

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

Building Science

Adventures In Building Science

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Arrhenius Equation

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For Every 10 Degree K Rise
Activation Energy Doubles

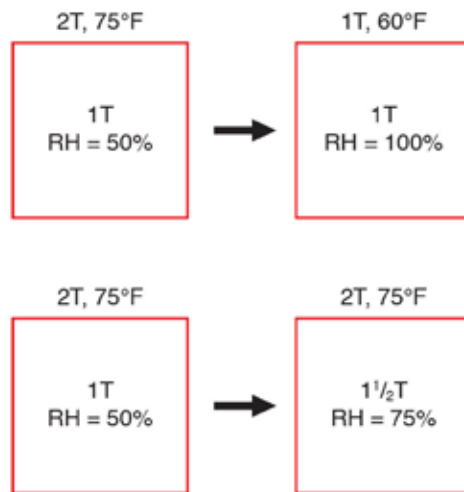
$$k = Ae^{-E_a/(RT)}$$

Damage Functions
Water
Heat
Ultra-violet Radiation

Vapor Pressure and Relative Humidity

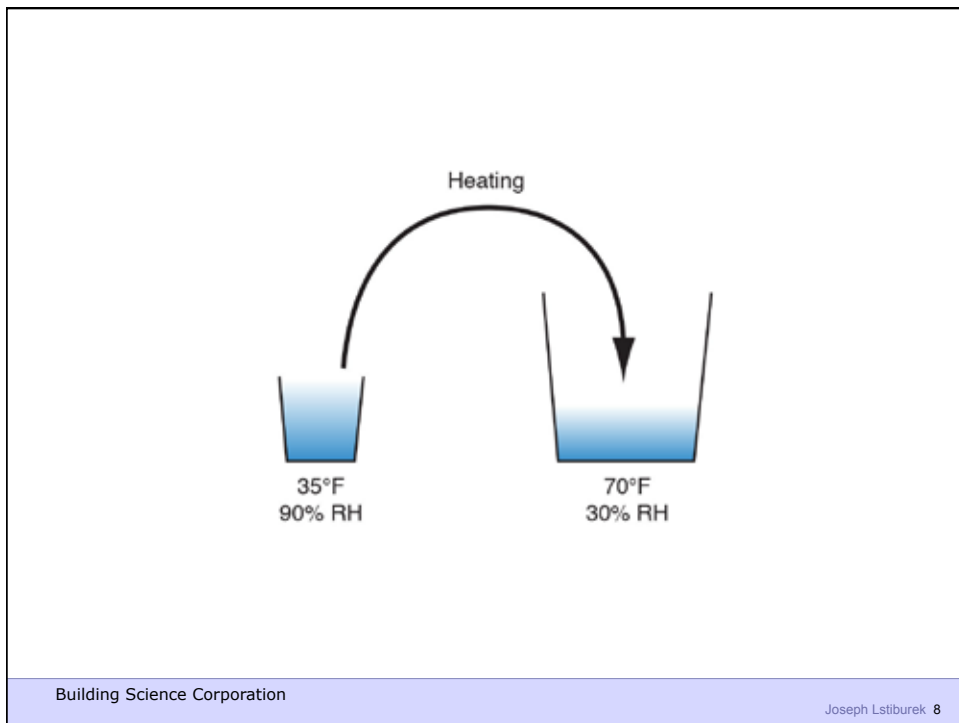
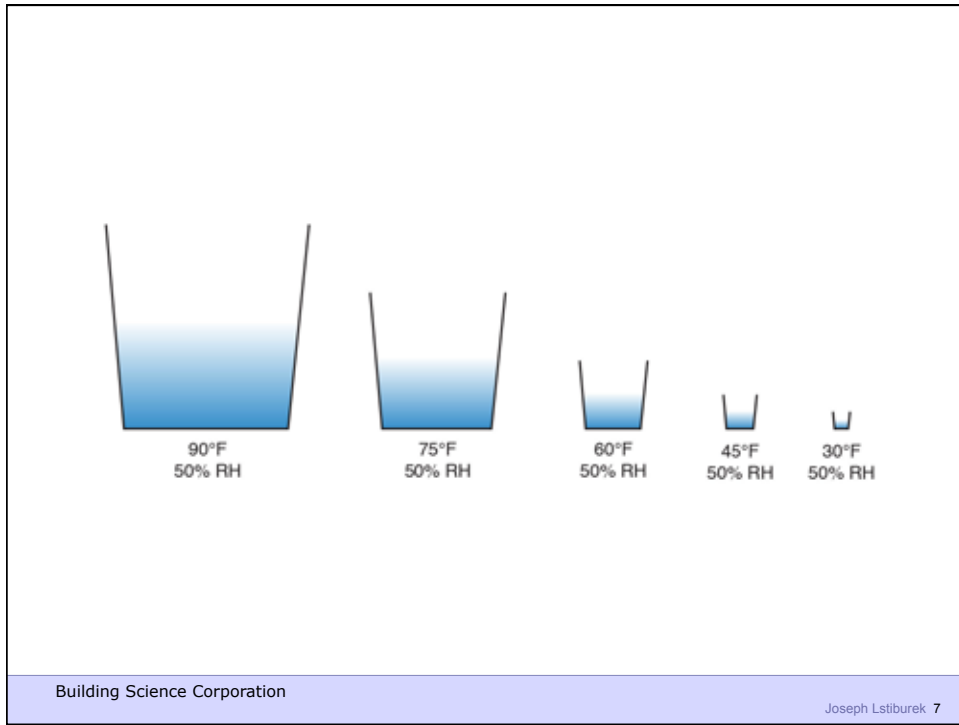
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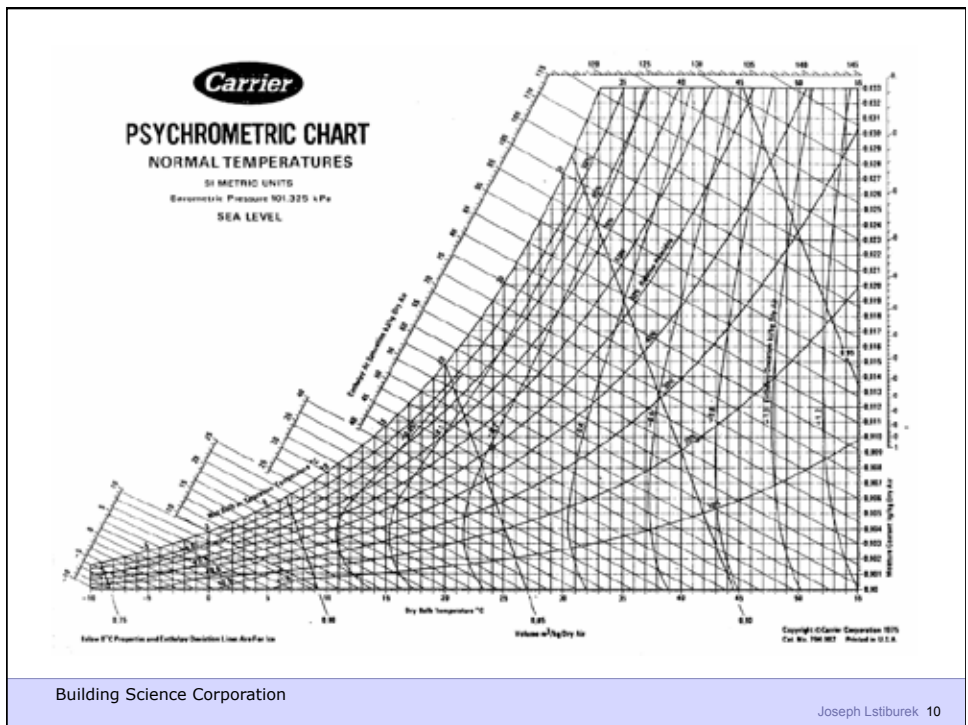
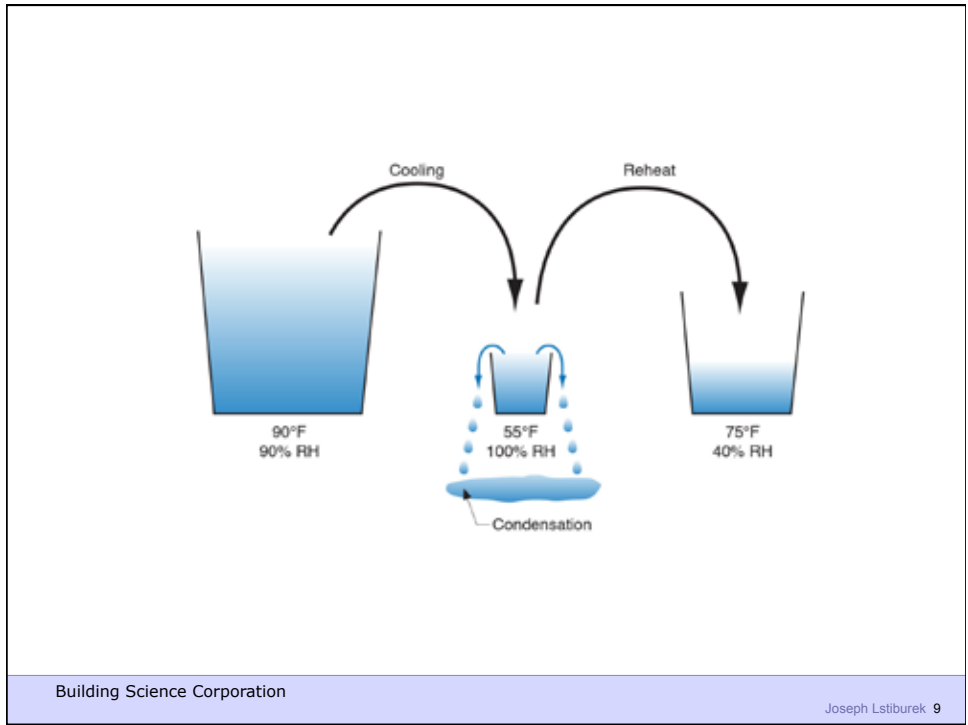
Joseph Lstiburek 5



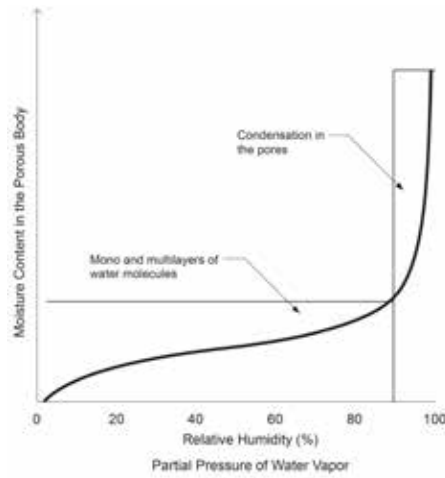
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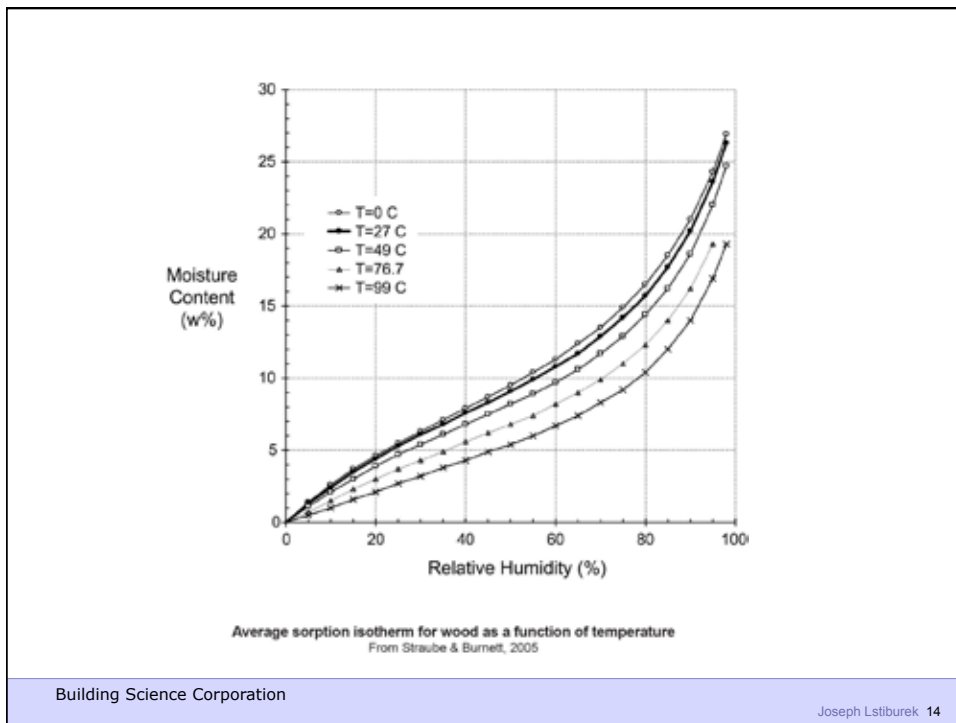
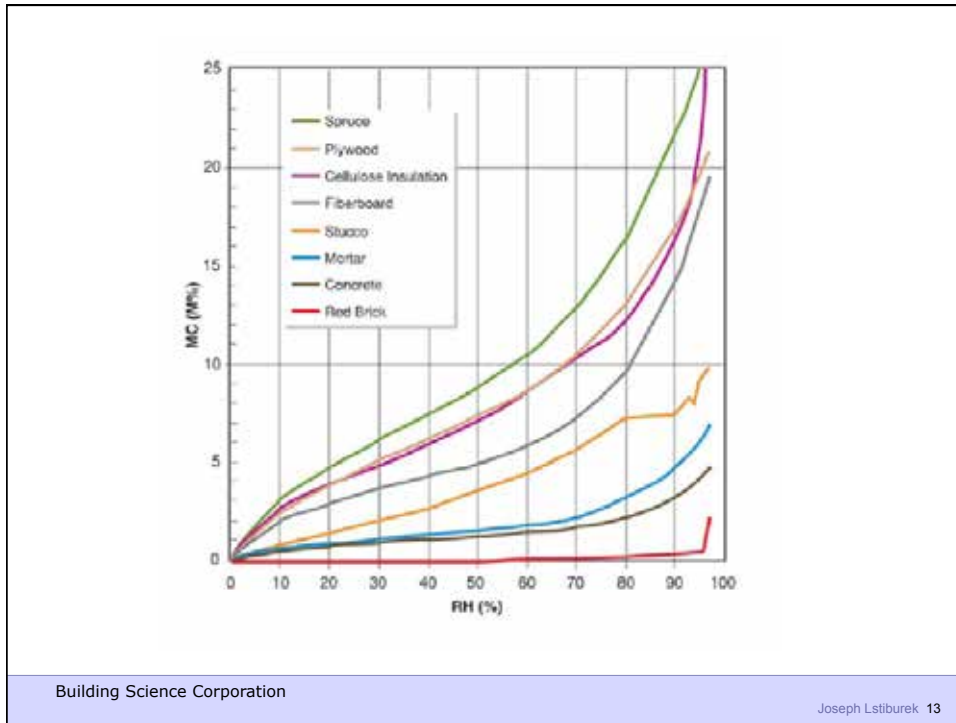


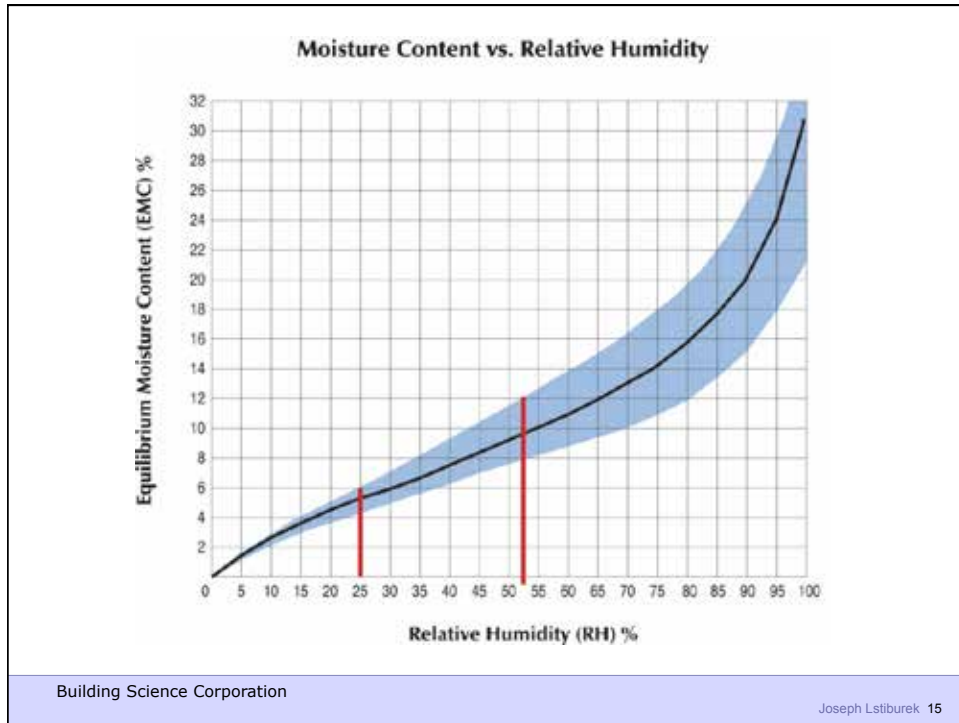
Sorption Isotherms



Change in the storage of moisture in a porous building material as the partial pressure of water vapor in the ambient air increases from zero to full saturation value at a given temperature.

Sorption Curve
From M.K. Kumaran, ASTM MN, 16-2nd Edition,
Moisture Control in Buildings, 2009



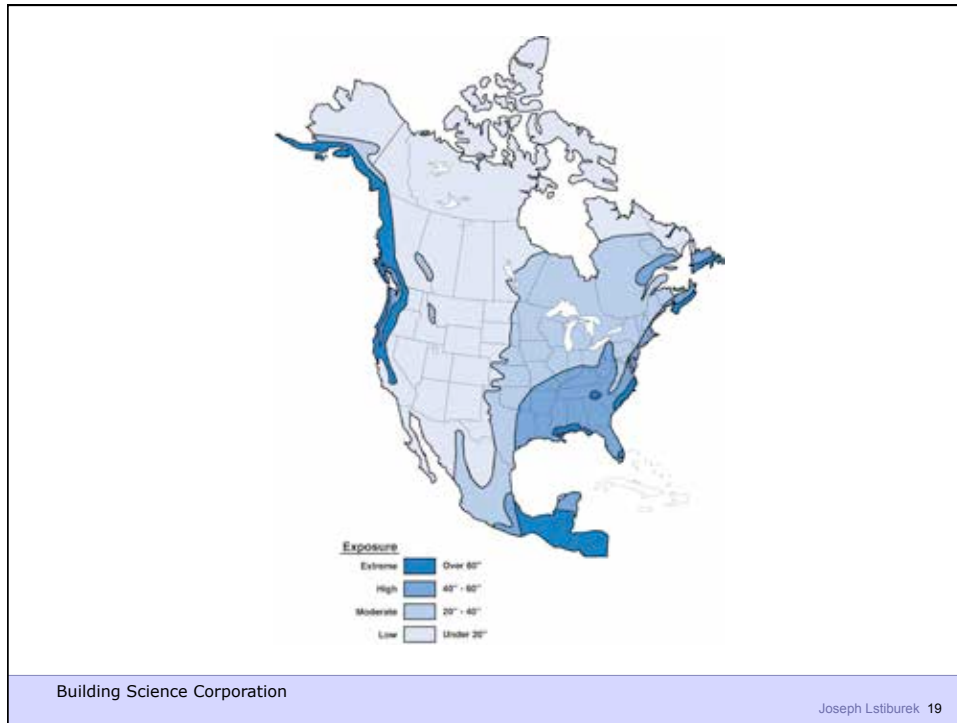


2nd Law of Thermodynamics

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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

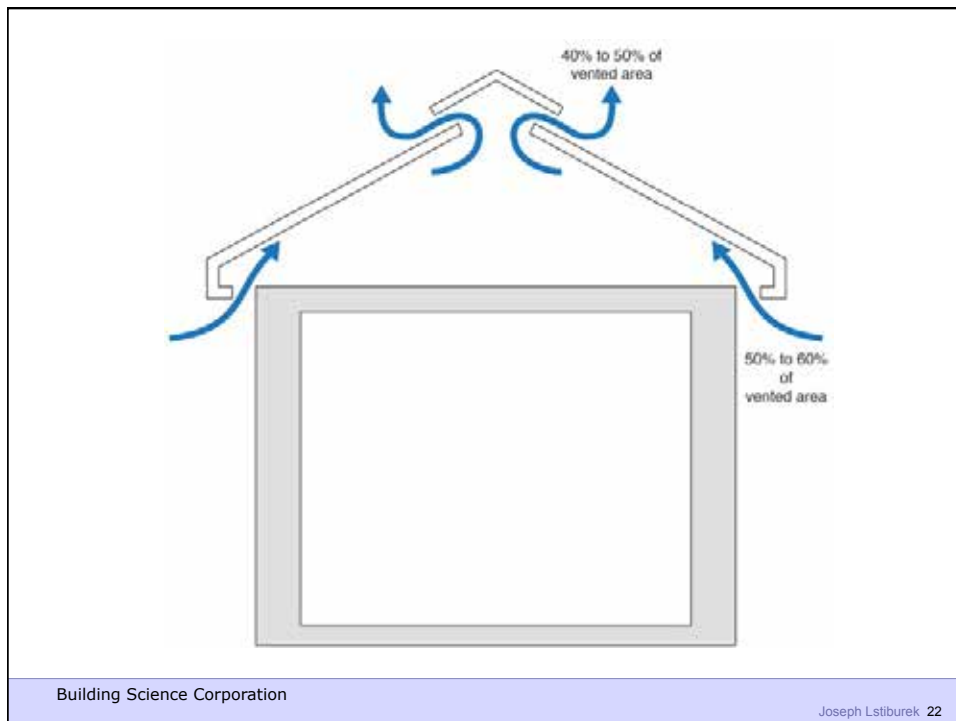
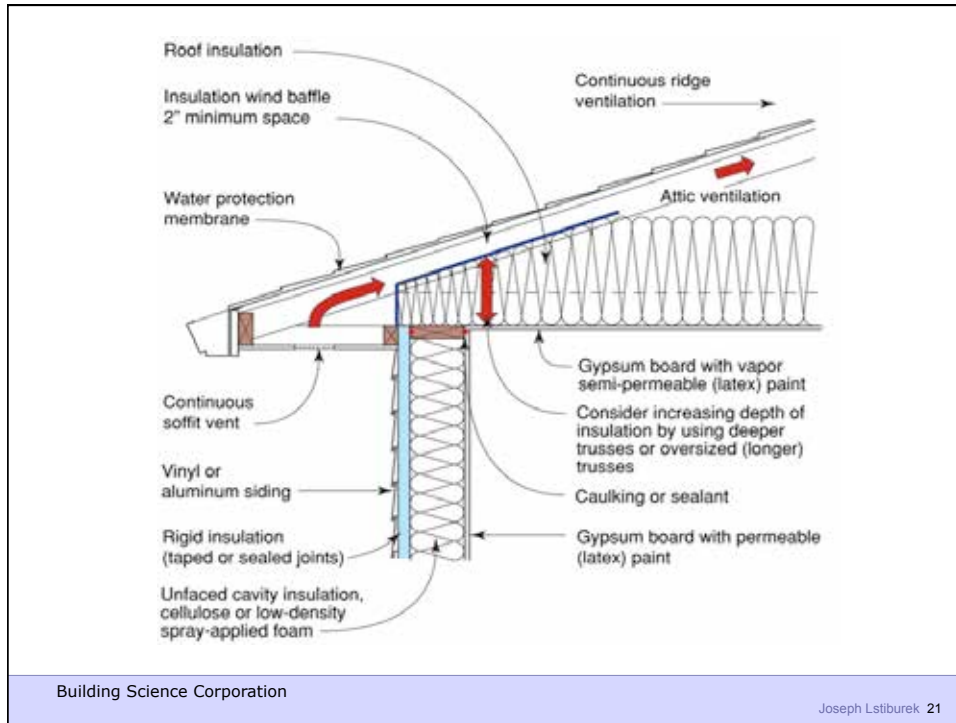


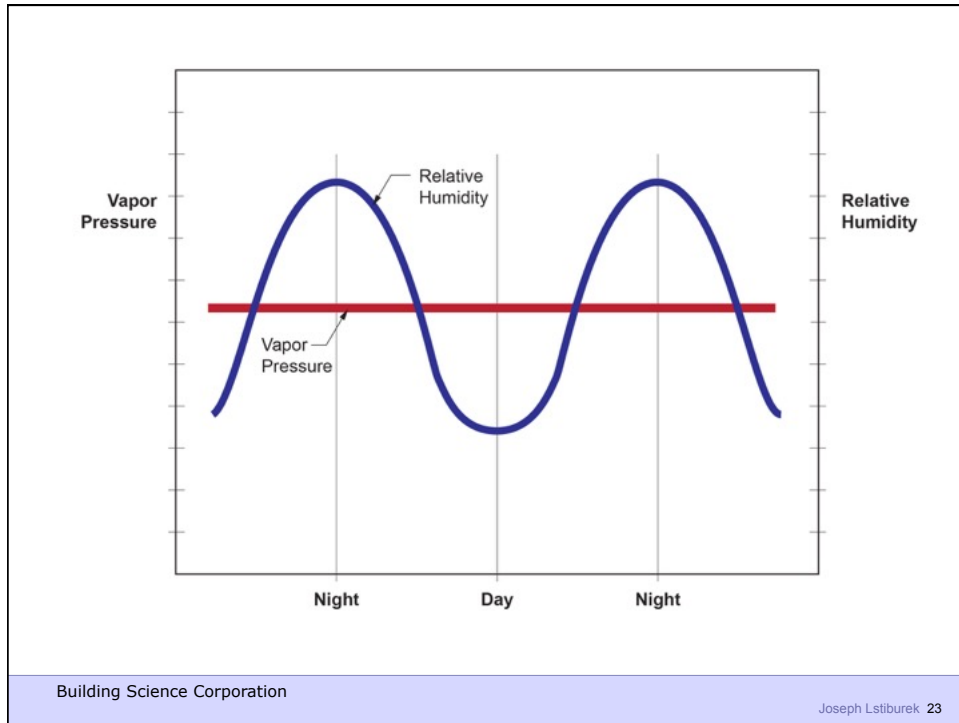


Vented Attics Are Climate Dependant

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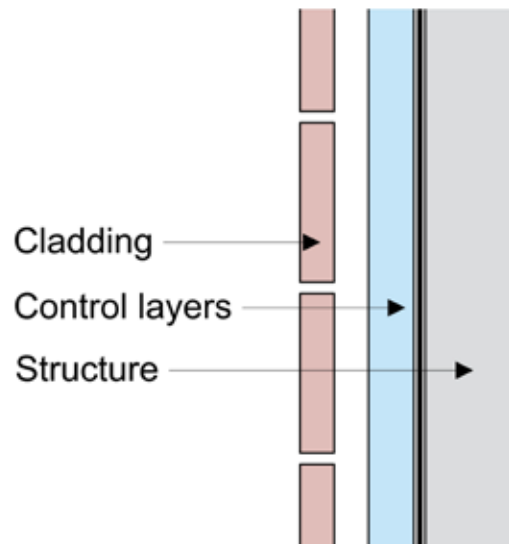


