

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

Building Science

Adventures In Building Science

www.buildingscience.com

What is a Building?

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A Building is an Environmental Separator

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- Control heat flow
- Control airflow
- Control water vapor flow
- Control rain
- Control ground water
- Control light and solar radiation
- Control noise and vibrations
- Control contaminants, environmental hazards and odors
- Control insects, rodents and vermin
- Control fire
- Provide strength and rigidity
- Be durable
- Be aesthetically pleasing
- Be economical

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Zeroth Law – $A=B$ and $B=C$ therefore $A=C$
First Law - Conservation of Energy
Second Law - Entropy
Third Law – Absolute Zero

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2nd Law of Thermodynamics

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In an isolated system, a process can occur
only if it increases the total entropy of the
system

Rudolf Clausius

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Heat Flow Is From Warm To Cold
Moisture Flow Is From Warm To Cold
Moisture Flow Is From More To Less
Air Flow Is From A Higher Pressure to a
Lower Pressure
Gravity Acts Down

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

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

Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

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

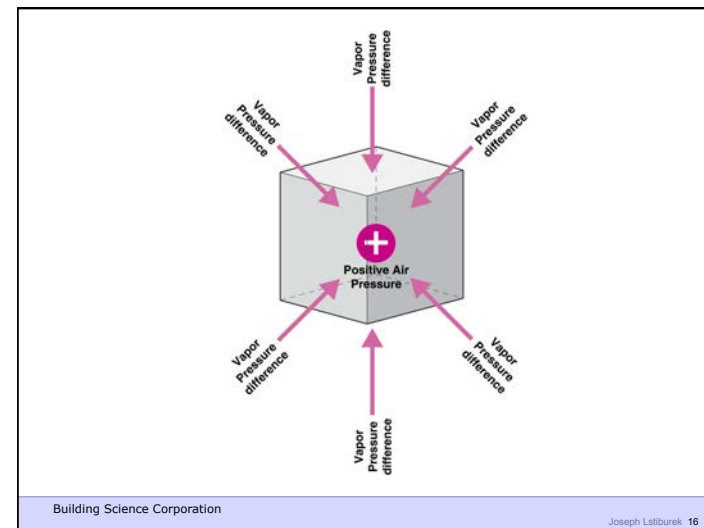
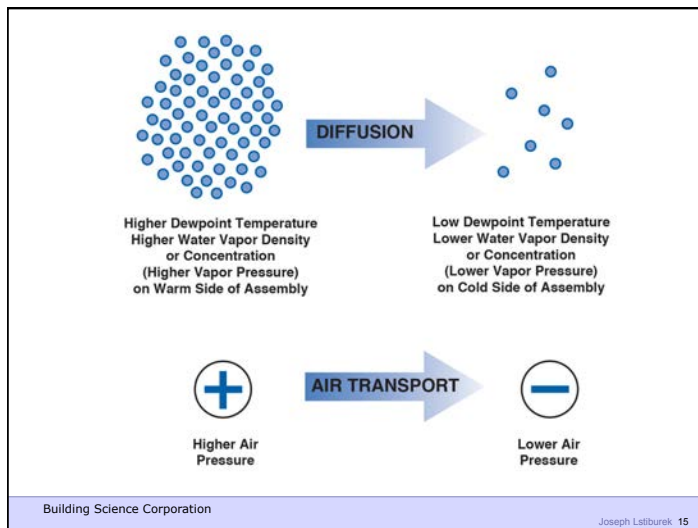
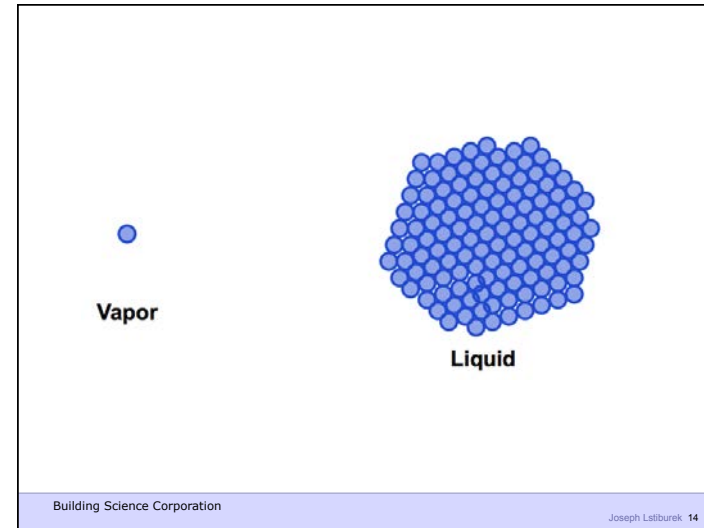
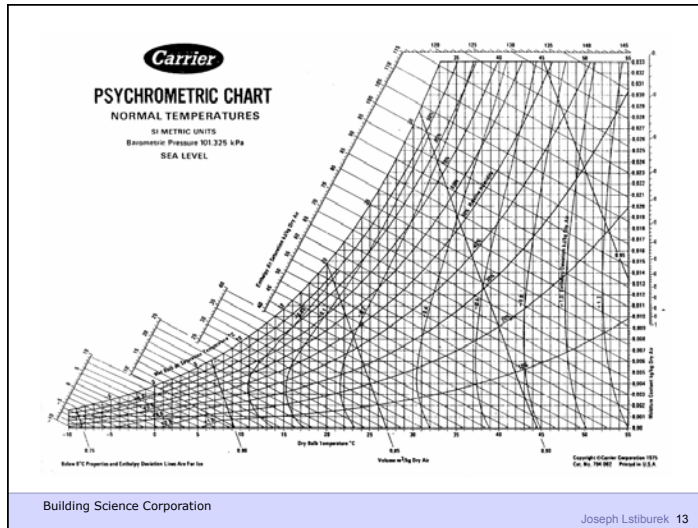
Thermal Gradient – Thermal Diffusion
Concentration Gradient – Molecular Diffusion

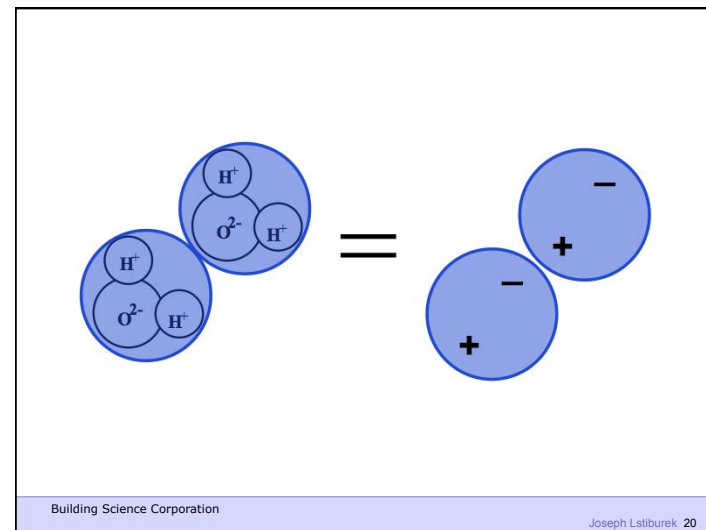
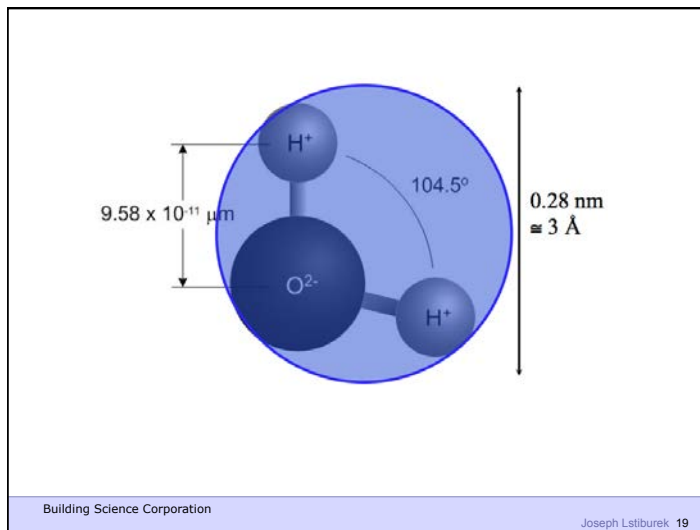
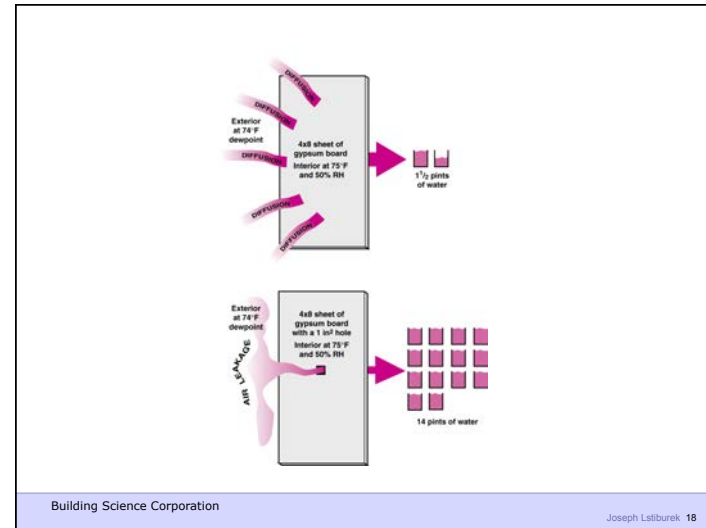
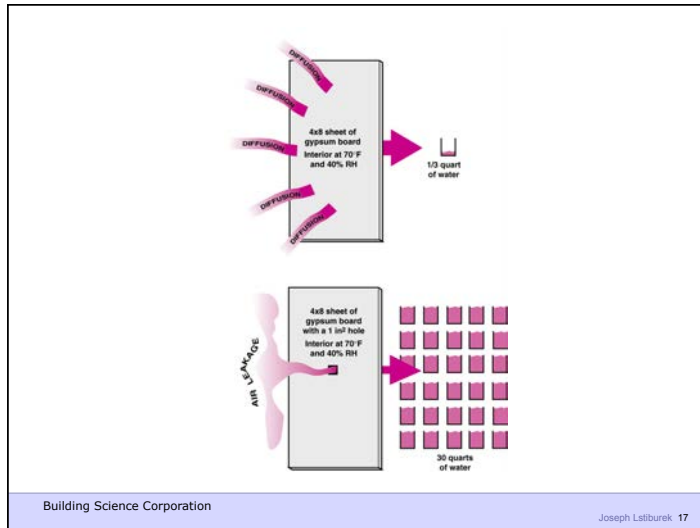
Vapor Diffusion

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Thermodynamic Potential

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Damage Functions

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Damage Functions
Water
Heat
Ultra Violet Radiation

