

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

# Building Science

Adventures In Building Science

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Life is Tough Enough As it Is...

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Life is Tough Enough As it Is...  
It's Harder When You Are Stupid

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Don't Do Stupid Things

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Joseph Lstiburek 4


**R2**




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**R2**



**R4**



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Joseph Lstiburek 6

**R2**



**R4**



**R6**



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**R2**



**R4**



**R6**

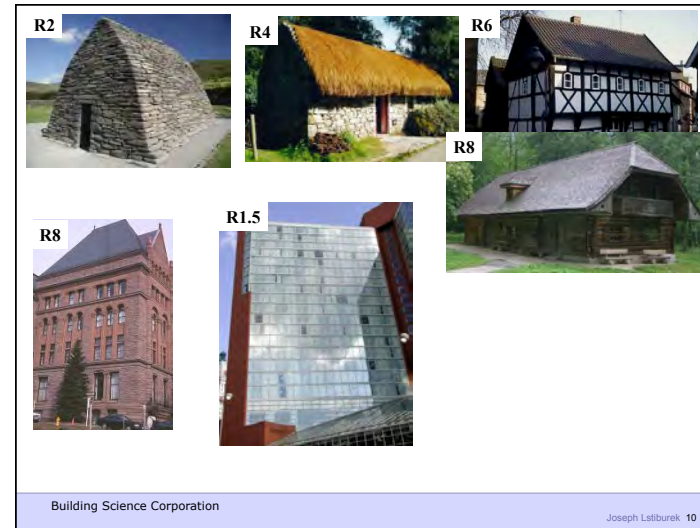
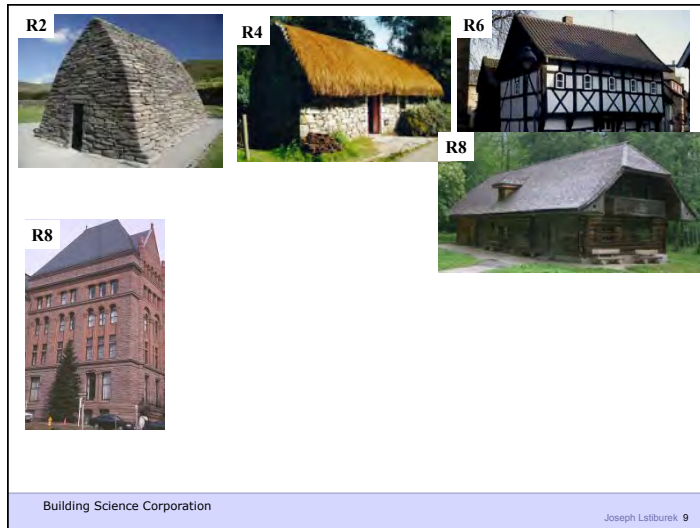


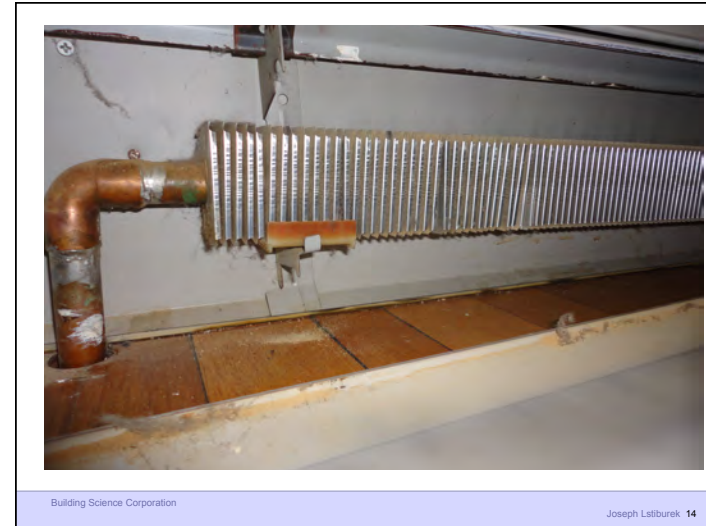
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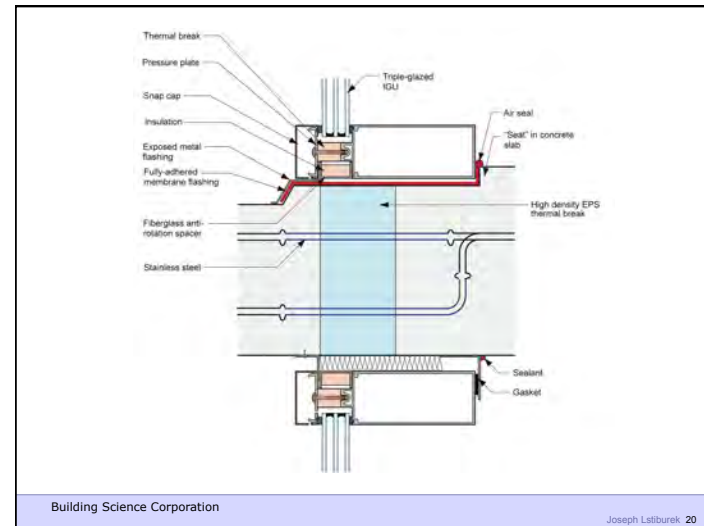
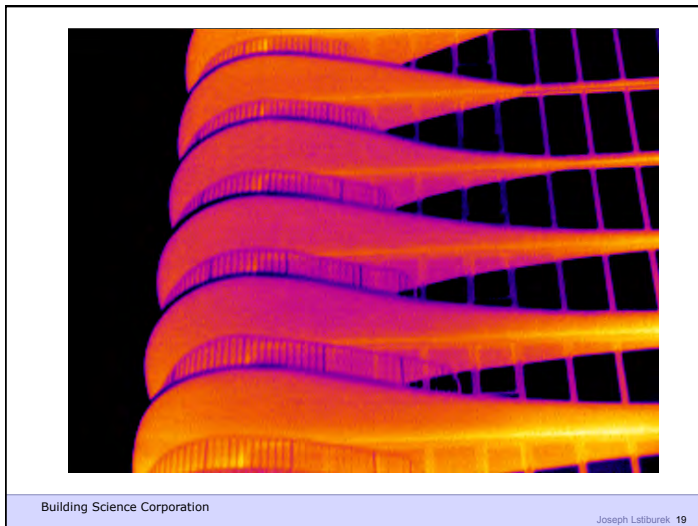
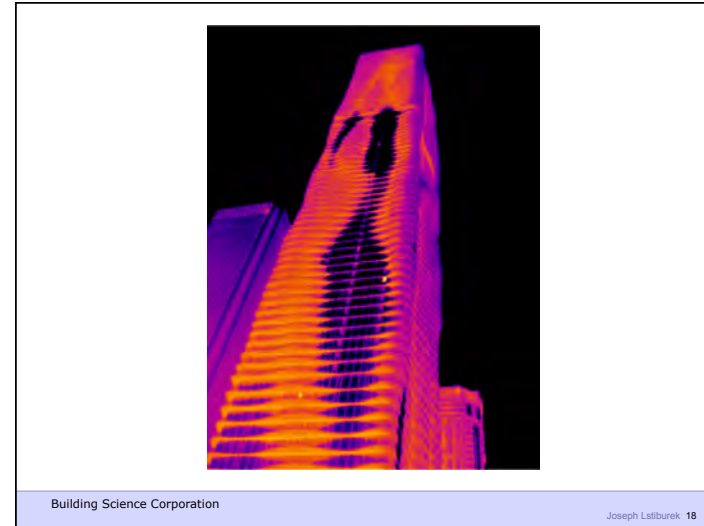
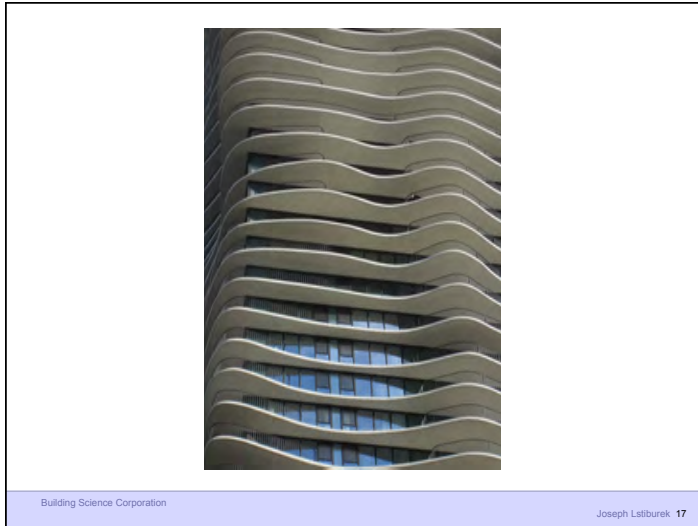


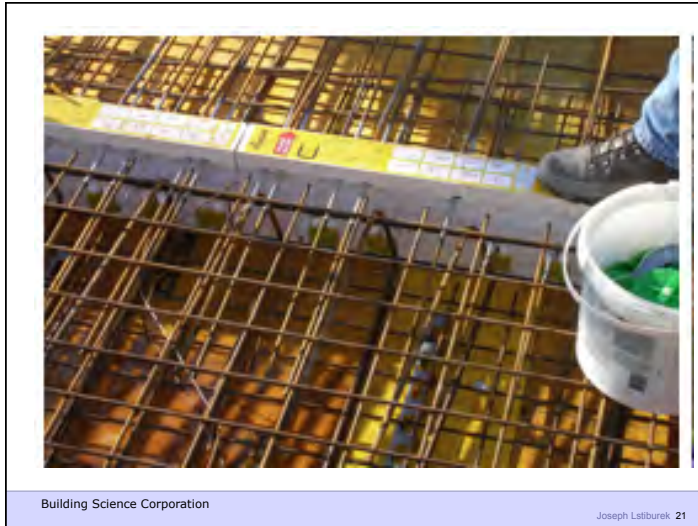
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What Is A Building?

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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

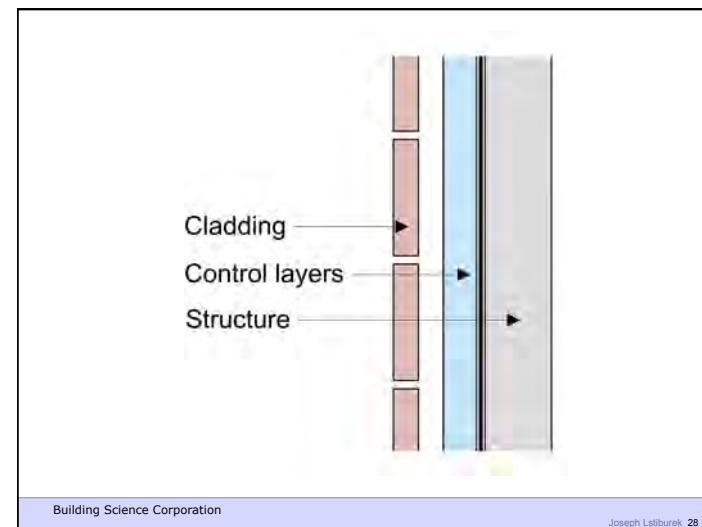
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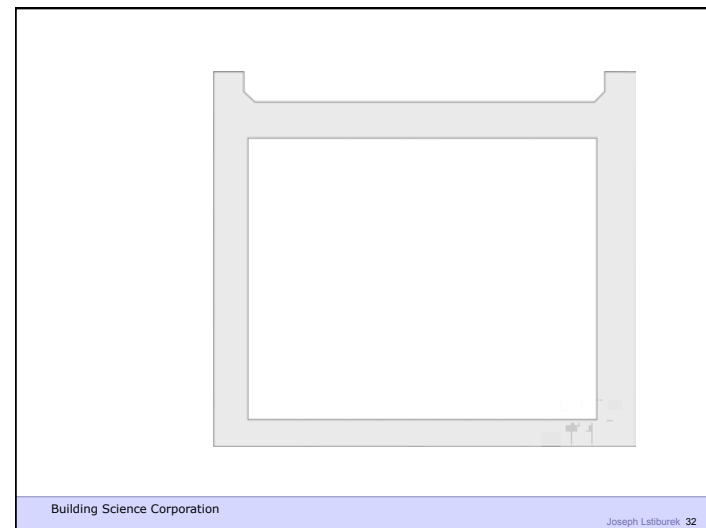
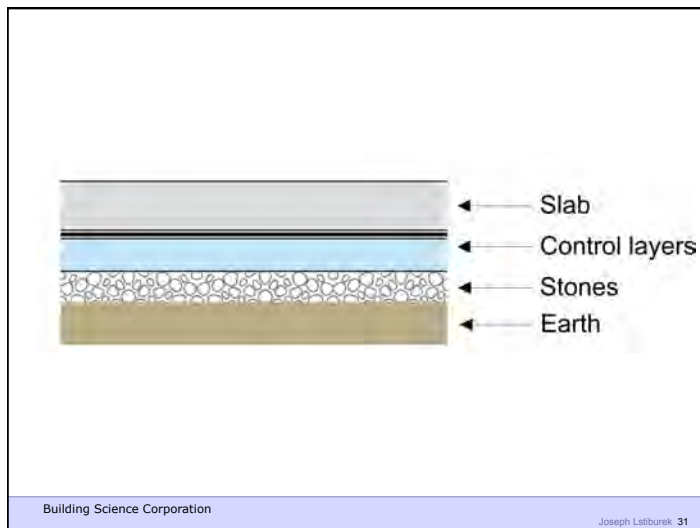
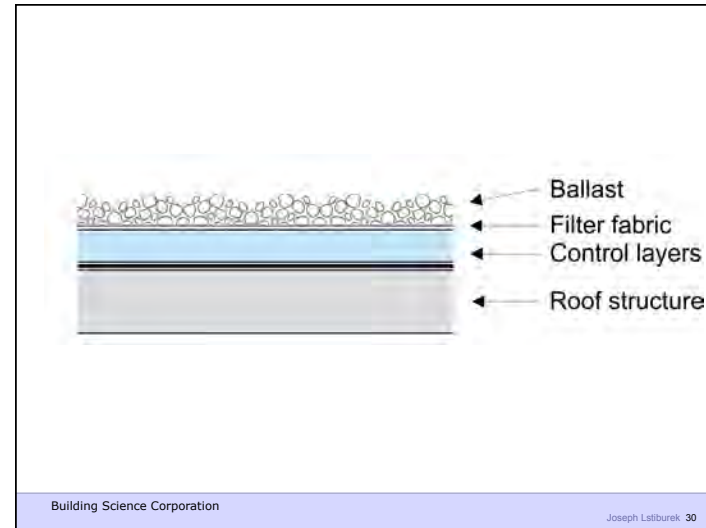
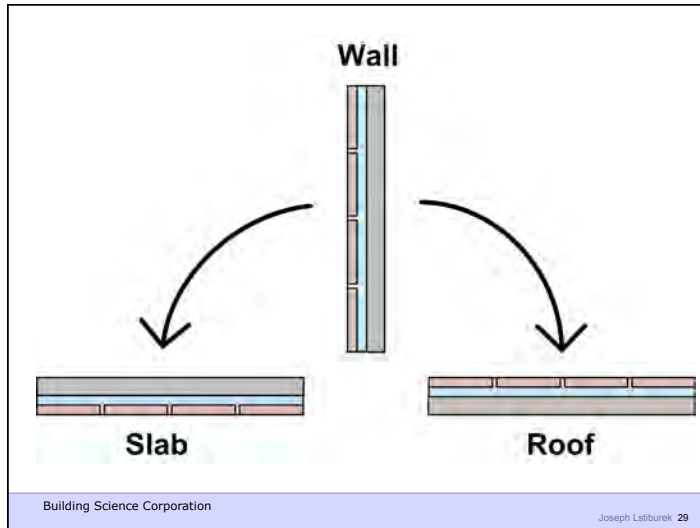
Heat Flow Is From Warm To Cold  
 Moisture Flow Is From Warm To Cold  
 Moisture Flow Is From More To Less  
 Air Flow Is From A Higher Pressure to a Lower Pressure  
 Gravity Acts Down

