Building Better Basements, or "How to Build Basements that Don't Stink"

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This presentation

- Basements
  - How are they changing
  - What they do
- Performance
  - Problems
  - Causes
- Solutions

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Basements are Changing

- Increasingly used as living space
  - Not a root 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
  - Slabs growing (old people) unlikely to make a major dent
- Modern basements are different – they need different approaches!

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Basements – Part of the Enclosure

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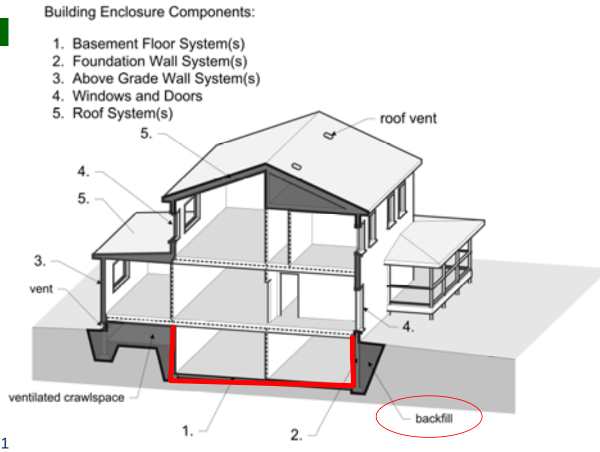

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Basements

- Below grade enclosure
  - Includes floor slabs, and practically rim joist
  - Separates exterior (soil/air) and interior
- Functions of <u>all parts</u> of the enclosure
  - Support
  - Control
  - Finish (usually)

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Functions of the building enclosure

- 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)

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Support (Structural performance)

- Structural system
  - Does not work based on rational analysis
  - Don't ask for an engineers stamp
- Failure modes
  - Poorly compacted subsoil
  - Top-edge Bracing
    - Raised bungalows
    - Stairwells parallel to wall

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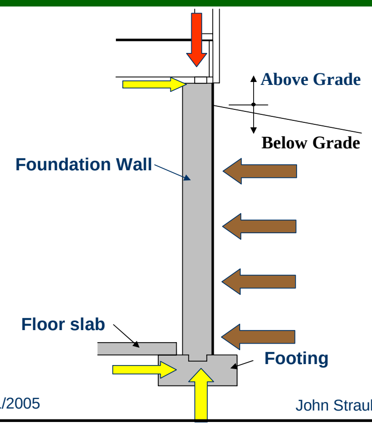
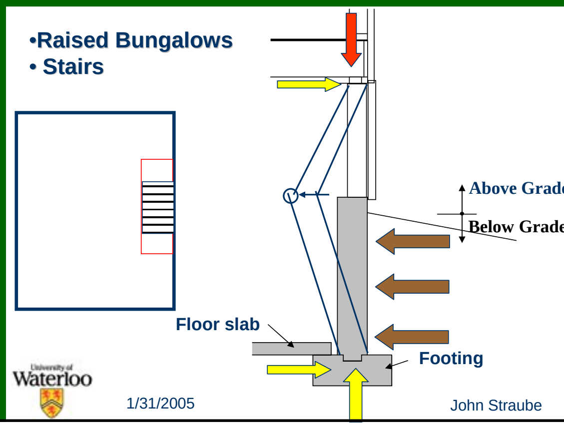
Basement Structural System

Similar for most basements



Basement Structural System

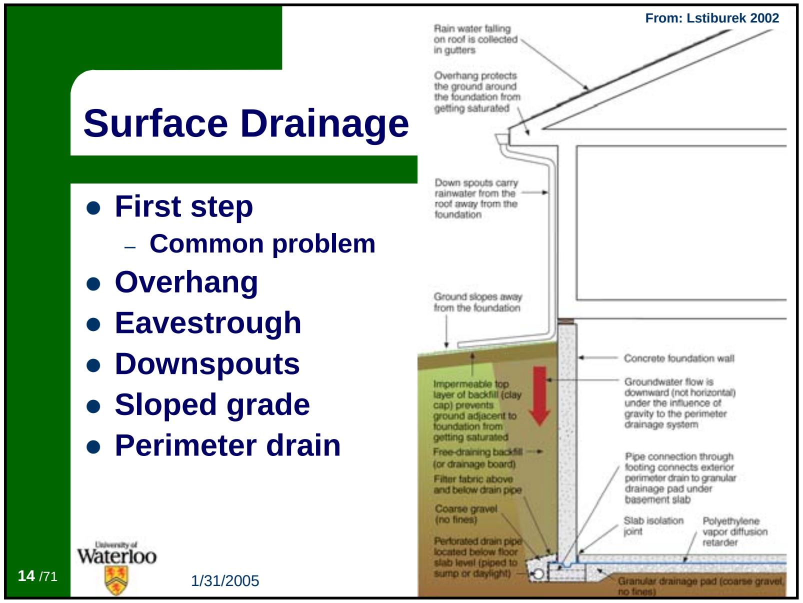
- Raised Bungalows
- Stairs



Control: Moisture

- Moisture causes most failures (less spectacular)
  - Mold (musty 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?
  - Exterior
  - Interior
  - Built in
- Recent studies – Minn, Chicago, CMHC, IRC


Exterior surface water


Surface Drainage
• First step
– Common problem
• Overhang
• Eavestrough
• Downspouts
• Sloped grade
• Perimeter drain
From: Lstiburek 2002
Rain water falling on roof is collected in gutters
Overhang protects the ground around the foundation from getting saturated
Down spouts carry rainwater from the roof away from the foundation
Ground slopes away from the foundation
Impermeable top layer of backfill (clay cap) prevents ground adjacent to foundation from getting saturated
Free-draining backfill (or drainage board)
Filter fabric above and below drain pipe
Coarse gravel (no fines)
Perforated drain pipe located below floor slab level (piped to sump or daylight)
Concrete foundation wall
Groundwater flow is downward (not horizontal) under the influence of gravity to the perimeter drainage system
Pipe connection through footing connects exterior perimeter drain to granular drainage pad under basement slab
Slab isolation joint
Polyethylene vapor diffusion retarder
Granular drainage pad (coarse gravel, no fines)
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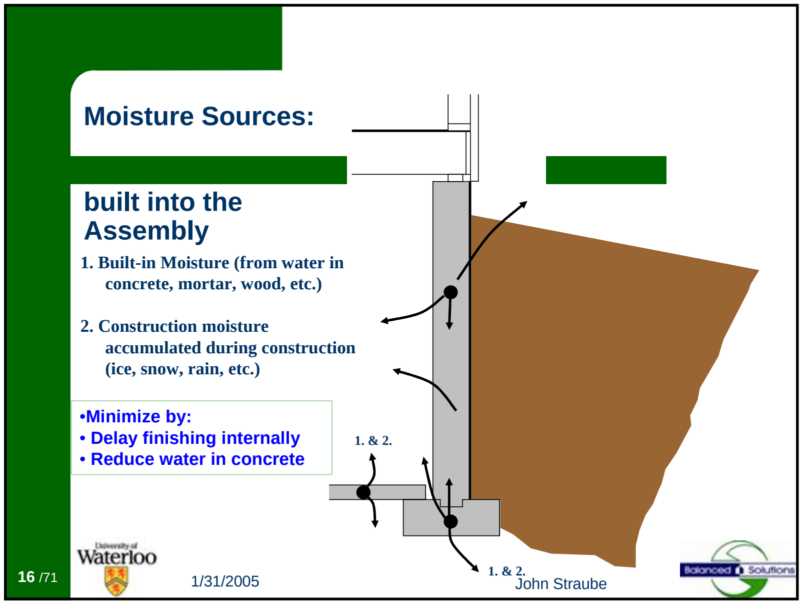
Exterior surface water
•Drainage wont help here
•Damage recovery