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

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

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Heat
Air
Moisture

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HAM

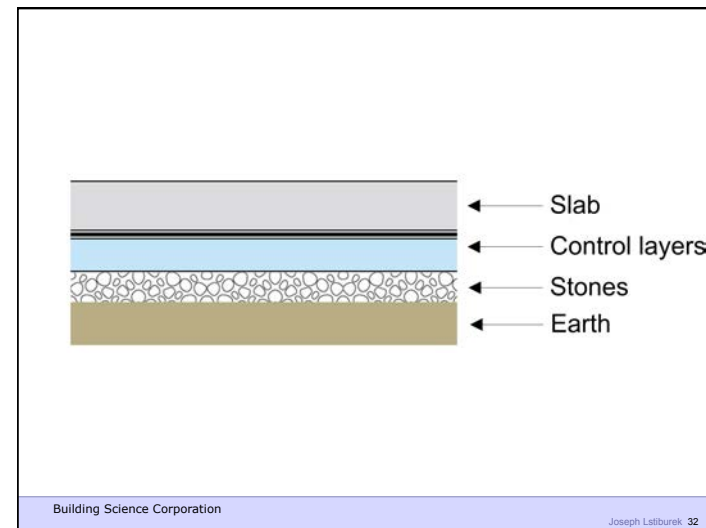
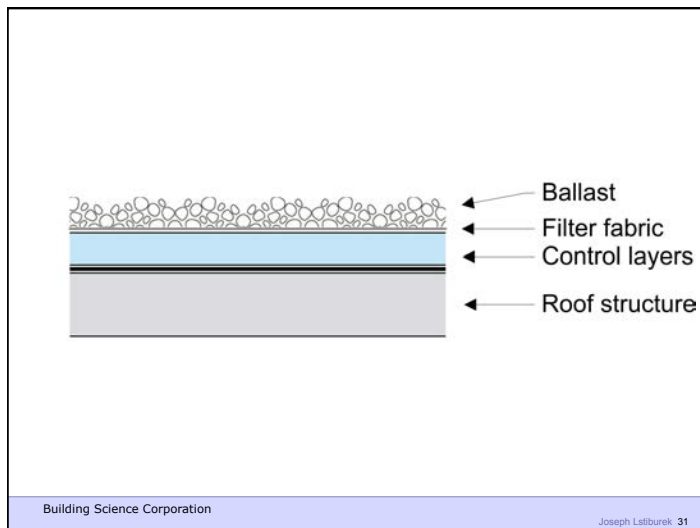
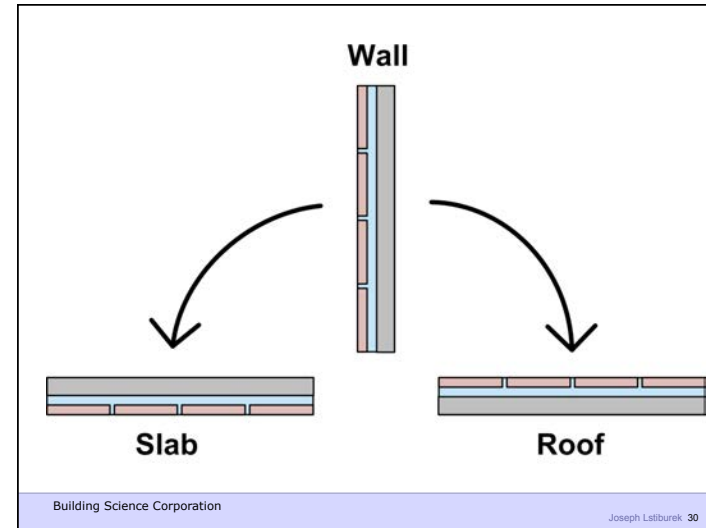
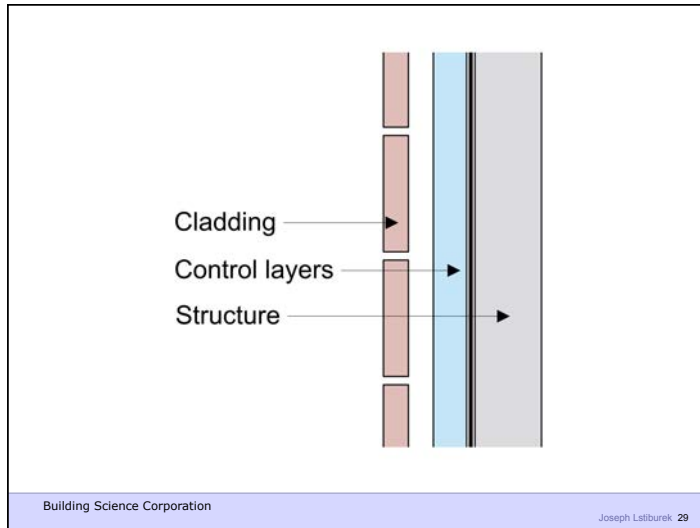
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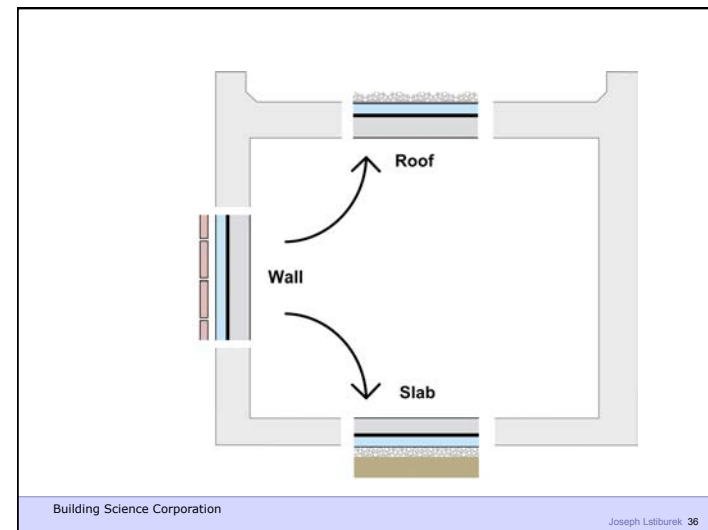
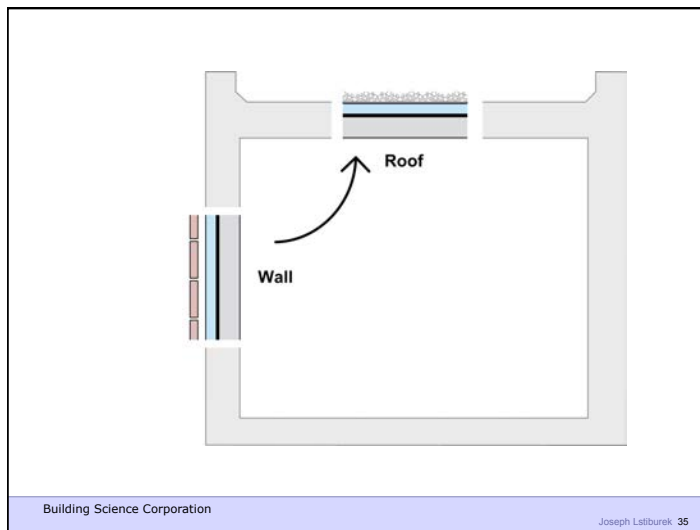
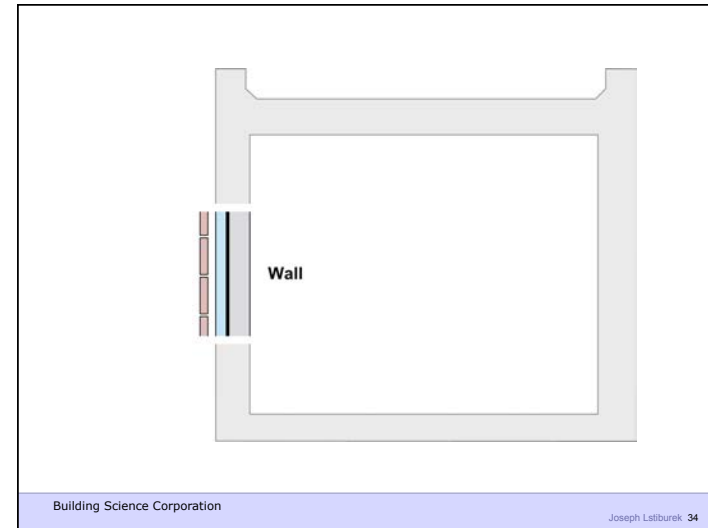
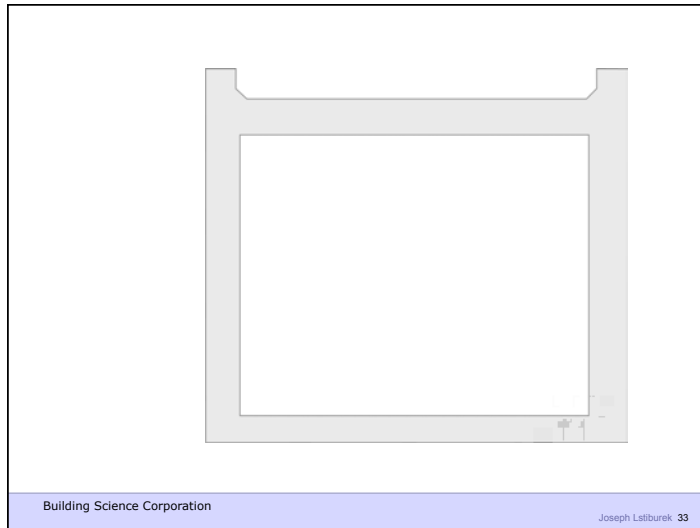
Hygrothermal Analysis

