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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:

 - Basement Floor System(s)
 - Foundation Wall System(s)
 - Above Grade Wall System(s)
 - Windows and Doors
 - Roof System(s)

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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. Well-drained basement wall.

Figure 2. Exterior insulation of basement wall.

Exterior insulation
Drainage layer
Capillary break
Air tightness

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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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1. Exterior Environment Moisture Sources

1. Precipitation
2. Rainwater shedding
3. Surface water Run-off
4. Water vapor
5. Sub-surface Moisture - Groundwater - Vapor

Solutions:
Minimize Rain loads
Provide Good Shedding
Provide Good Drainage
Provide Capillary Breaks

5. Sub-surface Moisture

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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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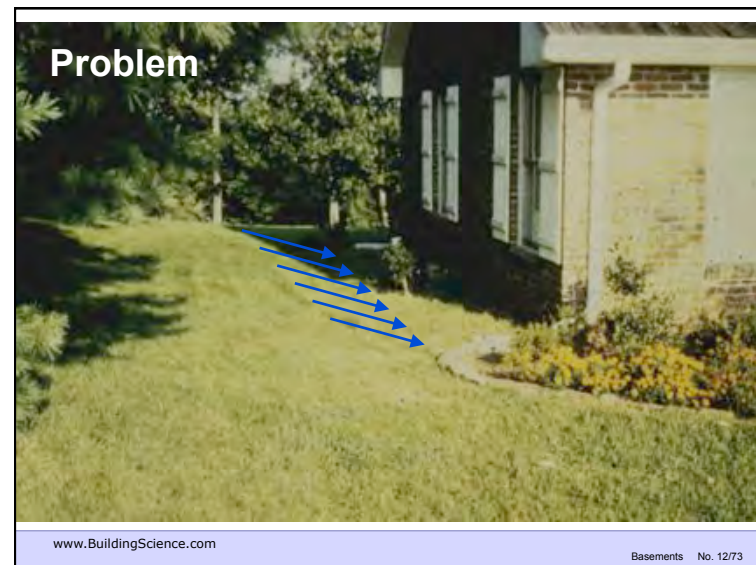
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Solution

- Patios and decks lower than floors and slope away from building.
- Garage floor lower than main floor and slope away from building.
- Driveway lower than garage floor and slope away from building.
- Grade lower than main floor and slope away from building.
- Stoops and walkways lower than main floor and slope away from building.
- Kick out flashings or diverters direct water away from walls at roof/wall intersections.

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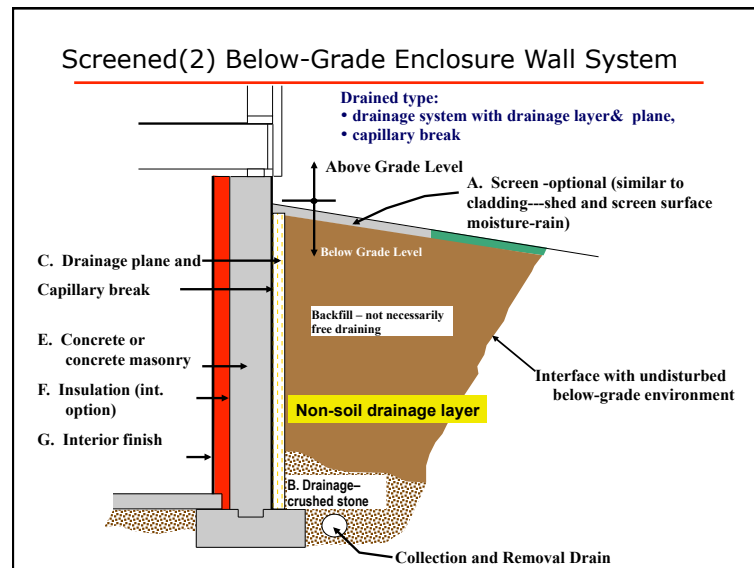
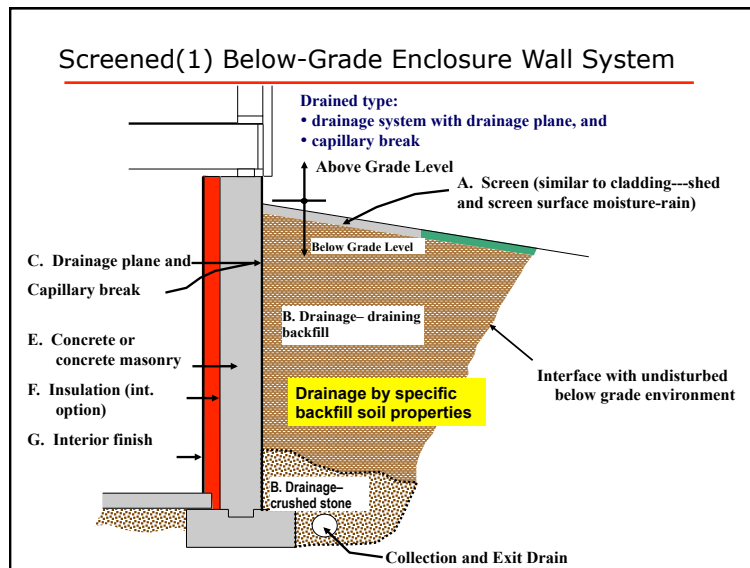


