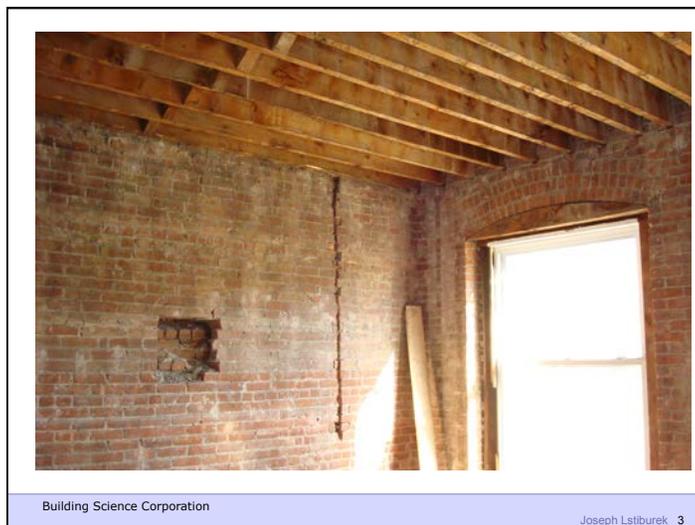


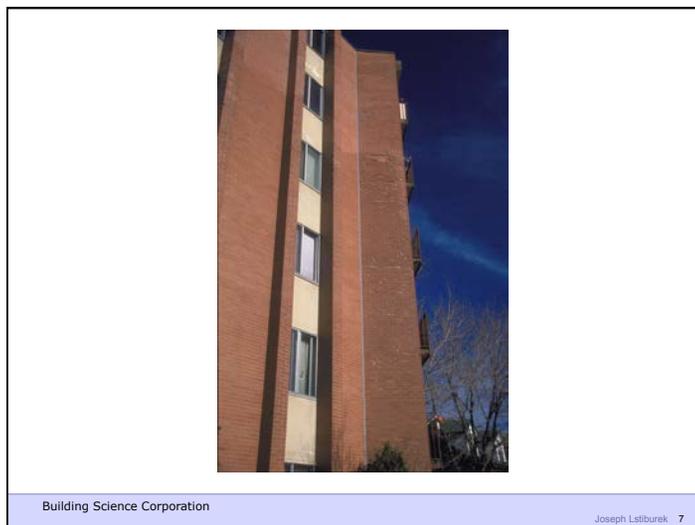
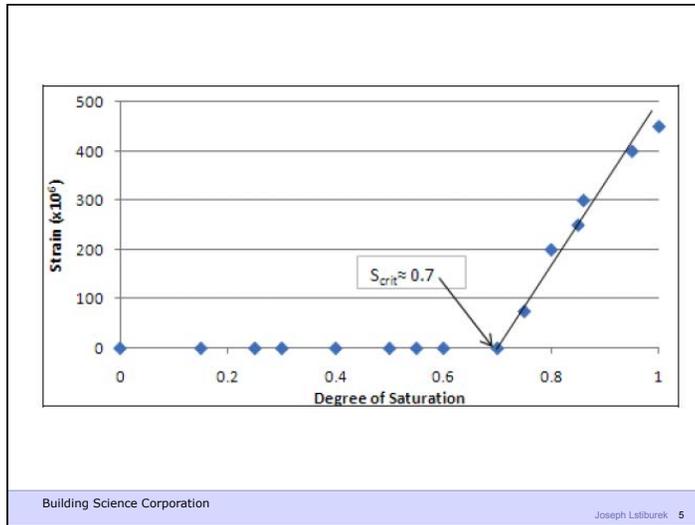
Joseph Lstiburek, Ph.D., P.Eng., ASHRAE Fellow

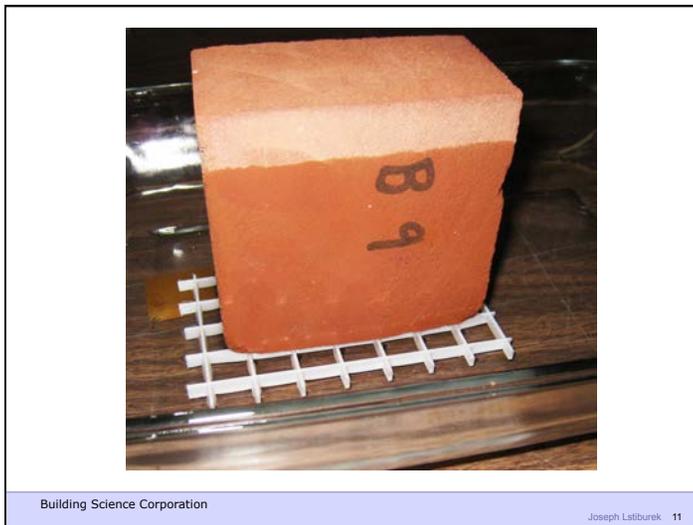
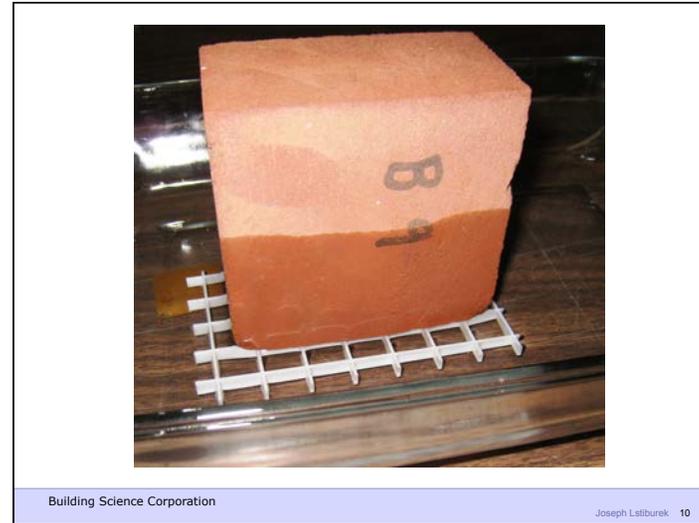
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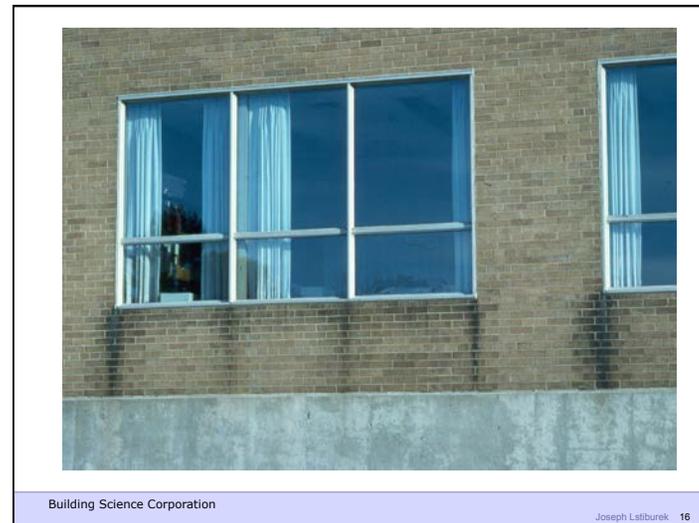
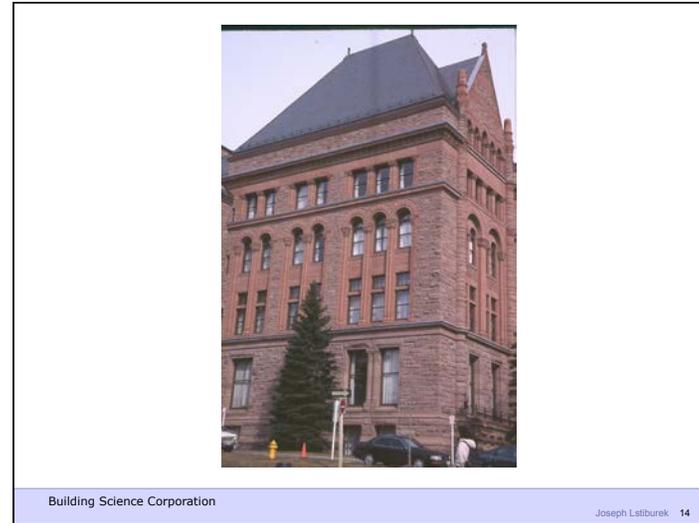
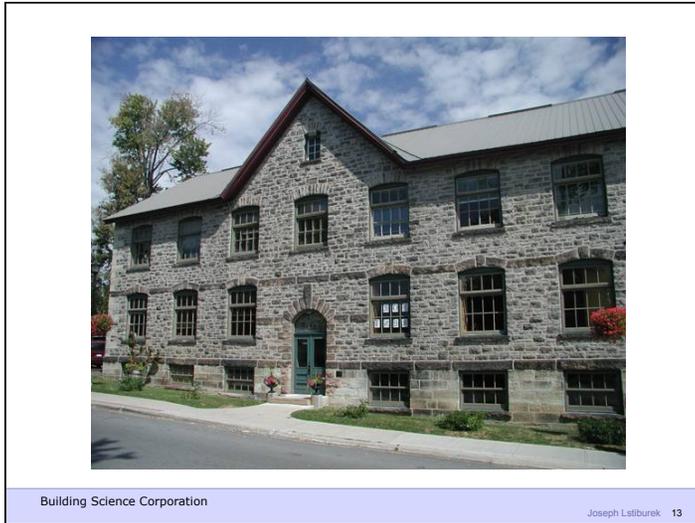
## Mass Assemblies