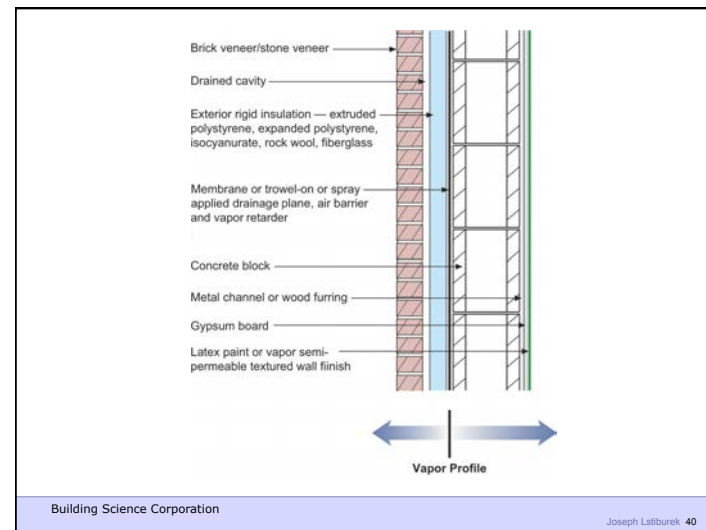
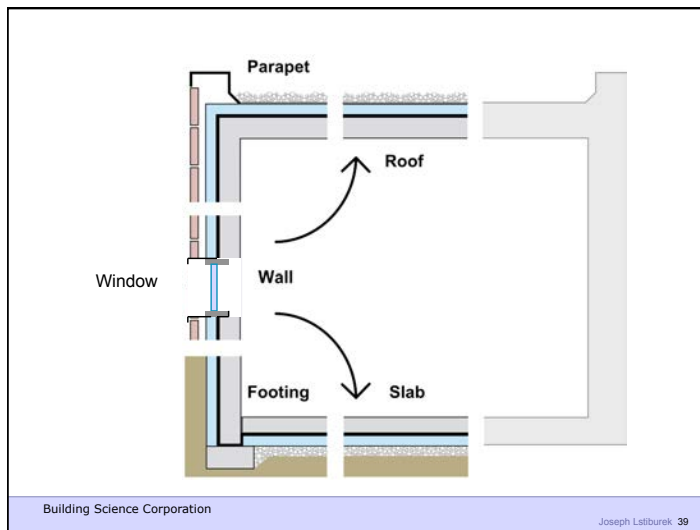
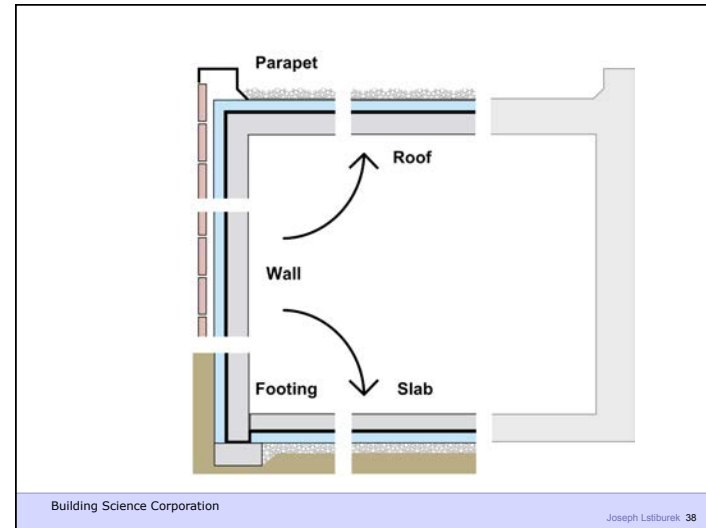
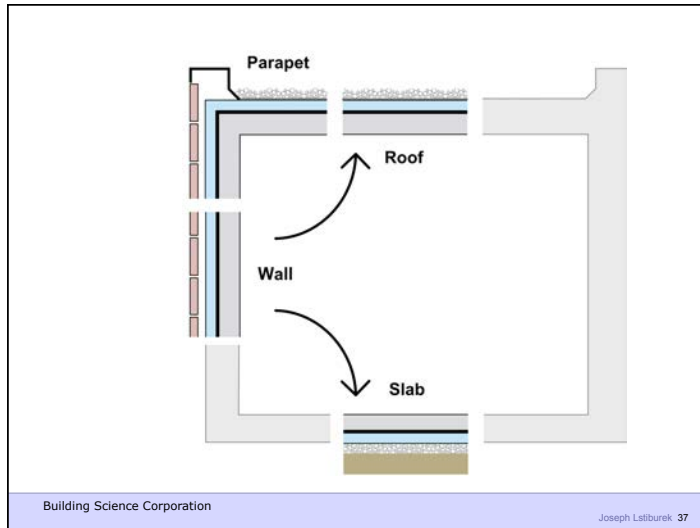
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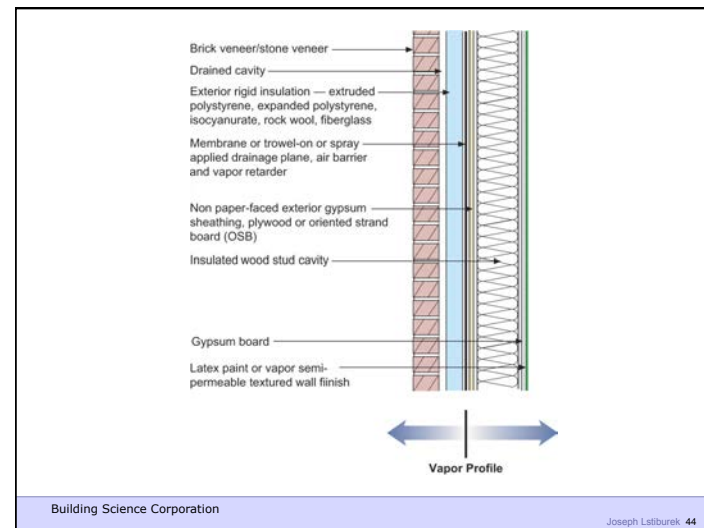
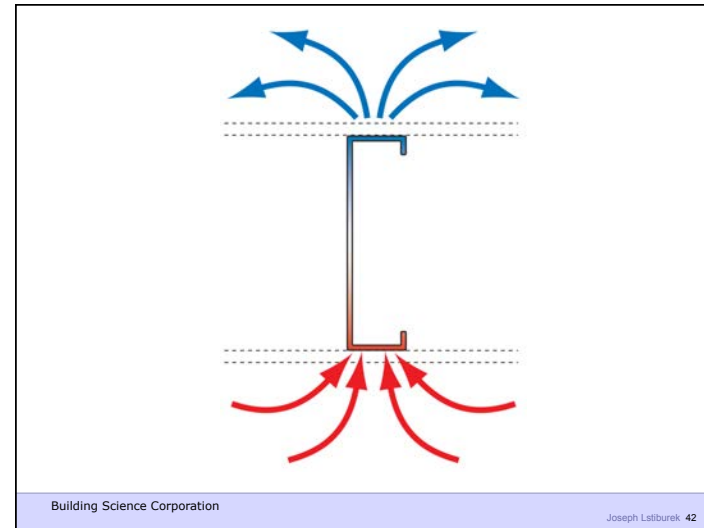
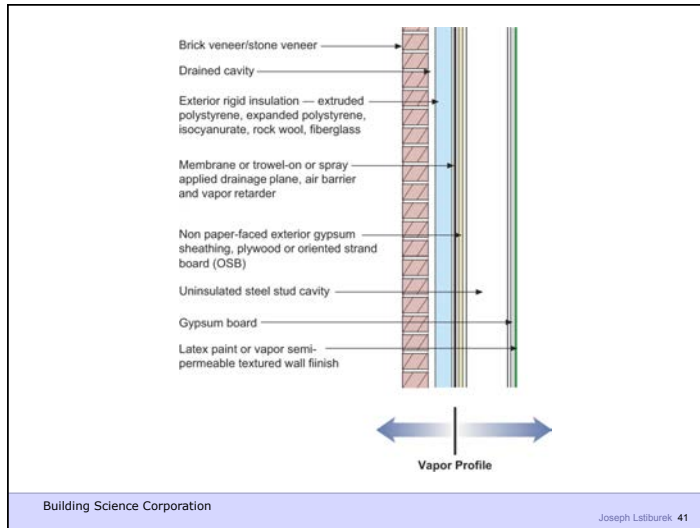
Water Control Layer
Air Control Layer
Vapor Control Layer
Thermal Control Layer

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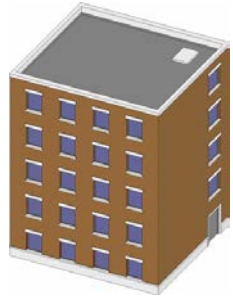








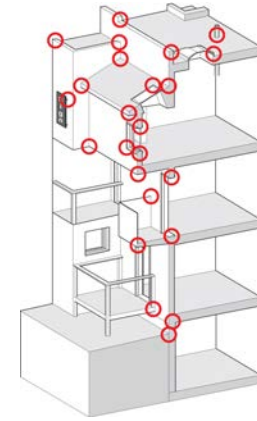
Commercial Enclosure: Simple Layers



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

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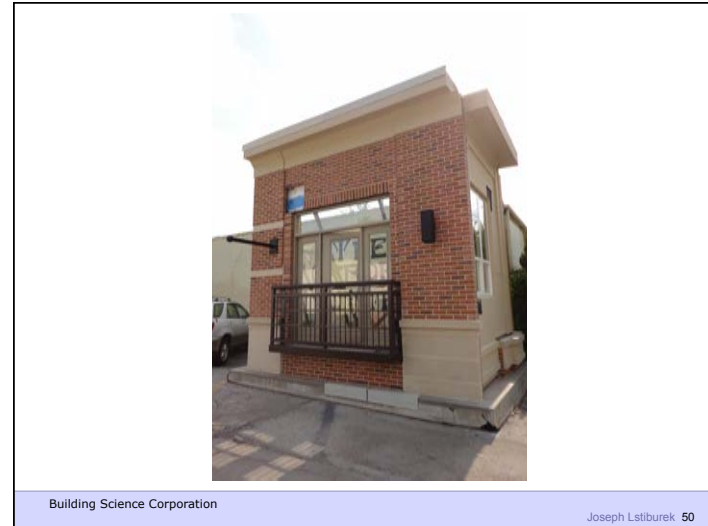
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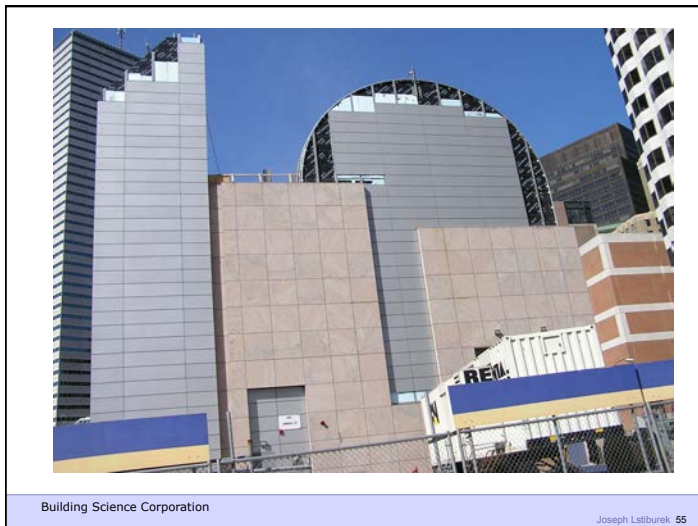
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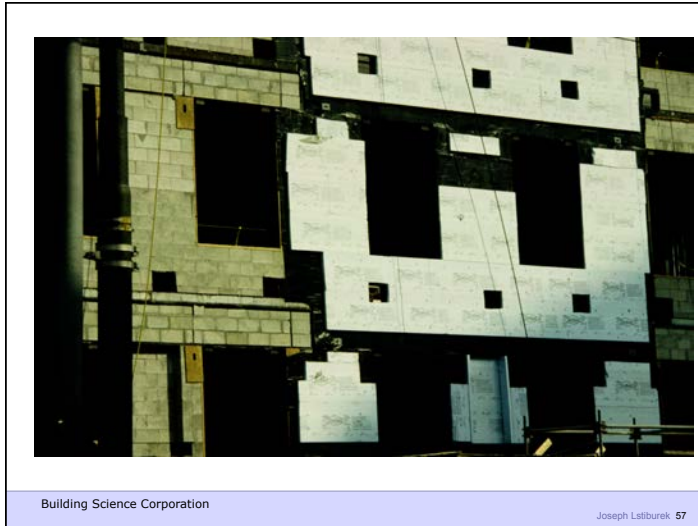


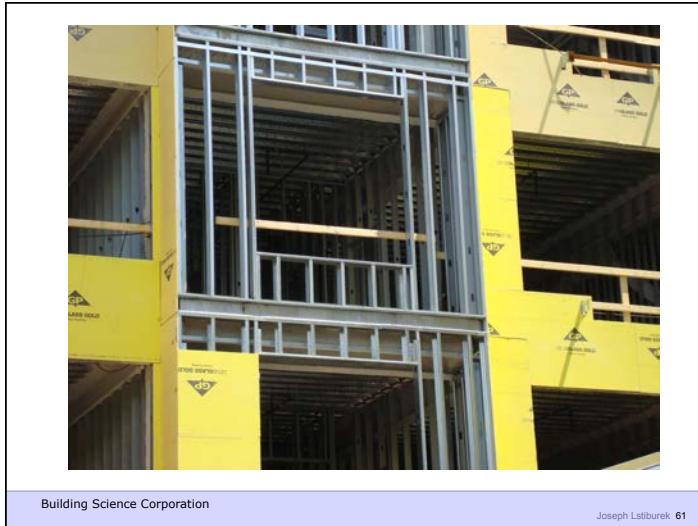
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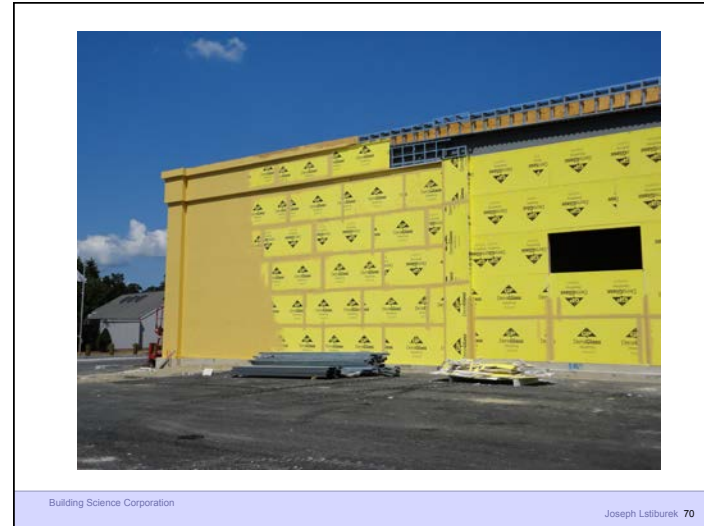








