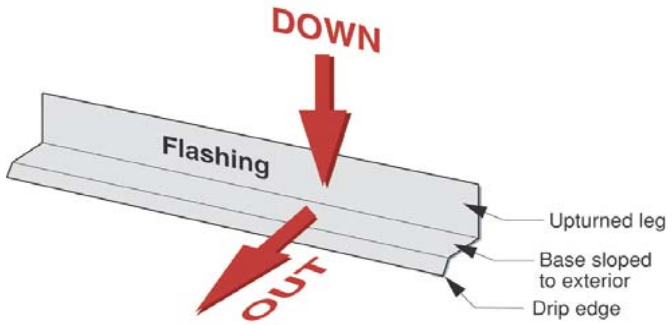
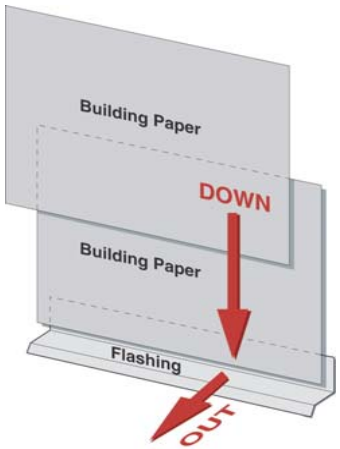
Joseph Lstiburek, Ph.D., P.Eng, ASHRAE Fellow