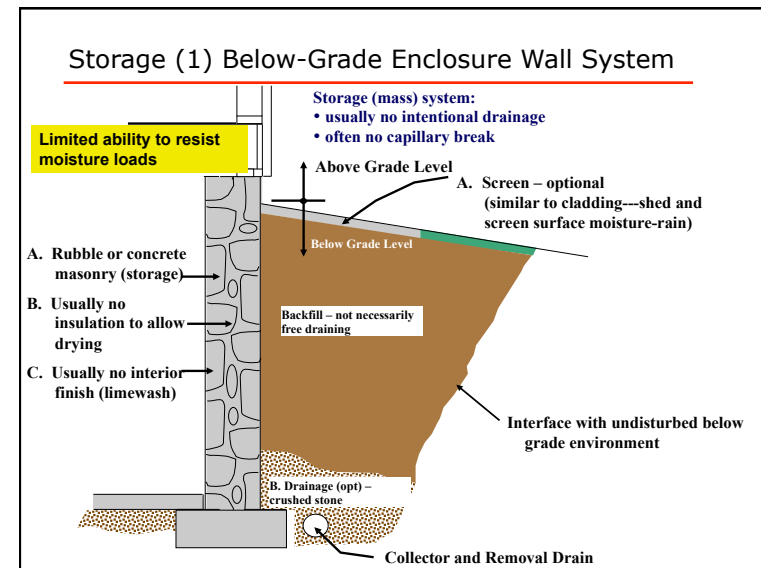
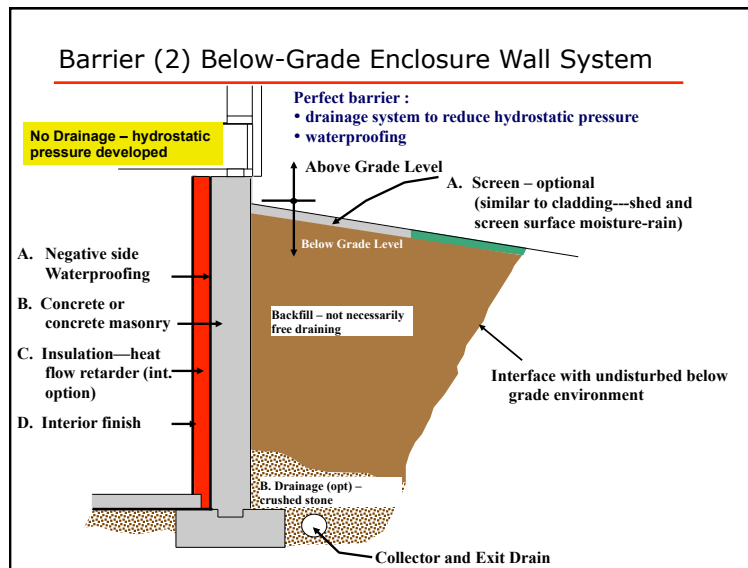
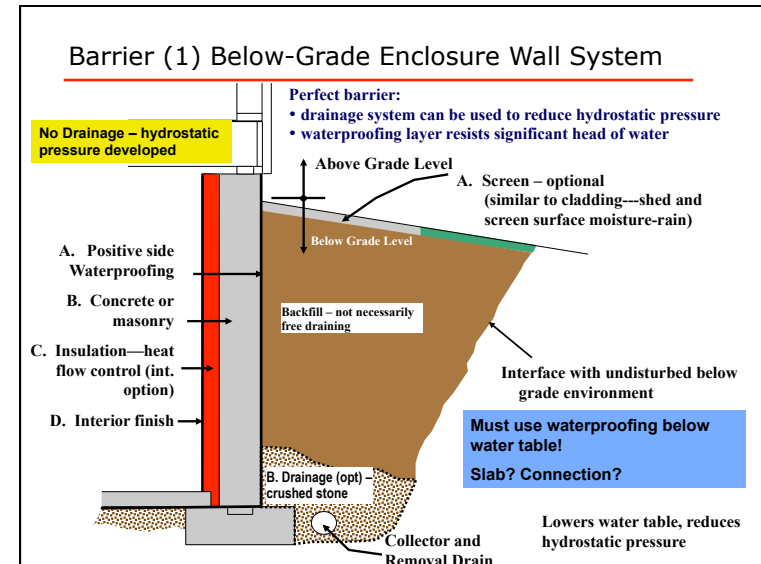
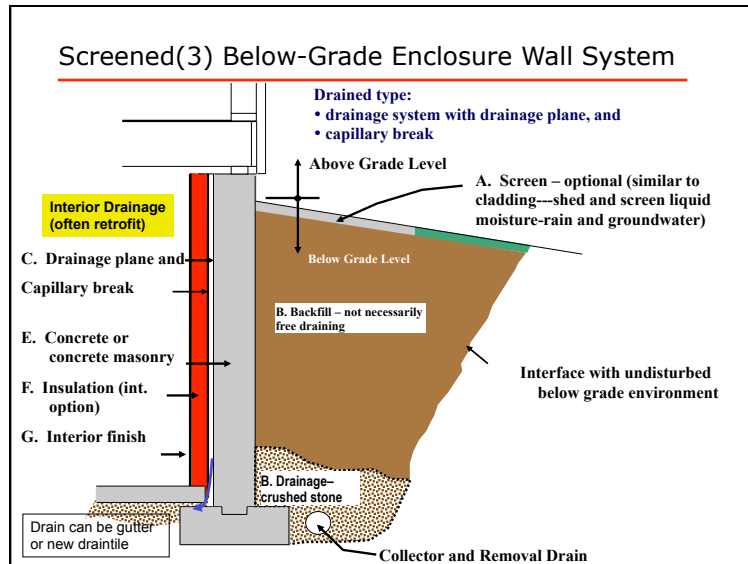


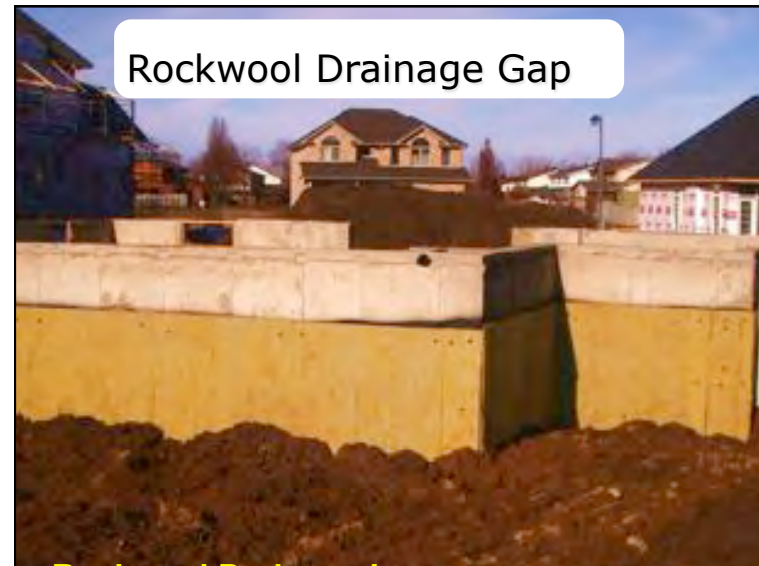
Basement Enclosure Strategies

- 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

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3. Interior Moisture Sources