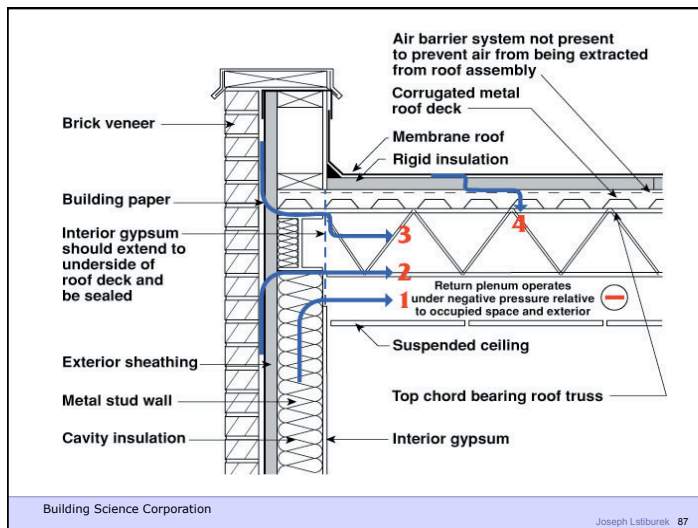
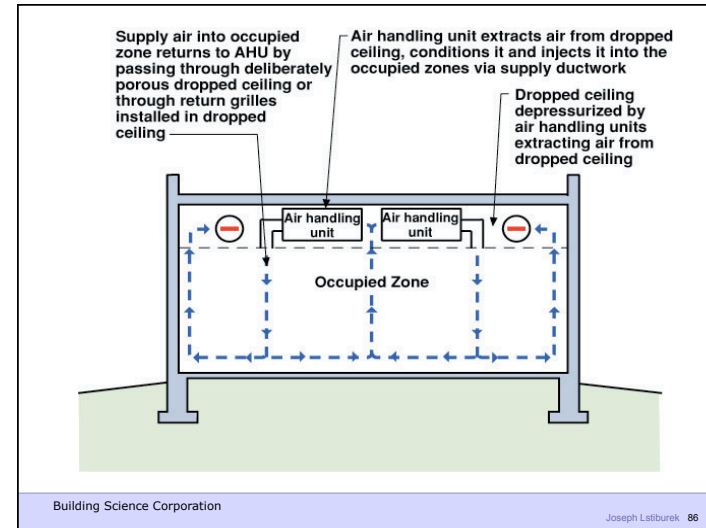
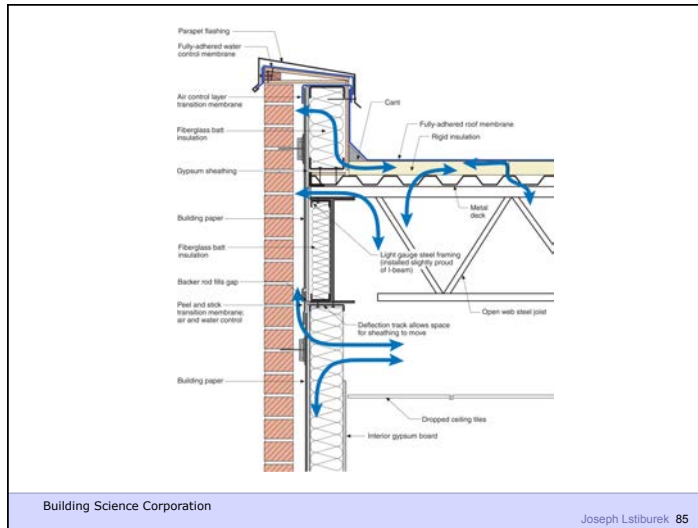


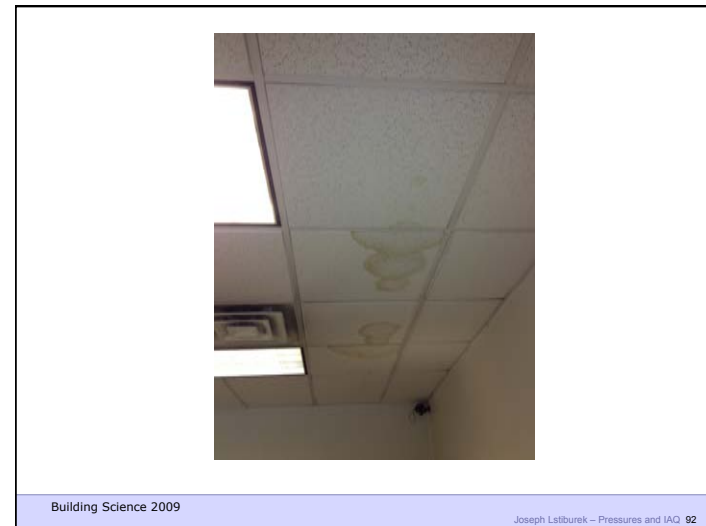
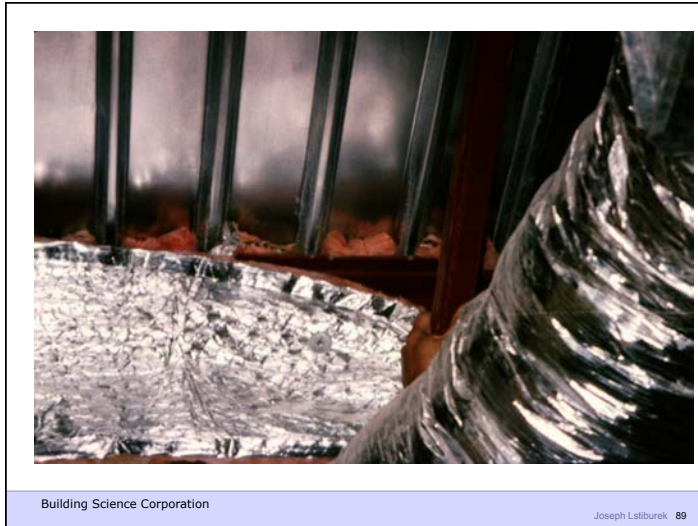


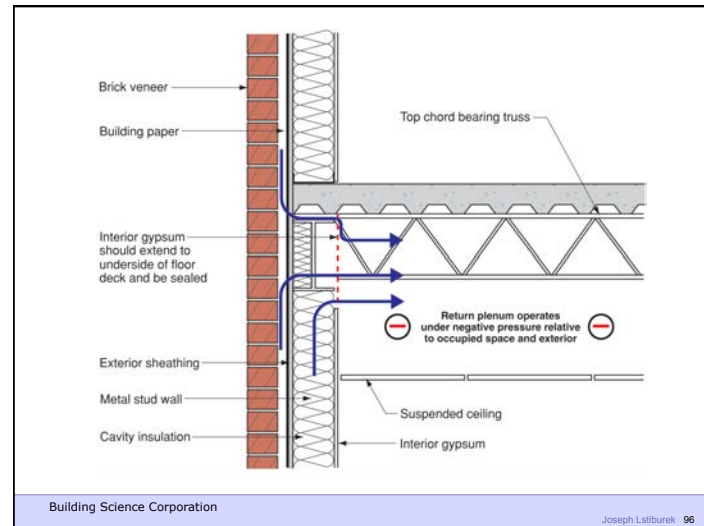
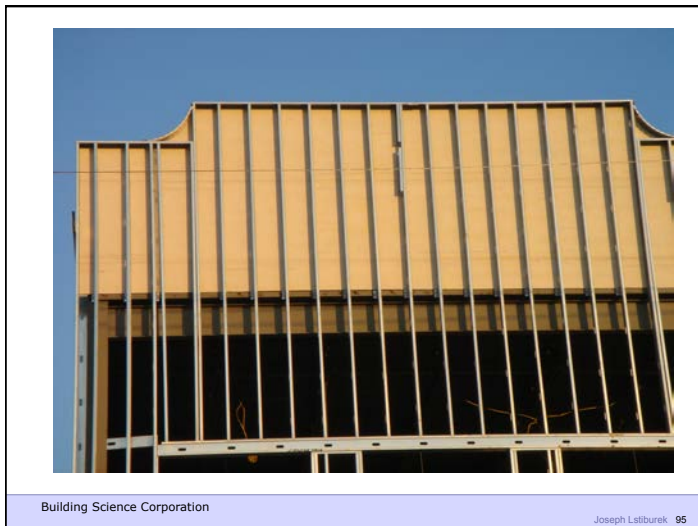
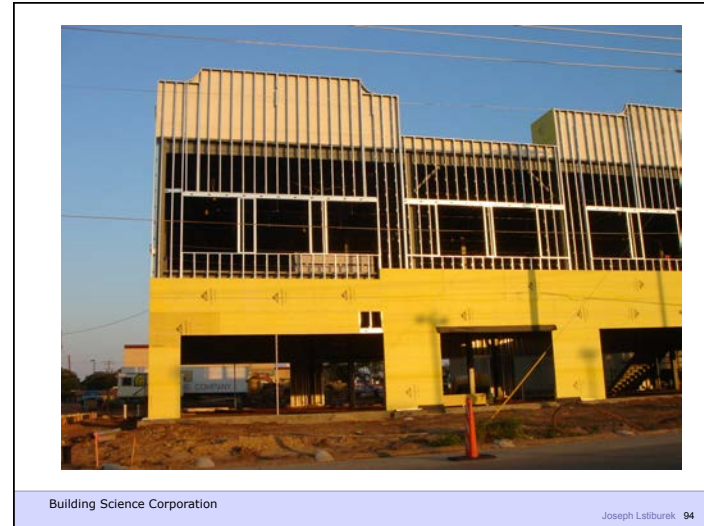
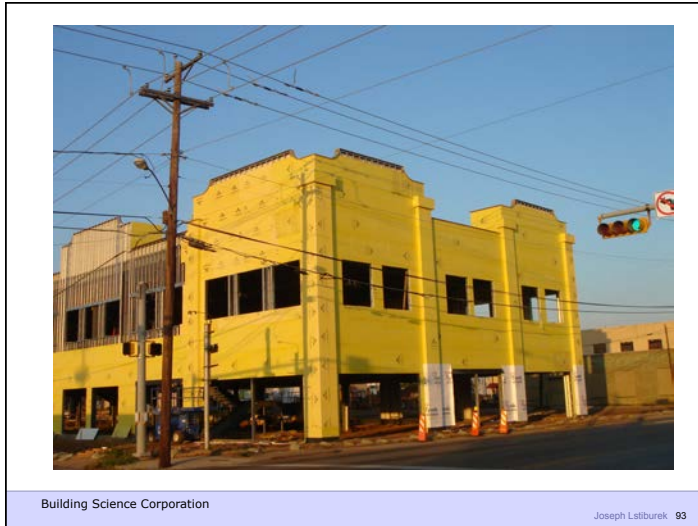