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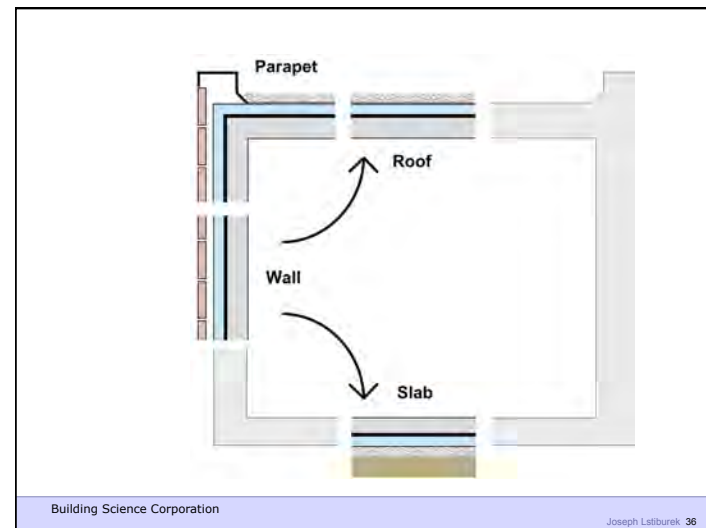
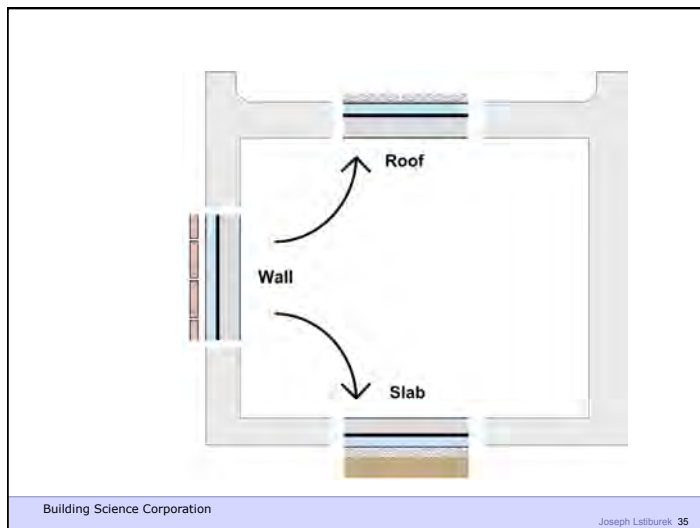
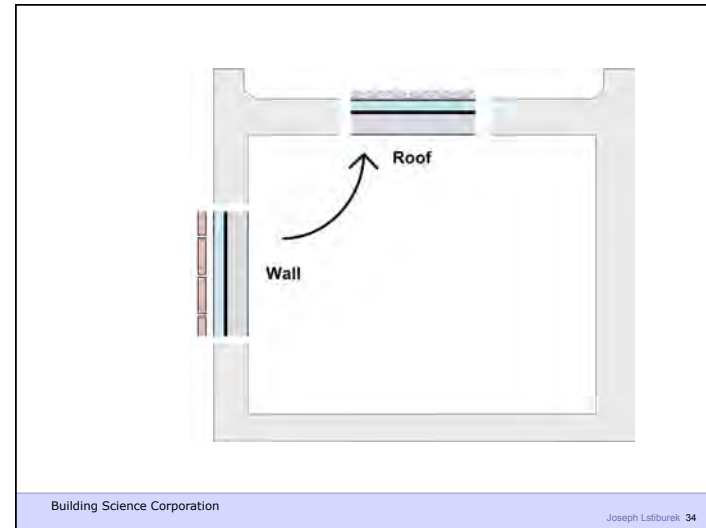
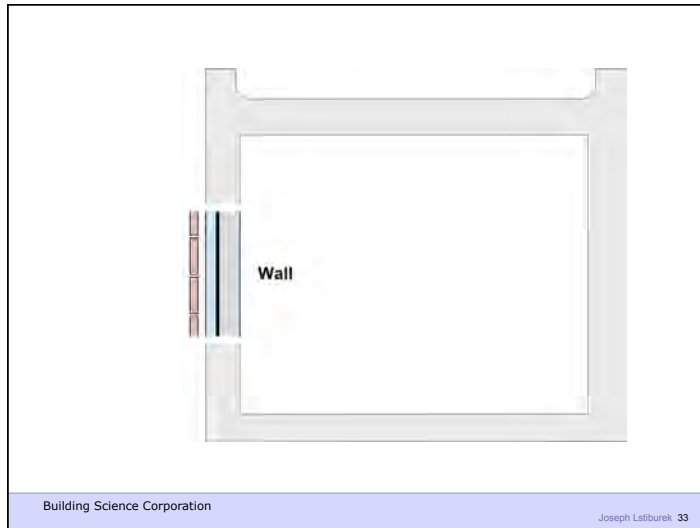
Water Control Layer  
 Air Control Layer  
 Vapor Control Layer  
 Thermal Control Layer

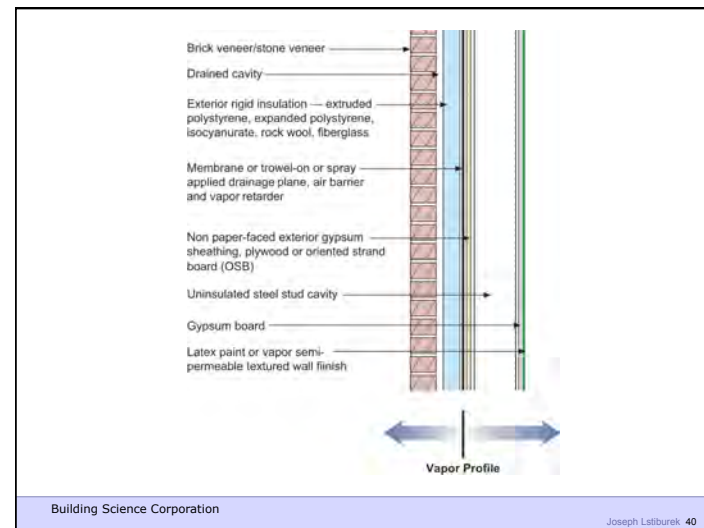
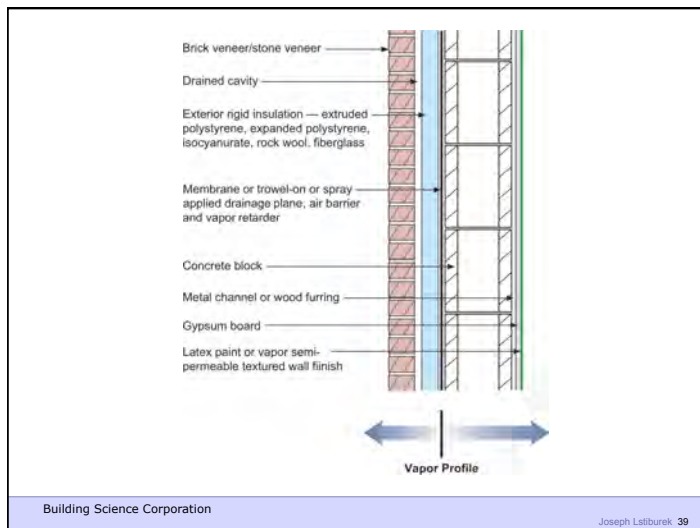
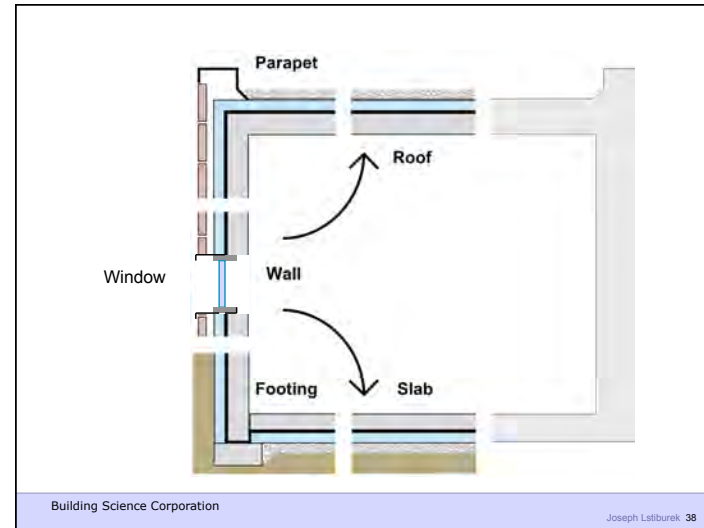
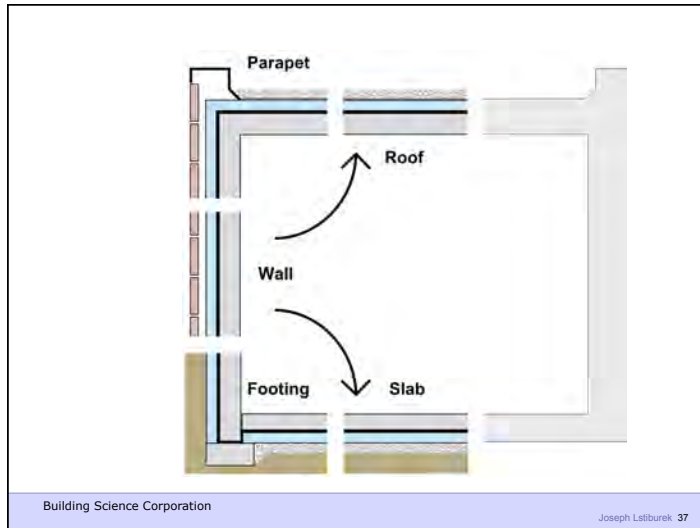
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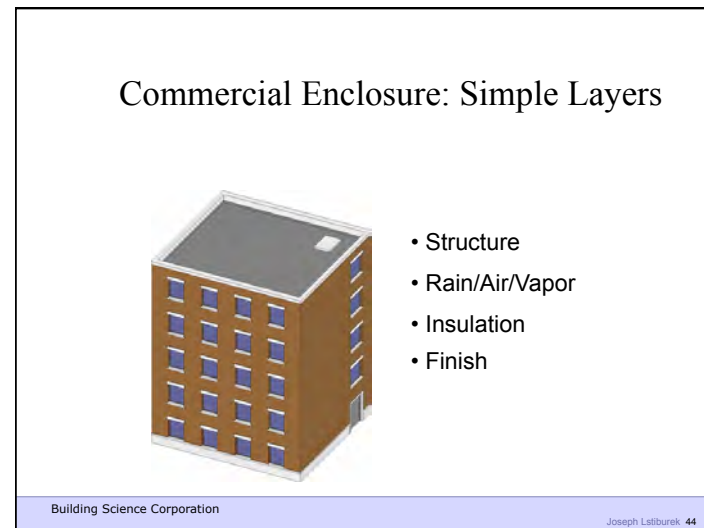
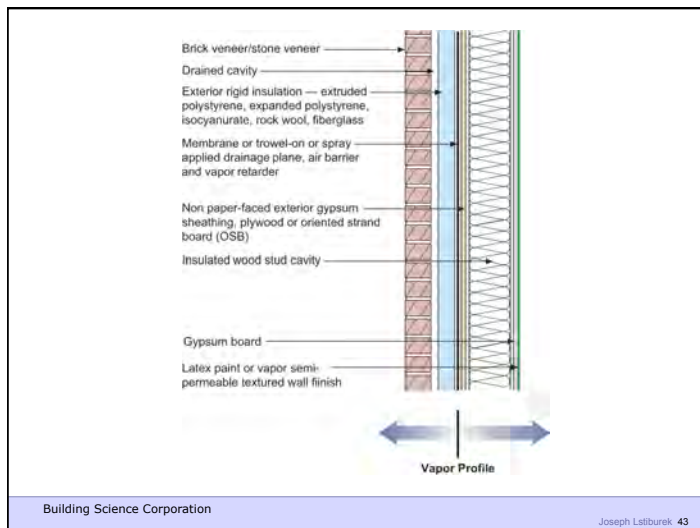
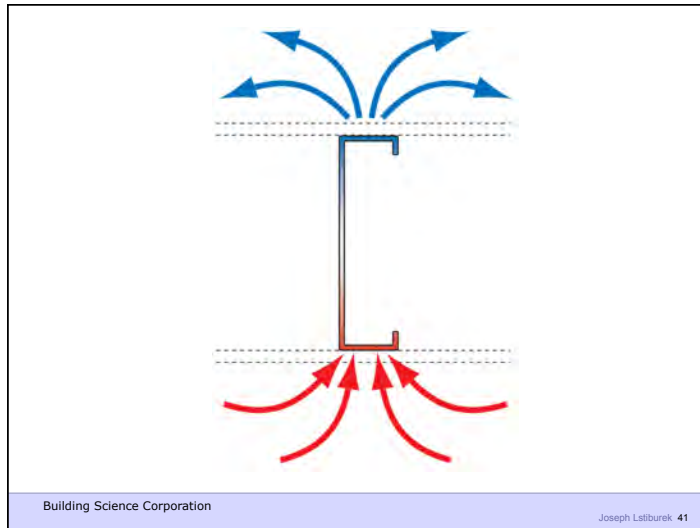


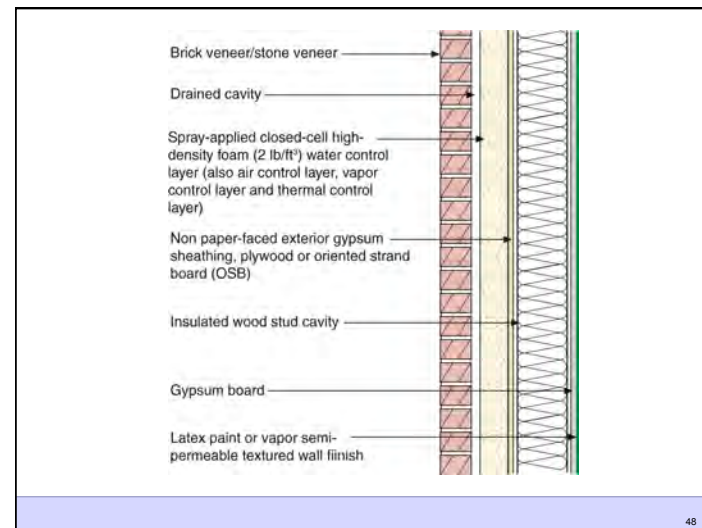
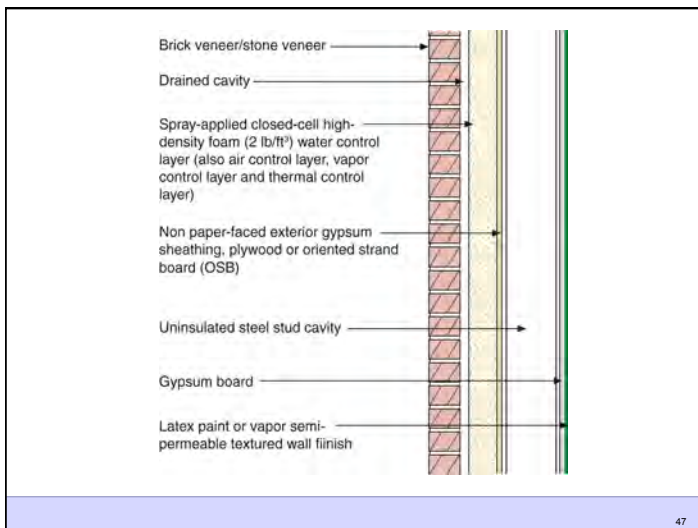
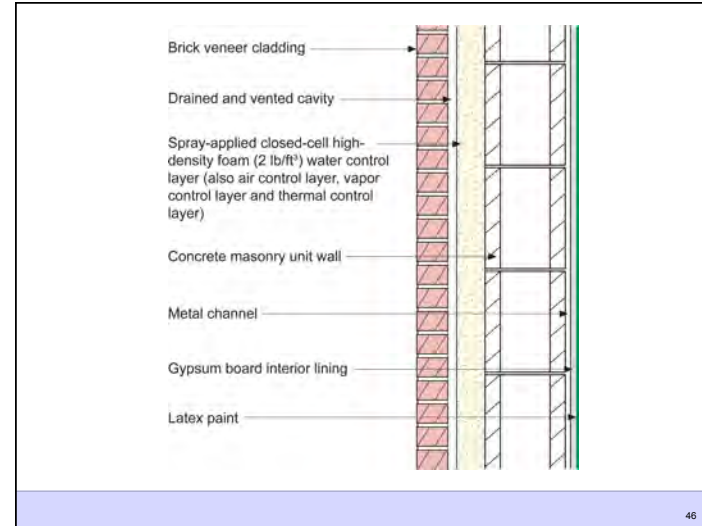
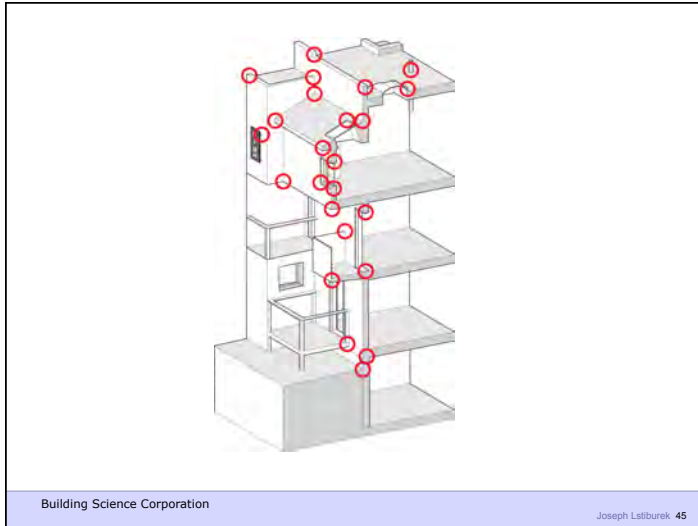