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

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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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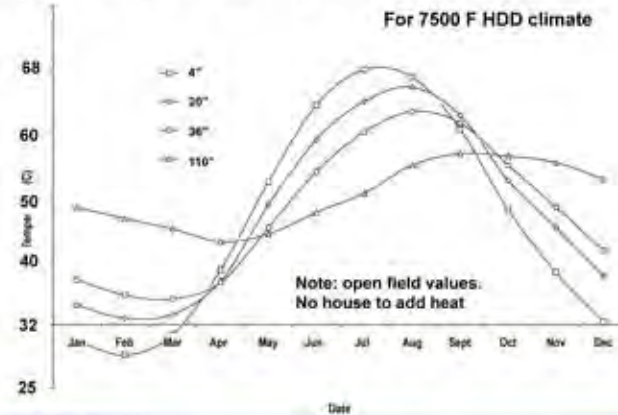
Context: Below-grade Conditions

- 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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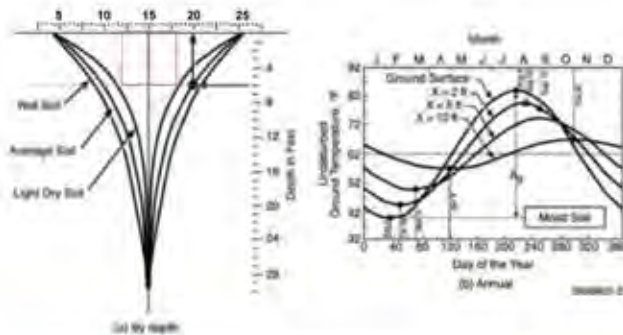
Typical Soil Temperatures



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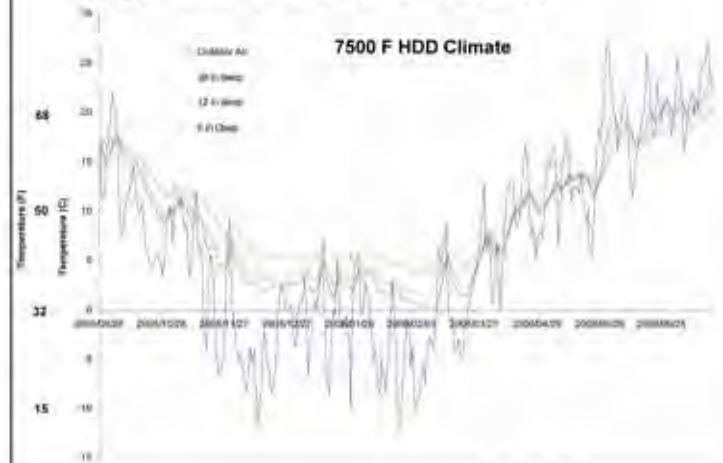
Soil Temperatures

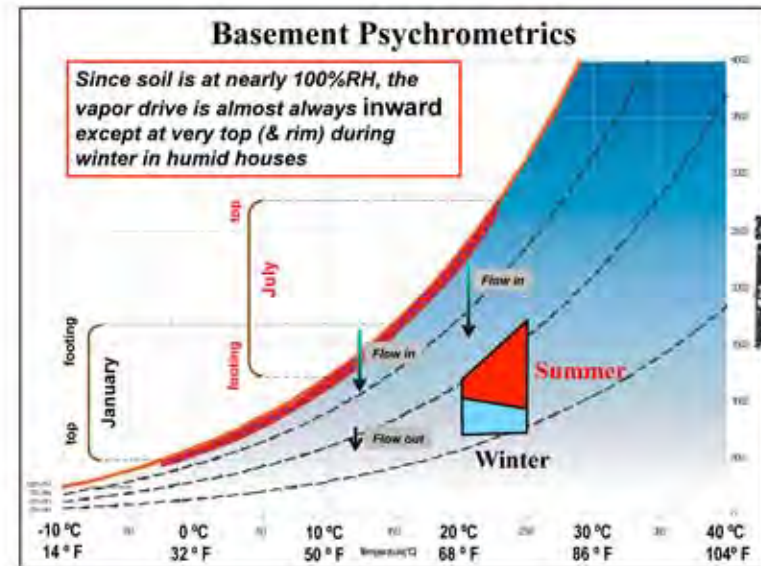
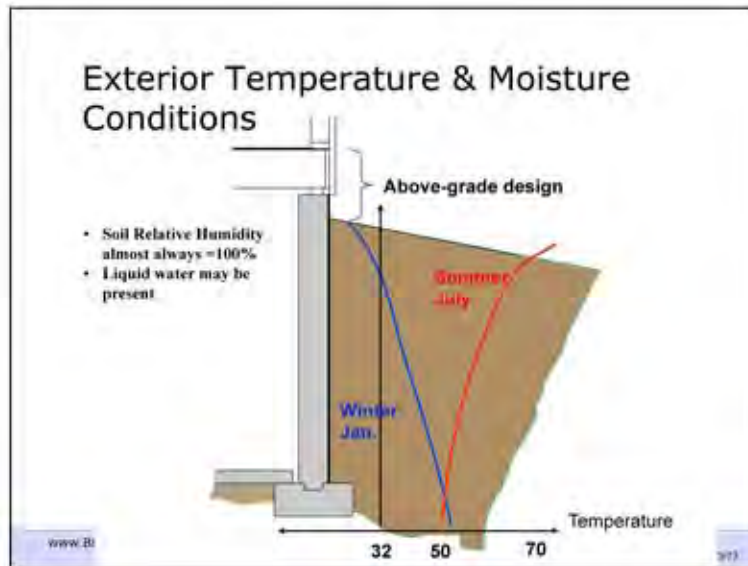


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Measured Soil / Air Temperatures

