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Basements: New & Retrofit

Energy Efficient, Durable, Healthy

Building Science Corporation

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This presentation

- Basement functions
- Basement Performance
  - Problems
  - Causes
- Solutions
- *Crawlspaces & Slabs next session*

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

Basements – Part of the Enclosure

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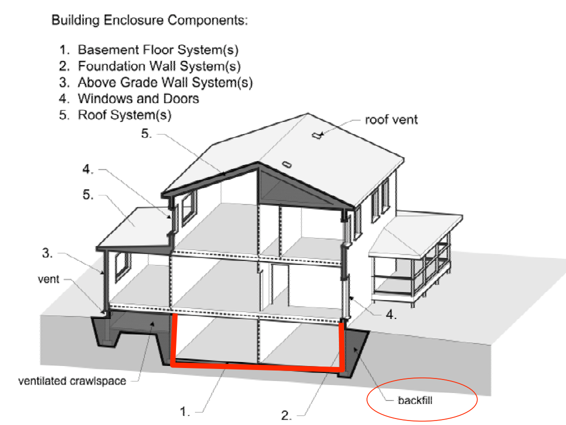


Basements

- 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
  - Control
  - Finish (usually)

Building Enclosure Functions

- Support
  - Structure: wind, gravity, earthquake
  - Below grade – Soil pressure, hydrostatic?
- Control
  - Heat (less extreme than above grade)
  - Air (less air pressure, but it stinks, Radon?)
  - Moisture (vapor, free and bound liquid)
- Finish – usually, but optional
- Distribute (sometimes)

Moisture: Old ideas

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

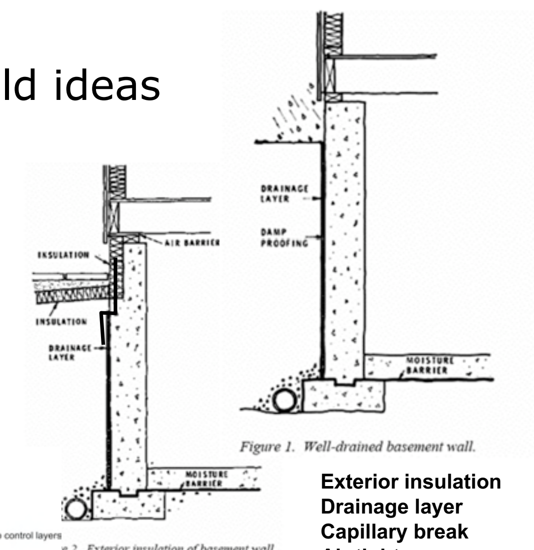
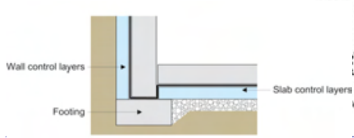


Figure 1. Well-drained basement wall.

e 2. Exterior insulation of basement wall.

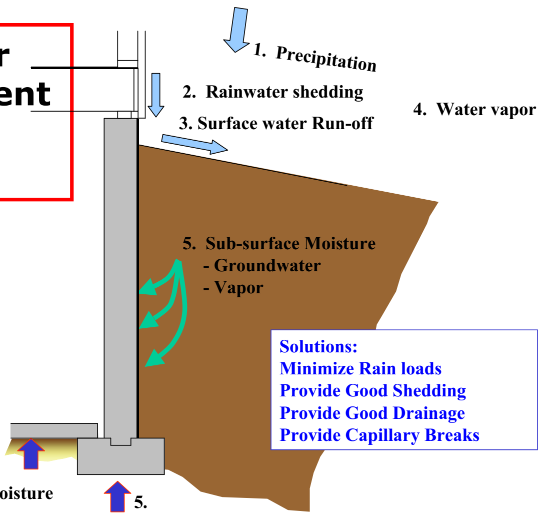
Exterior insulation
Drainage layer
Capillary break
Air tightness



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

1. Exterior Environment Moisture Sources

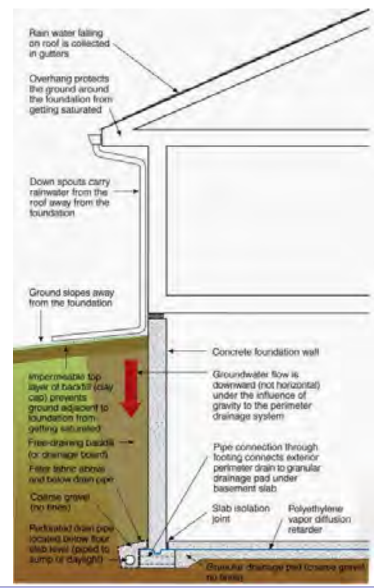


1. Controlling Exterior Moisture Sources

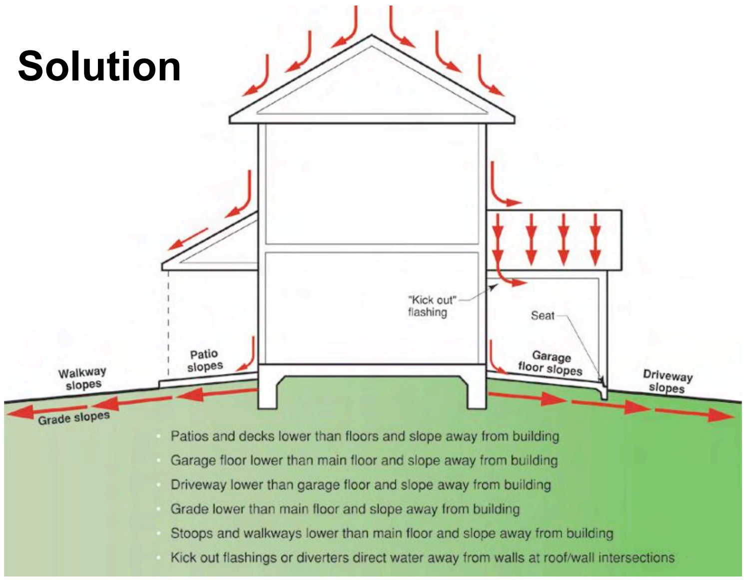
- Same approach as above-grade rain control
  - **D**eflection
    - Overhangs, slopes, gutters
  - **D**rainage/Exclusion/Storage
    - Three strategies for the enclosure
  - **D**rying
    - Remove built-in incidental moisture