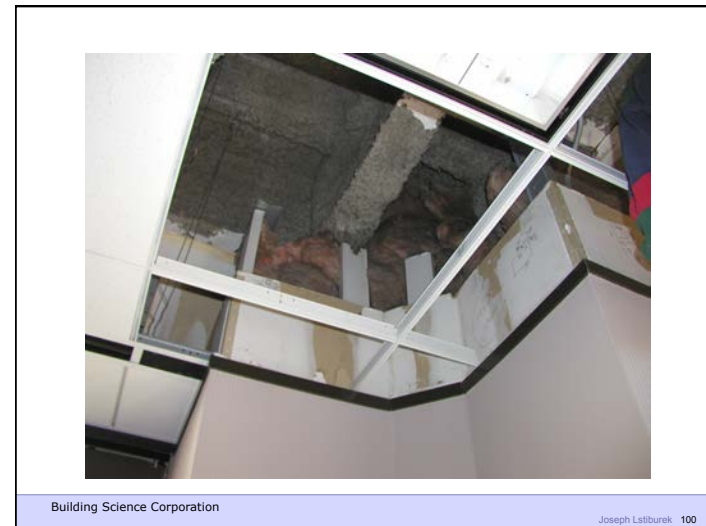
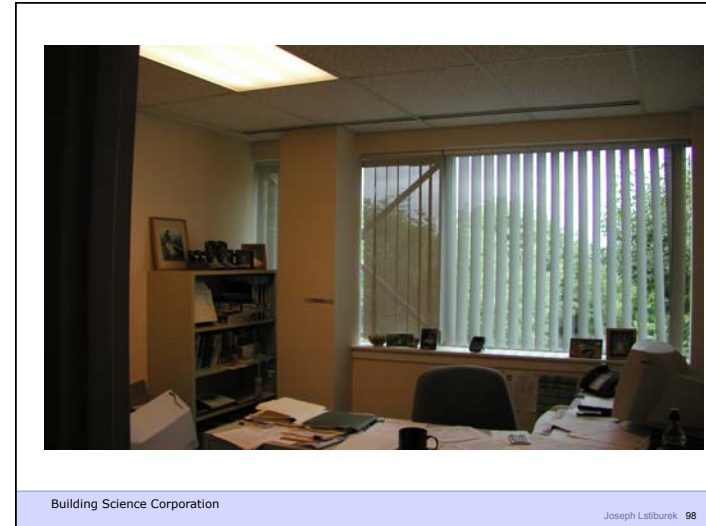


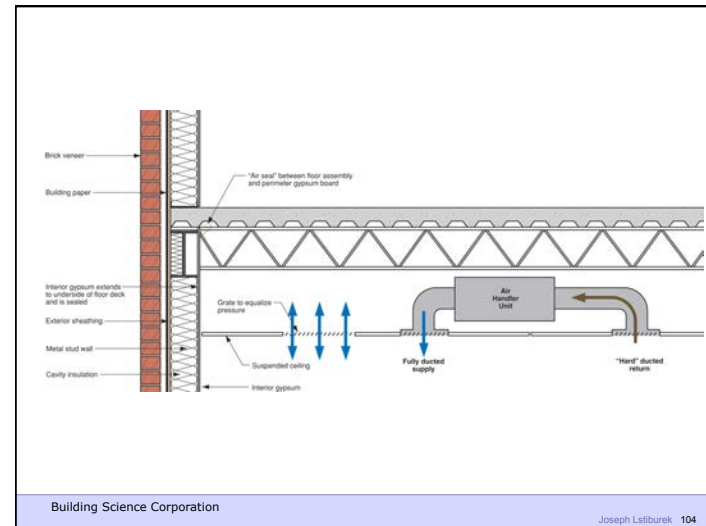
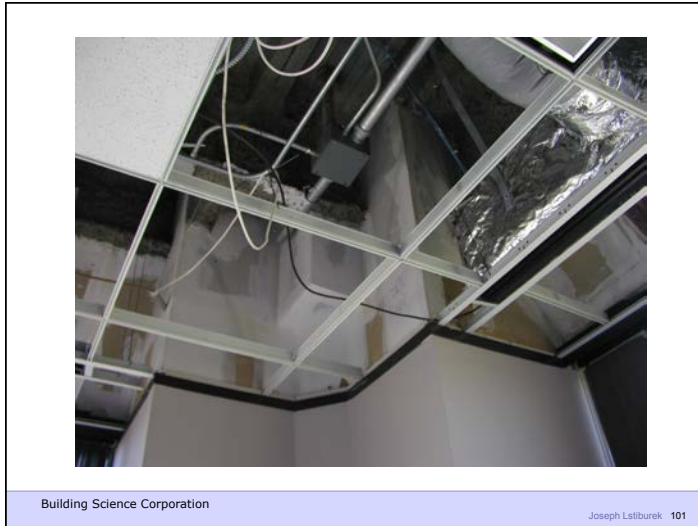


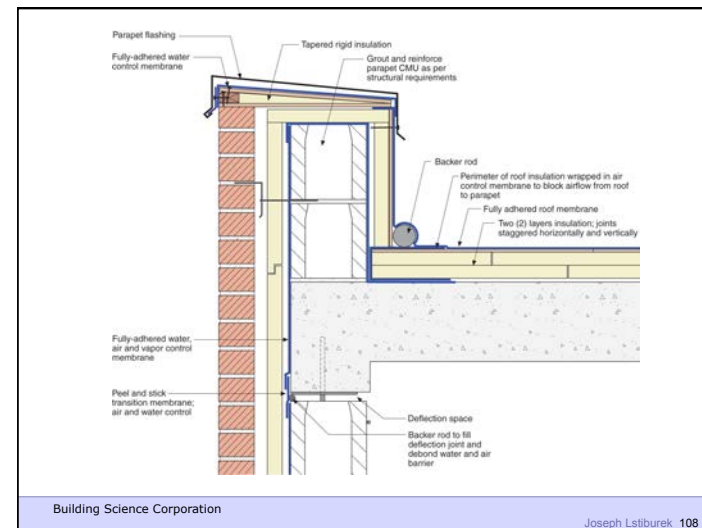
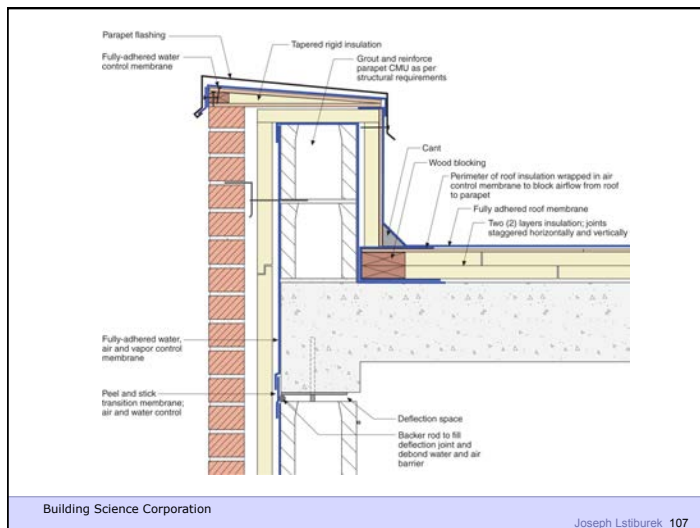
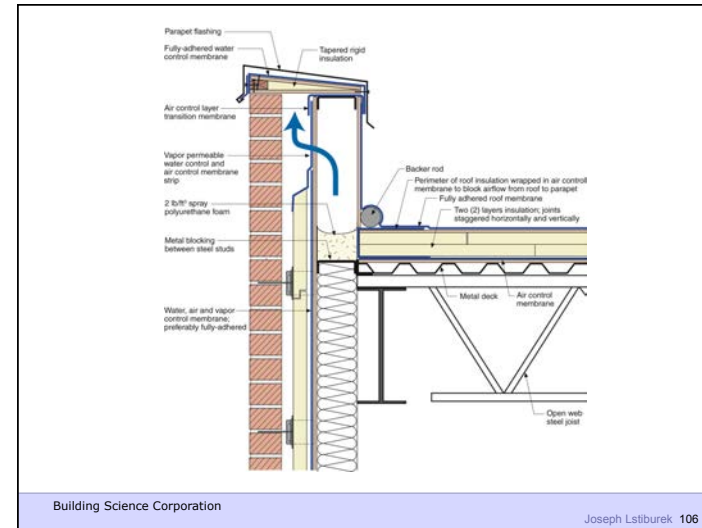
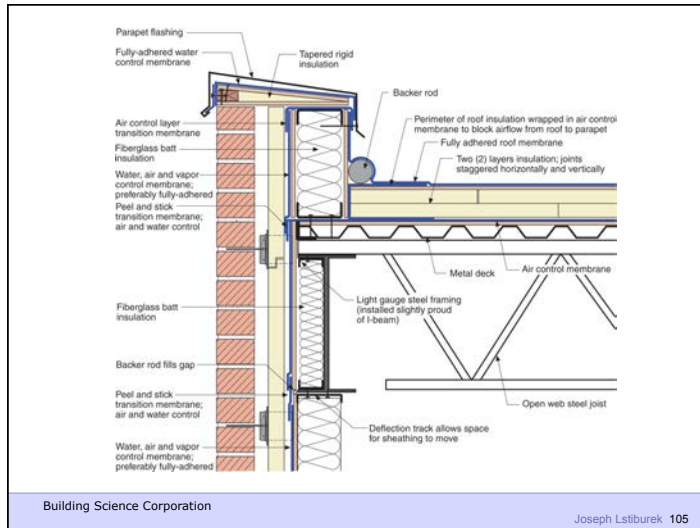


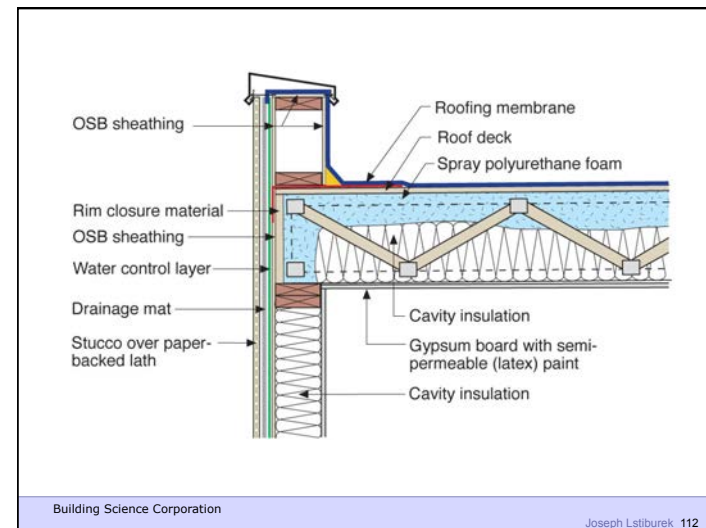
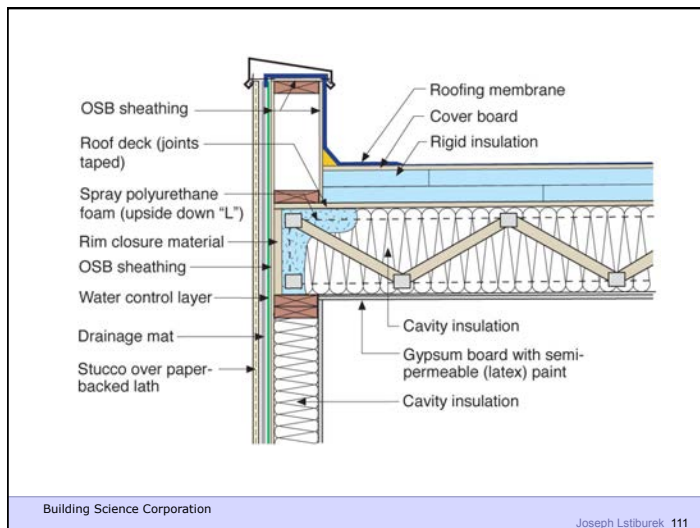
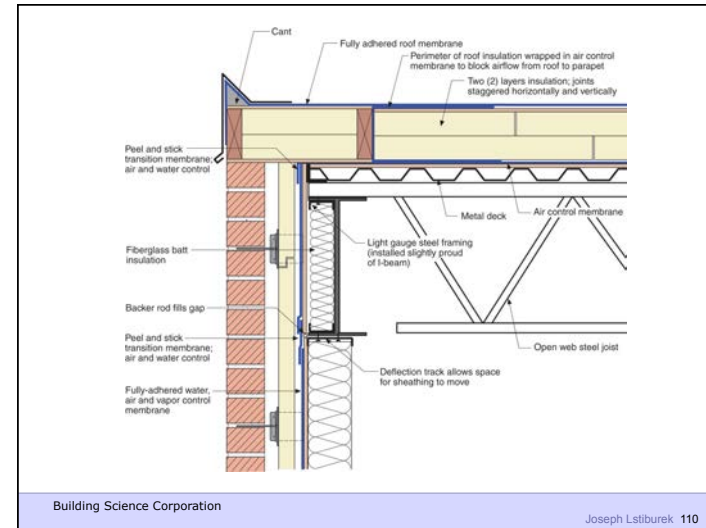
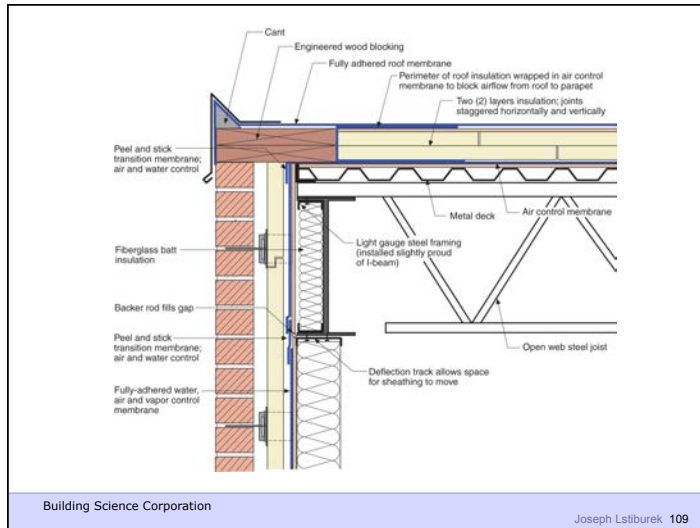


