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Hybrid Foundation Retrofits

Building America Webinar
November 30, 2011

Background

Background

- Space conditioning energy use for basements
- Known moisture-safe solutions (previous research)

- Persistent bulk water (leakage) issues
- Retrofits of existing foundations
  - Especially uneven wall (rubble stone) foundations

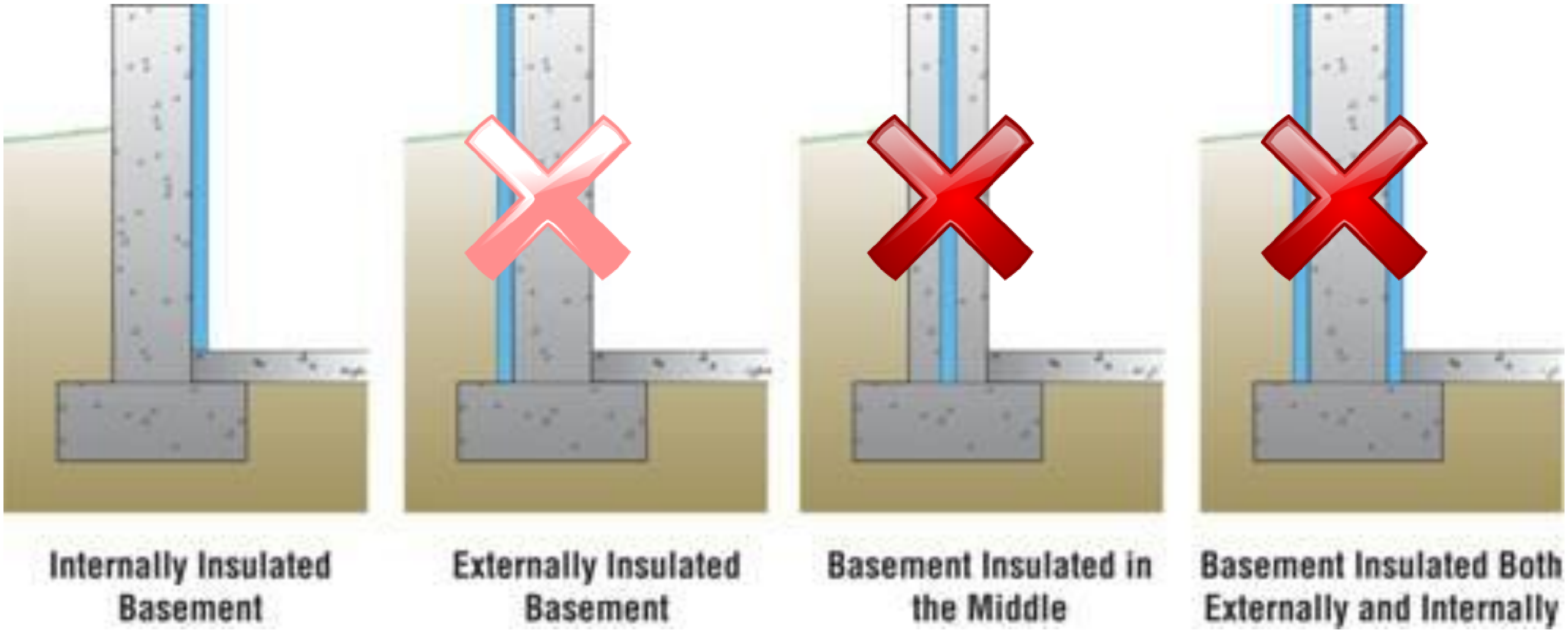
- "Hybrid" insulation and bulk water control assemblies

Foundations w. bulk water issues

- Severe and rapid damage to interior insulation and finishes due to bulk water intrusion

Insulation Location Choices

- Retrofits: interior insulation is often the only available option

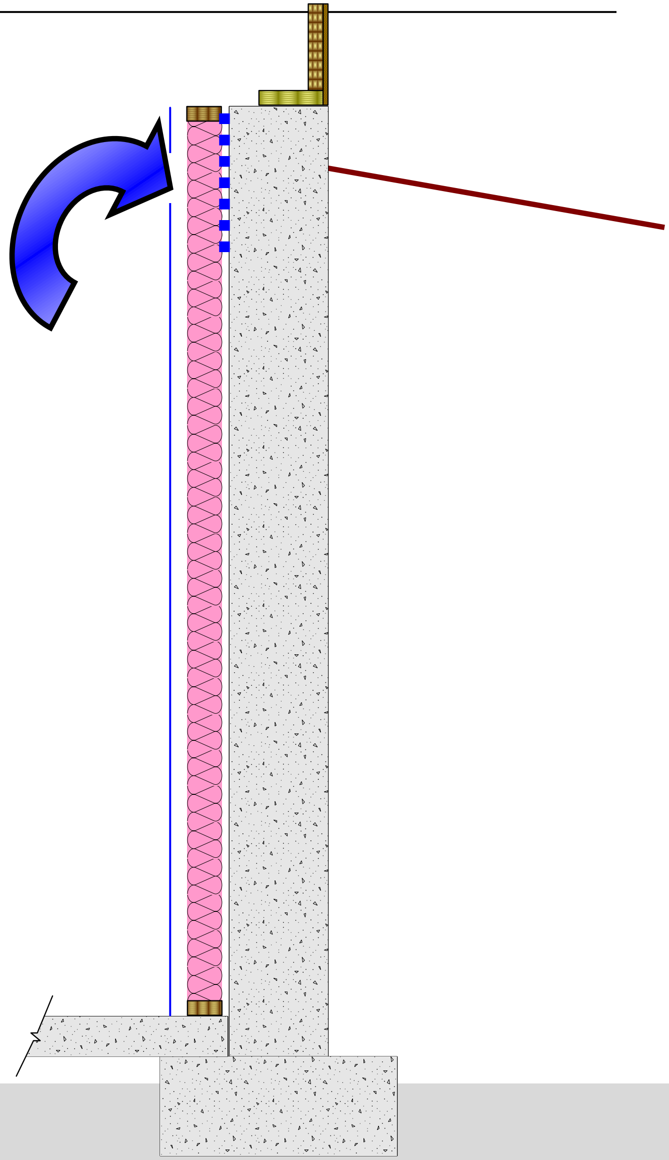


Basement Insulation Location

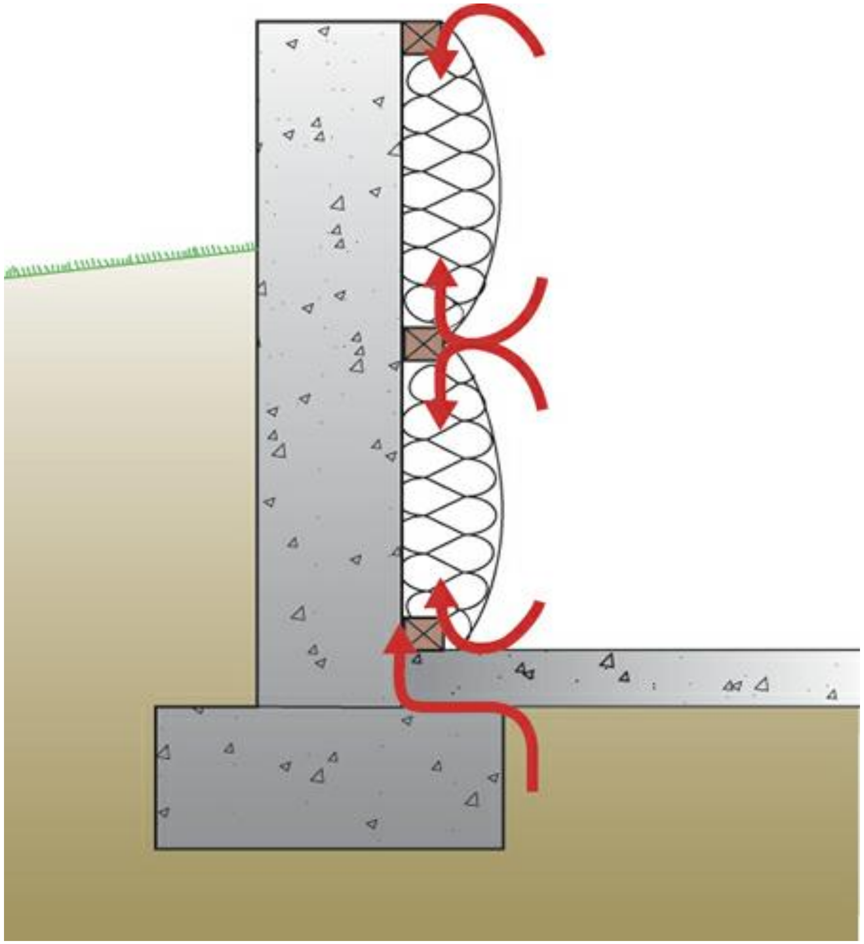
- 4.6 ACH50; 2129 CFM 50 total;
  1100 CFM 50 through floor
- 8.5 ACH50; 3590 CFM 50 total;
  1740 CFM 50 through floor

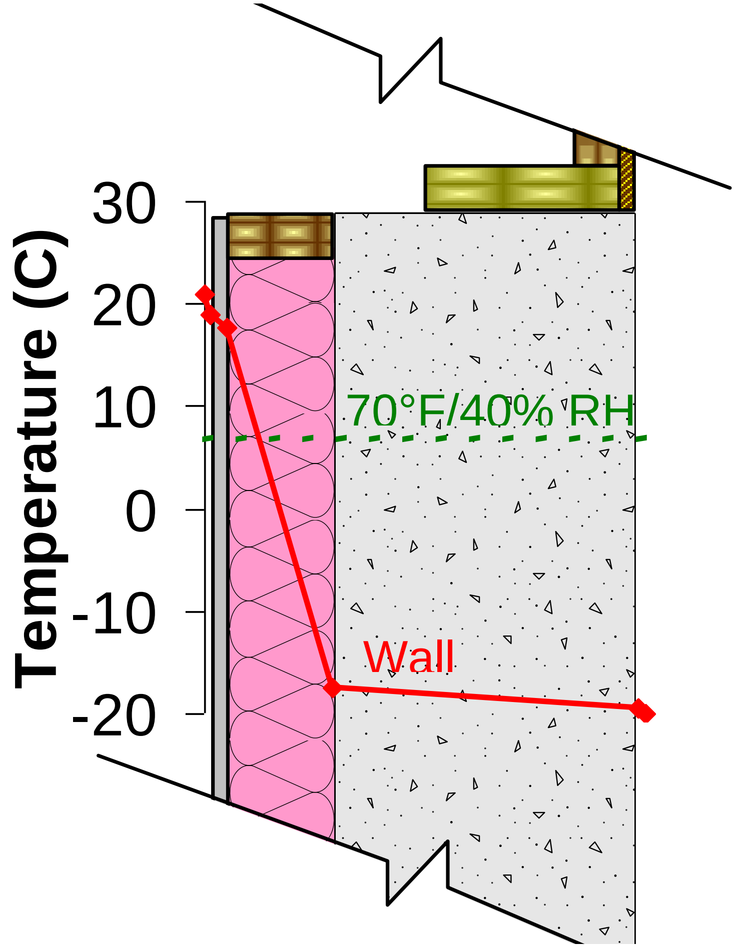
Basement Insulation Problems

- Wintertime interior moisture condensation (like above-grade walls)