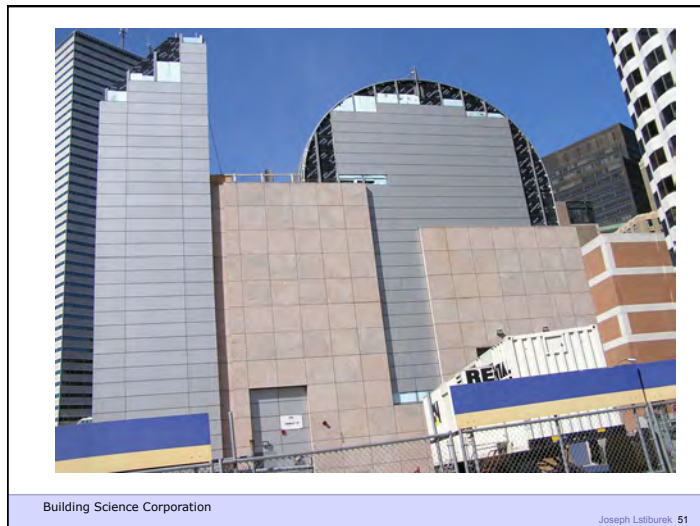


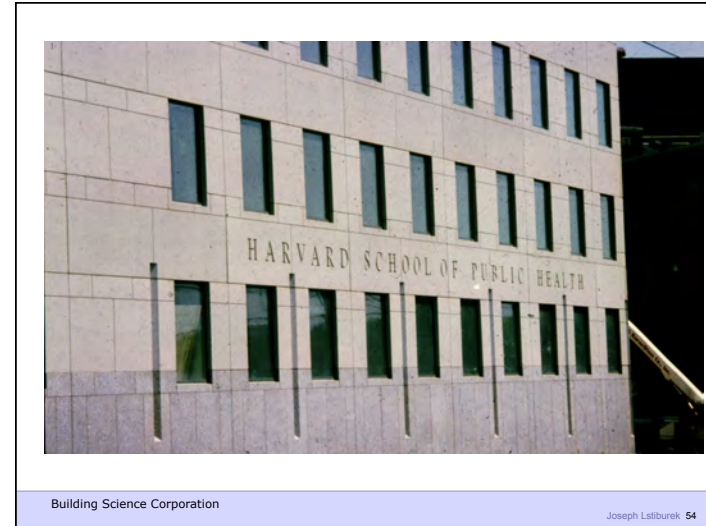
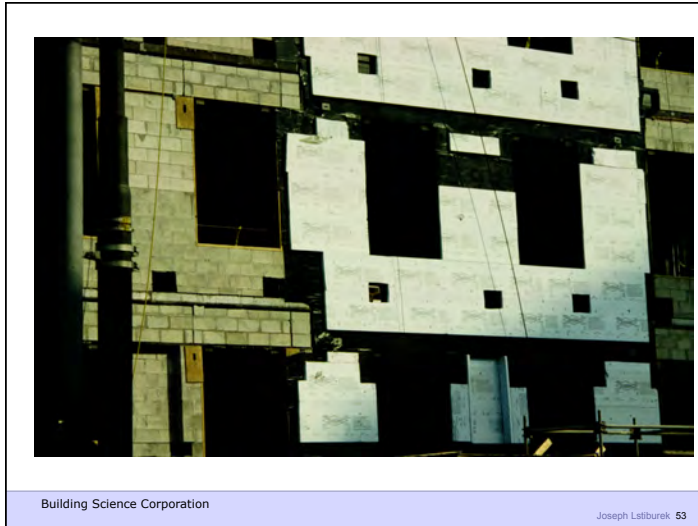














Don't Do Stupid Things


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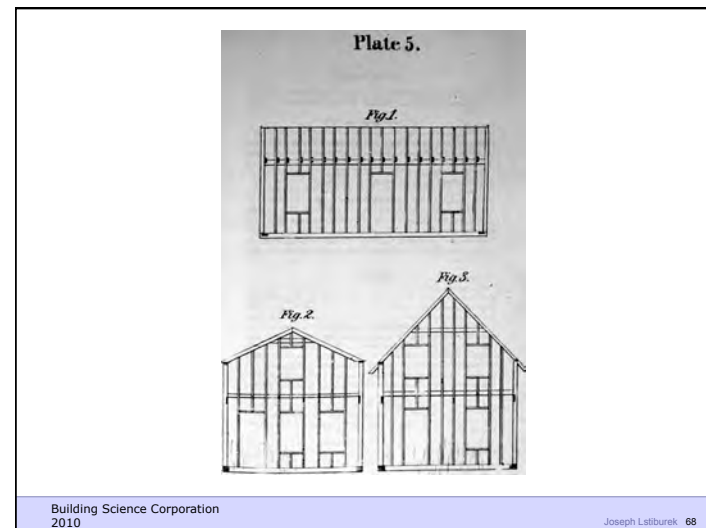
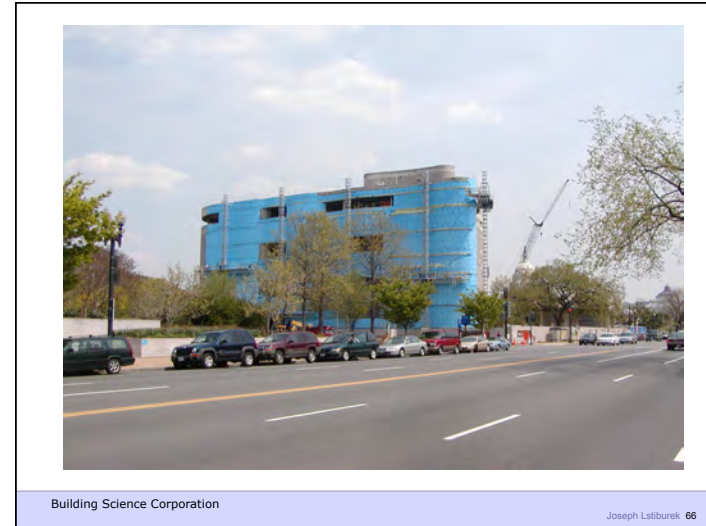
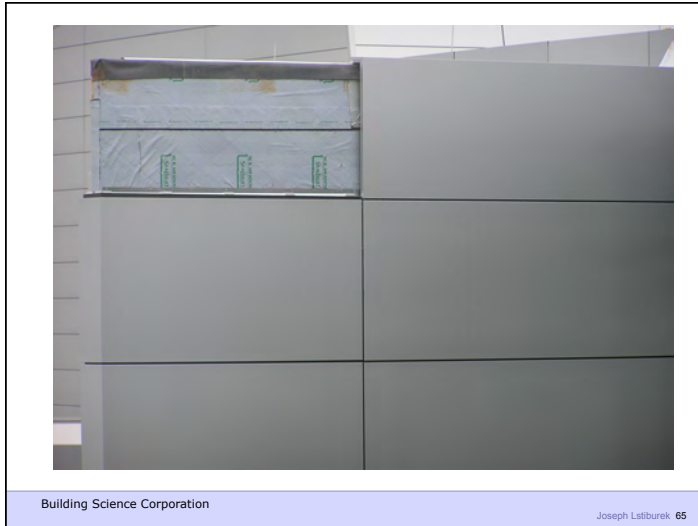
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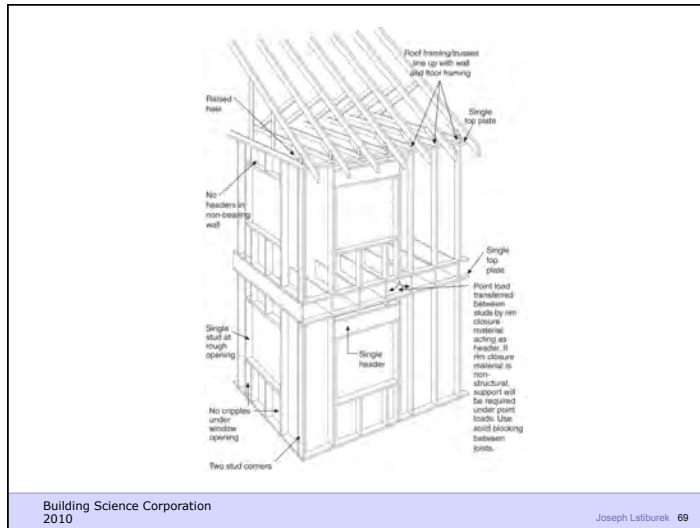


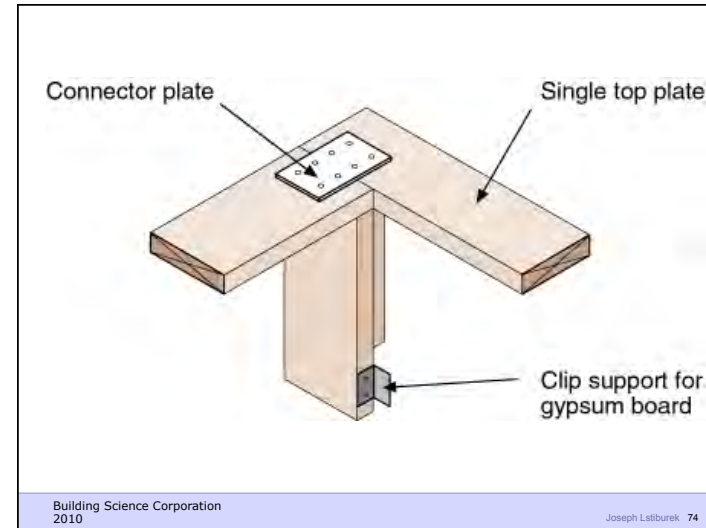
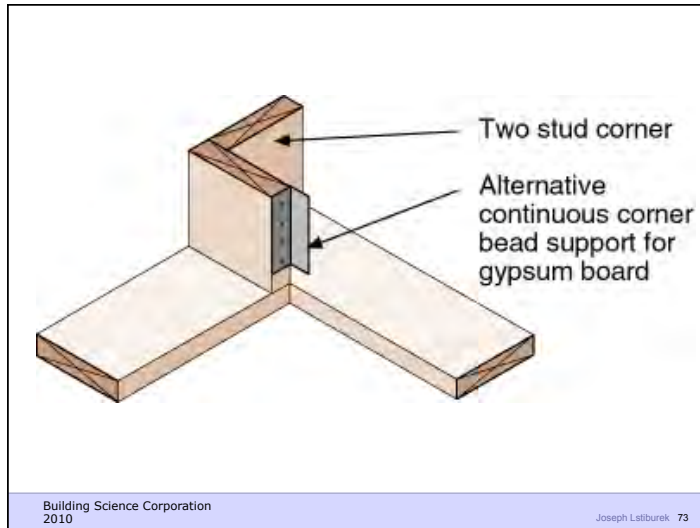
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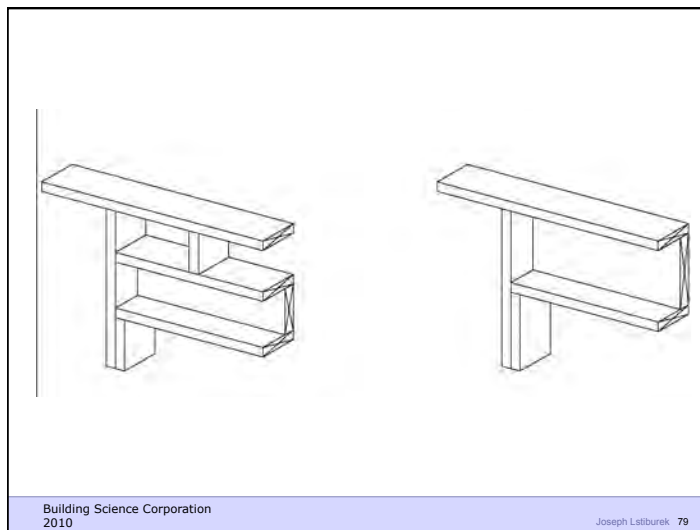
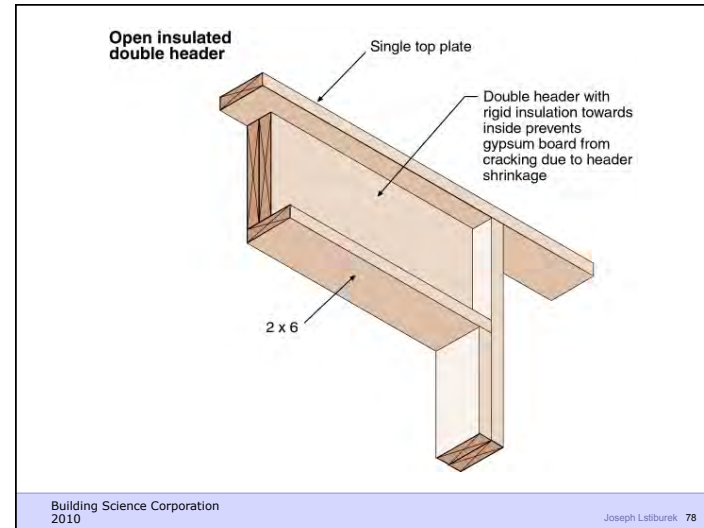
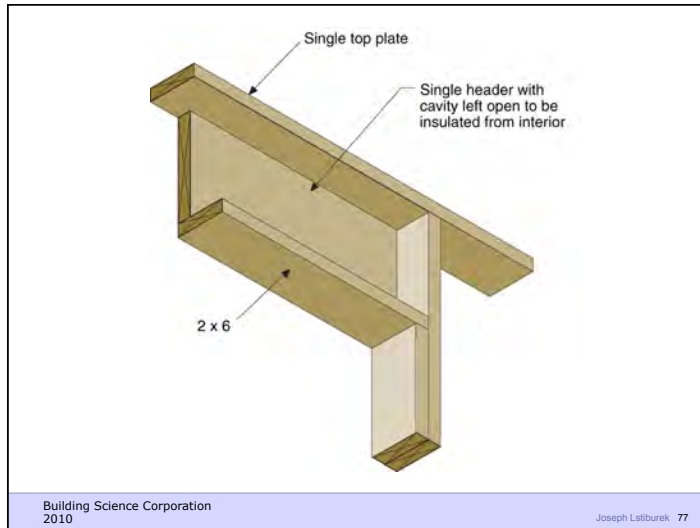
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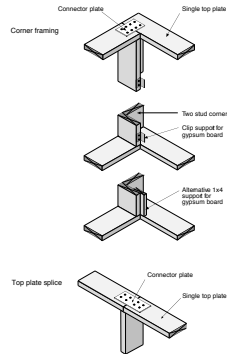






### Advanced Framing System

- 2 Stud Corners



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### Advanced Framing System

- Insulated headers
- No header necessary at non-bearing walls

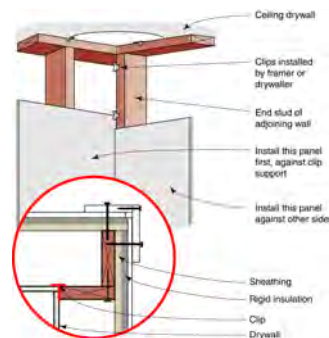


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### Advanced Framing System

- Drywall clips allow for better installation with less drywall cracking



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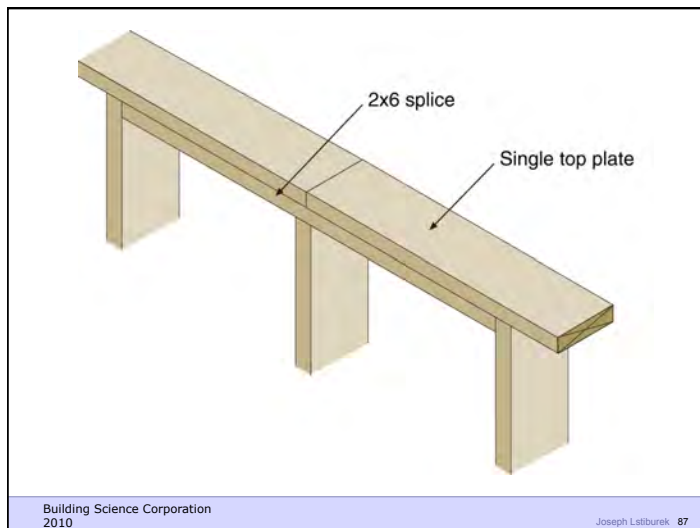
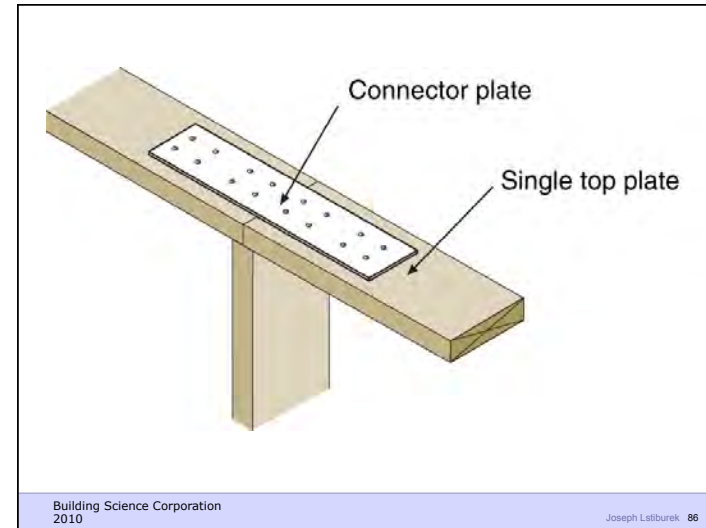
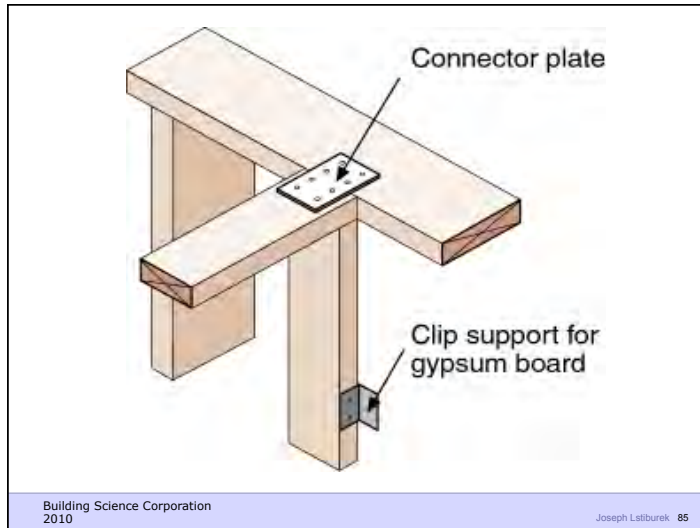
### Advanced Framing System