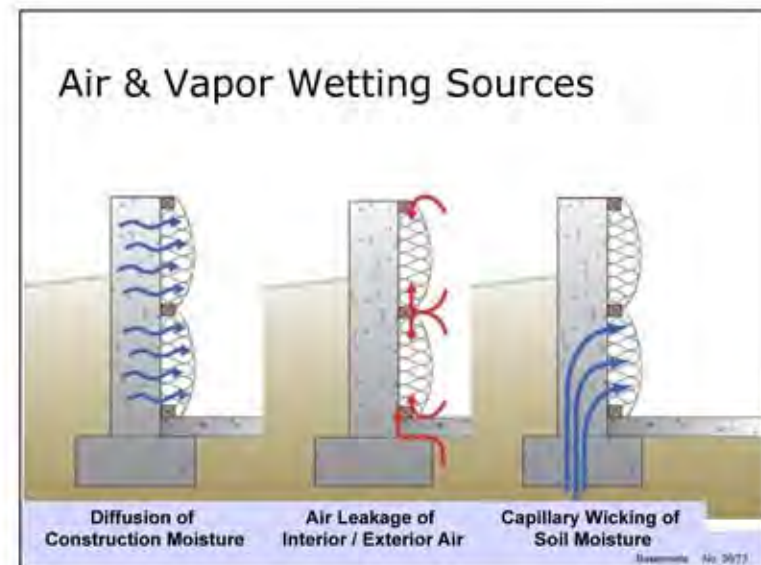


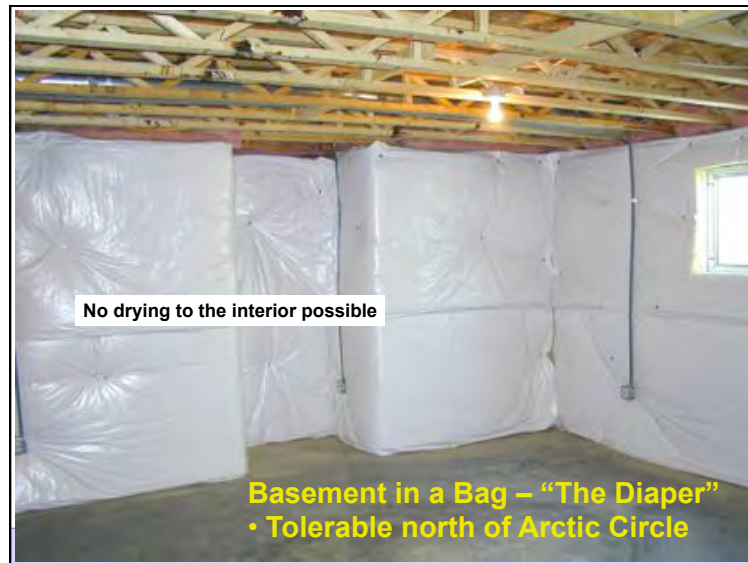


Basement Vapor Diffusion

- 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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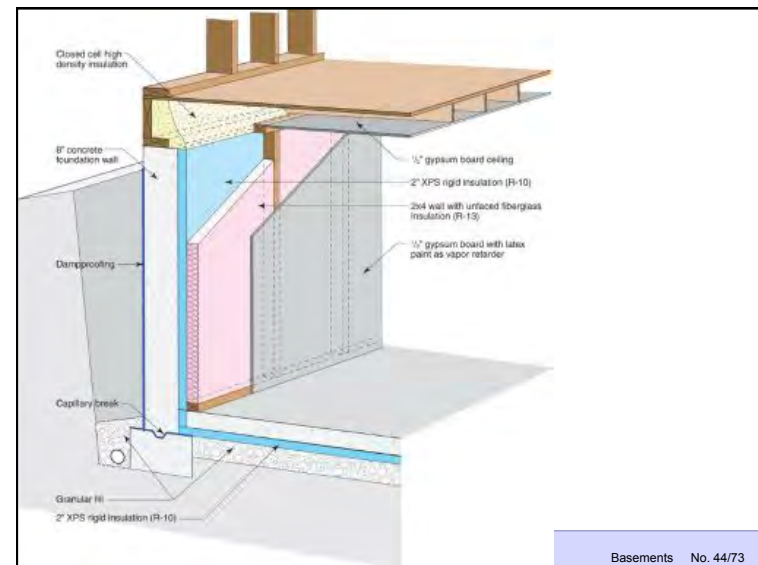
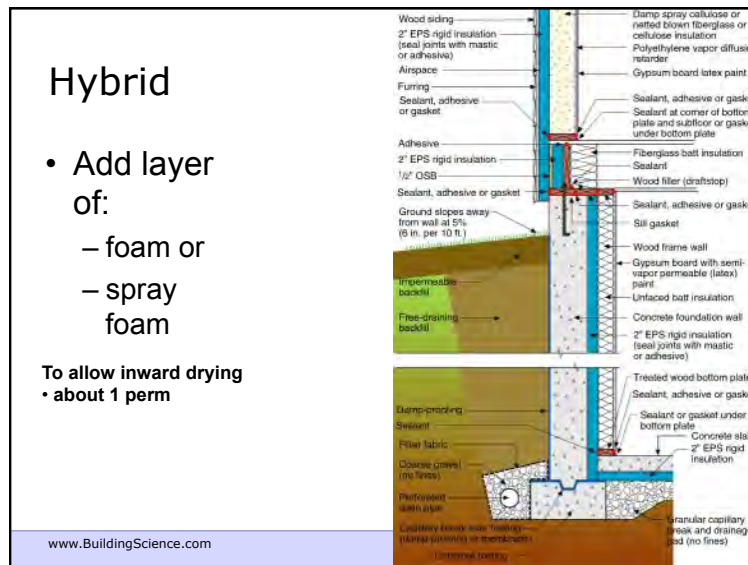