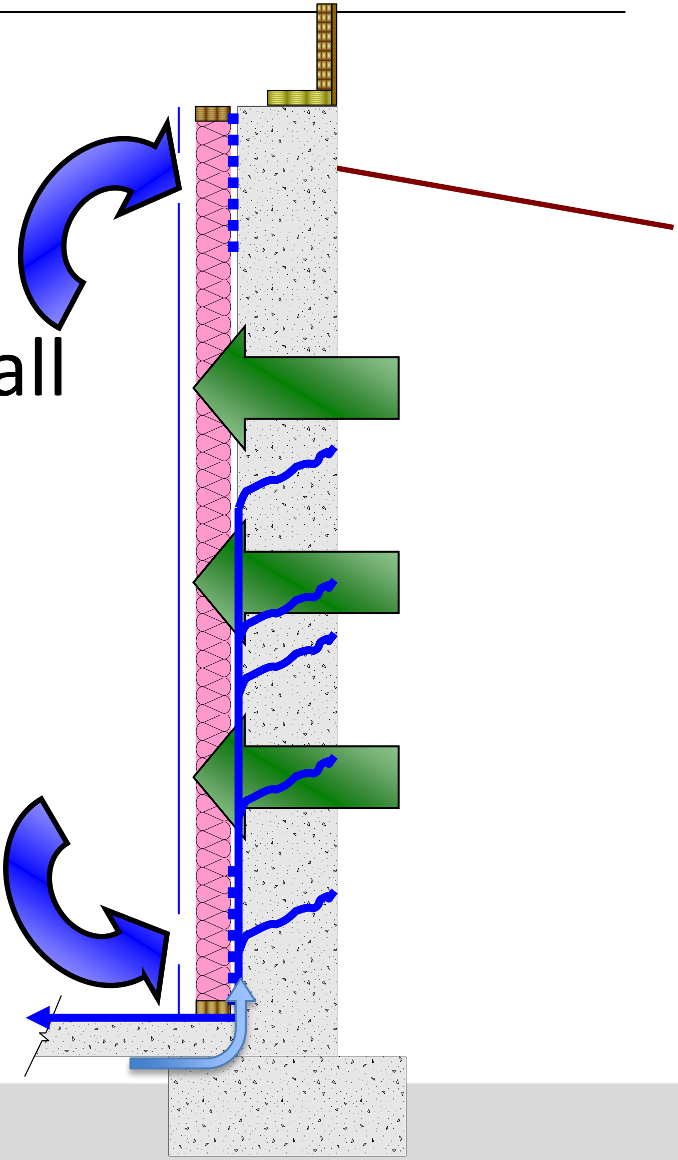
Cold Weather Condensation Issues





Basement Insulation Problems

- Wintertime interior moisture condensation (like above-grade walls)
- Condensation at bottom of wall (thermal lag of soil)
- Lack of drying of assembly (moisture from concrete and soil); soil is at 100% RH
- Soil gas condensation
- Liquid water through wall

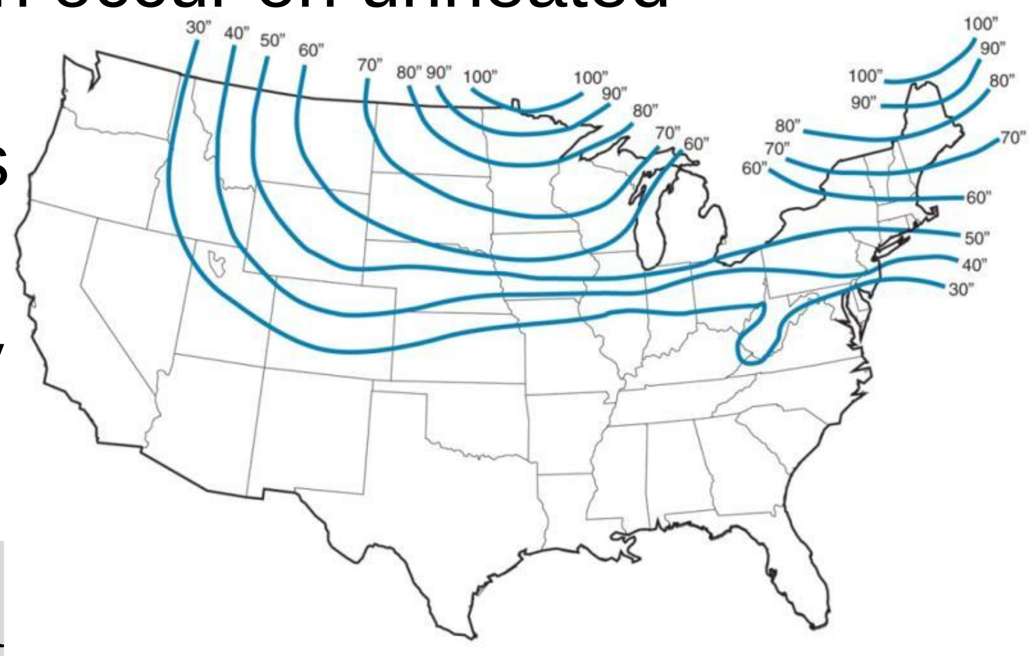


Priorities for Dealing with Water

- Damage Functions (In Order of Importance)
- Liquid Water
  - Control from exterior—drainage, grading
- Capillary Water (“wicking”)
- Air-Transported Moisture
- Vapor Diffusion
- General rules; can vary on case-to-case basis

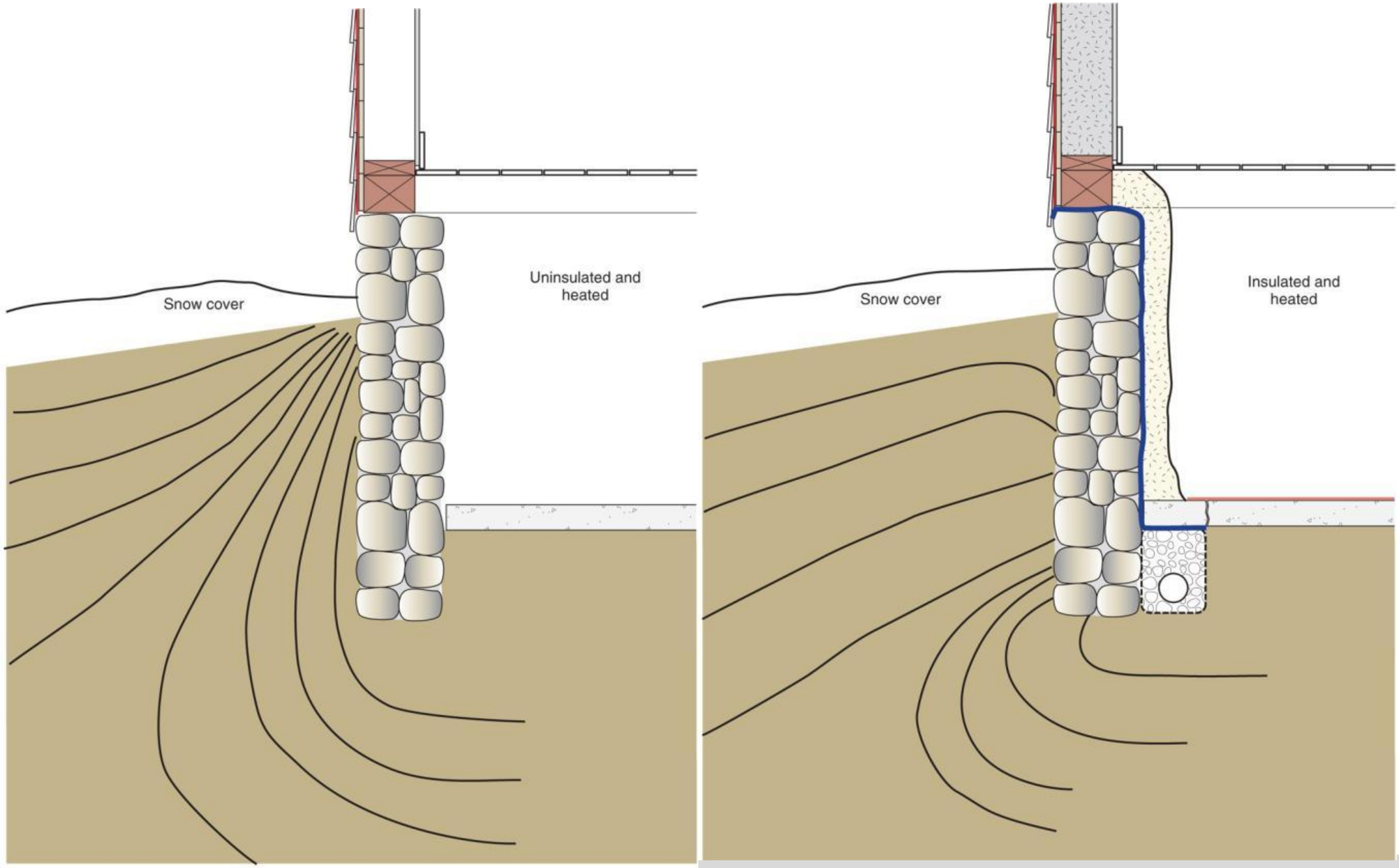
Freezing/Frost Heave Issues

- Interior insulation reduces heat flux → colder ground temperatures/deeper frost penetration
- Frost damage unlikely <60” extreme frost depth
- Inward frost heave impossible → directional heave
- Adfreezing similar: can occur on unheated structures. Heated → heat flux still outwards (although reduced)
- Canadian BETT study (1980s)