Moisture Sources:
built into the Assembly
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.
1. & 2.
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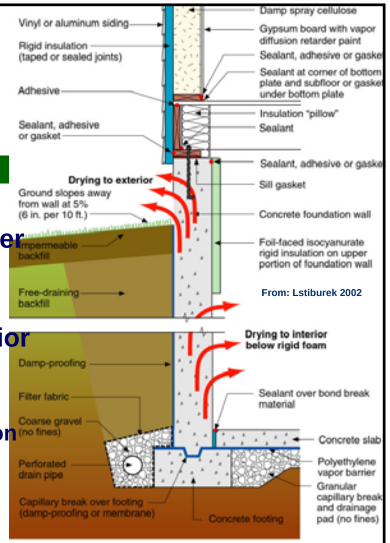
Initial Drying

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



Unfinished Basement — Half-height insulation
- Lower portion of wall dries to the interior
- Upper portion of wall dries to the exterior

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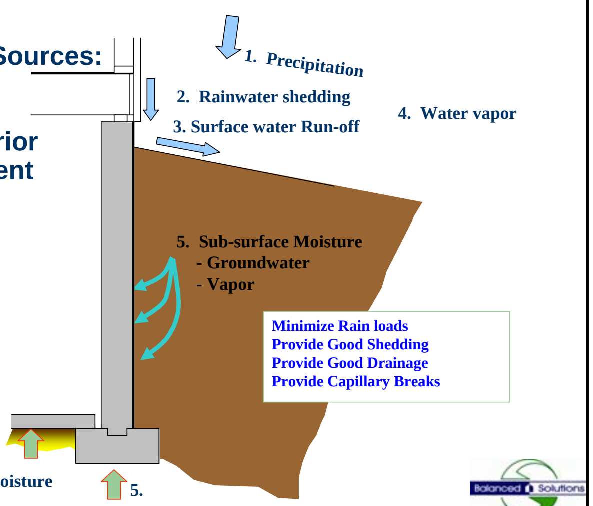
Moisture Sources:

from Exterior Environment



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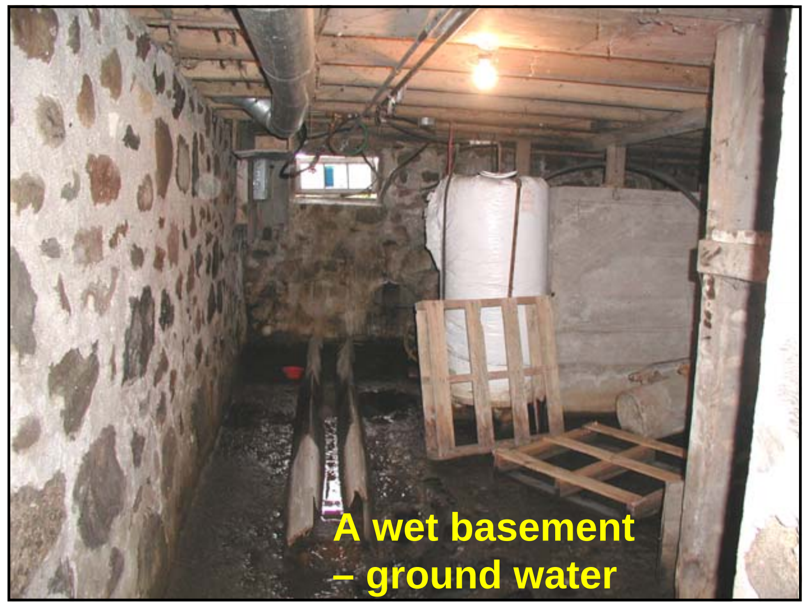

Exterior Moisture

Controlling ground/rain water

- Many different acceptable methods
- Classification of Groundwater control
  - 1. Drained
    - Needs capillary break and gap/drain space
  - 2. Perfect Barrier
    - 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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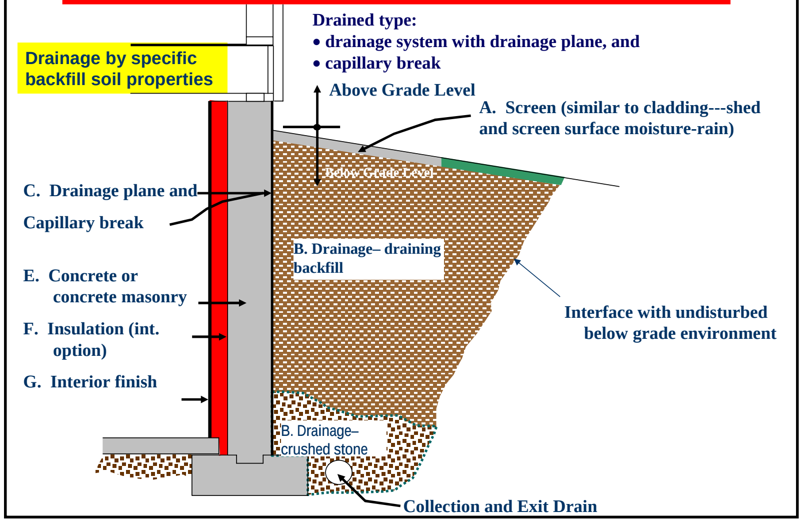
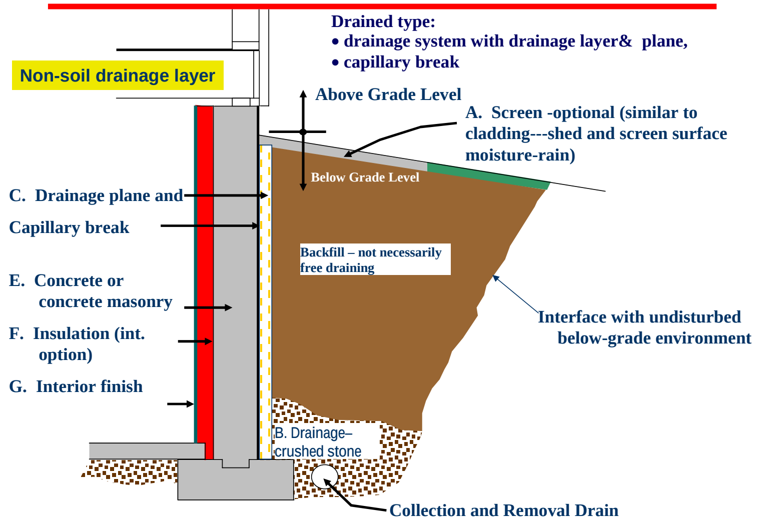
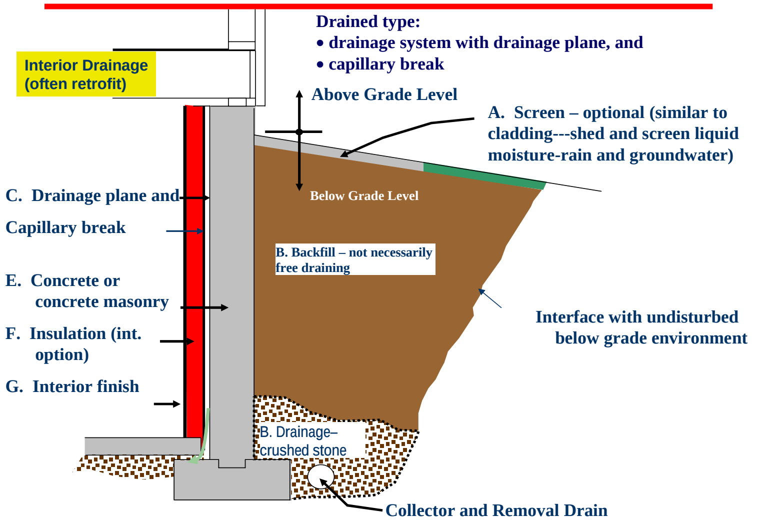
Screened(1) Below-Grade Enclosure Wall System