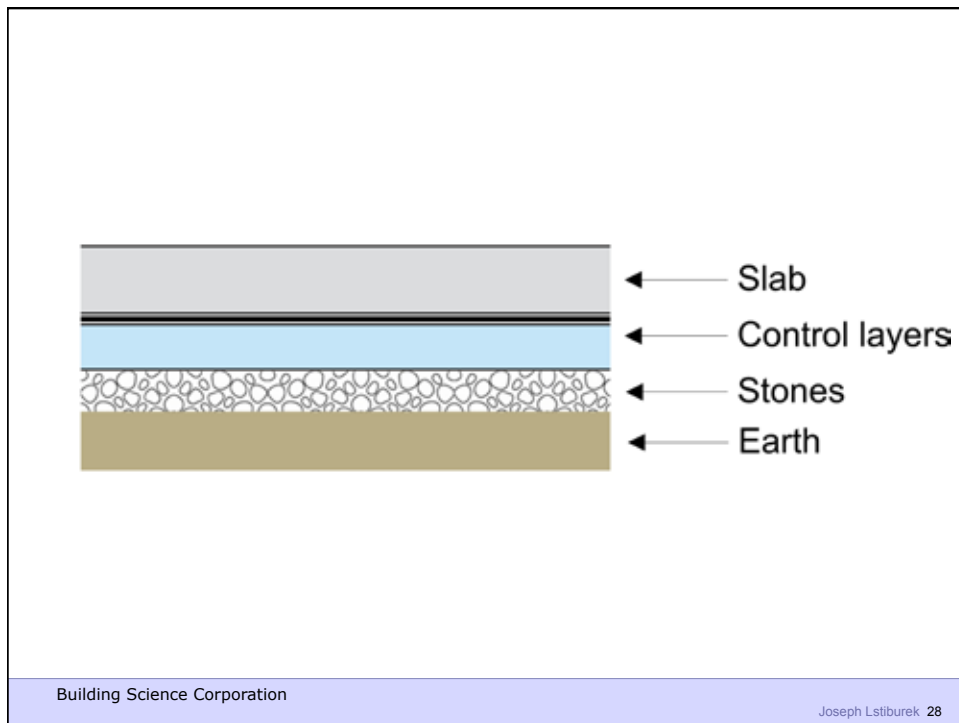
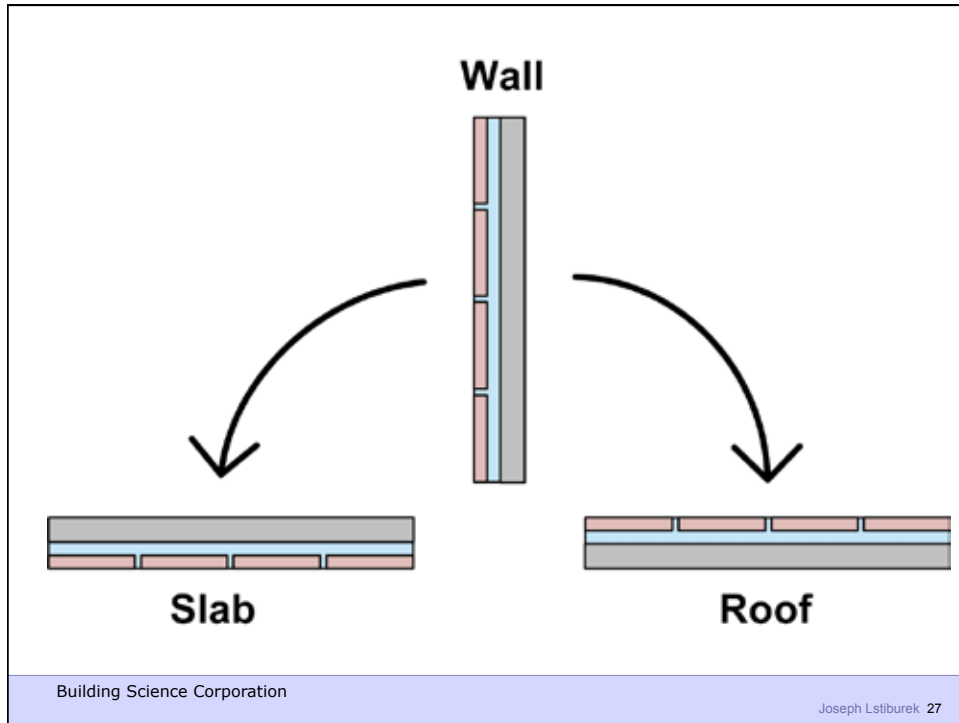
Enclosures

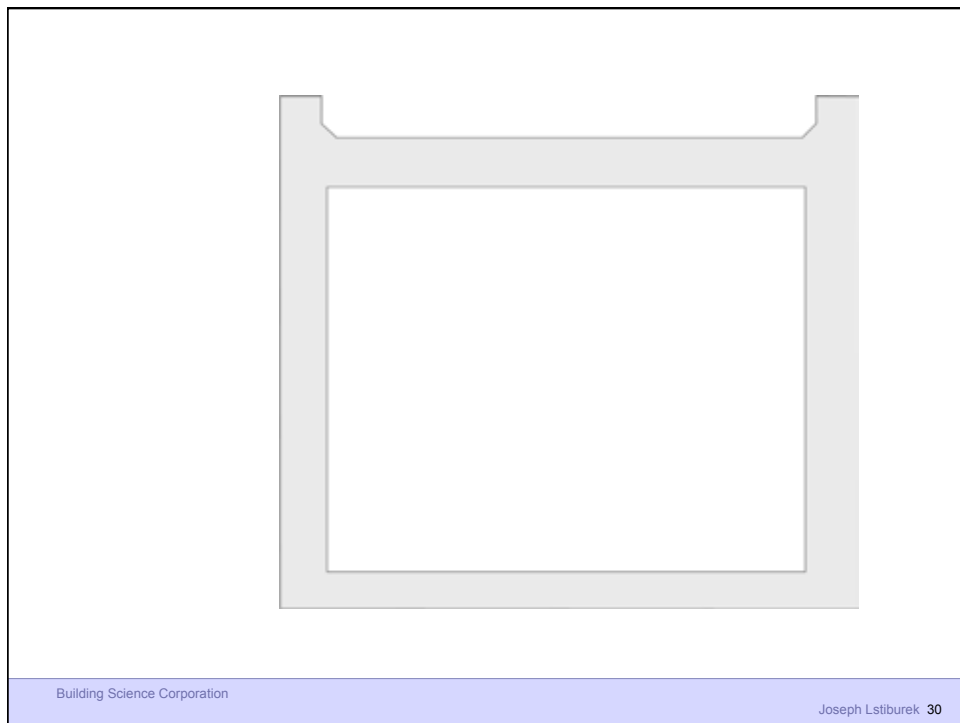
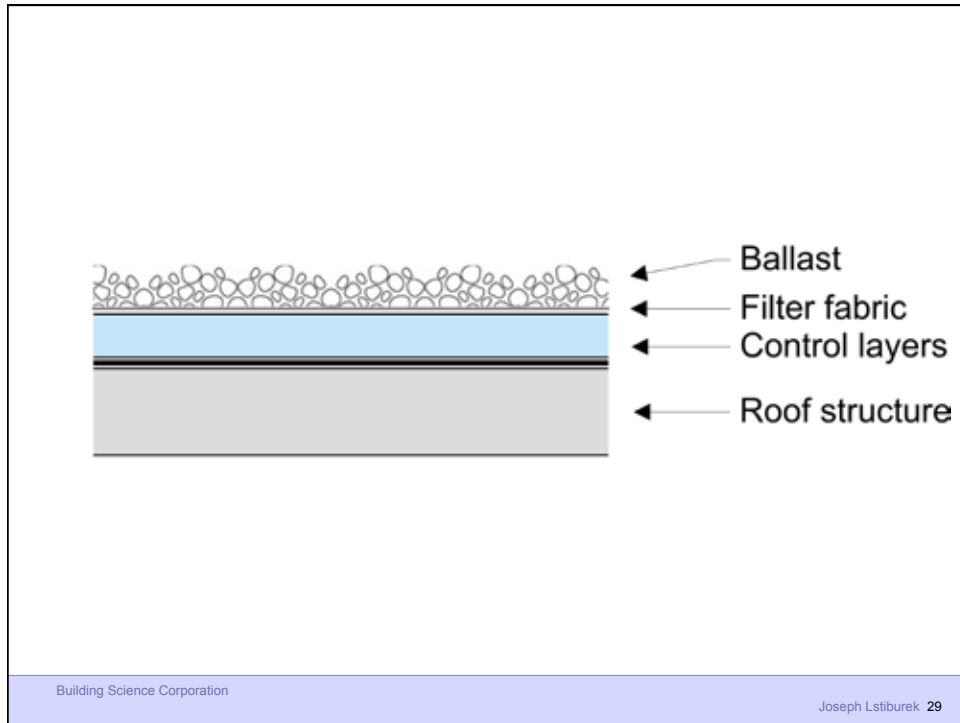
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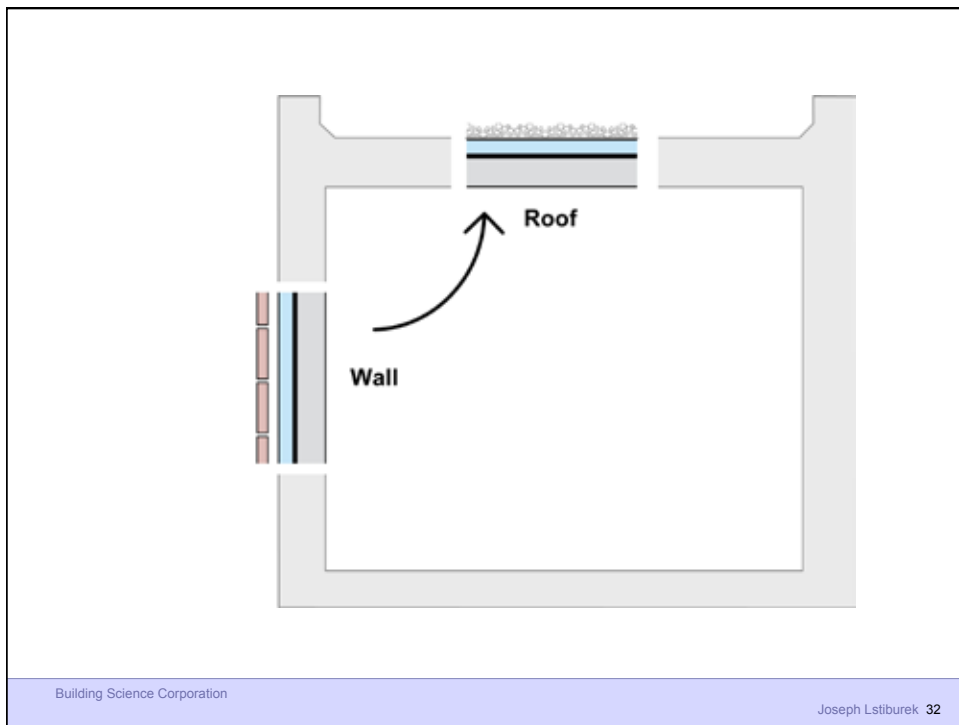
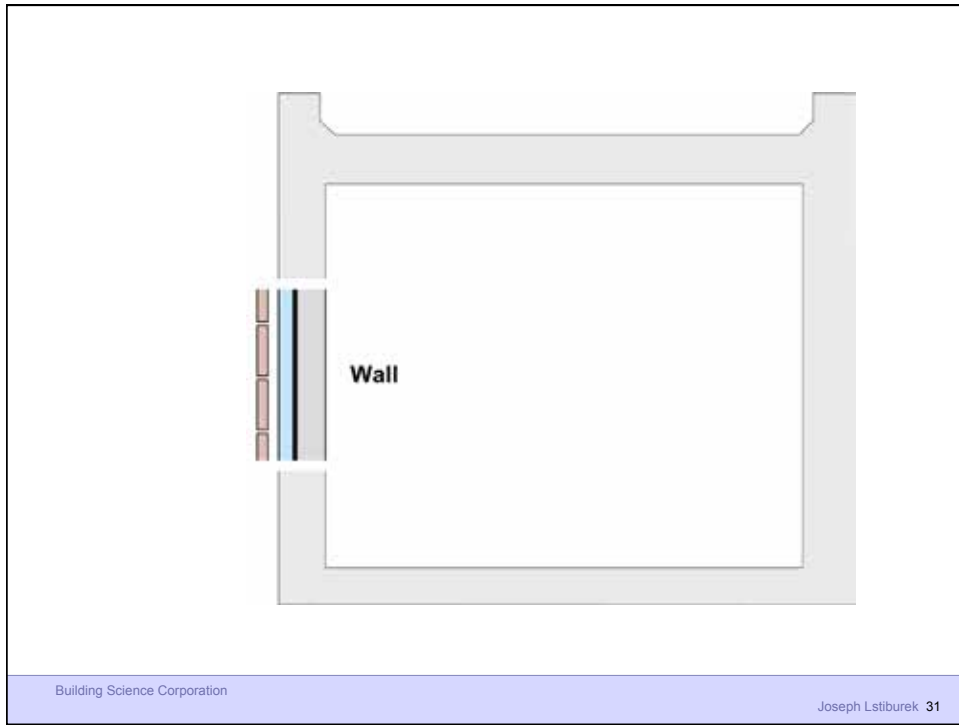
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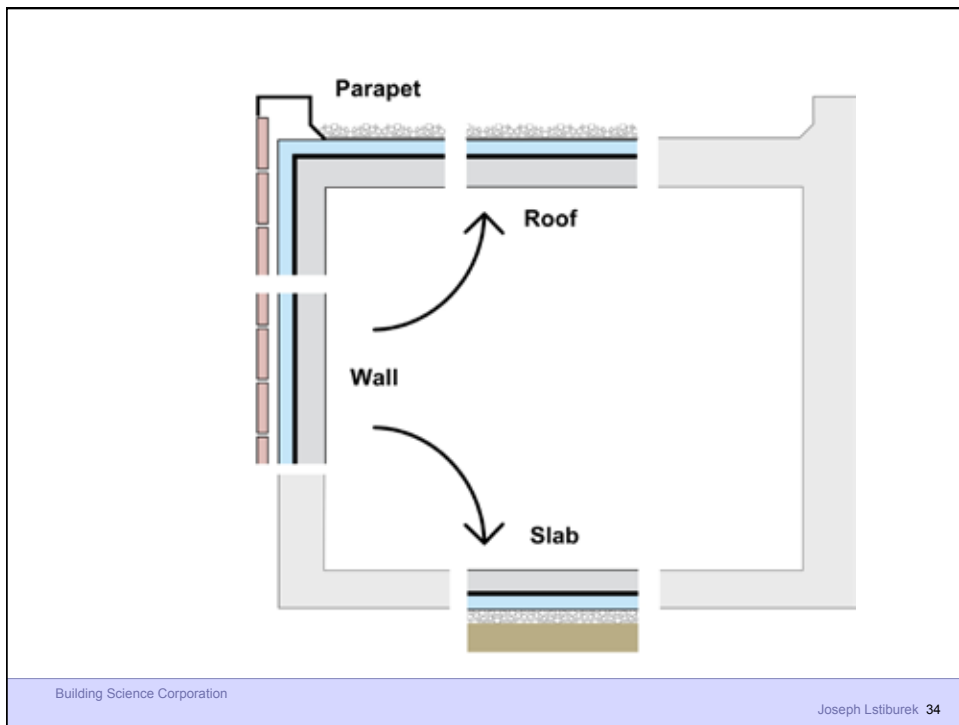
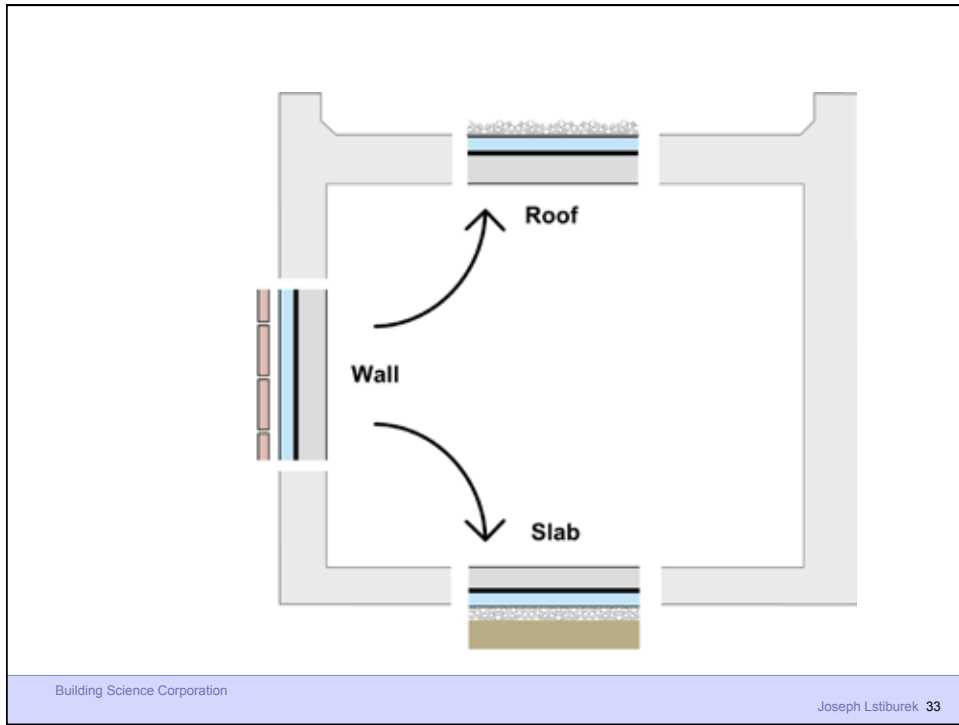
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

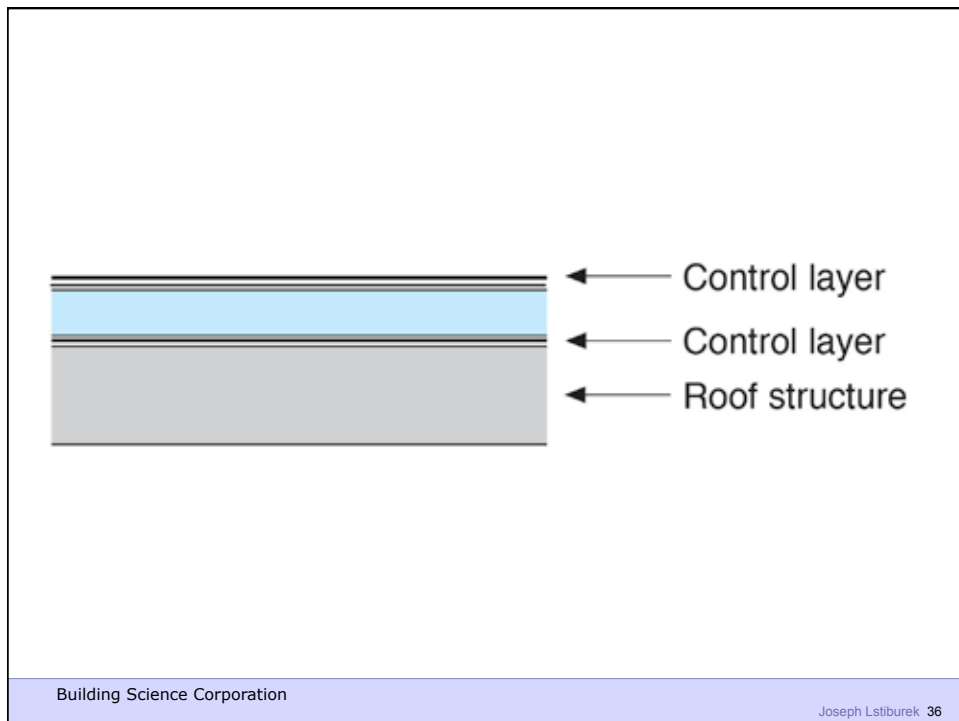
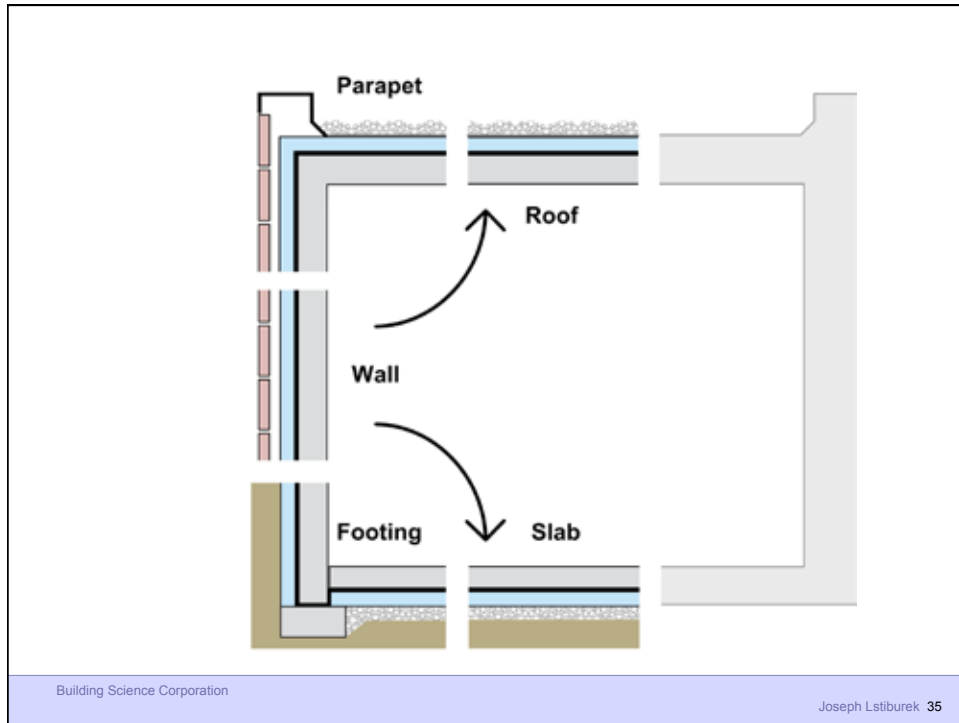


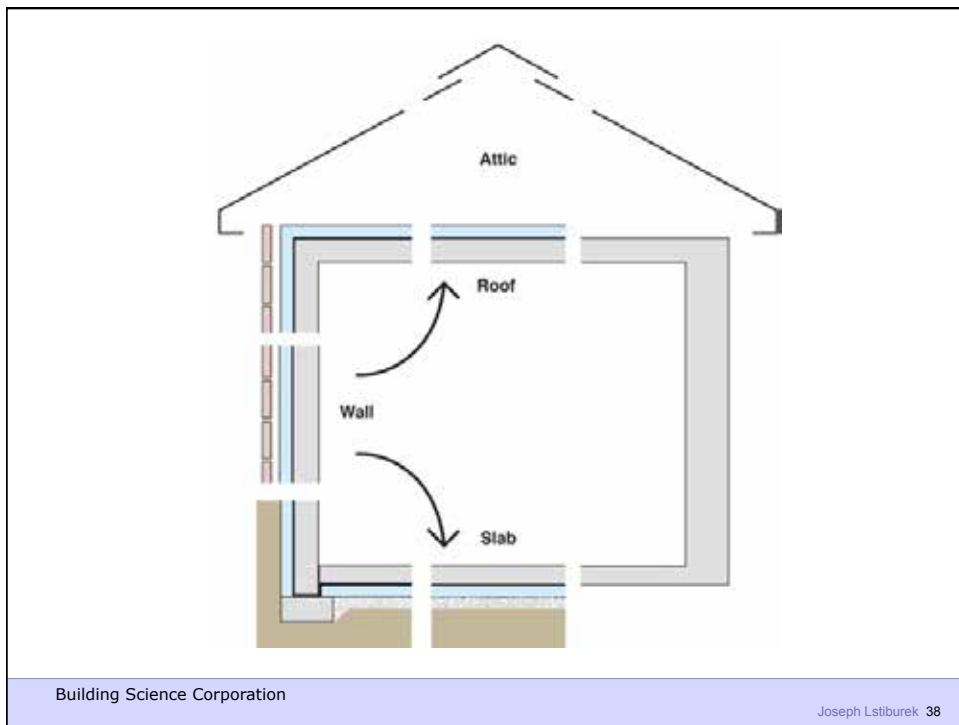
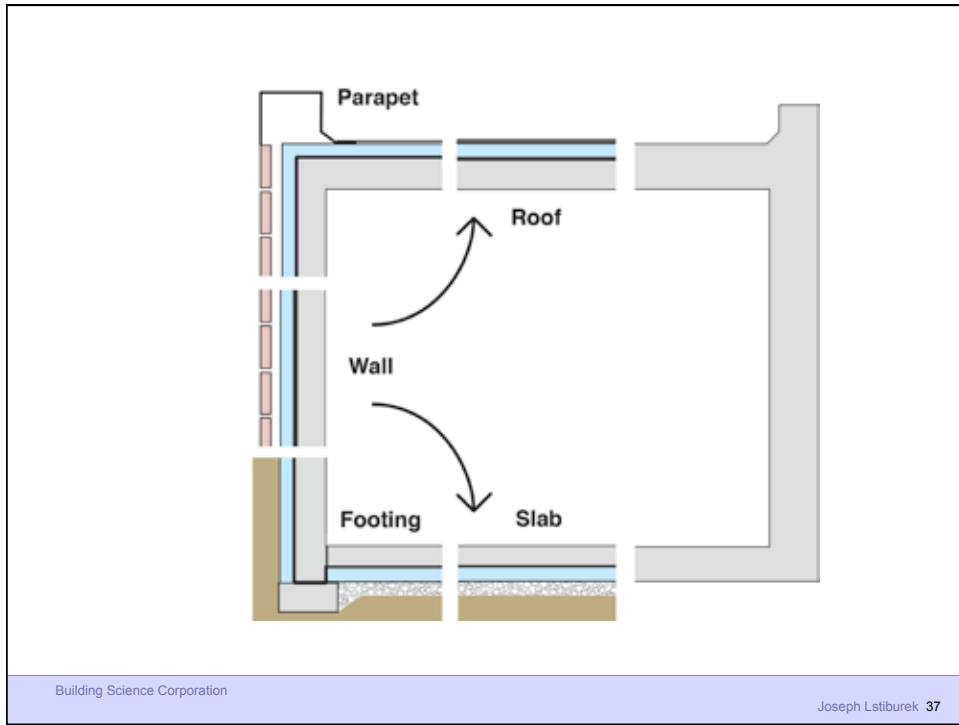


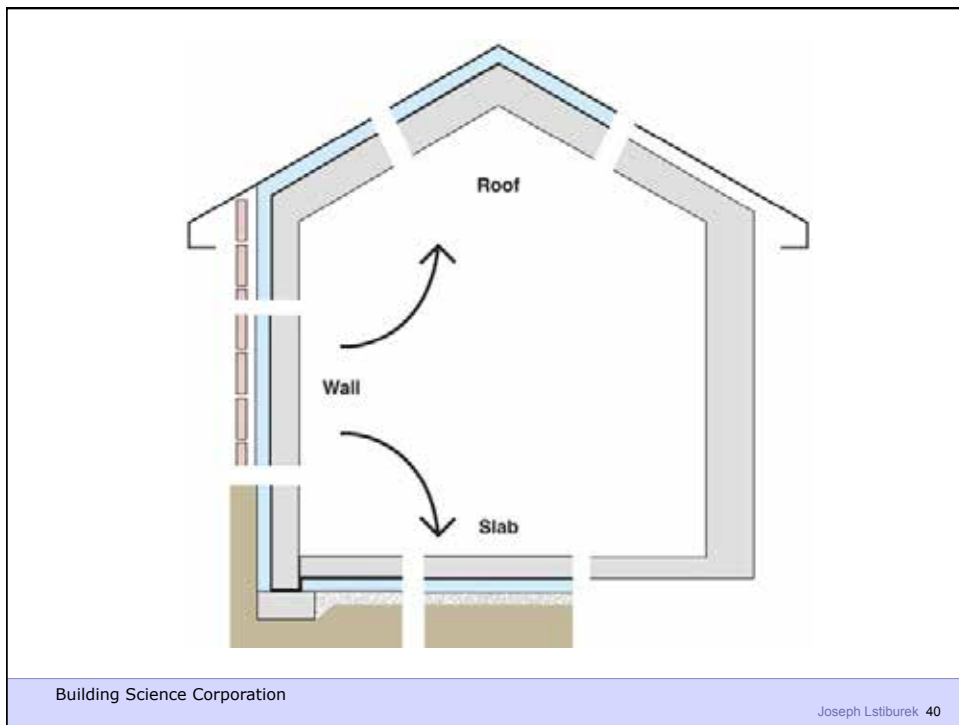
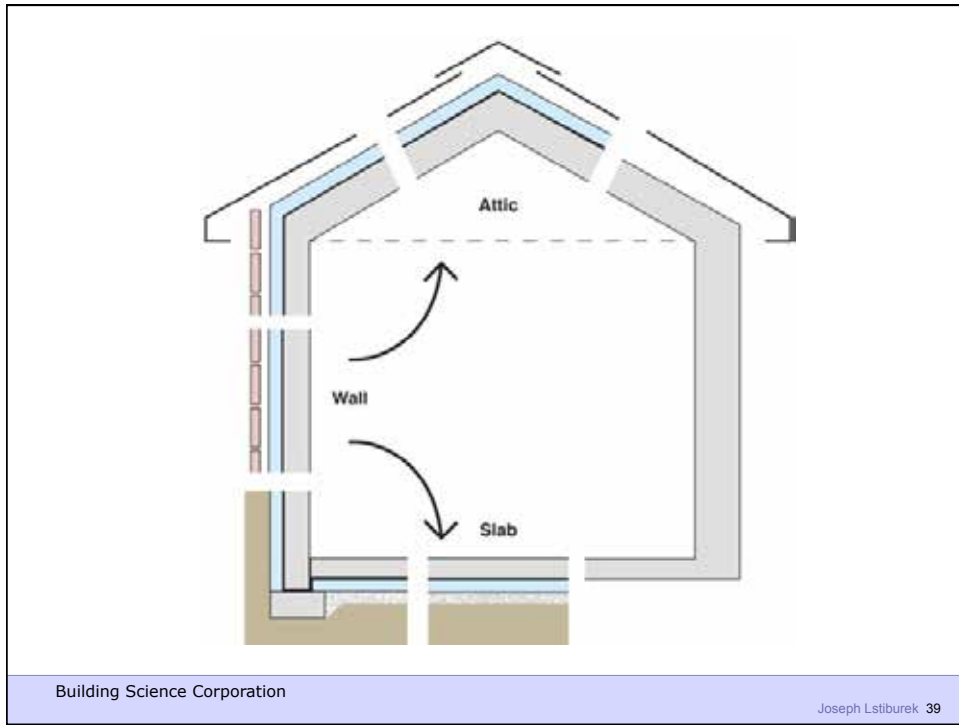