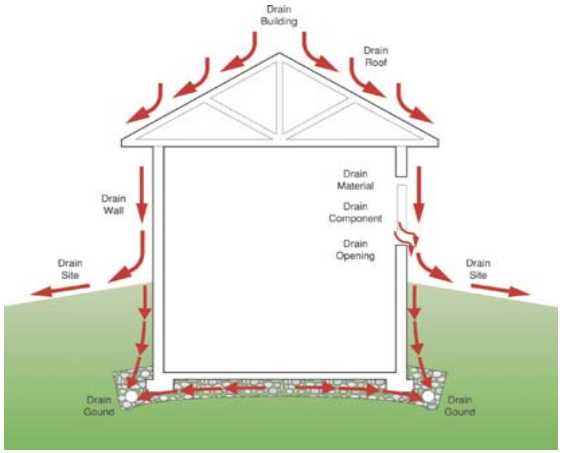
Building Science

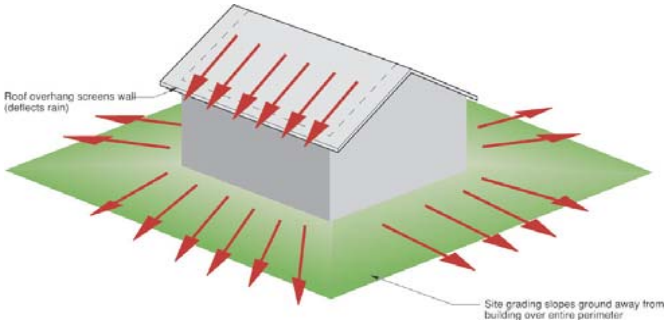
Adventures In Building Science

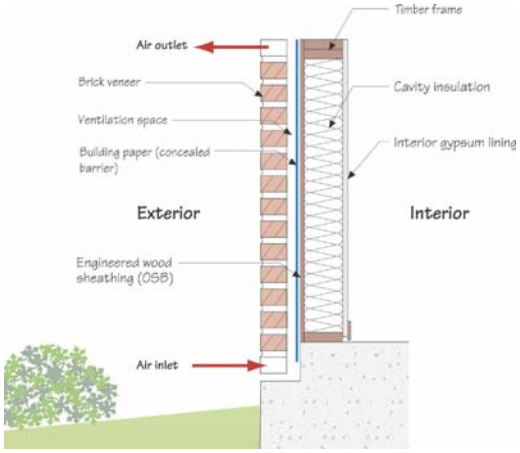
presented by www.buildingscience.com

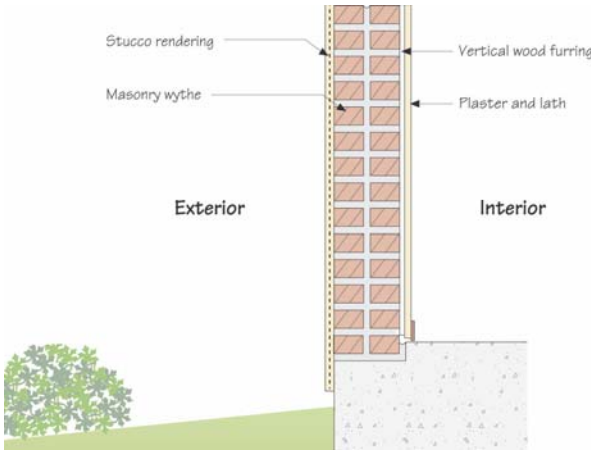

DOWN
Flashing
OUT
Upturned leg
Base sloped to exterior
Drip edge


Building Paper
DOWN
Building Paper
Flashing
OUT

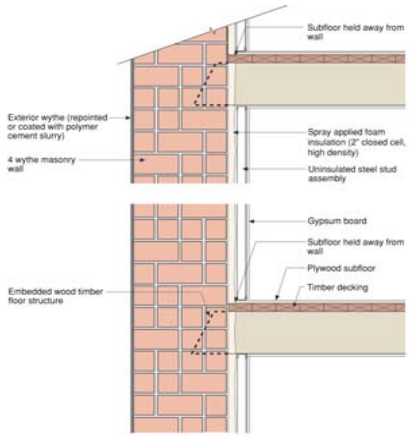

Drain Building
Drain Roof
Drain Material
Drain Component
Drain Opening
Drain Wall
Drain Site
Drain Site
Drain Gound
Drain Gound

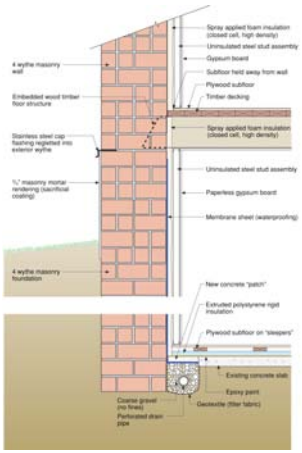

Roof overhang screens wall (deflects rain)
Site grading slopes ground away from building over entire perimeter

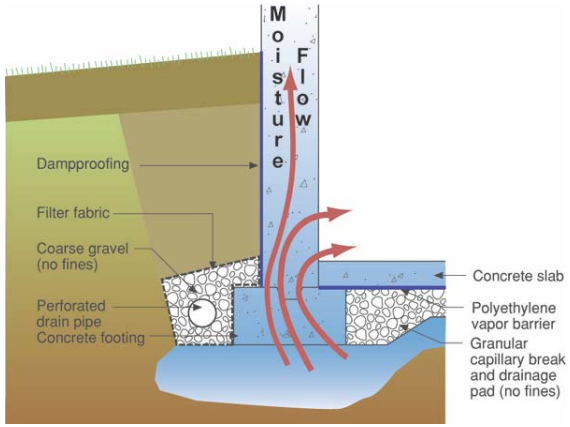

Timber frame
Air outlet
Brick veneer
Cavity insulation
Ventilation space
Interior gypsum lining
Building paper (concealed barrier)
Exterior
Interior
Engineered wood sheathing (OSB)
Air inlet

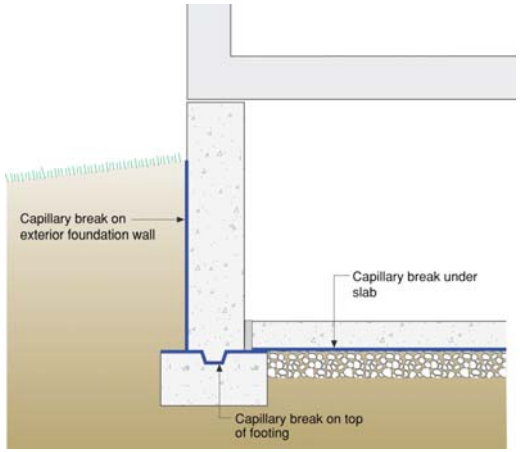

Stucco rendering
Masonry wythe
Vertical wood furring
Plaster and lath
Exterior
Interior


WEST SIDE VILLAGE
113 North 13th Street
An RPM Managed Community


Subfloor held away from wall
Exterior wythe (repointed or coated with polymer cement slurry)
Spray applied foam insulation (2" closed cell, high density)
4 wythe masonry wall
Uninsulated steel stud assembly
Gypsum board
Subfloor held away from wall
Plywood subfloor
Timber decking
Embedded wood timber floor structure


Spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board
Subfloor held away from wall
Plywood subfloor
Timber decking
4 wythe masonry wall
Embedded wood timber floor structure
Stainless steel cap flashing regleted into exterior wythe
Spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Paperless gypsum board
Membrane sheet (waterproofing)
4 wythe masonry foundation
New concrete "patch"
Extruded polystyrene rigid insulation
Plywood subfloor on "sleepers"
Existing concrete slab
Epoxy paint
Geotextile (filter fabric)
Coarse gravel (no fines)
Perforated drain pipe

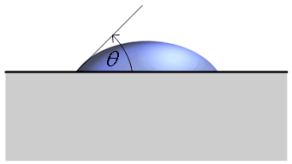




Surface Tension: Wettable

Water attracted to surface more than self

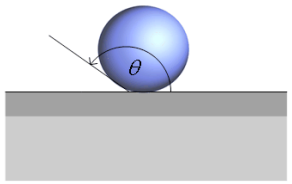
$\theta < 90^o$



normal material:
"wettable"

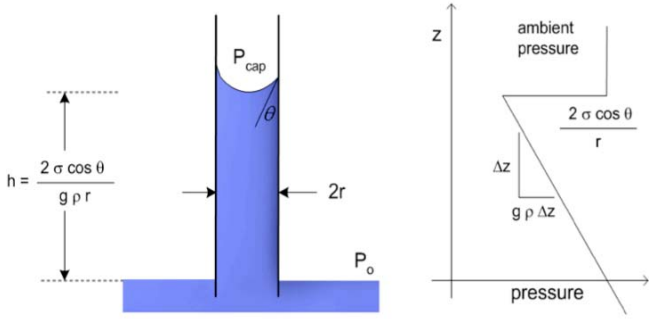
Water attracted to self more than surface

$\theta > 90^o$

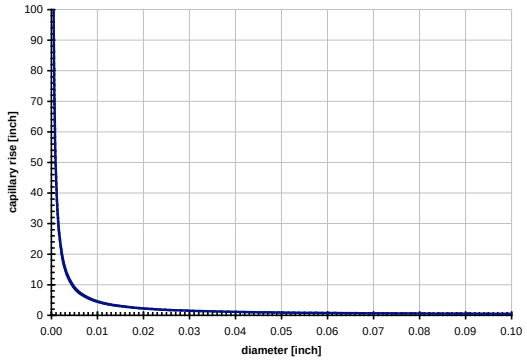


hydrophobically treated:
"non-wettable"

Calculating capillary rise

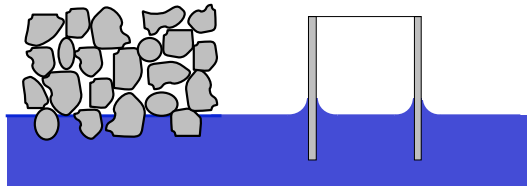


Capillary rise versus diameter



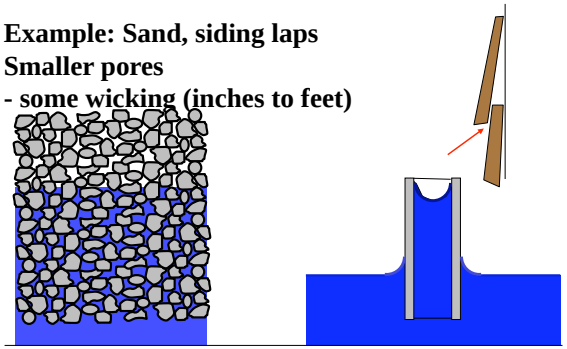
Capillary Flow

- Eg. : Crushed stone, air gaps
- large pores - no suction (“wicking”)



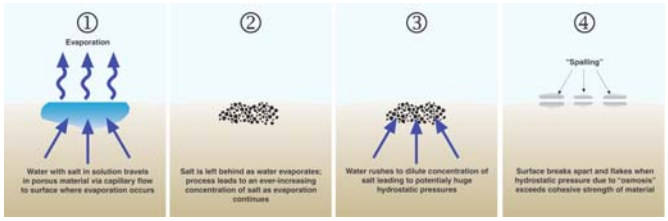
Capillary Flow

Example: Sand, siding laps
Smaller pores
- some wicking (inches to feet)