Surface Drainage

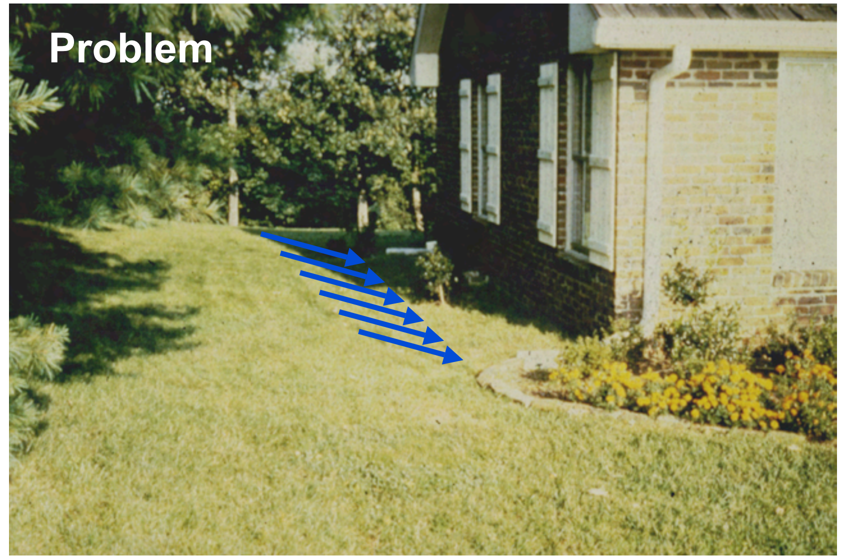
- First step
  - Common problem
- Overhang
- Gutters
- Downspouts
- Sloped grade
- Perimeter drain



Solution



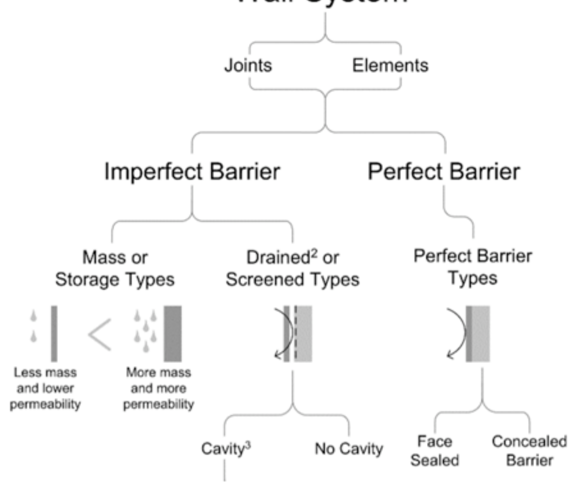
Problem



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)

Basement Ground Water Control



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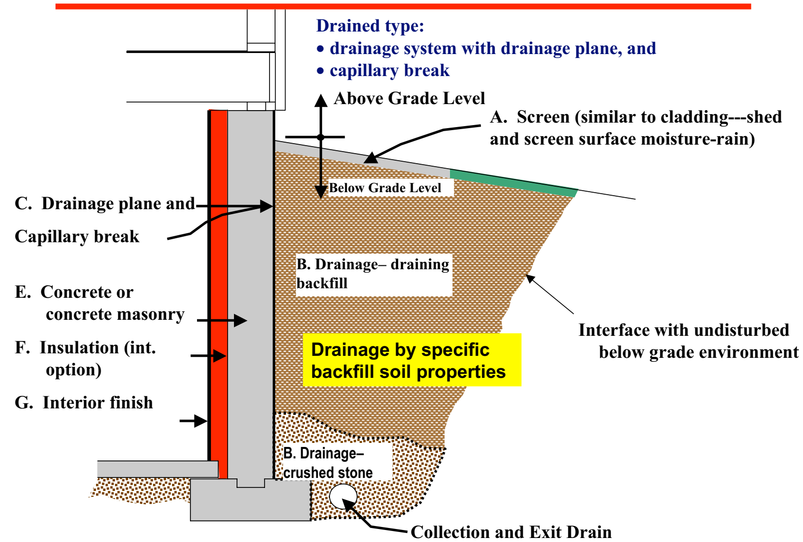
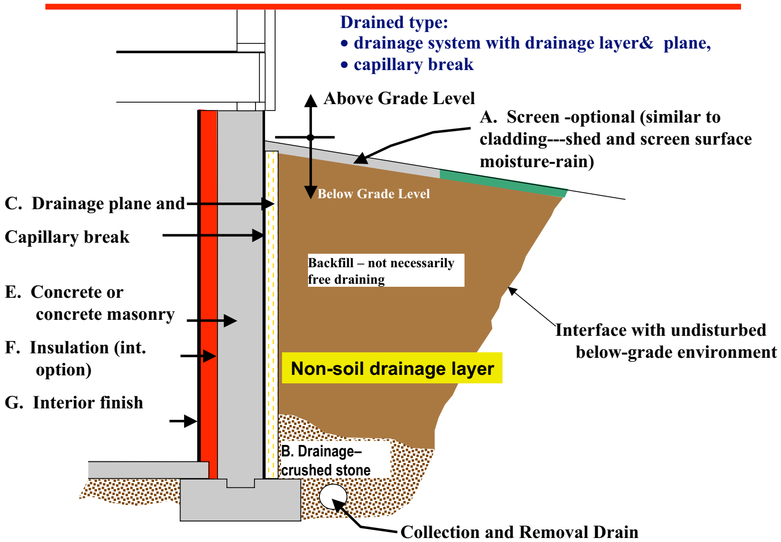
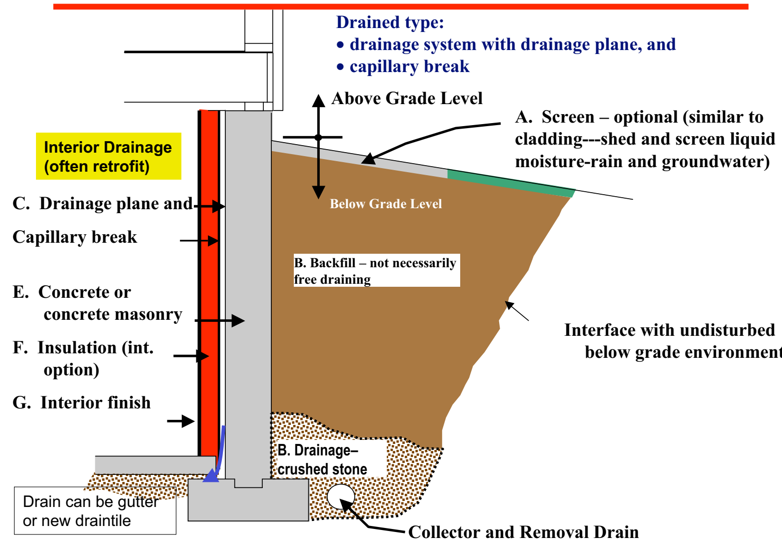
Screened(1) Below-Grade Enclosure Wall System