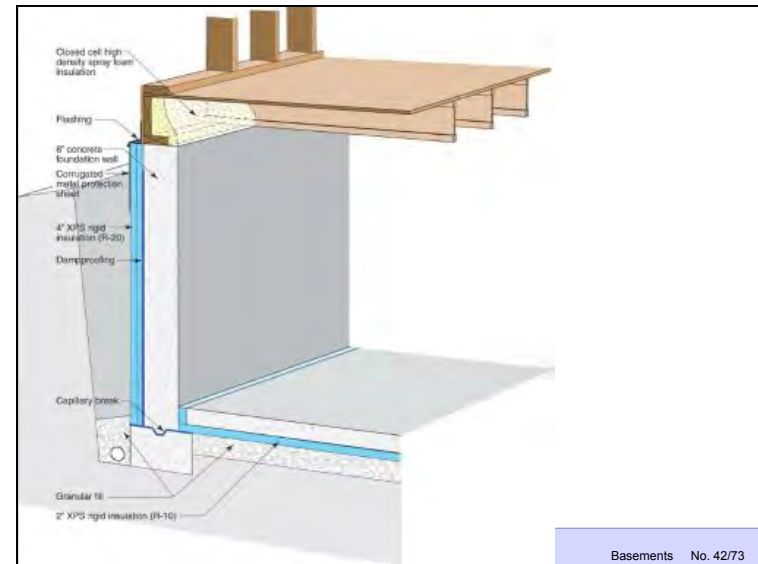
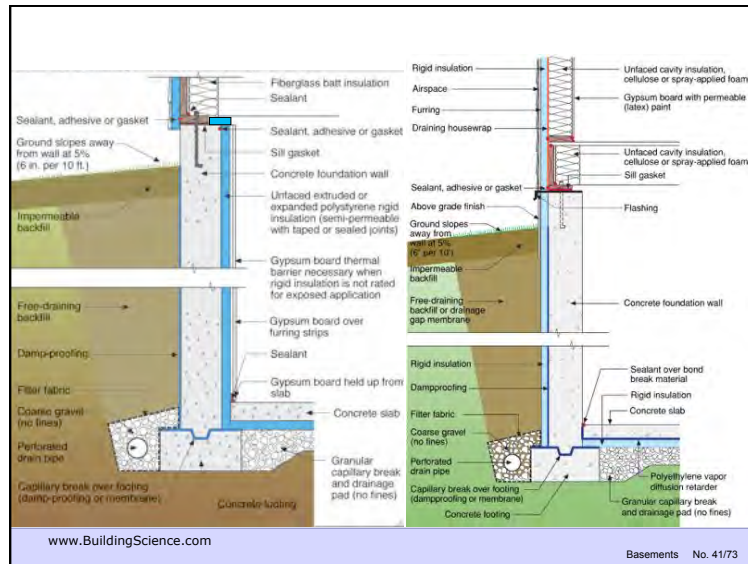
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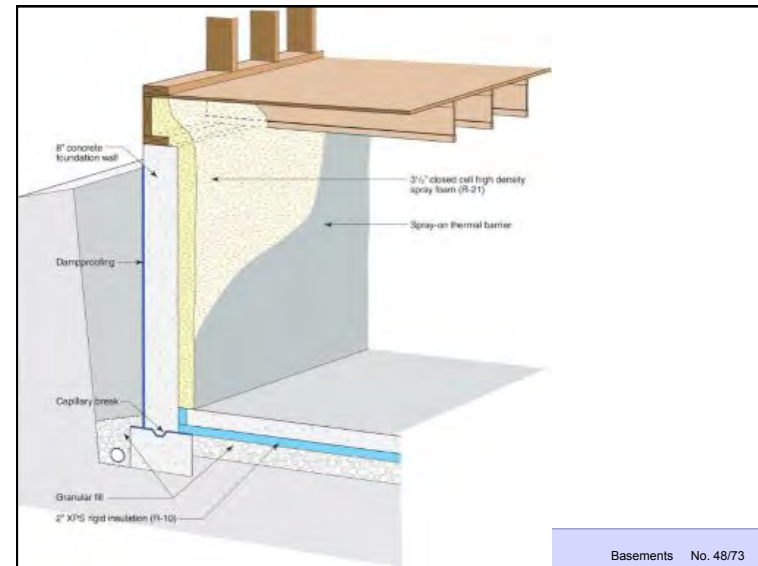
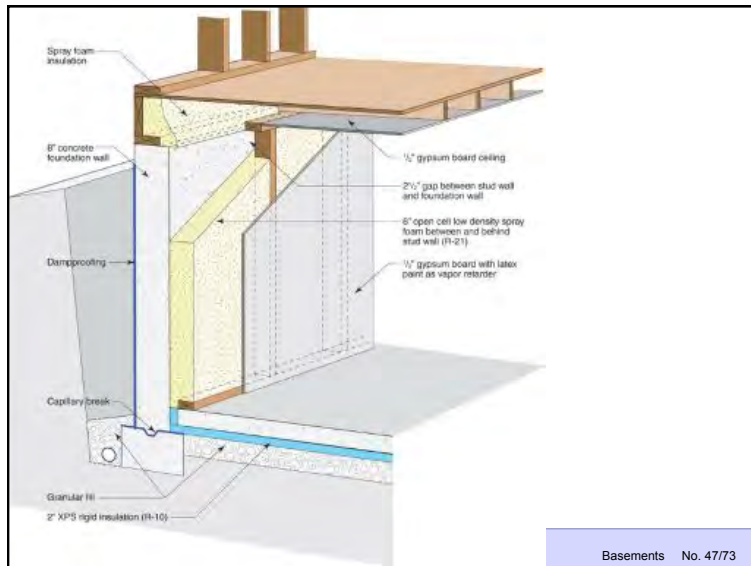
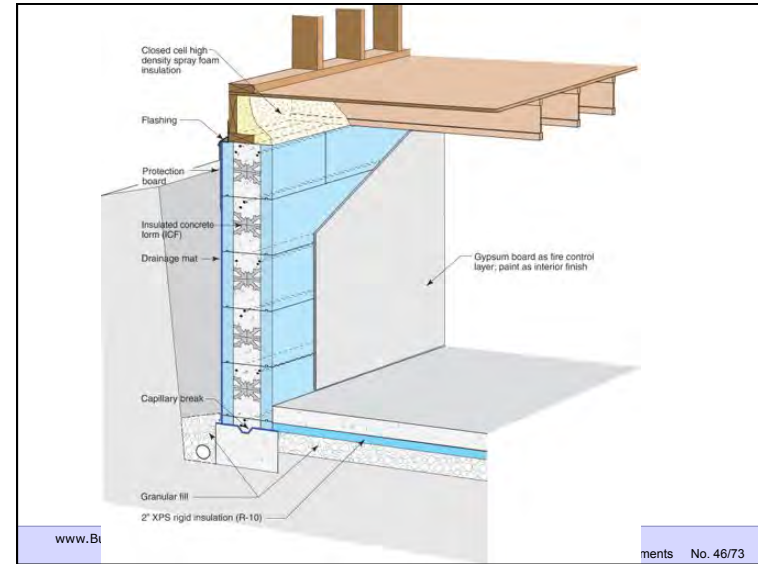
Insulation Location Choices