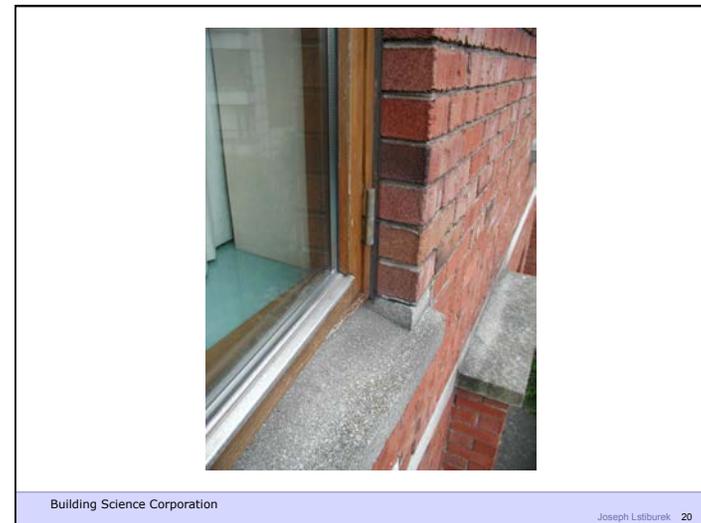
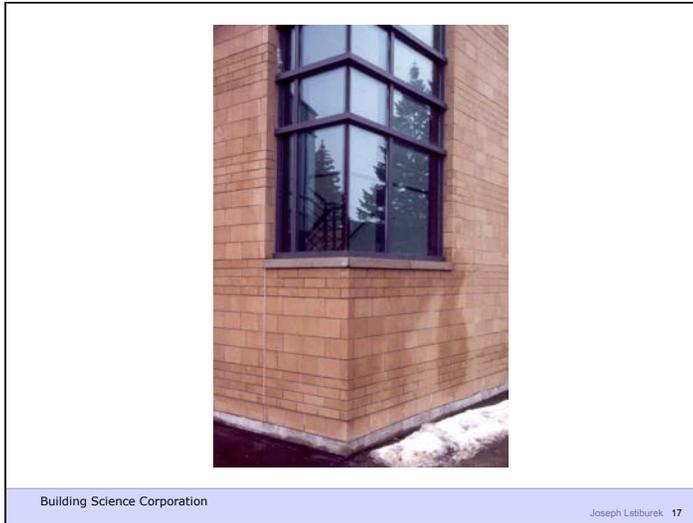
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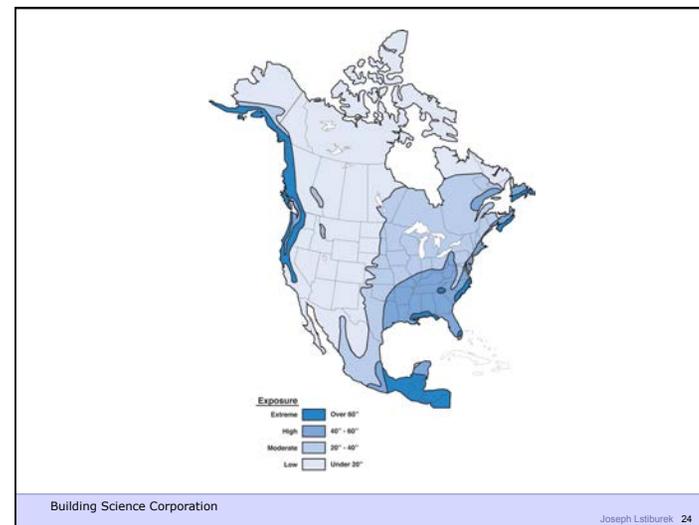
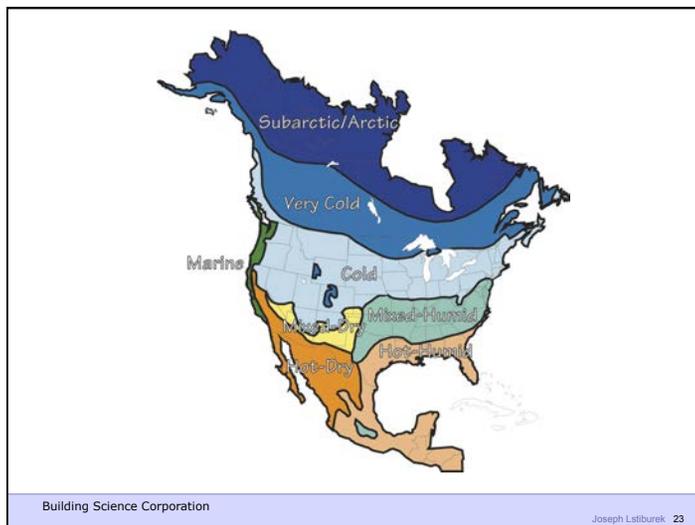
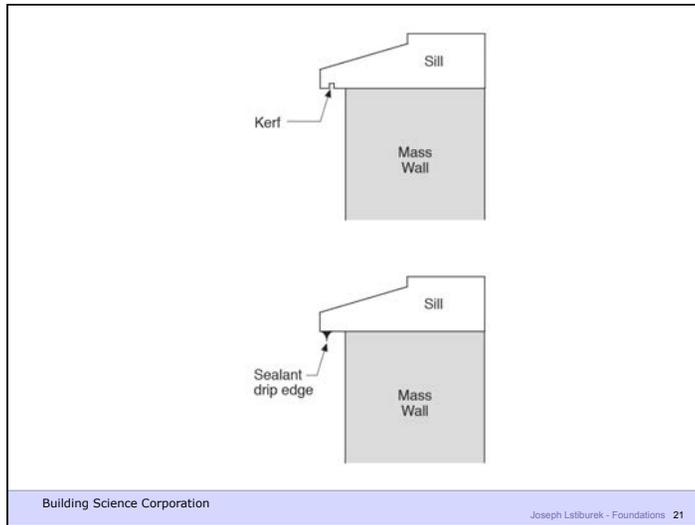










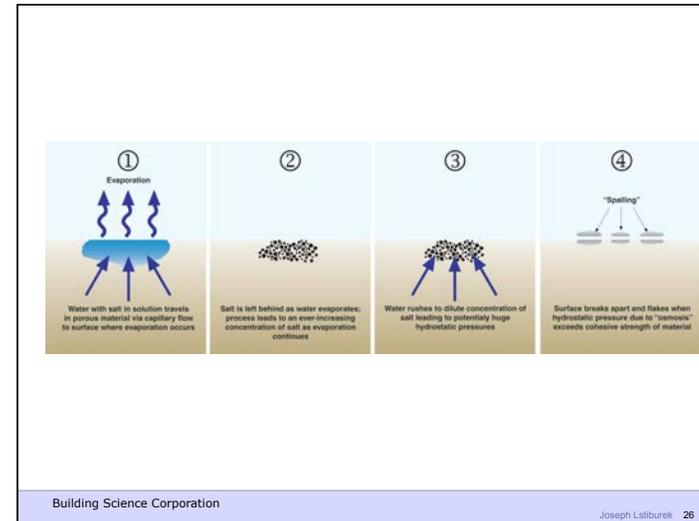


## Capillarity + Salt = Osmosis

- Mineral salts carried in solution by capillary water
- When water evaporates from a surface the salts left behind form crystals in process called efflorescence
- When water evaporated beneath a surface the salts crystallize within the pore structure of the material in called sub-efflorescence
- The salt crystallization causes expansive forces that can exceed the cohesive strength of the material leading to spalling

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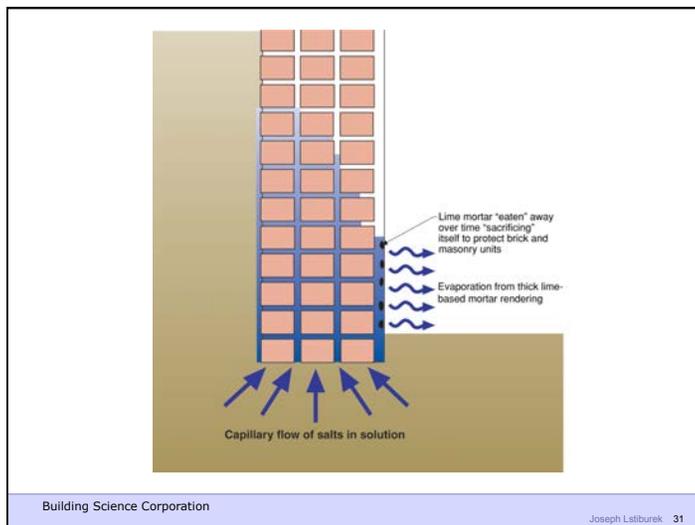
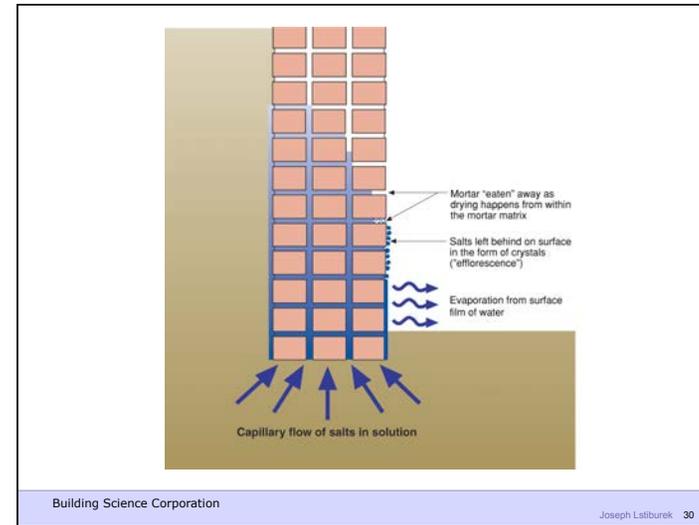
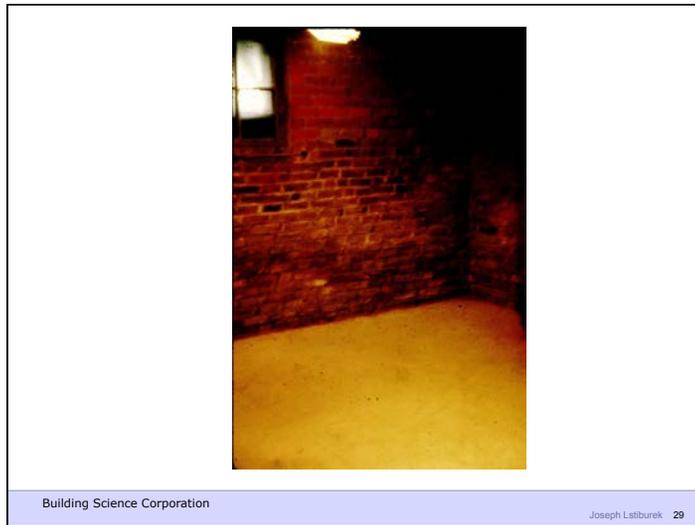
## Diffusion + Capillarity + Osmosis = Problem