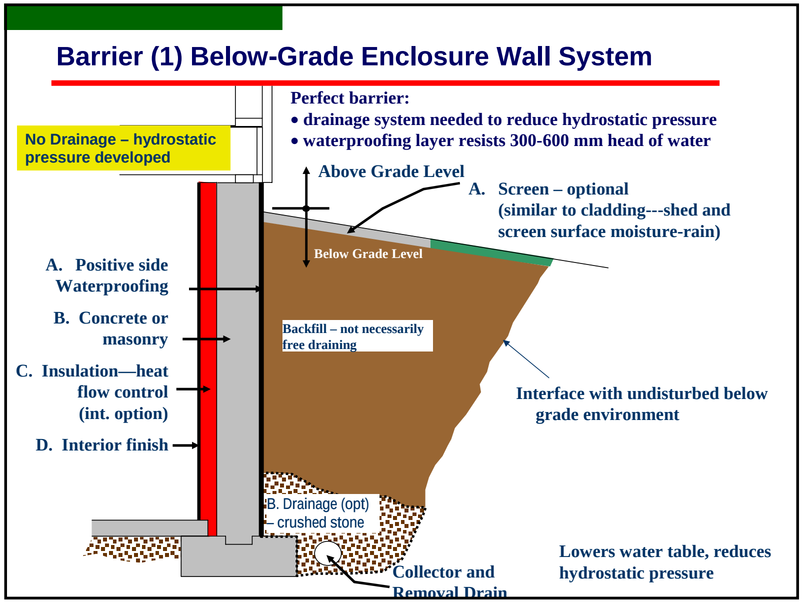


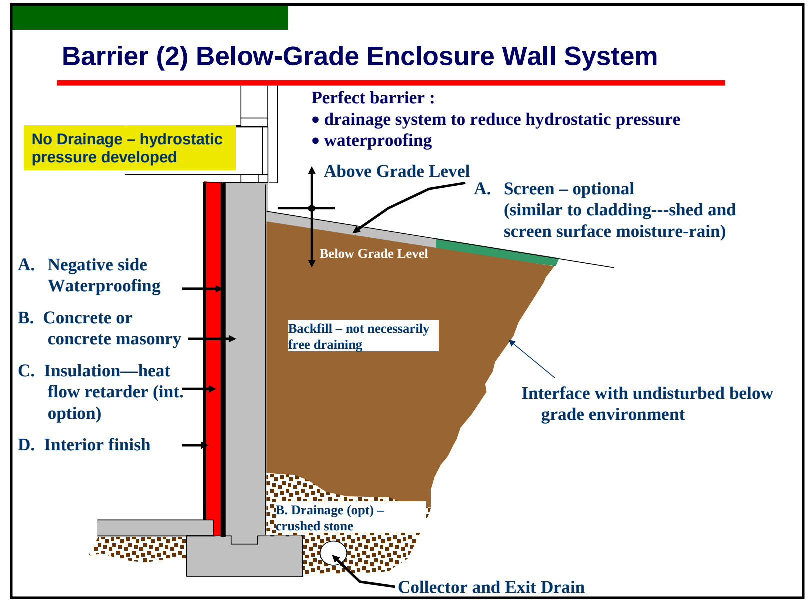
Screened(2) Below-Grade Enclosure Wall System

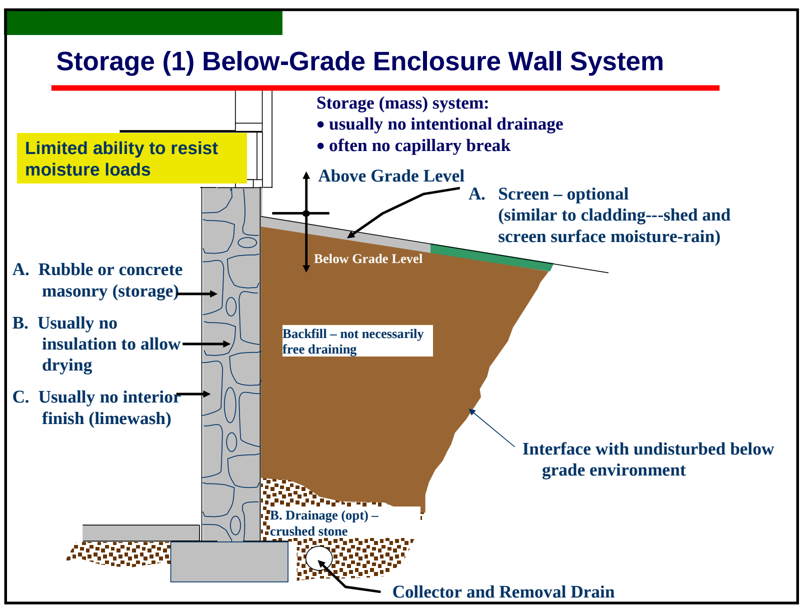


Screened(3) Below-Grade Enclosure Wall System




Barrier (1) Below-Grade Enclosure Wall System
Perfect barrier:
• drainage system needed to reduce hydrostatic pressure
• waterproofing layer resists 300-600 mm head of water
No Drainage – hydrostatic pressure developed
Above Grade Level
A. Screen – optional (similar to cladding---shed and screen surface moisture-rain)
Below Grade Level
A. Positive side Waterproofing
B. Concrete or masonry
C. Insulation—heat flow control (int. option)
D. Interior finish
Backfill – not necessarily free draining
Interface with undisturbed below grade environment
B. Drainage (opt) – crushed stone
Collector and Removal Drain
Lowers water table, reduces hydrostatic pressure


Barrier (2) Below-Grade Enclosure Wall System
Perfect barrier :
• drainage system to reduce hydrostatic pressure
• waterproofing
No Drainage – hydrostatic pressure developed
Above Grade Level
A. Screen – optional (similar to cladding---shed and screen surface moisture-rain)
Below Grade Level
A. Negative side Waterproofing
B. Concrete or concrete masonry
C. Insulation—heat flow retarder (int. option)
D. Interior finish
Backfill – not necessarily free draining
Interface with undisturbed below grade environment
B. Drainage (opt) – crushed stone
Collector and Exit Drain


Storage (1) Below-Grade Enclosure Wall System
Storage (mass) system:
• usually no intentional drainage
• often no capillary break
Limited ability to resist moisture loads
Above Grade Level
A. Screen – optional (similar to cladding---shed and screen surface moisture-rain)
Below Grade Level
A. Rubble or concrete masonry (storage)
B. Usually no insulation to allow drying
C. Usually no interior finish (limewash)
Backfill – not necessarily free draining
Interface with undisturbed below grade environment
B. Drainage (opt) – crushed stone
Collector and Removal Drain