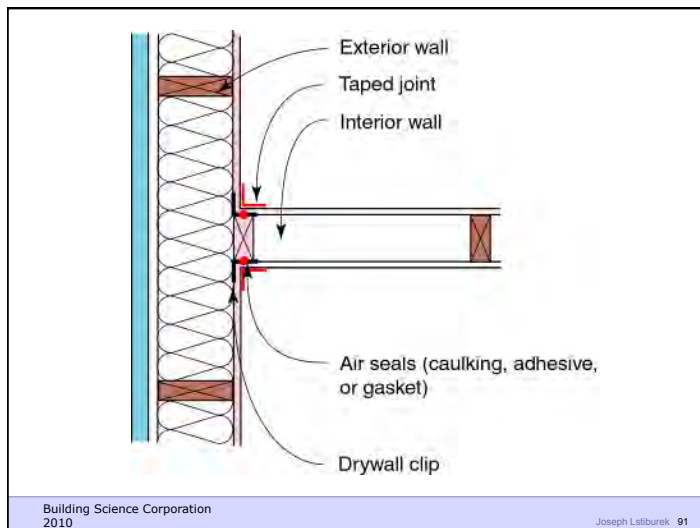
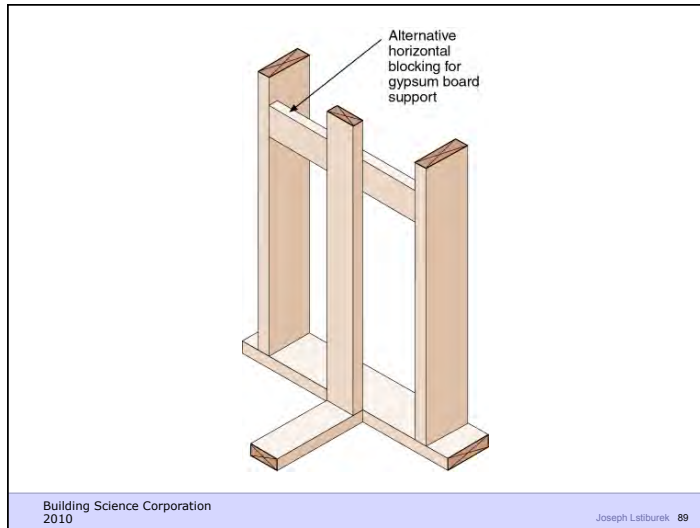
- Drywall clips at corner and intersecting wall



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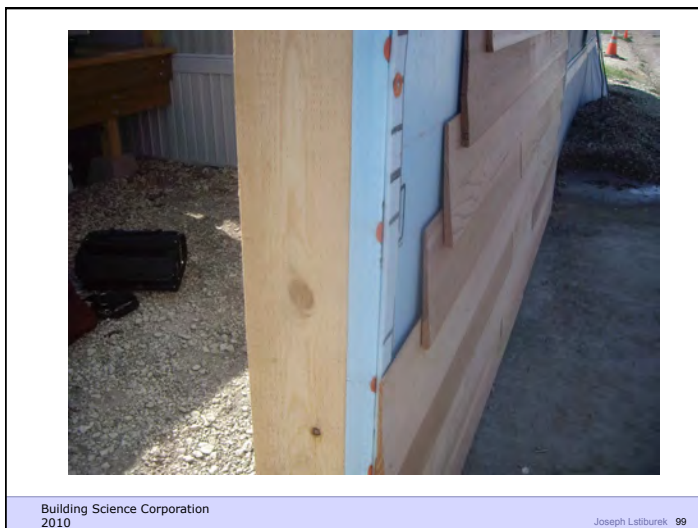
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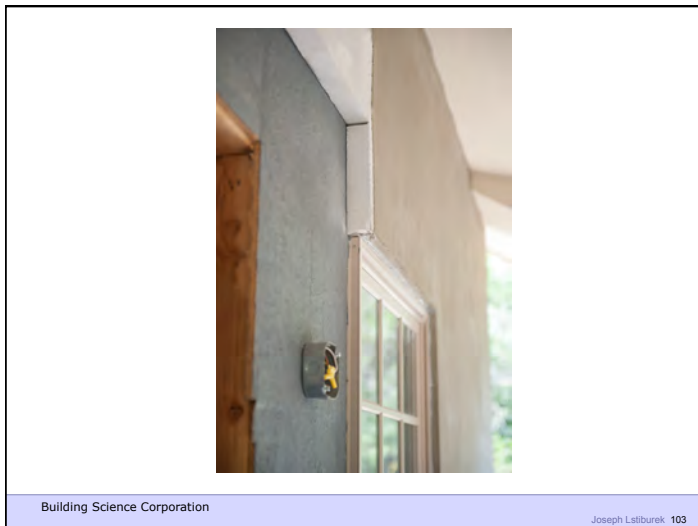




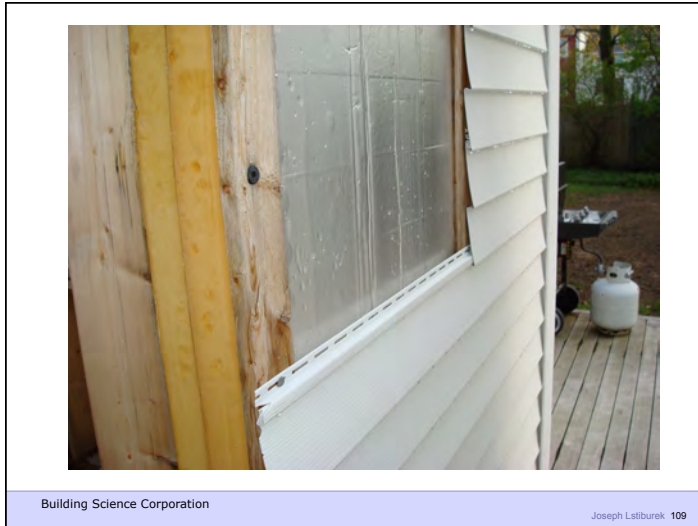


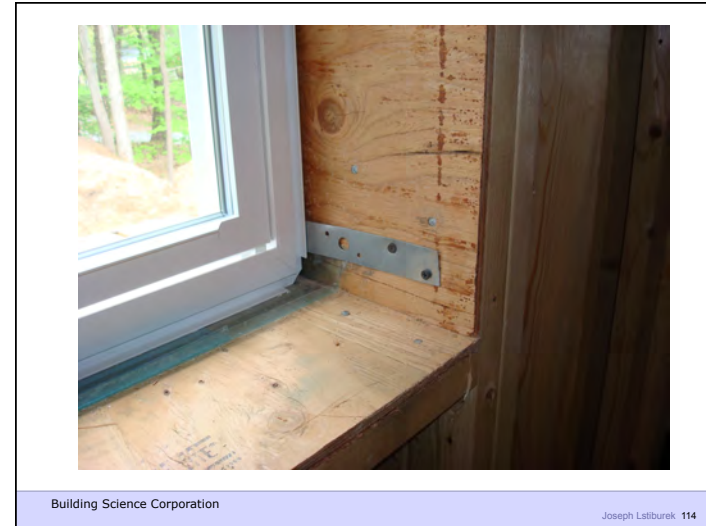


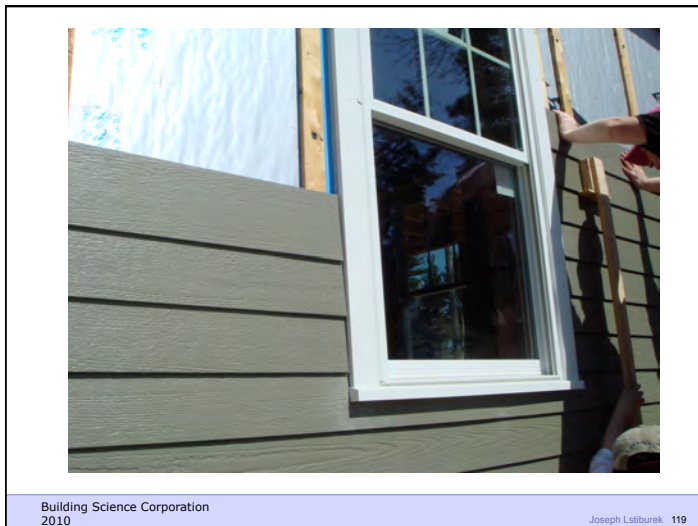


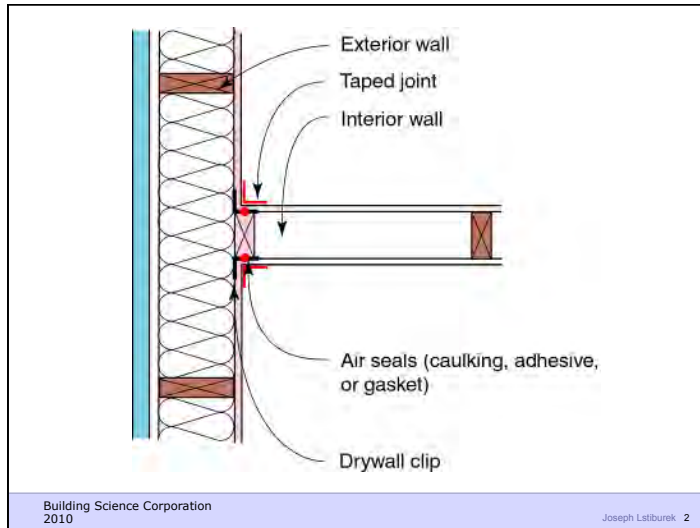


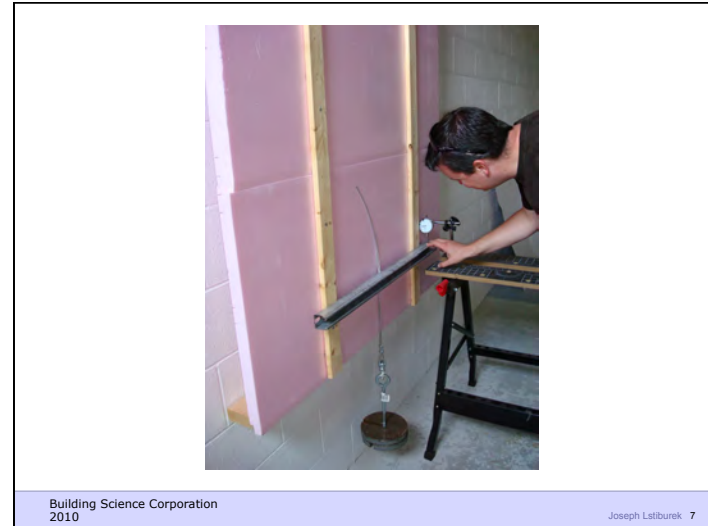




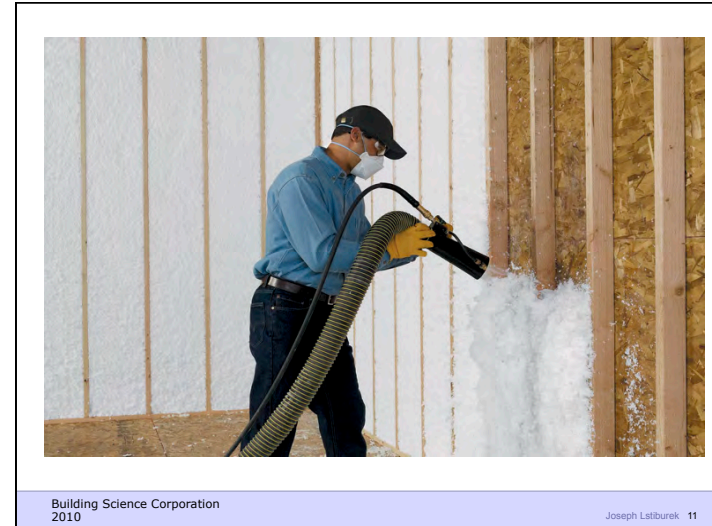


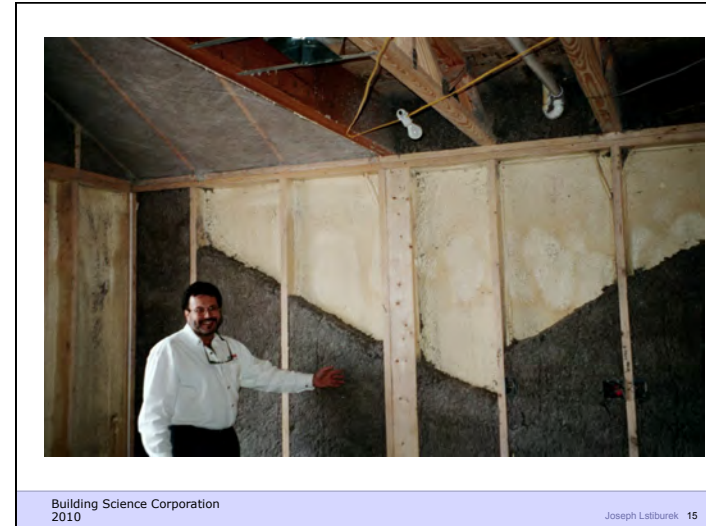














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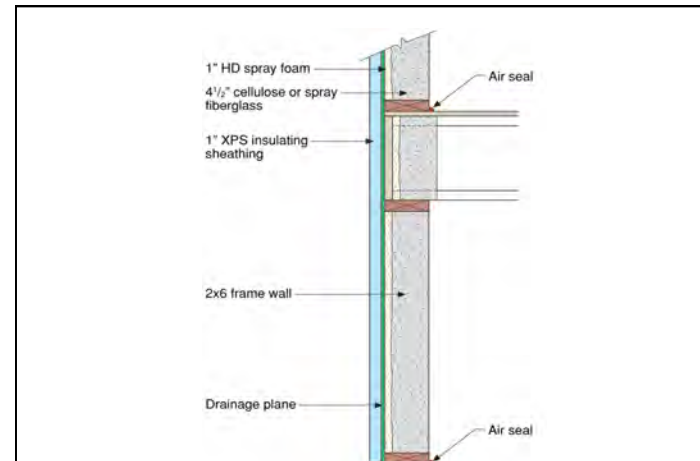
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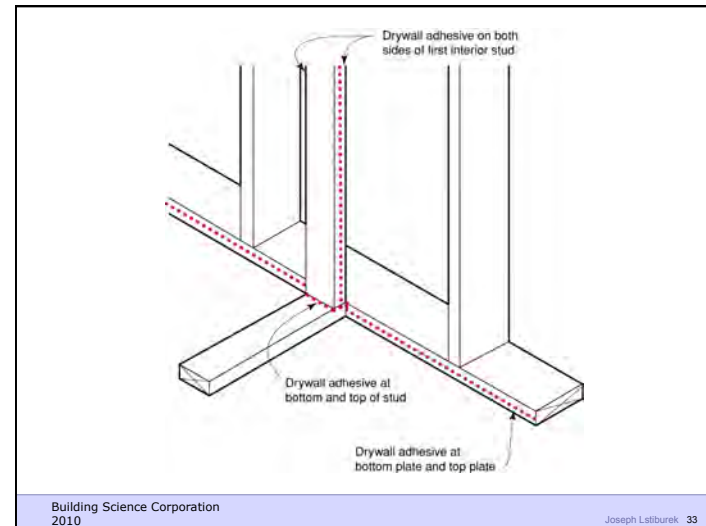
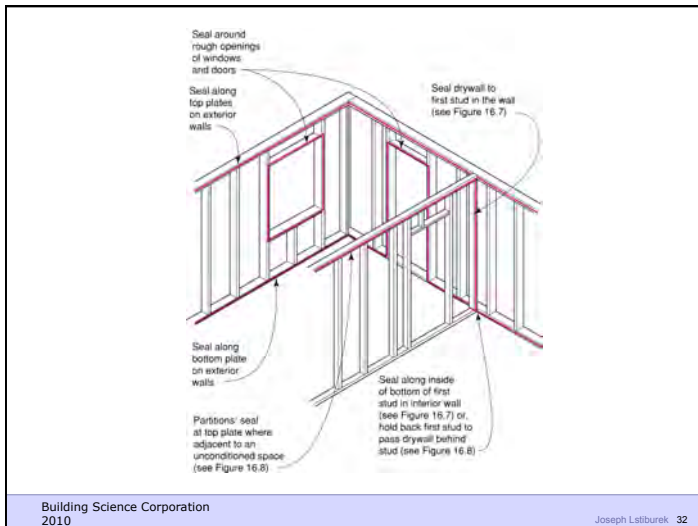