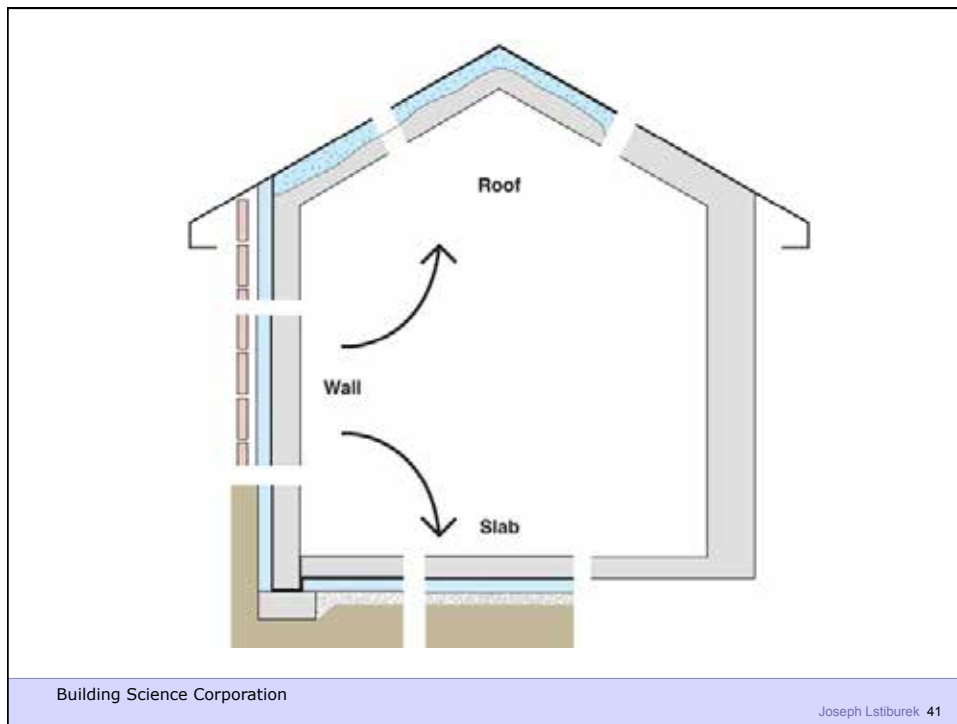




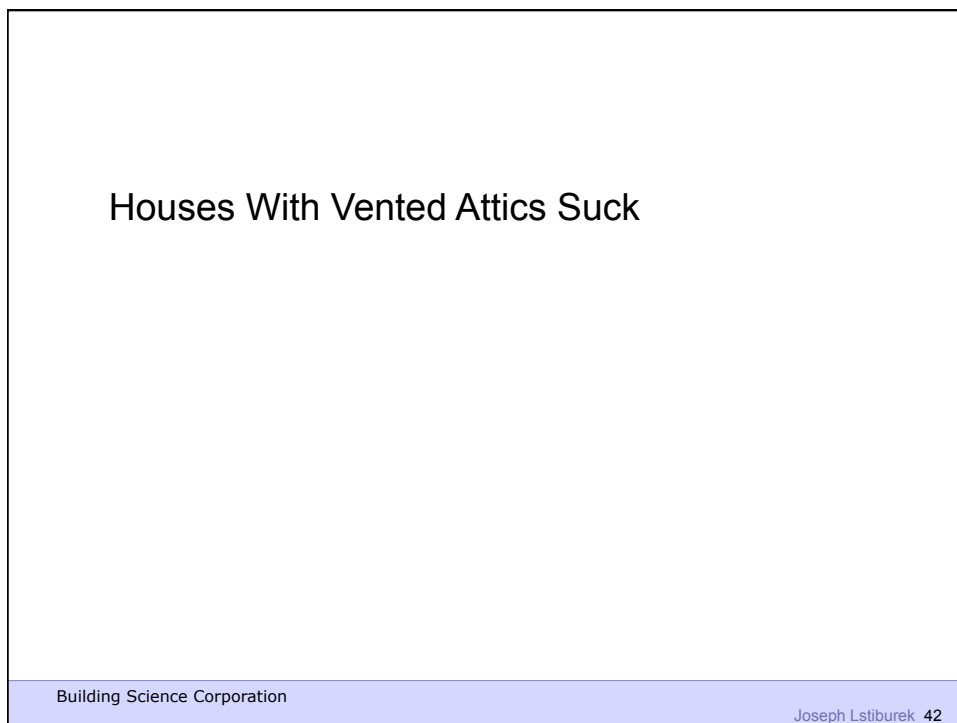








Houses With Vented Attics Suck



Houses With Vented Attics Suck Not all the Time.....but.....

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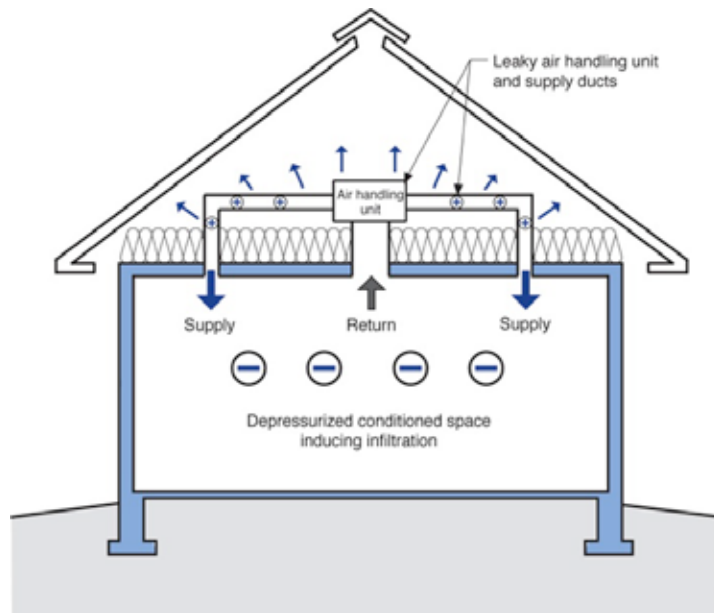
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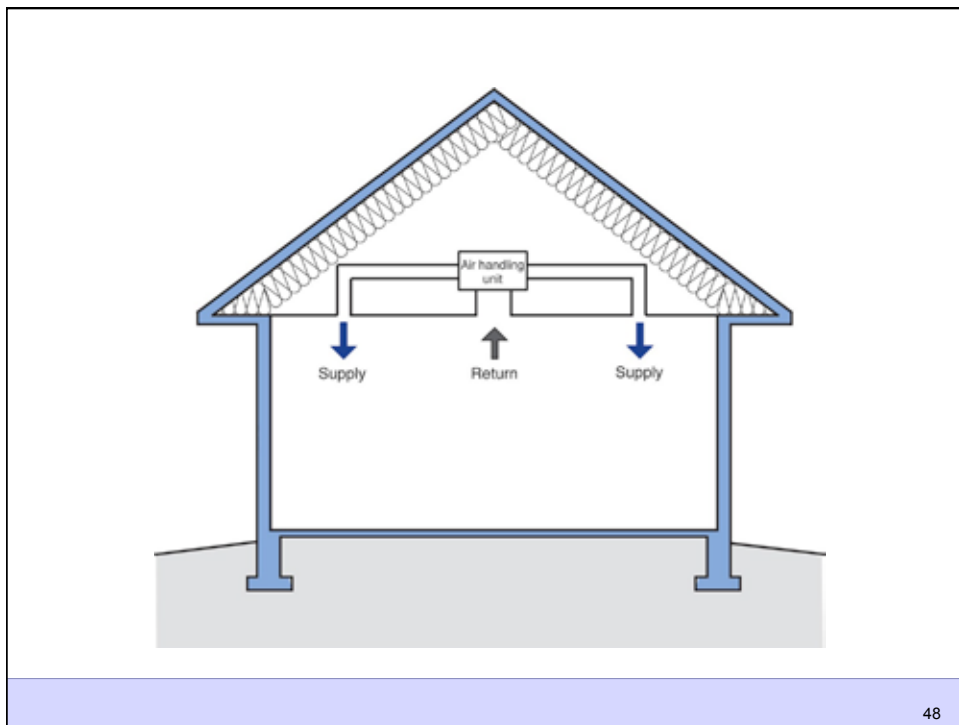
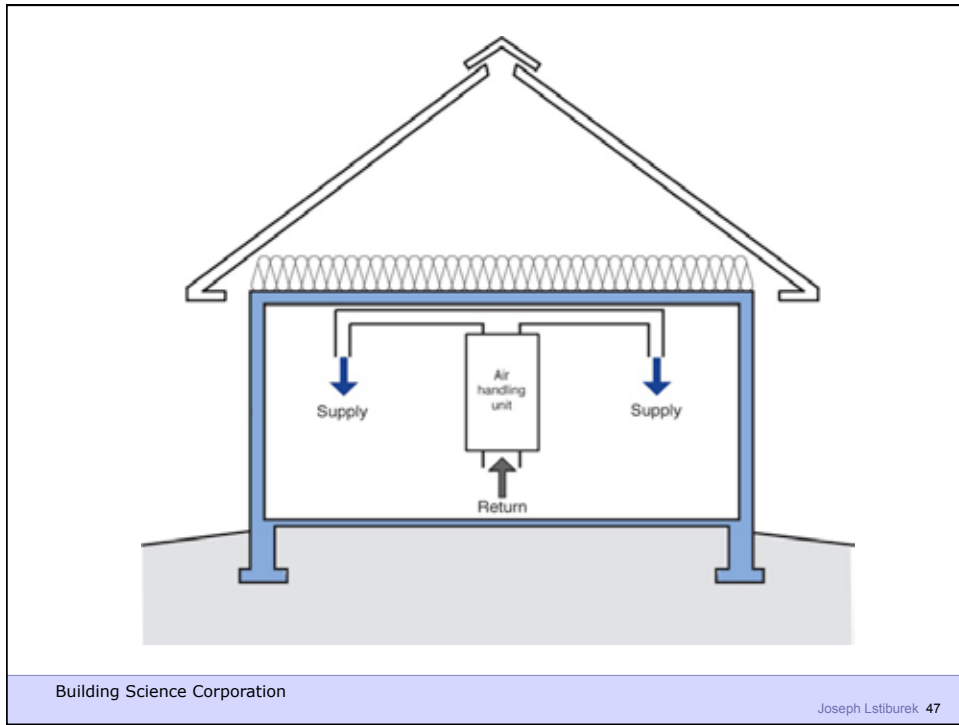
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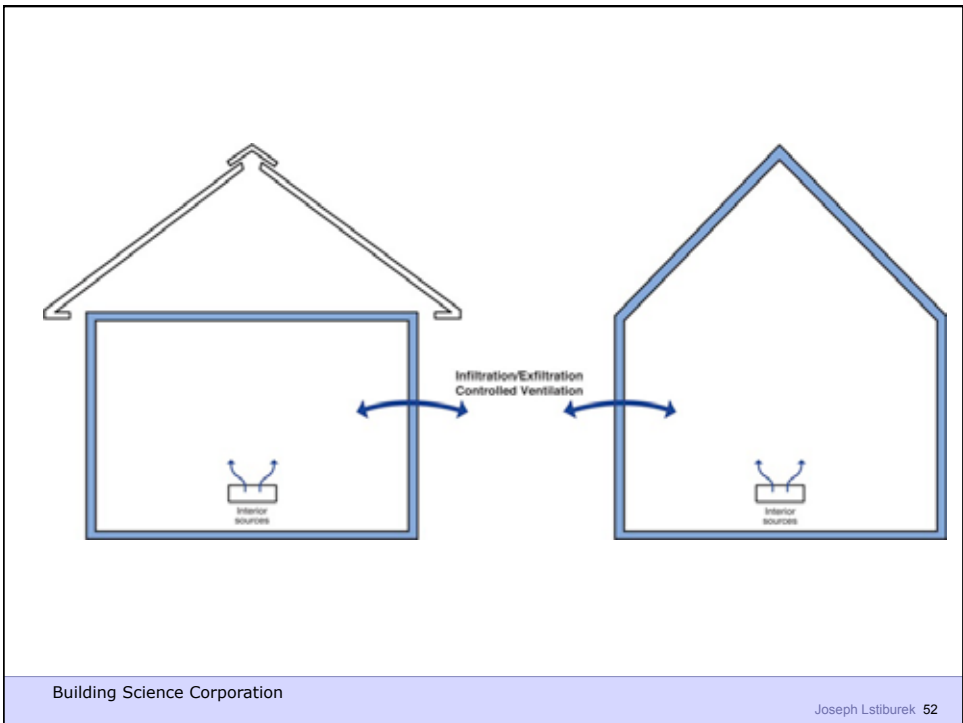
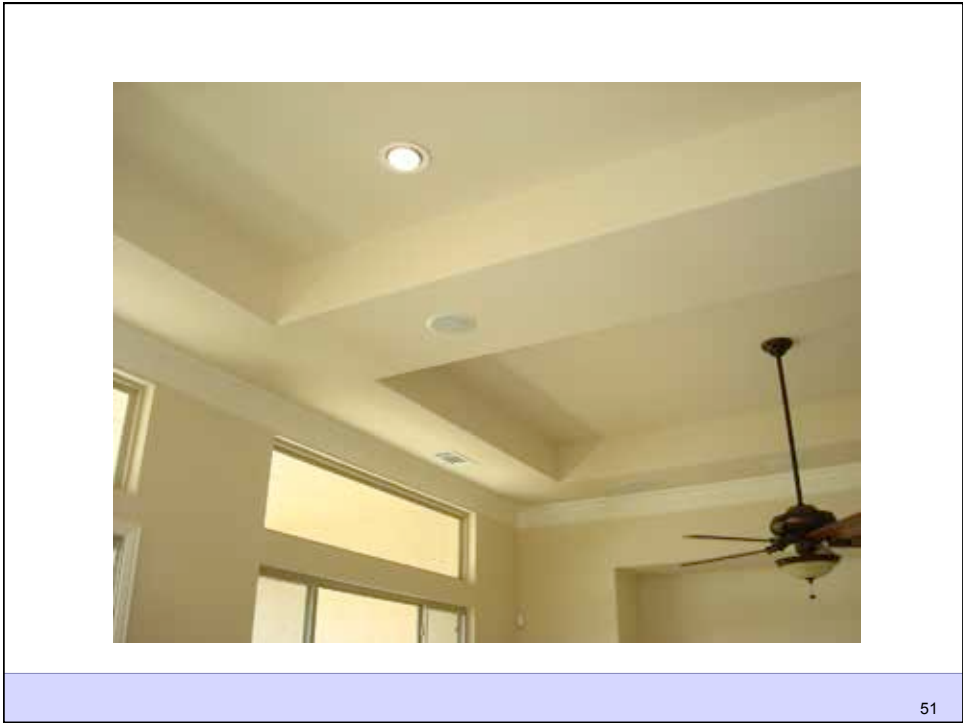


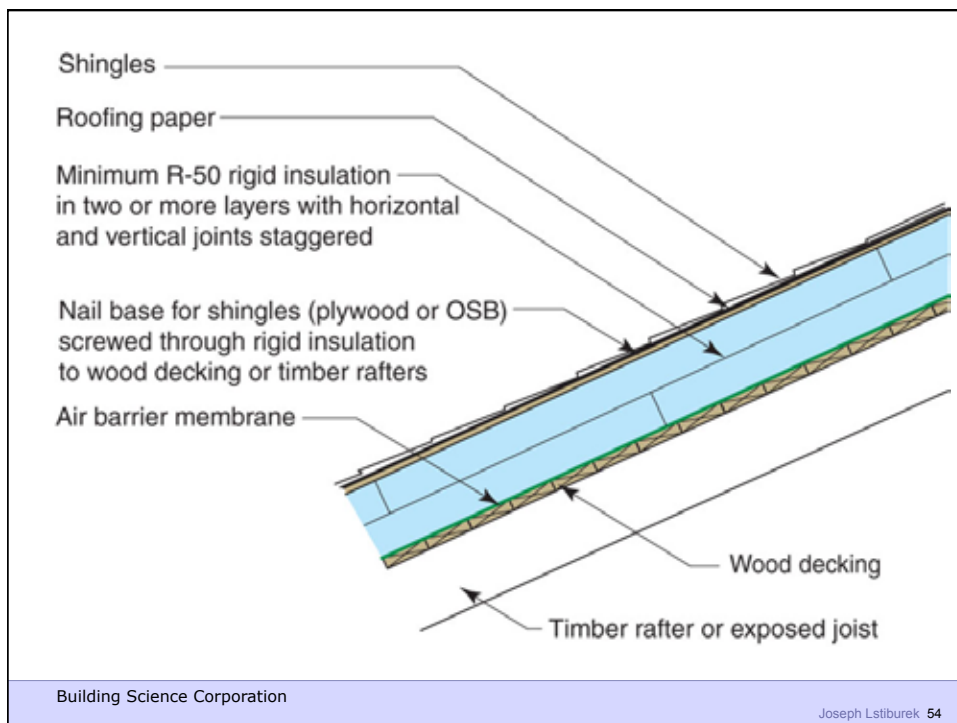
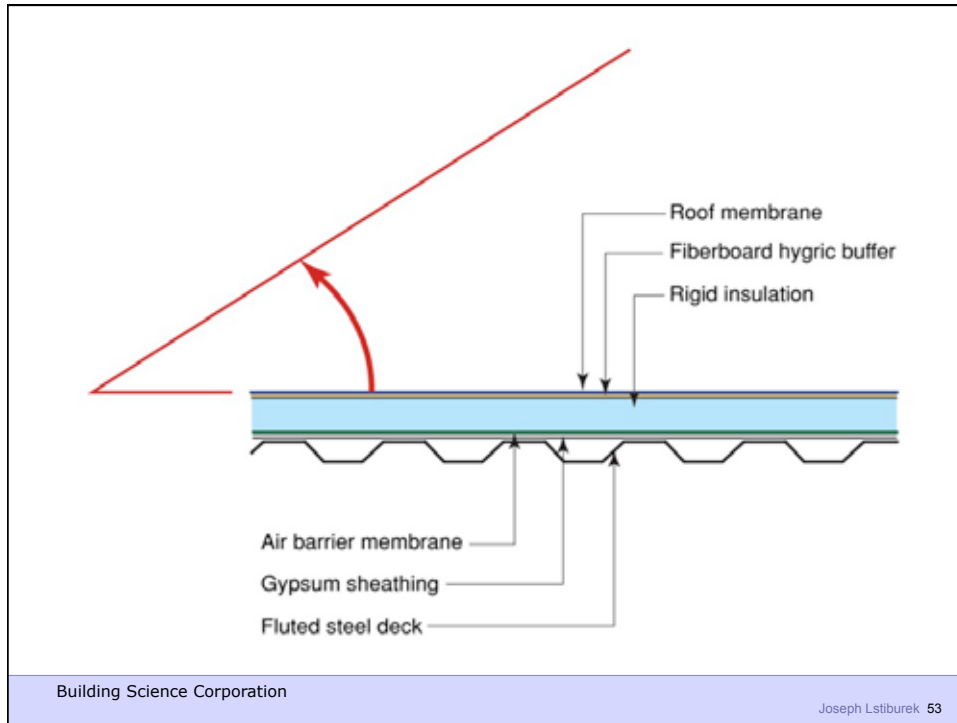
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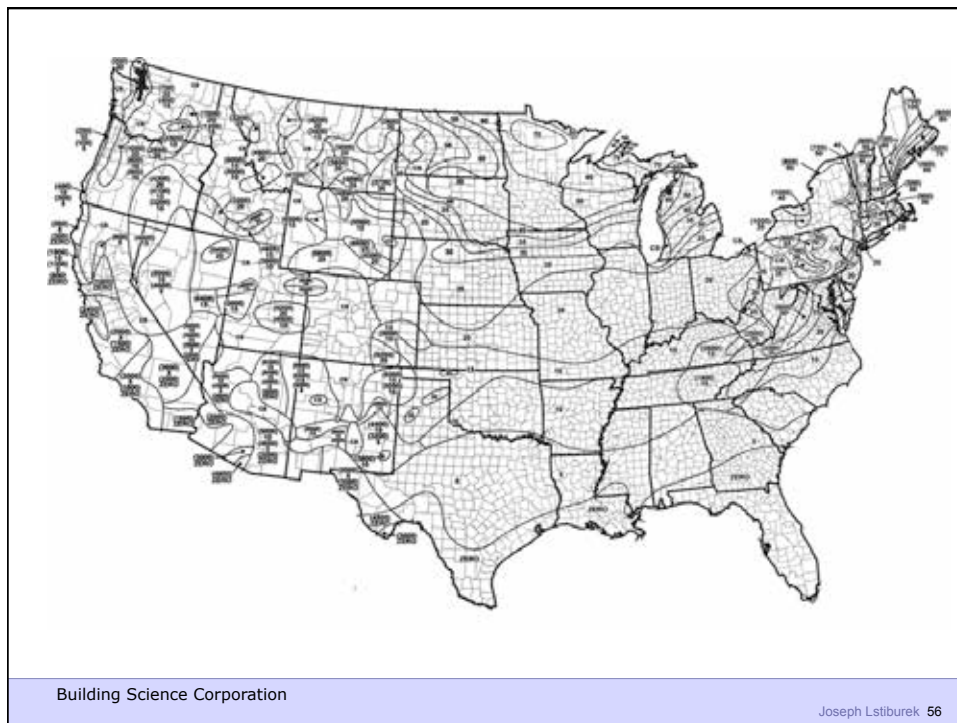
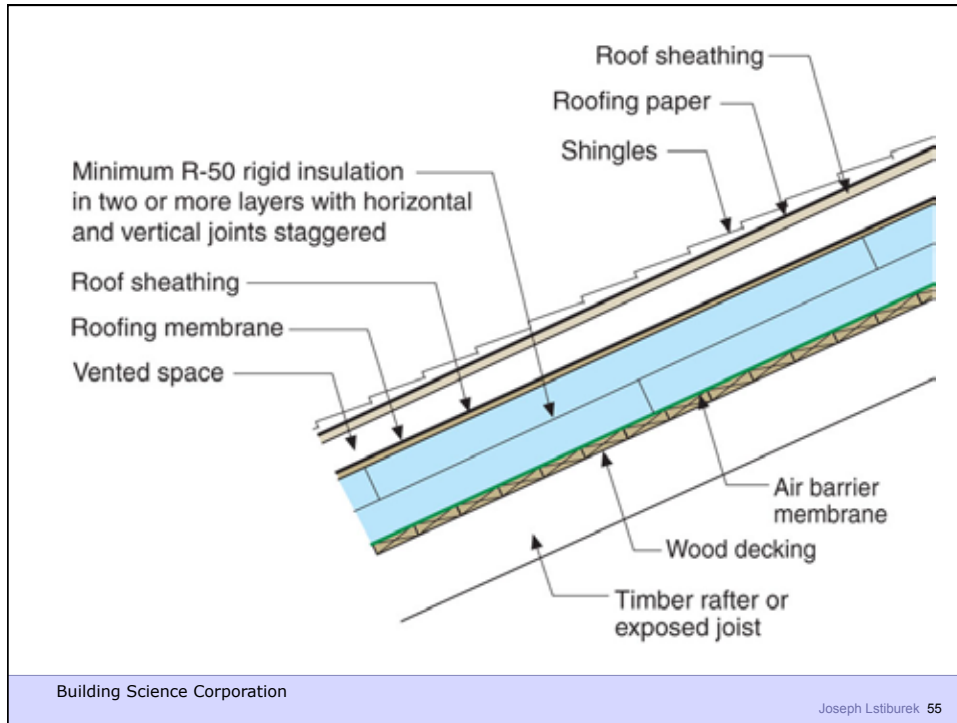
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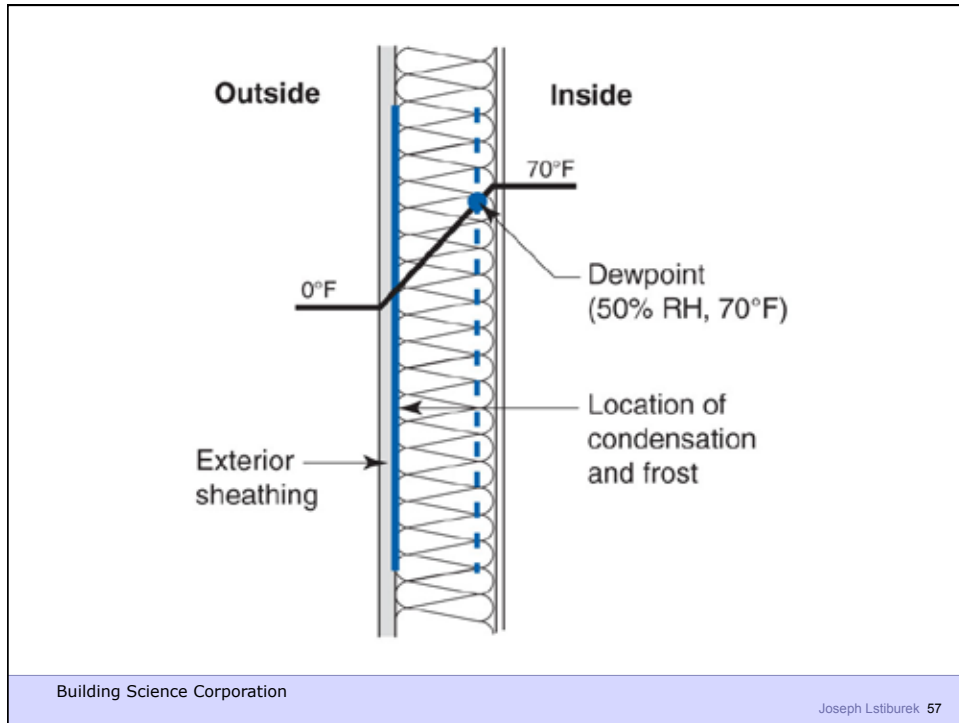