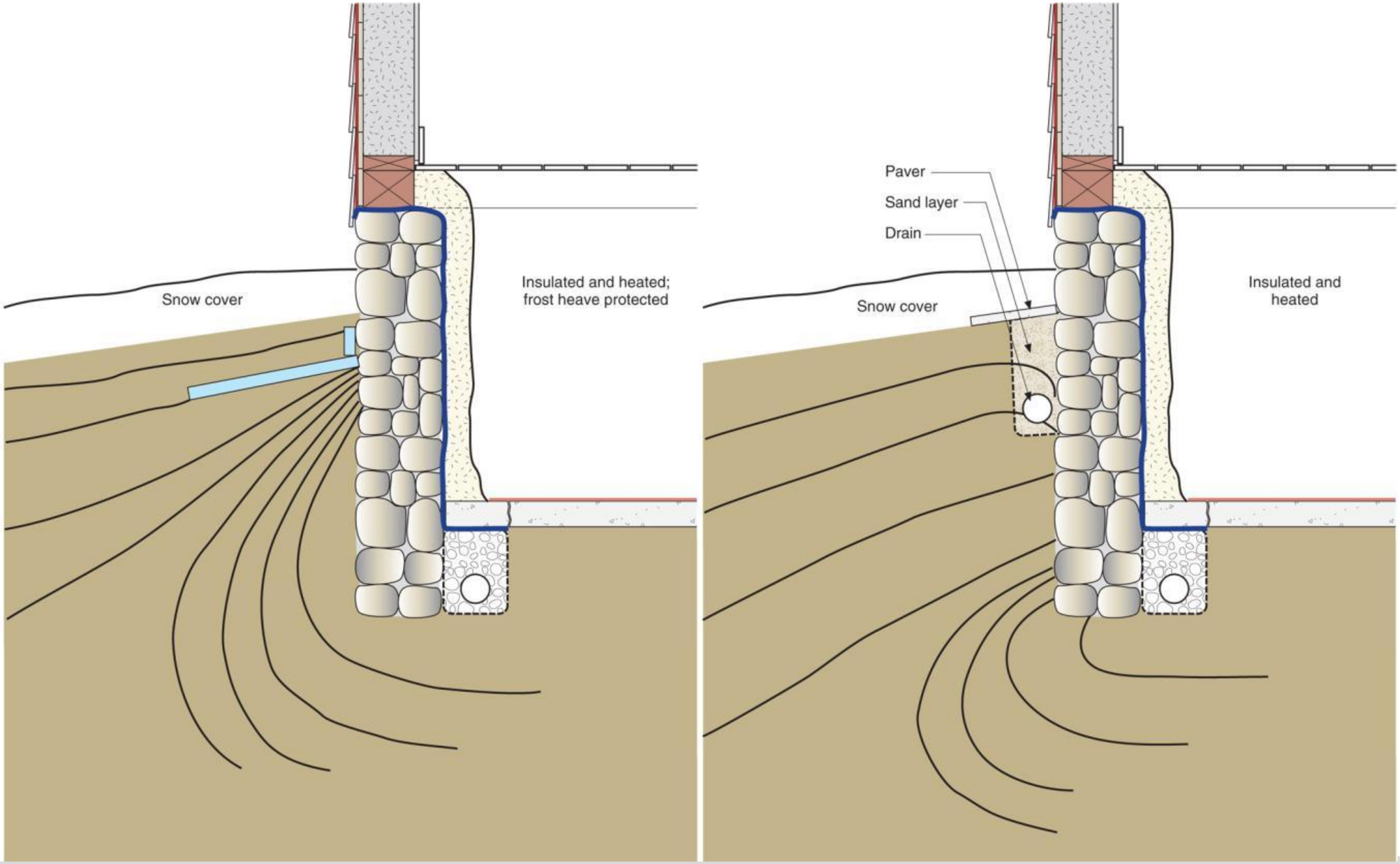


From the US Army Corps Engineers Extreme Frost Penetration (in inches) based on state averages.

Freezing/Frost Heave Issues

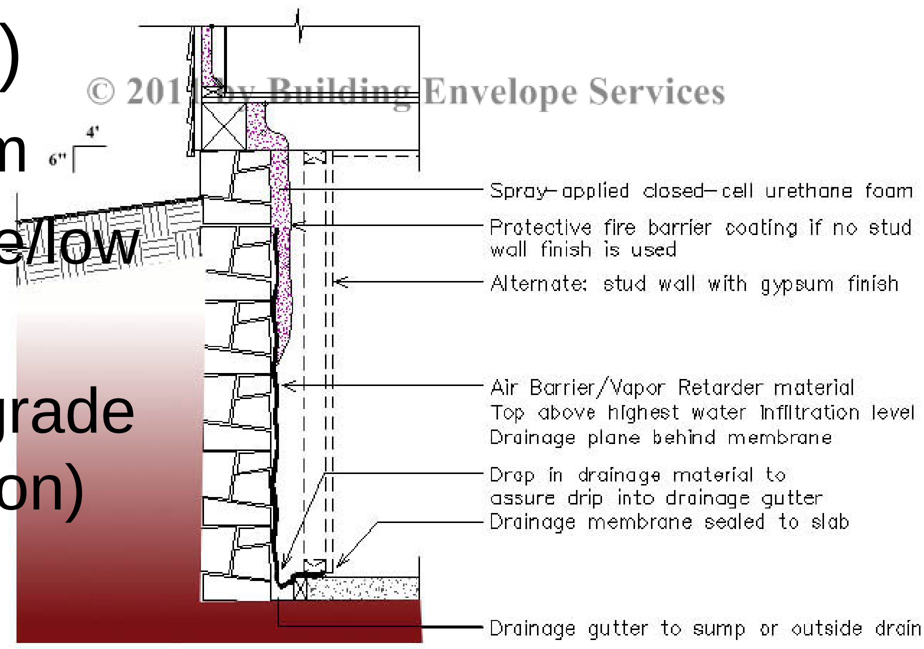


Freezing/Frost Heave Issues



Previous Work

- Trade press: interior perimeter drainage
  - Drains slab and wall: no air barrier between sub-slab and interior
- AVID System (Air/Vapor/Insulation/Drainage)
  - Interior drainage; half-height insulation
- Goldberg & Farkas (2004)
  - Interior 0.5 PCF spray foam
  - Typically good performance/low moisture accumulation
  - Zone 7 frosting on above-grade portion (insulation/foundation)



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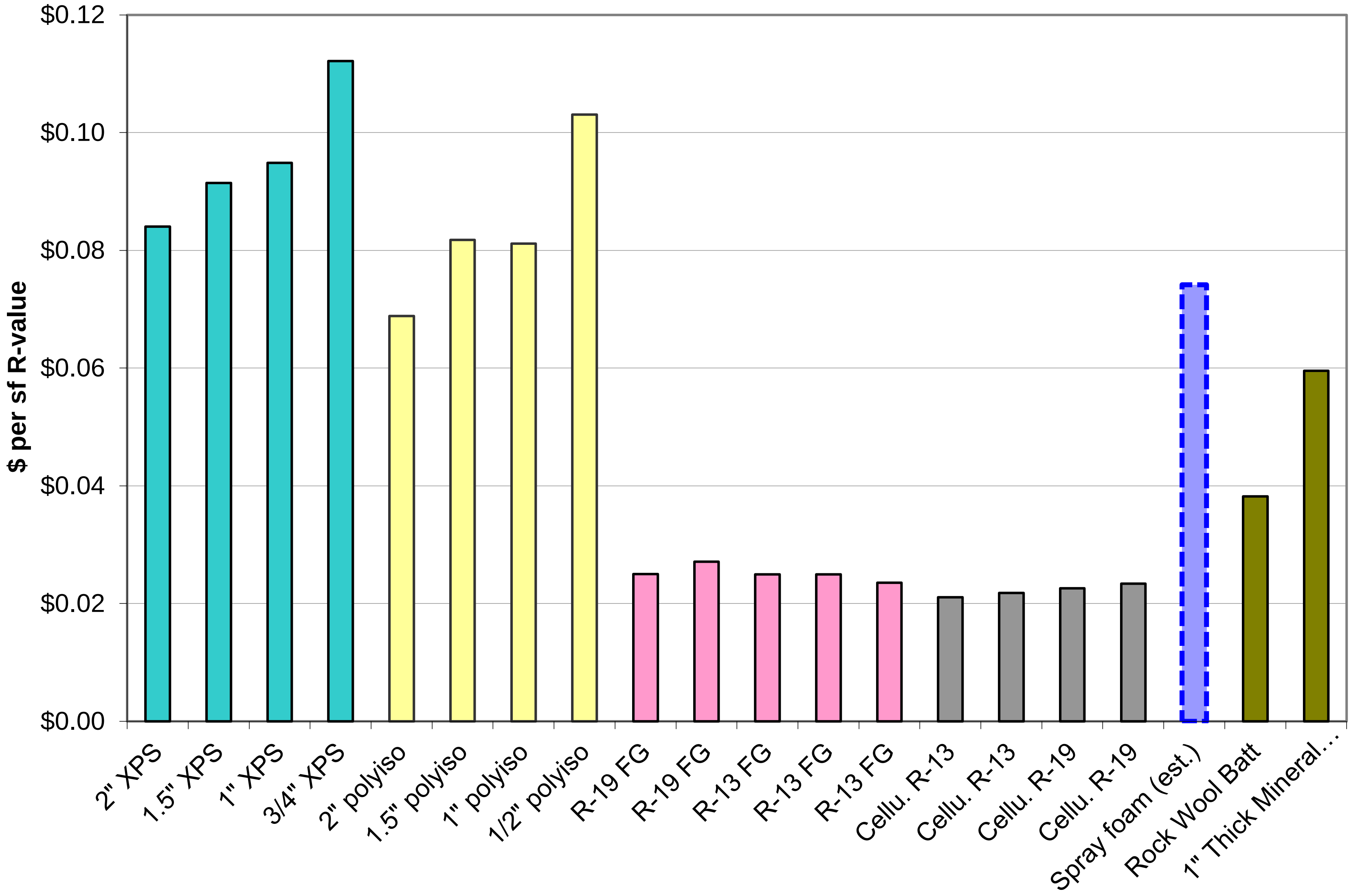
Closed Cell Spray Foam Characteristics

- Insulation value ~R-6/inch
- Air control layer: air impermeable material
- Vapor permeability: 0.8 perms at 2” thickness
- Water control: moisture tolerant/hydrophobic
- Code Requirements (ICC)
  - Separate from interior by “thermal barrier” (R316.4) ½” GWB or equivalent, intumescent paint
  - “Ignition barrier” permitted for some attic/crawl cases: (less stringent requirements; R316.5.4)
- Installed cost typically ~$1-$1.50/board ft. (1’x1’x1”)