Dampproofing
• Capillary break = drainage plane, but needs gap
• vapour barrier?
•NOT waterproofing

Glassfiber Drainage Layer

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Rockwool Drainage Layer

Dimple Sheets

- Drainage gap
- act as vapor barrier
- So little water = maybe no capillary break needed

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Exterior Moisture

Controlling ground/rain water

- Roof and Surface Drainage
- Classification of Groundwater control
  - 1. Drained
    - Needs capillary break & gap/drain space
  - 2. Perfect Barrier
    - 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)
- Perimeter Drains

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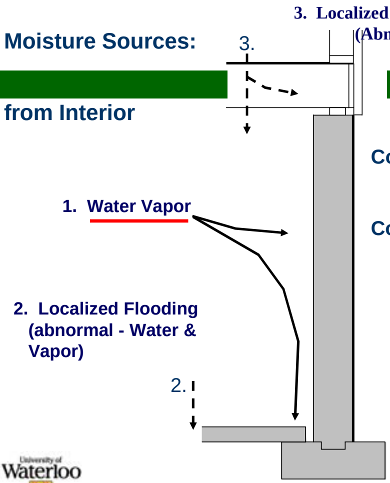
Moisture Sources: from Interior



Control interior vapor levels by:
- winter ventilation
- summer dehumidcation

Control flooding
- floor drains
- disaster pans at appliances

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Air and vapor

- Surface condensation
- Interstitial condensation
- Solar driven summer condensation
- Drying retarders
- Psychrometric Chart

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Special Exterior 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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Moisture – not ground water

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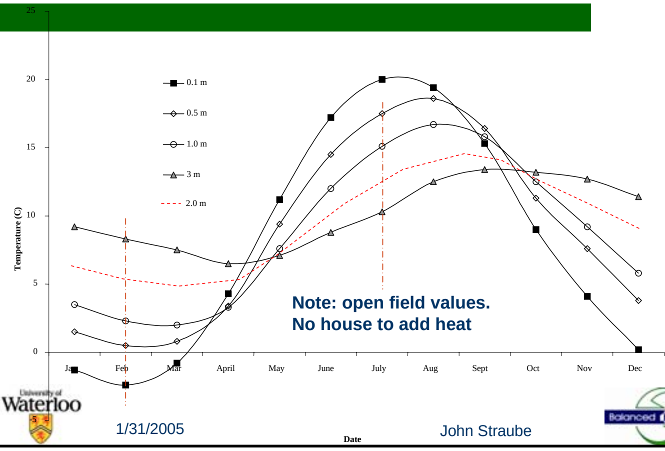
Measured Soil Temperatures



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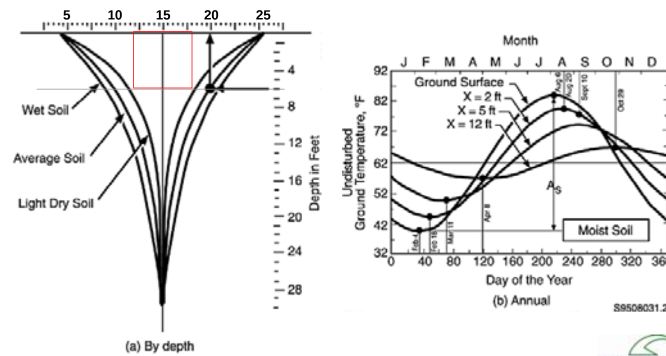
Measured Soil Temperatures



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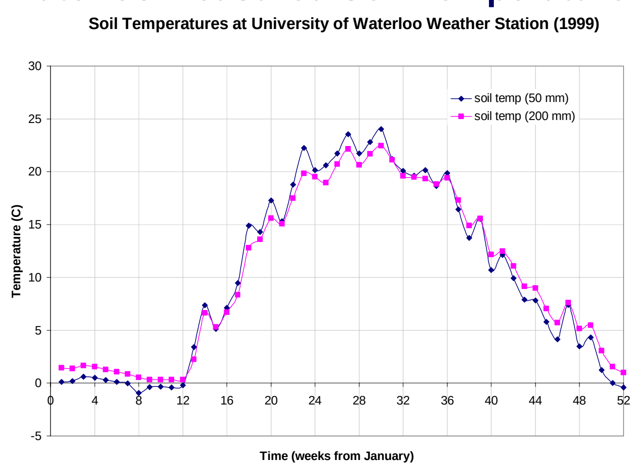
Waterloo Measured Soil Temperatures



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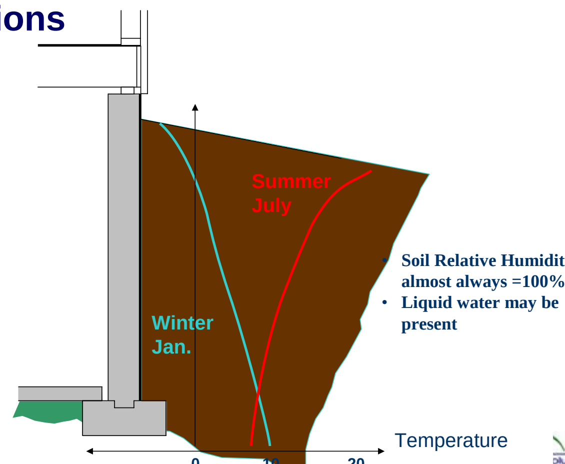
Exterior Temperature and Moisture Conditions



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

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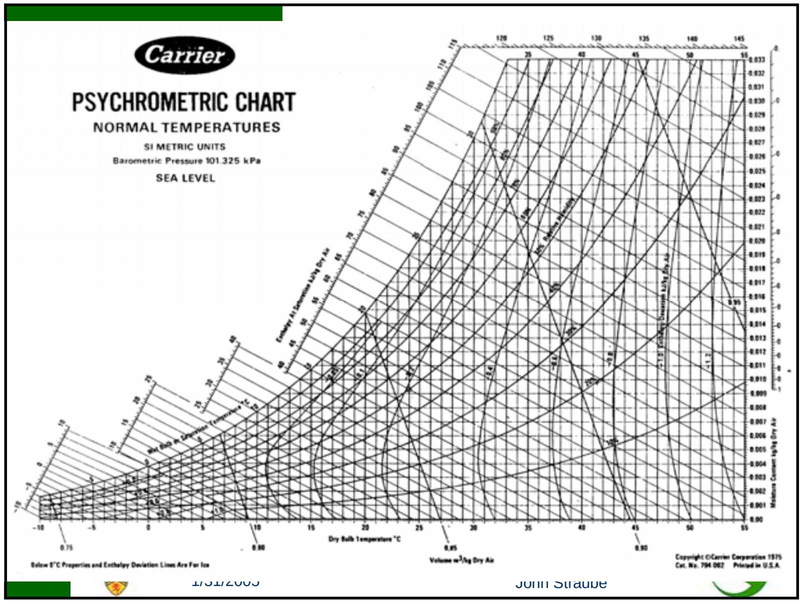

