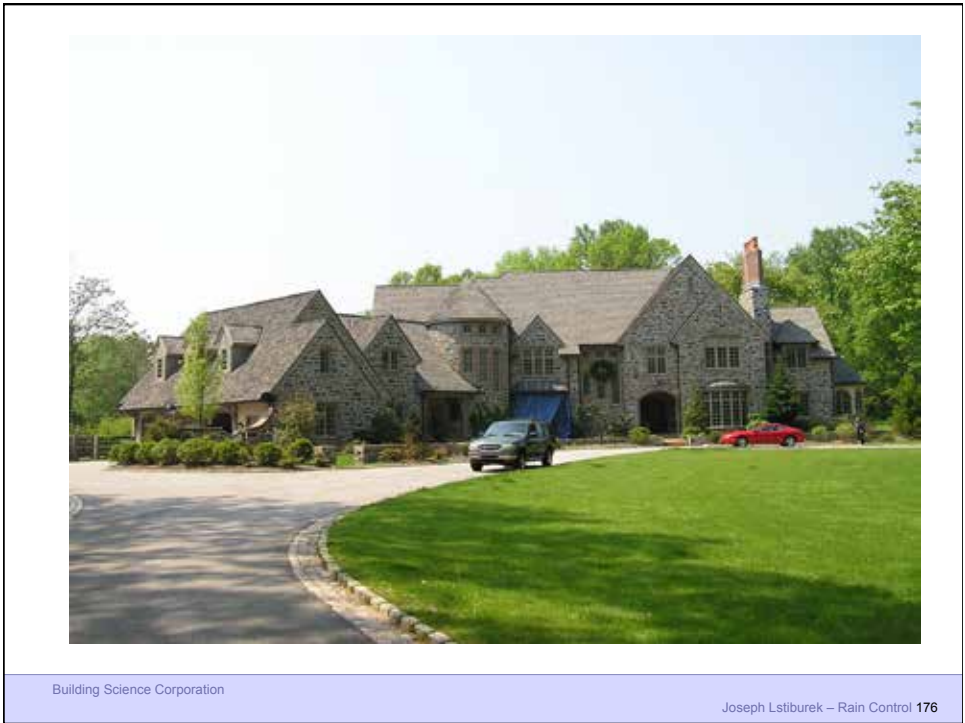
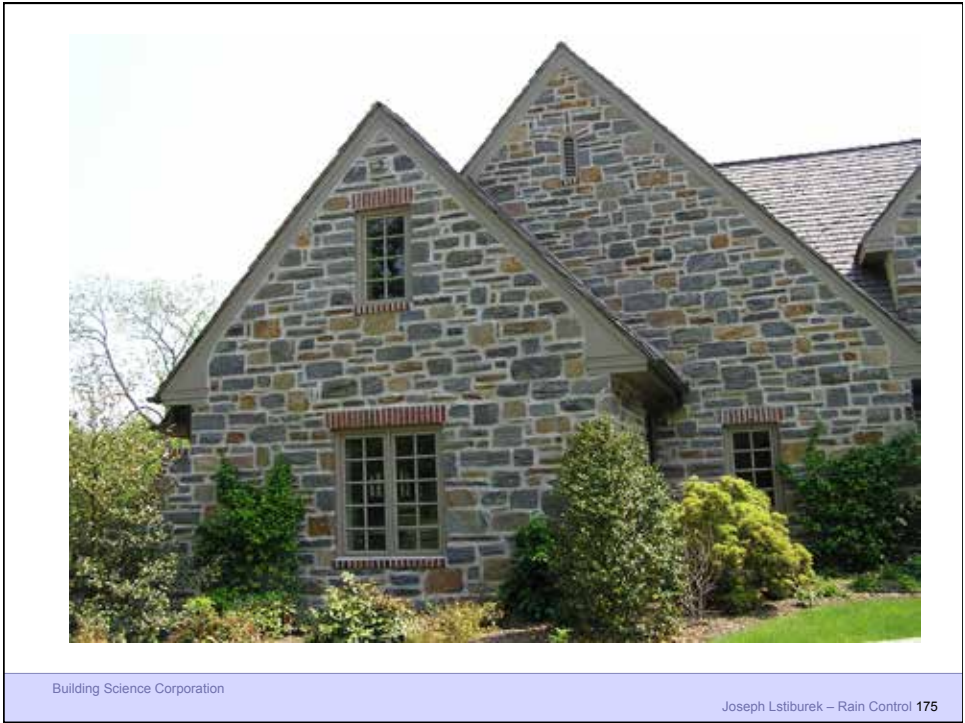


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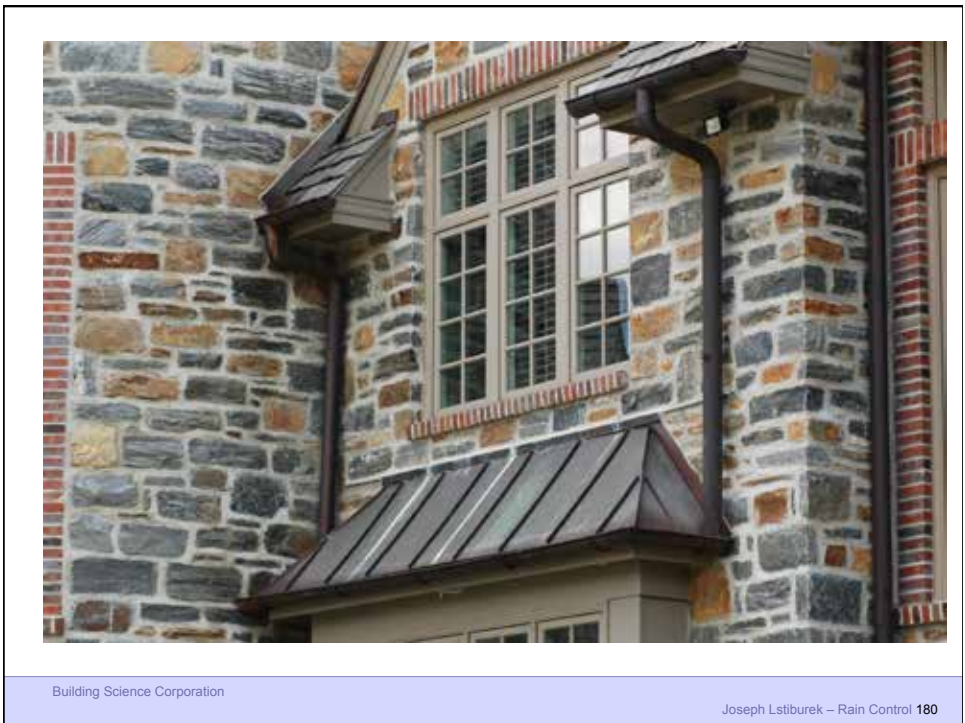
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