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**Basements: New & Retrofit**  
 Energy Efficient, Durable, Healthy

Building Science Corporation  
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## Basements are Changing

- Increasingly used as living space
  - Not a root /coal cellar anymore!
  - High quality space expected - new and retrofit
  - Owner can finish herself
  - Low cost for high density sites (cities)
  - Can now locate laundry, heating, hotwater elsewhere
- Modern basements are different – they need different approaches!
- Commercial basements are similar

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## Basements – Part of the Enclosure

- 

Building Enclosure Components:

1. Basement Floor System(s)
2. Foundation Wall System(s)
3. Above Grade Wall System(s)
4. Windows and Doors
5. Roof System(s)

Labels: roof vents, roof, exterior foundation, basements

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## Basements

- Below grade enclosure
  - Includes floor slabs,
  - practically need to include transition
  - Separates exterior (soil/air) and interior
- Functions of all parts of the enclosure
  - Support – heavy lateral loads
  - Control – less temperature, more water
  - Finish (usually)

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## Moisture: Old ideas

- CBD#161 - 1974
- Drainage layer
- Exterior moisture barrier
- Exterior insulation
- Air barrier

Figure 1. Wall-drained basement wall.

Figure 2. Exterior insulation of basement wall.

Labels: insulation, drainage layer, air barrier, moisture barrier, exterior foundation

Exterior insulation  
 Drainage layer  
 Capillary break  
 Air tightness

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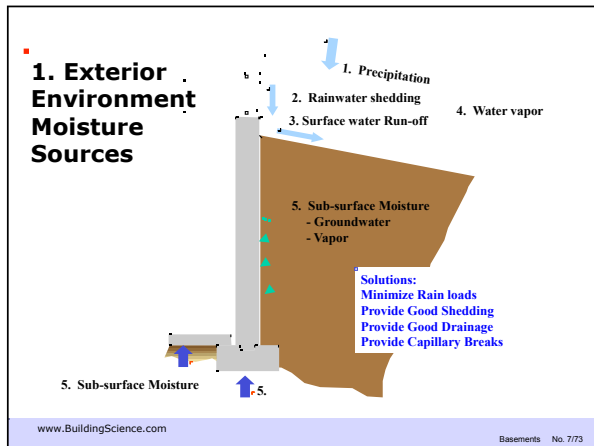
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## Control: Moisture

- Moisture causes most failures
  - Mold (musty basement smell)
  - Decay (especially rim joist)
  - Staining /Paint peeling
  - Floods and leaks, eventually causing the above
  - Salt damage to masonry – old basements
- Where does moisture come from?
  - 1. Exterior
  - 2. Built in
  - 3. Interior

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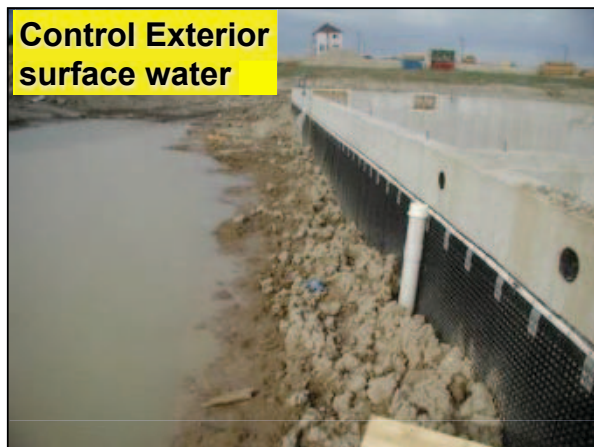
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### 1. Controlling Exterior Moisture Sources

- Same approach as above-grade rain control
  - Deflection
    - Overhangs, slopes, gutters
  - Drainage/Exclusion/Storage
    - Three strategies for the enclosure
  - Drying
    - Remove built-in incidental moisture

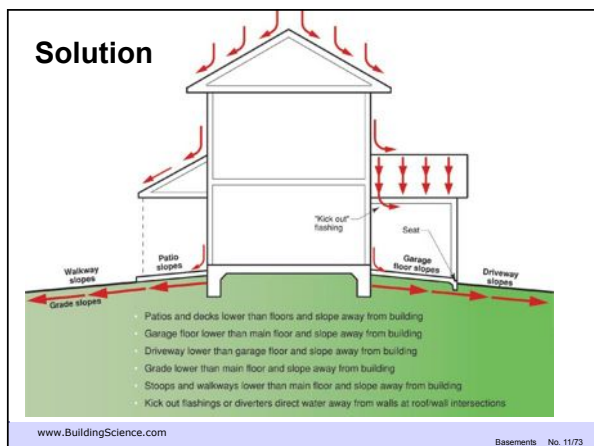
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### Surface Drainage