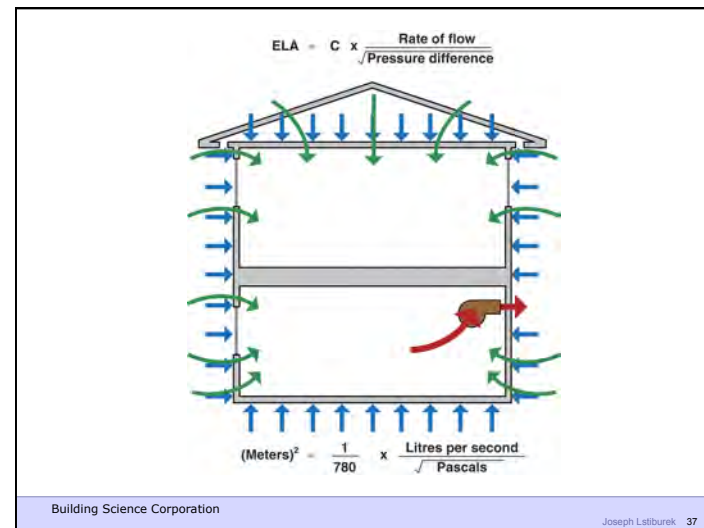
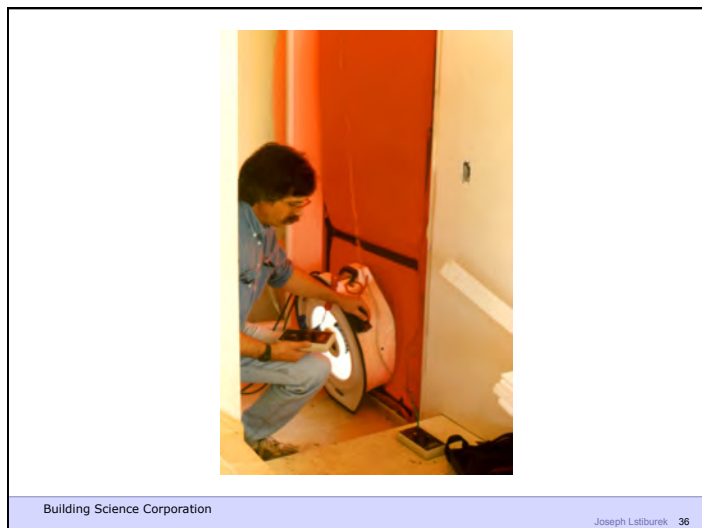
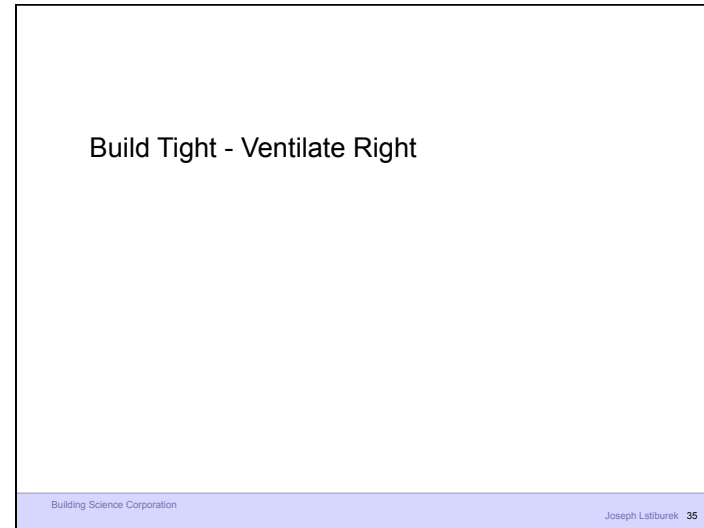
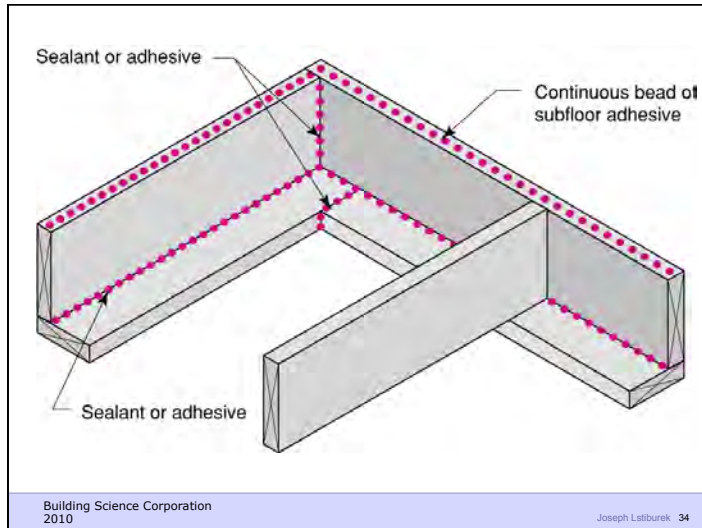
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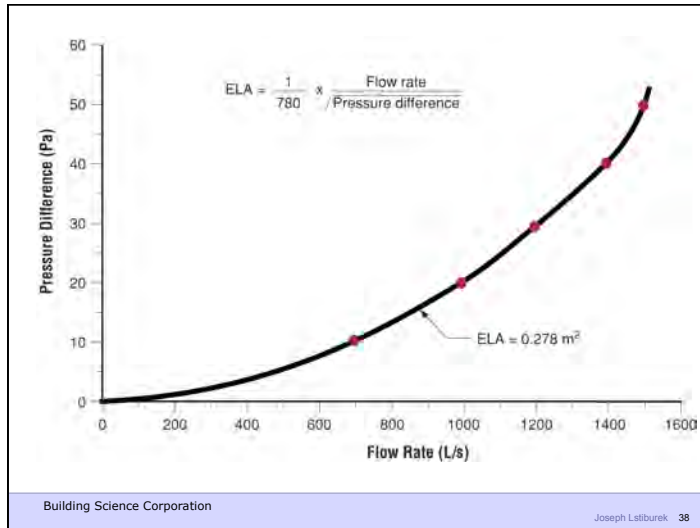
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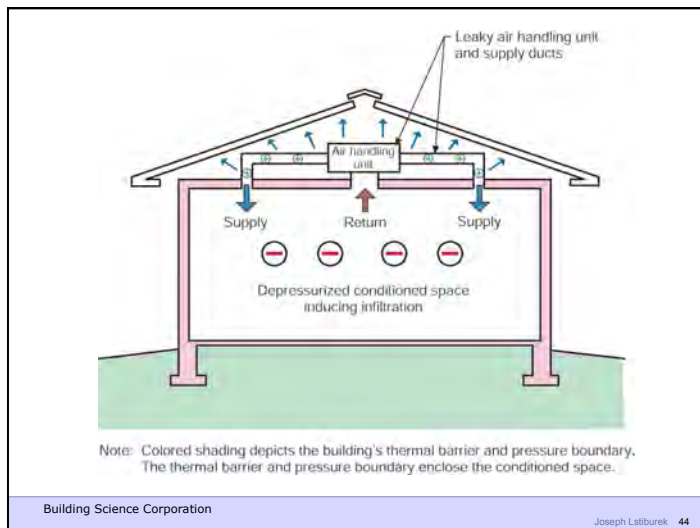
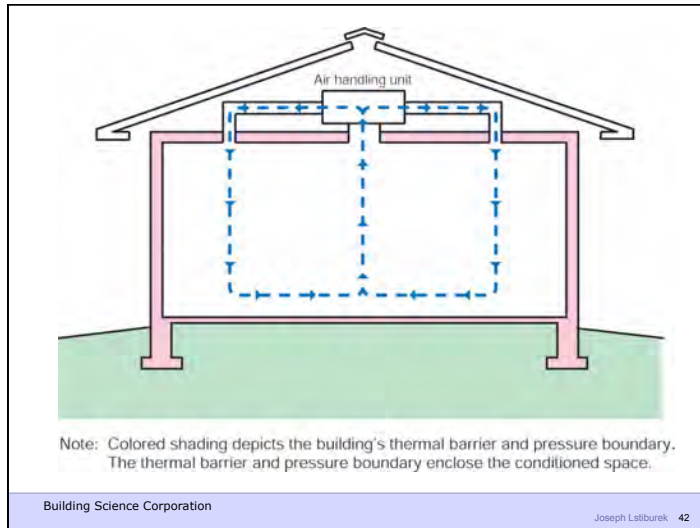


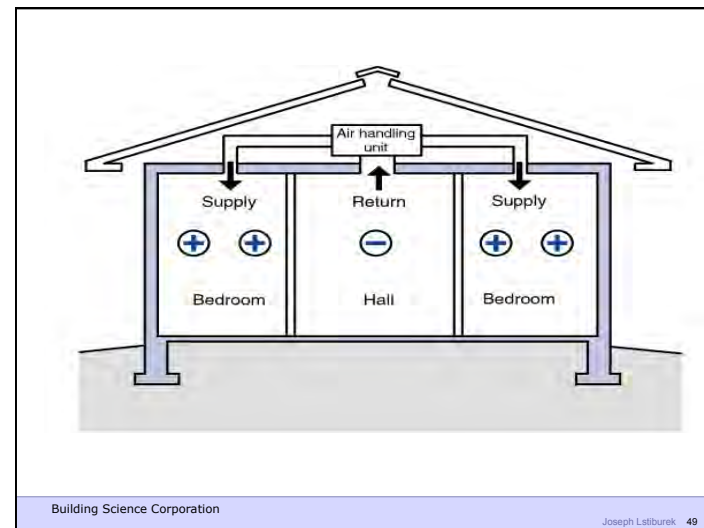
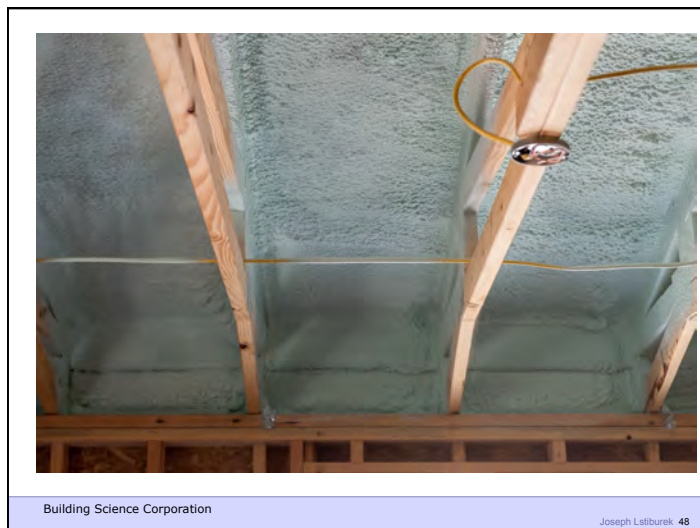
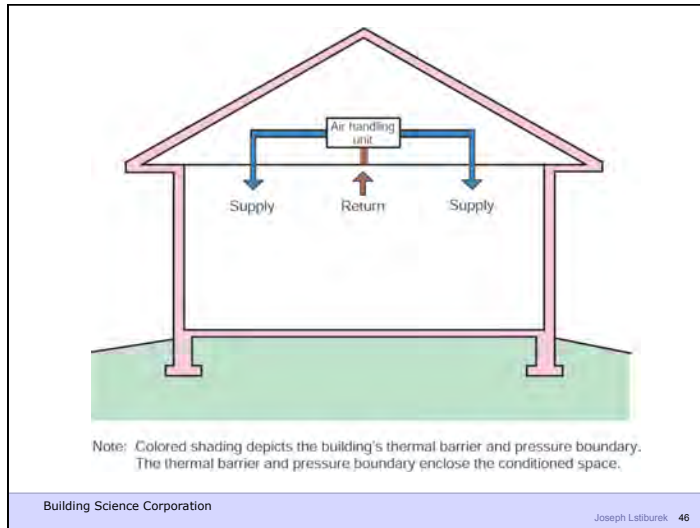
Duct Leakage Should Be Less Than 5% of Rated Flow As Tested by Pressurization To 25 Pascals

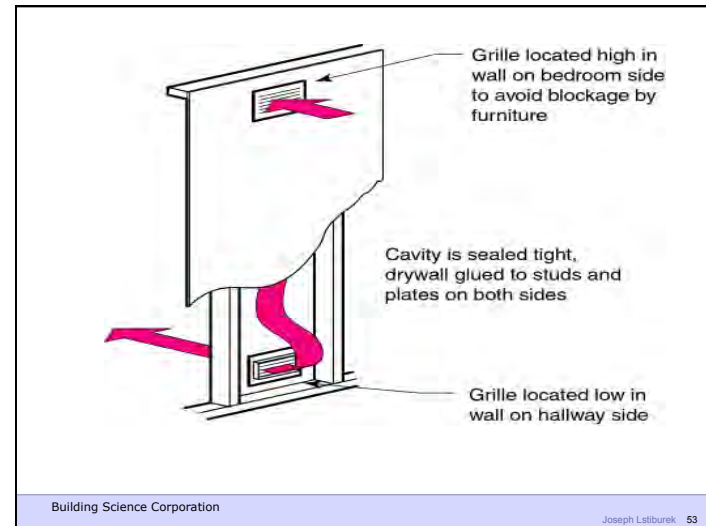
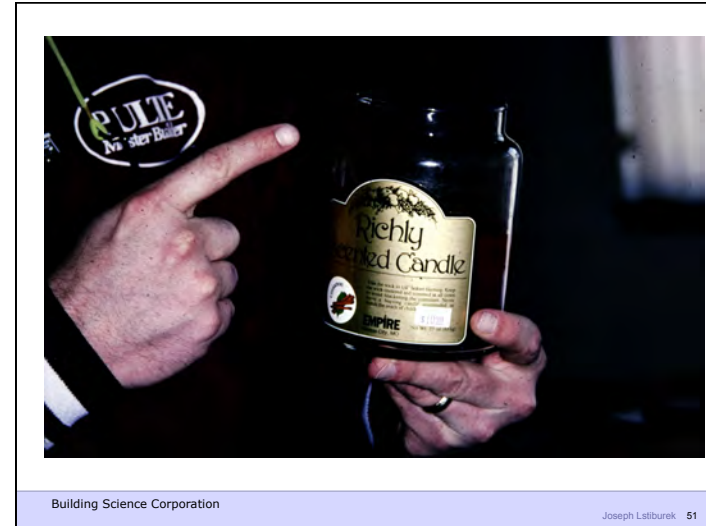
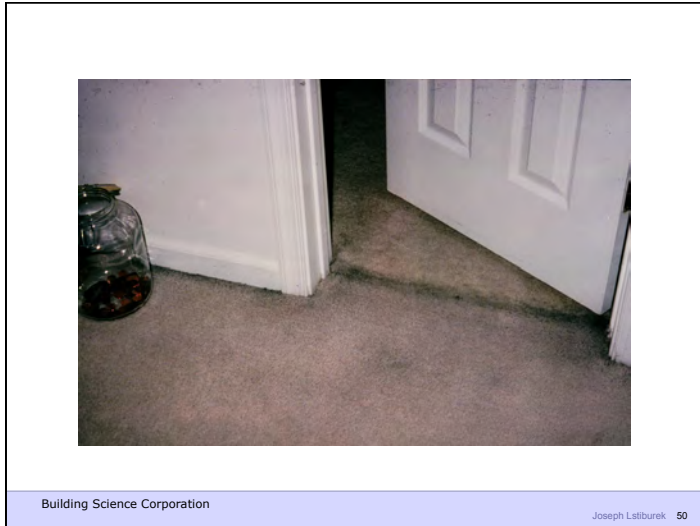
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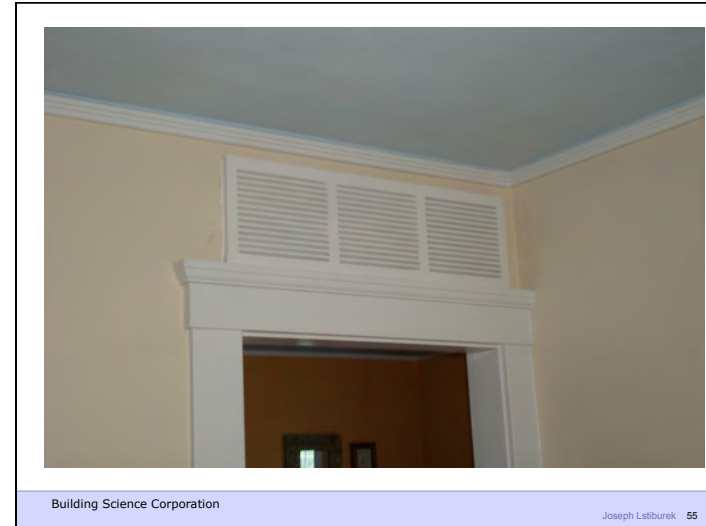






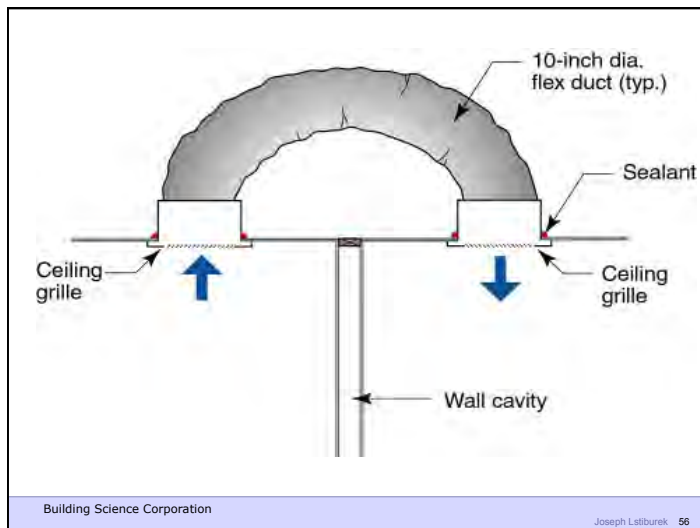
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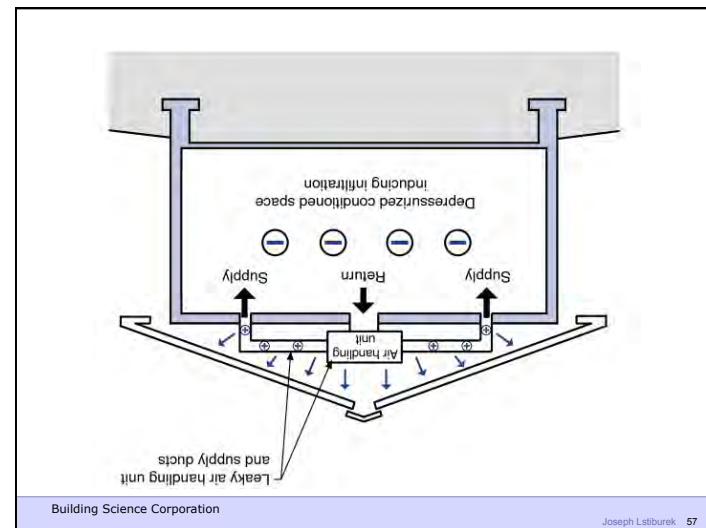
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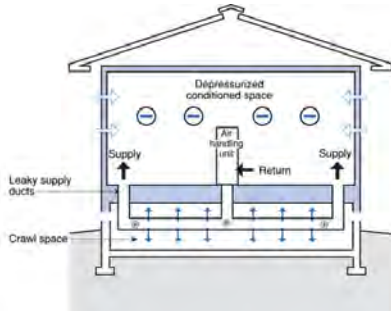