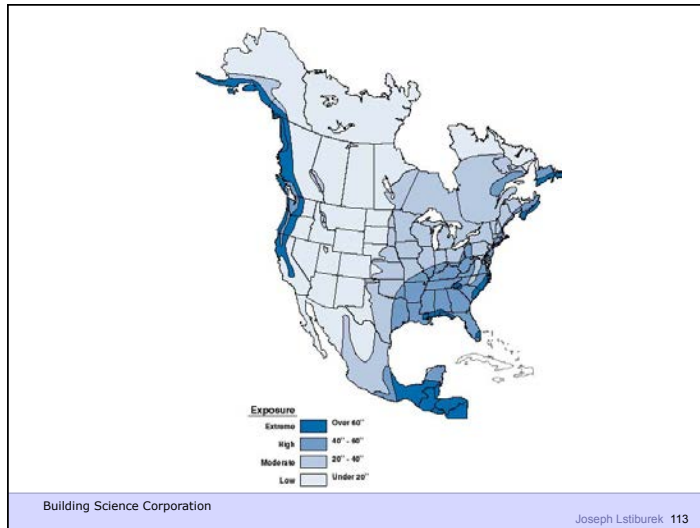






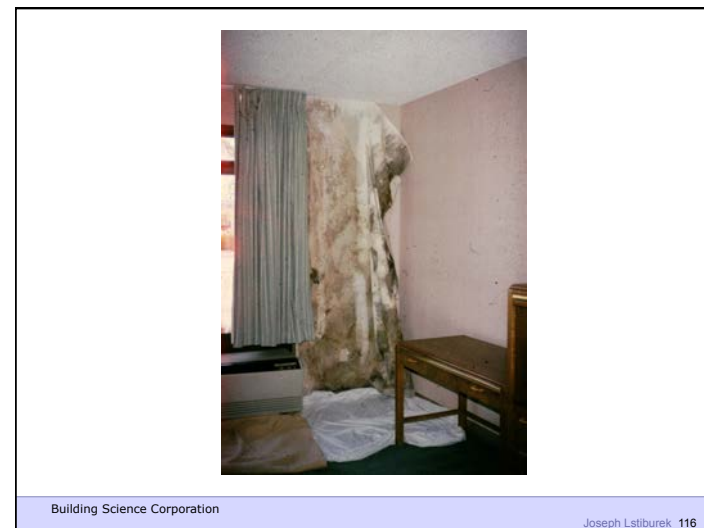


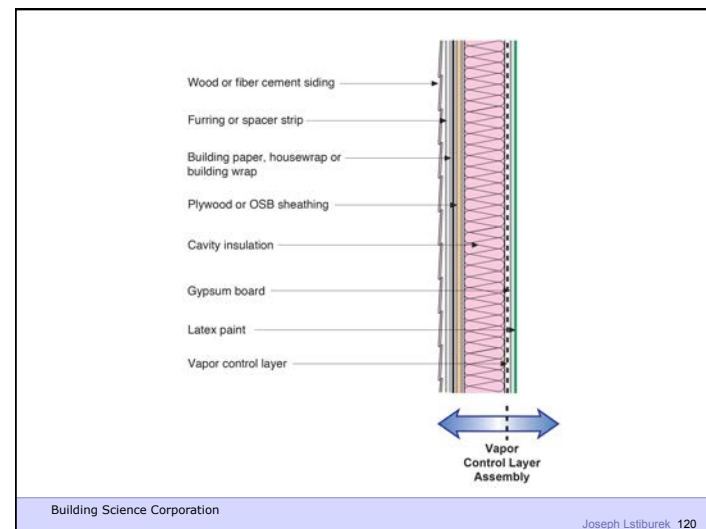
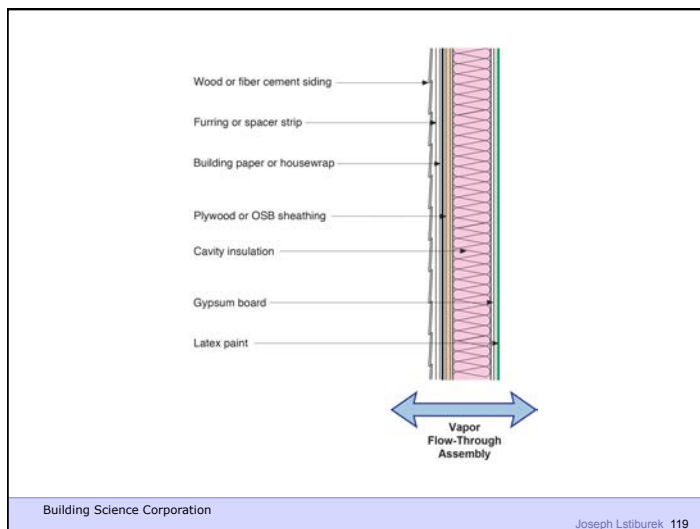


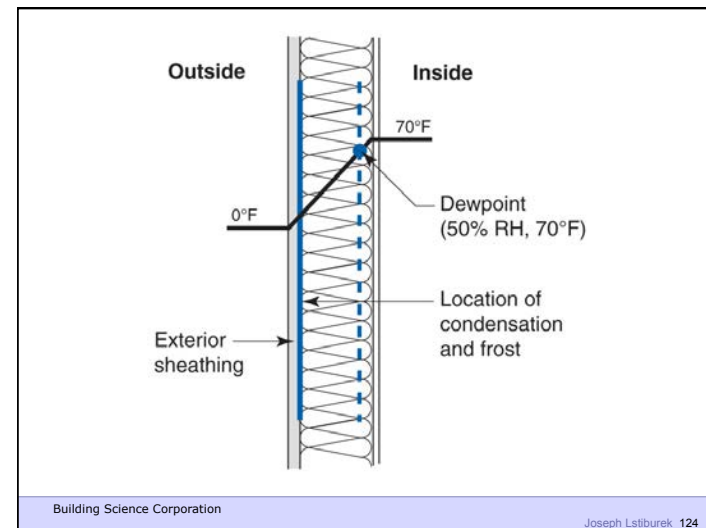
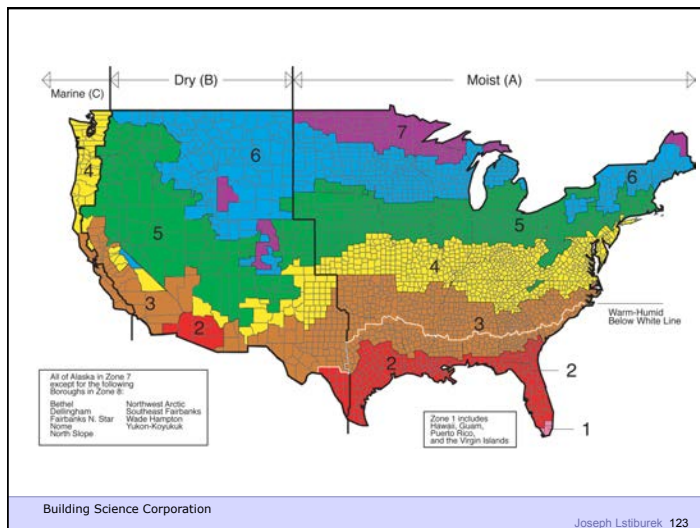
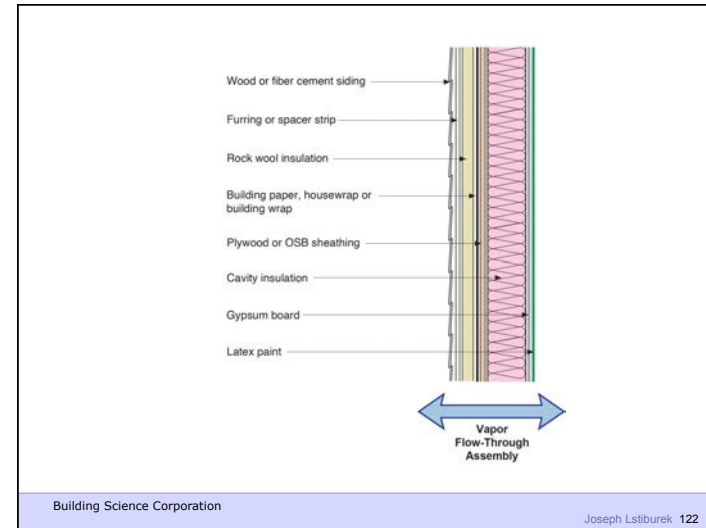
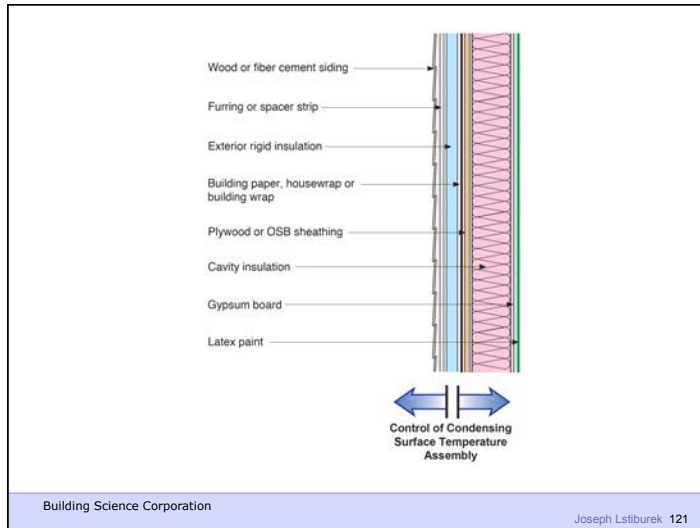