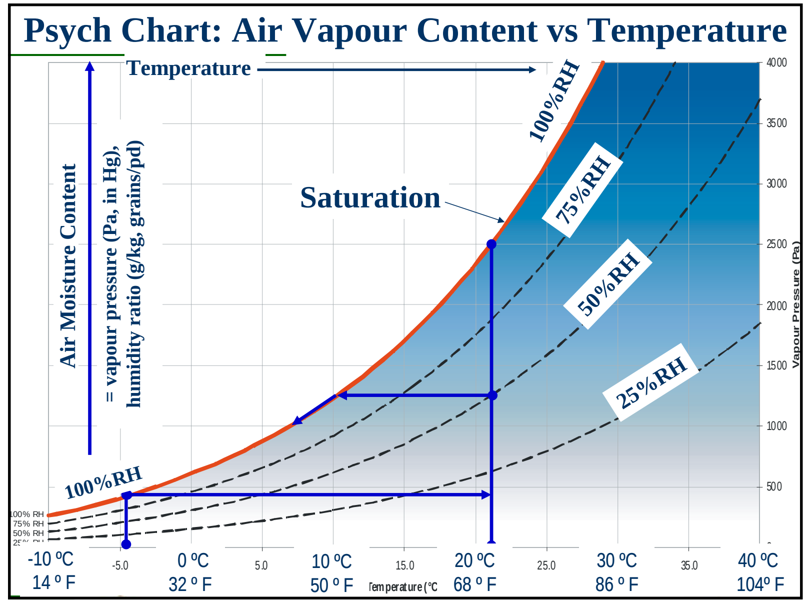

Basement Vapour Movement

- **Vapor moves by Diffusion & Air movement**

  Diffusion
- **Water vapor moves from more to less**
- **Common rule:**
  - **place vapor retarding layers on moist (i.e. high vapor pressure) side to control vapor diffusion**

  Air Leakage
- **Vapor moves with air flow (high to low pressure)**
  - **Stop air flow or flow from dry side**

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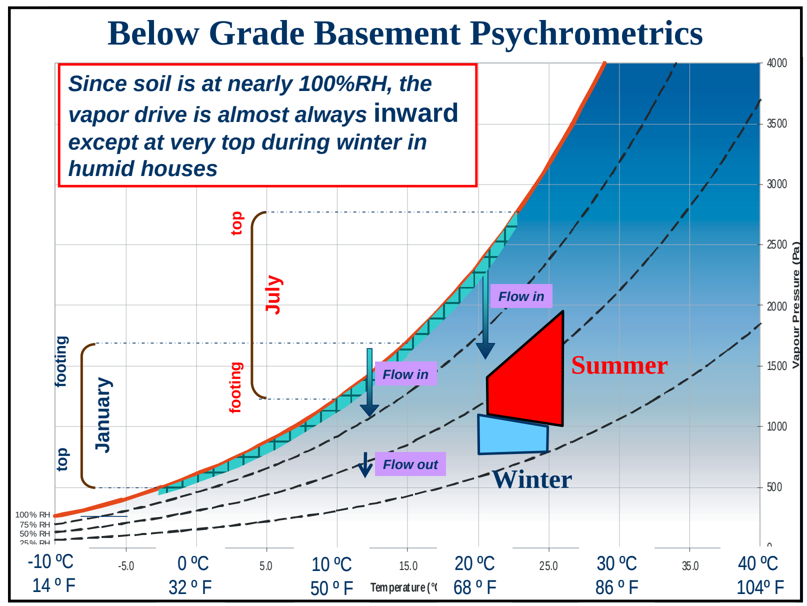
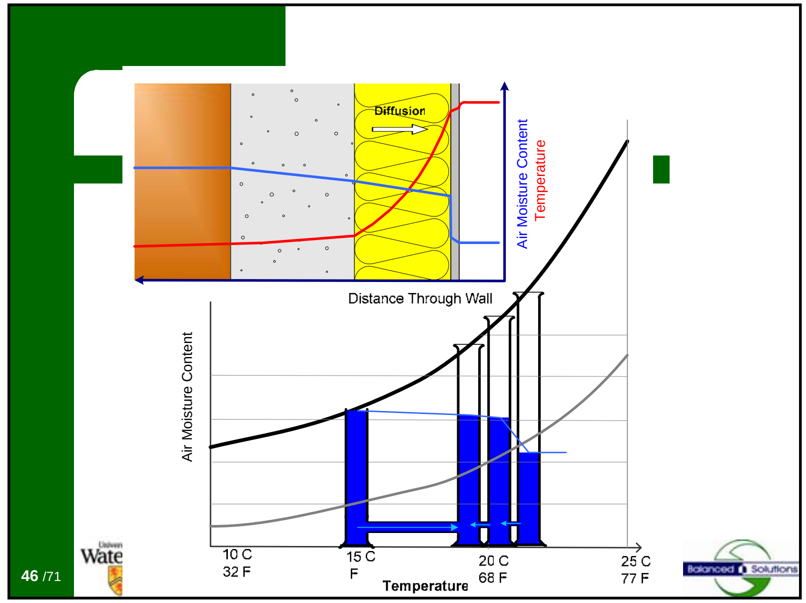


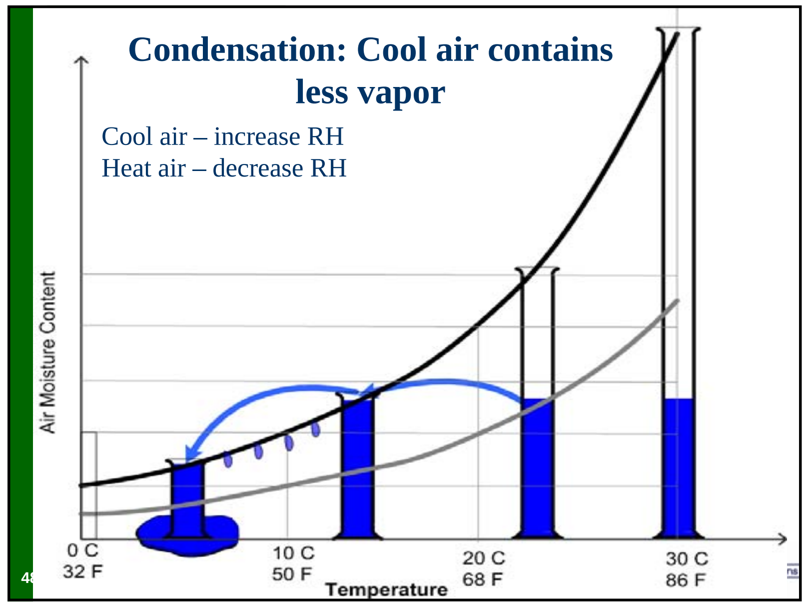
Basement Vapour Diffusion

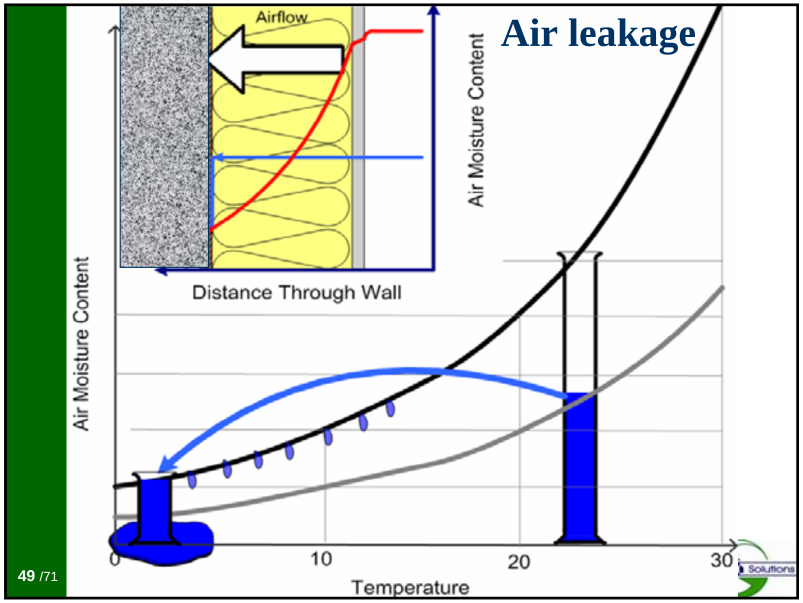
- Water vapor is moving from soil to interior
  - for almost the entire year
  - over all but the top foot of basement
- Hence, place vapor barrier on outside
- But we put it on the inside!
- Moisture moving by diffusion from drying concrete and soil is trapped by interior vapor barriers