- First step
  - Common problem
- Overhang
- Gutters
- Downspouts
- Sloped grade
- Perimeter drain

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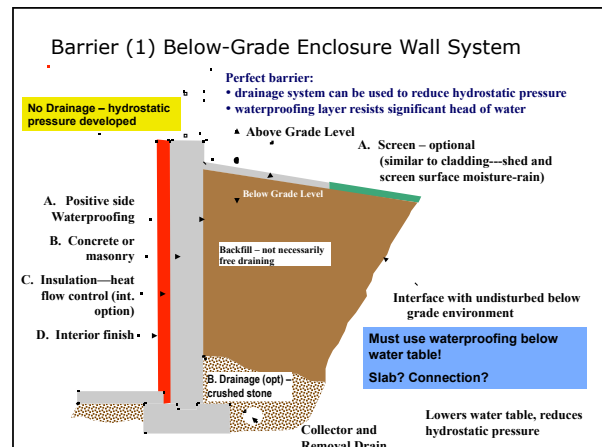
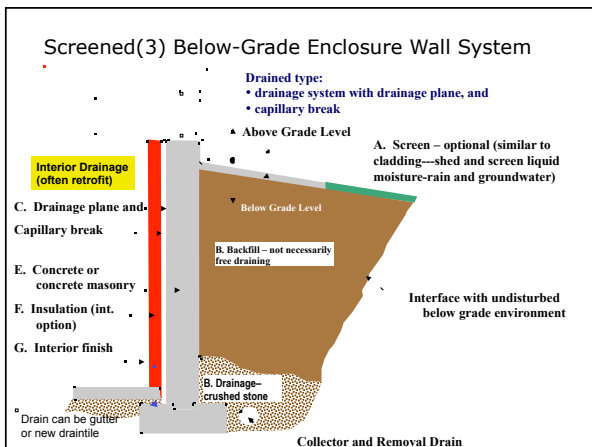
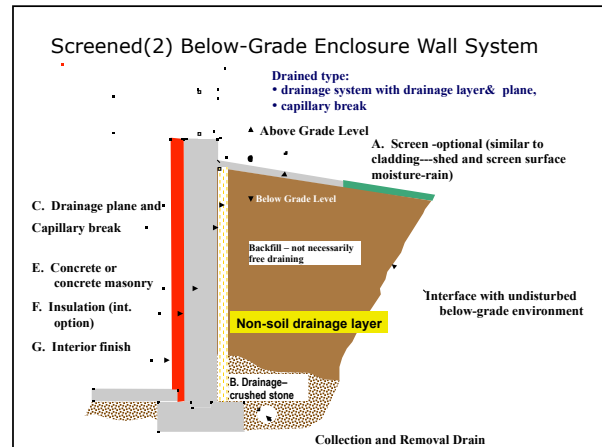
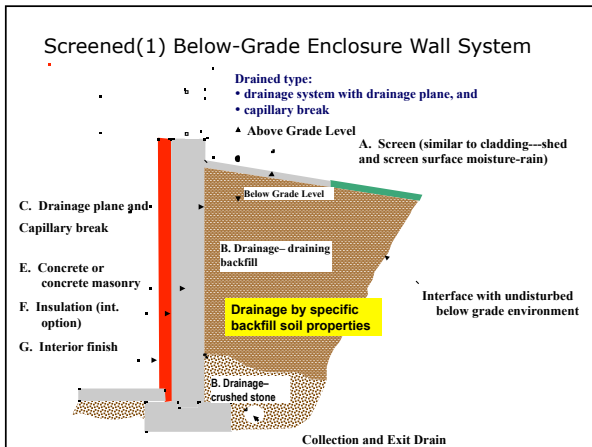