Screened(2) Below-Grade Enclosure Wall System

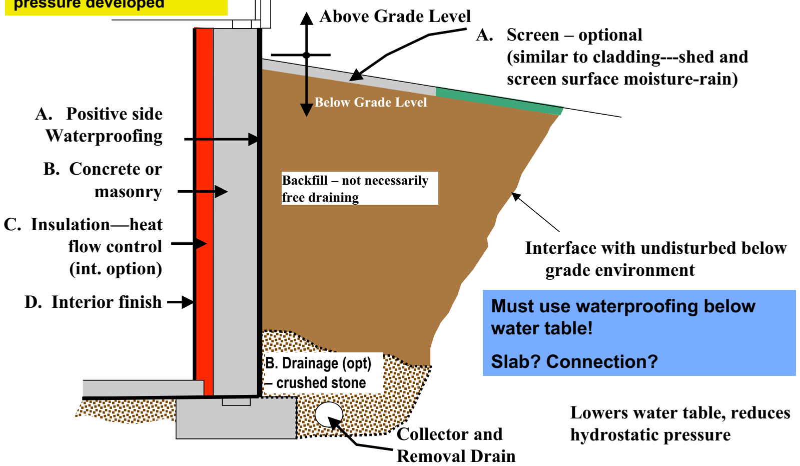


Screened(3) Below-Grade Enclosure Wall System



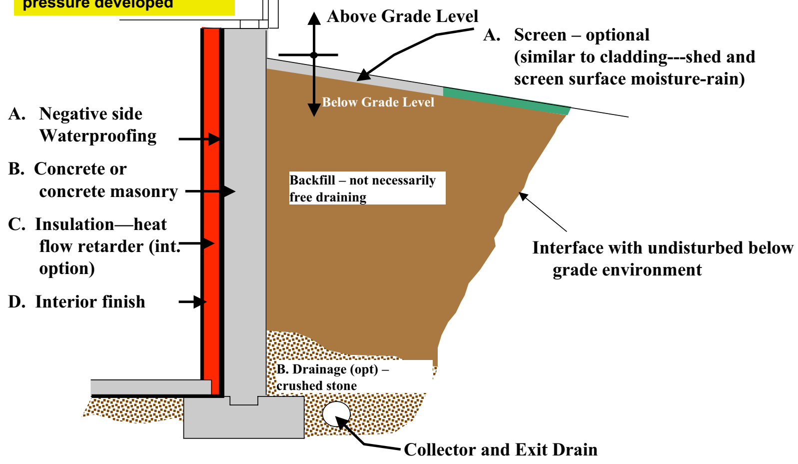
Barrier (1) Below-Grade Enclosure Wall System

Perfect barrier:
- drainage system can be used to reduce hydrostatic pressure
- waterproofing layer resists significant head of water



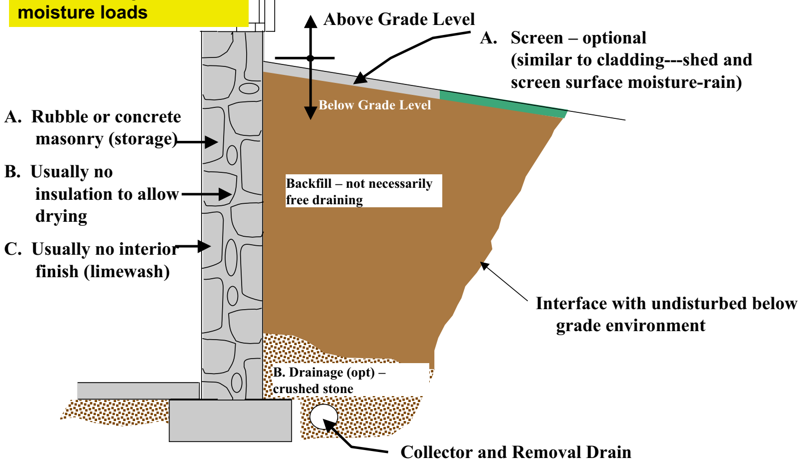
Barrier (2) Below-Grade Enclosure Wall System

Perfect barrier :
- drainage system to reduce hydrostatic pressure
- waterproofing



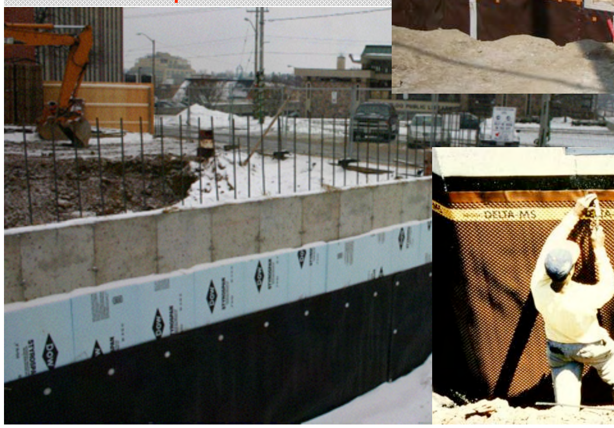
Storage (1) Below-Grade Enclosure Wall System

Storage (mass) system:
- usually no intentional drainage
- often no capillary break



Air gap membranes aka Dimple Sheets

- provide drainage gap
- act as vapor barrier



Glassfiber Drainage Gap

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Rockwool Drainage Gap

Controlling ground/rain water

Review: Exterior Moisture

- Deflection: Roof and Surface Drainage
- Classification of Groundwater control
  - 1. Drained
    - Needs capillary break & gap/drain space
  - 2. Perfect Barrier
    - One layer of <u>perfect</u> water resistance
    - Beware hydrostatic forces
  - 3. Storage (mass)
    - Safe storage capacity and <u>drying</u>
    - <u>Don't</u> use vapor barriers, do insulate (carefully)
- Drying to Inside and Perimeter Drains

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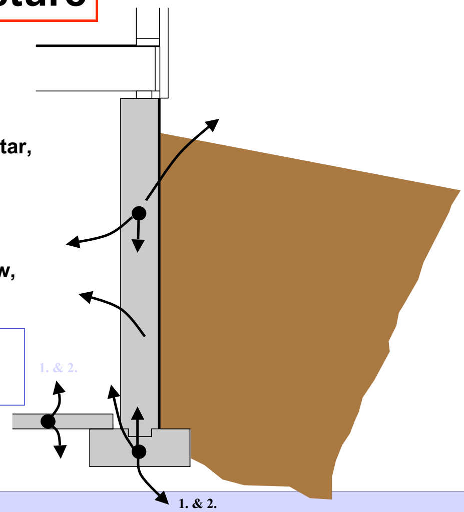
2. Built-in Moisture