Basement Air Movement

- Water vapor moves along with airflow
- If moist air touches a cold surface, condensation occurs
- Control?
  - Include an air barrer
  - Avoid air loops
  - Avoid pressures




Air leakage
Airflow
Air Moisture Content
Distance Through Wall
Air Moisture Content
0
10
20
30
Temperature
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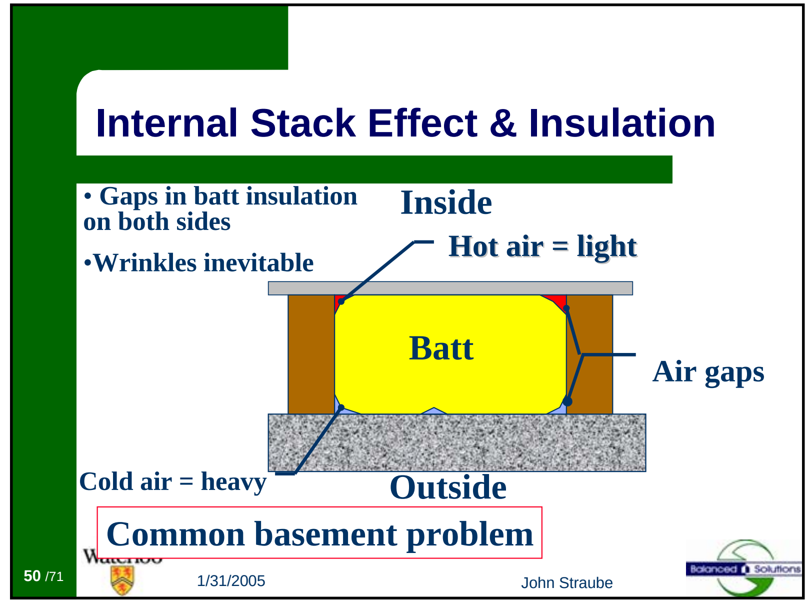
Internal Stack Effect & Insulation
• Gaps in batt insulation on both sides
•Wrinkles inevitable
Inside
Hot air = light
Batt
Air gaps
Cold air = heavy
Outside
Common basement problem
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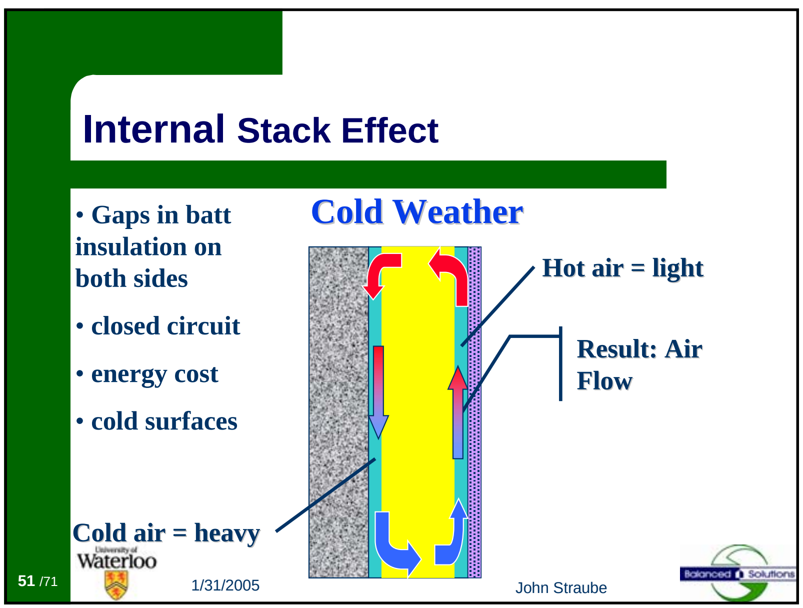
Internal Stack Effect
• Gaps in batt insulation on both sides
• closed circuit
• energy cost
• cold surfaces
Cold Weather
Hot air = light
Result: Air Flow
Cold air = heavy
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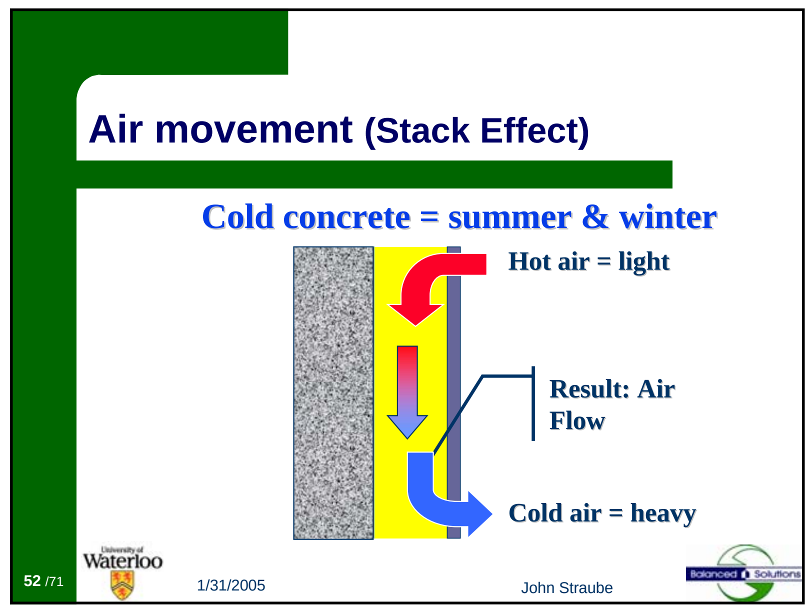
Air movement (Stack Effect)
Cold concrete = summer & winter
Hot air = light
Result: Air Flow
Cold air = heavy
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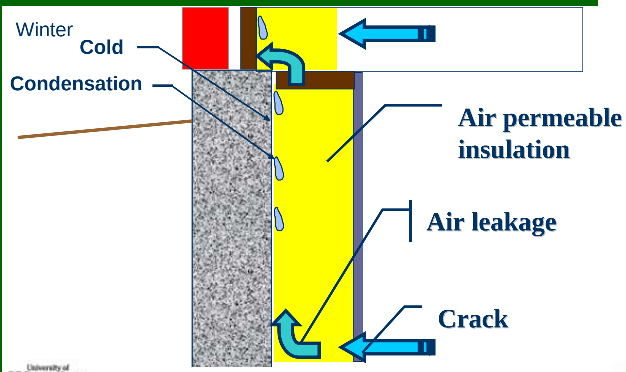
Wall w/ only Batt Insulation