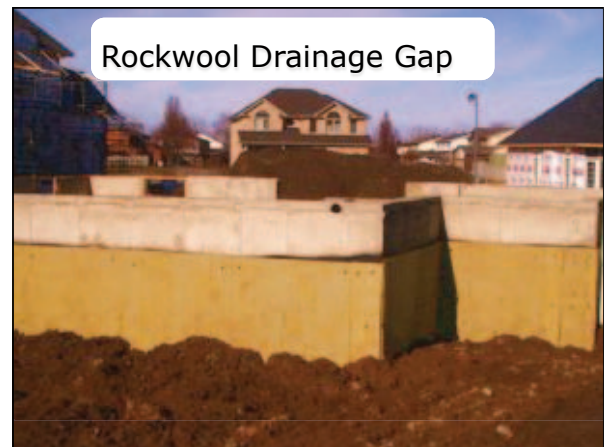
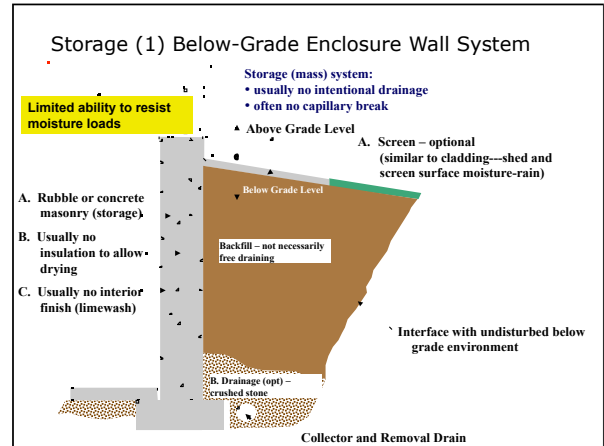
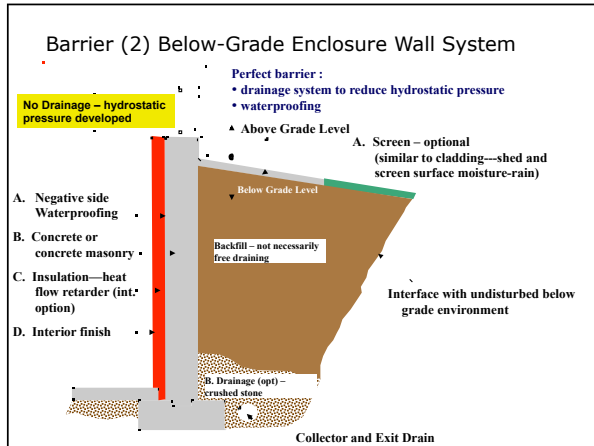
## Basement Enclosure Strategies

- Classification of Groundwater control
  - 1. Drained
    - Needs capillary break and gap/drain space
  - 2. Perfect Barrier (“waterproofing”)
    - One layer of perfect water resistance
    - Beware hydrostatic forces
  - 3. Storage (mass)
    - Safe storage capacity and drying
    - Don't use vapor barriers, do insulate (carefully)

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## 2. Built-in Moisture

1. Built-in Moisture (from water in concrete, mortar, wood, etc.)
2. Construction moisture accumulated during construction (ice, snow, rain, etc.)

•Minimize by:  
 • Delay finishing internally  
 • Reduce water in concrete

1. & 2.

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## 3. Interior Moisture Sources

2. Localized Flooding

1. Water Vapor in contact with cold surfaces: air movement, and diffusion
2. Localized Flooding (abnormal - Water & Vapor)

**Solutions**

1. Control interior vapor levels by:
  - winter ventilation
  - summer dehumidification
1. Avoid contact with cold surfaces
  - keep surfaces warm
  - stop water vapor moving
2. Control flooding
  - floor drains
  - disaster pans at appliances

2. 1

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### Managing Air and Vapor

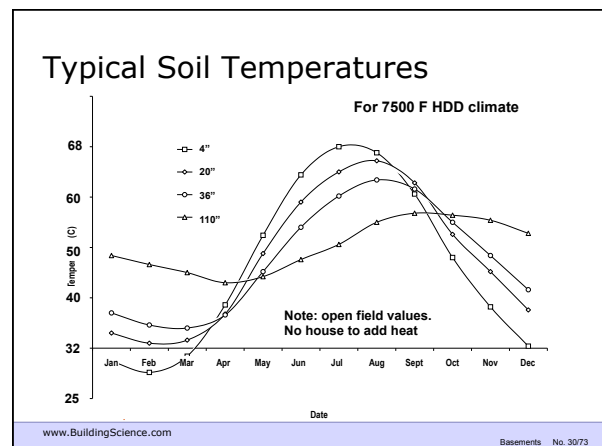
- Need to solve
  - Surface condensation
    - Sol'n: Keep surface warm & air dry
  - Interstitial condensation
    - Control air/vapor flow to cold surfaces & dry air
  - Solar driven summer condensation
    - Allow vapor flow in, slow rate of flow