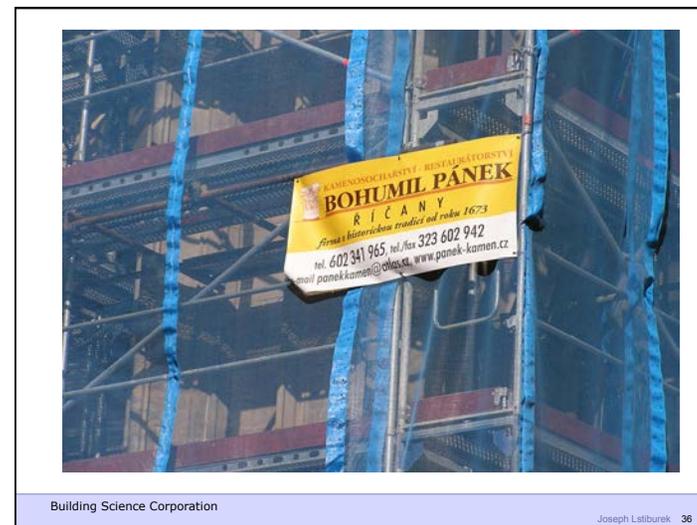
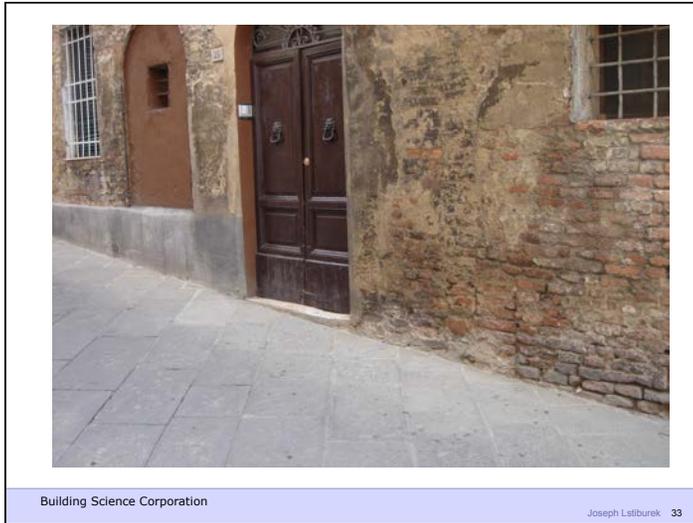
- |                            |                    |
|----------------------------|--------------------|
| • Diffusion Vapor Pressure | 3 to 5 psi         |
| • Capillary Pressure       | 300 to 500 psi     |
| • Osmosis Pressure         | 3,000 to 5,000 psi |

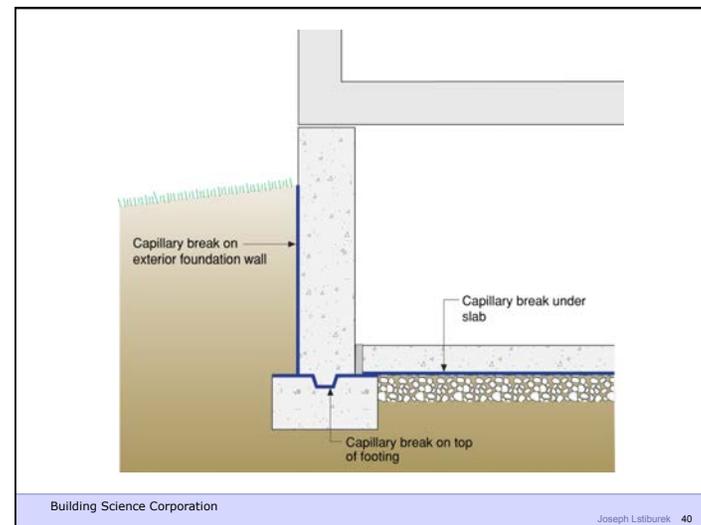
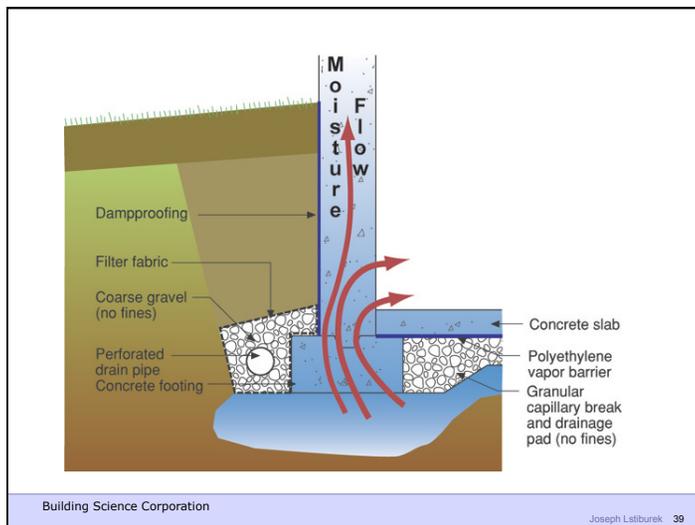
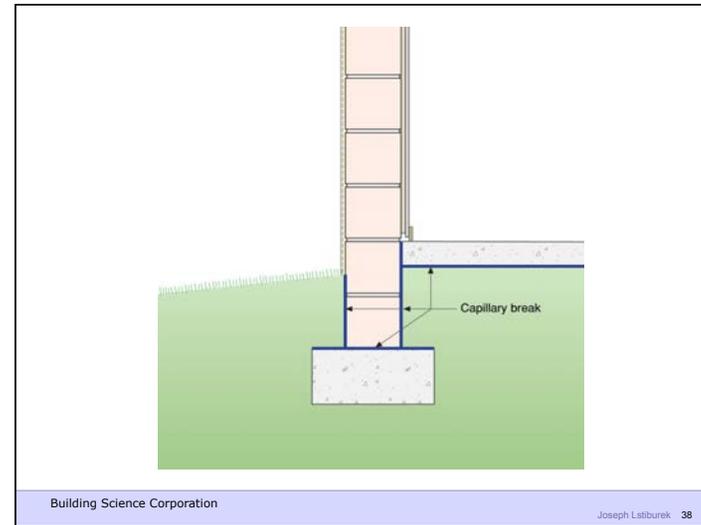
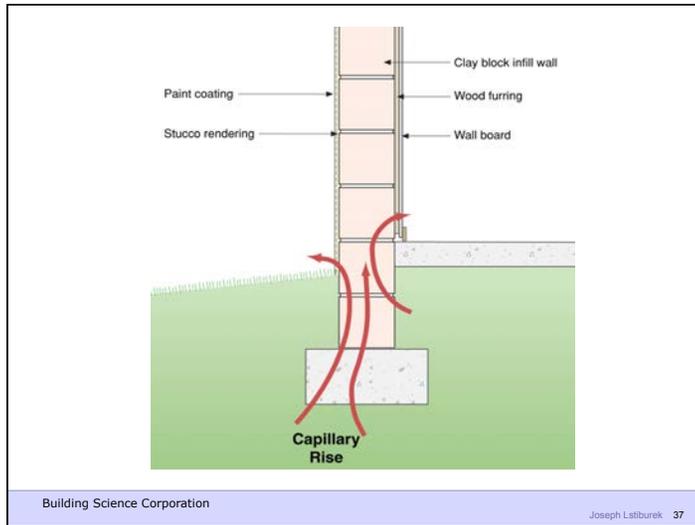
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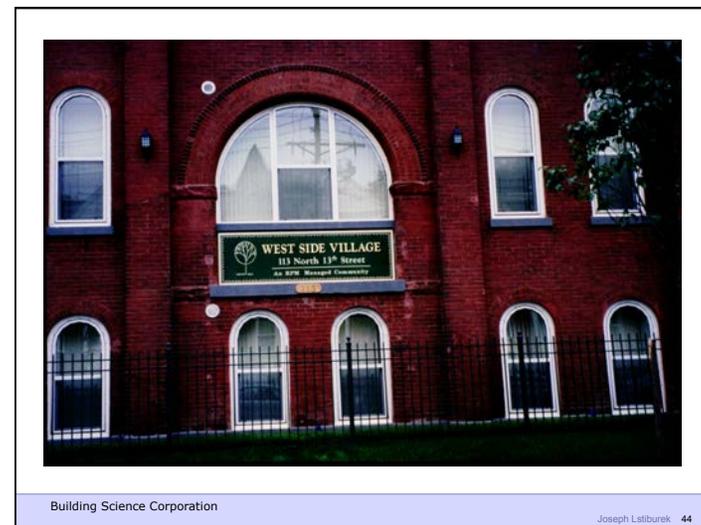
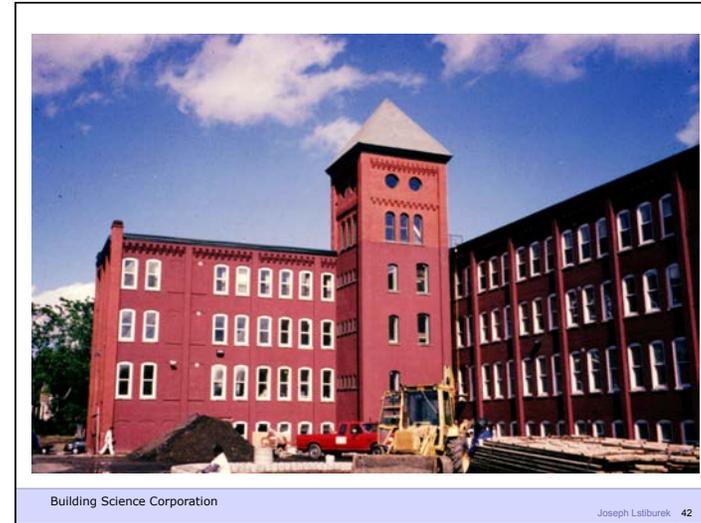
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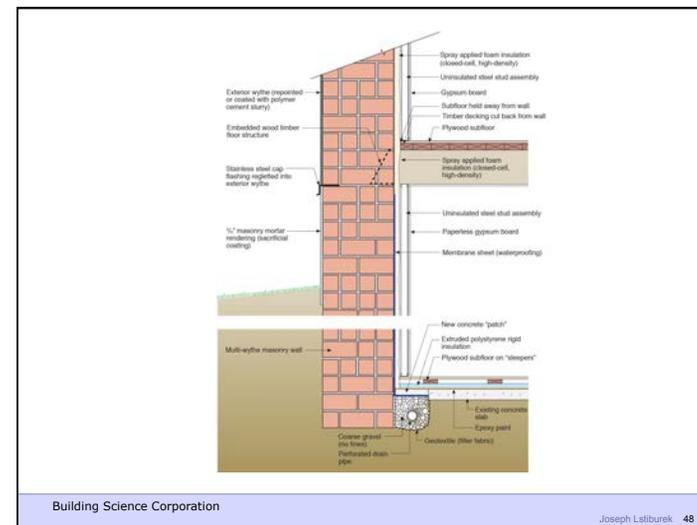
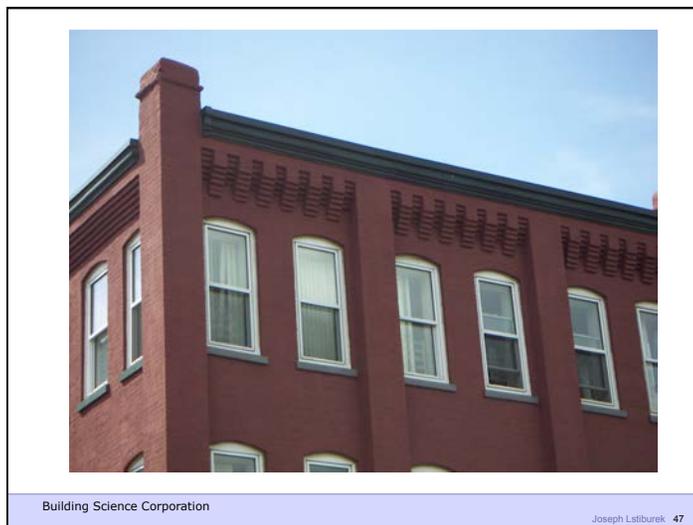
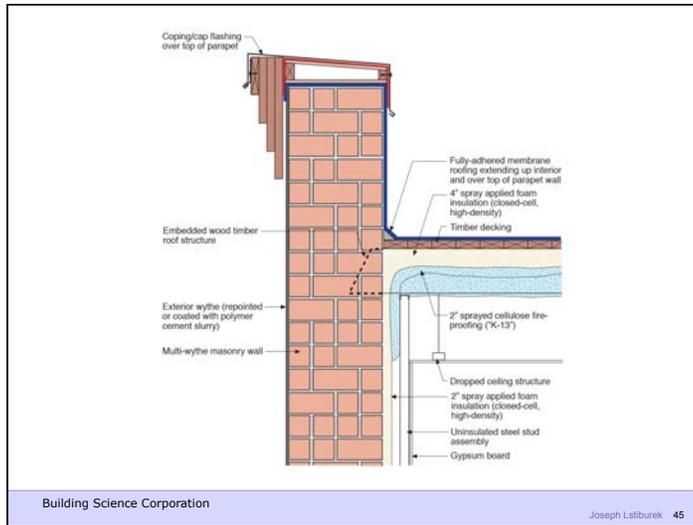