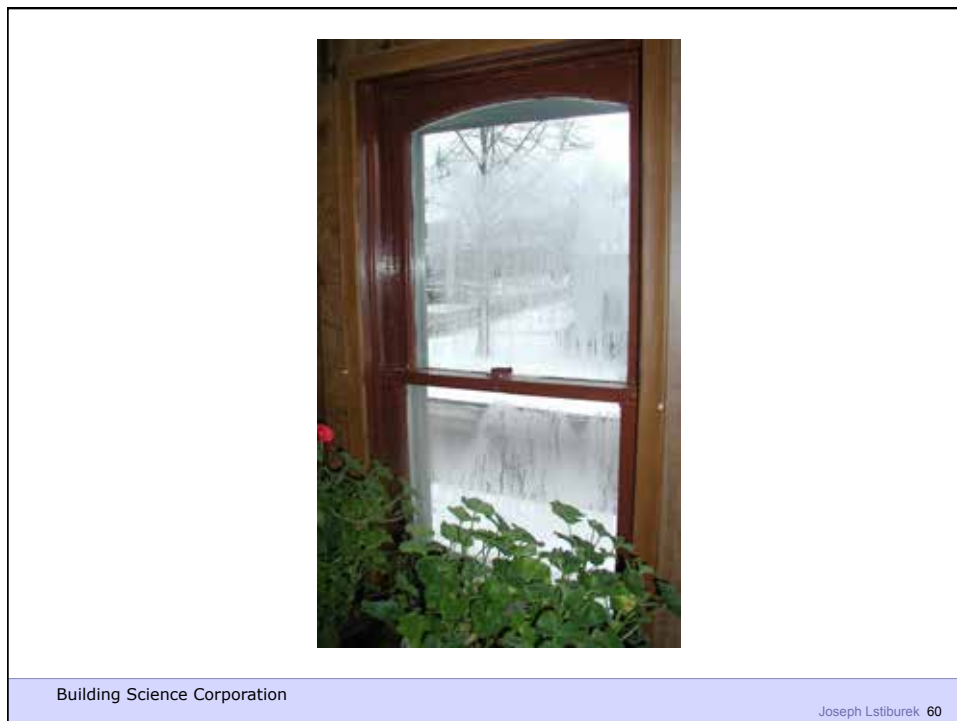
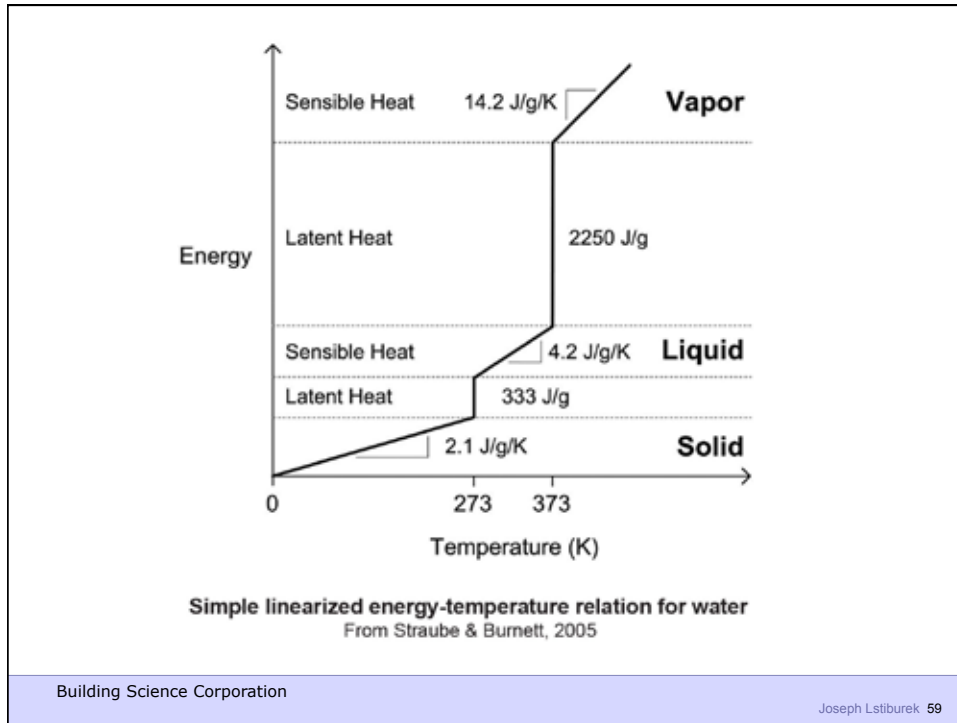
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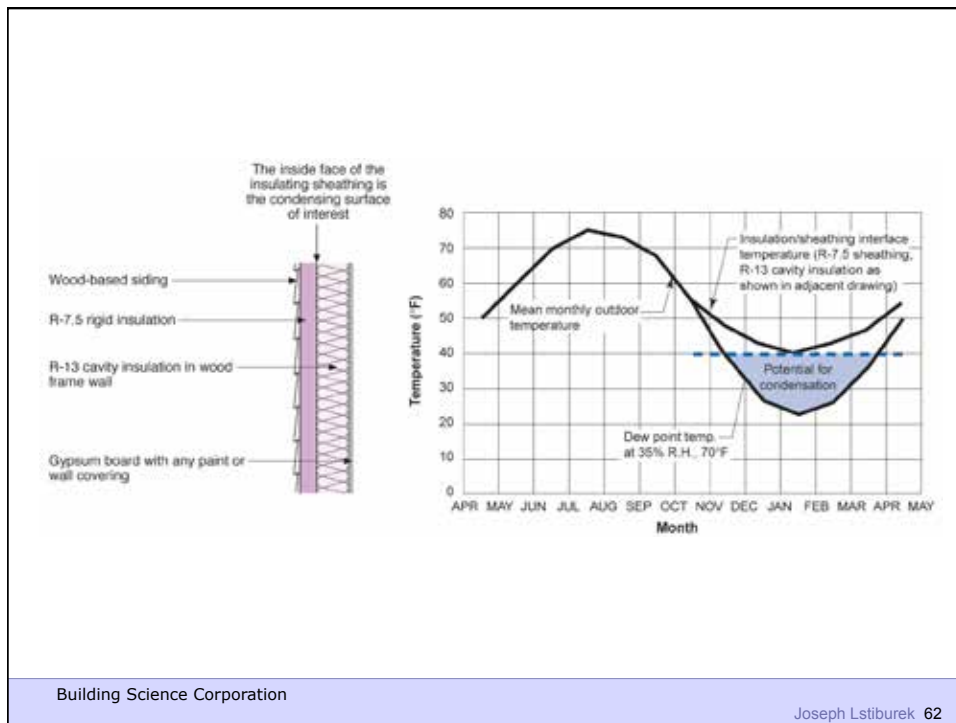
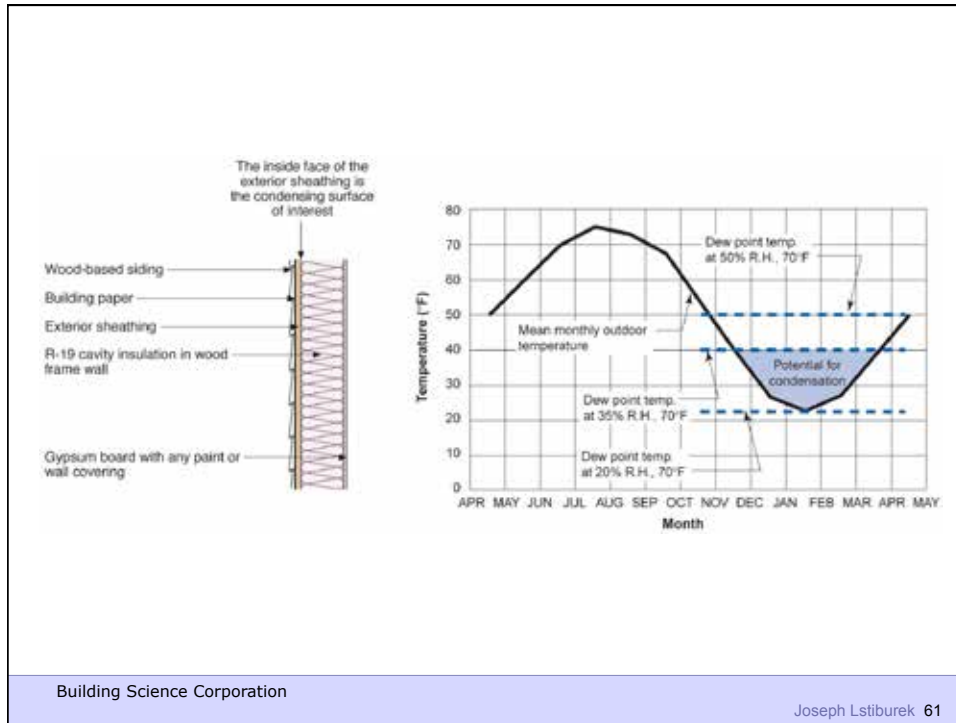


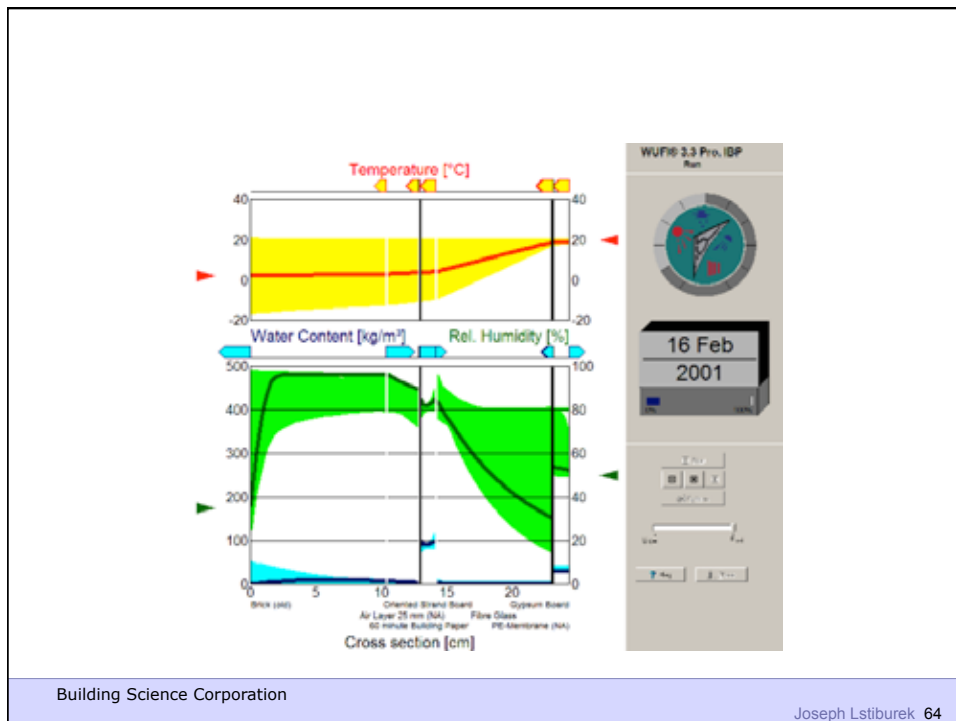
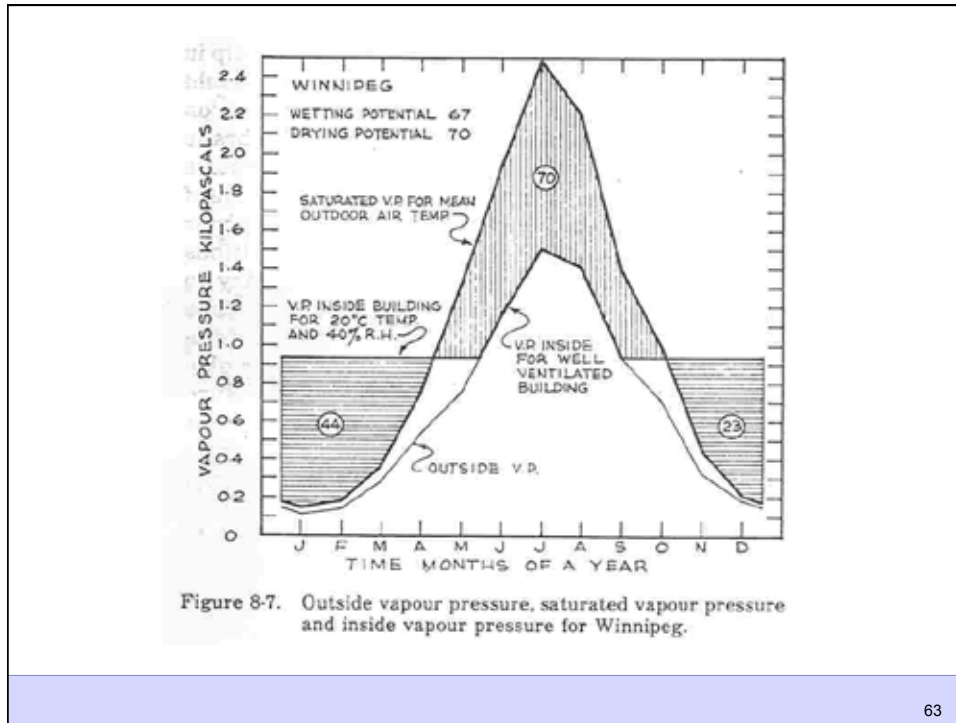


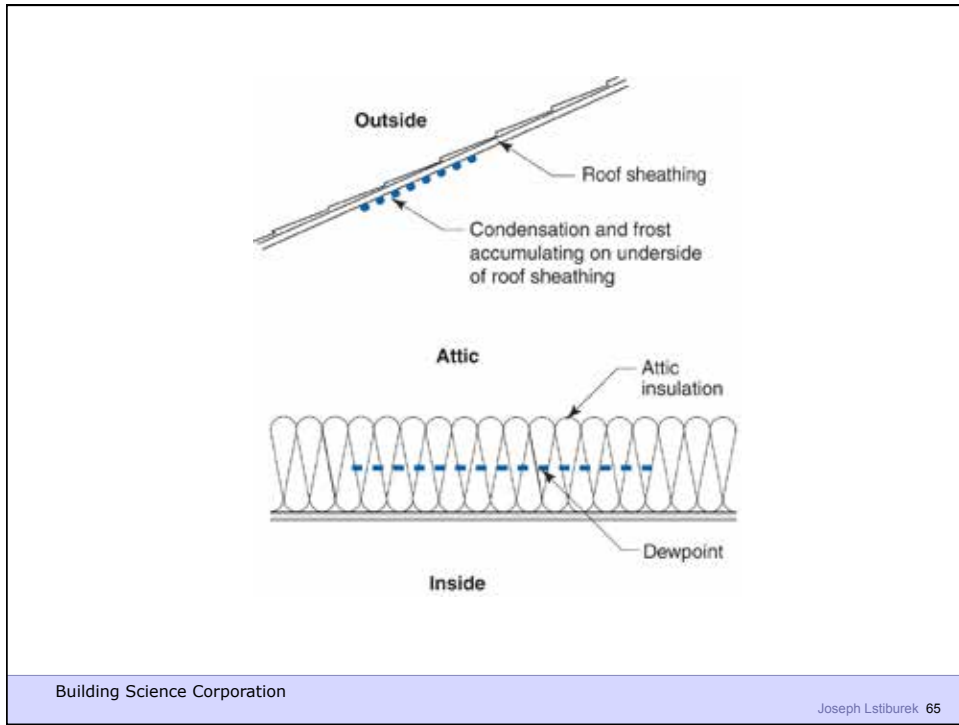


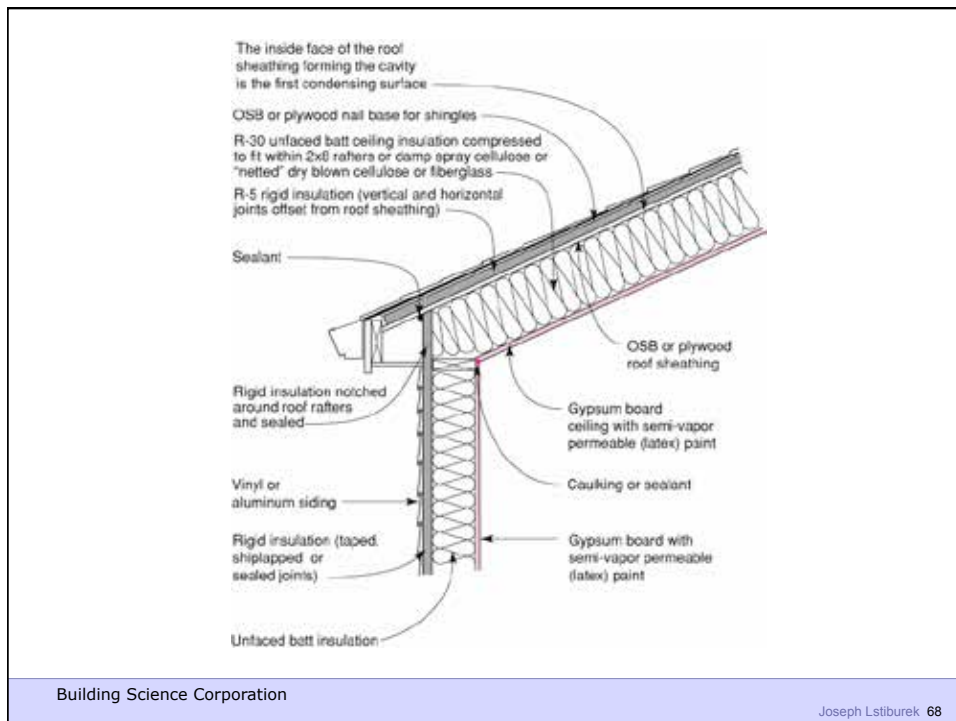
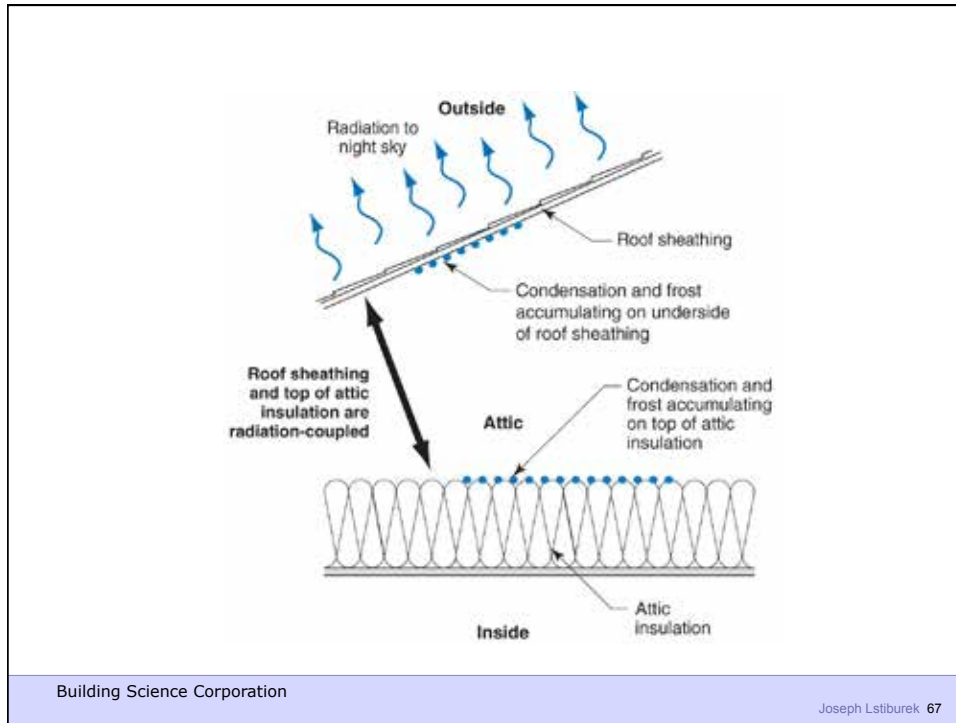


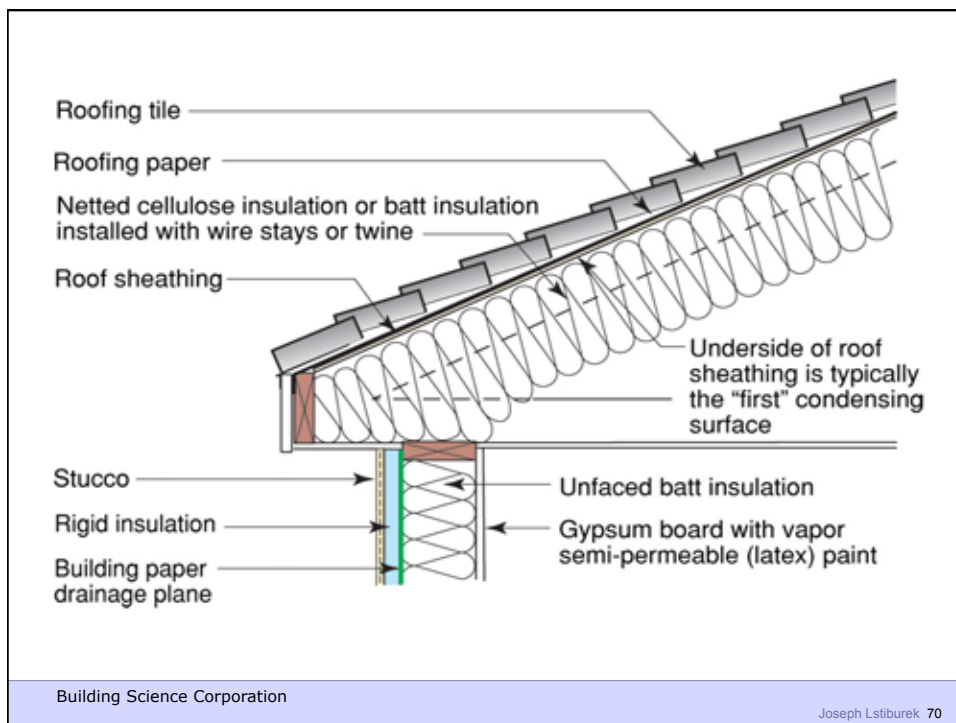
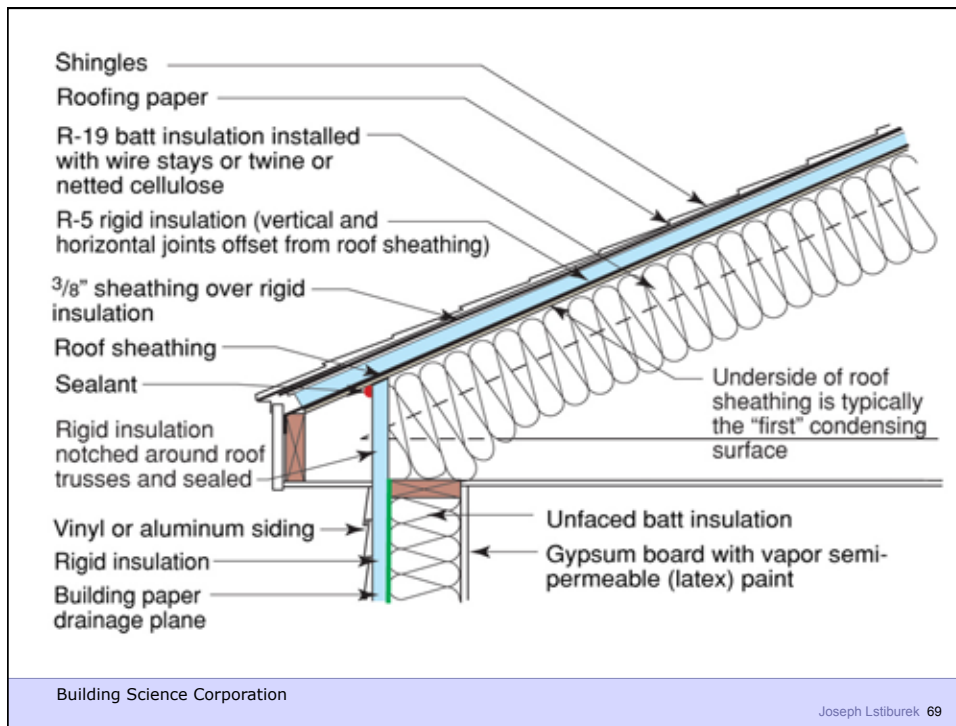