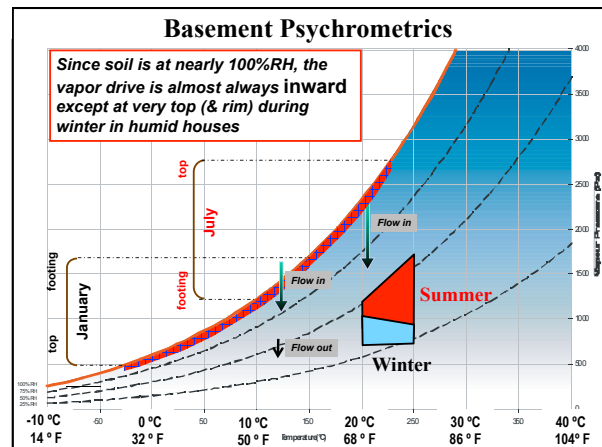
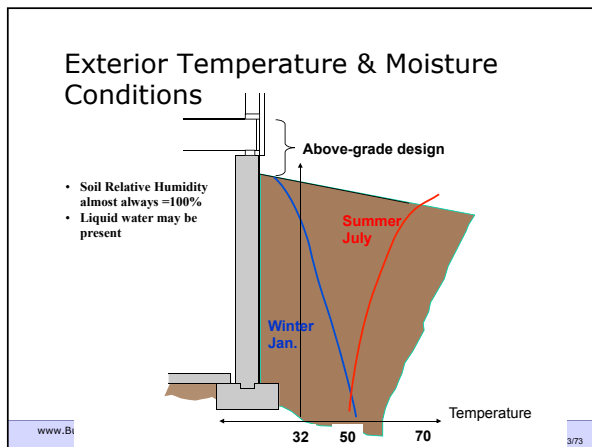
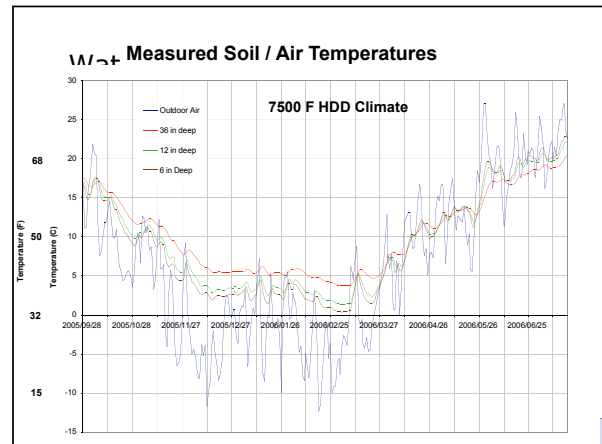
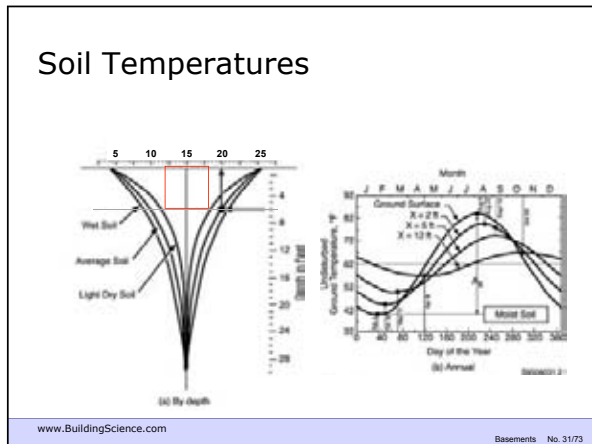
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### Context: Below-grade Conditions

- Exterior soil is almost always at 100%RH
  - Plus liquid water can press against wall
- Never gets as cold or as hot as above grade
- Significant vertical temperature gradients
  - Top is different than bottom

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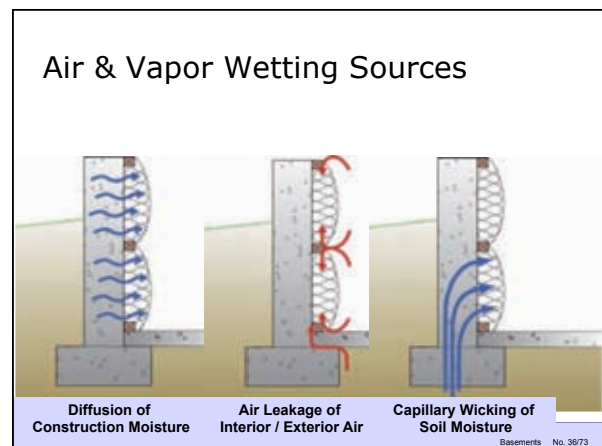