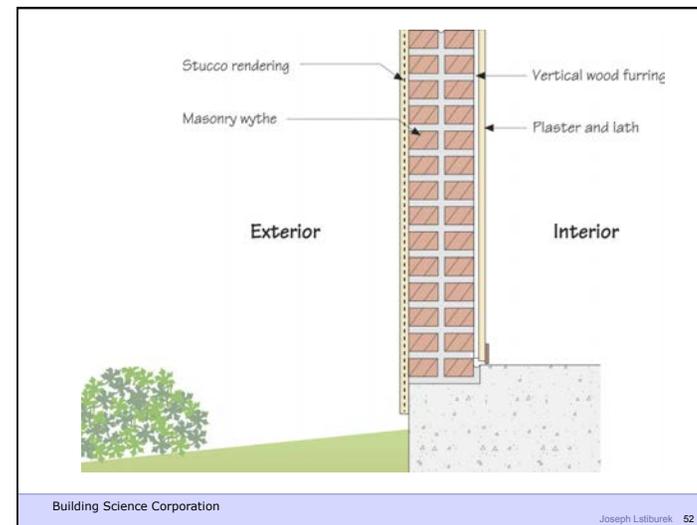
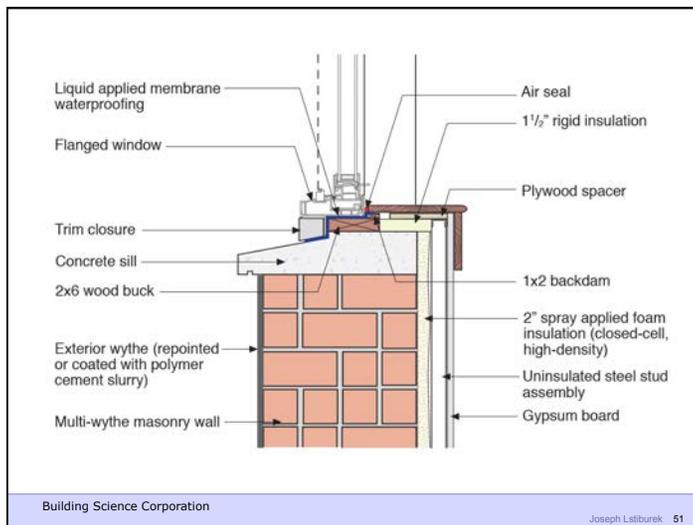
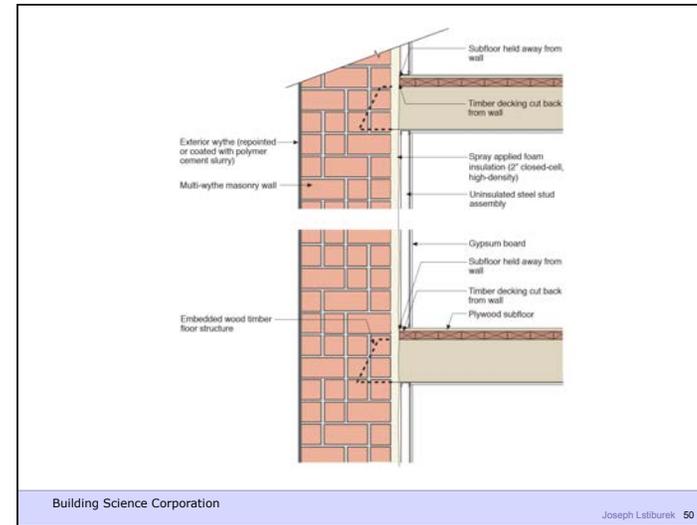
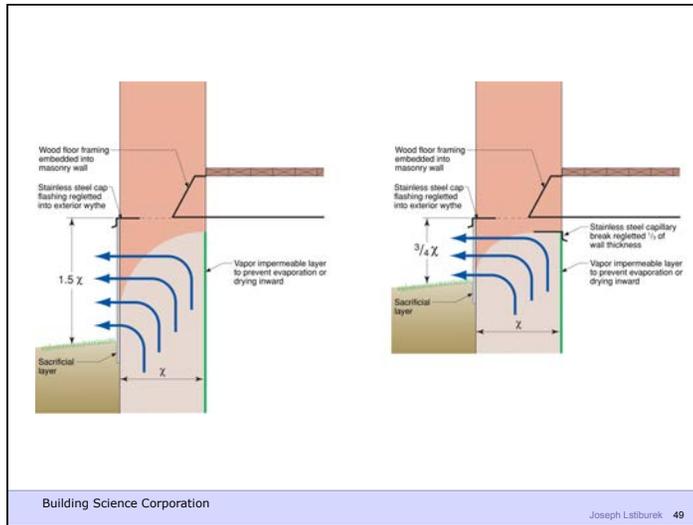


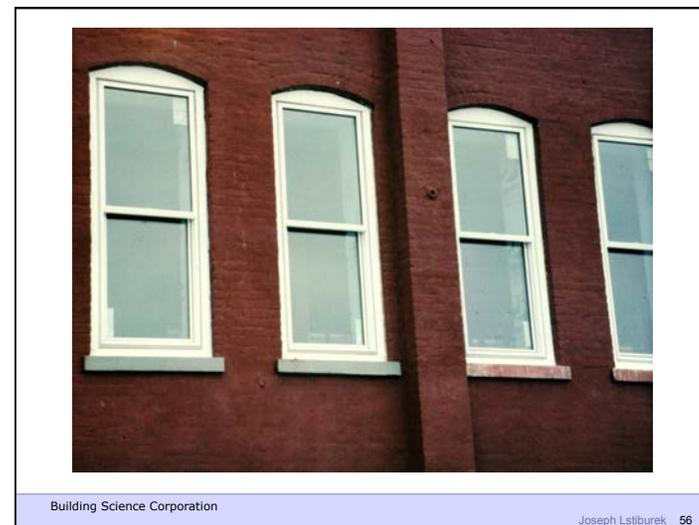
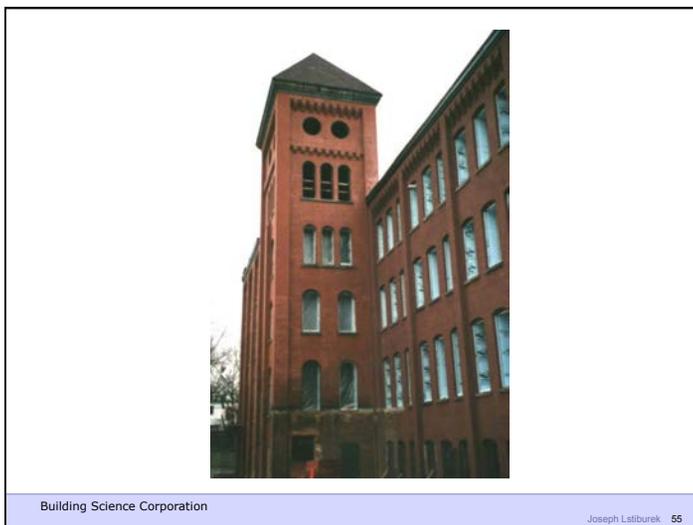
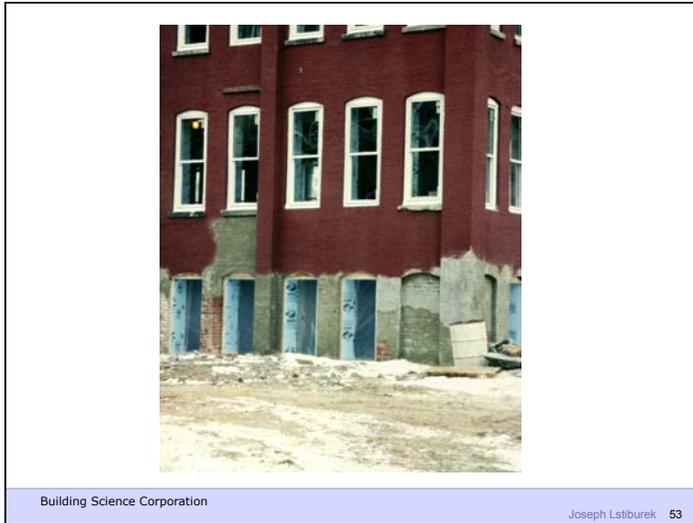