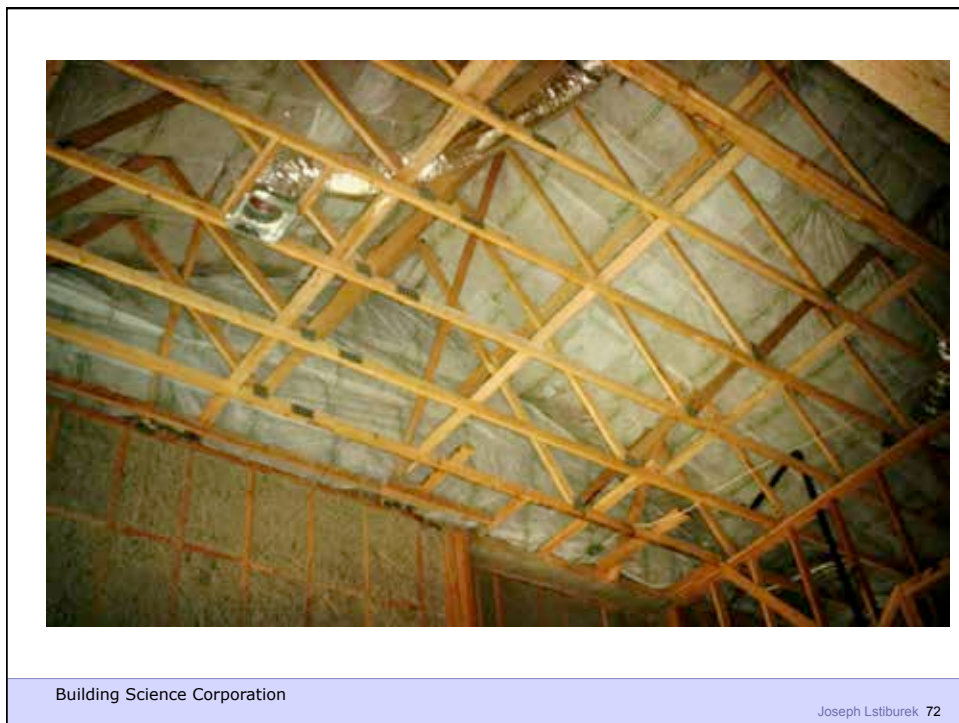


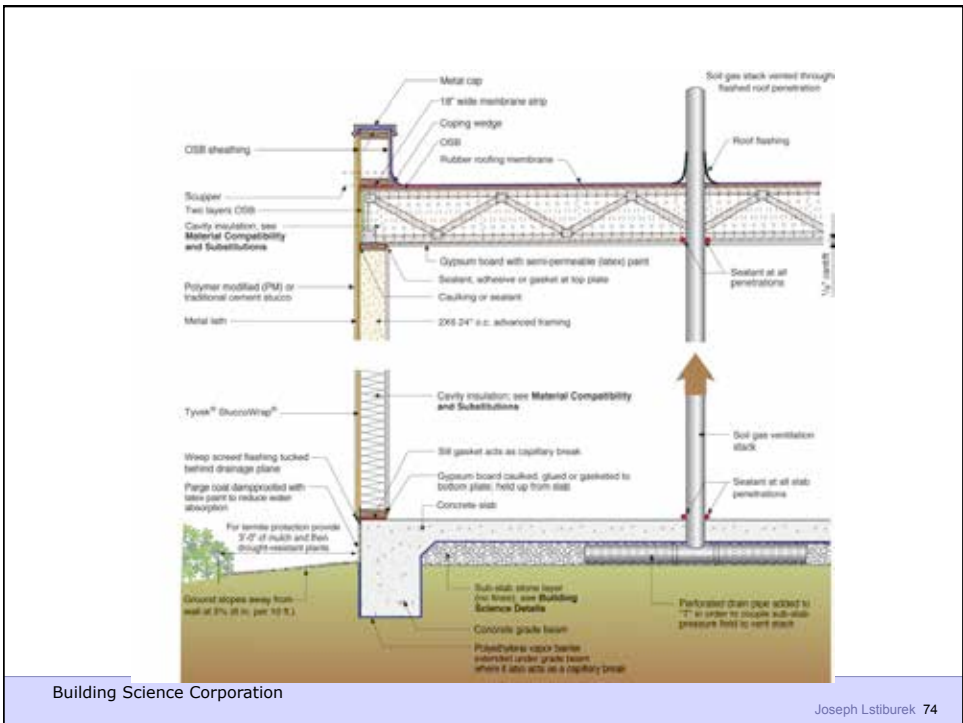












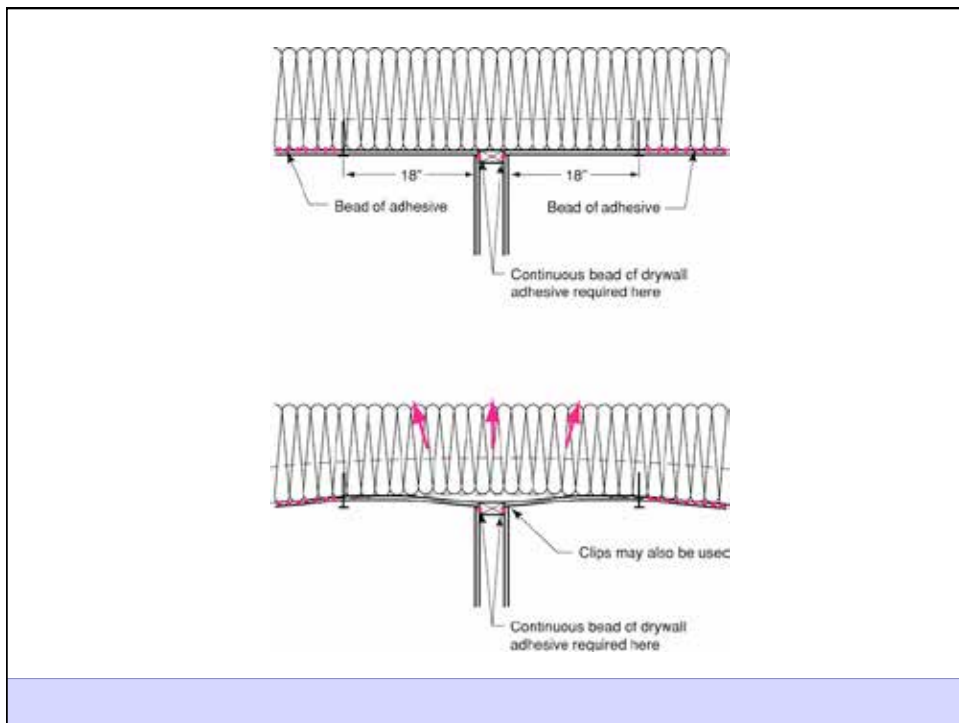
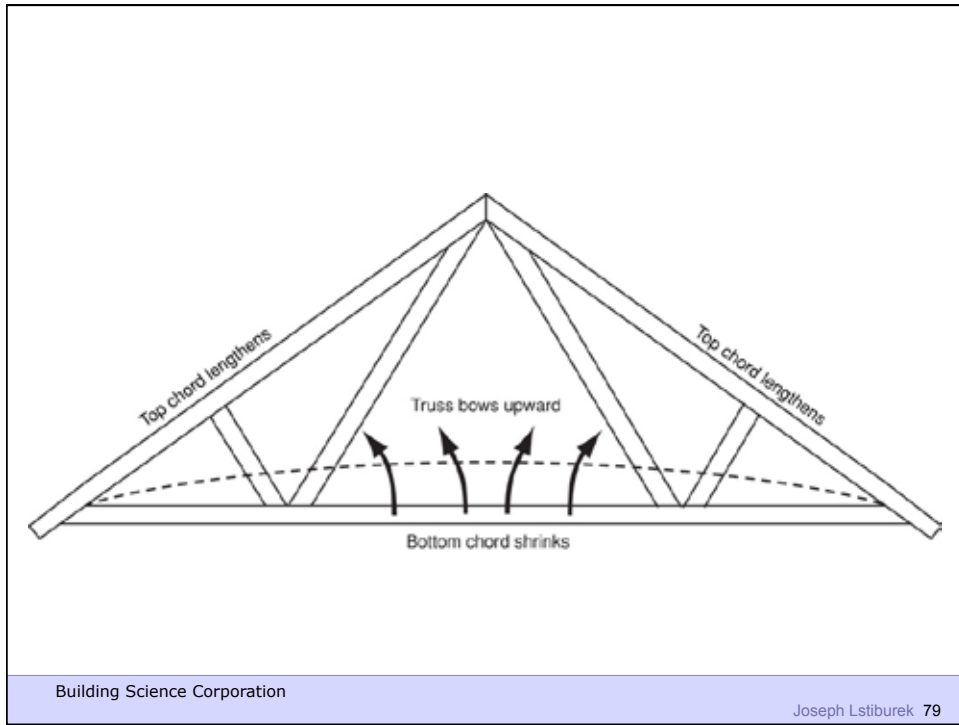
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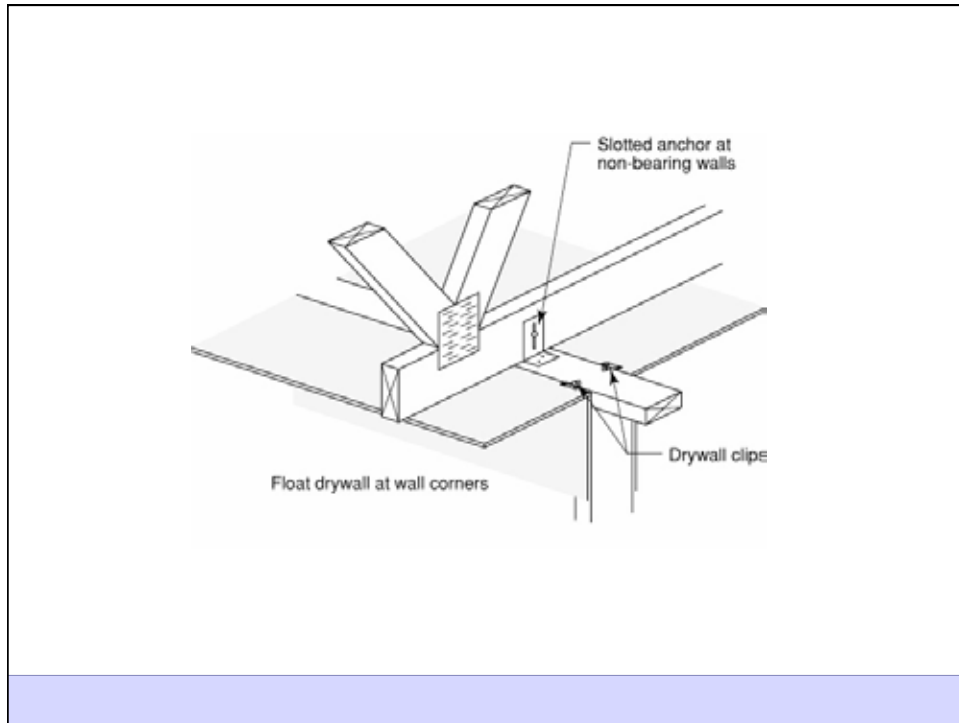
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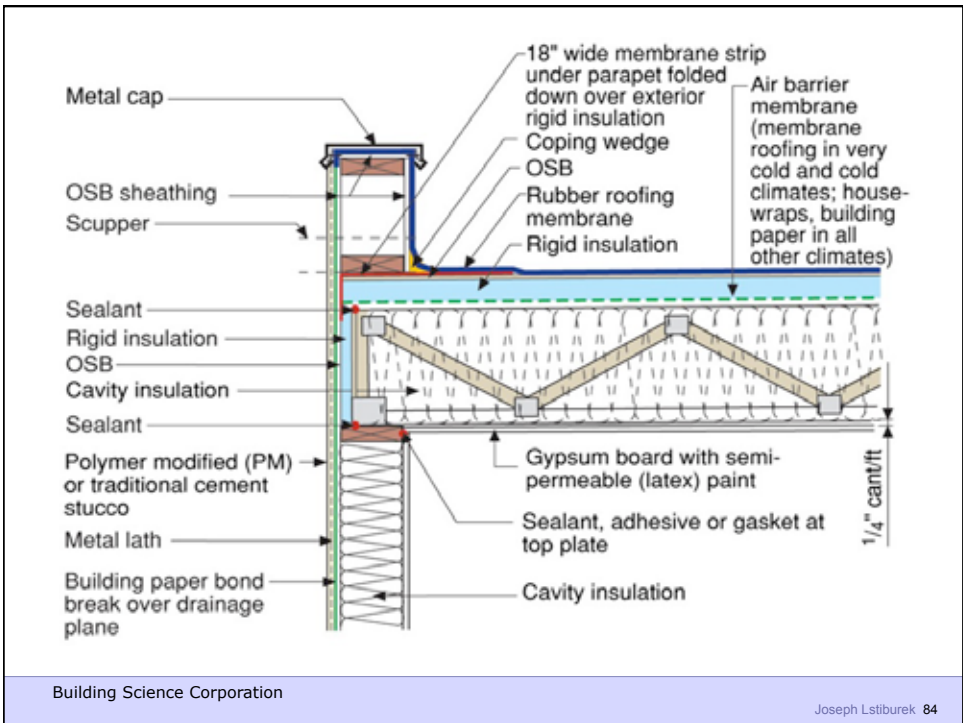
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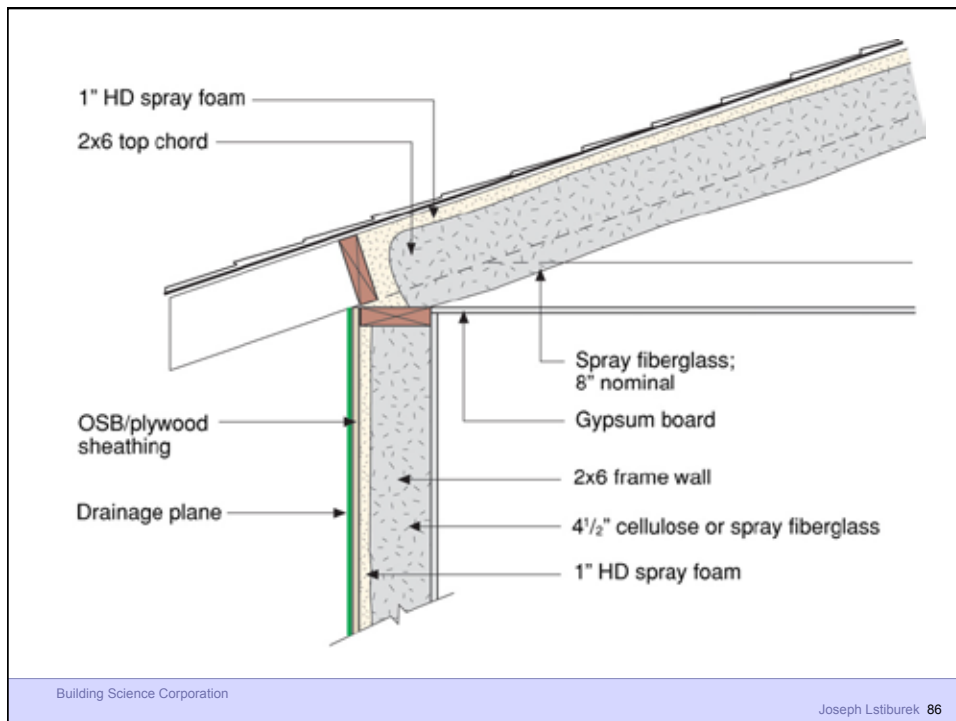
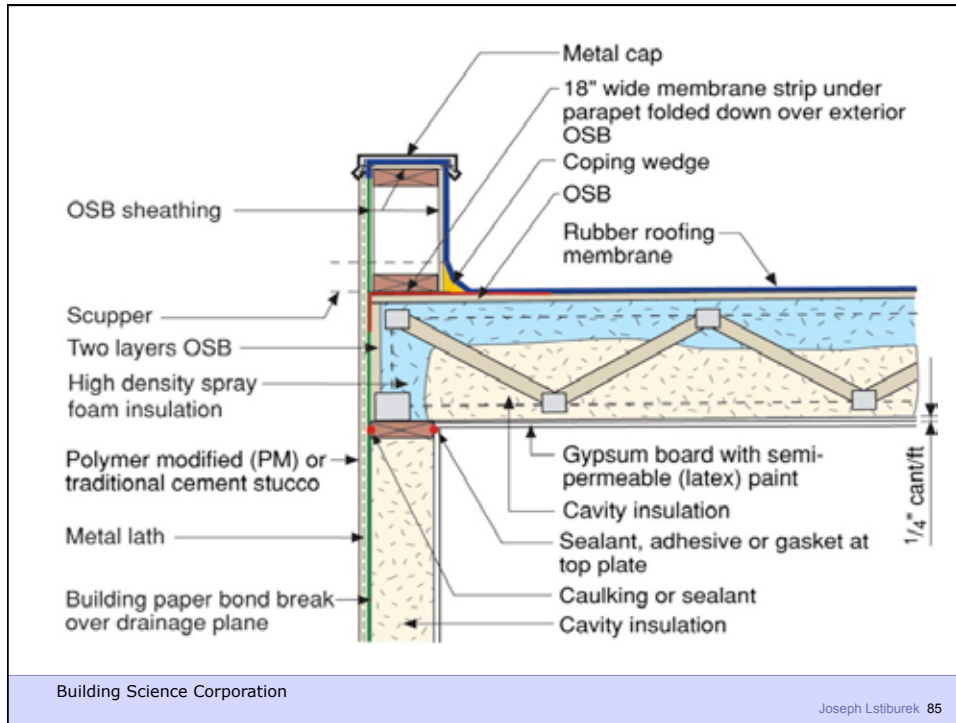


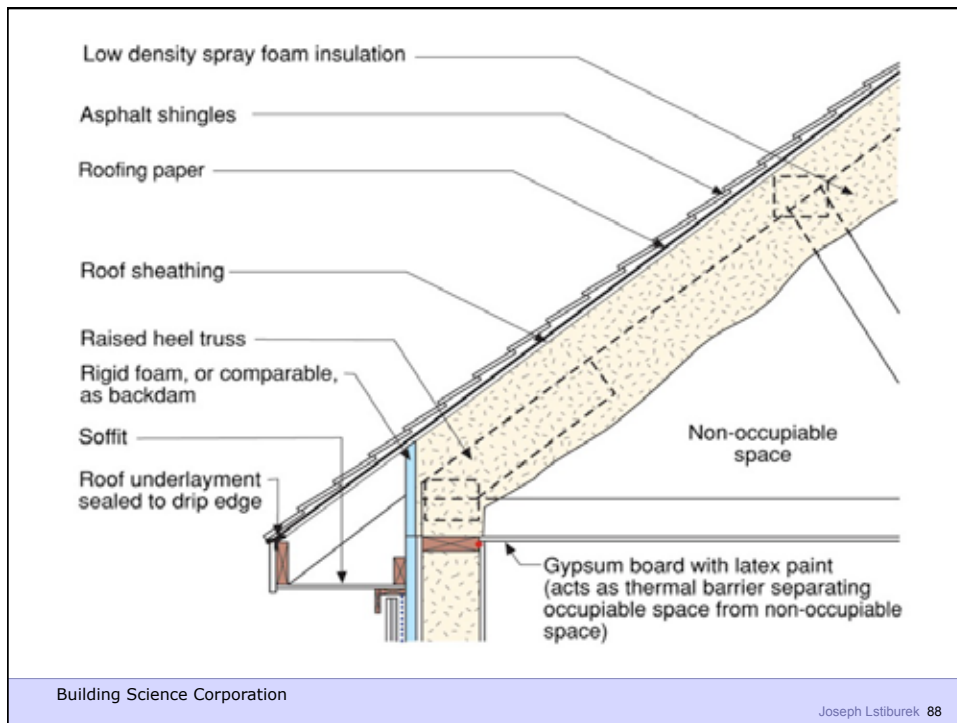
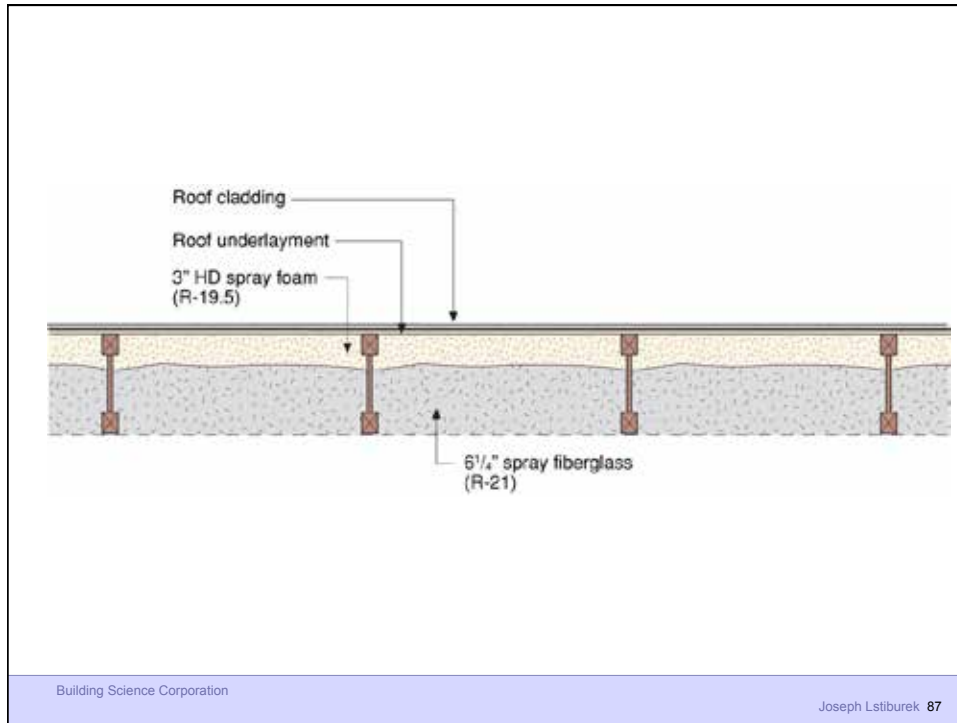














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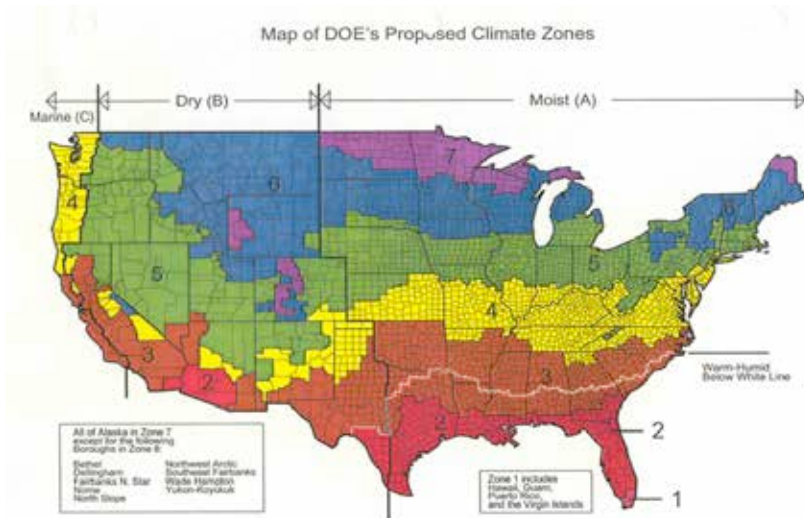
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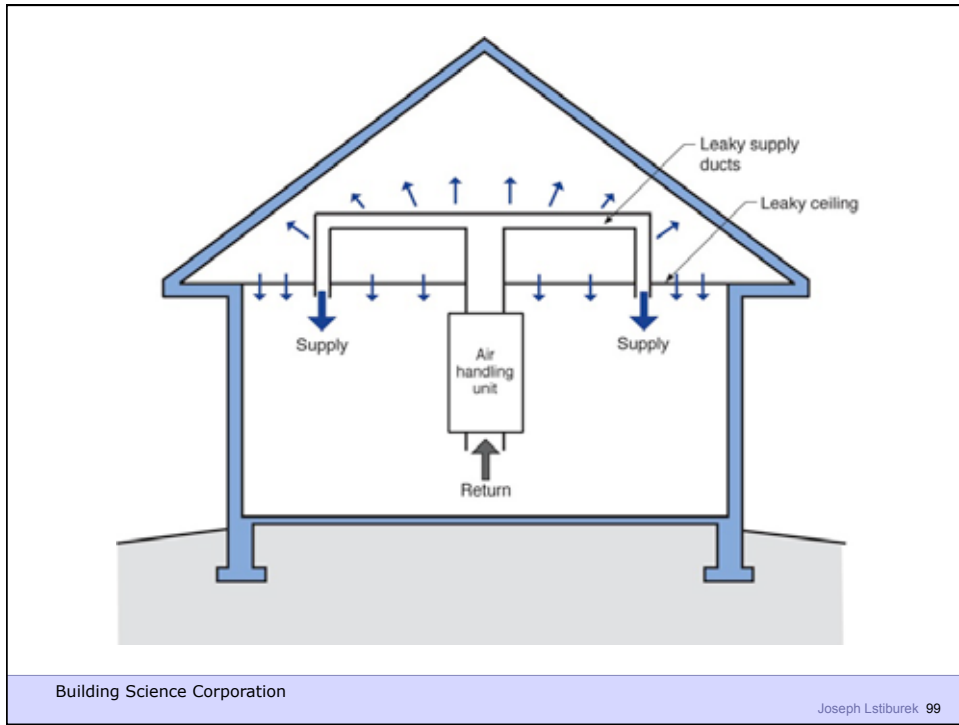
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Conditioned Attics Not Unvented Attics

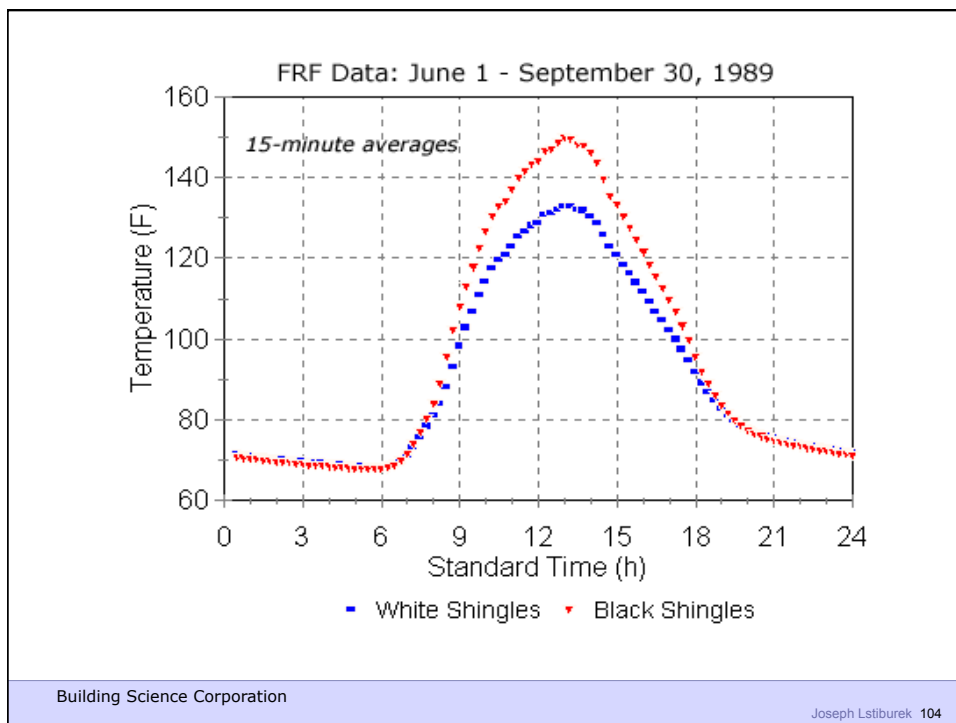
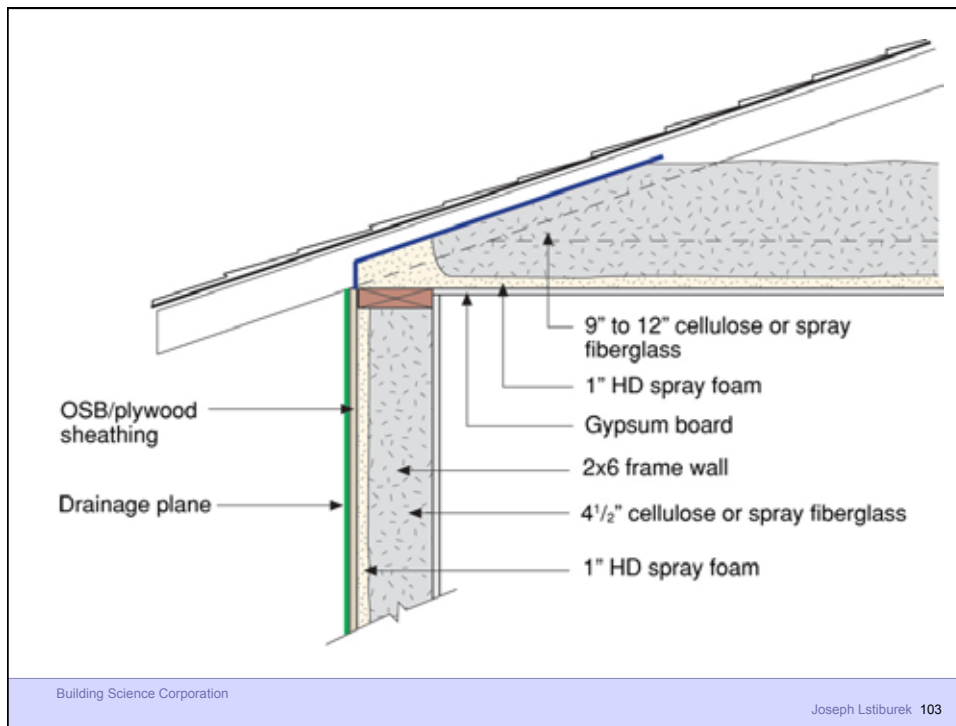
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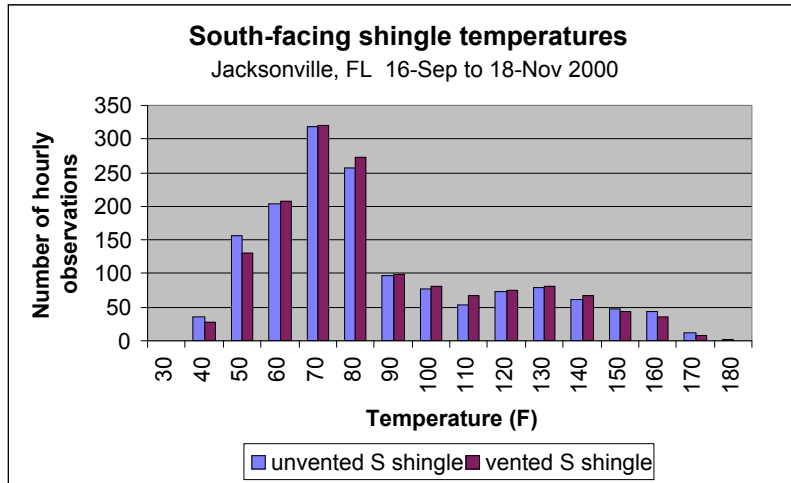