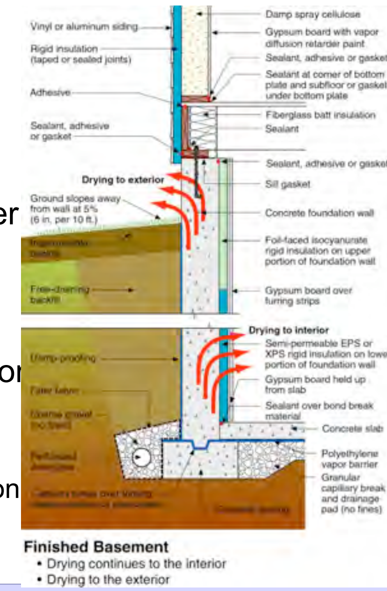
1. Built-in Moisture (from water in concrete, mortar, wood, etc.)
2. Construction moisture accumulated during construction (ice, snow, rain, etc.)

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

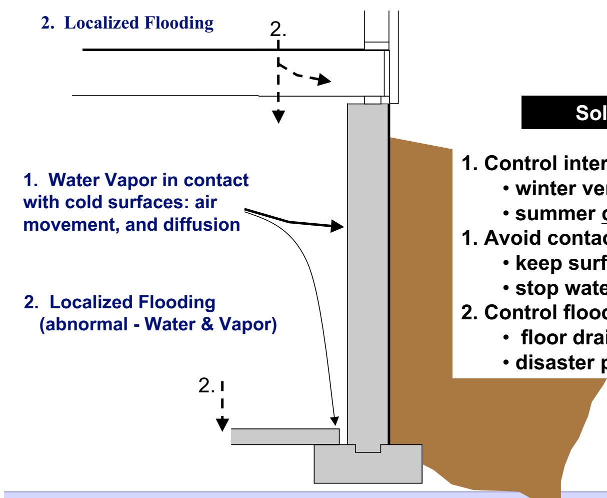


Initial Drying

- Soil cold for first yr
- Excavation collects water
- Concrete is wet
  - _ to 1 gal/ft^2
  - 25-50 liters/m^2
- Cannot dry to wet exterior
- Solutions = dry in
  - No low perm interior
  - Semi-permeable insulation
  - Smart vapor barrier