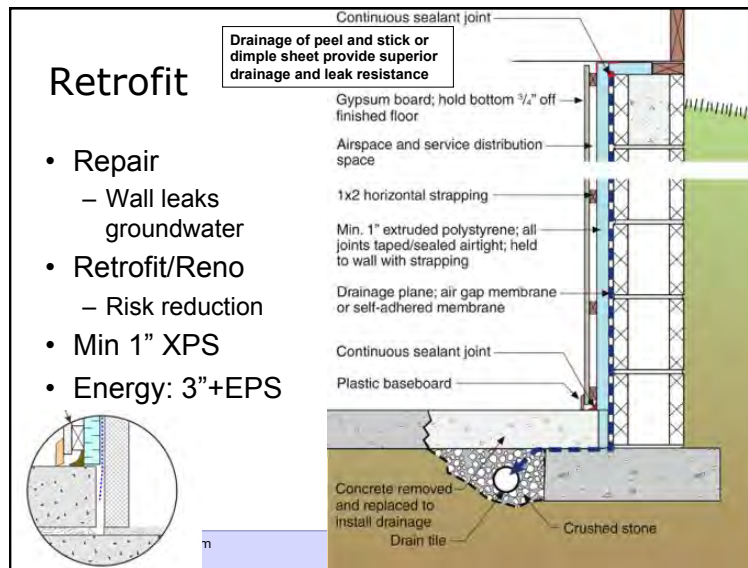
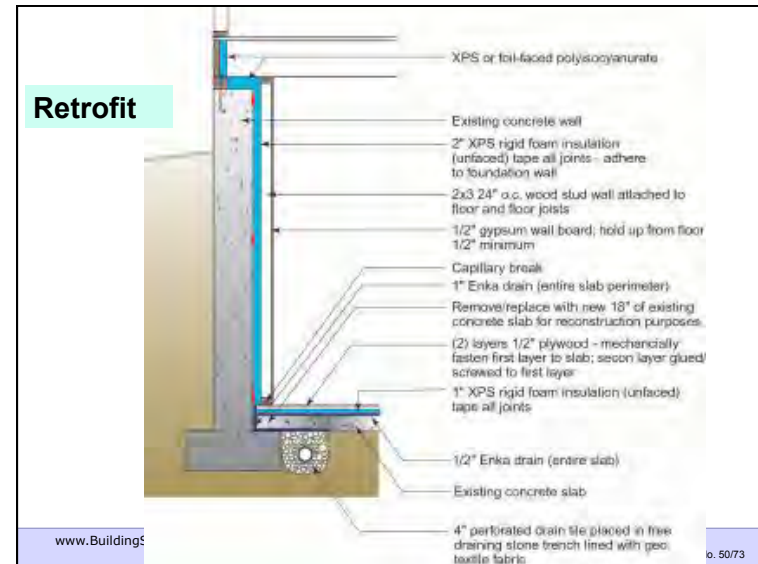
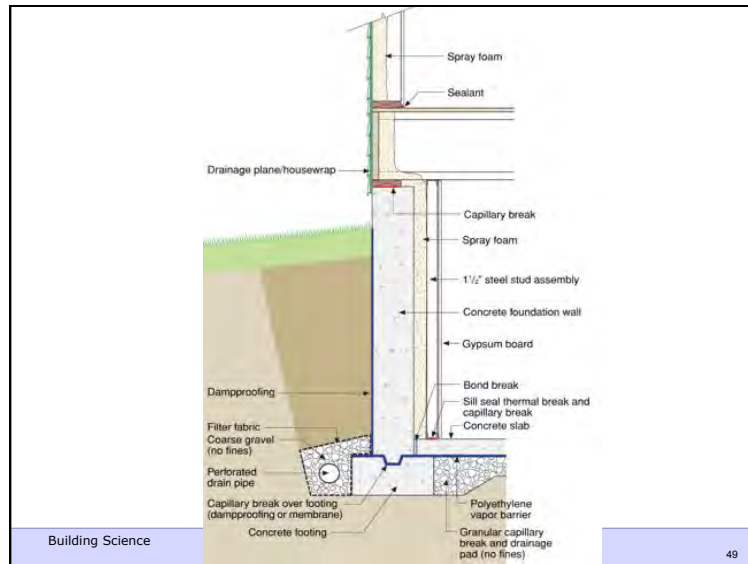
- Builders like to insulate the interior

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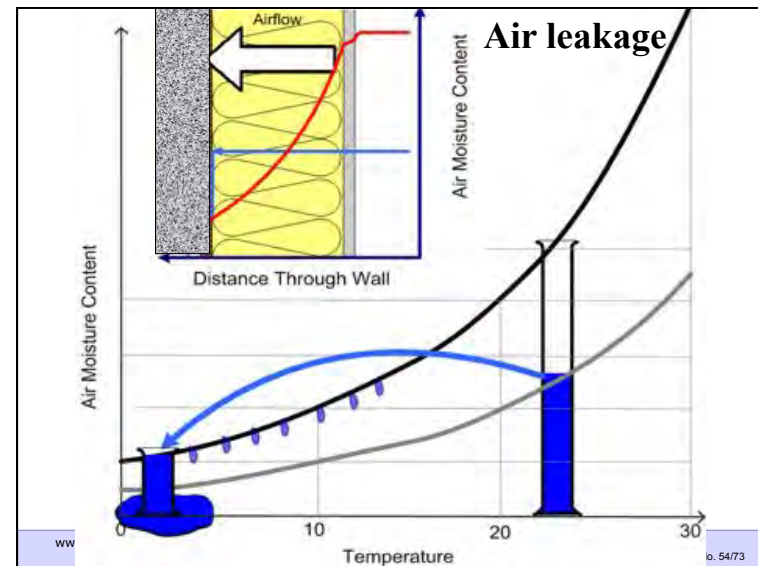


Basement Wall Air Movement

- Water vapor moves along with airflow
- If moist air touches a cold surface, condensation occurs
 - Summer and winter problem
- Control?
 - Include an air barrier
 - Avoid air loops
 - Manage pressures