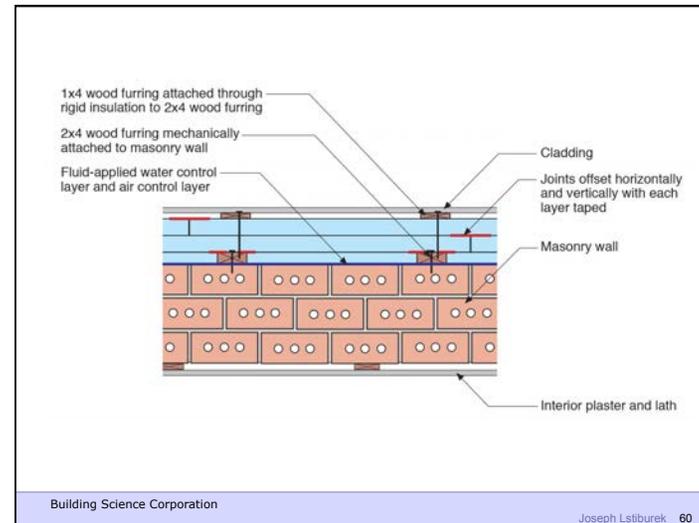
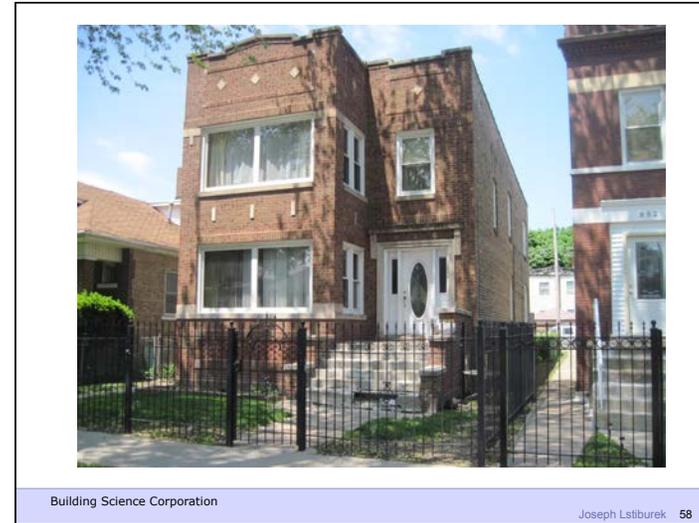








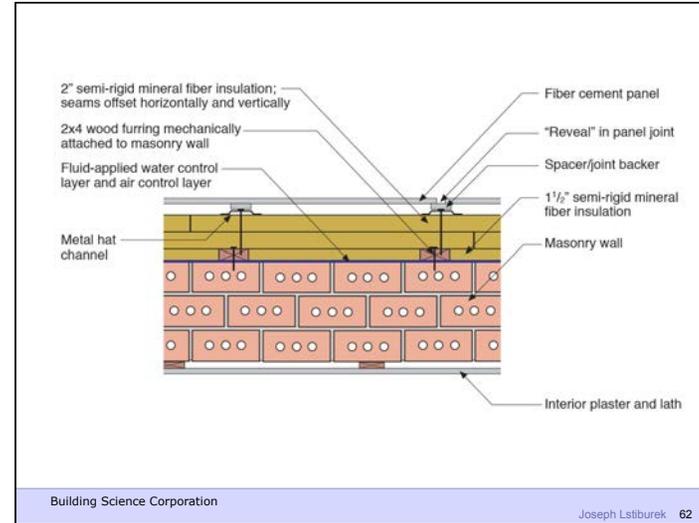






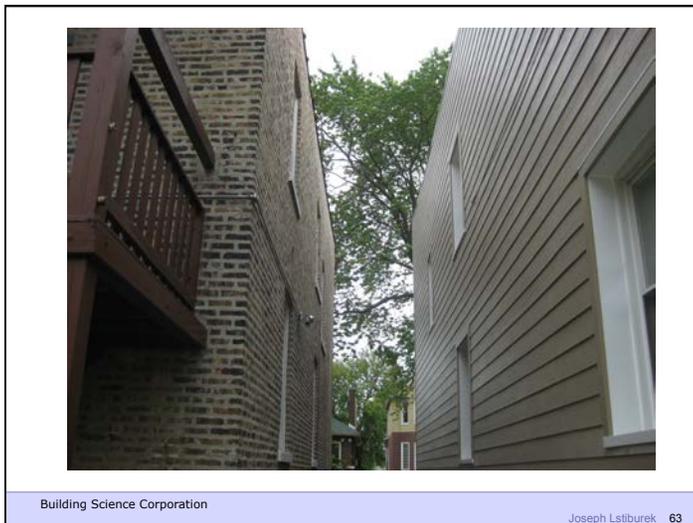
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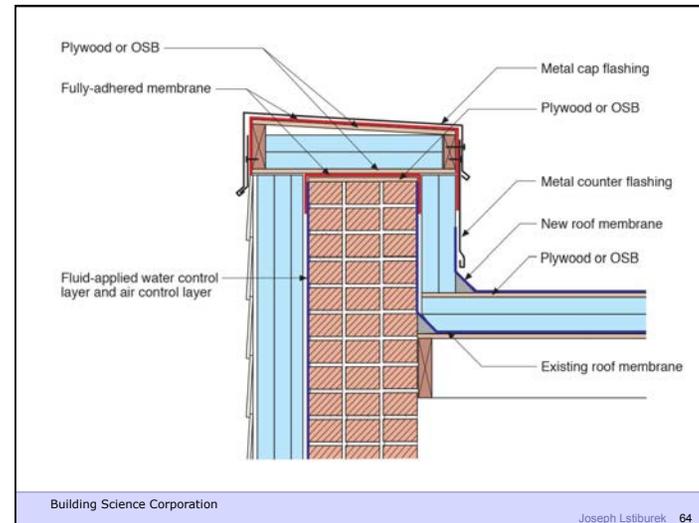
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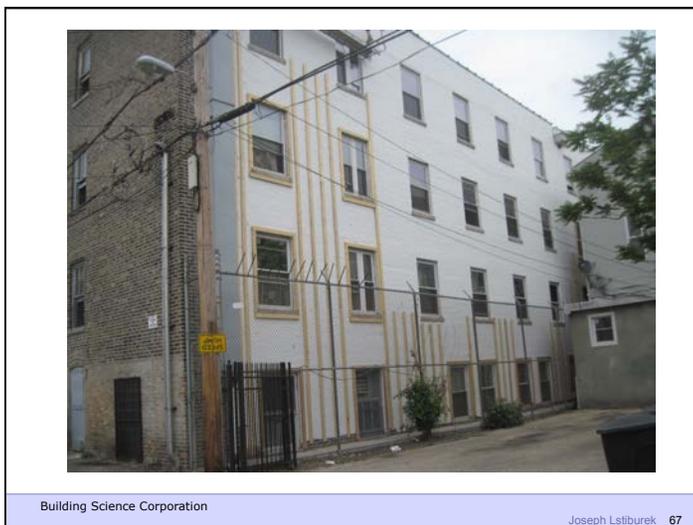
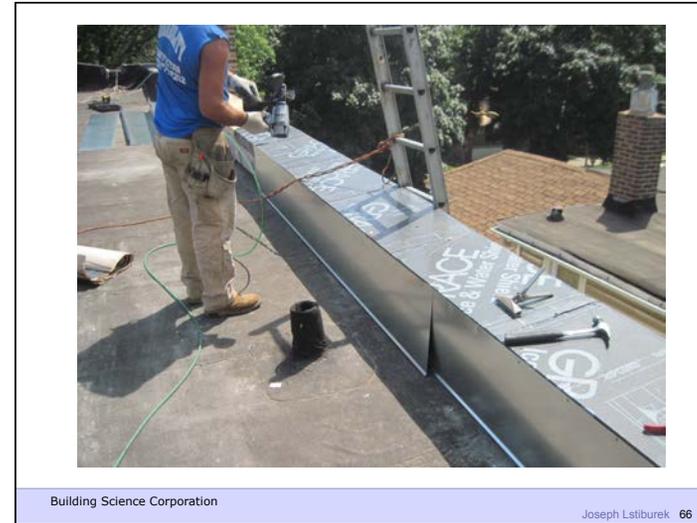
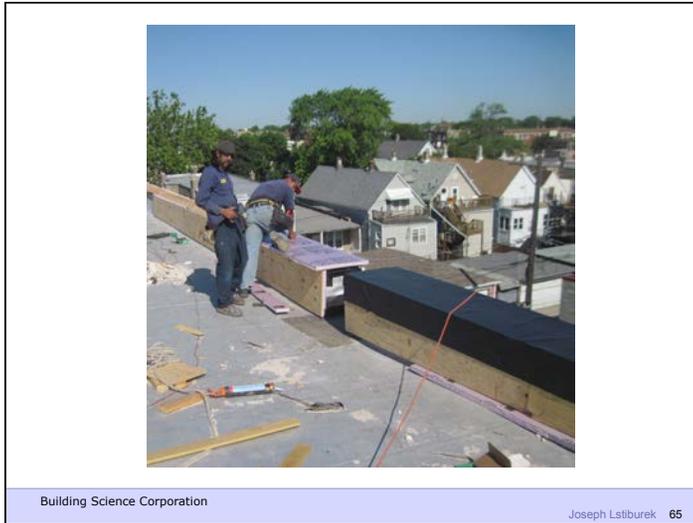
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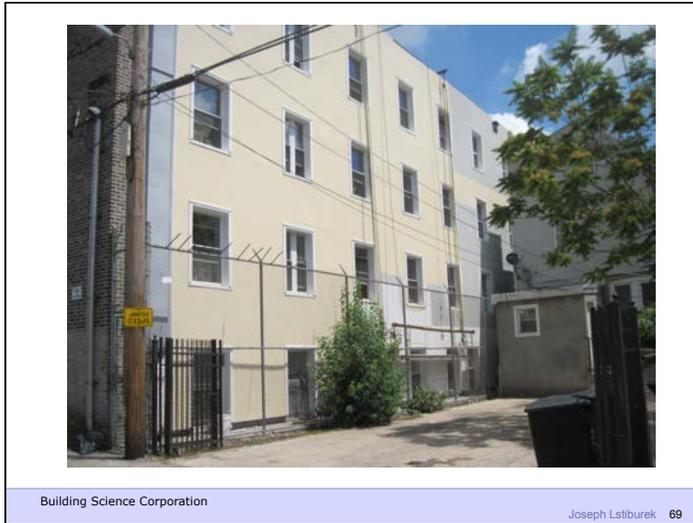
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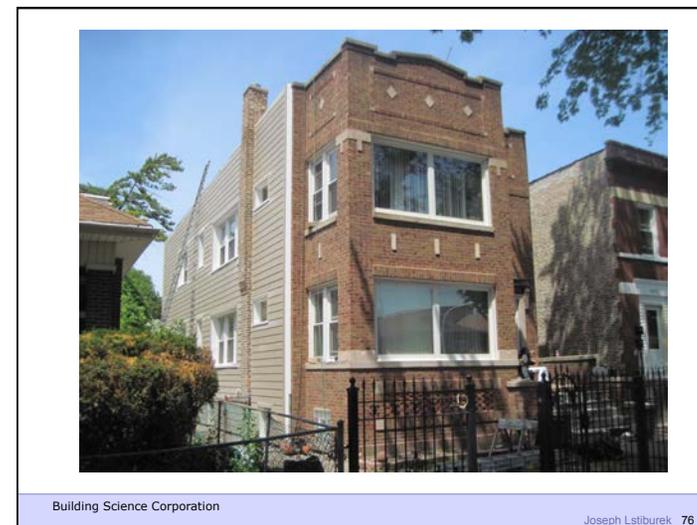
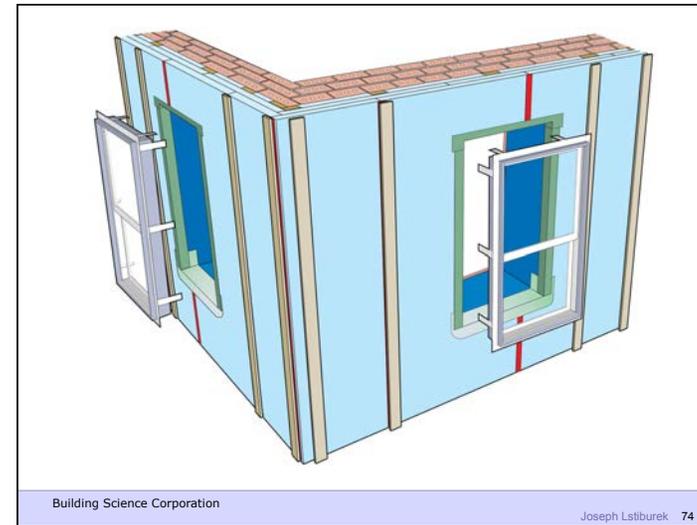
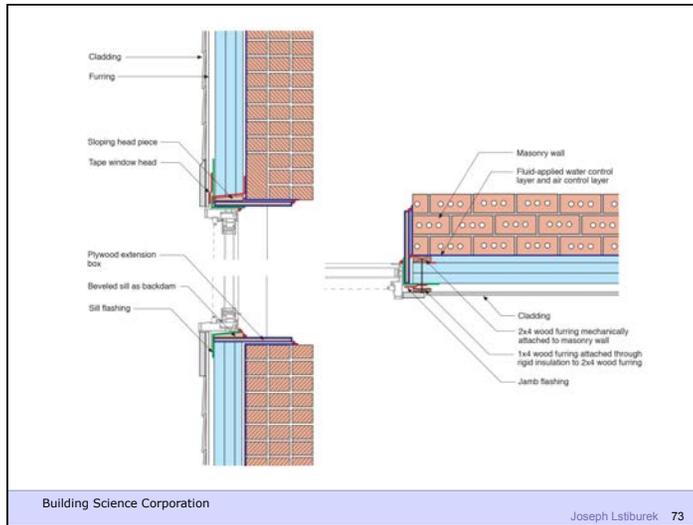