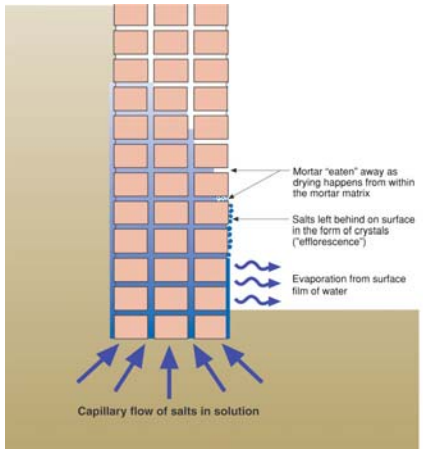
Capillarity + Salt = Osmosis

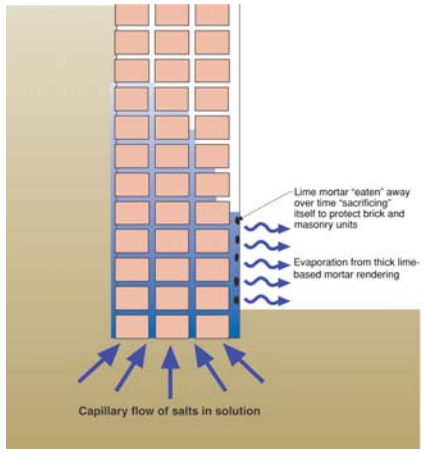
- Mineral salts carried in solution by capillary water
- When water evaporates from a surface the salts left behind form crystals in process called efflorescence
- When water evaporated beneath a surface the salts crystallize within the pore structure of the material in called sub-efflorescence
- The salt crystallization causes expansive forces that can exceed the cohesive strength of the material leading to spalling



Diffusion + Capillarity + Osmosis = Problem

- Diffusion Vapor Pressure 3 to 5 psi
- Capillary Pressure 300 to 500 psi
- Osmosis Pressure 3,000 to 5,000 psi


Mortar "eaten" away as drying happens from within the mortar matrix
Salts left behind on surface in the form of crystals ("efflorescence")
Evaporation from surface film of water
Capillary flow of salts in solution


Lime mortar "eaten" away over time "sacrificing" itself to protect brick and masonry units
Evaporation from thick lime-based mortar rendering
Capillary flow of salts in solution


KAMENOSOCHAŘSTVÍ - RESTAURÁTORSTVÍ
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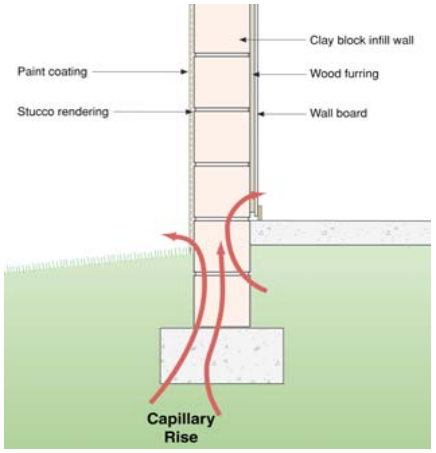
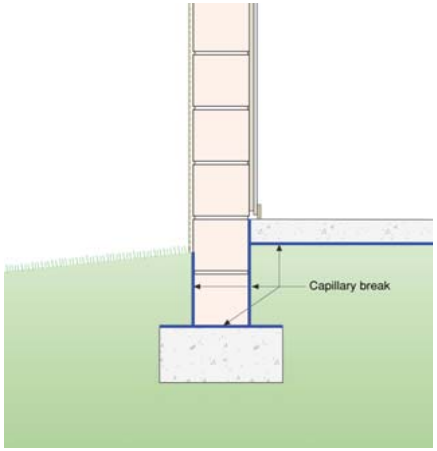
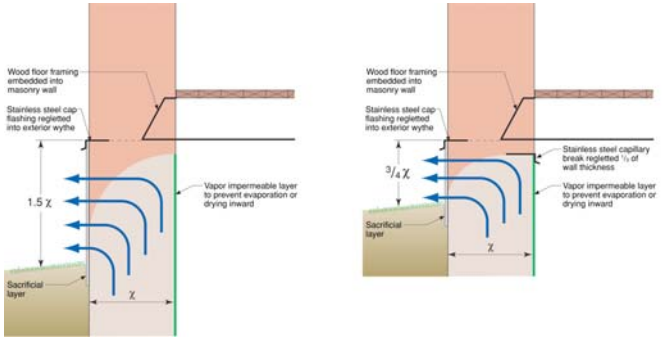
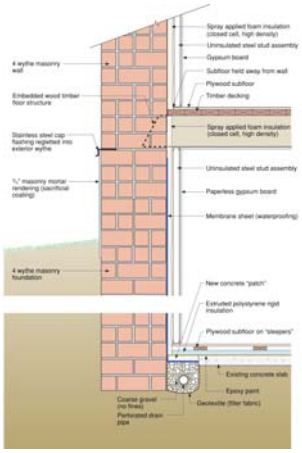
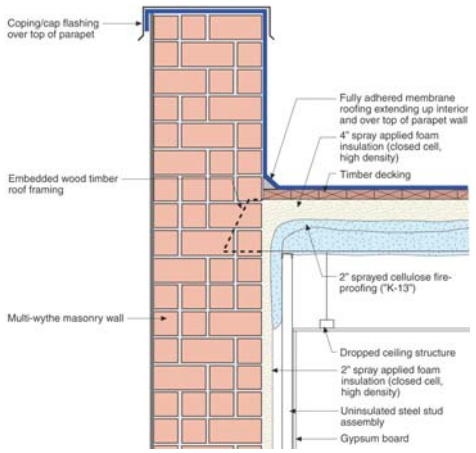
tel. 602 341 965, tel./fax 323 602 942
mail panekkamen@atlas.cz, www.panek-kamen.cz