3. Interior Moisture Sources



Solutions

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

Vapor failure– not ground water

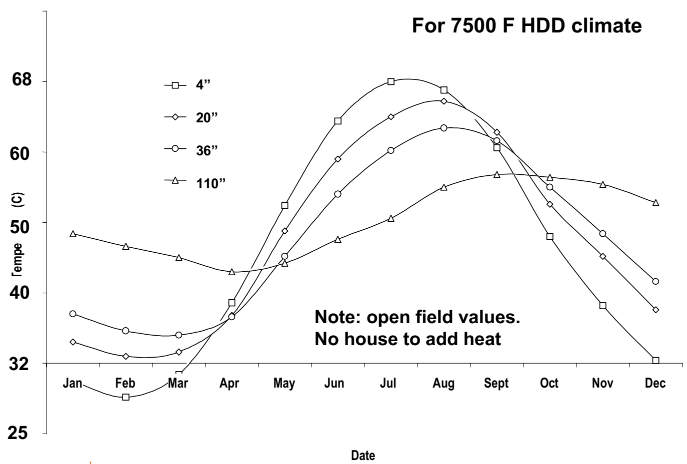
Managing Air and vapor

- 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

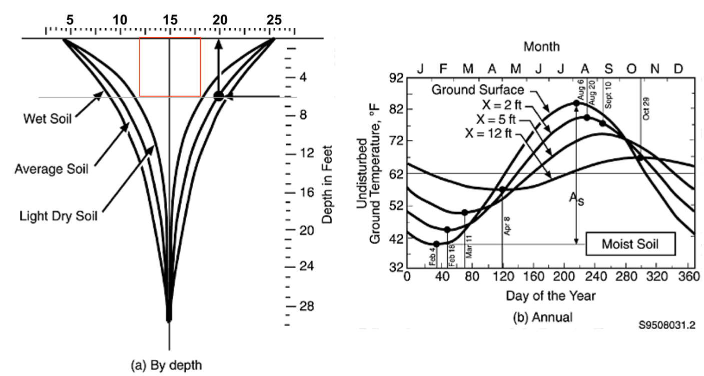
Context: Below-grade Conditions

- 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

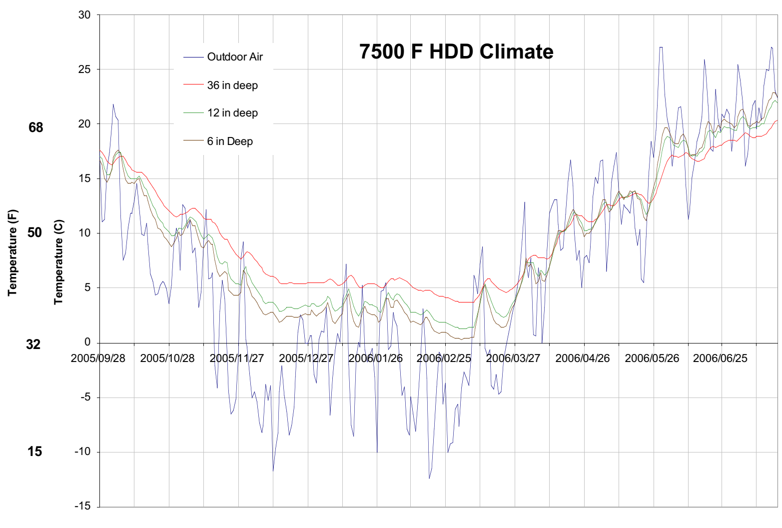
Typical Soil Temperatures



Soil Temperatures

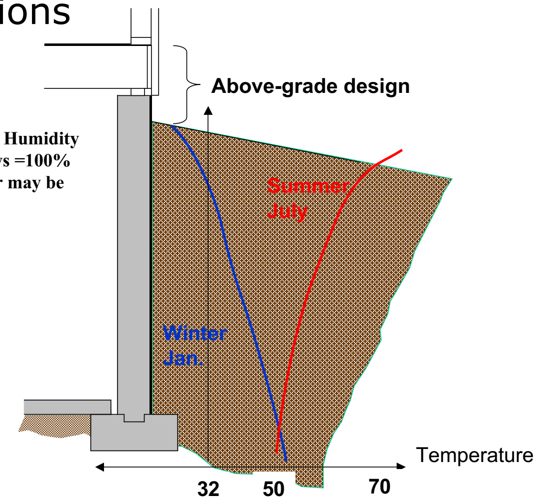


Waterloo Measured Soil / Air Temperatures

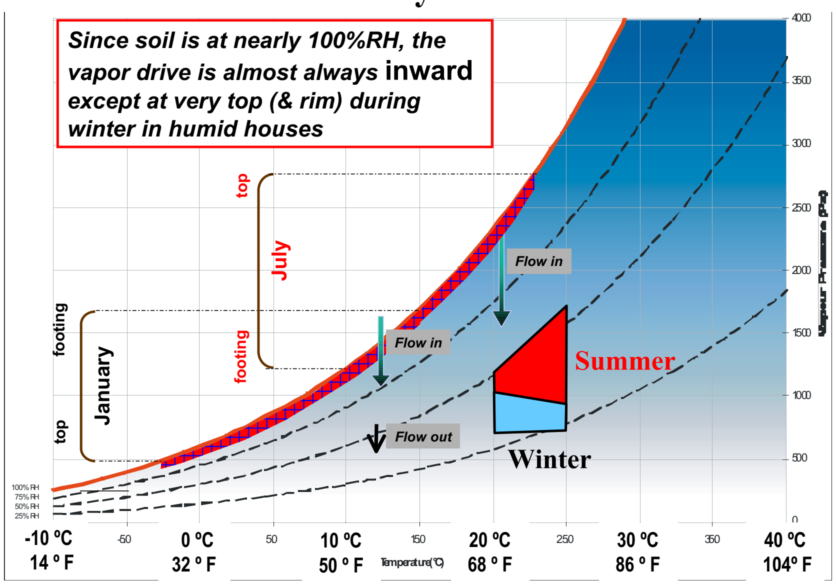


Exterior Temperature & Moisture Conditions

- Soil Relative Humidity almost always =100%
- Liquid water may be present



Basement Psychrometrics



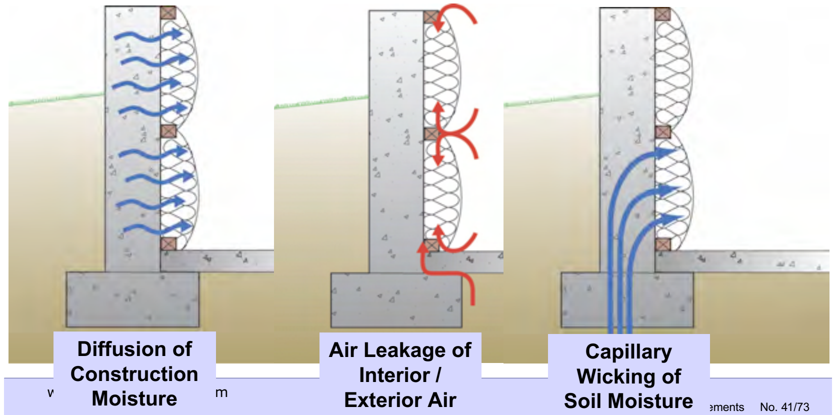
Basement Vapor Diffusion

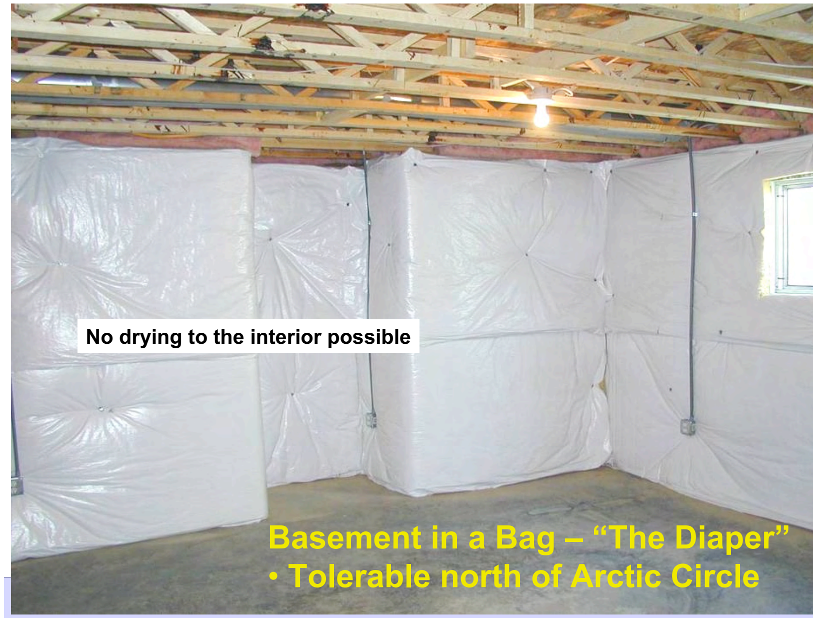
- Water vapor is moving from soil to interior
  - for almost the entire year
  - over all but the top foot of basement
- Hence, should place vapor barrier on outside
- But we put it on the inside!

- Moisture from drying concrete, air leakage, wicking and soil also trapped by interior vapor barriers

Air & Vapor Wetting Sources

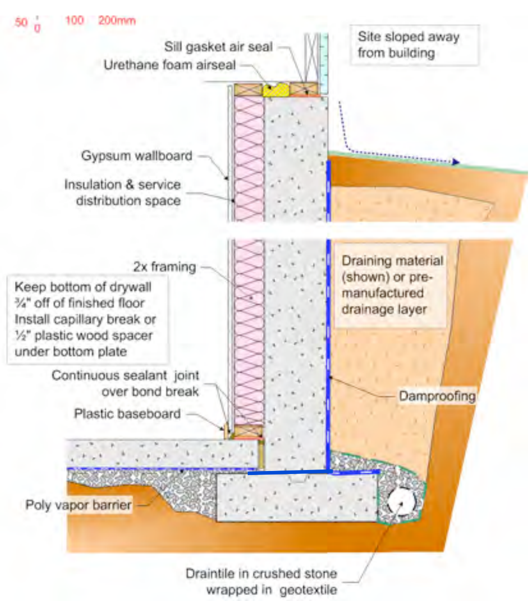
- Problems with fibrous insulation & vapor barrier