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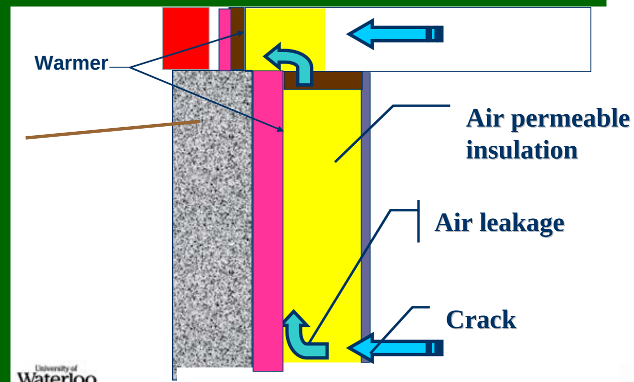
Wall w/ Insulated Sheathing



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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 4.4/inch
  - vapour semi-permeable (Icynene much more)

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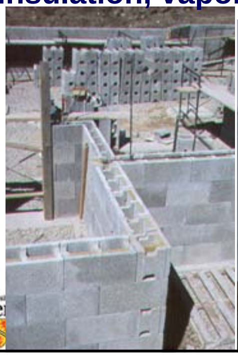
ICFs

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



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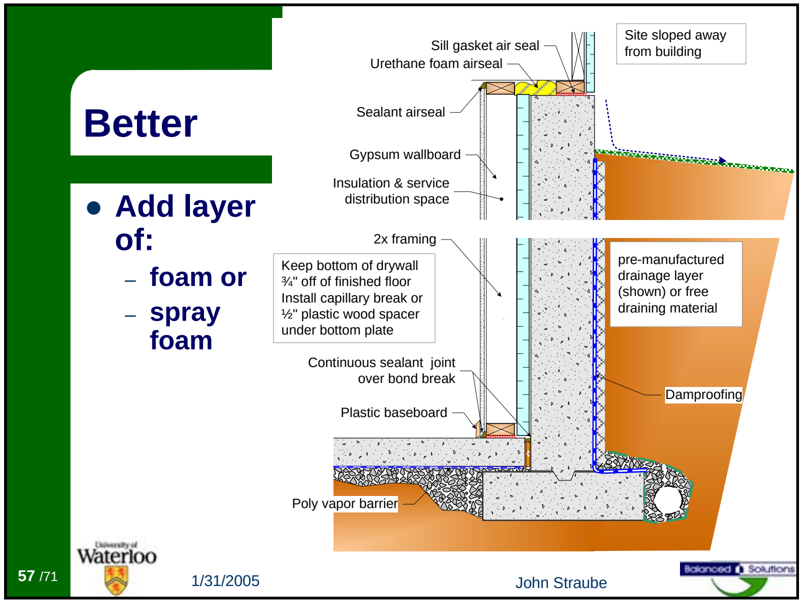
Better
Add layer of:
– foam or
– spray foam
Sill gasket air seal
Urethane foam airseal
Site sloped away from building
Sealant airseal
Gypsum wallboard
Insulation & service distribution space
2x framing
Keep bottom of drywall ¾" off of finished floor Install capillary break or ½" plastic wood spacer under bottom plate
pre-manufactured drainage layer (shown) or free draining material
Continuous sealant joint over bond break
Dampproofing
Plastic baseboard
Poly vapor barrier
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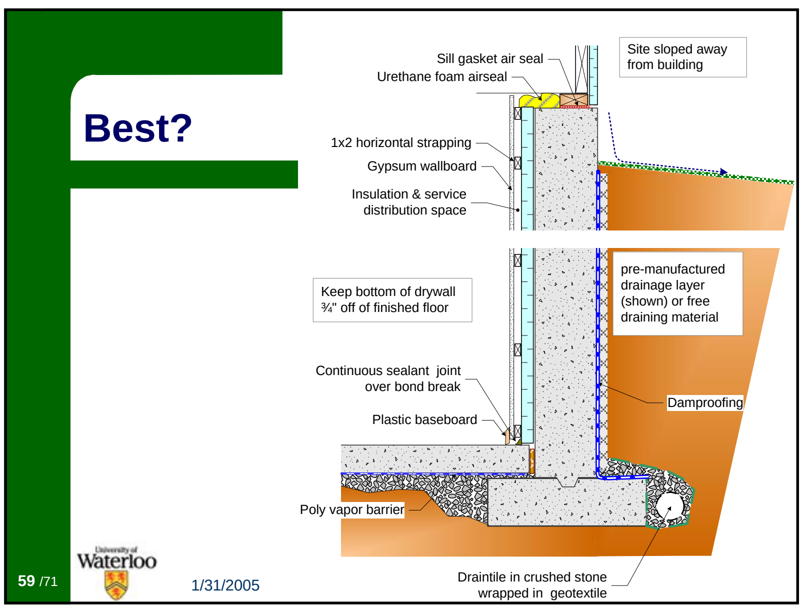
Best?
Sill gasket air seal
Urethane foam airseal
Site sloped away from building
1x2 horizontal strapping
Gypsum wallboard
Insulation & service distribution space
Keep bottom of drywall ¾" off of finished floor
pre-manufactured drainage layer (shown) or free draining material
Continuous sealant joint over bond break
Dampproofing
Plastic baseboard
Poly vapor barrier
Draintile in crushed stone wrapped in geotextile
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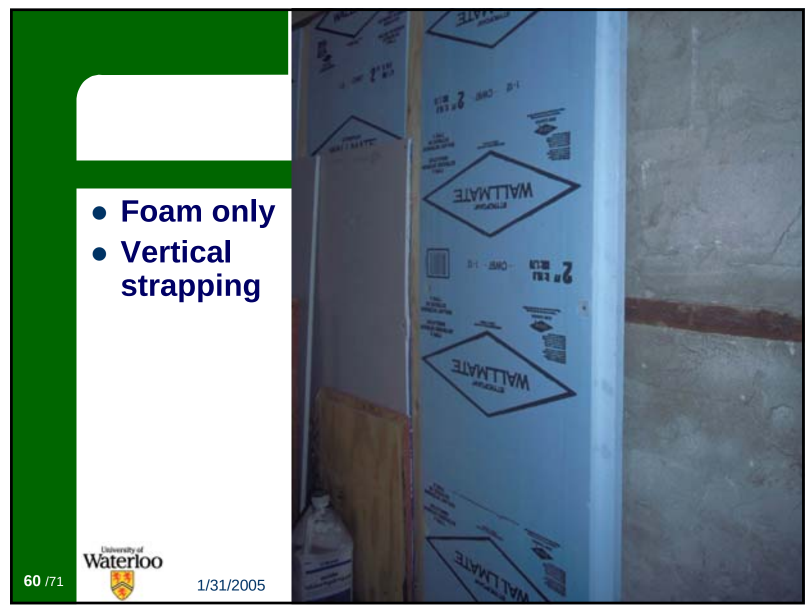
Foam only
Vertical strapping
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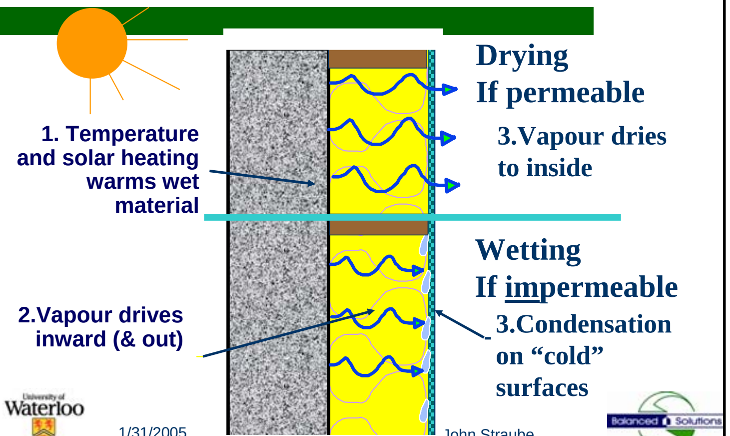
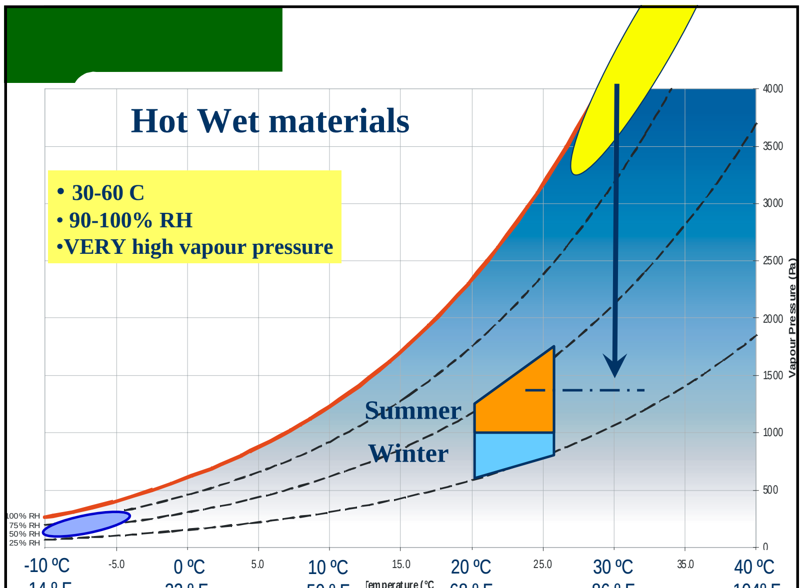
Solar Drives at Grade