Figure 3.16  
**Leaky Supply Ductwork in Vented Crawl Space**  
• Air pressurization pattern with mechanical system ducts in the crawl space

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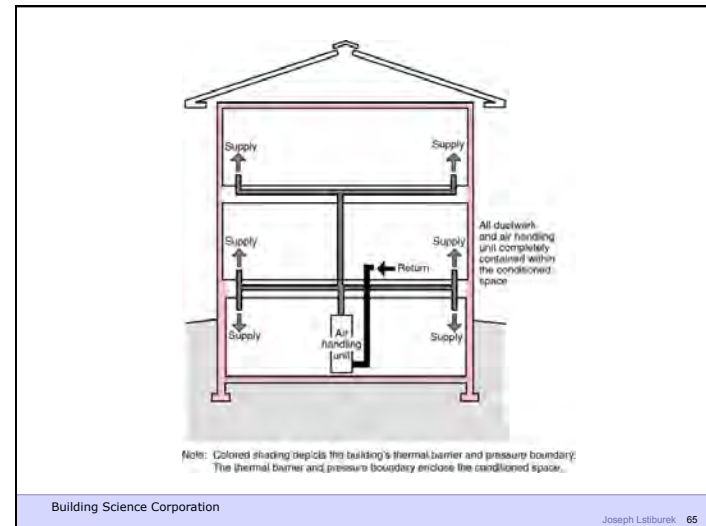
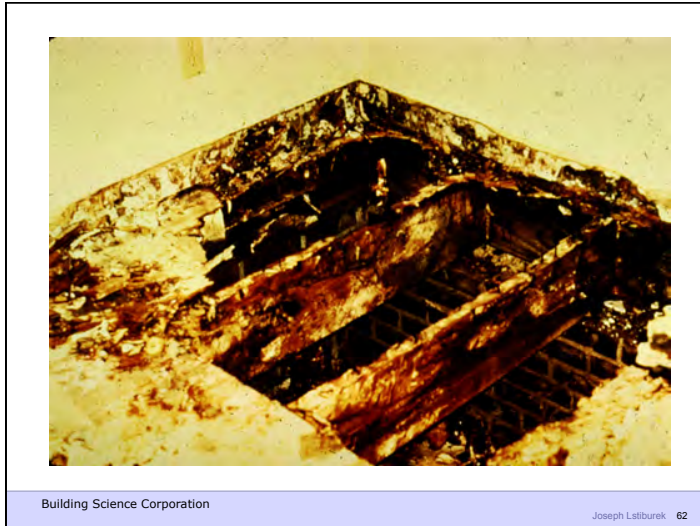
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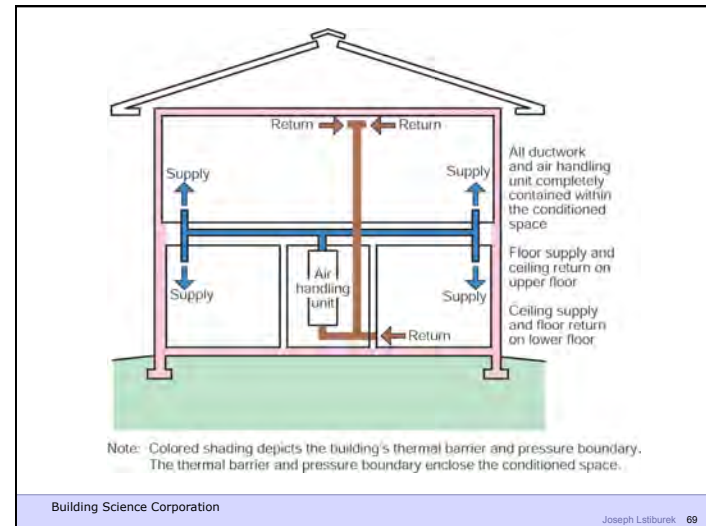


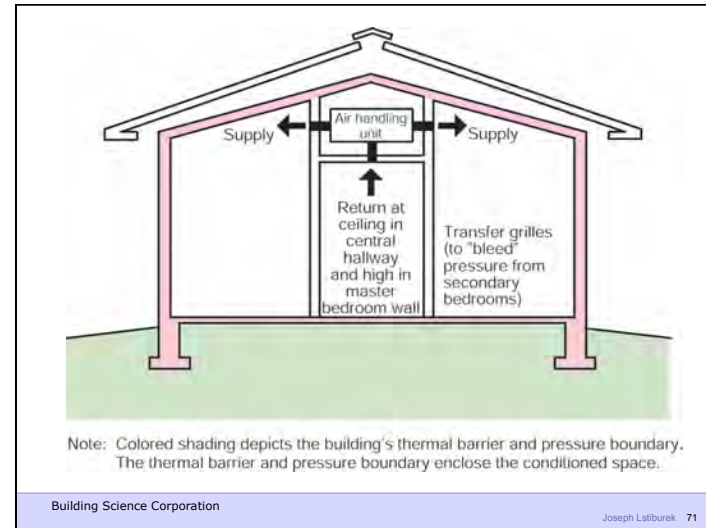
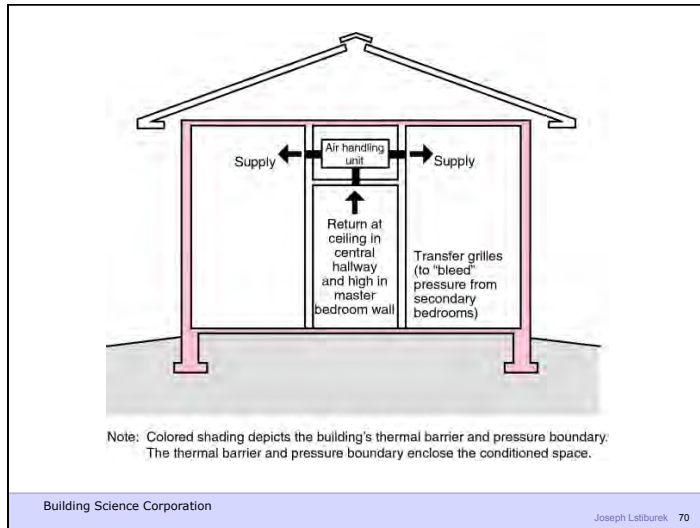
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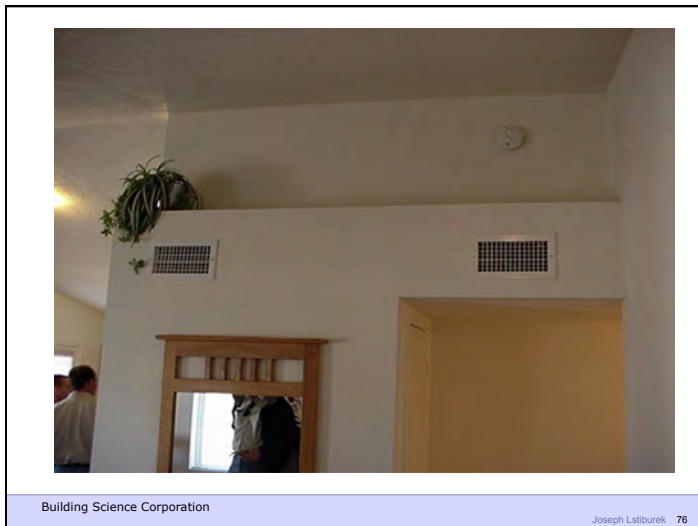
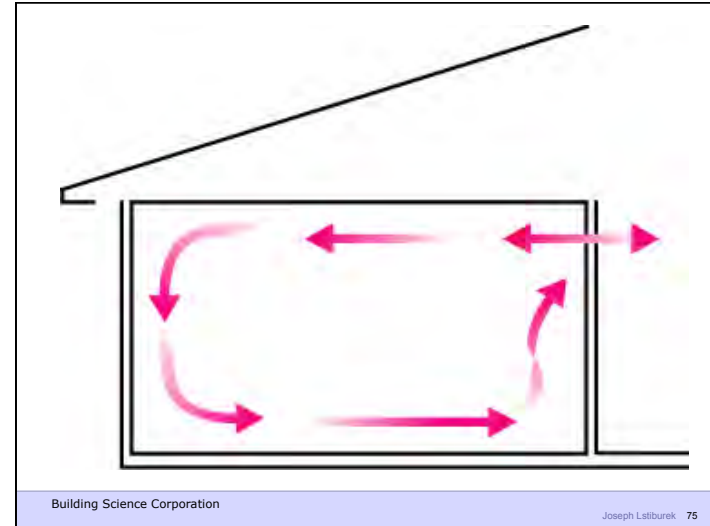
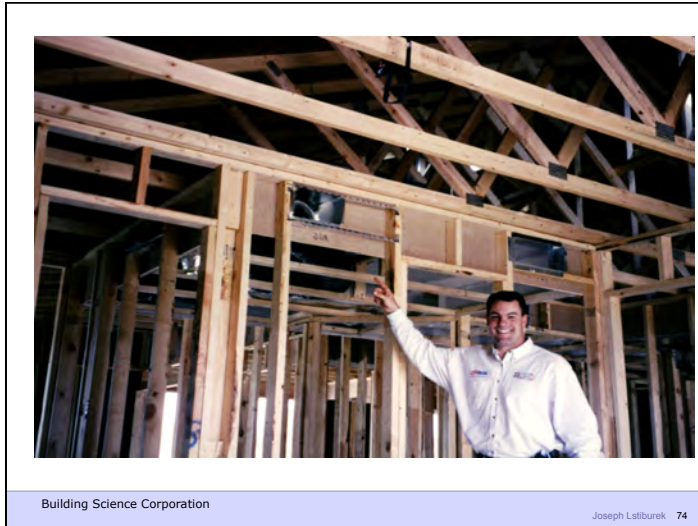
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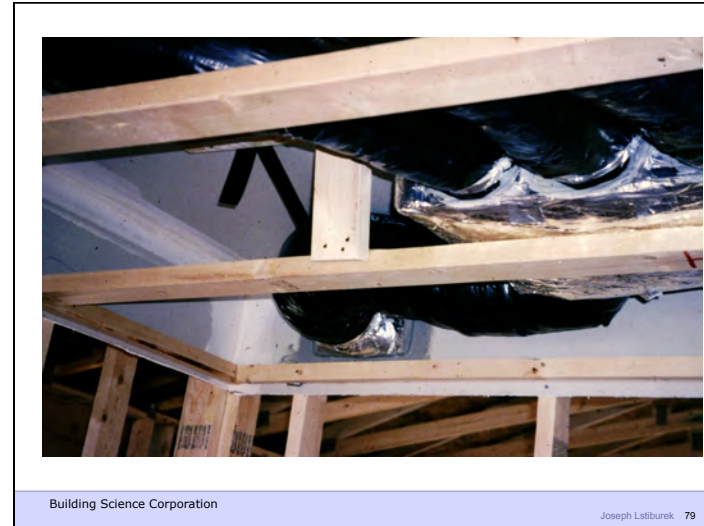