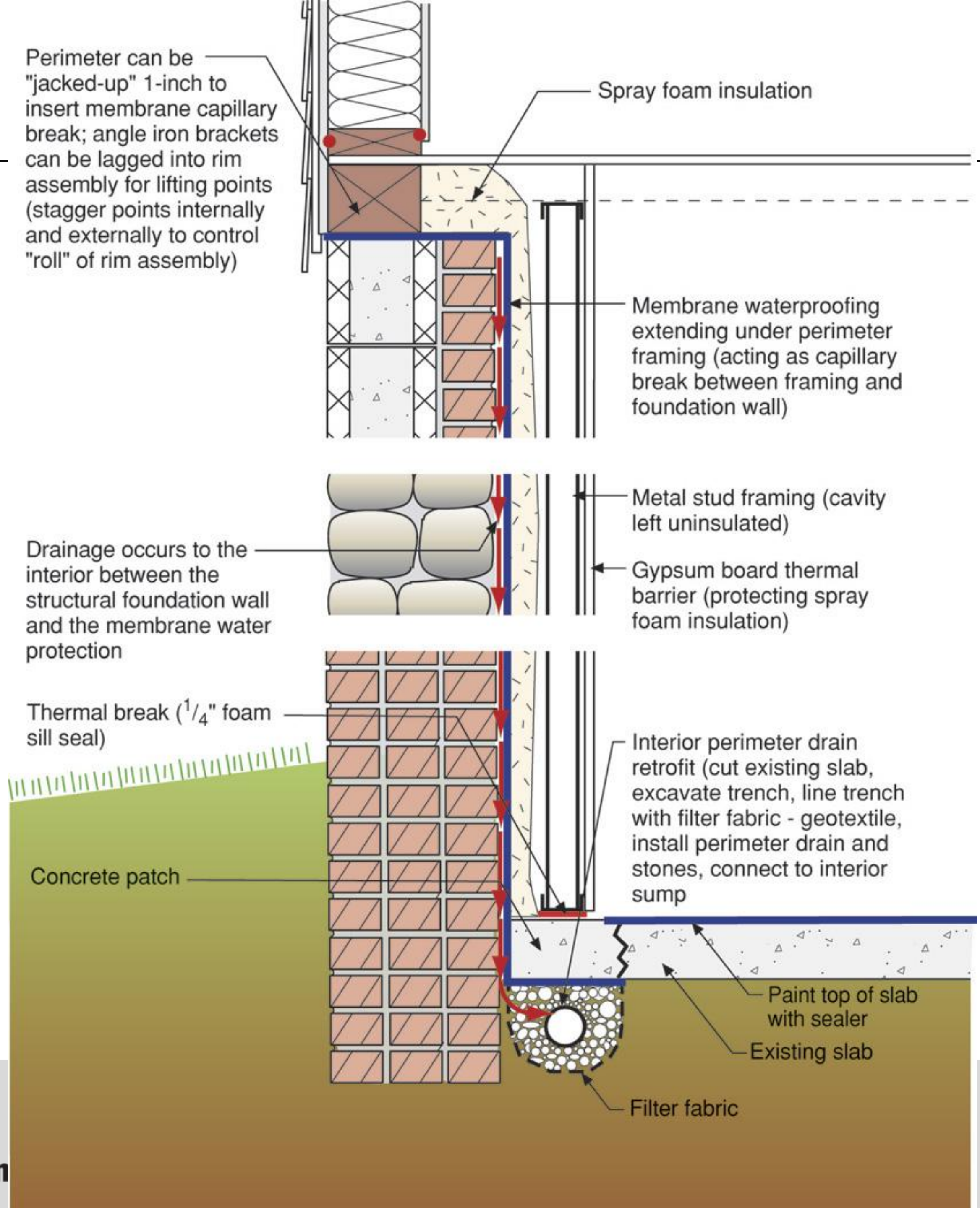
Insulation Normalized Costs



Installed Costs

- AVID example ~$2/sf floor area for 4’ crawl, half height, polyethylene only on floor (~$4/sf wall)
- Full retrofit $5-$7/sf basement wall area (R-20)
- With stud wall $10-$11/sf basement wall area
- Spray foam (installed) $1.00-$1.50/board foot
- Perimeter drains ~$20-40/lineal foot
- Rat slab (2” thick) ~$3.25-$4.00/sf floor area
- Insulation system + water management
  - Cost comparisons should be to insulation + drainage
- Has to be compared to what actually works!

Recommended Designs & Variants



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Interior Rubble Retrofit

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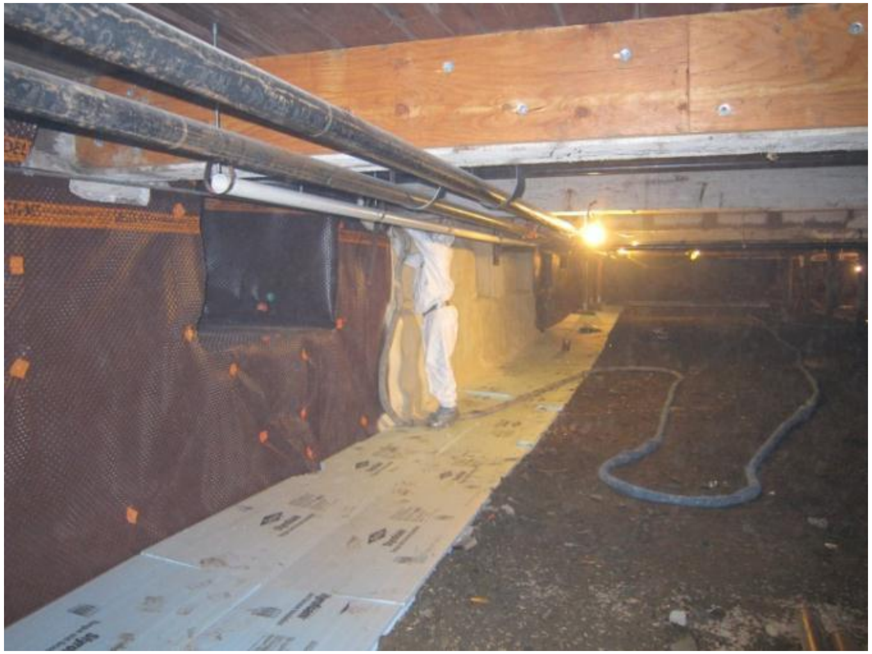
Air Gap Membrane Variant



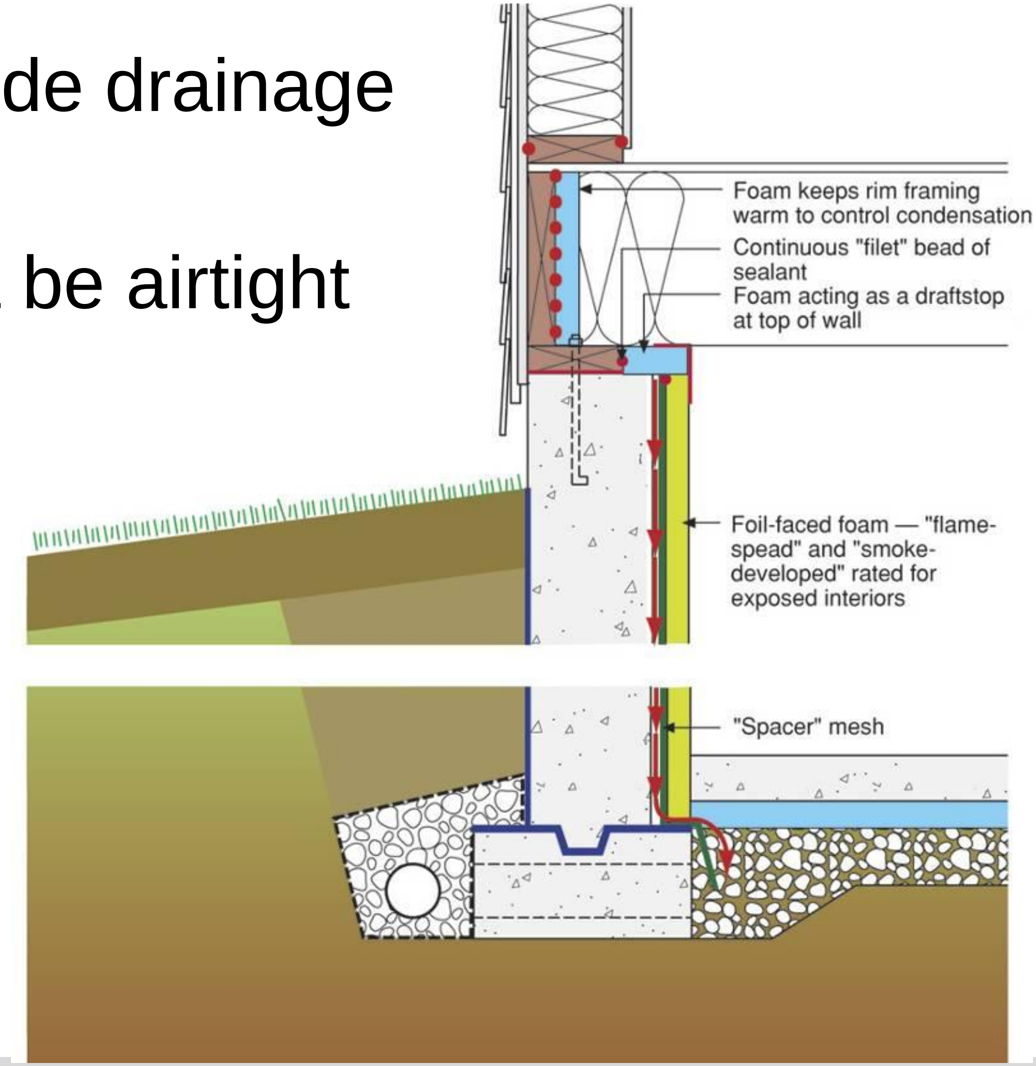
- Spray foam sufficiently stiff at typ. thickness (2” +)
- XPS basement slab perimeter insulation
- Spray foam forms concrete slab thermal break

Beam pocket detail (air seal)

- Beam pocket detail (air seal from subslab)