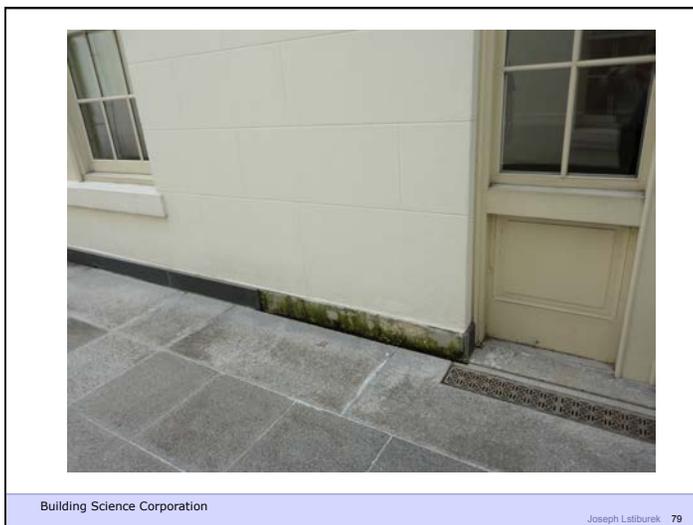
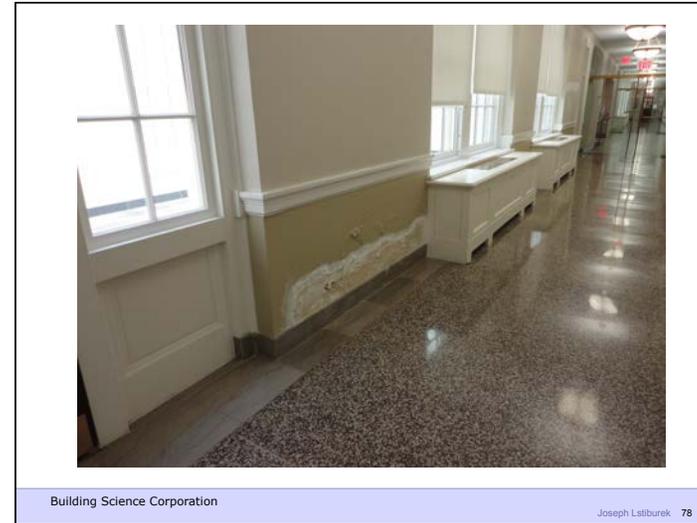
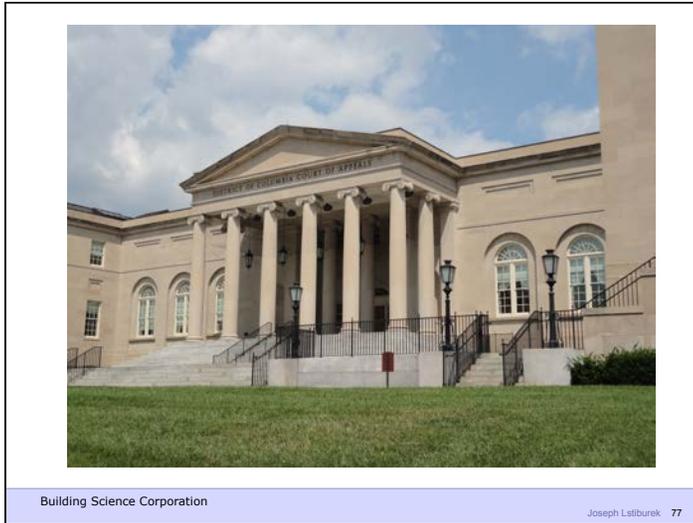
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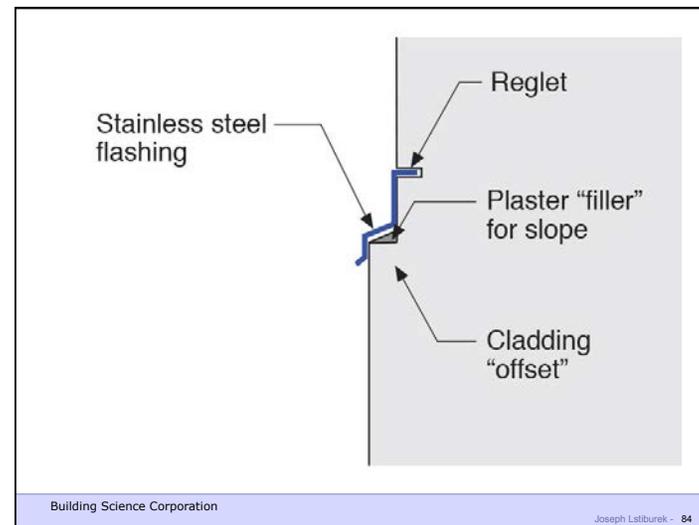
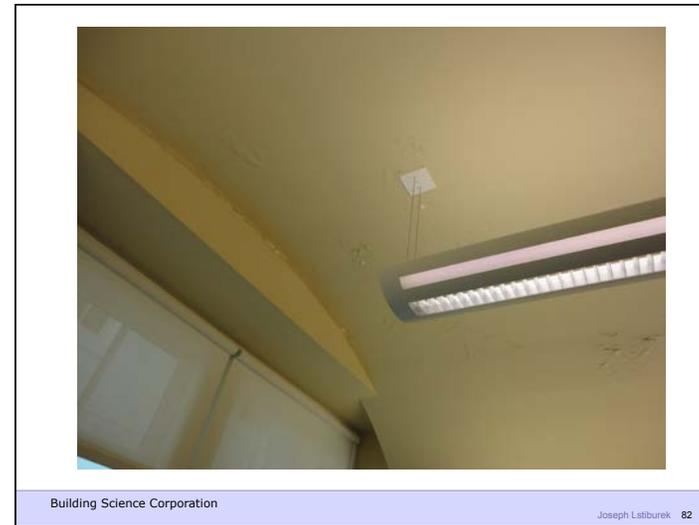
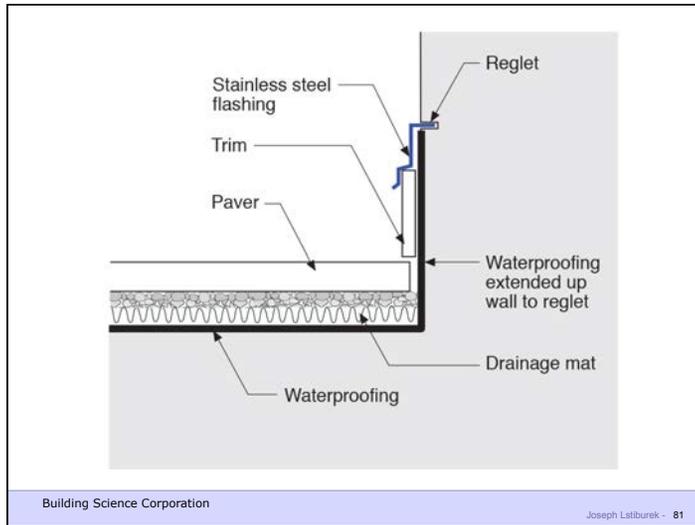
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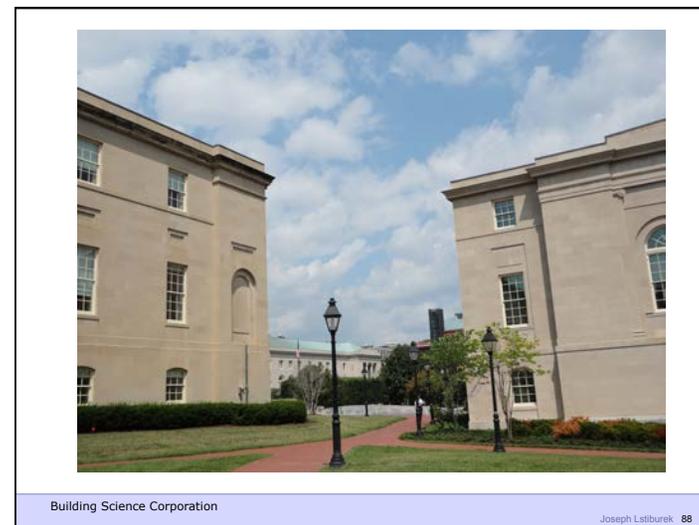
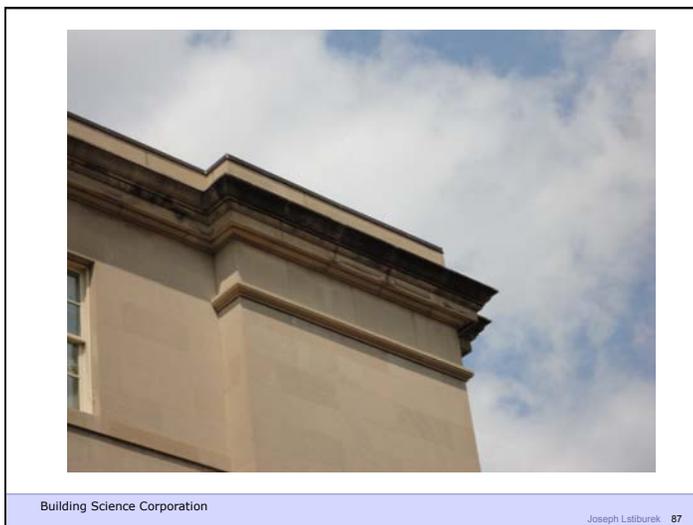
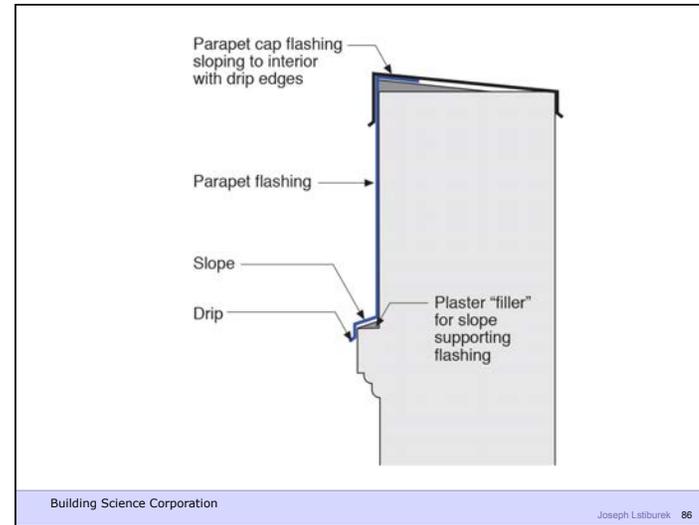
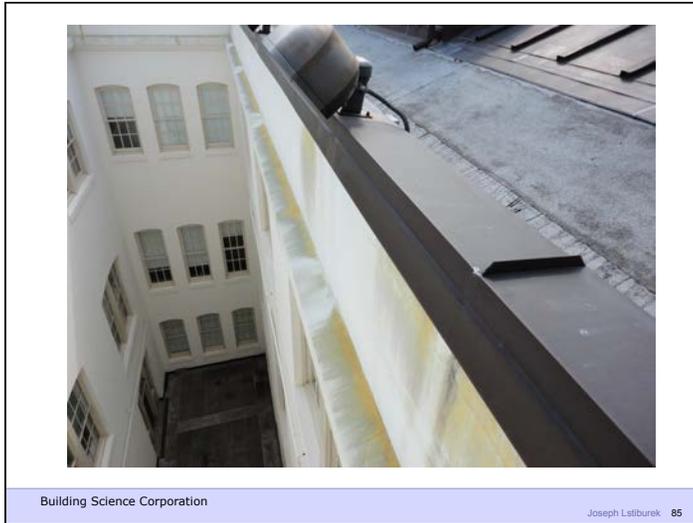