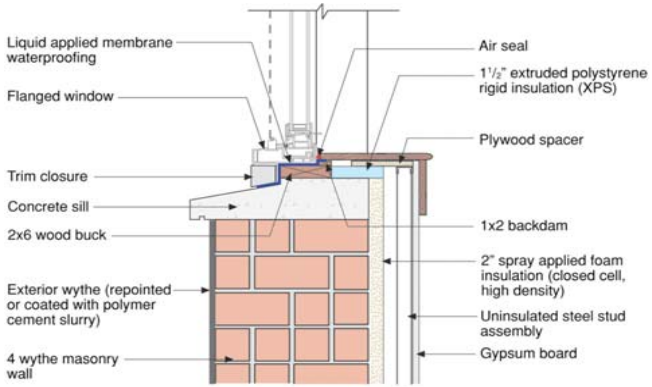

Clay block infill wall
Paint coating
Wood furring
Stucco rendering
Wall board
Capillary Rise

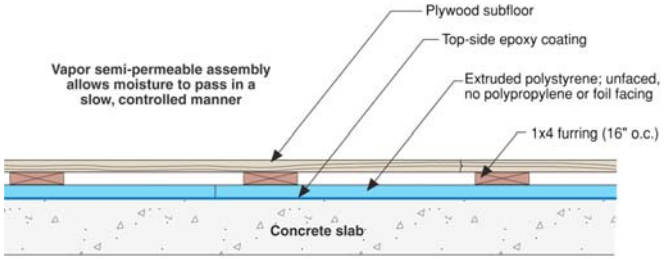

Capillary break

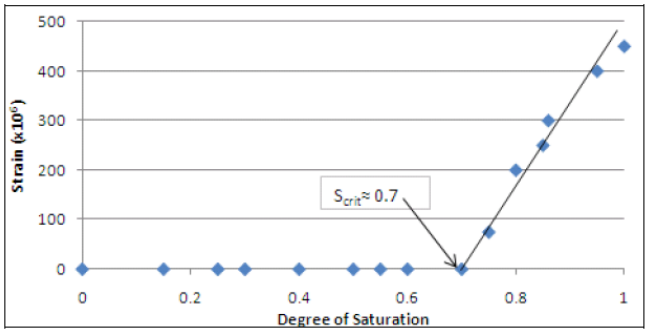

Wood floor framing embedded into masonry wall
Stainless steel cap flashing reglefted into exterior wythe
1.5 χ
Vapor impermeable layer to prevent evaporation or drying inward
Sacrificial layer
χ
Wood floor framing embedded into masonry wall
Stainless steel cap flashing reglefted into exterior wythe
3/4 χ
Stainless steel capillary break reglefted 1/3 of wall thickness
Vapor impermeable layer to prevent evaporation or drying inward
Sacrificial layer
χ