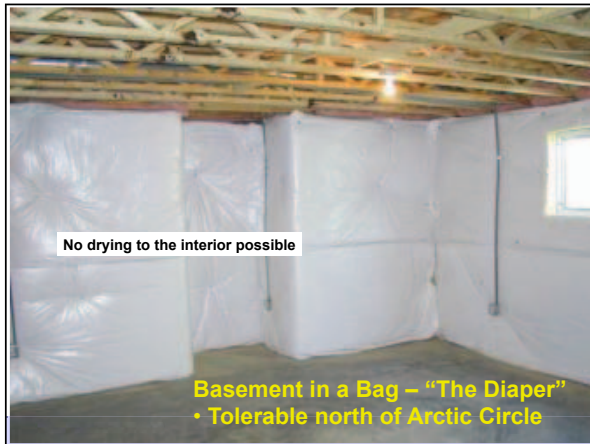


### Basement Vapor Diffusion

- Water vapor is moving from soil to interior
  - for almost the entire year
  - over all but the top foot of basement
- Hence, should place vapor barrier on outside
- But we put it on the inside!
- Moisture from drying concrete, air leakage, wicking and soil also trapped by interior vapor barriers

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- Typical basement (“normal practice”)
  1. Start dry
  2. No leaks
  3. No poly
  4. Be lucky

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### How to insulate/finish basement wall?

- We need to:
  - Control exterior ground water
  - Insulate (energy, comfort and moisture)
  - Control air leakage and diffusion condensation
  - Provide (a little) inward drying
  - Accommodate different conditions over height
- How to do we all this?

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### Insulation Location Choices

- Builders like to insulate the interior

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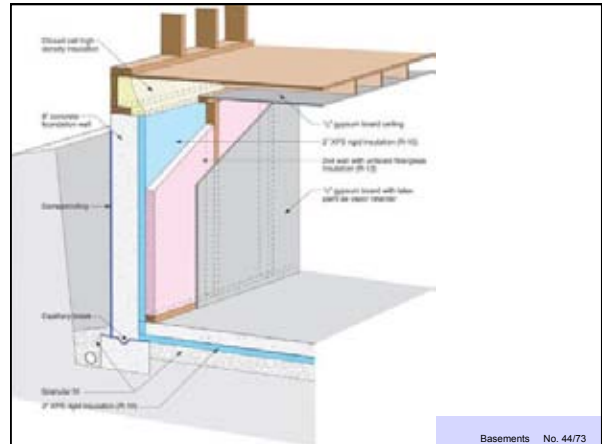
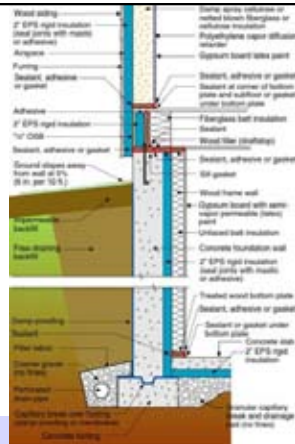
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Hybrid

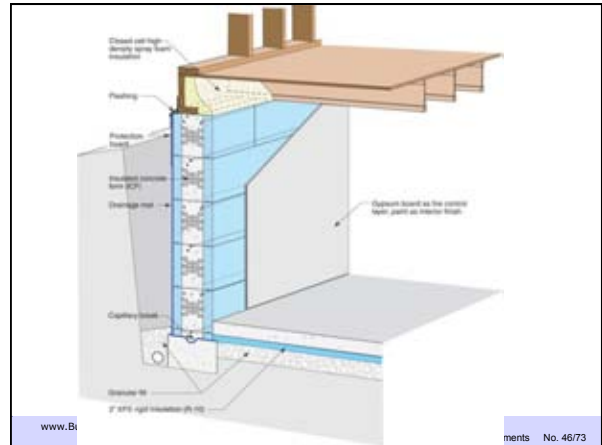
- Add layer of:
  - foam or
  - spray foam

To allow inward drying  
• about 1 perm

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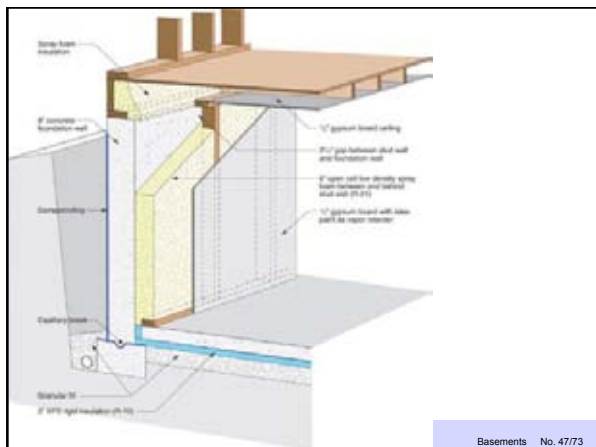