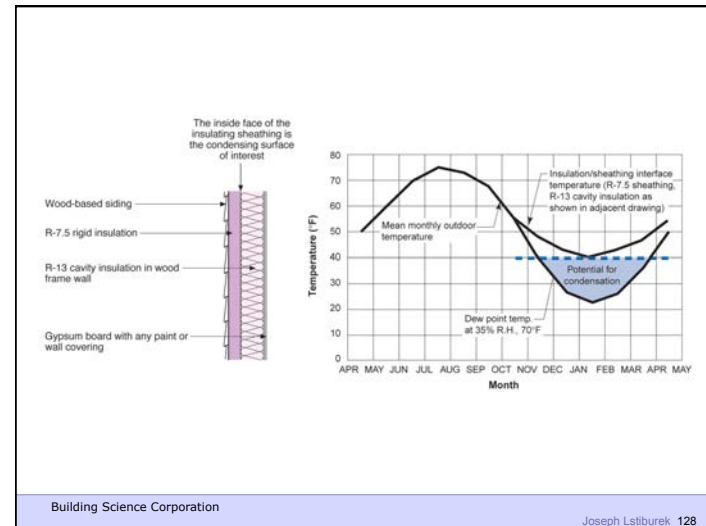
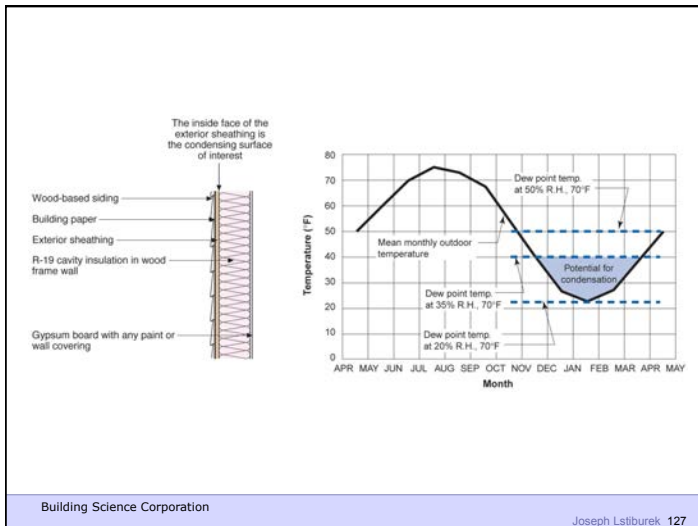
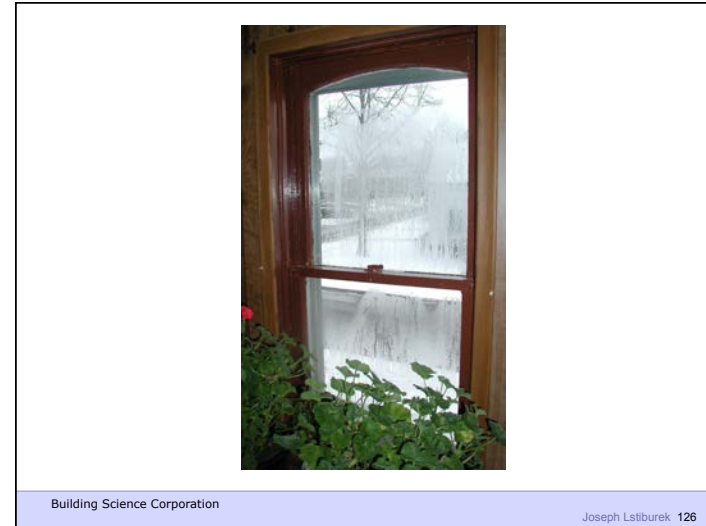
Don't Do Stupid Things

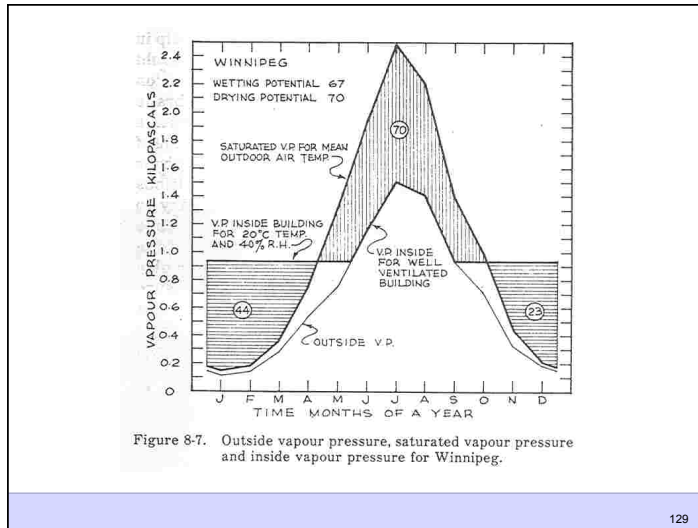
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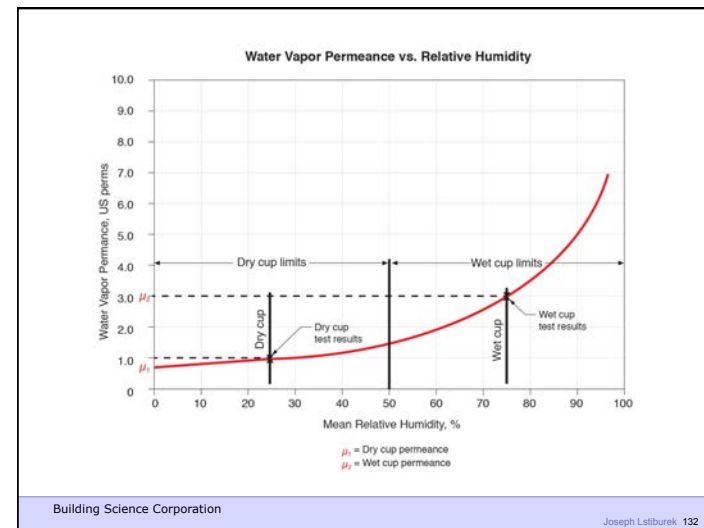
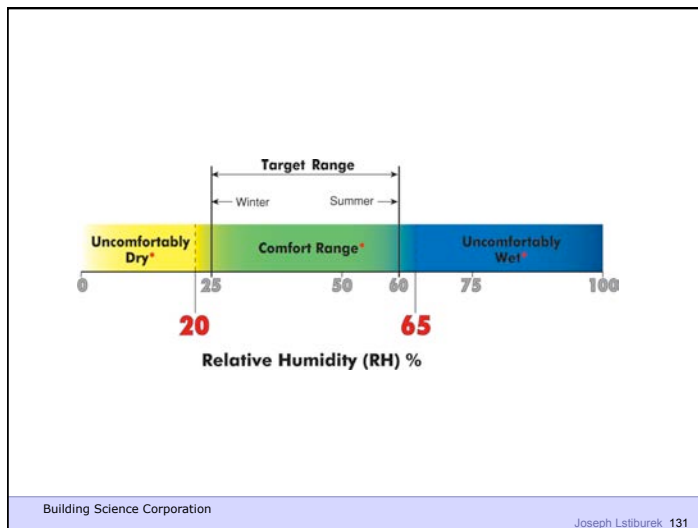
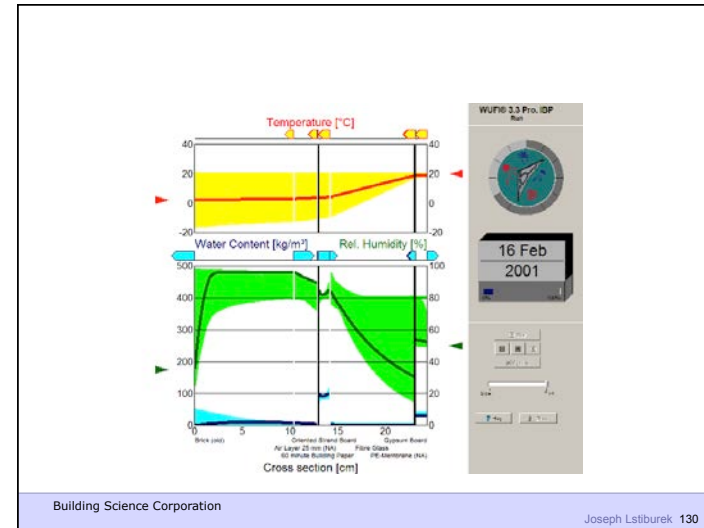


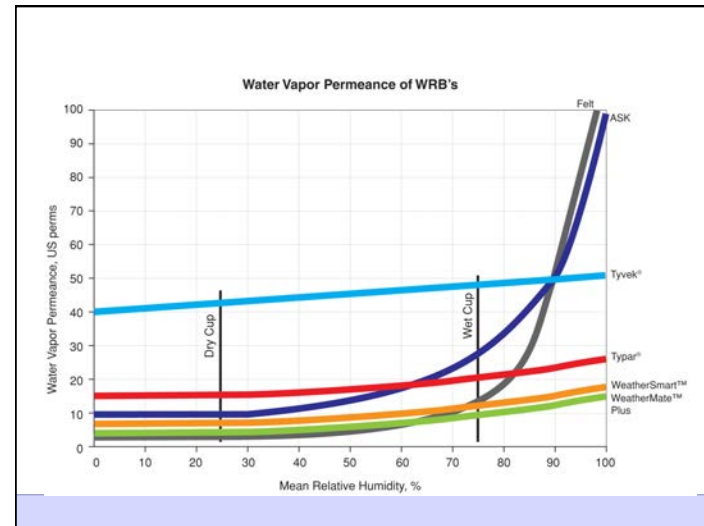
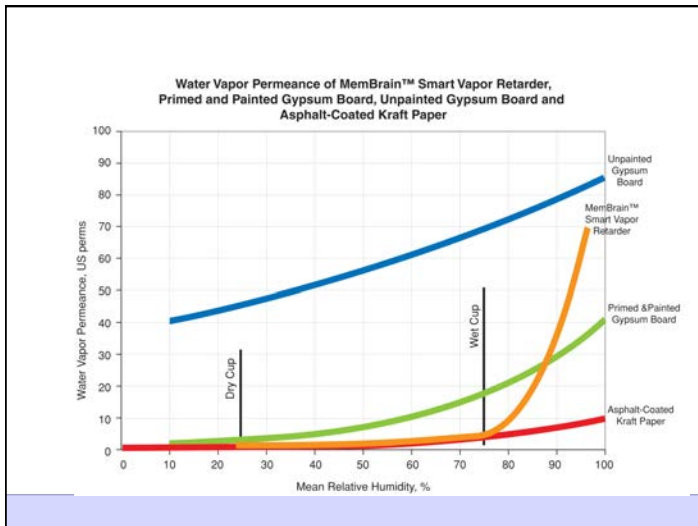
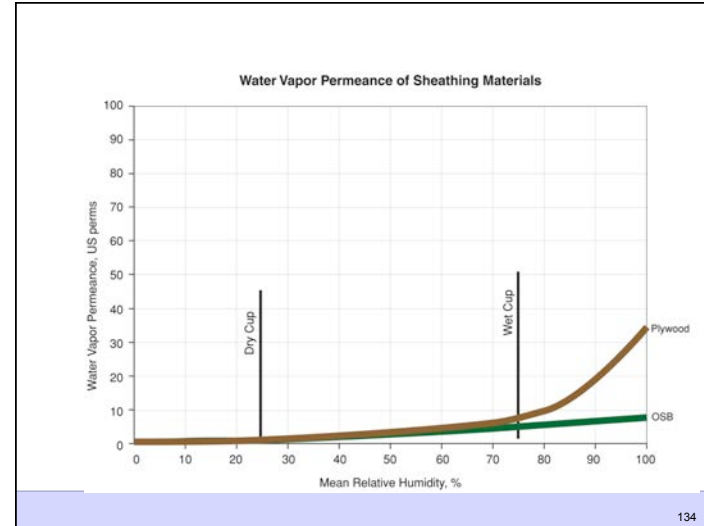