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

Inward Diffusion @ grade

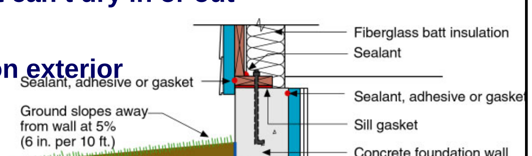


Hot Wet materials



Rim joists

- Scenario
  - Wood generally on exterior
  - 38 mm 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 Floors

- Basement floors
  - Part of enclosure
- Concrete alone fine but when you finish…
  - Comfort (cold and hard)
  - Water under finish flooring
  - Water condensing on top (summer)
- Solutions
  - Install finish over small amount of insulation
  - Install vapor barrier

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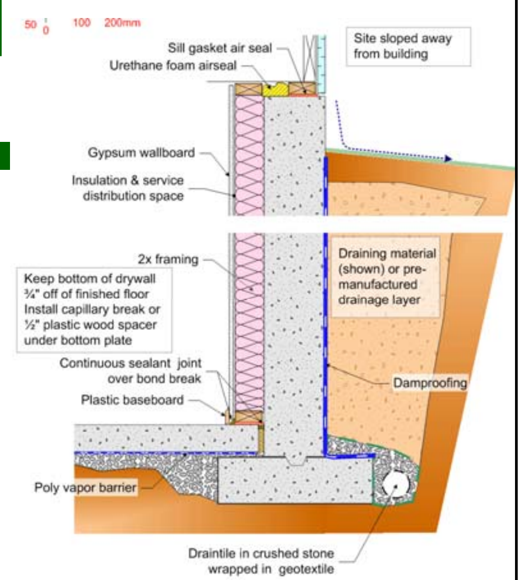
Slabs

Summary

- Tolerable
- Risky
- Be perfect ..& lucky



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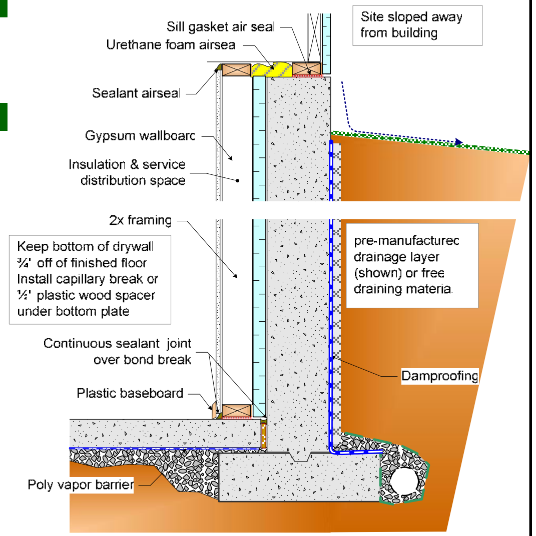
Summary

- good



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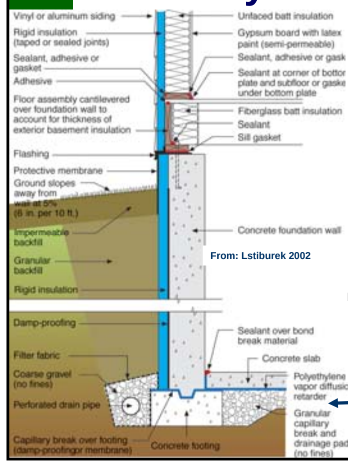
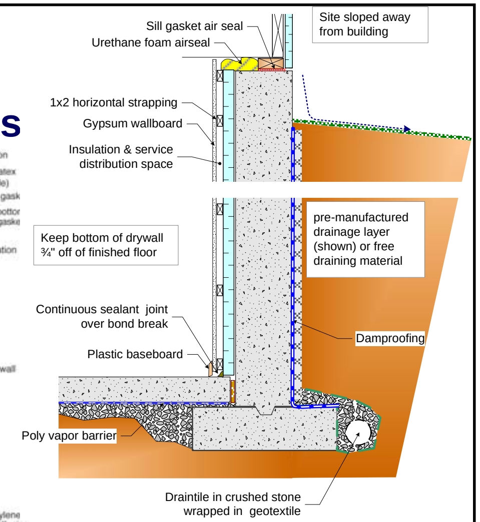
Summary-bes





This is theoretically best, but thermal mass of walls requires good summer humidity control and floor should be insulated

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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

www.civil.uwaterloo.ca/beg publications
www.balancedsolutions.com

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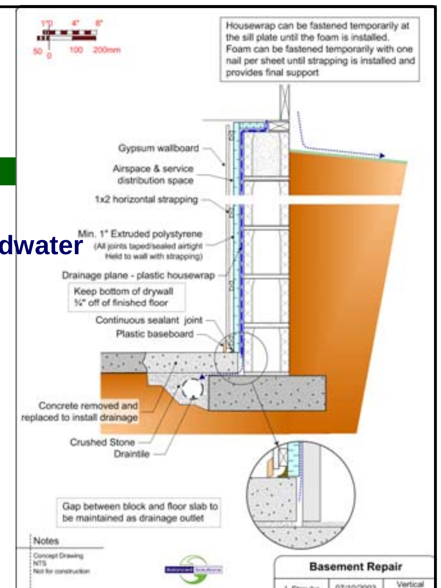
Addition

- Repair
  - Wall leaks groundwater
- Retrofit/Reno
  - Risk reduction



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