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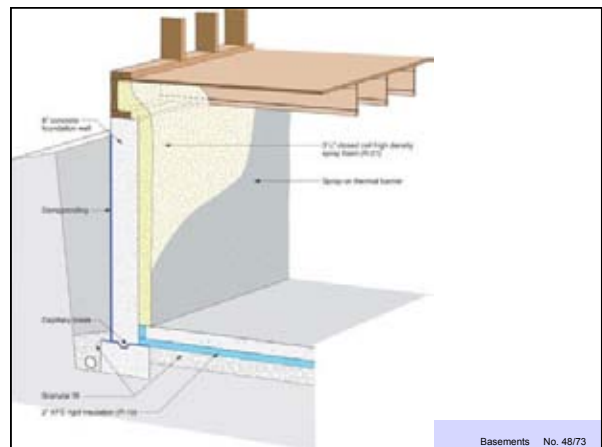


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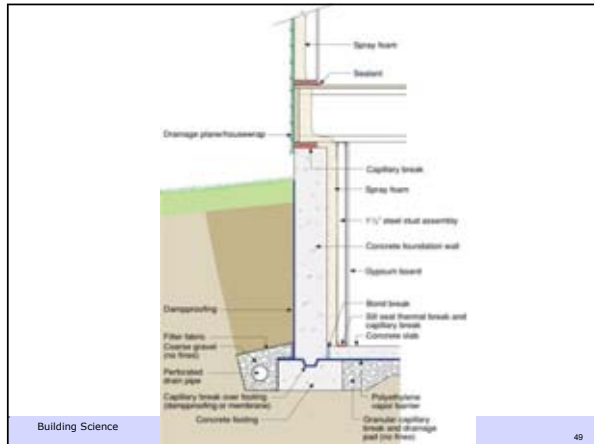


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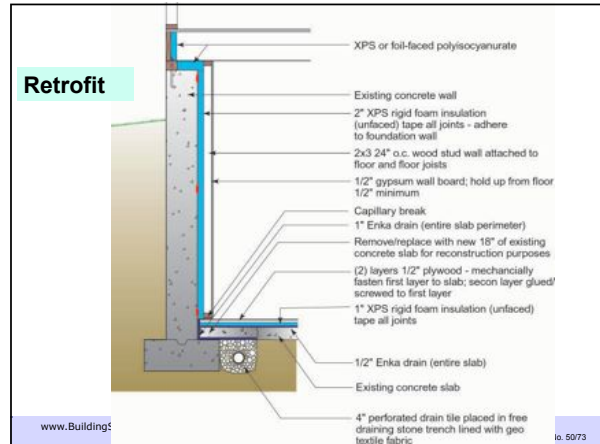
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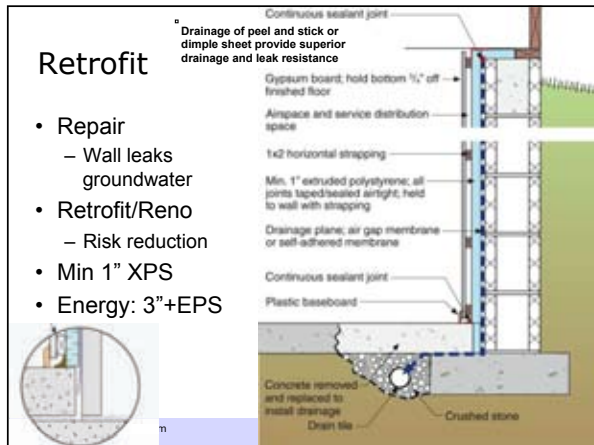
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**Retrofit**

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**Retrofit**

- Repair
  - Wall leaks groundwater
- Retrofit/Reno
  - Risk reduction
- Min 1" XPS
- Energy: 3"+EPS