Conditioned Attics Not Unvented Attics
Need Supply Air

Conditioned Attics Not Unvented Attics
Need Supply Air
50 cfm/1000 ft² of Attic

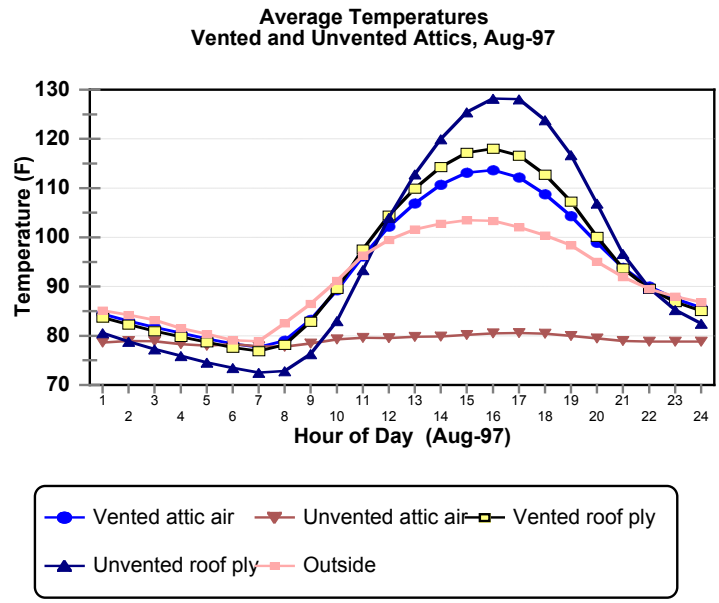


Vented vs. unvented shingle temperatures



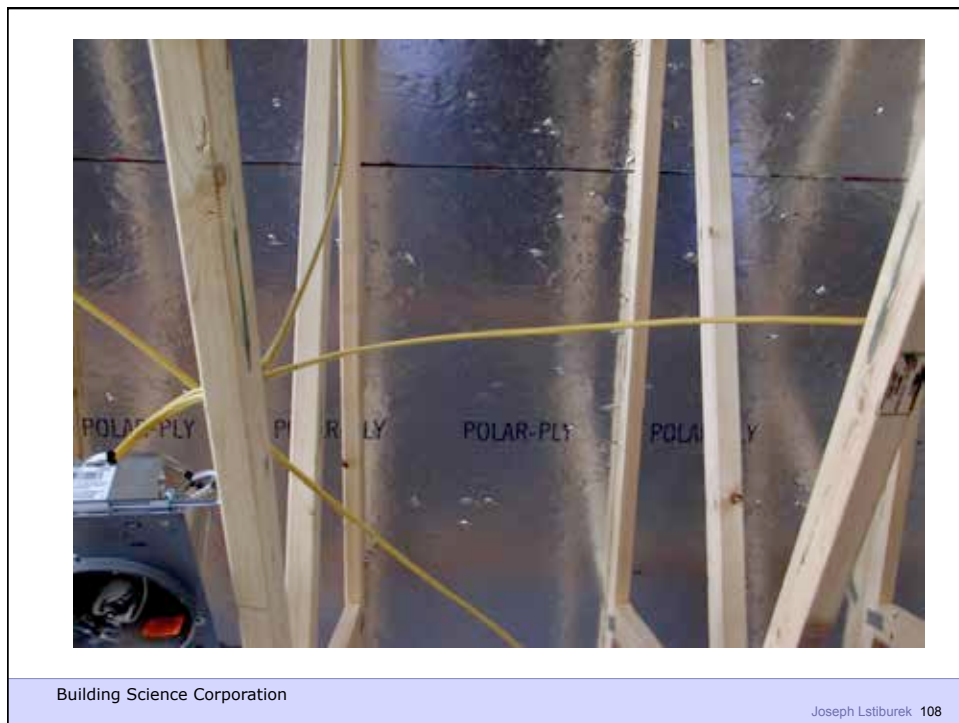
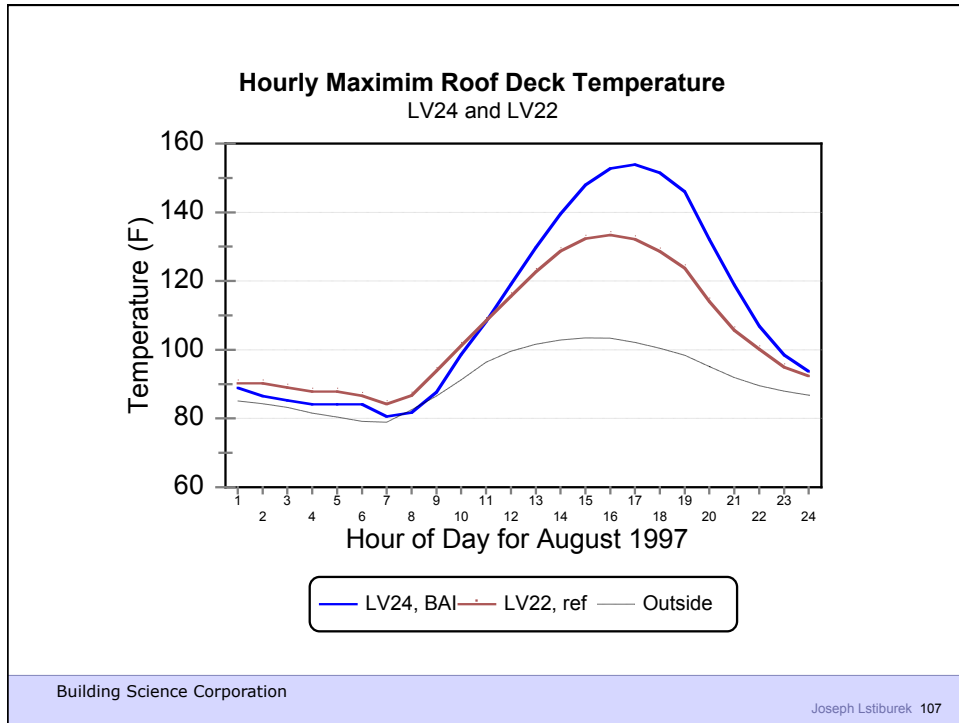
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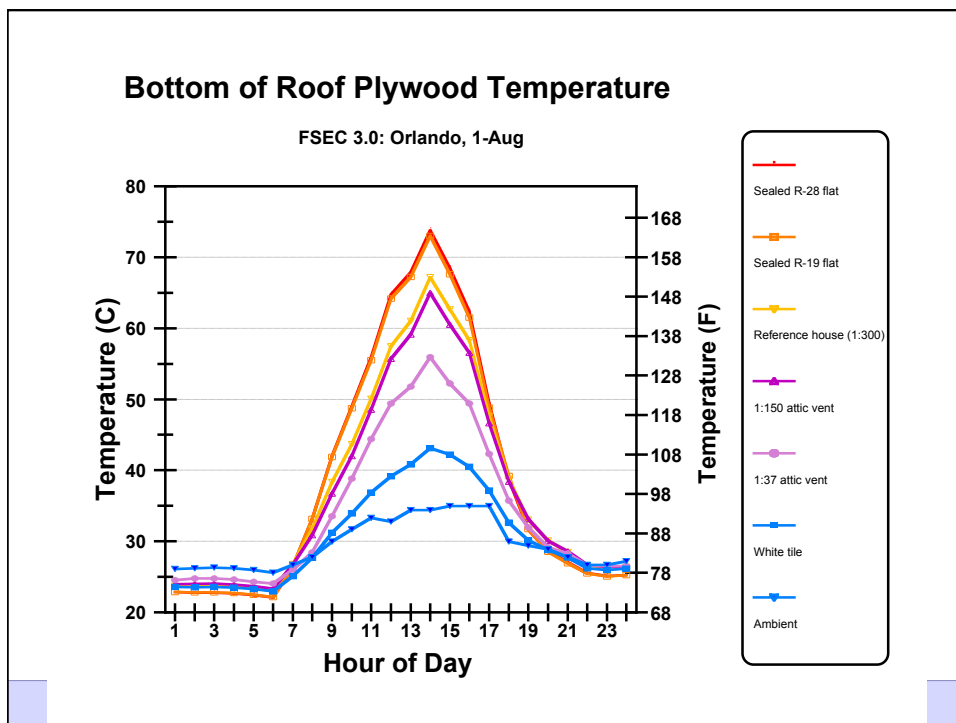
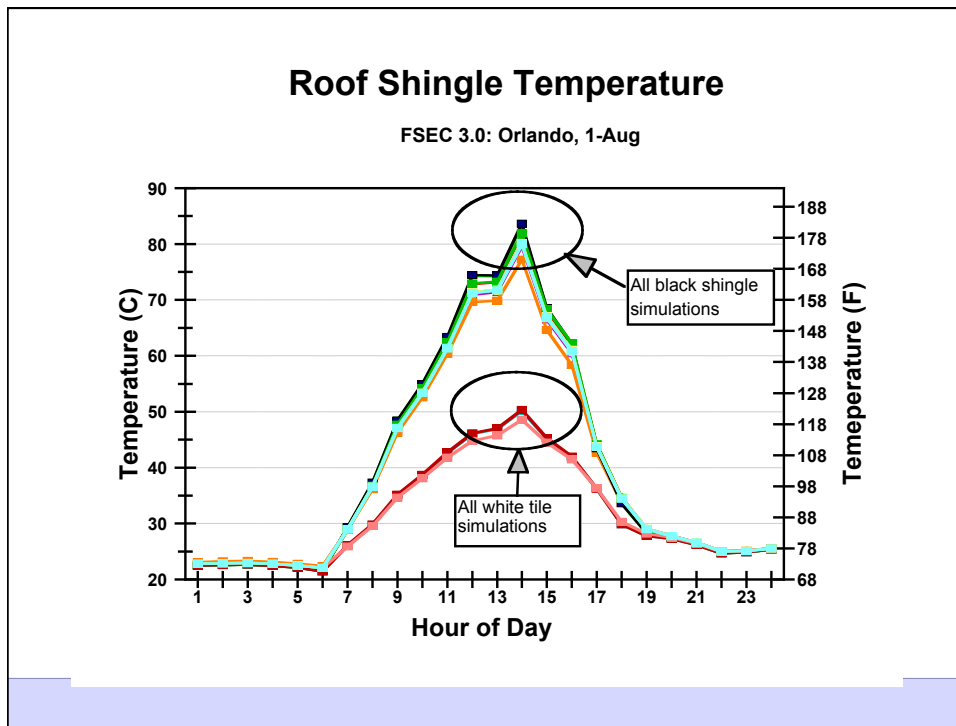
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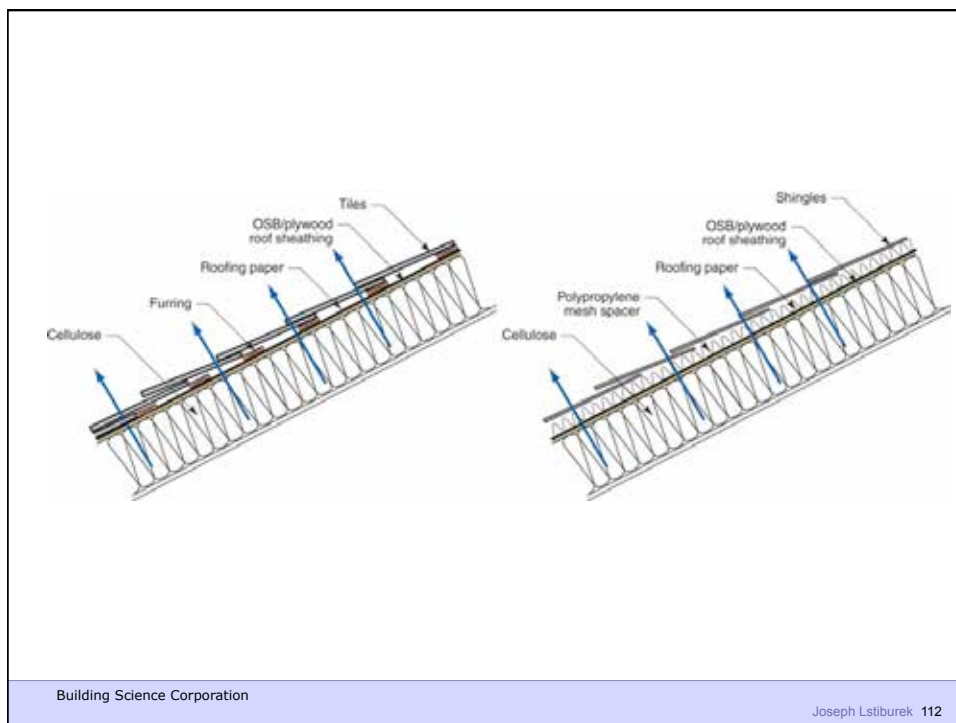
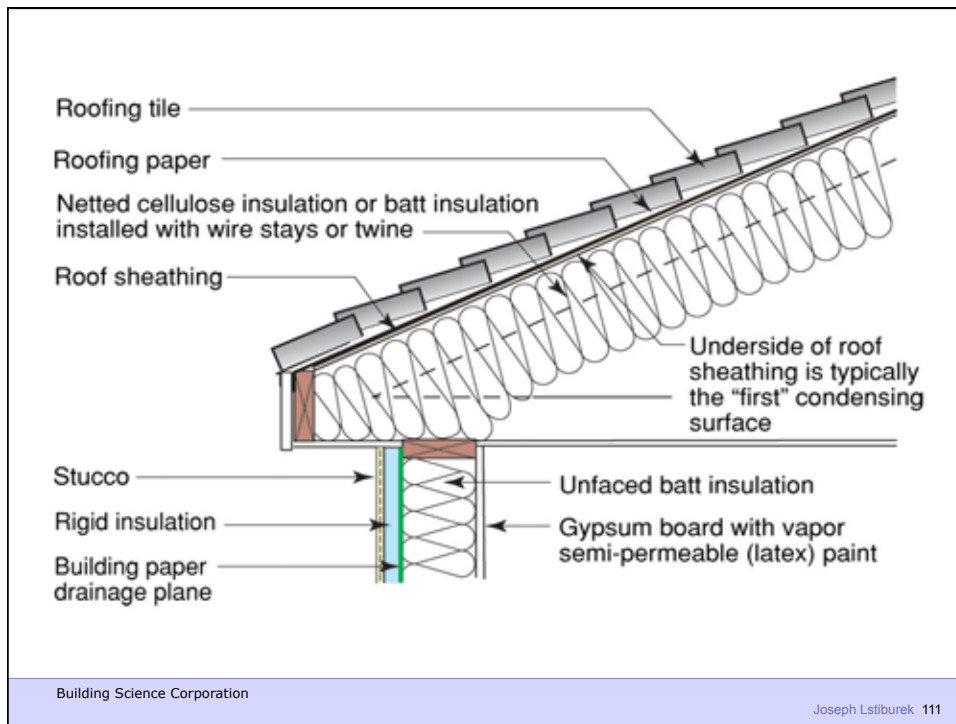


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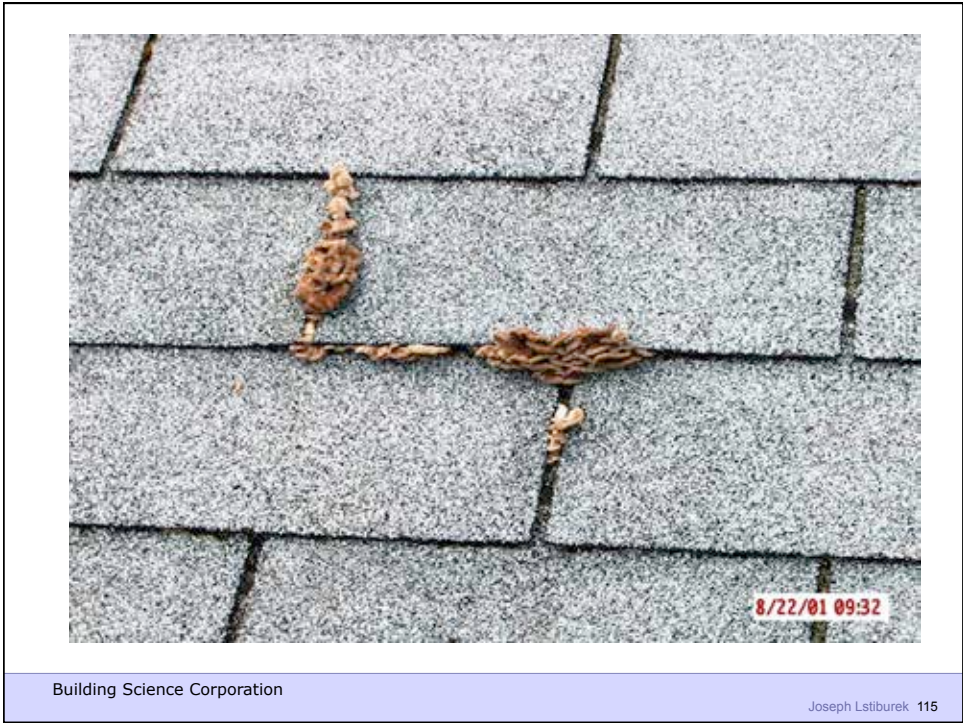
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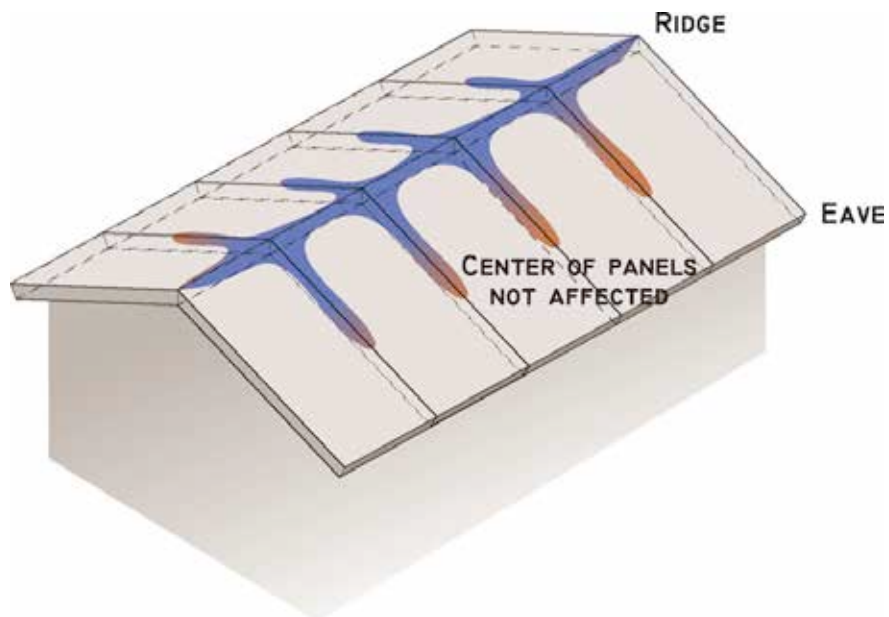
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Joseph Lstiburek 118



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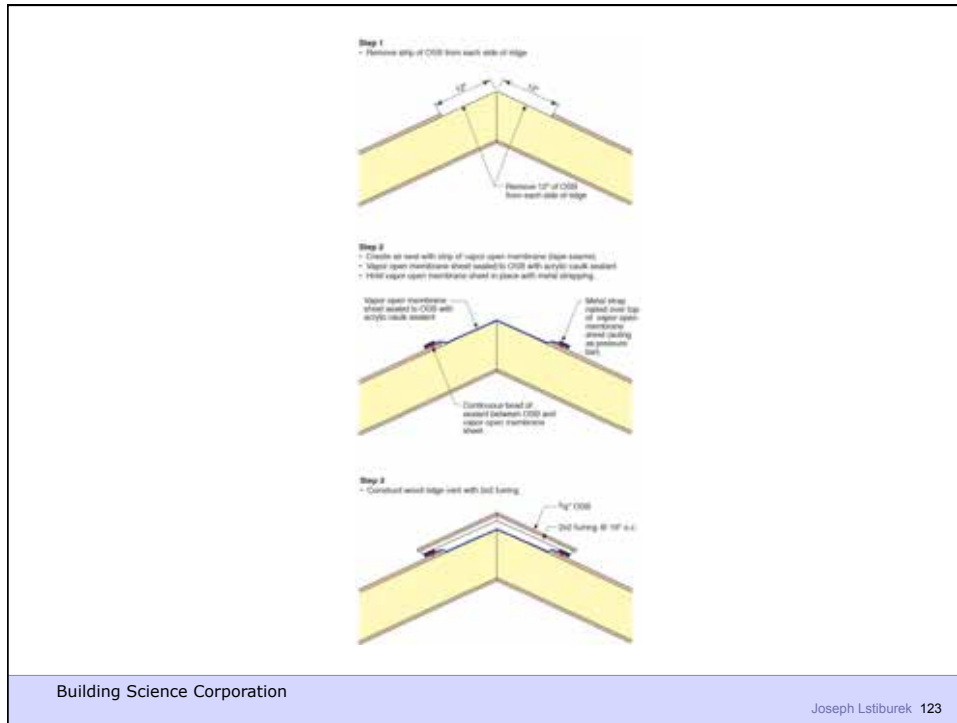
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Joseph Lstiburek 120





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Joseph Lstiburek 123



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Joseph Lstiburek 124



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Joseph Lstiburek 125



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Joseph Lstiburek 126



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Joseph Lstiburek 127



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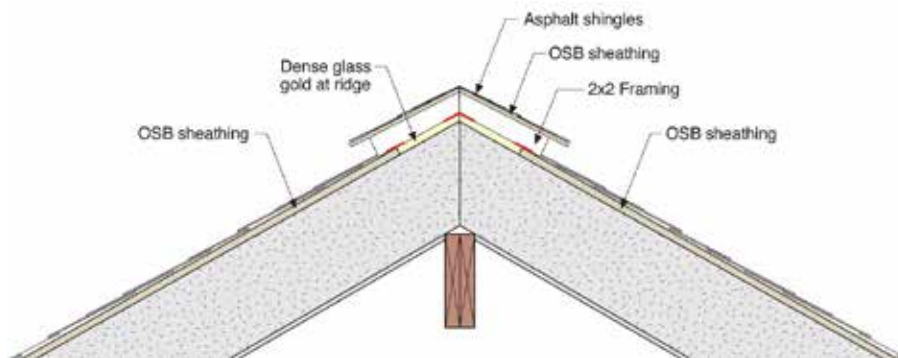
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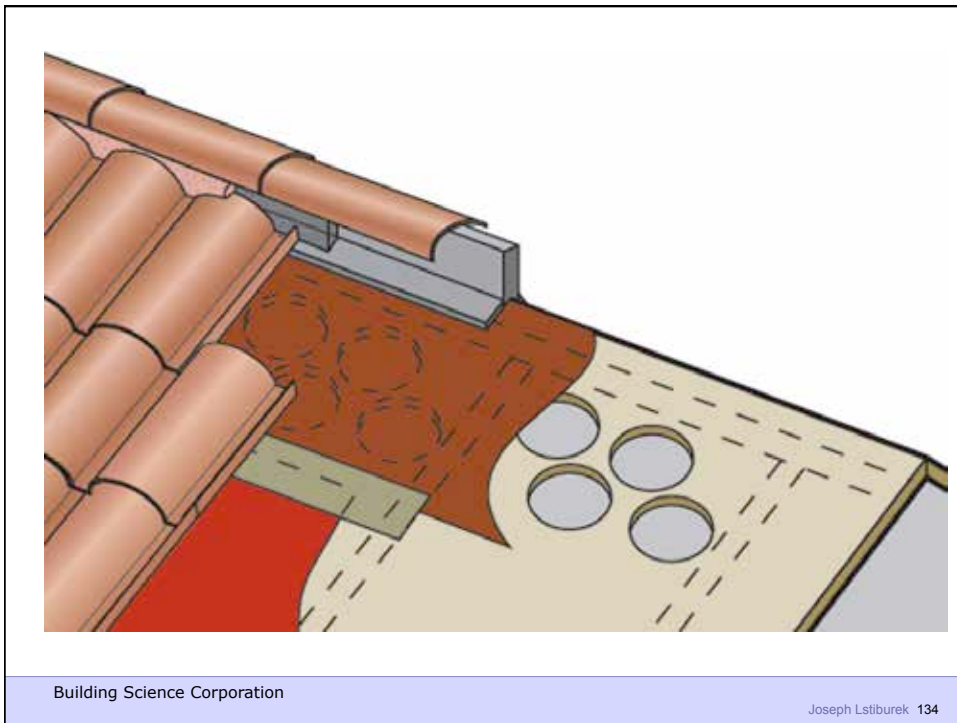
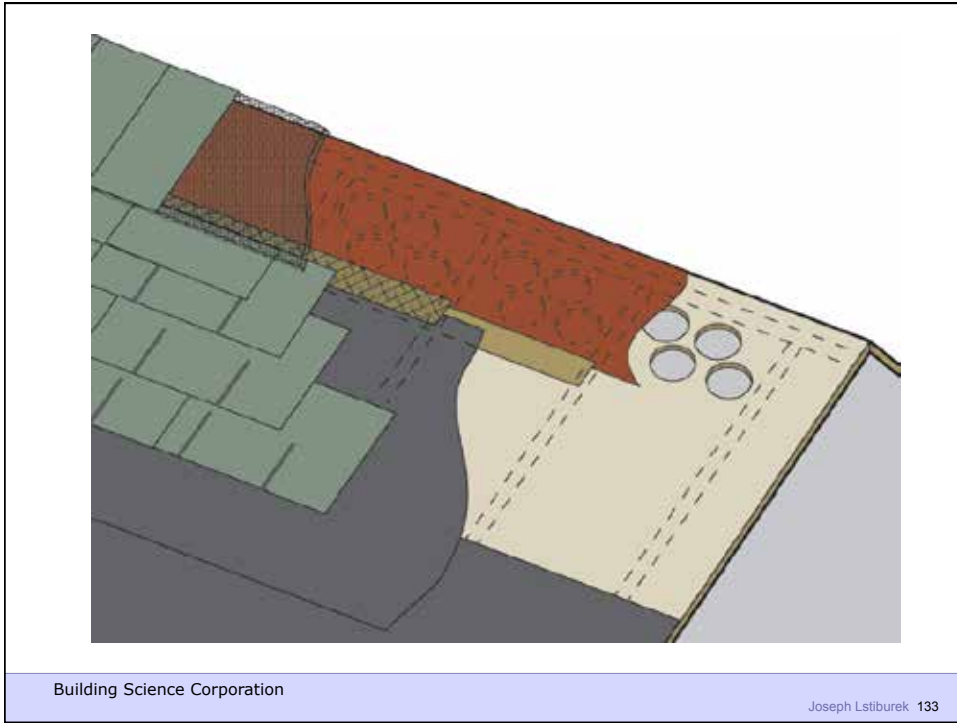
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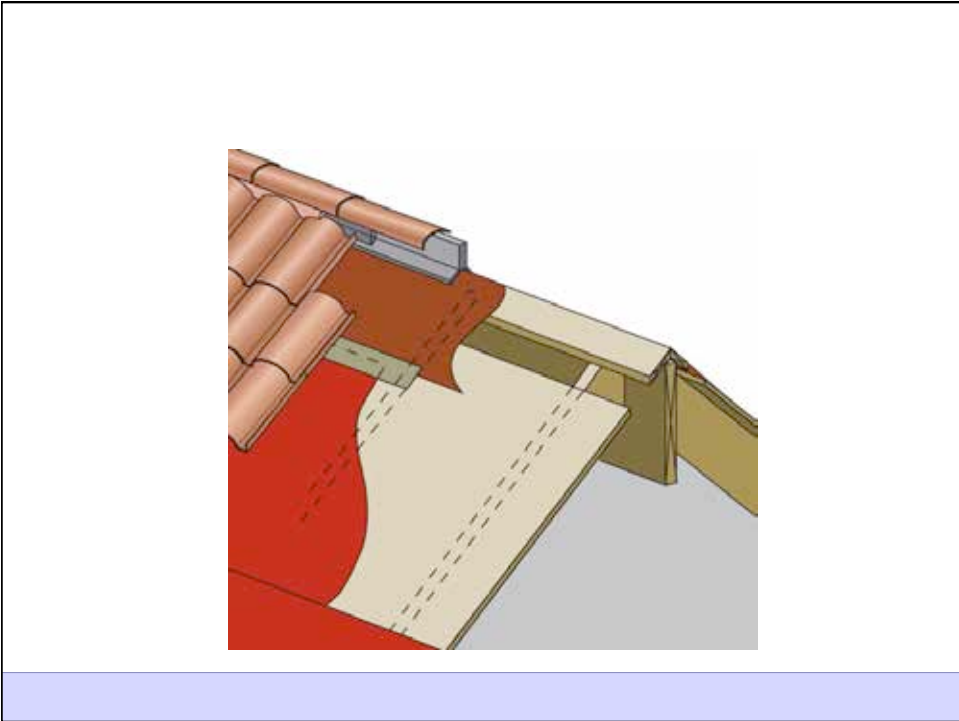
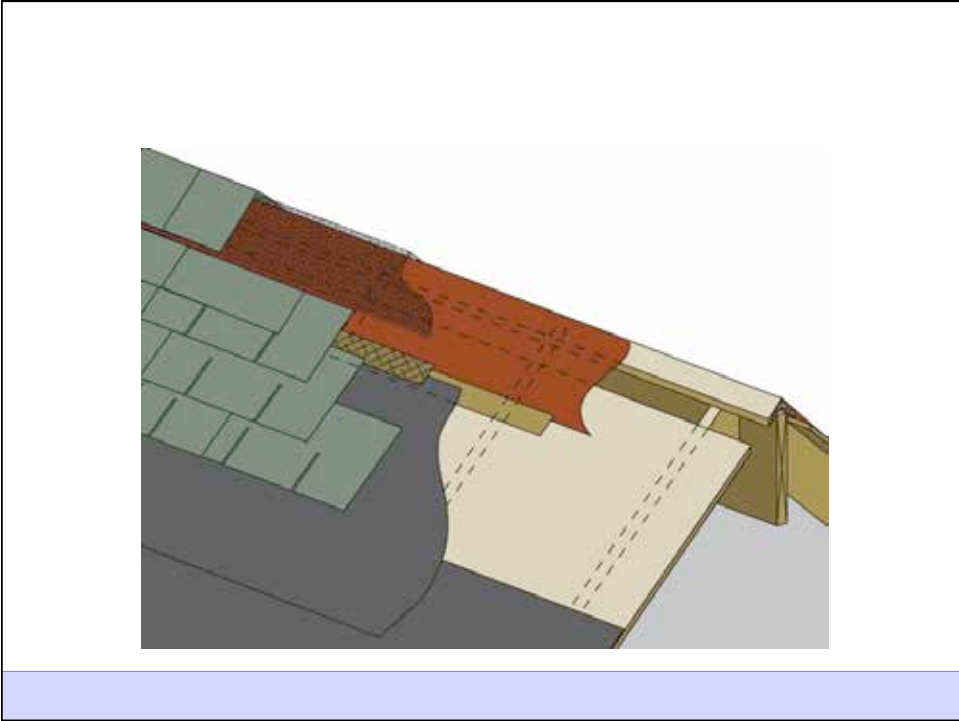
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Joseph Lstiburek 137



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Joseph Lstiburek 138



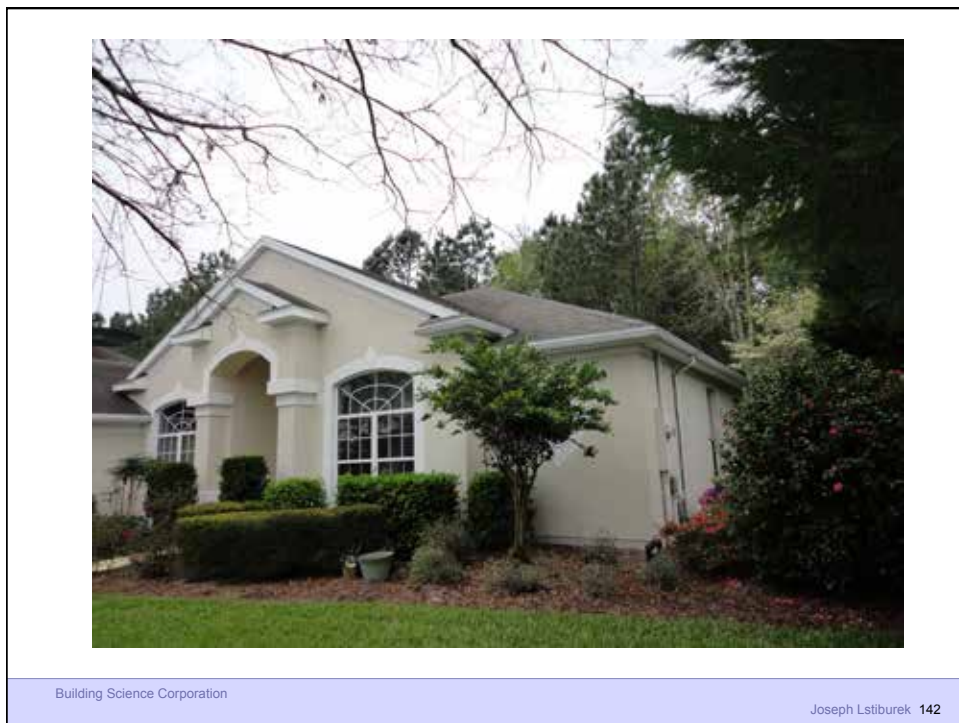
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Joseph Lstiburek 140