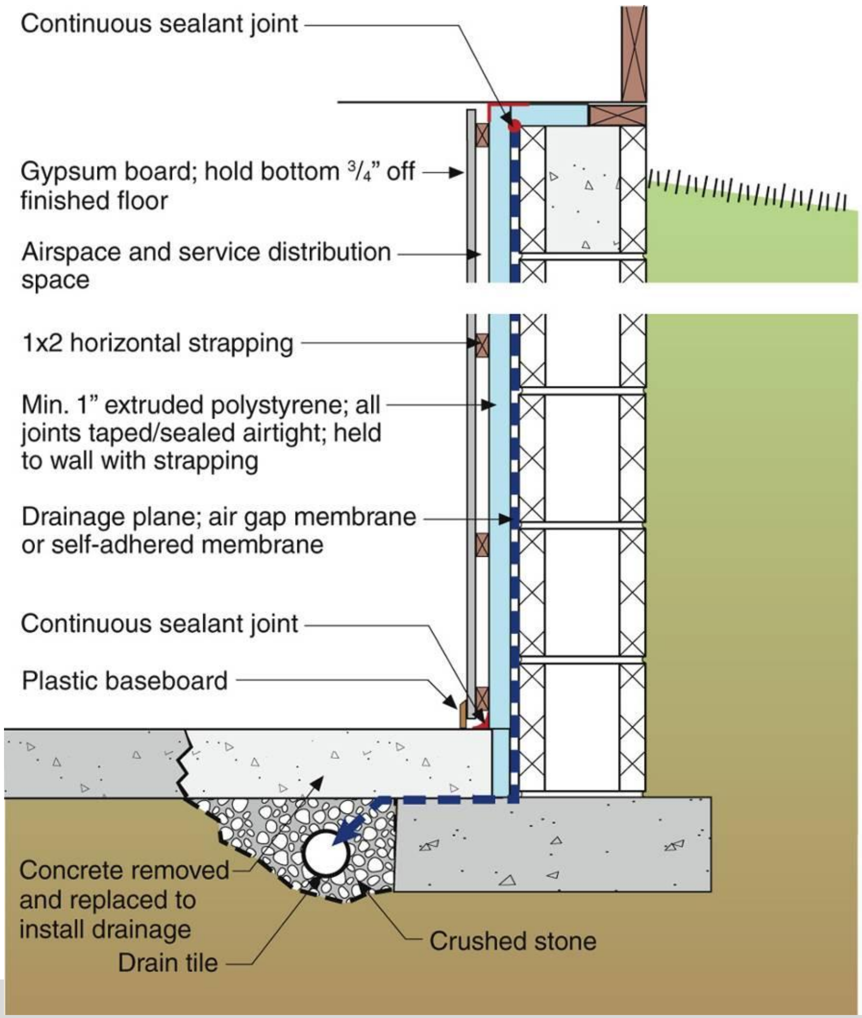
Flat Surface Walls

- Spacer mesh to provide drainage behind foam
- Drainage space must be airtight



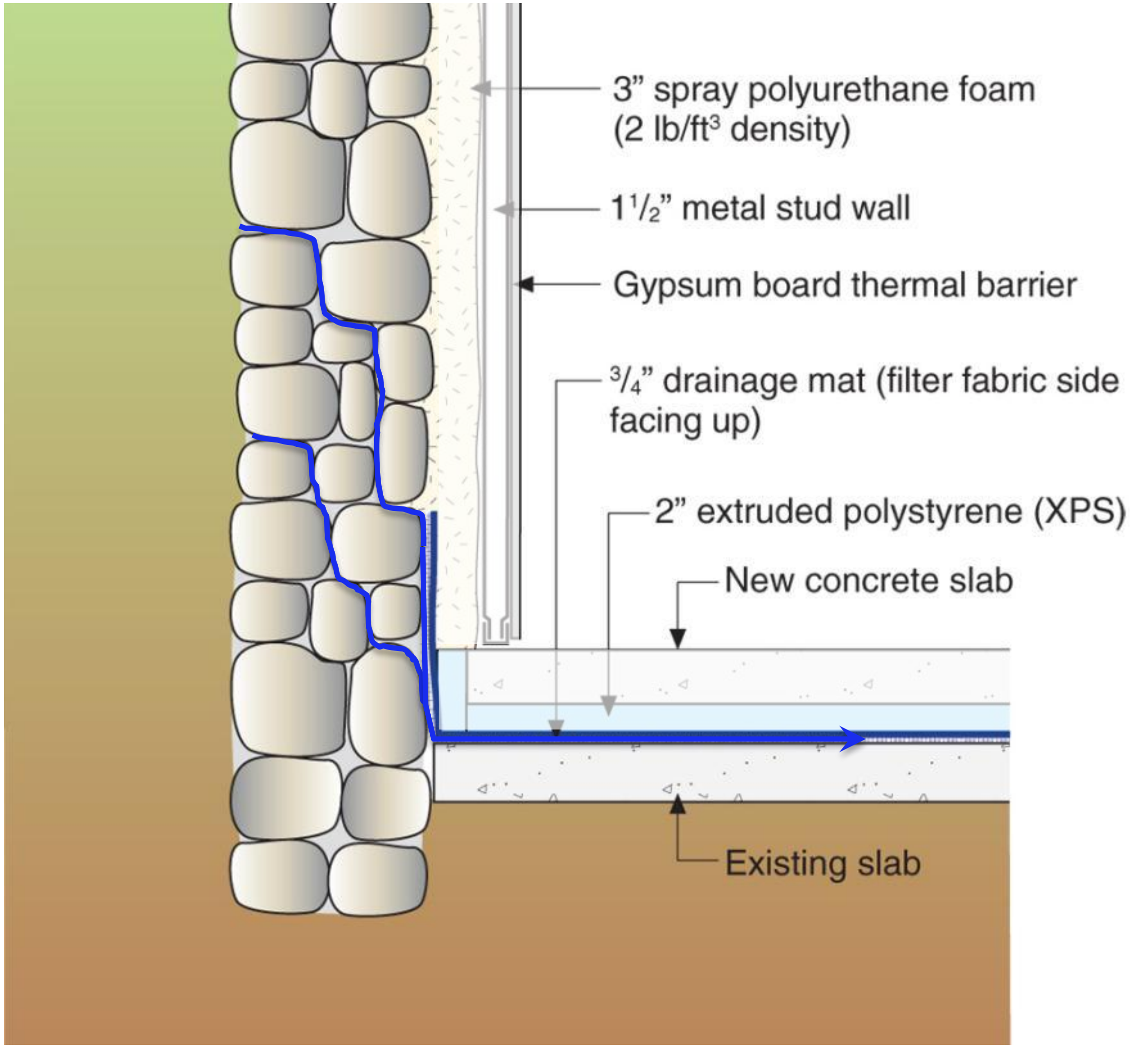
Flat Surface Walls

- Alternate version: air gap membrane layer
- Drainage space must be airtight
- Another option: XPS with channels and filter fabric



Partial Drainage Detail

- Insulated slab on top of existing slab
- No membrane up wall surface
- Light gauge steel framing interior wall
- Wet vs. dry basement?

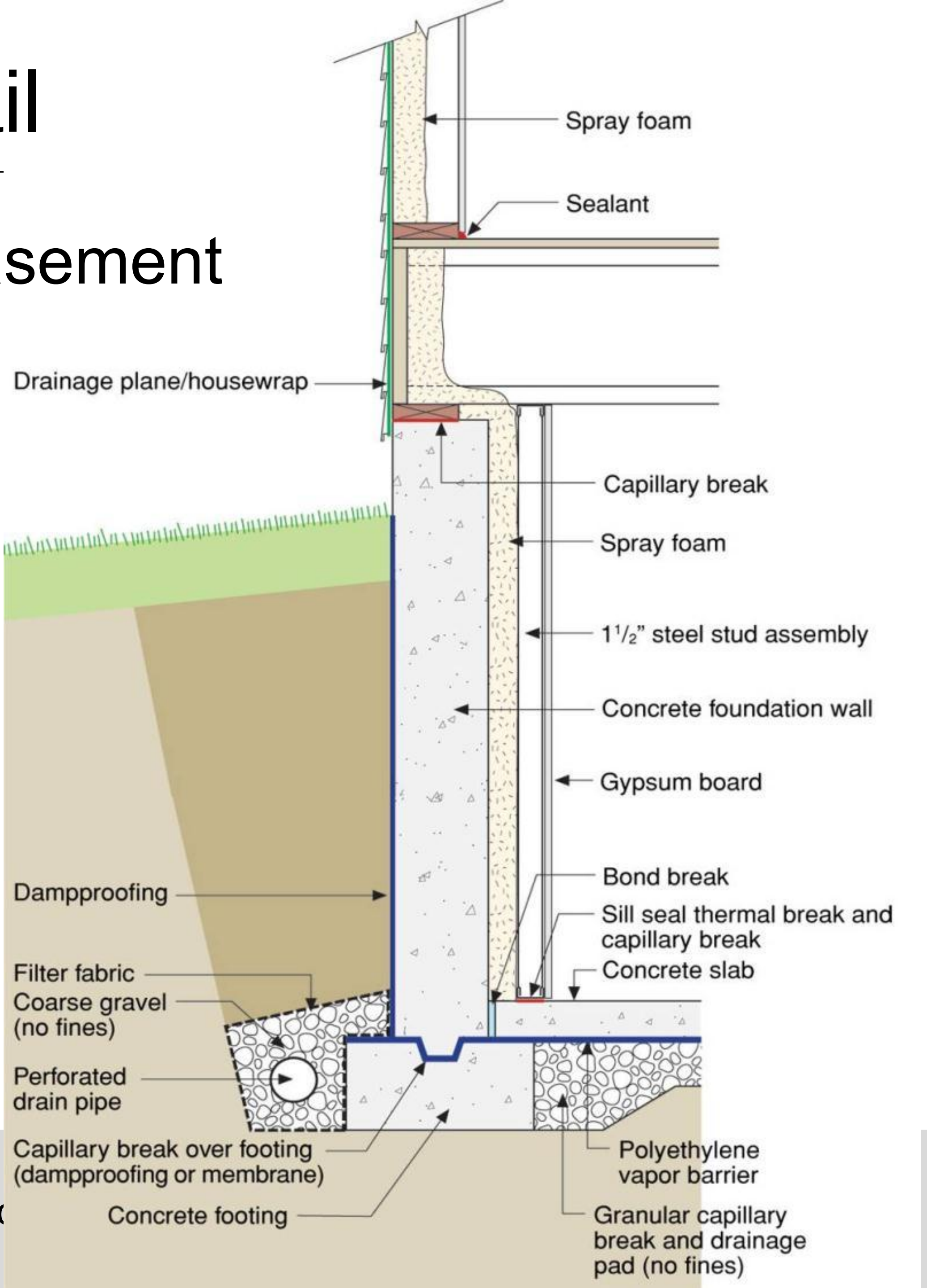


Partial Drainage Detail

- Sump must be connected to drainage mesh
- Air leakage around drainage space termination (interior chimney)