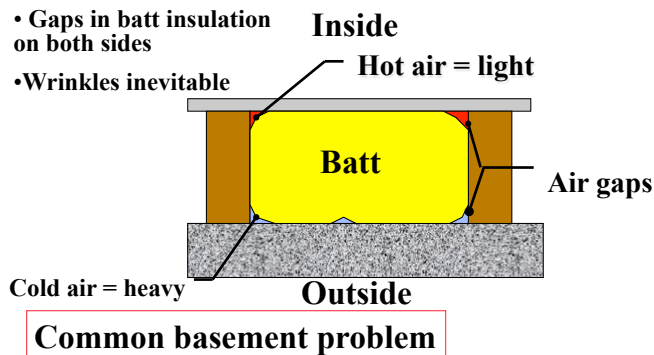
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Internal Stack Effect & Insulation

- Gaps in batt insulation on both sides
- Wrinkles inevitable



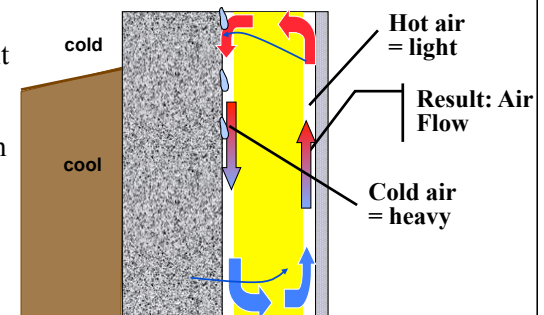
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Internal Stack Effect

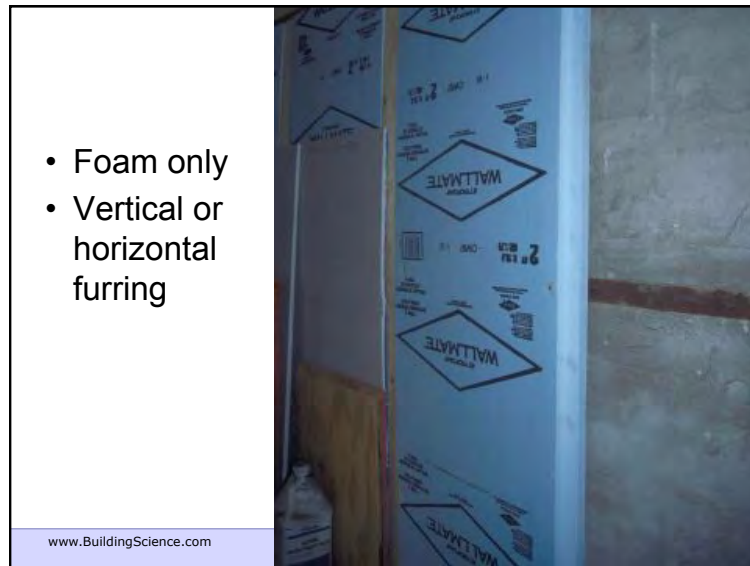
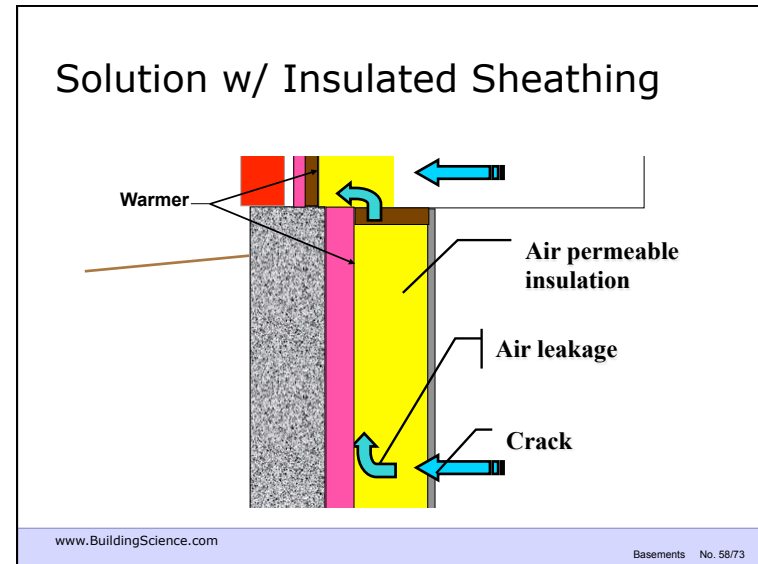
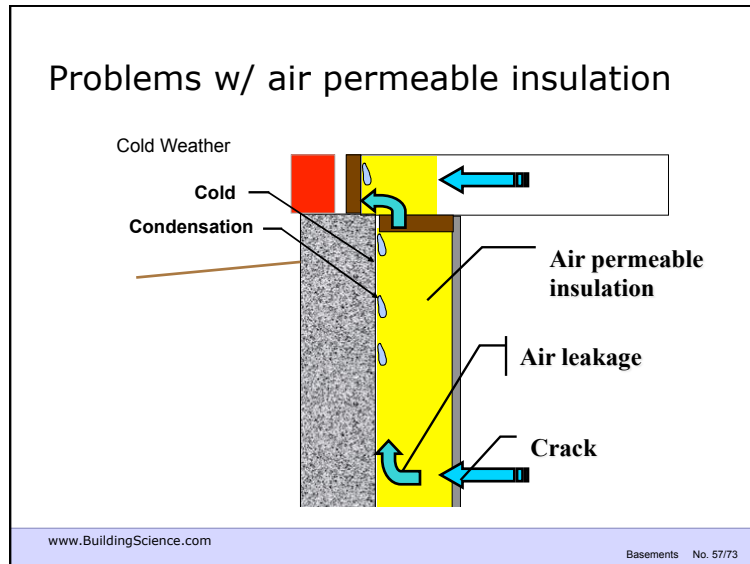
- Gaps in batt insulation on both sides
- closed circuit
- energy cost
- condensation