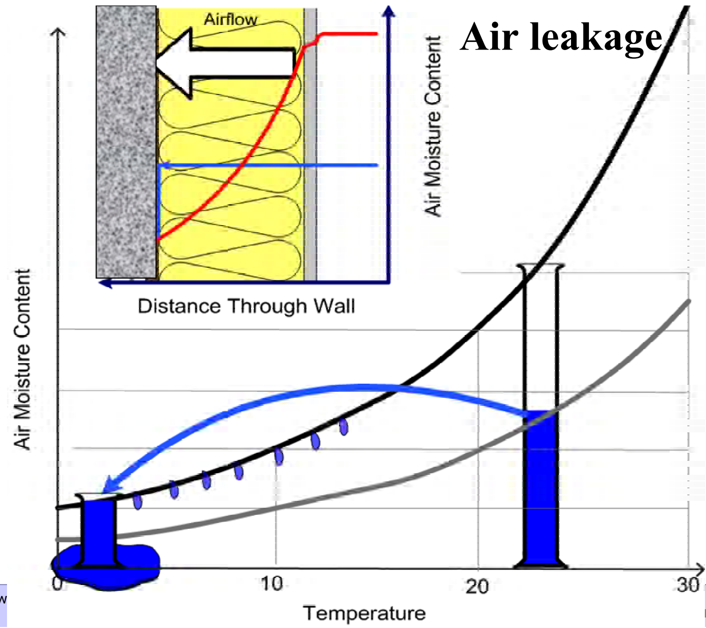
- Typical basement ("normal practice")

1. Start dry
2. No leaks
3. No poly
4. Be lucky



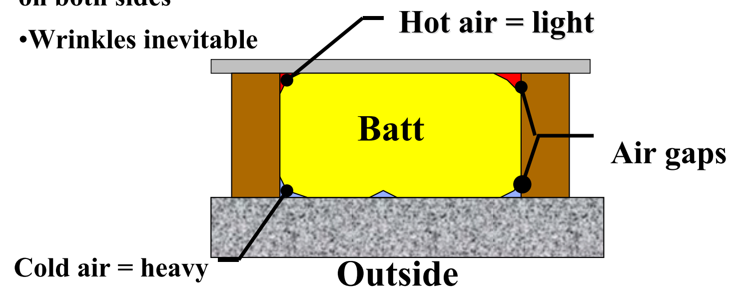
Basement Wall Air Movement

- 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



Internal Stack Effect & Insulation

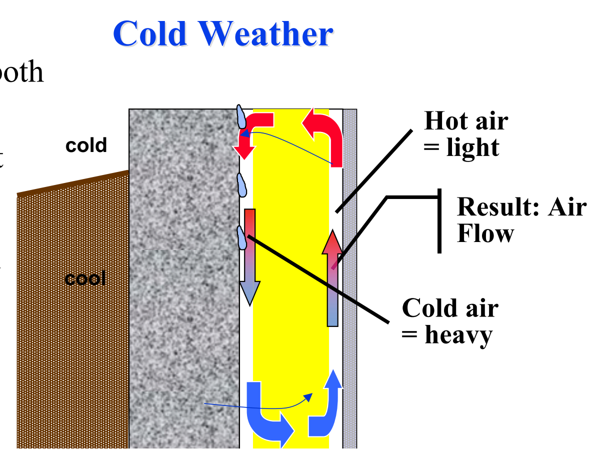
- Gaps in batt insulation on both sides
- Wrinkles inevitable



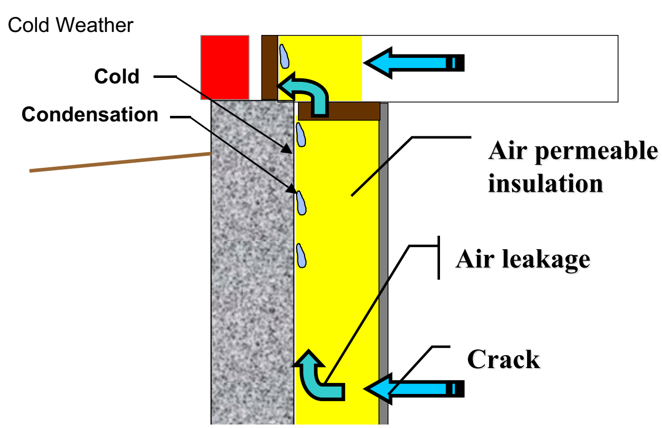
Common basement problem

Internal Stack Effect

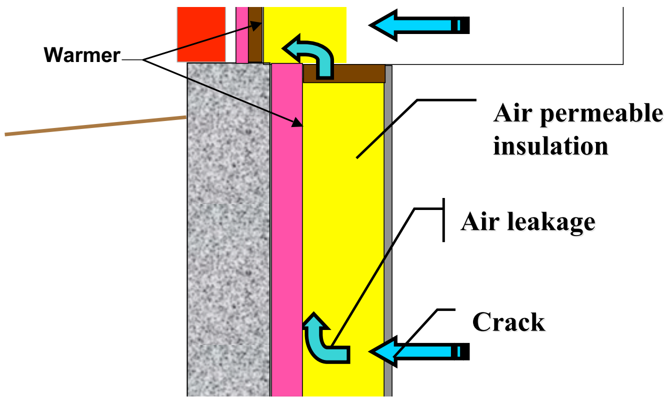
- Gaps in batt insulation on both sides
- closed circuit
- energy cost
- condensation



Problems w/ air permeable insulation



Solution w/ Insulated Sheathing

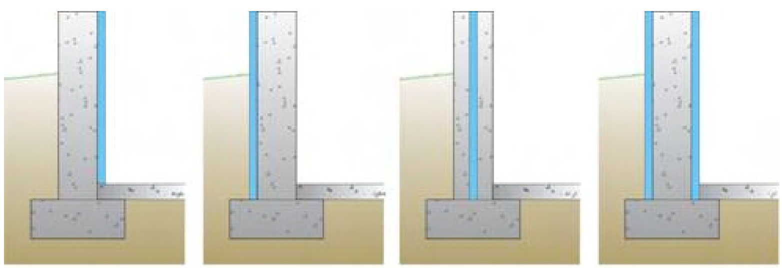


How to insulate/finish basement wall?