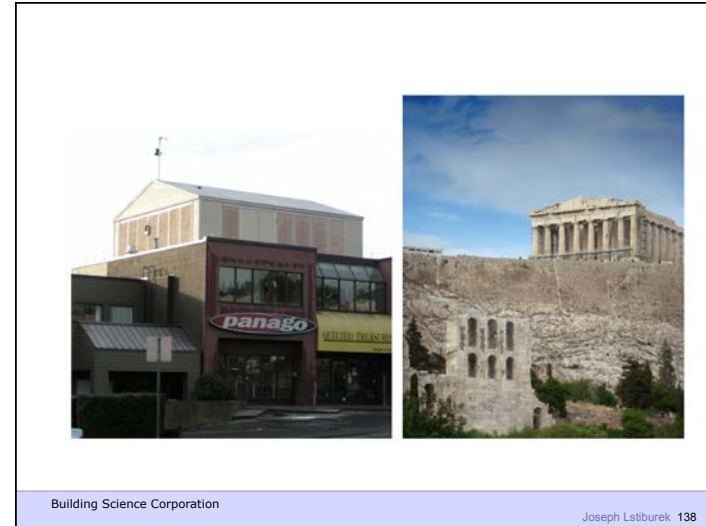
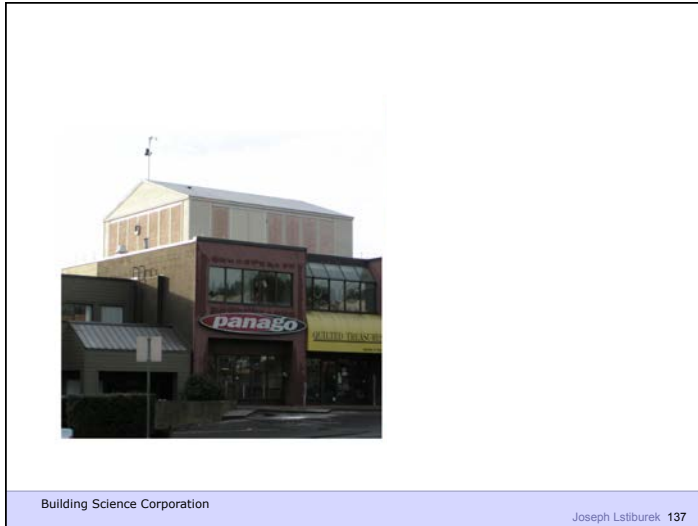


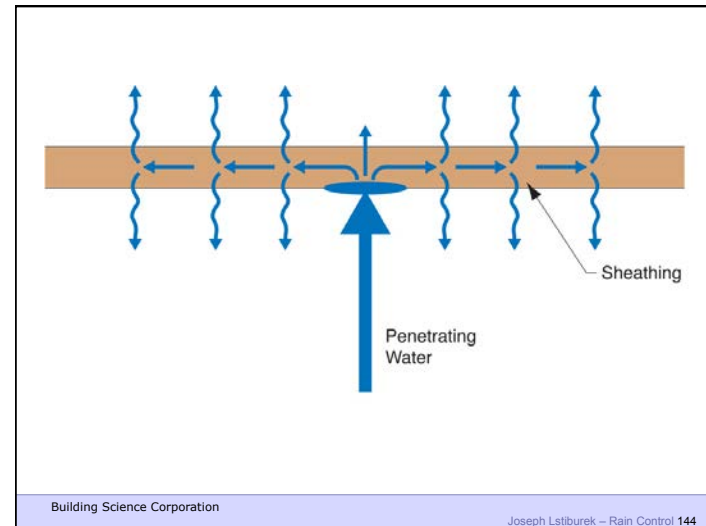
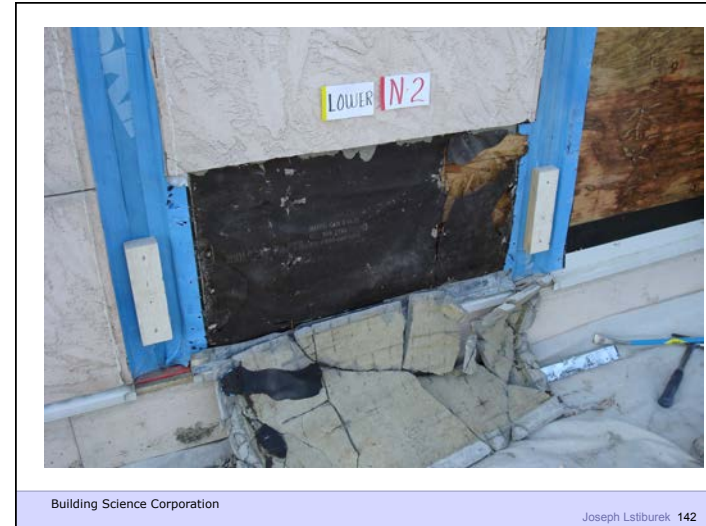


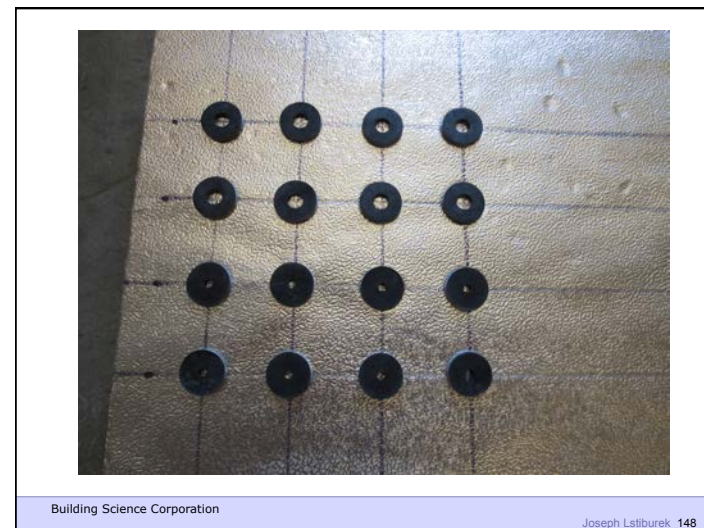
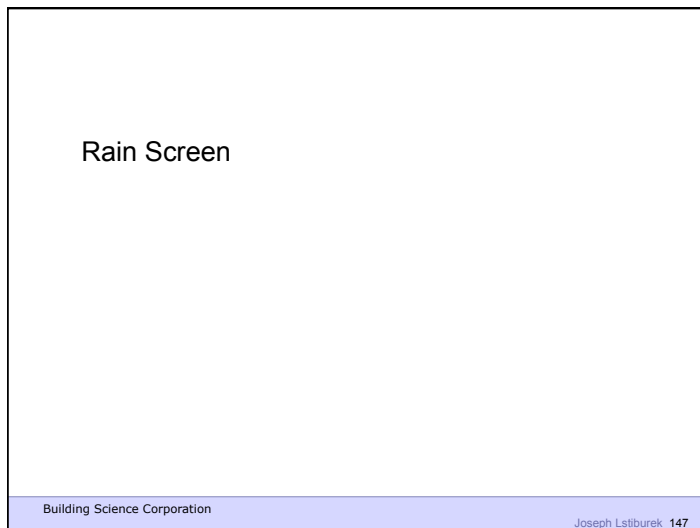
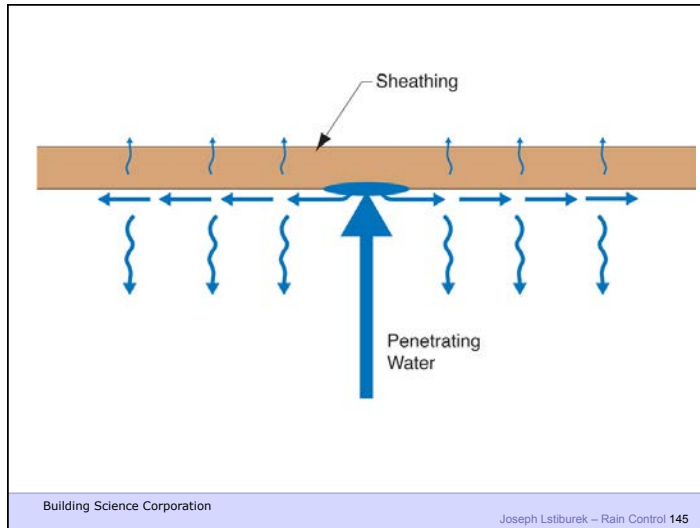
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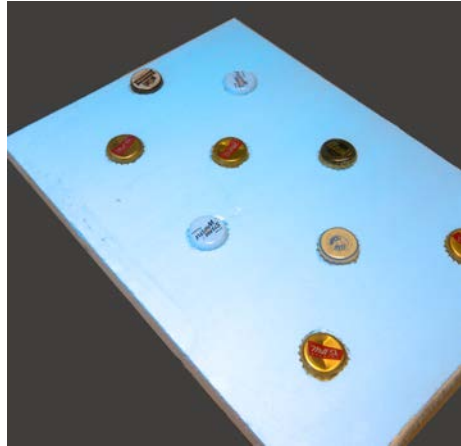




Beer Screen?


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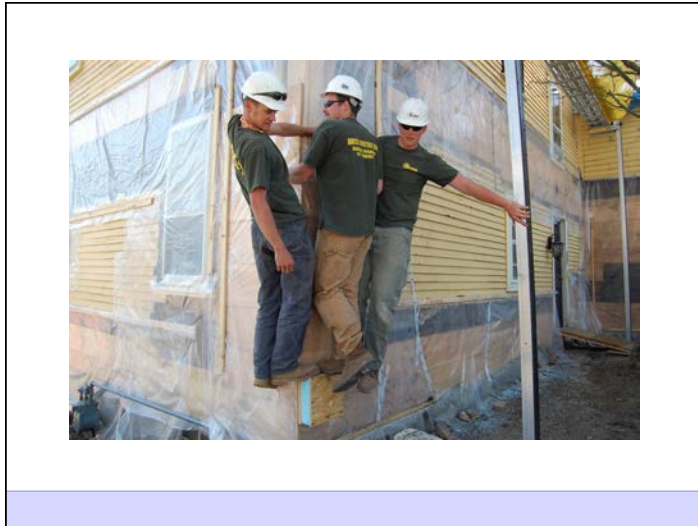
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2010

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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

Average Deflection of Framing (Inches) (Right-to-Left)	Vertical Load (Pounds) (Average)
0.00	0
0.02	1000
0.04	1800
0.06	2200
0.08	2400
0.10	2500
0.12	2550
0.14	2580
0.16	2600
0.18	2620
0.20	2630
0.22	2640
0.24	2650
0.26	2660
0.28	2670
0.30	2680
0.32	2690
0.34	2700
0.36	2710
0.38	2720
0.40	2730
0.42	2740
0.44	2750
0.46	2760
0.48	2770
0.50	2780
0.52	2790
0.54	2800
0.56	2810
0.58	2820
0.60	2830
0.62	2840
0.64	2850
0.66	2860
0.68	2870
0.70	2880
0.72	2890
0.74	2900
0.76	2910
0.78	2920
0.80	2930
0.82	2940
0.84	2950
0.86	2960
0.88	2970
0.90	2980
0.92	2990
0.94	3000
0.96	3010
0.98	3020
1.00	3030