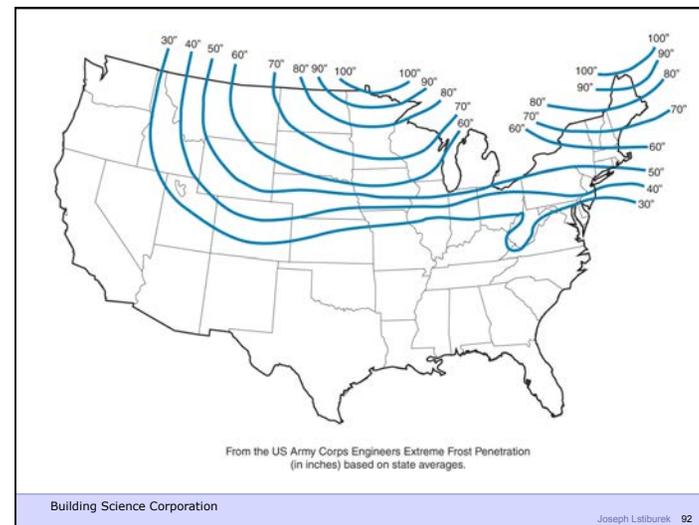
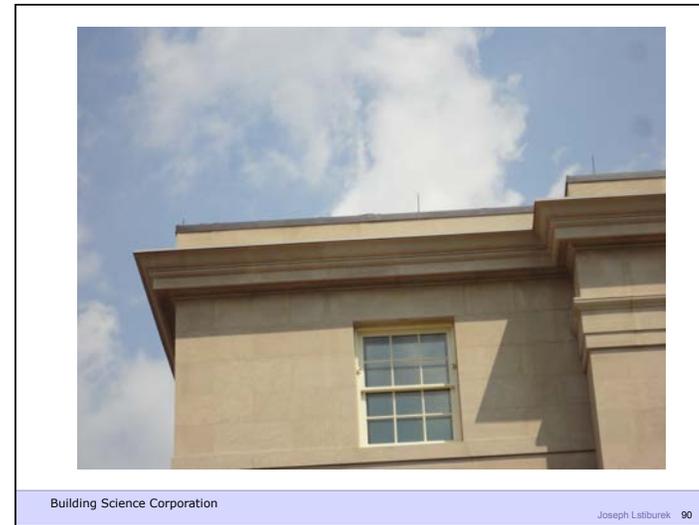
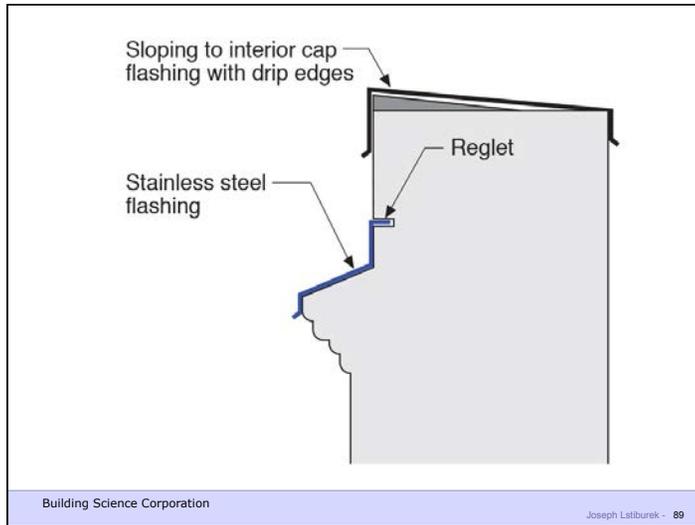