Cold Weather



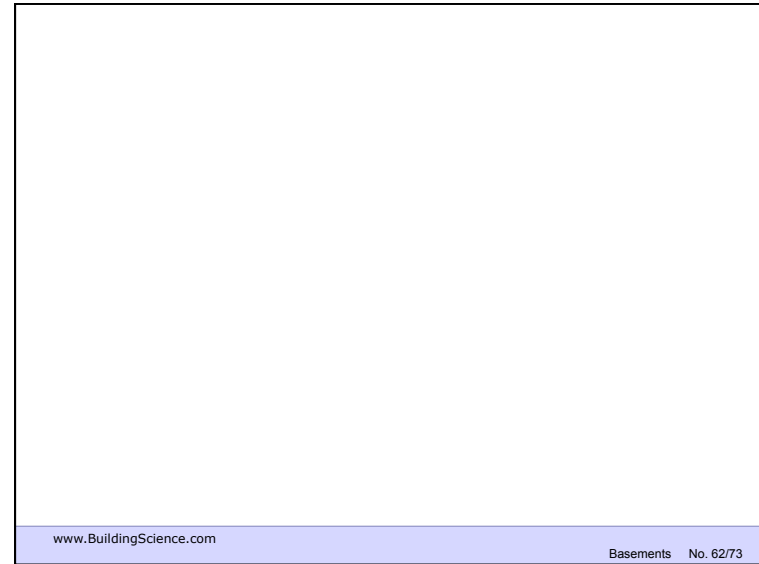
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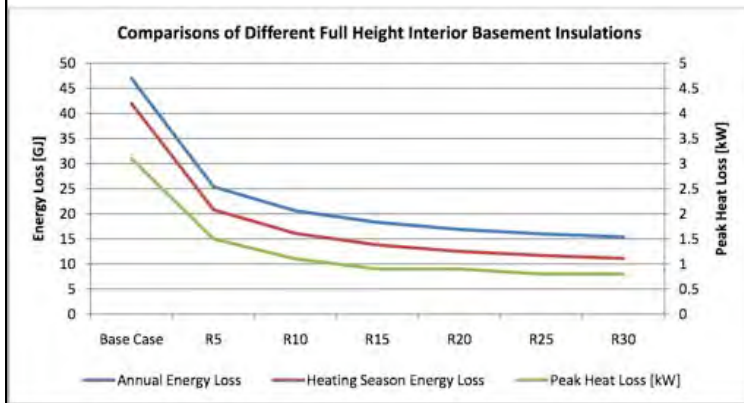
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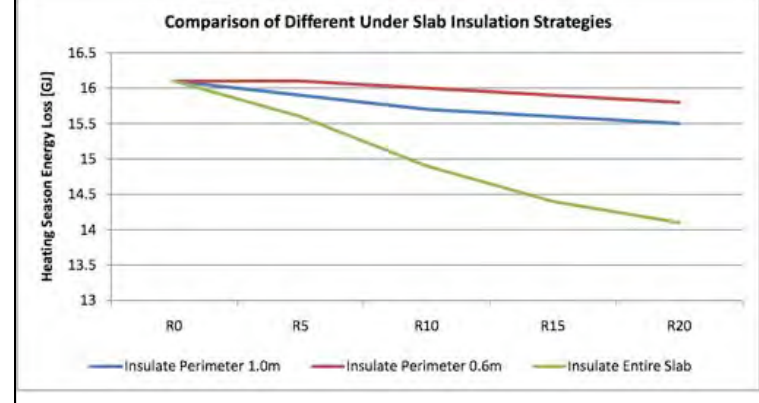
Basement Heat Loss



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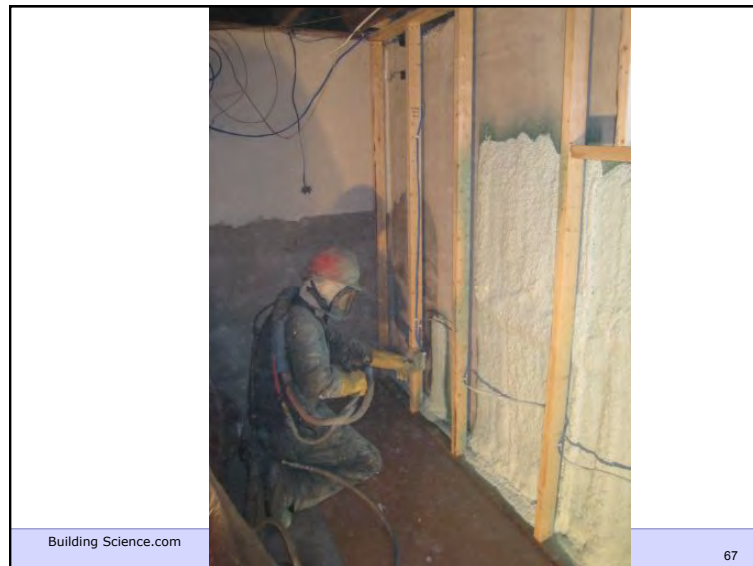
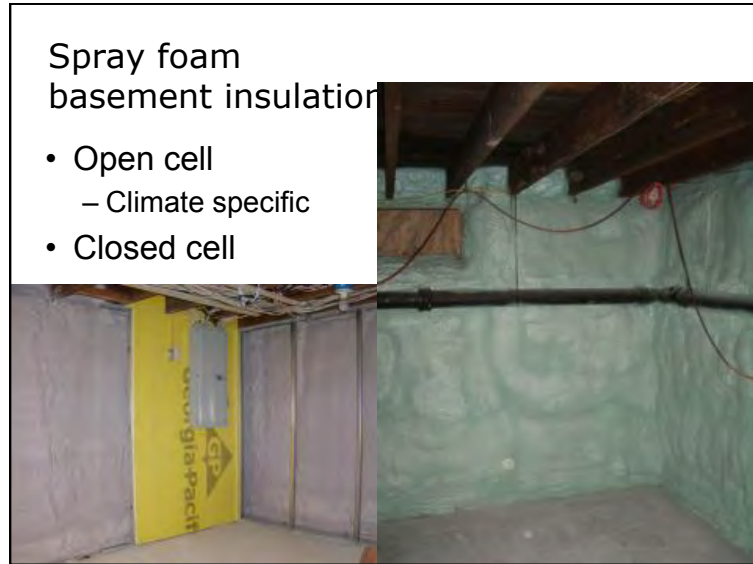
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Slab heat loss



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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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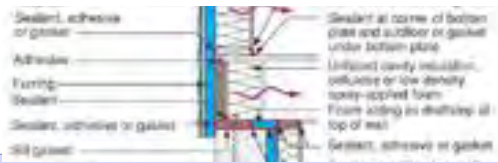


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Rim joists

- 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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Inward Diffusion @ grade

1. Temperature and solar heating warms wet material

2. Vapour drives inward (& out)

3. Vapour dries to inside

3. Condensation on "cold" surfaces

Drying If permeable

Wetting If impermeable

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