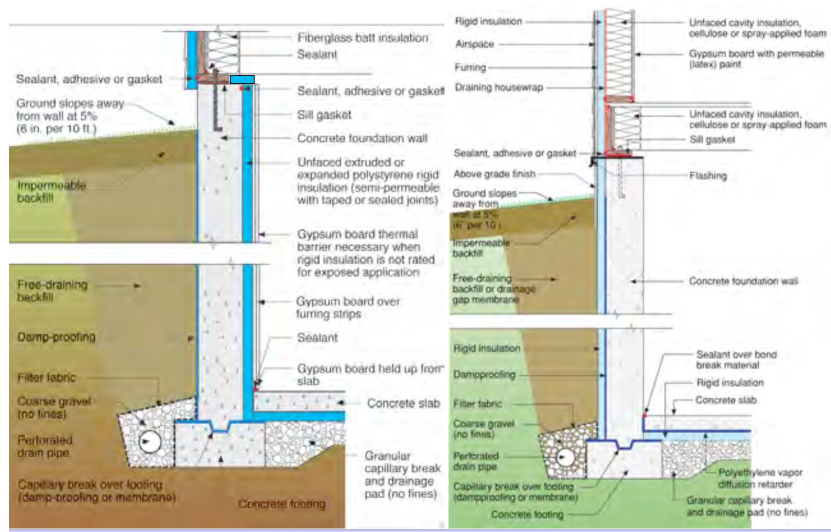
- We need to:
  - Control exterior ground water
  - Insulate (energy, comfort and moisture)
  - Control air leakage and diffusion condensation
  - Provide (a little) inward drying
  - Accommodate different conditions over height
- How to do we all this?

Insulation Location Choices

- Builders like to insulate the interior



Internally Insulated Basement | Externally Insulated Basement | Basement Insulated in the Middle | Basement Insulated Both Externally and Internally



Hybrid

- Add layer of:
  - foam or
  - spray foam

To allow inward drying
• about 1 perm

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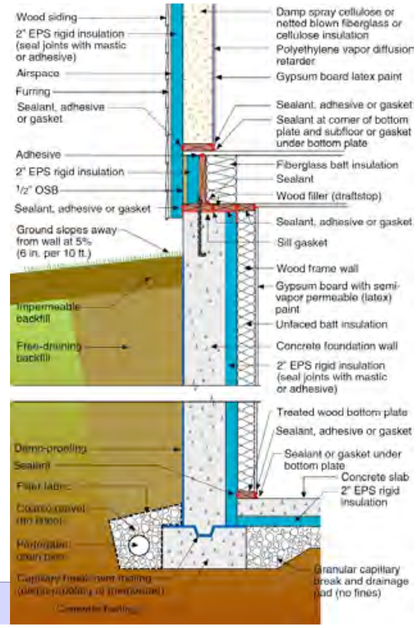

Best?

- No summer thermal lag
- Sub-slab insulation a plus

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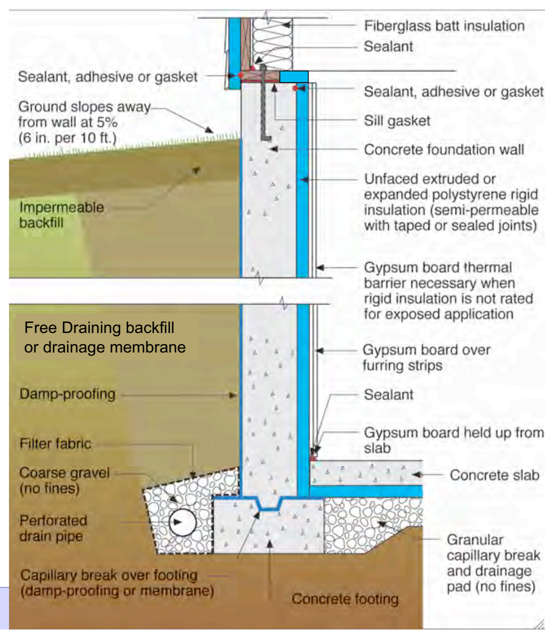

- Foam only
- Vertical or horizontal furring

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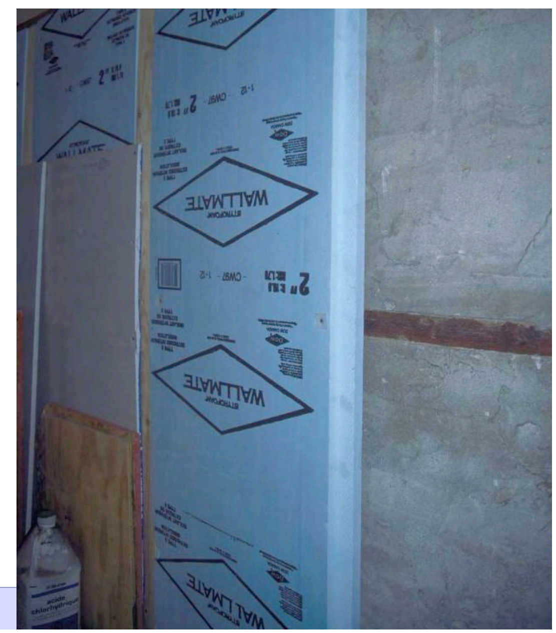


Spray foam basement insulation

- Open cell
  - Climate specific
- Closed cell

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)

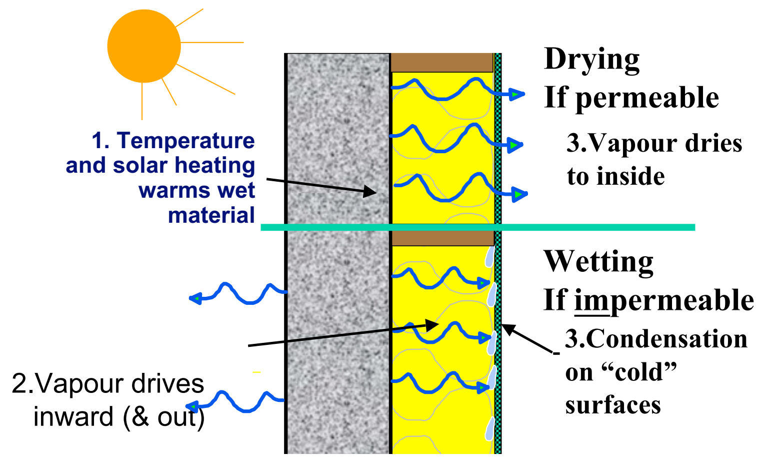
Insulated Concrete Forms (ICF)