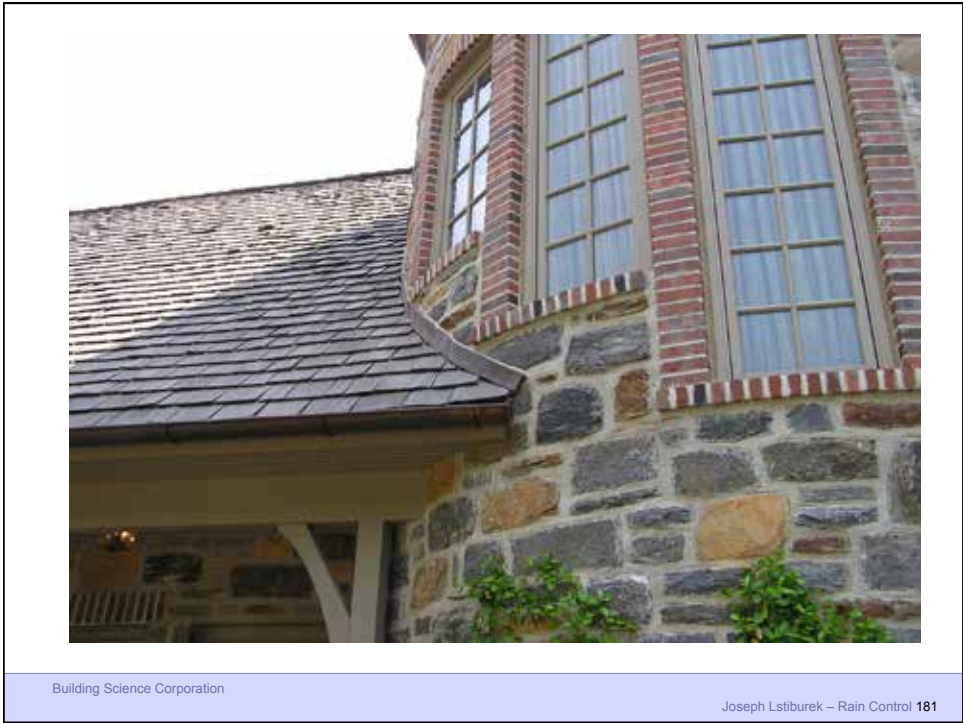
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Joseph Lstiburek – Rain Control 178







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