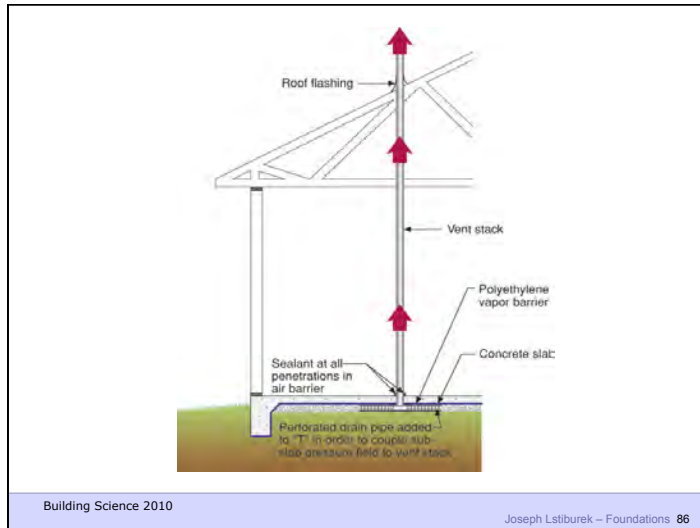








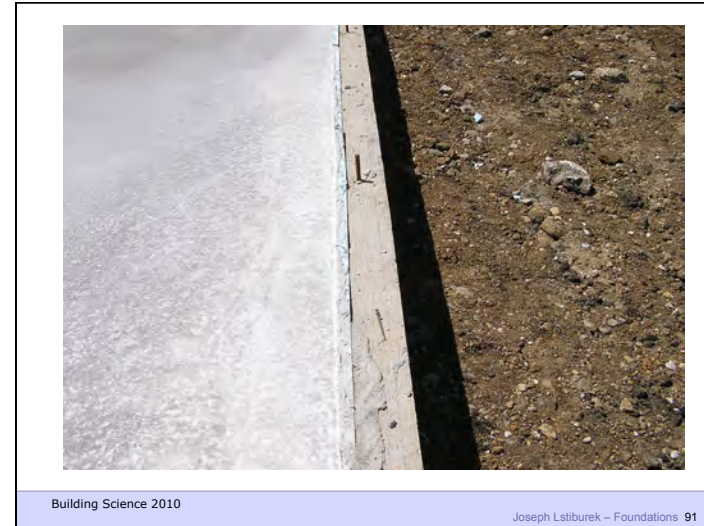






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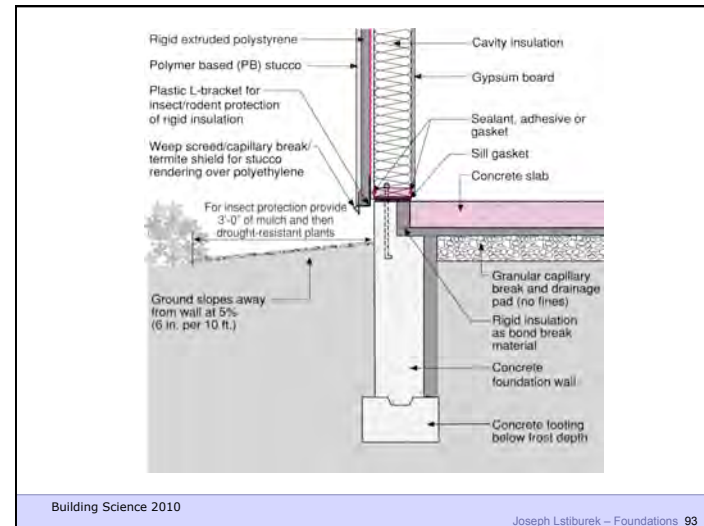
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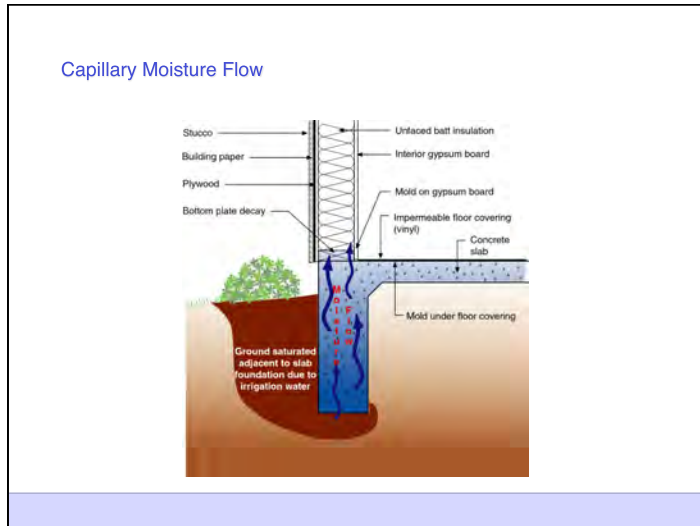
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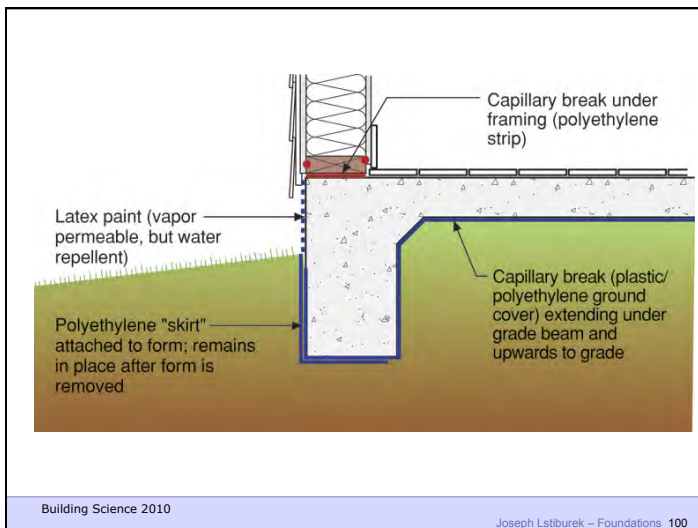
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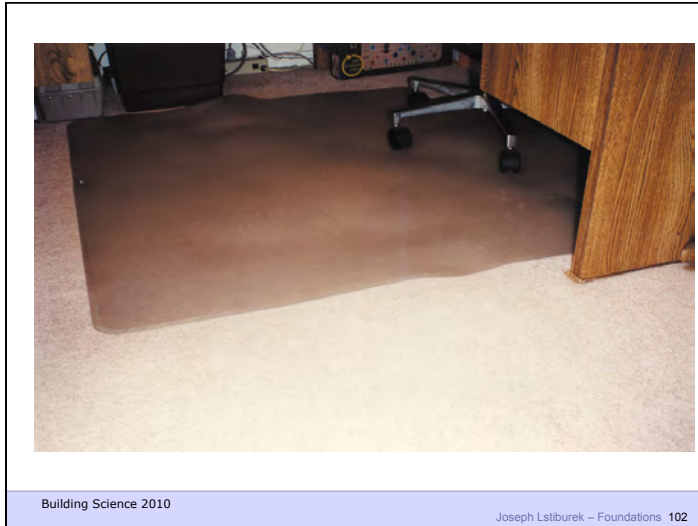
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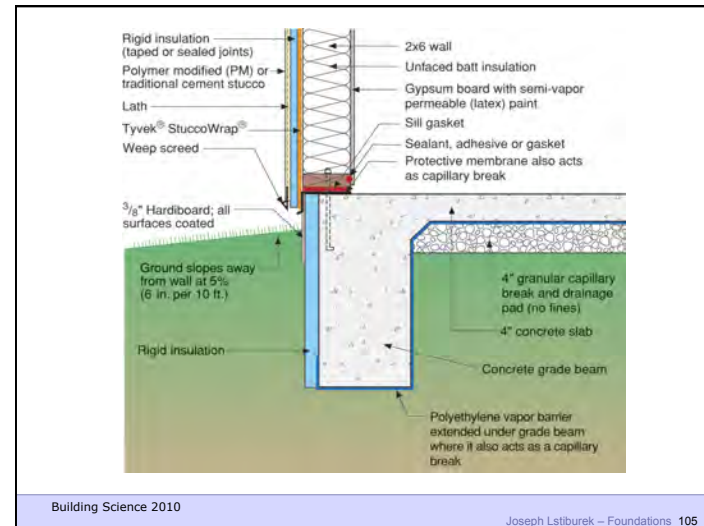
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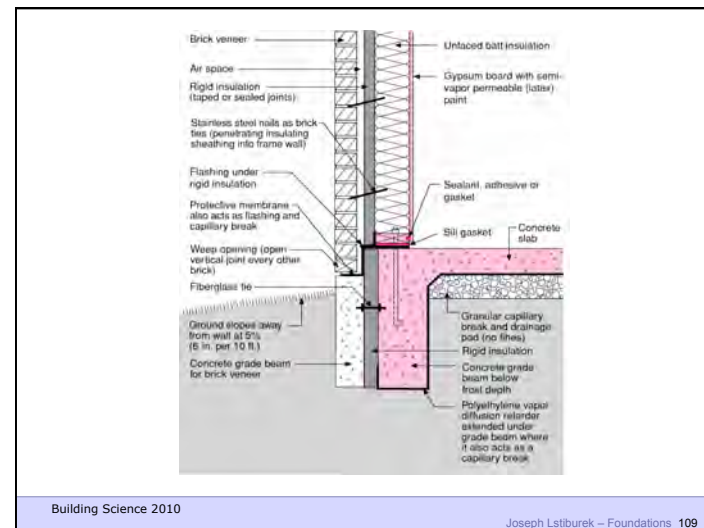
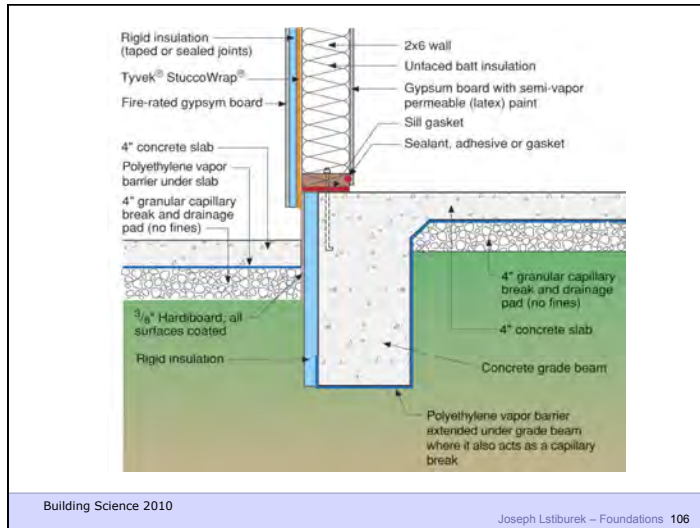
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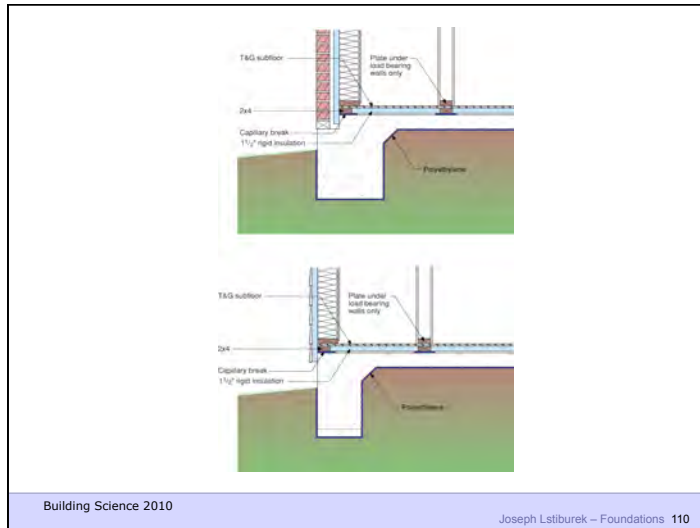


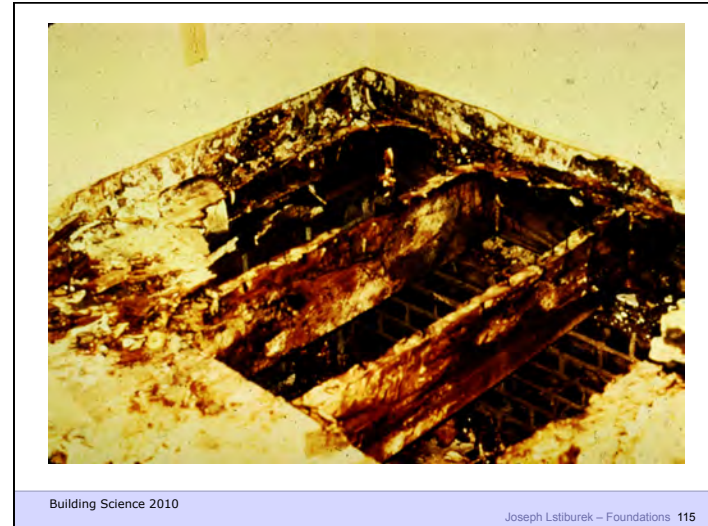
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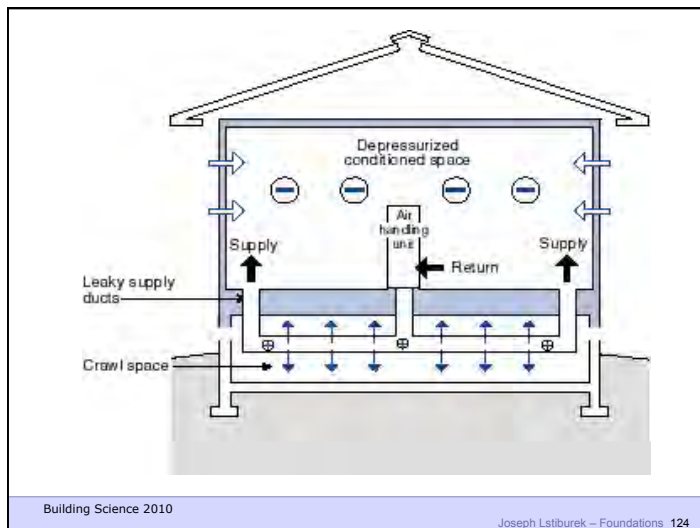
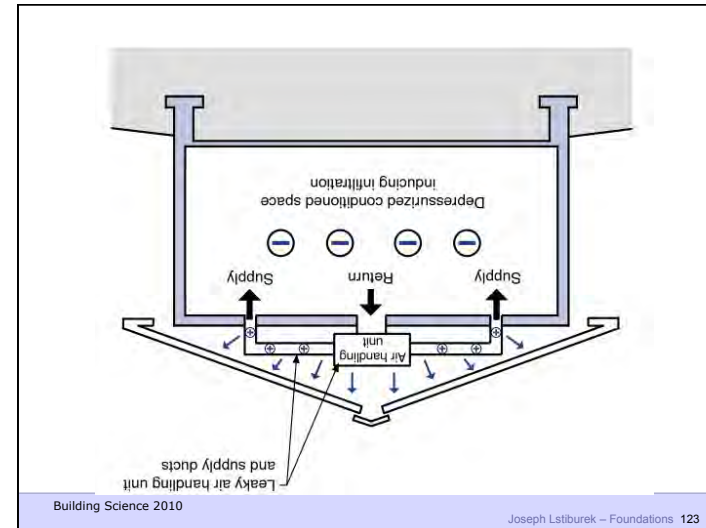
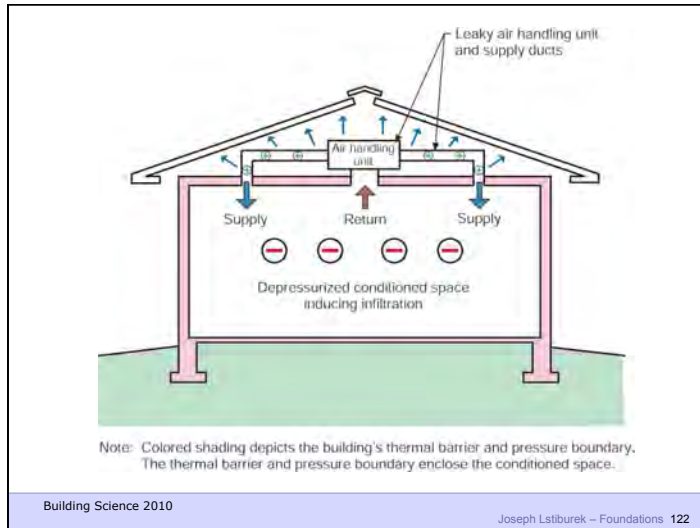




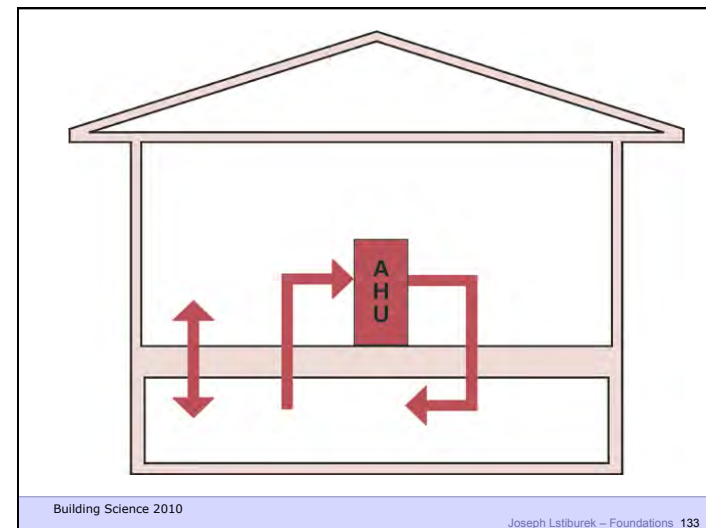
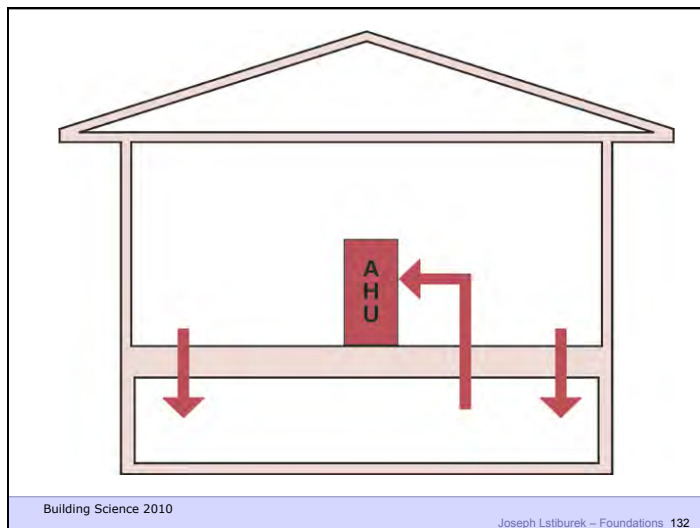
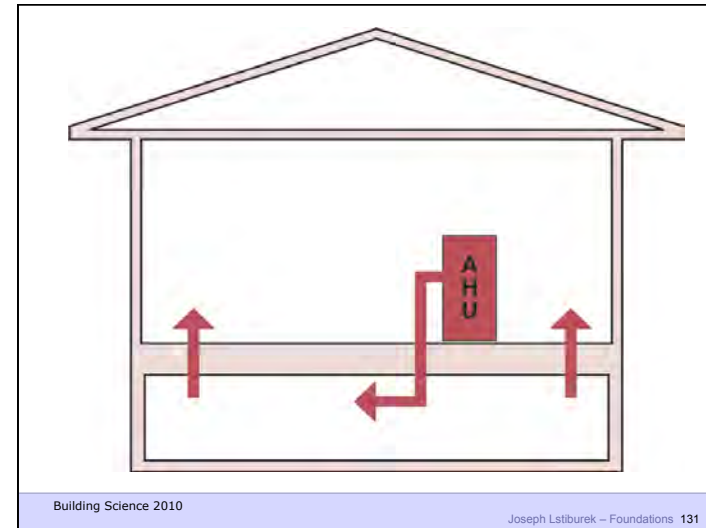
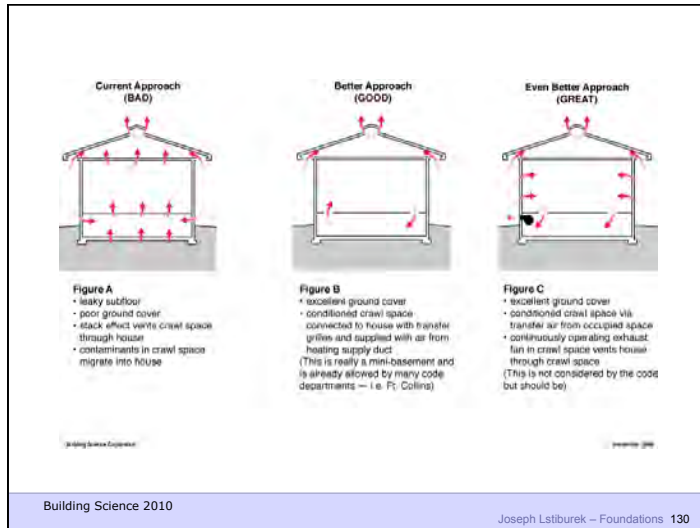


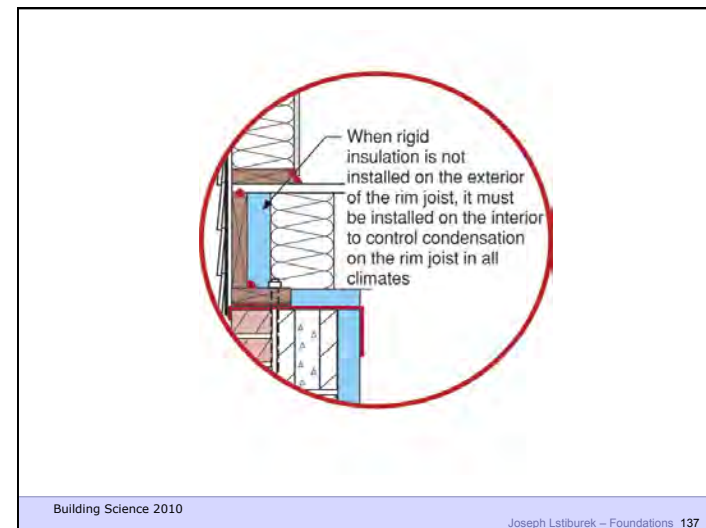
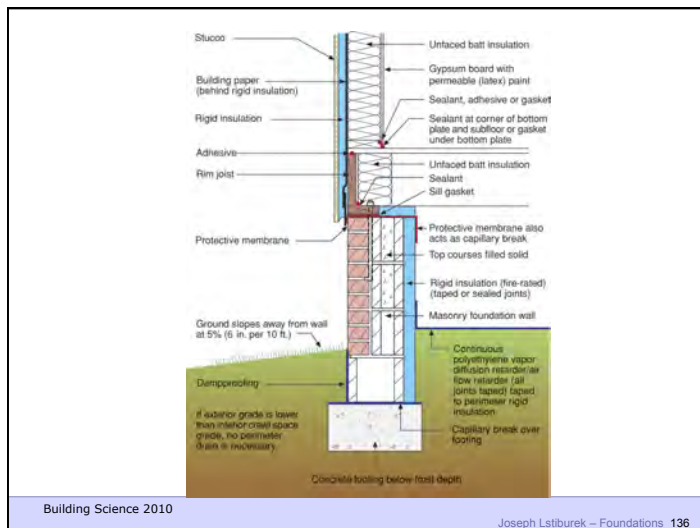
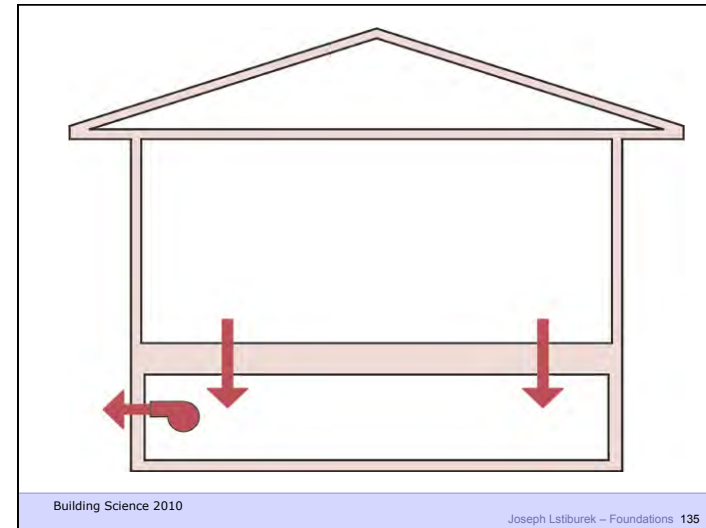
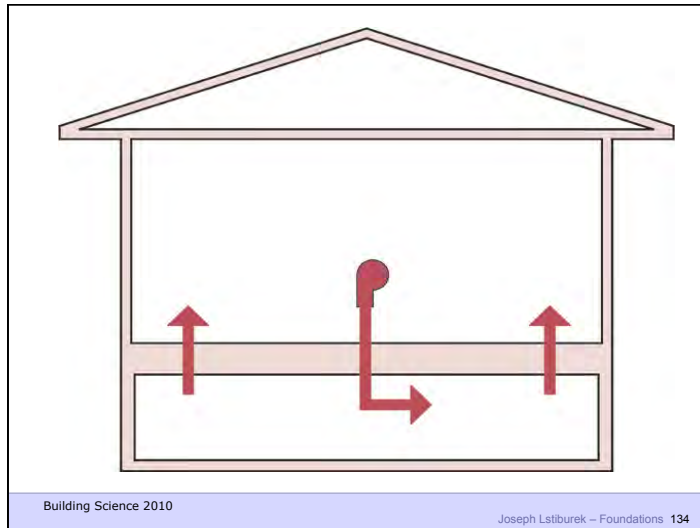