Non-Drained Detail

- "Substantially dry" basement
- Judgment call
- Steel studs clear of spray foam

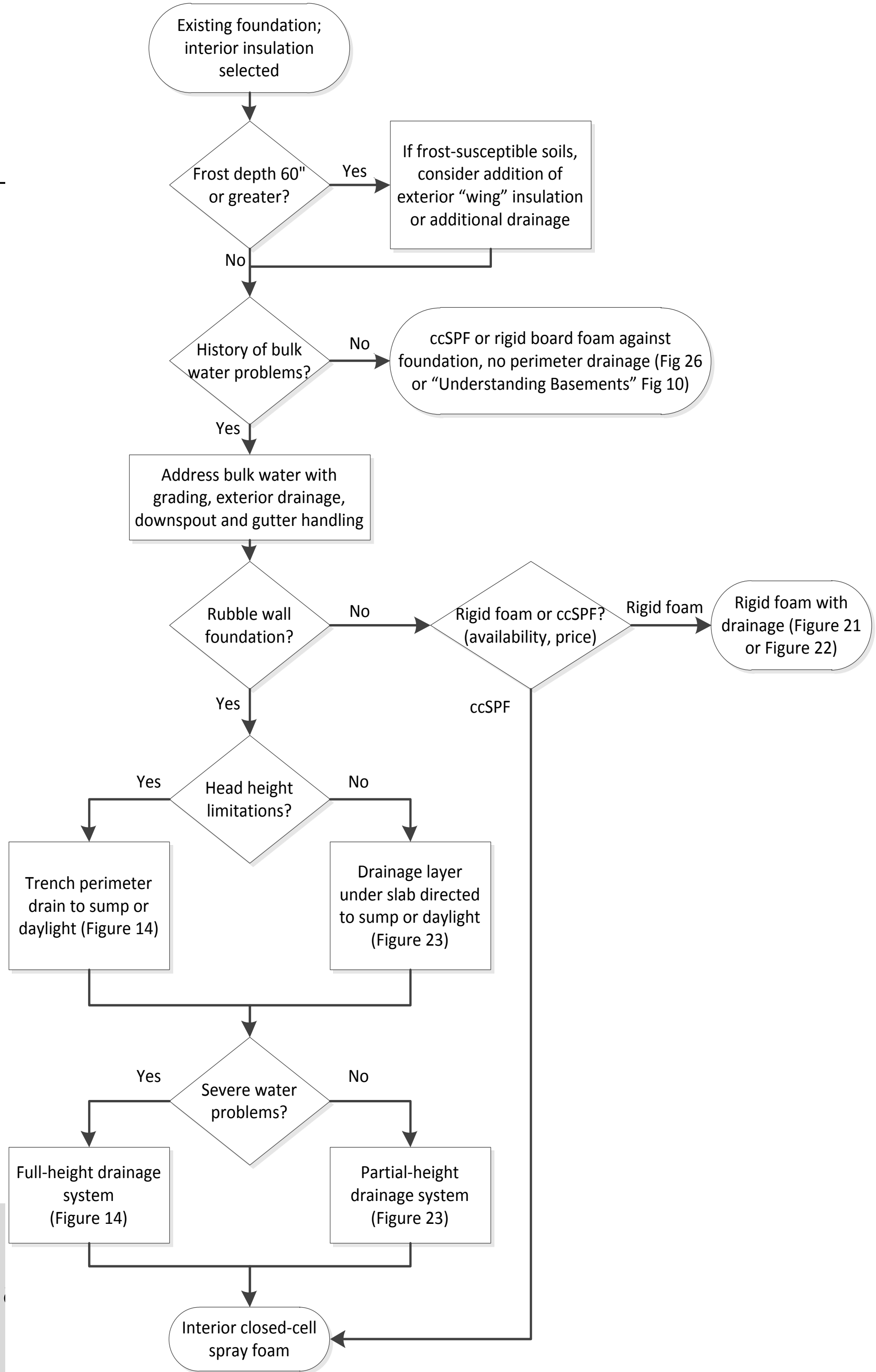


Spray foam basement insulation

- Open cell
  - Climate specific
- Closed cell

Guidance Flowchart

- Rough guidelines
- User judgment required



Additional Research: Moisture Flow

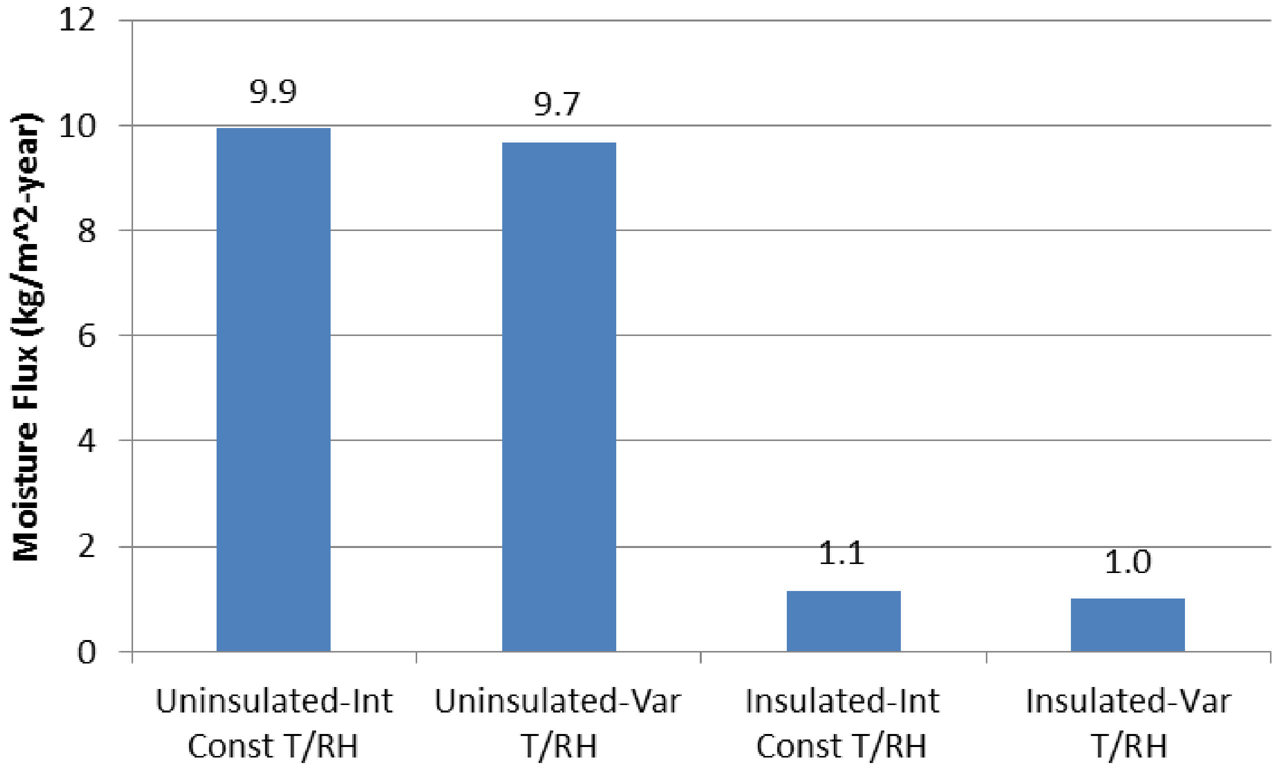
Hygrothermal Simulations

- Moisture emissions before/after interior ccSPF
  - No drainage layer—spray foam only
  - kg/m^2·year
  - Constant and variable interior T/RH

2.8 liters day uninsulated vs. 0.3 l/day insulated

Family 4 = 10-15 l/day

Slows down capillary mortar erosion?



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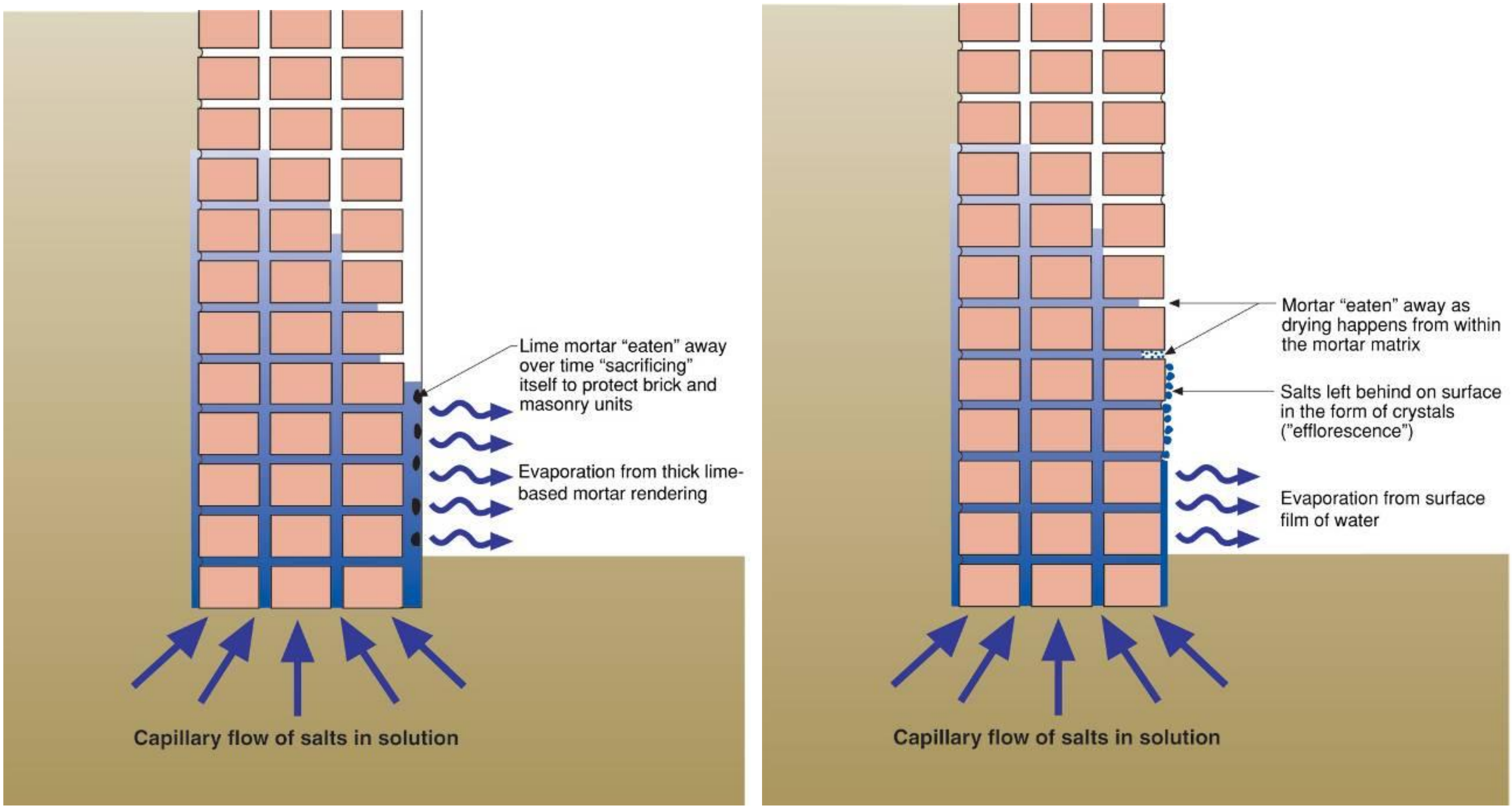
Hygrothermal Simulations (Capillarity)



Additional Research: Sill Beam Durability

Sill Beam Moisture Durability

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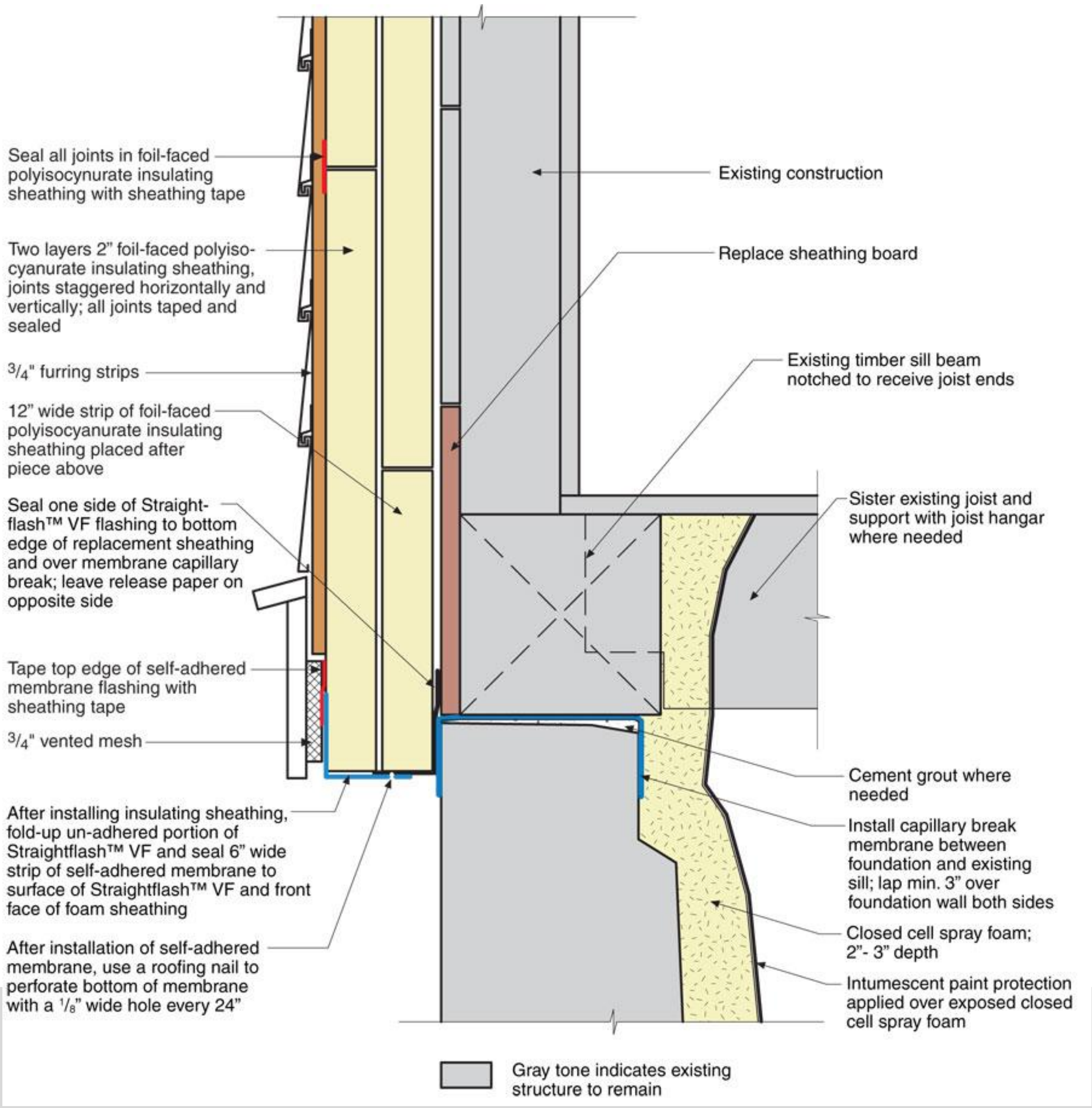