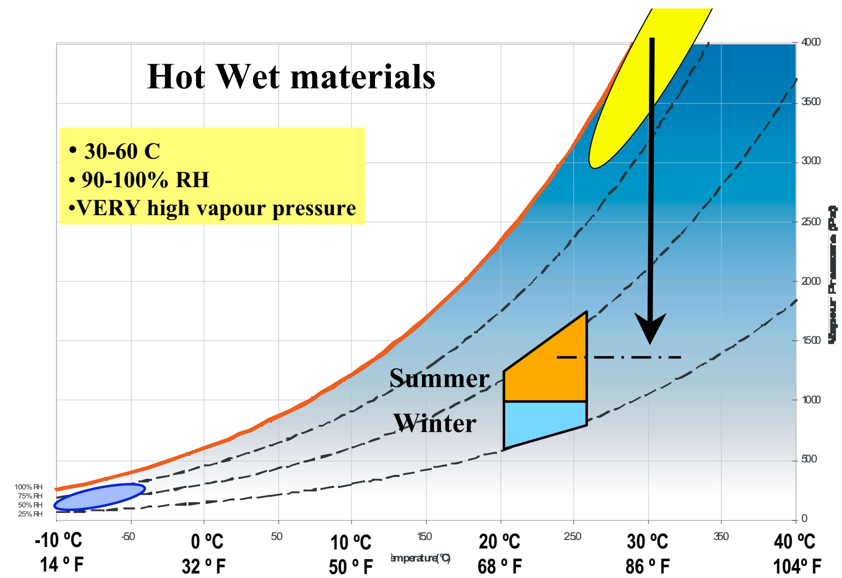
- If you afford it, use them –
  - cap break,
  - insulation,
  - vapor retarder,
  - above grade

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

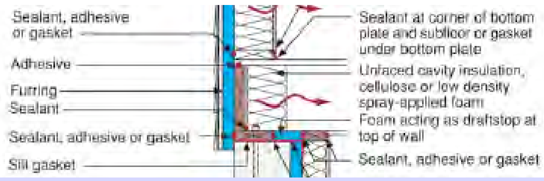
Inward Diffusion @ grade





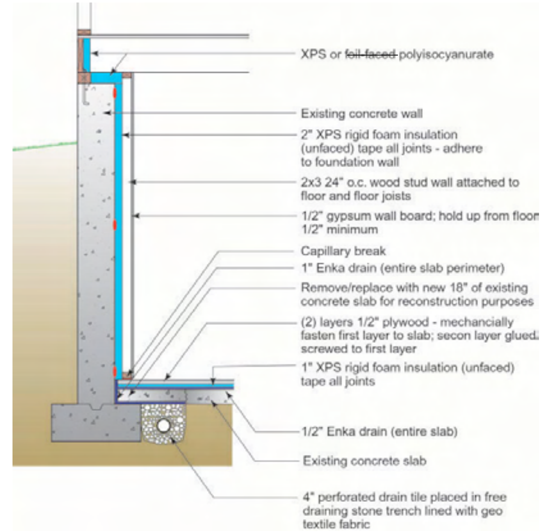
Rim joists

- 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



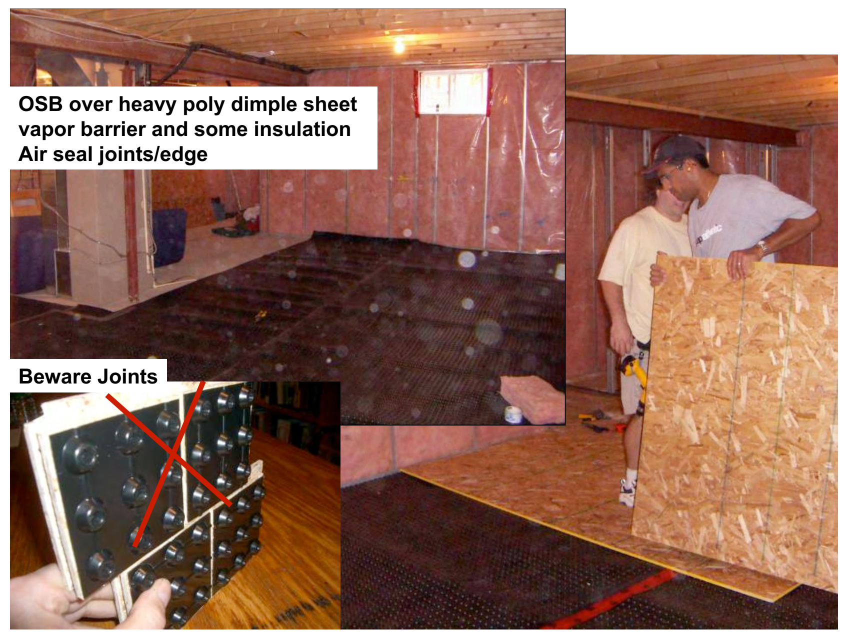
Basement

- New or retrofit
- Solves slab wetness & cold



Slabs

- Keep warm (comfort & condensation)
- Control wicking and diffusion
- Make softer
- Consider floods

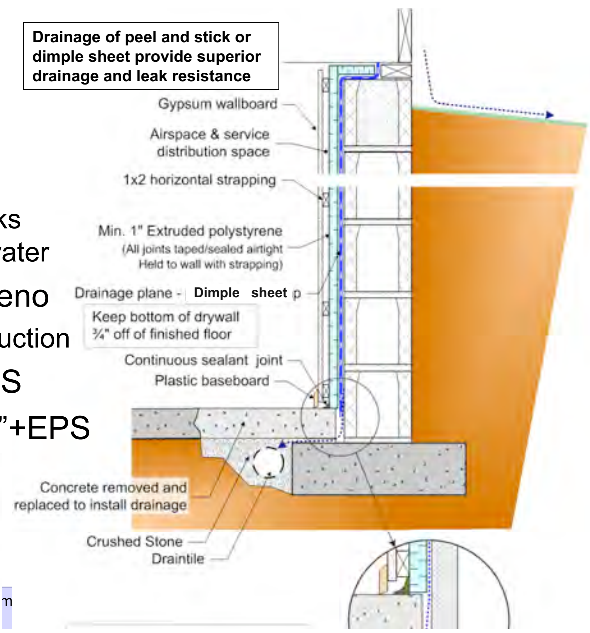


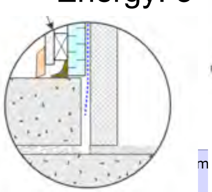
Slabs

Retrofit Slab, drainage and sump before wall insulated

Retrofit

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





Summary

- Control surface water by drainage
- Drainage layer on exterior of walls
- Poly interior stop drying and often result in problems
- Painted stud with foam OK
- Care needed at rim joist
- What happens if there is a flood, leak, etc.

Conclusions

- Building in a hole in the ground is hard
- Don’t forget about built-in moisture
  - and remember summer
- Moisture comes in liquid AND vapor
- Insulation and drainage are the best tools, not vapor barriers and waterproofing