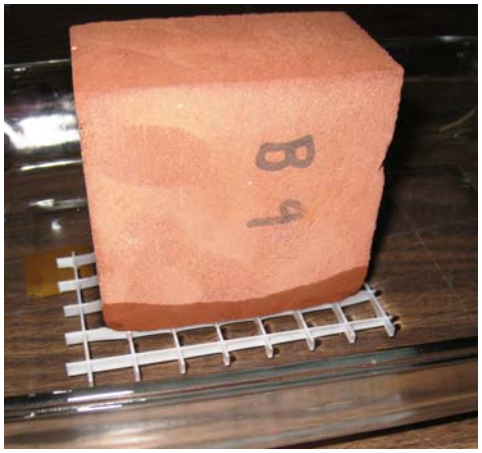

Coping/cap flashing over top of parapet
Fully adhered membrane roofing extending up interior and over top of parapet wall
4" spray applied foam insulation (closed cell, high density)
Timber decking
Embedded wood timber roof framing
2" sprayed cellulose fire-proofing ("K-13")
Multi-wythe masonry wall
Dropped ceiling structure
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board

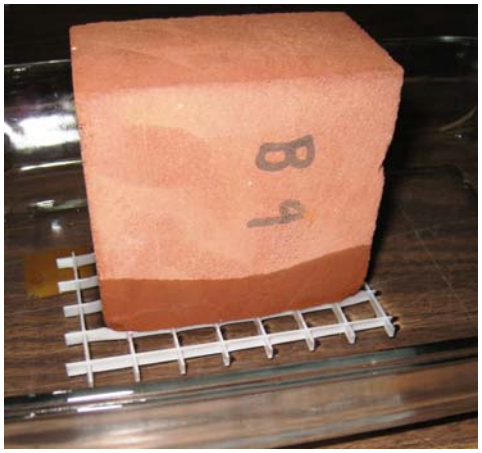

Liquid applied membrane waterproofing
Flanged window
Trim closure
Concrete sill
2x6 wood buck
Exterior wythe (repointed or coated with polymer cement slurry)
4 wythe masonry wall
Air seal
1½" extruded polystyrene rigid insulation (XPS)
Plywood spacer
1x2 backdam
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board

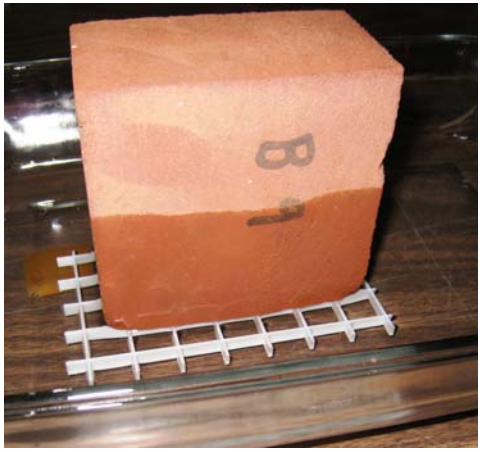

Plywood subfloor
Top-side epoxy coating
Vapor semi-permeable assembly allows moisture to pass in a slow, controlled manner
Extruded polystyrene; unfaced, no polypropylene or foil facing
1x4 furring (16" o.c.)
Concrete slab

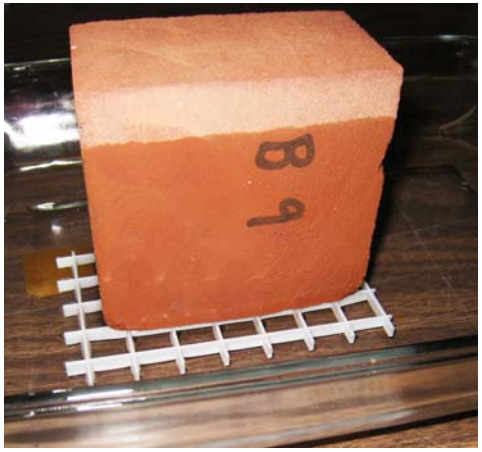

500
400
300
200
100
0
Strain (x10⁶)
0
0.2
0.4
0.6
0.8
1
Degree of Saturation
$S_{crit} \approx 0.7$