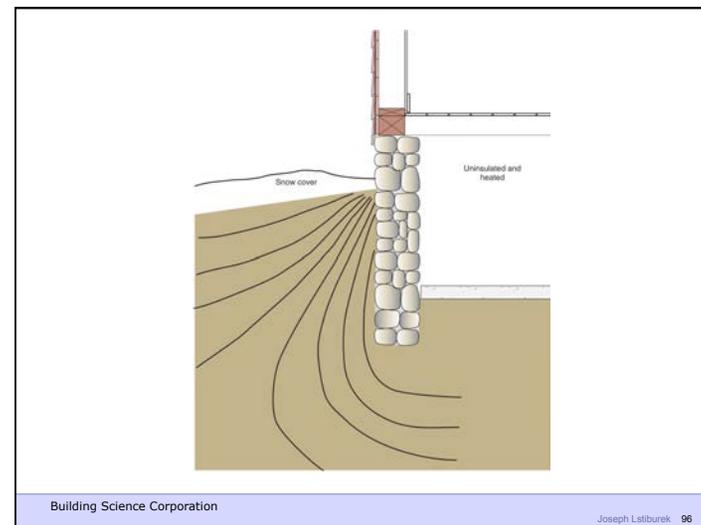
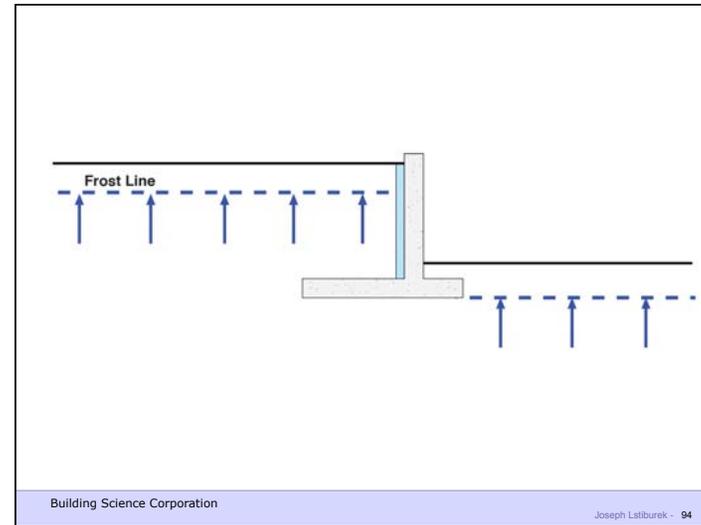
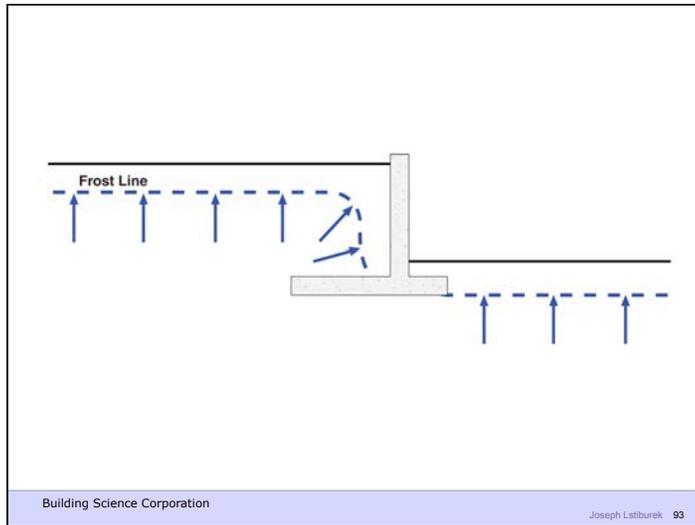


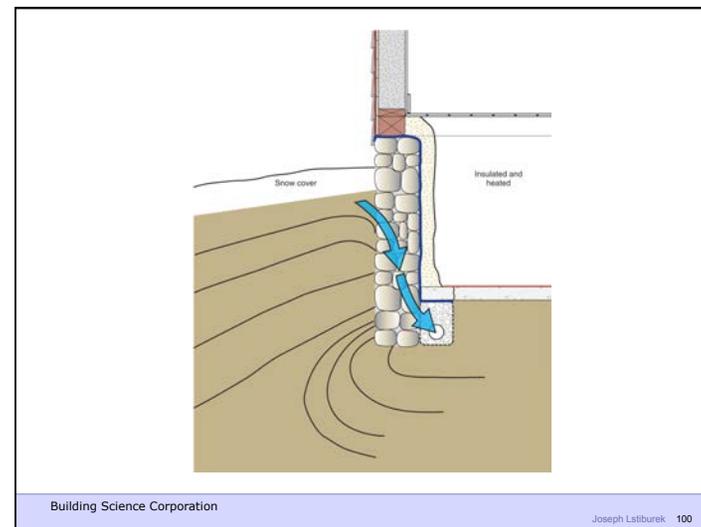
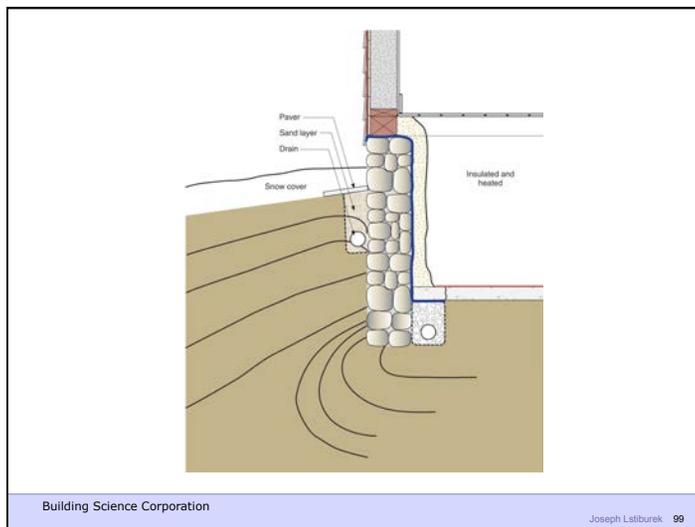
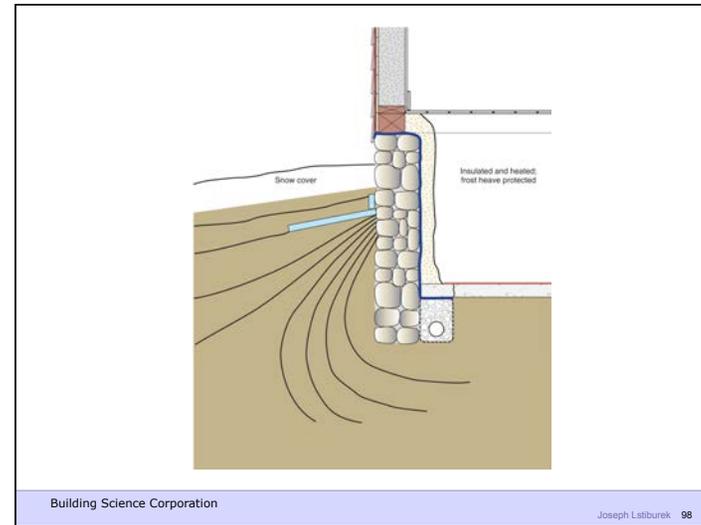
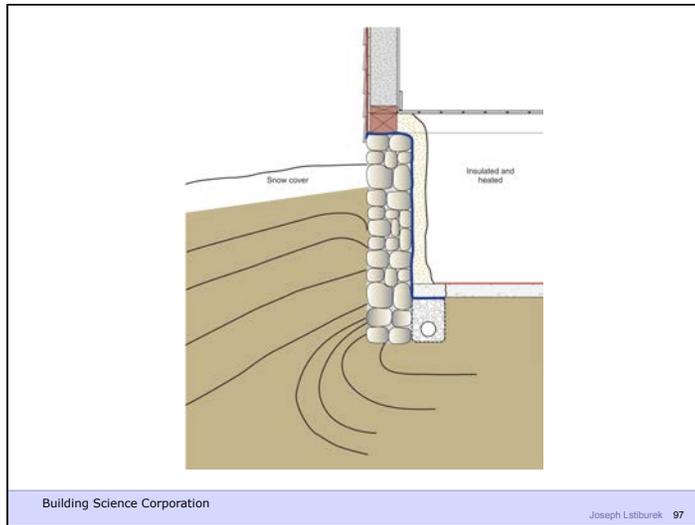


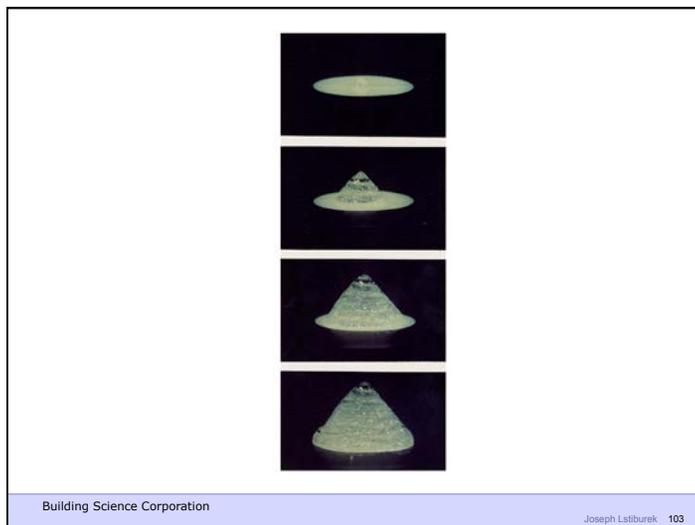
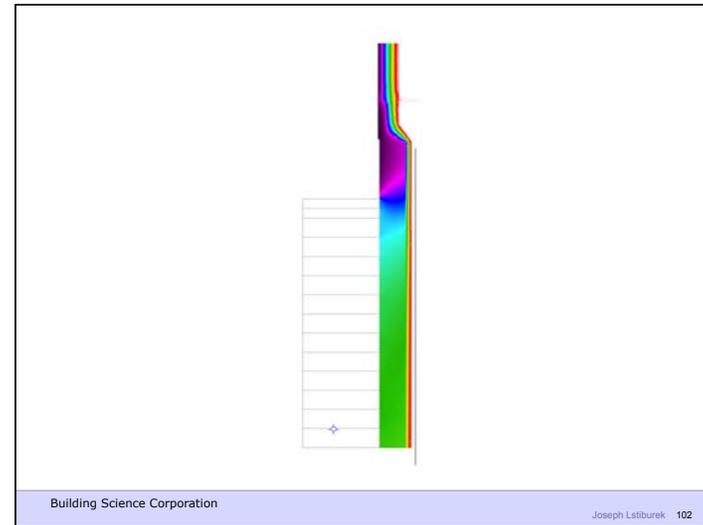
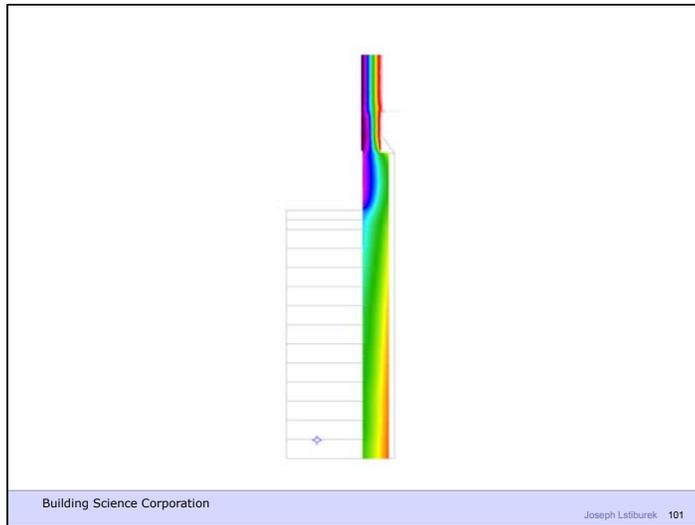














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