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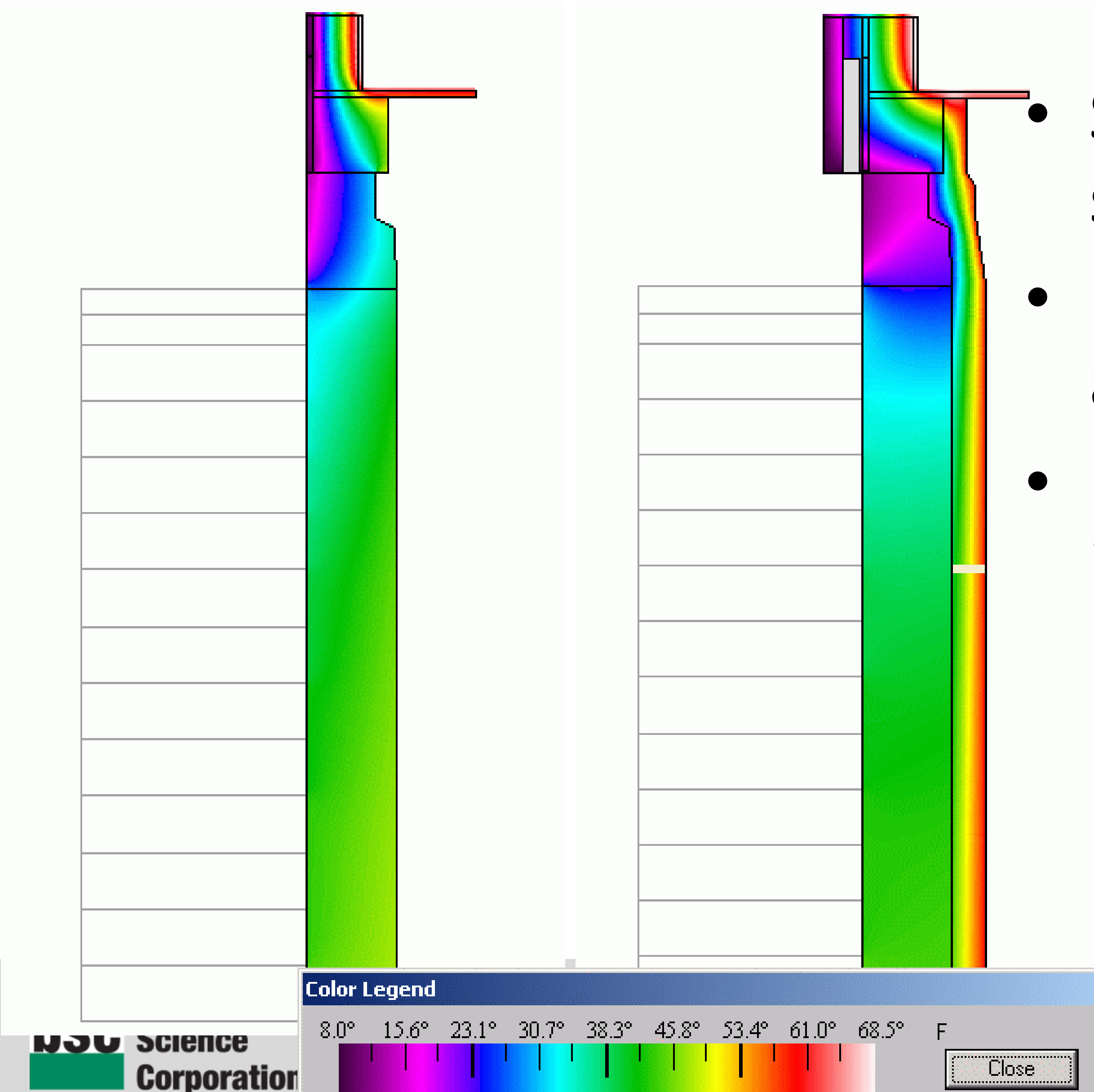
Sill Beam Moisture Durability

“This building has been around for the last 100 years…”

Sill Beam Moisture Durability



- Sill-to-foundation surface colder
- Less drying available
- Permeable insulation detail?

Sill Beam Moisture Risk Factors

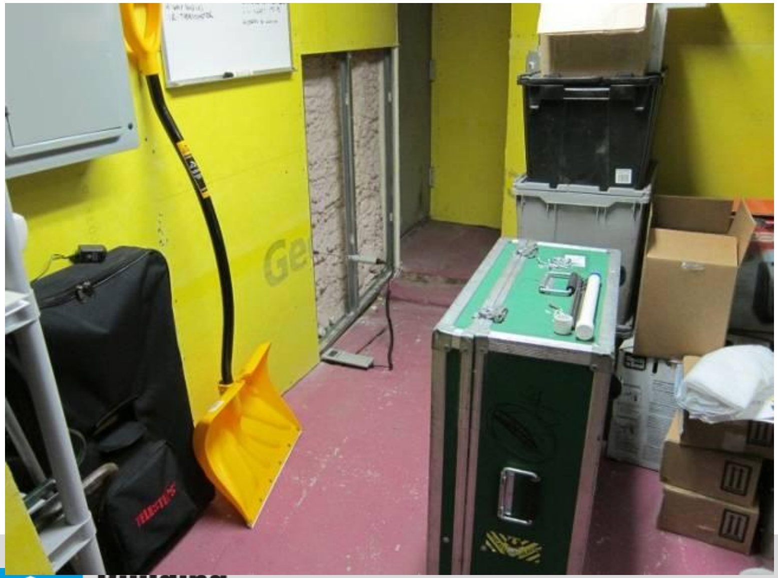
- Exterior water control features
- Capillary activity of foundation
- Magnitude of splashback
- Height of sill beam/rim joist above grade
- Drainage plane location
- Permeability of exterior

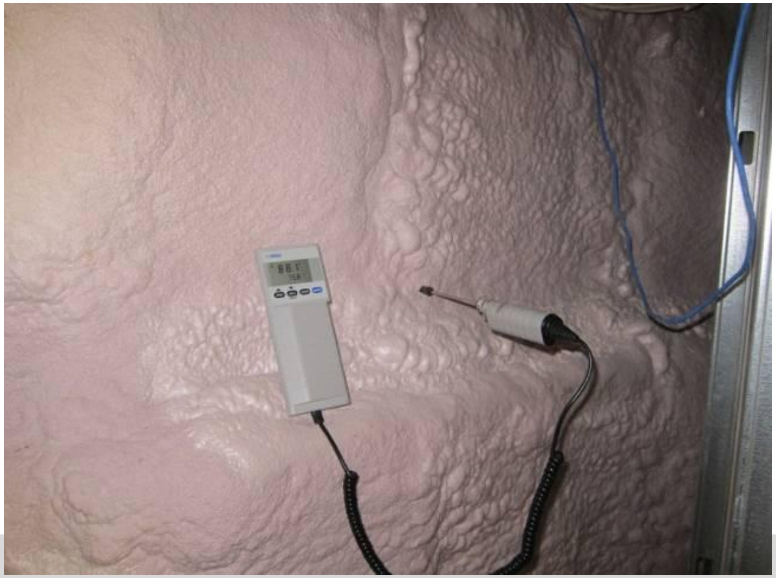
- Westford Barn retrofit sill beam example

Field Survey Work

Field Survey Work

- Existing foundation 1996 to 2009, Zone 5A
- Variety of interior ccSPF foundation insulation
- Temperatures and RHs
  - Basement/crawl space dewpoint vs. above grade
  - Behind foam ~80-90% consistently (not 100%)



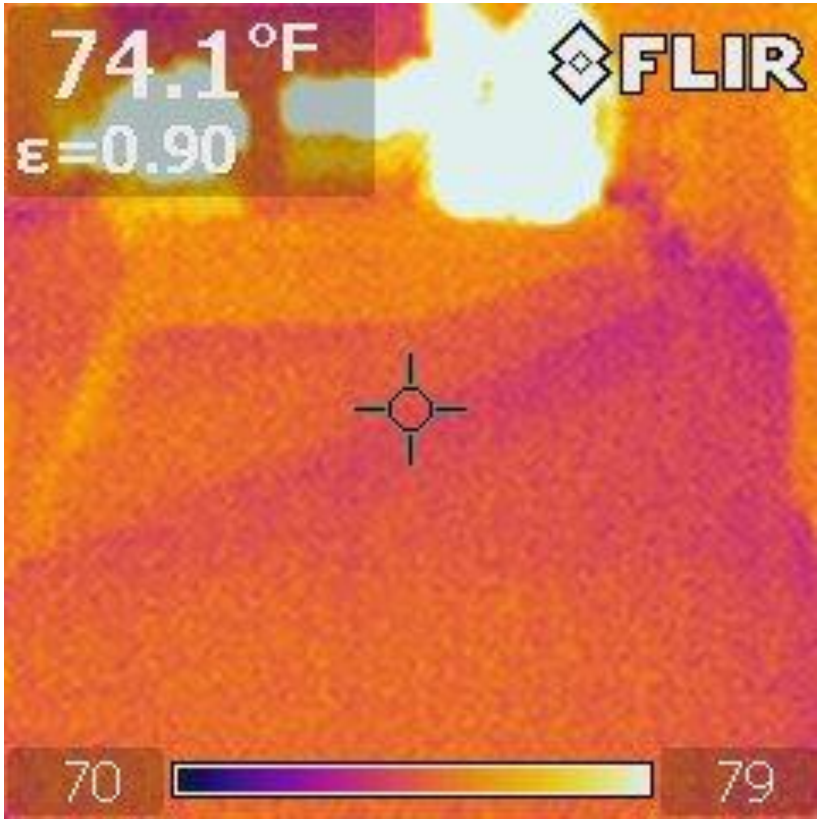


Field Survey Work

- Disassembly: no damage seen


- Rubble stone walls are not air barriers!