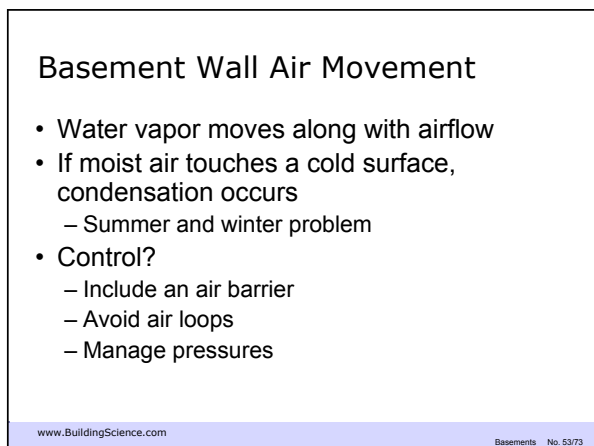


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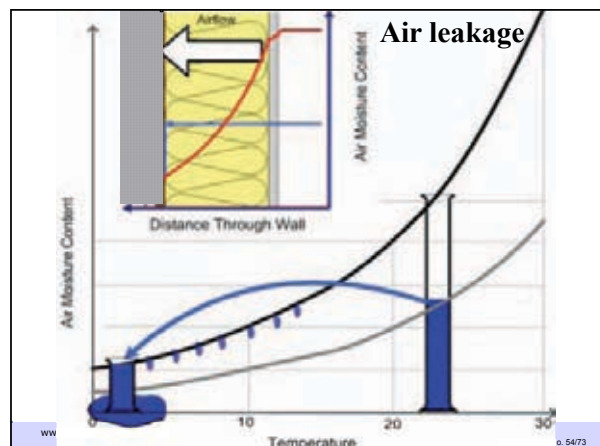
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### Internal Stack Effect & Insulation

- Gaps in batt insulation on both sides
- Wrinkles inevitable

Inside  
Hot air = light  
Batt  
Air gaps  
Cold air = heavy  
Outside  
**Common basement problem**

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### Internal Stack Effect

**Cold Weather**

- Gaps in batt insulation on both sides
- closed circuit
- energy cost
- condensation

Hot air = light  
Result: Air Flow  
Cold air = heavy  
cold  
cool

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### Problems w/ air permeable insulation

Cold Weather

Cold  
Condensation  
Air permeable insulation  
Air leakage  
Crack

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### Solution w/ Insulated Sheathing

Warmer

Warmer  
Air permeable insulation  
Air leakage  
Crack

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- Foam only
- Vertical or horizontal furring

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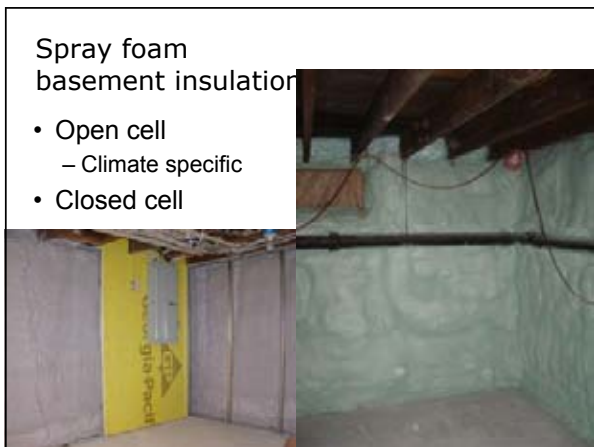
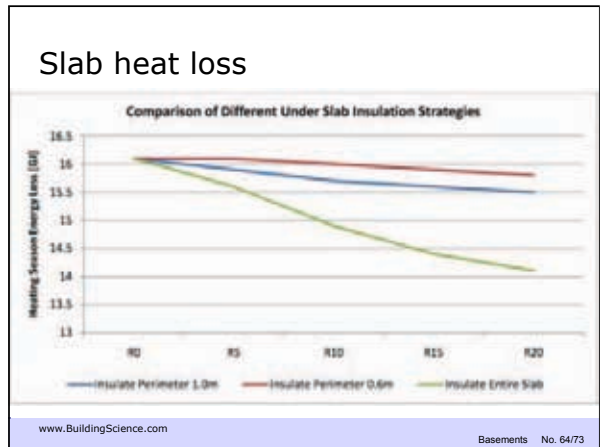
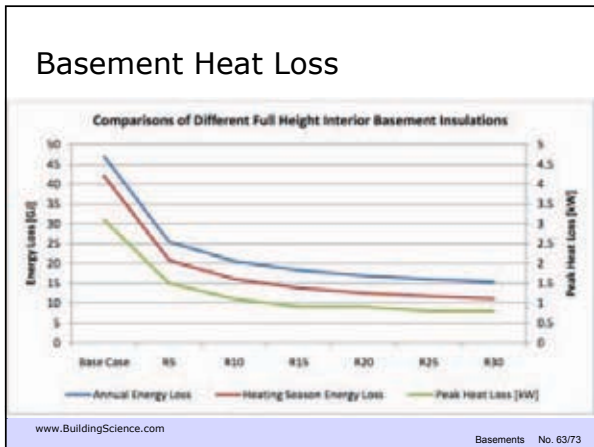


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## Materials to use?