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Joseph Lstiburek 143



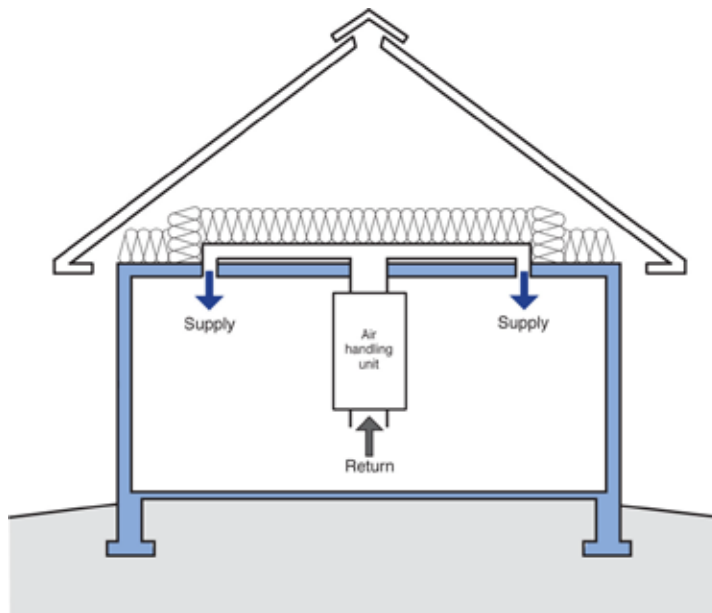
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Burying Ducts

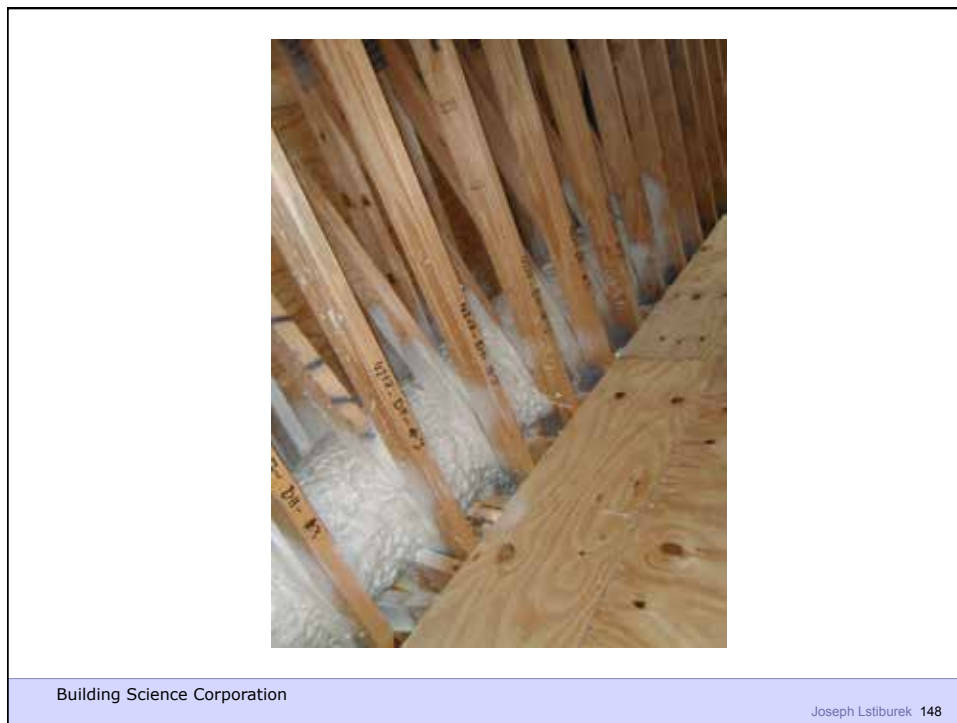
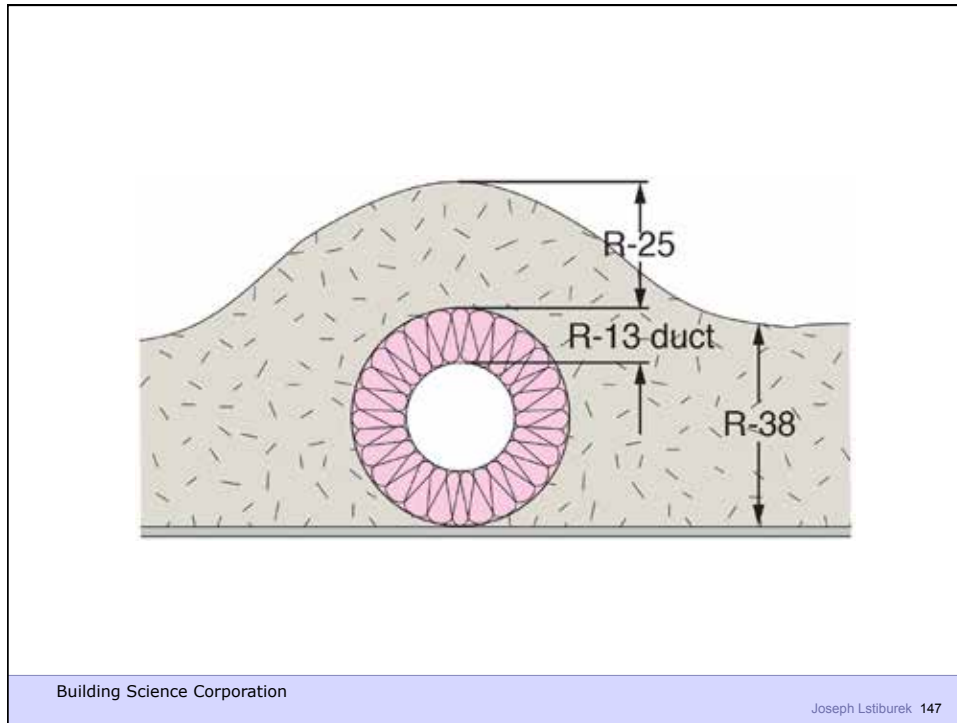
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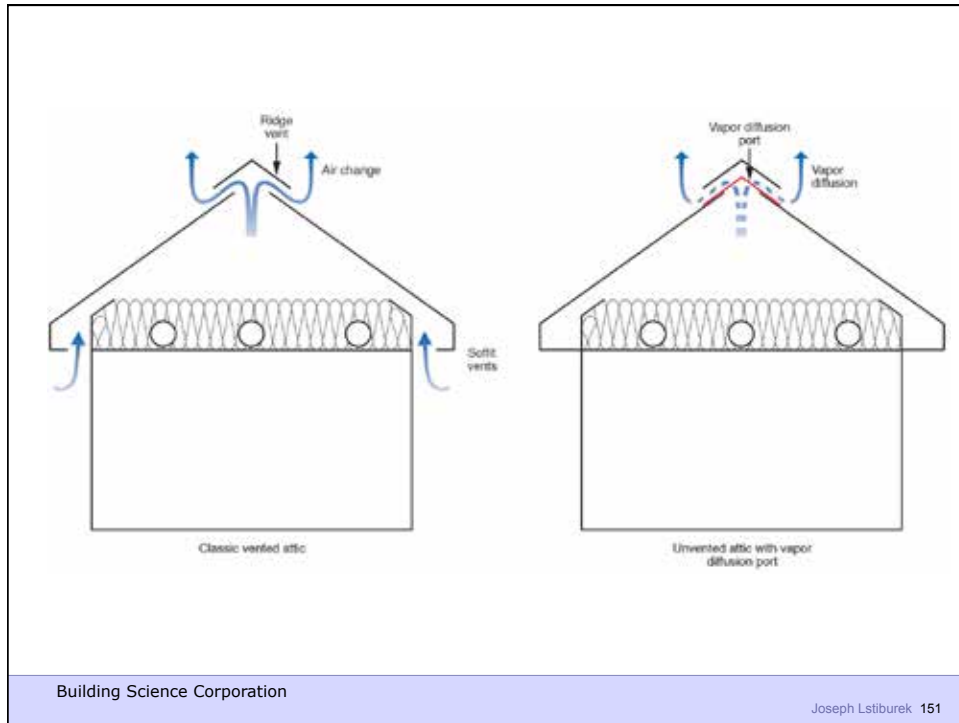
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Where It Started

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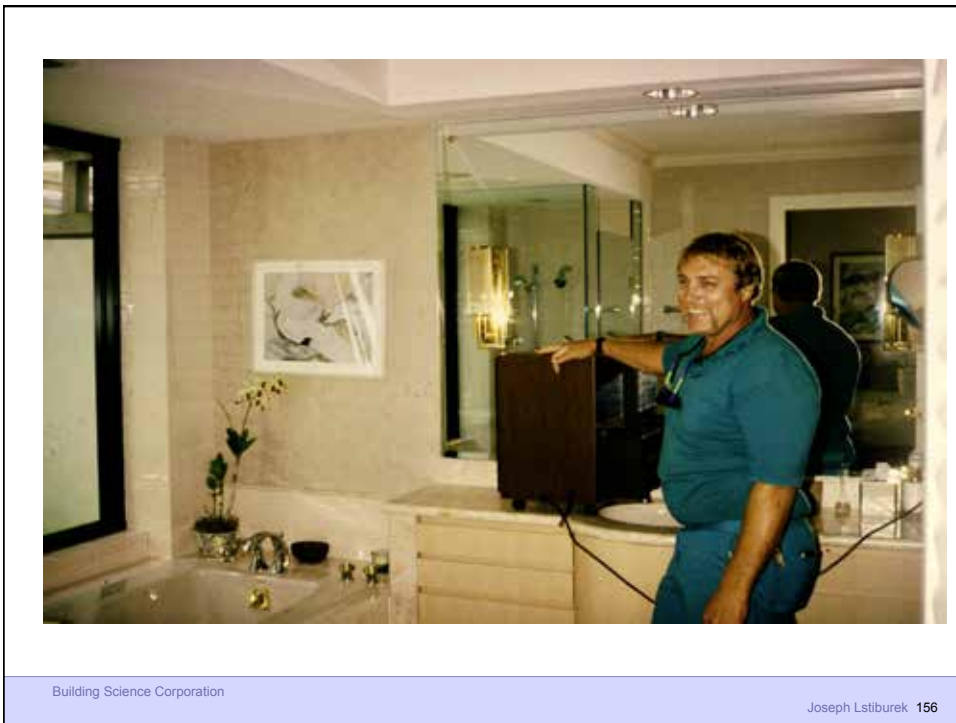
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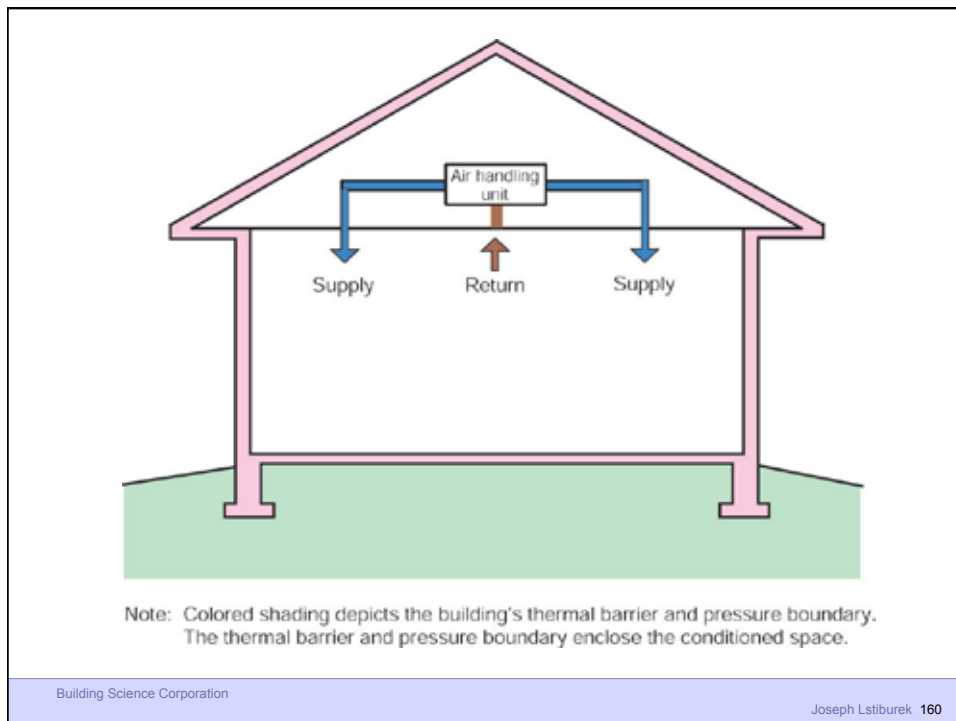
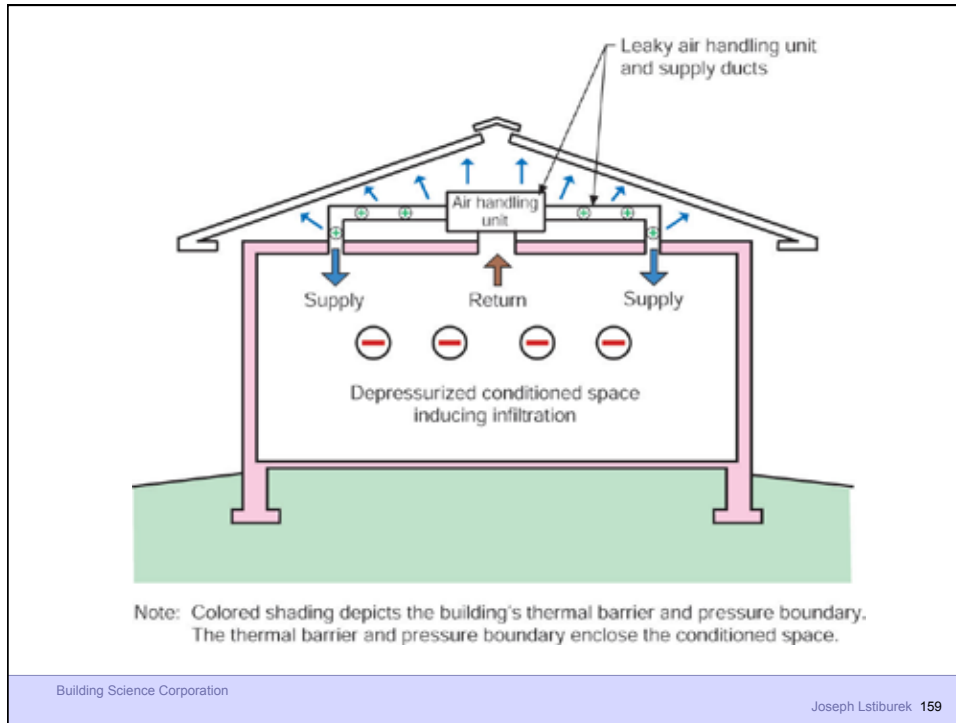


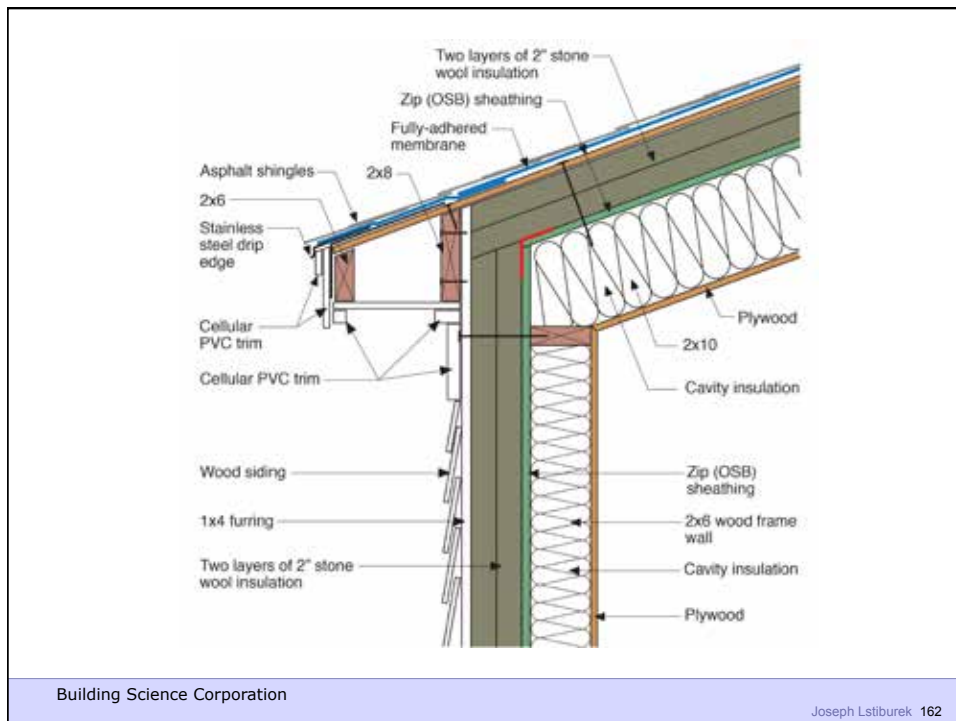
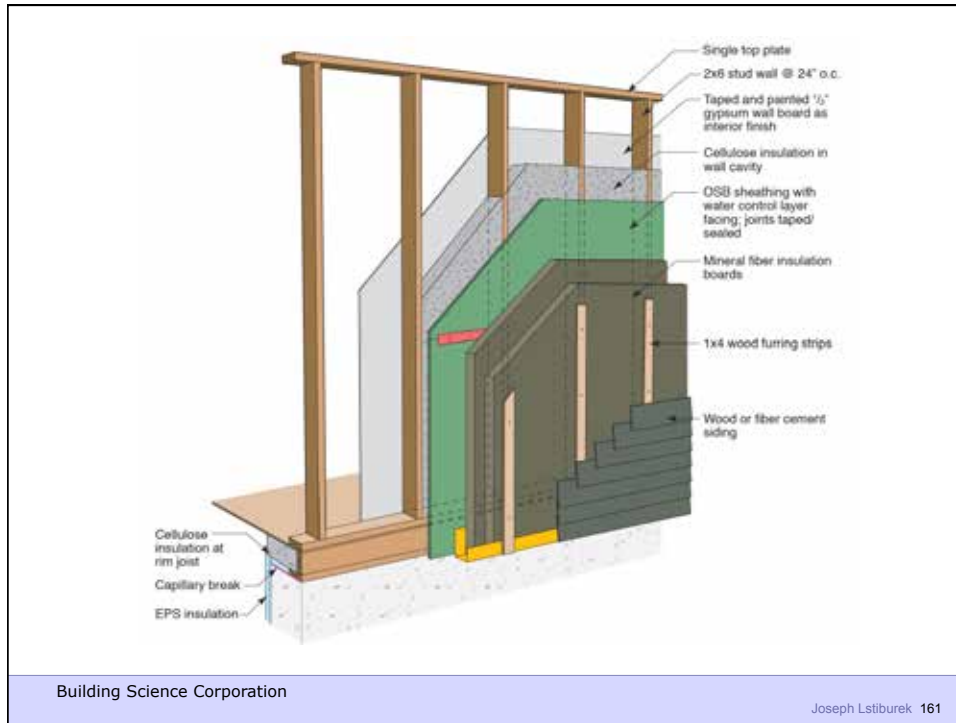
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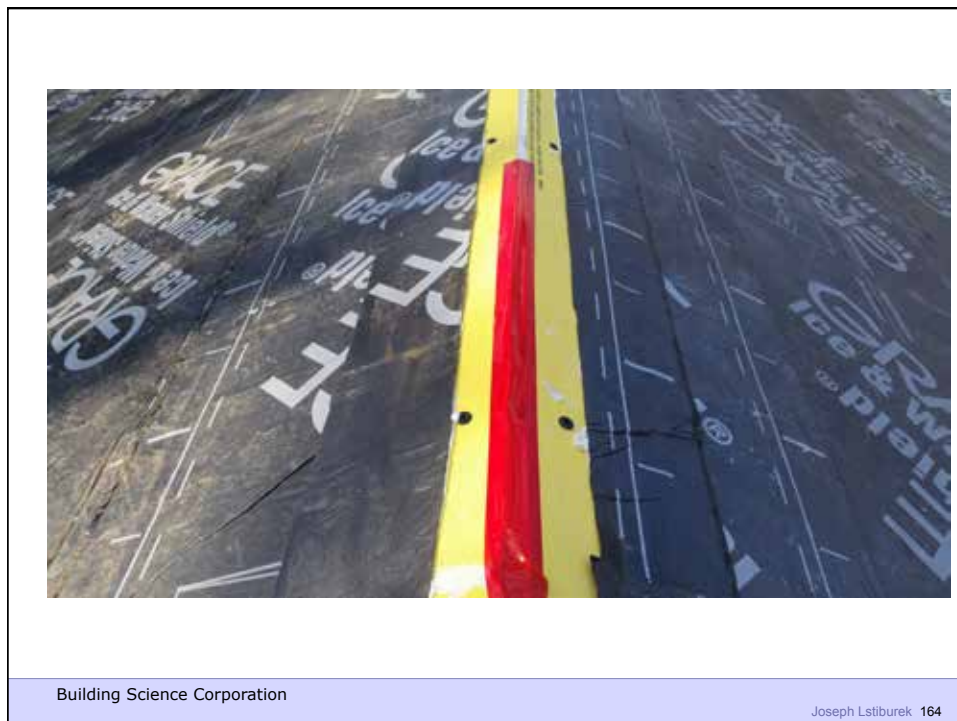
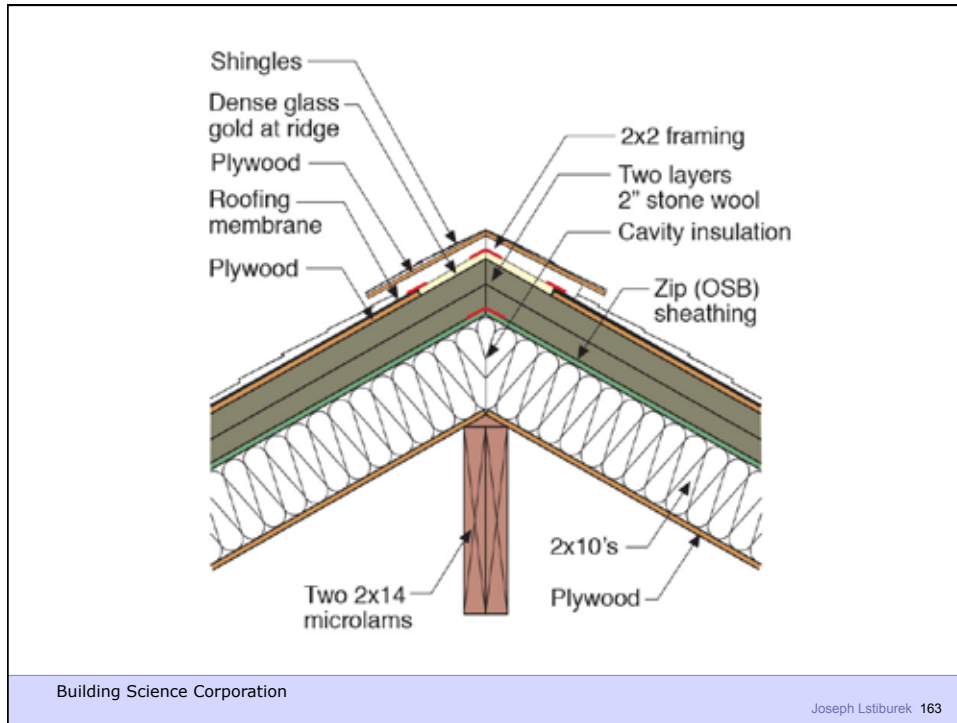
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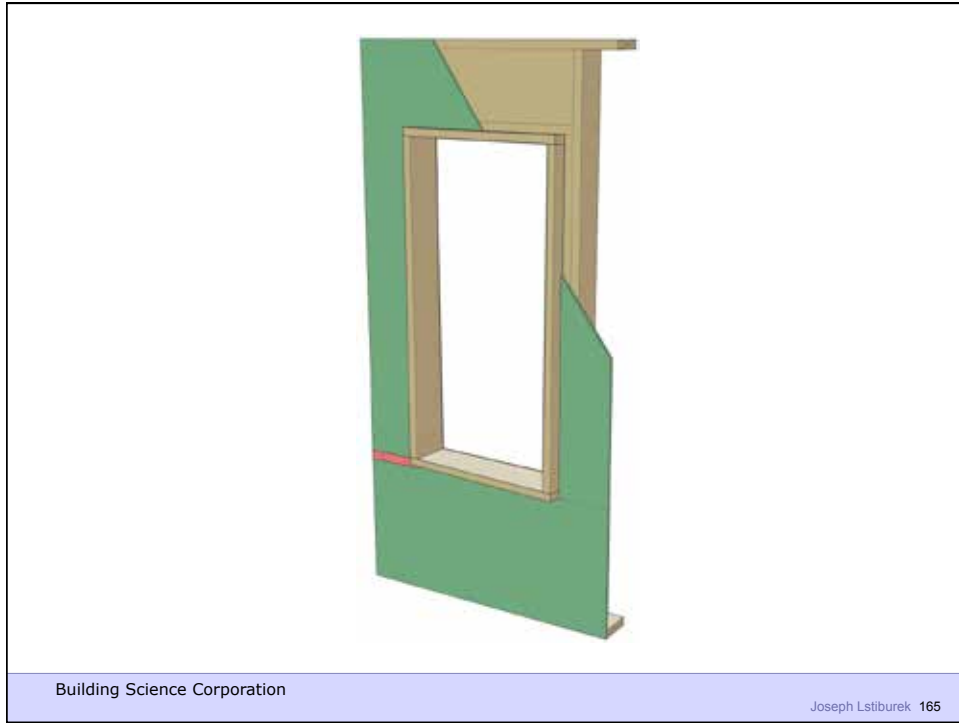


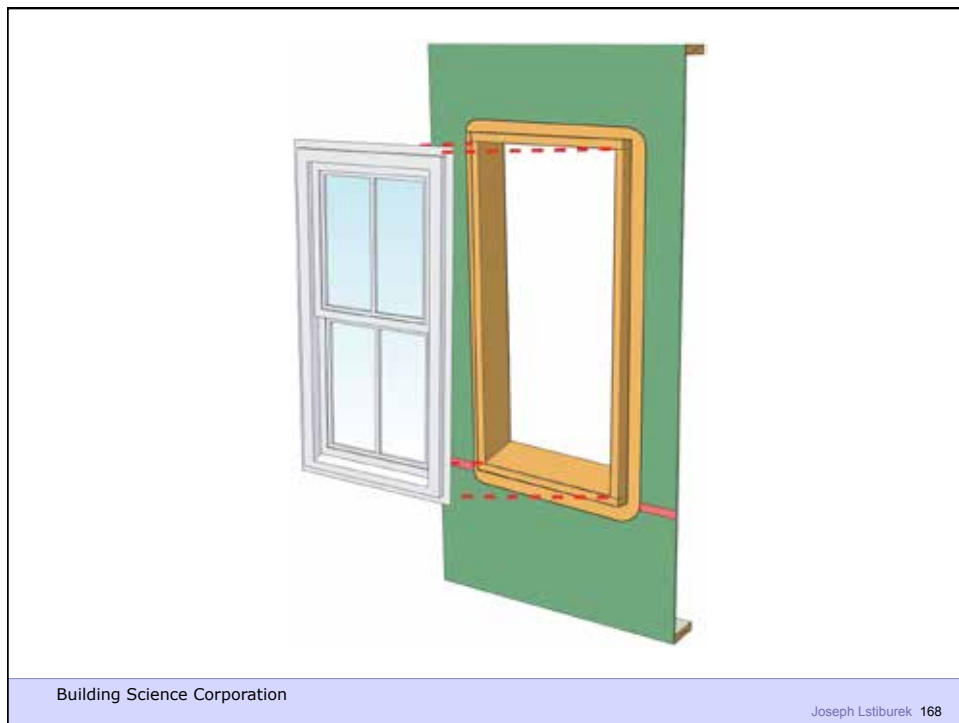
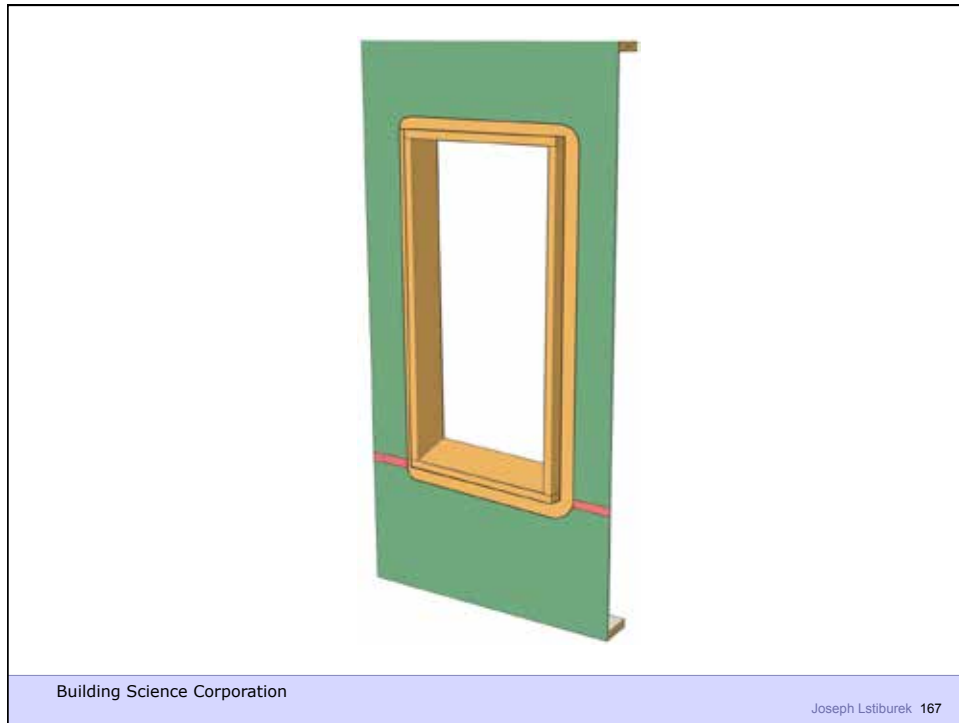