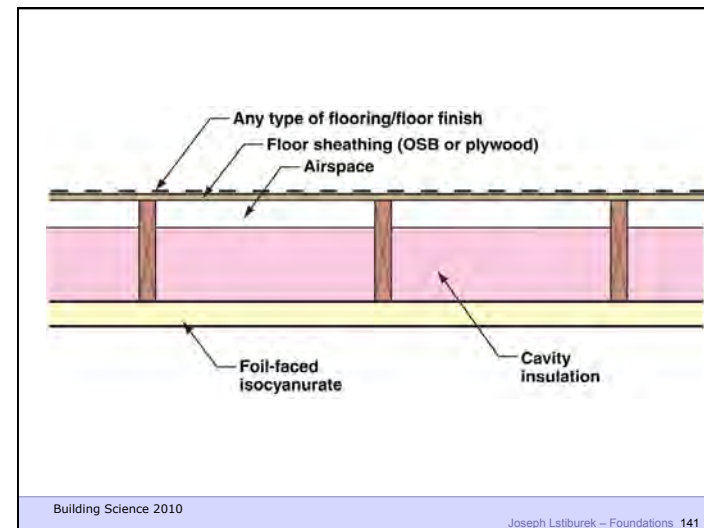
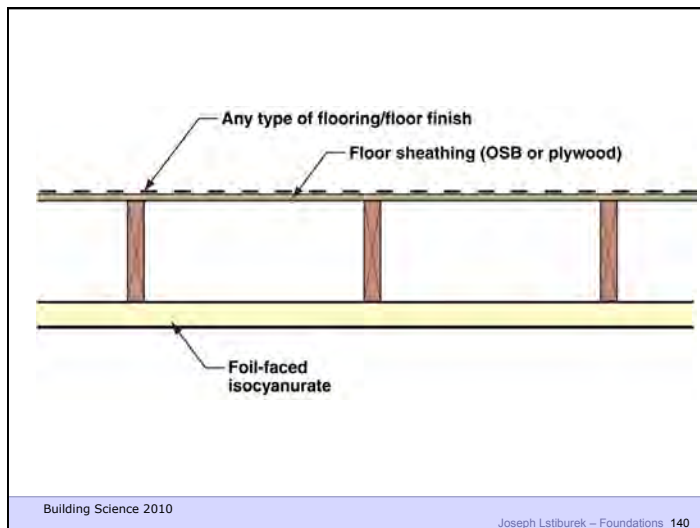
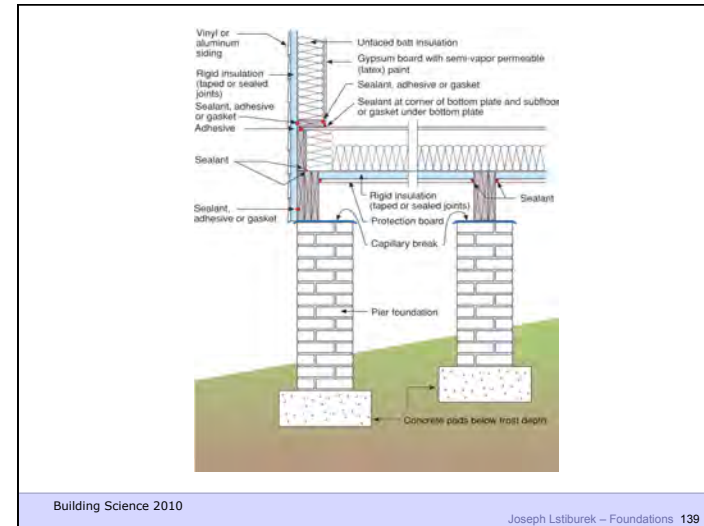
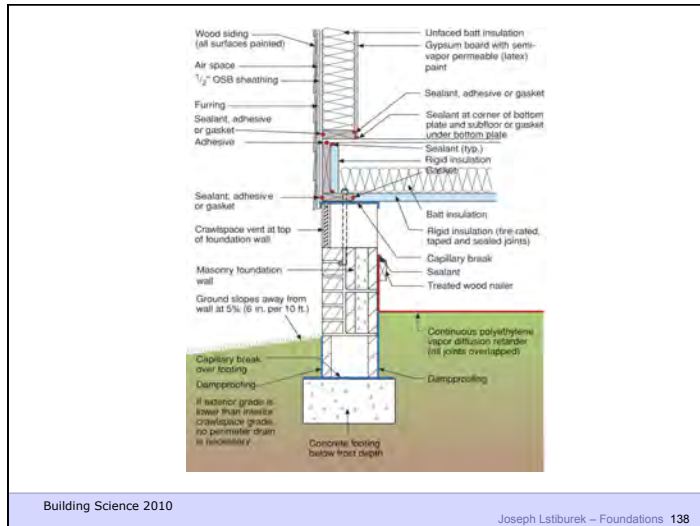


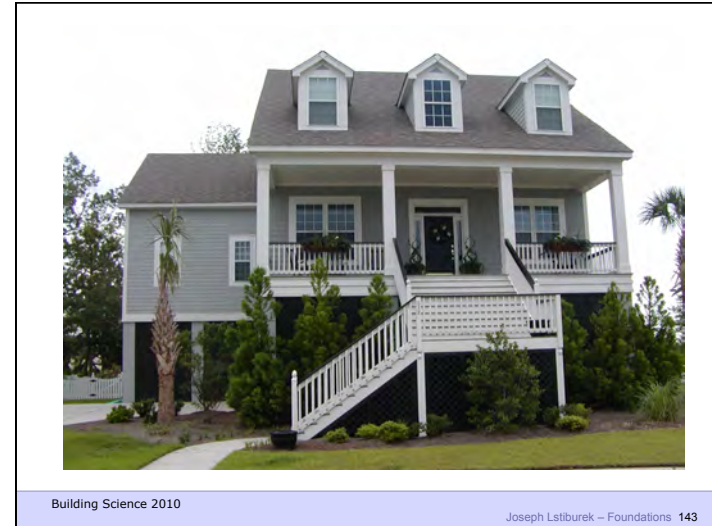
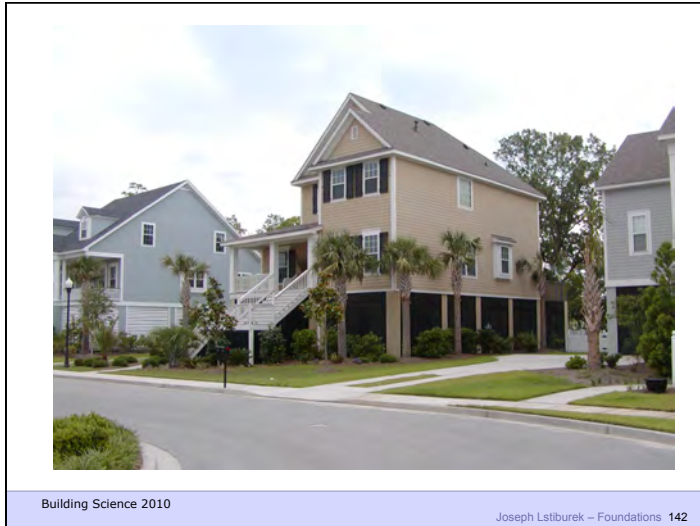


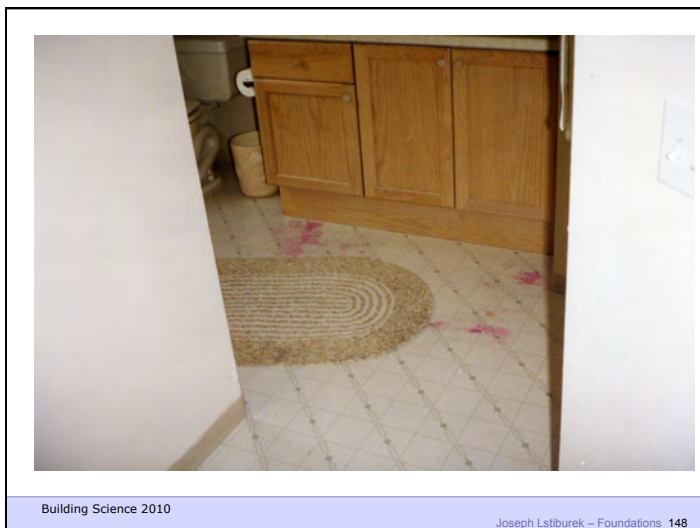












Build Tight - Ventilate Right

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Build Tight - Ventilate Right  
 How Tight?  
 What's Right?

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### Air Barrier Metrics

Material	0.02 l/(s-m <sup>2</sup> ) @ 75 Pa
Assembly	0.20 l/(s-m <sup>2</sup> ) @ 75 Pa
Enclosure	2.00 l/(s-m <sup>2</sup> ) @ 75 Pa
	0.35 cfm/ft <sup>2</sup> @ 50 Pa
	0.25 cfm/ft <sup>2</sup> @ 50 Pa
	0.15 cfm/ft <sup>2</sup> @ 50 Pa

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Getting rid of big holes	3 ach@50
Getting rid of smaller holes	1.5 ach@50
Getting German	0.6 ach@50

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### Best

As Tight as Possible - with -  
 Balanced Ventilation  
 Energy Recovery  
 Distribution and Mixing  
 Source Control - Spot exhaust ventilation  
 Filtration  
 Material selection

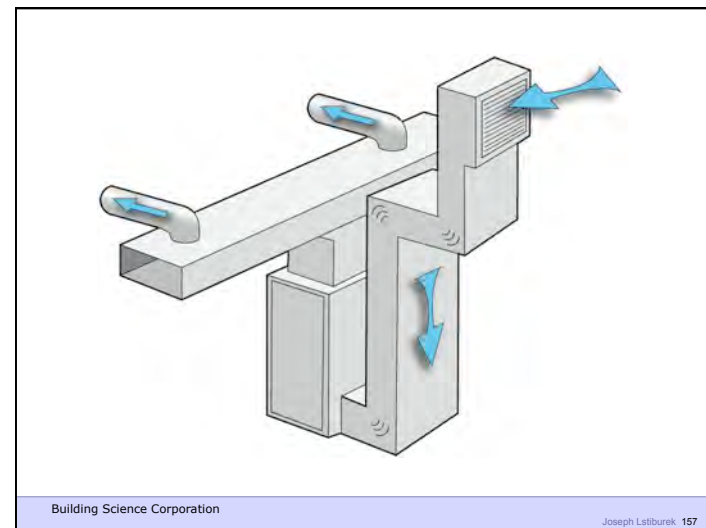
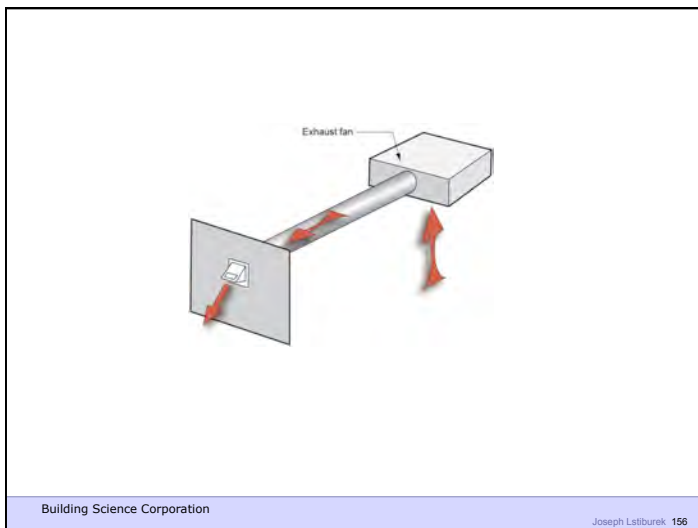
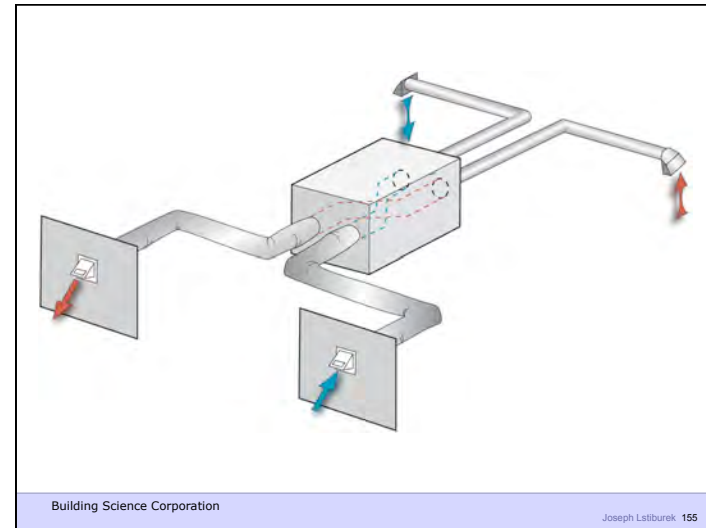
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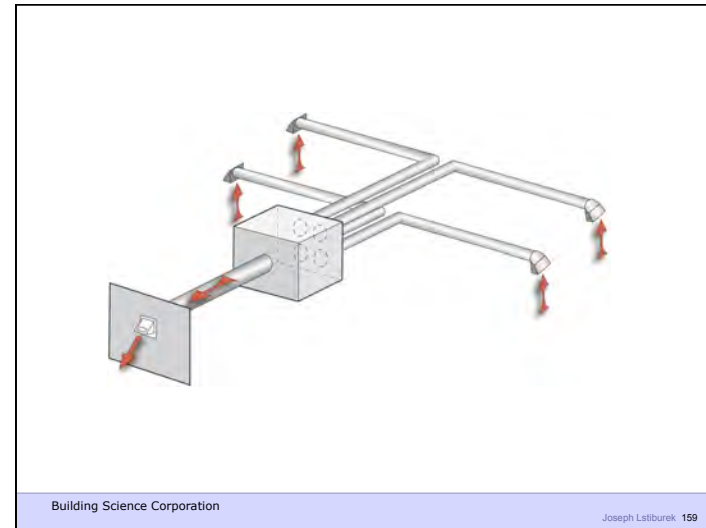
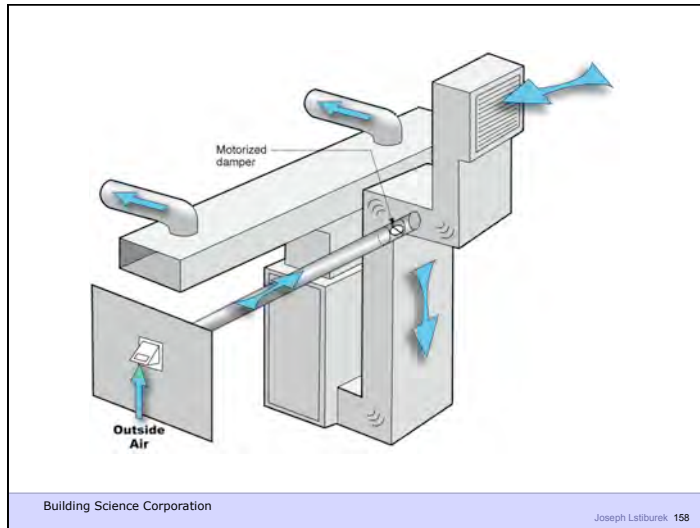
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Worst

Leaky - with – Nothing  
Spot Ventilation in Bathroom/Kitchen  
Exhaust Ventilation – with – No Distribution  
and No Mixing

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Cost	Exhaust	\$150
	Exhaust + Dist + Mix	\$200
	Supply + Dist + Mix	\$200
	Spot + Ex/Sup + Dist + Mix	\$500
	Balanced/HRV	\$1,250

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