- Foam Board: EPS, XPS, PIC
  - water tolerant
  - vapour barriers to vapour retarders
- spray foam
  - Semi-rigid (Icynene) and rigid (Spray polyurethane)
  - airtight
  - May allow some drainage
  - R values of 4 to 6/inch
  - vapour semi-permeable (Icynene much more)

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## Insulated Concrete Forms (ICF)

- If you afford it, use them –
  - cap break,
  - insulation,
  - vapor retarder,
  - above grade



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Thermomass

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### Rim joists

- Scenario
  - Wood generally on exterior
  - 1.5" wood is a vapor barrier
  - Practically difficult to stop air leakage
- Result
  - Condensation on rim joist in cold weather
  - Decay if it can't dry in or out
- Solutions
  - Insulate on exterior

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### Slabs

- Slabs can lose significant energy
  - Currently the only uninsulated part of many buildings
- Keep warm (comfort & condensation)
- Control wicking and diffusion
- Make softer
- Consider floods

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OSB over heavy poly dimple sheet vapor barrier and some insulation  
Air seal joints/edge

Beware Joints

### Slabs



### Summary

- Control surface water by drainage
- Drainage layer on exterior of walls
- No vapor barriers on inside
- Painted drywall, stud, batt with foam OK
- Care needed at rim joist
- What happens if there is a flood, leak, etc.

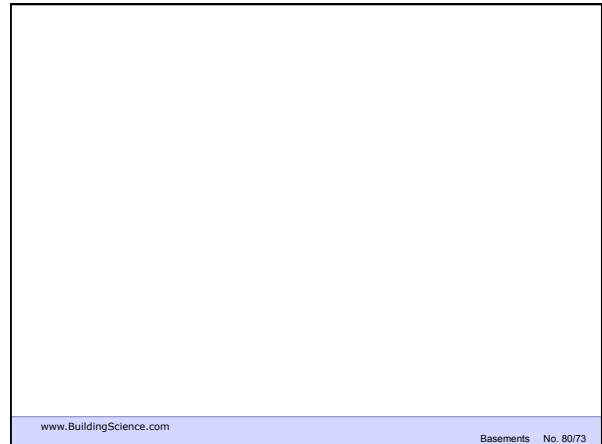
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### Conclusions

- Building in a hole in the ground is hard
- Drainage is better than waterproofing
- Don't forget about built-in moisture
  - and remember summer
- Insulation and drainage are the best tools, not vapor barriers and waterproofing

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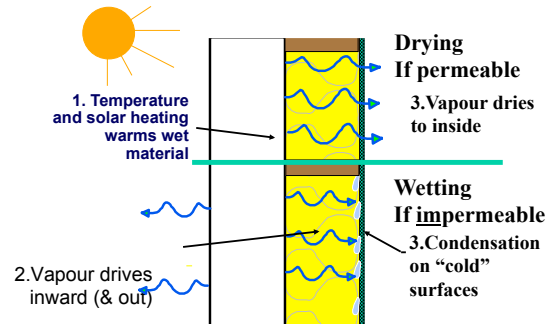
### Inward Solar Drives at Grade

- Wet concrete from rain, grade, built-in
- Sun shines on wall and heats it
- Water evaporates and diffuses in & out
- Can condense inside if cold and impermeable

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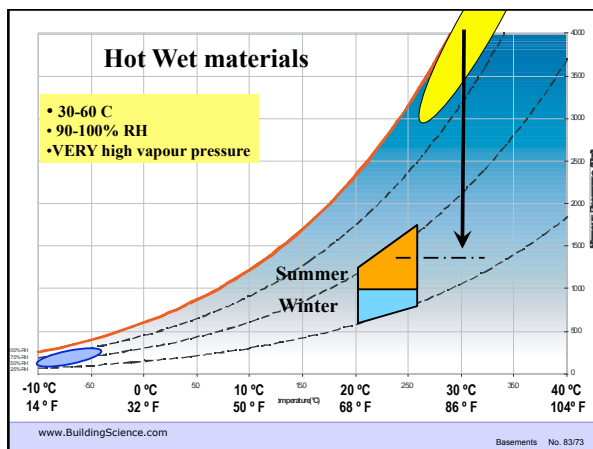
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### Inward Diffusion @ grade



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