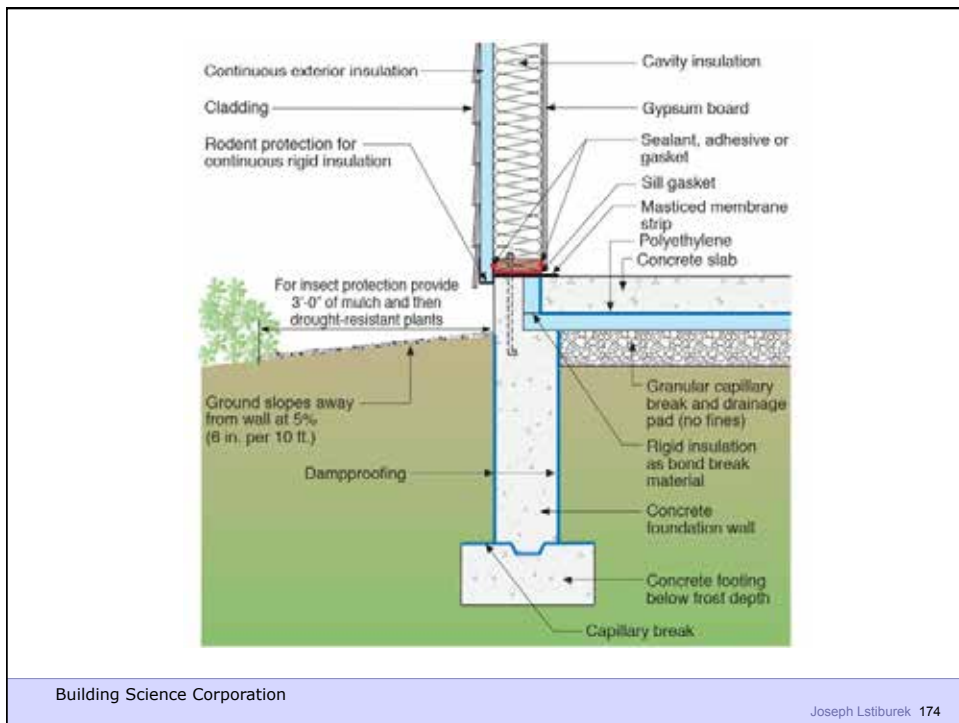


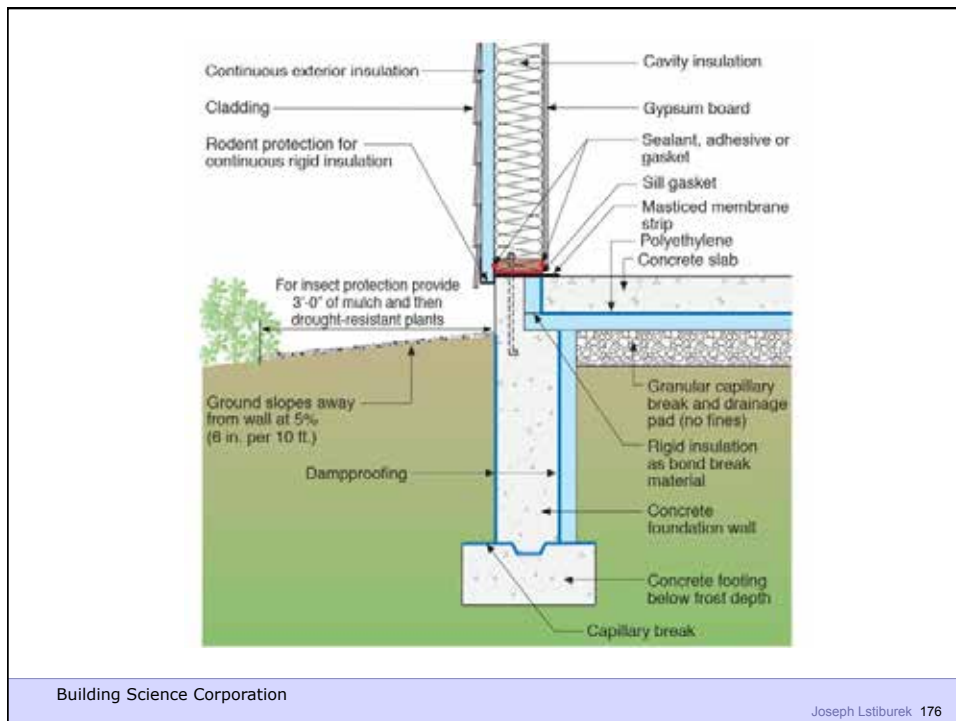
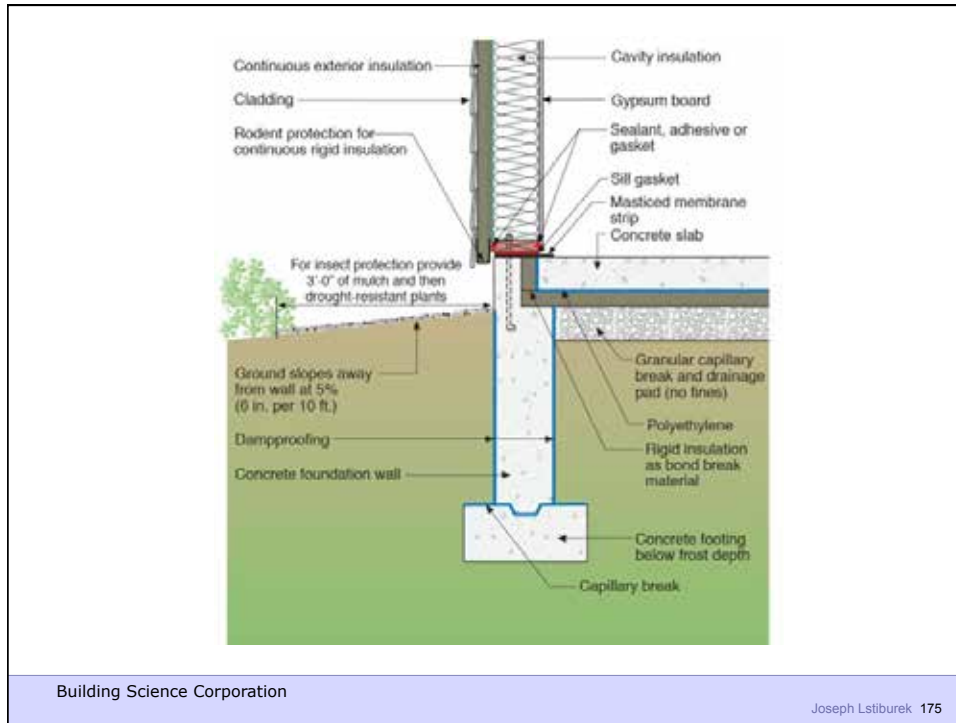


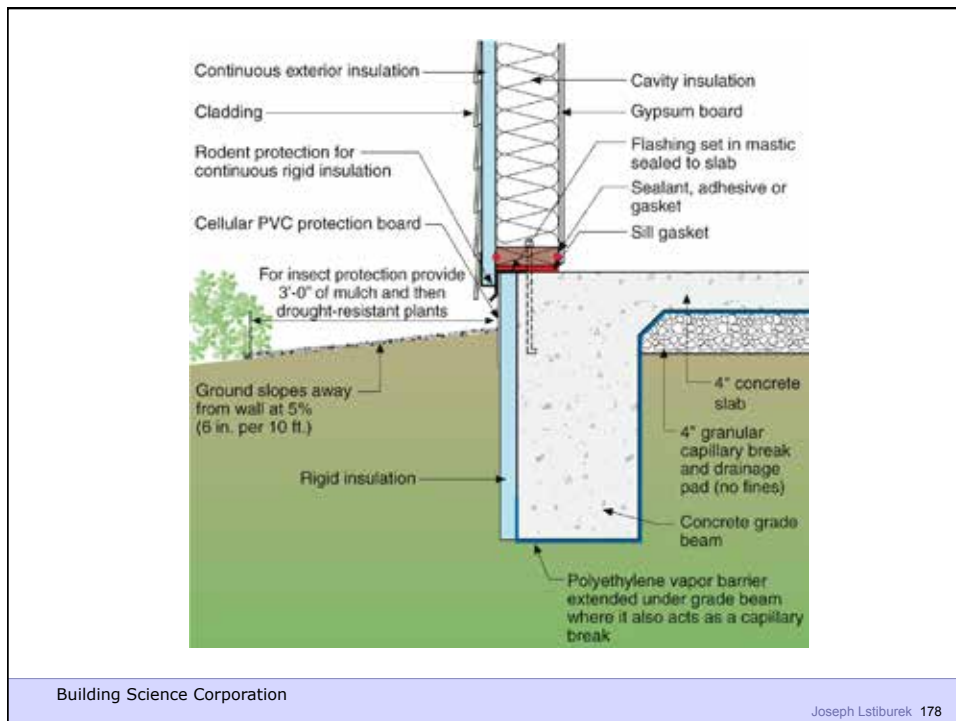
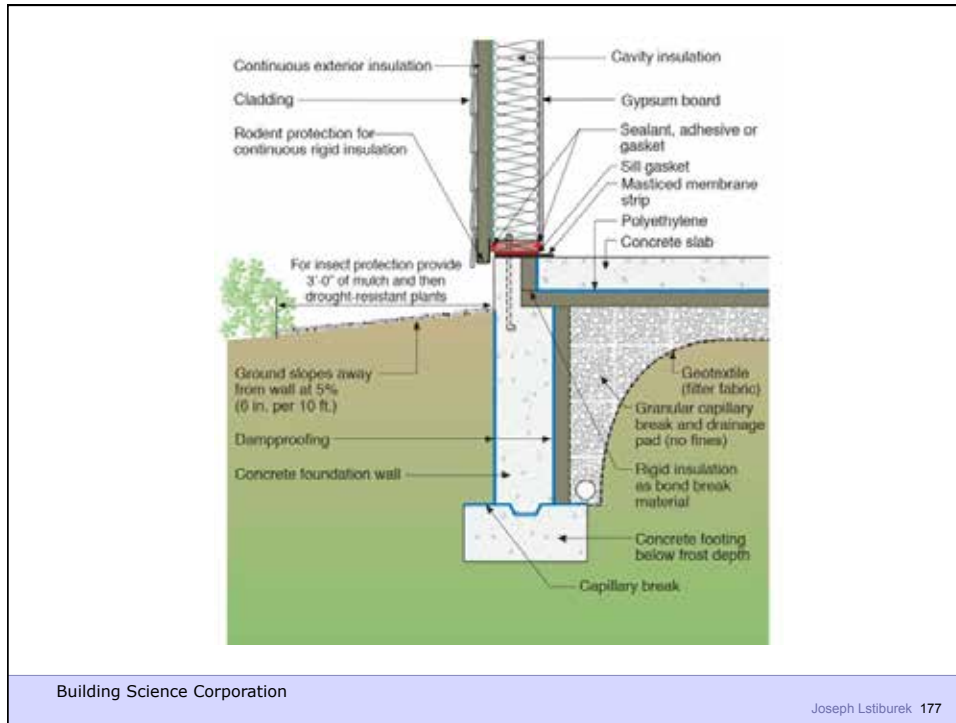


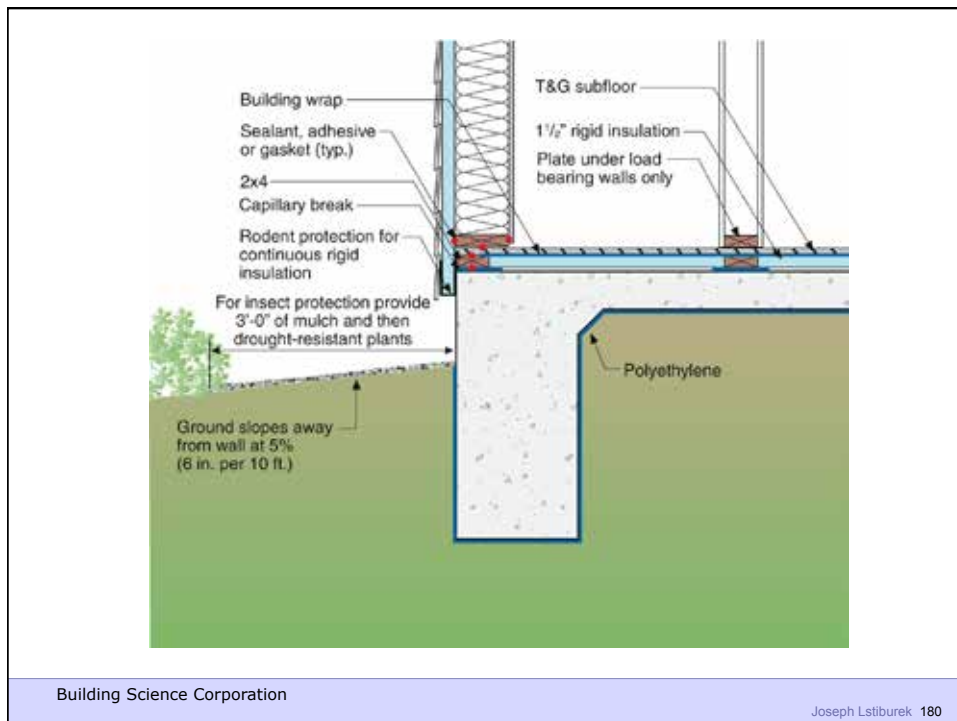
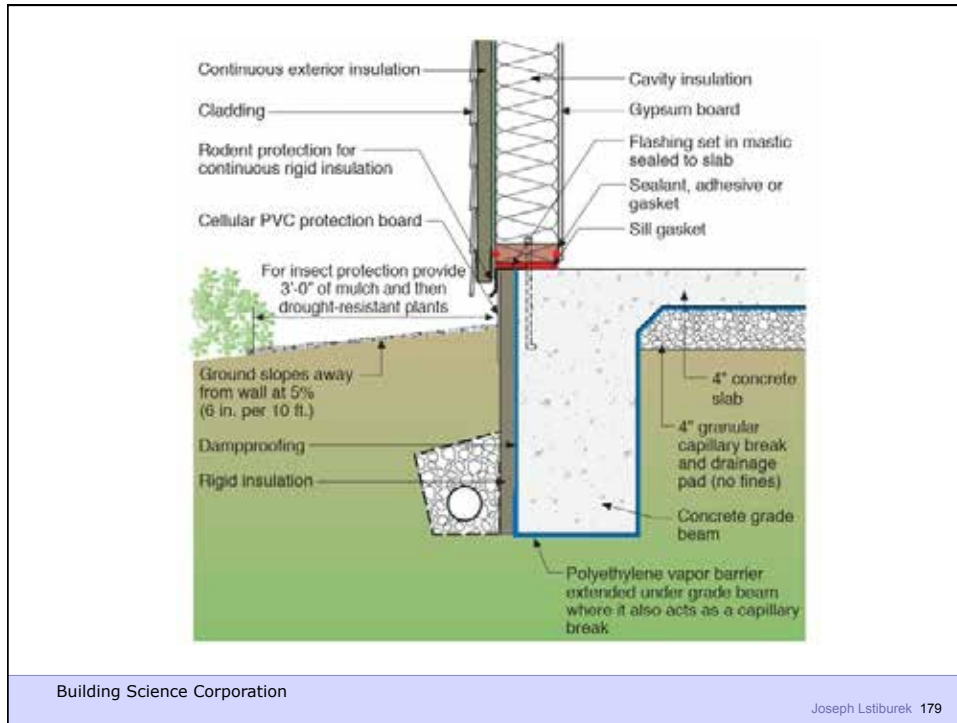


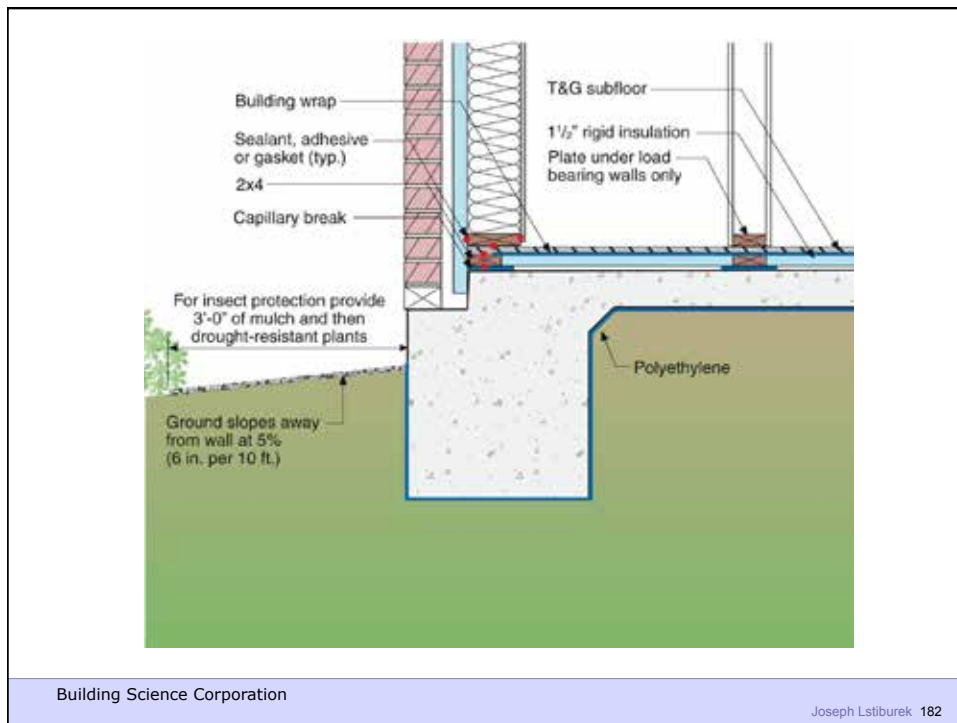
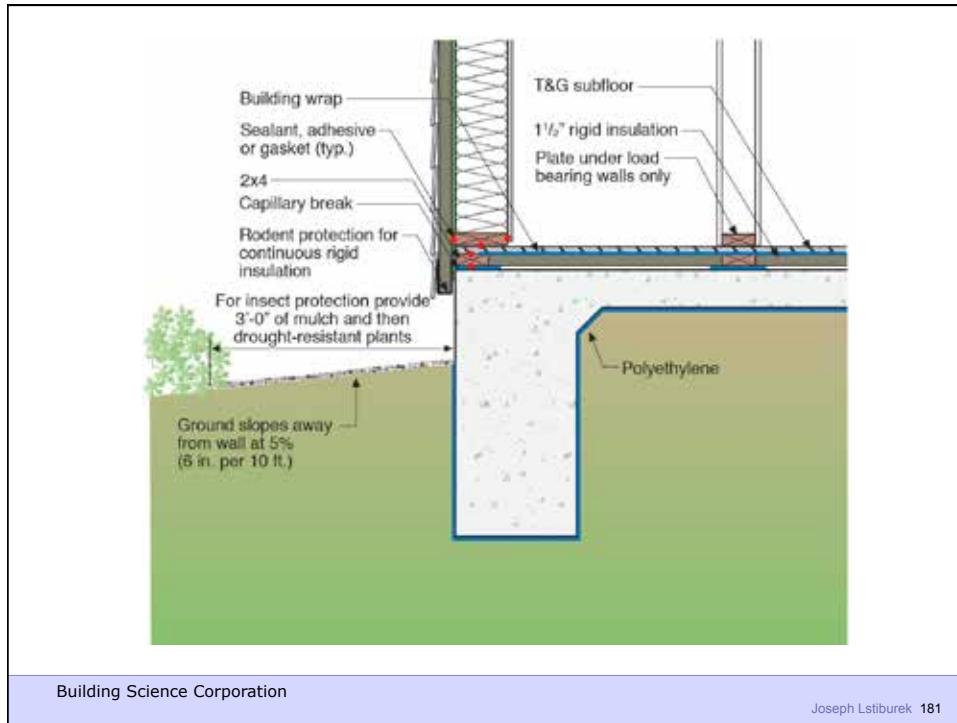


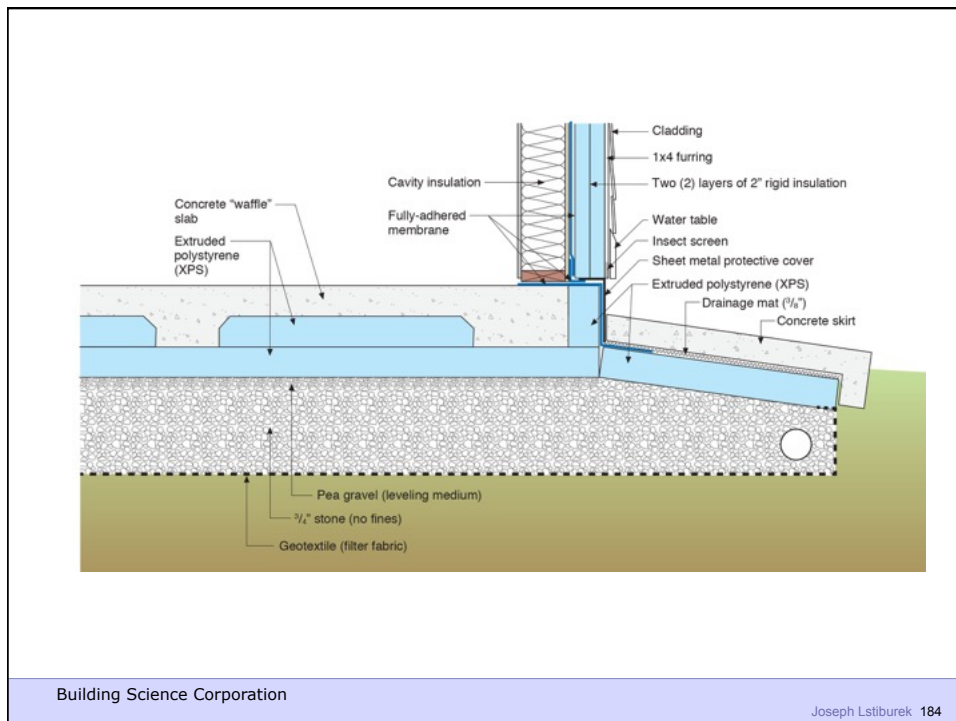
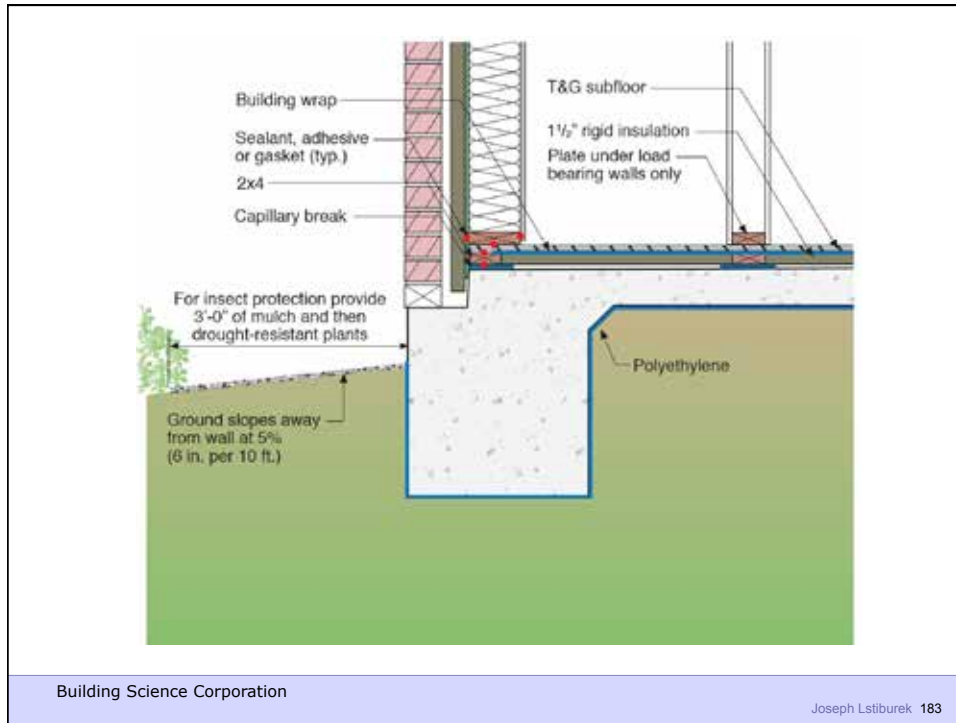


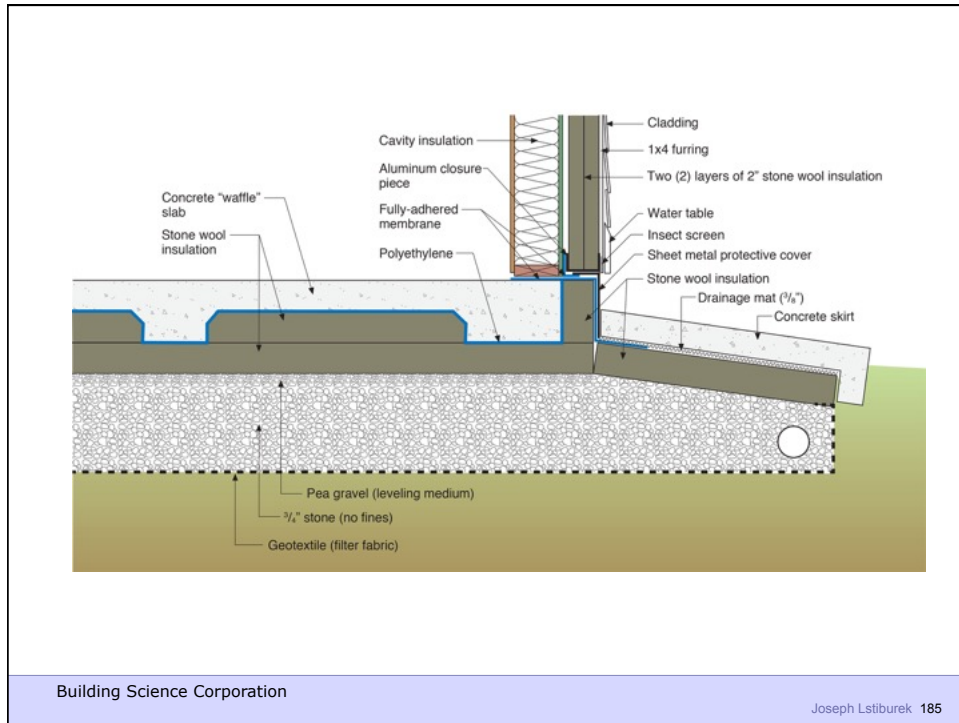














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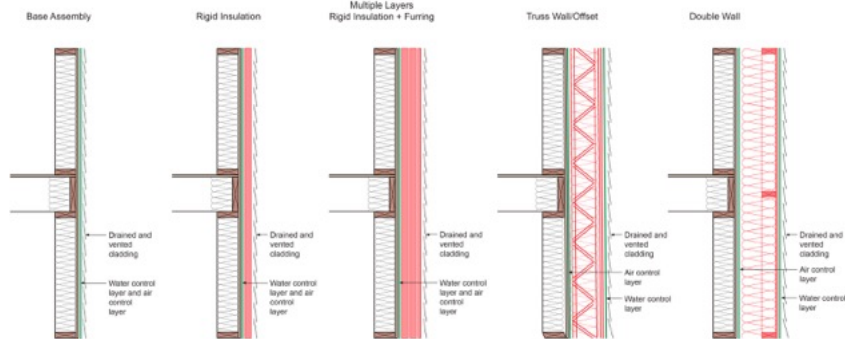
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Joseph Lstiburek 190

Mechanical Systems

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Joseph Lstiburek 191

Mechanical Systems Cooling System To Make It Cold

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Joseph Lstiburek 192

Mechanical Systems
Cooling System To Make It Cold
Dehumidification System To Make It Dry

Mechanical Systems
Cooling System To Make It Cold
Dehumidification System To Make It Dry
Heating System To Make It Warm

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold
and Dry and Warm and Comfortable

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold
and Dry and Warm and Comfortable

Distribution System To Make It Uniform

Mechanical Systems

Cooling System To Make It Cold

Dehumidification System To Make It Dry

Heating System To Make It Warm

Energy Recovery System To Keep It Cold
and Dry and Warm and Comfortable

Distribution System To Make It Uniform

Range Hoods Are A Special Kind of Hell

Don't Try to Combine Them.....