Field Survey Work



- Sub slab insulation reduces risk of moisture issues (carpets on slabs; cardboard boxes)

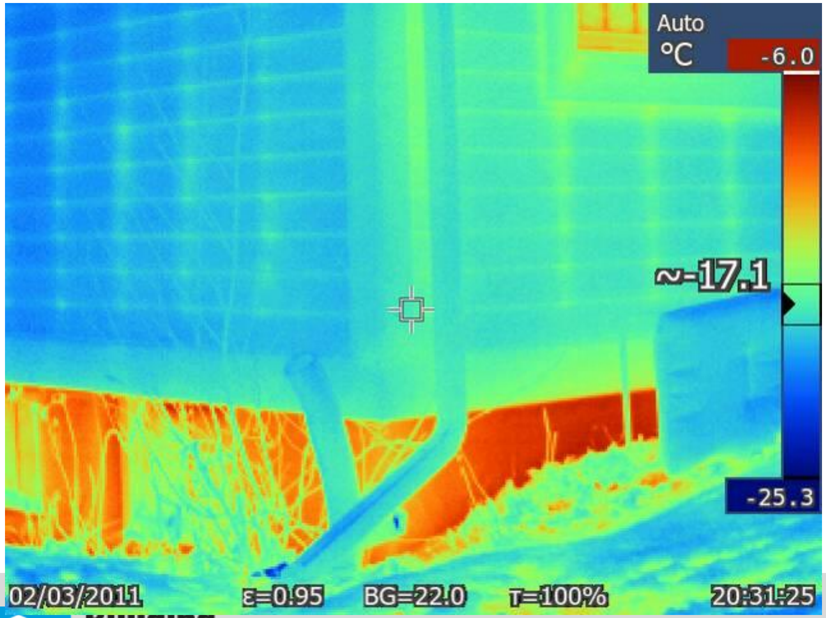
Field Survey Work

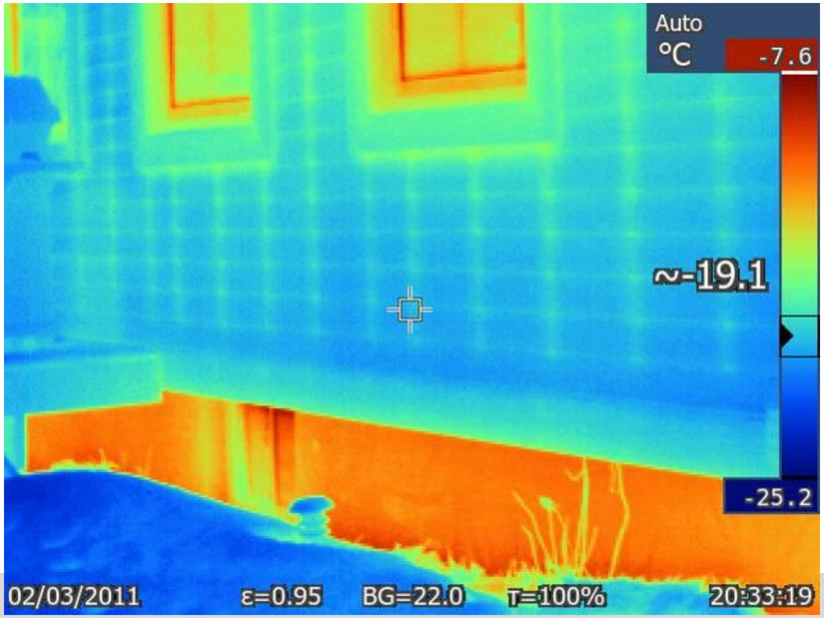
- Moisture contents uniformly in 8-13% range
- Limited survey

Additional Research: Foundation Surface Ts

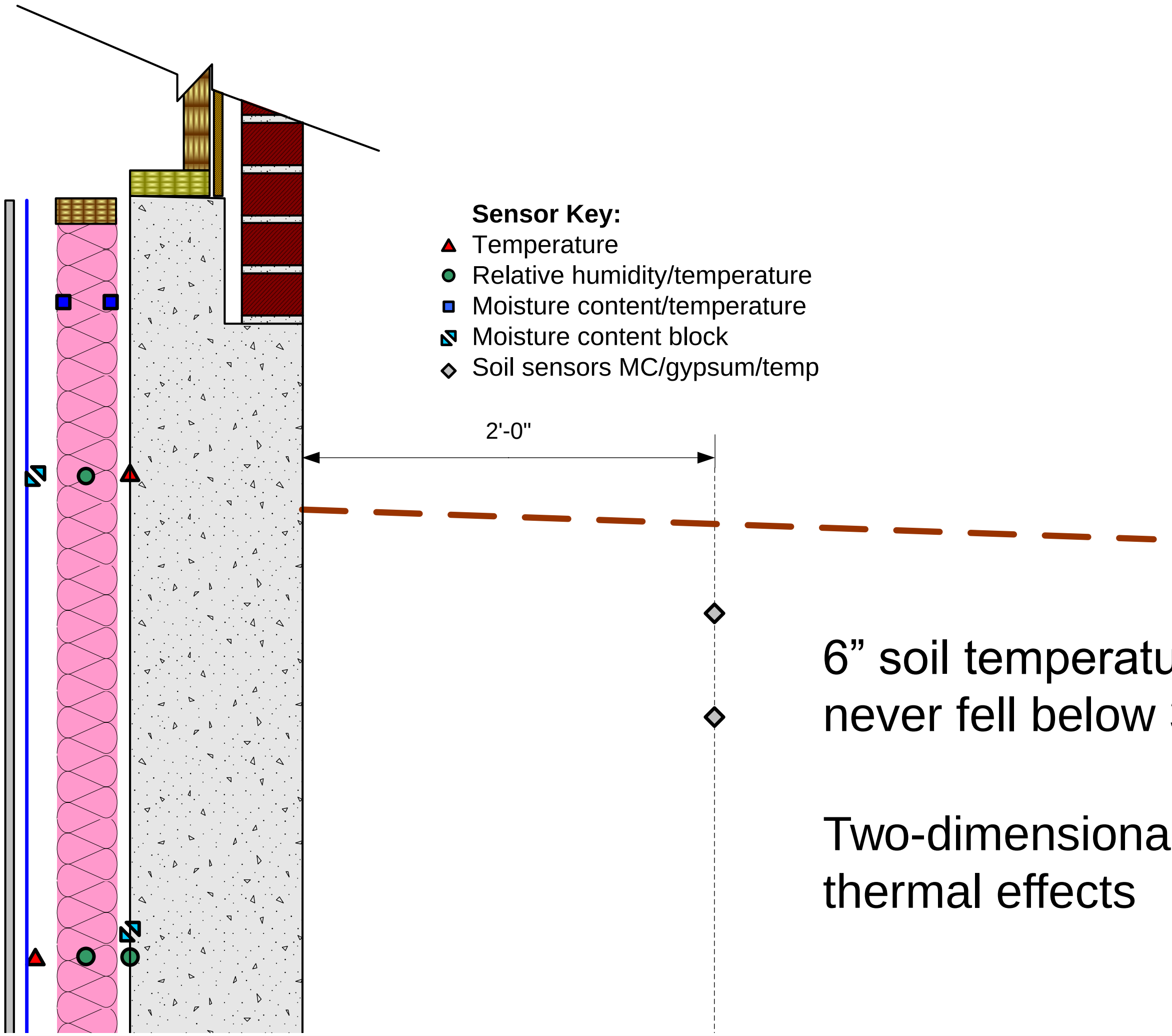
Concrete Surface Temperature

- Well insulated foundation (R-25)
- Above grade wall ~R-40
- Outdoor temperature -8 F (AM) to +23 F (PM)
- More than R value, solar exposure, thermal mass





Concrete Surface Temperature

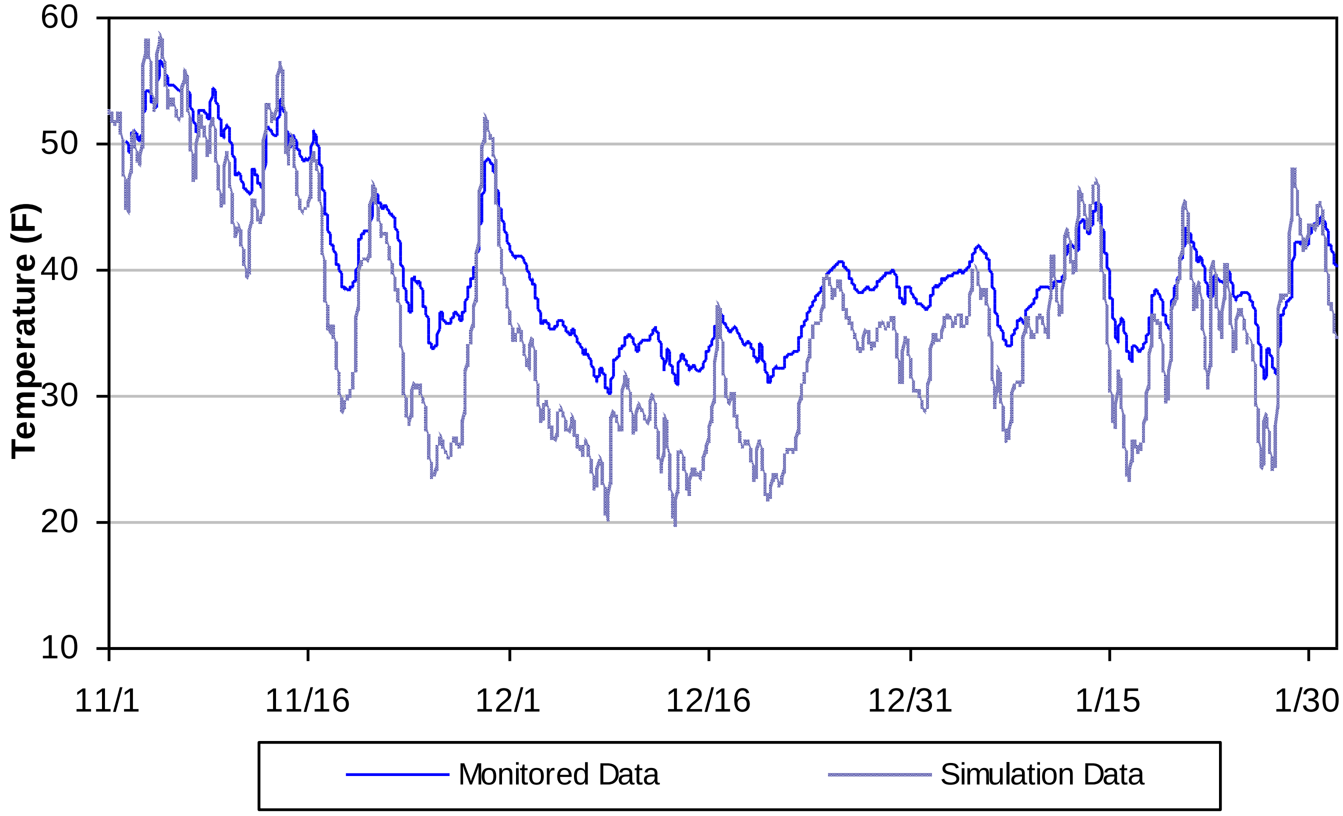


6" soil temperature never fell below 32° F

Two-dimensional thermal effects

Concrete Surface Temperature

Wintertime temperature moderated by soil coupling



Further Work

- Mature technology; extensive track record
- Frost damage to foundations in very cold (DOE Zones 6 & 7)—“Where is the edge?”
- Decision to use drainage layer—“historically dry” basement, etc.
- Efflorescence/mortar erosion—sufficiently slowed by reduced evaporation?
- Sill beam drying in interior retrofits; capillary break requirement guidelines?

Questions?

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This presentation is based research covered in BSC TO2 7.7 Hybrid Foundation Insulation