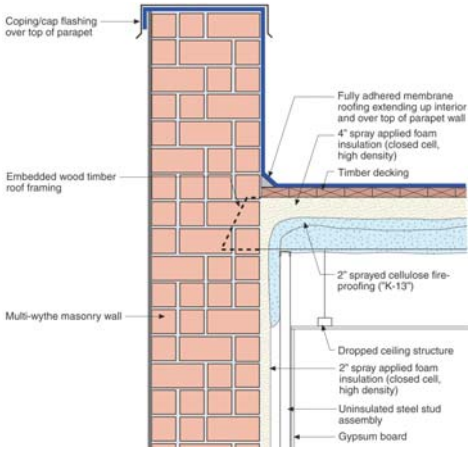

384295

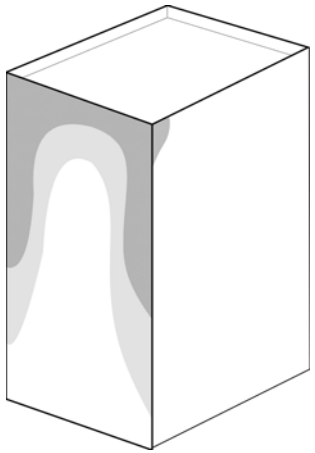

B 9

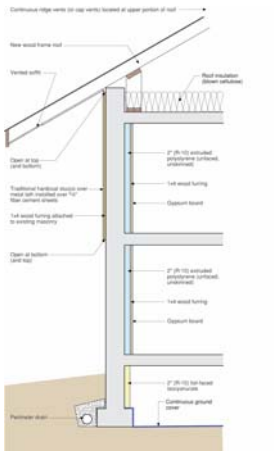

B 9

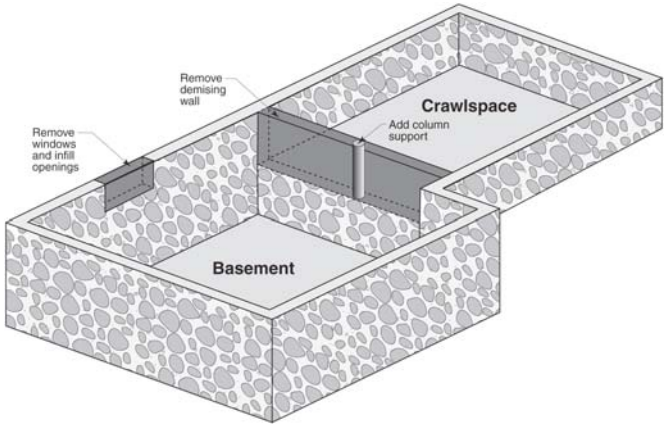

B 9

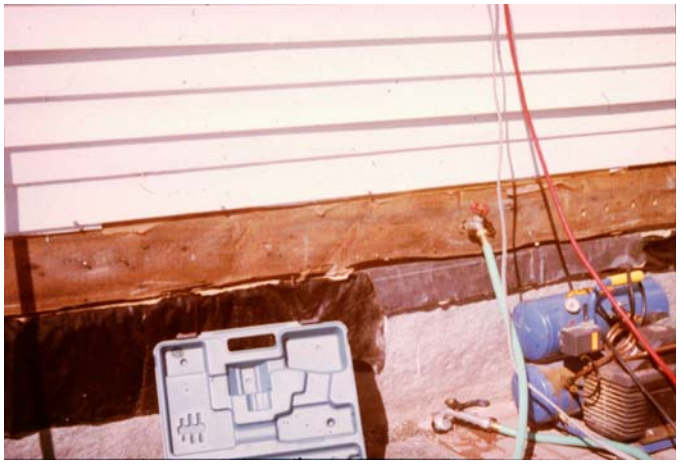

B 9

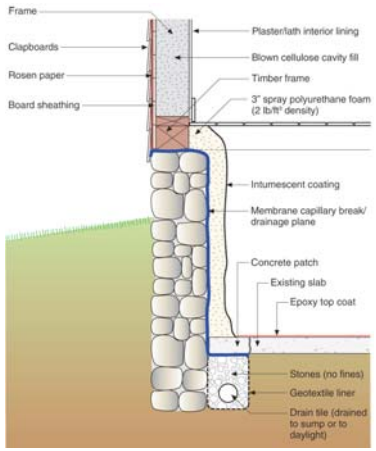

Coping/cap flashing over top of parapet
Fully adhered membrane roofing extending up interior and over top of parapet wall
4" spray applied foam insulation (closed cell, high density)
Timber decking
Embedded wood timber roof framing
2" sprayed cellulose fire-proofing ("K-13")
Multi-wythe masonry wall
Dropped ceiling structure
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board





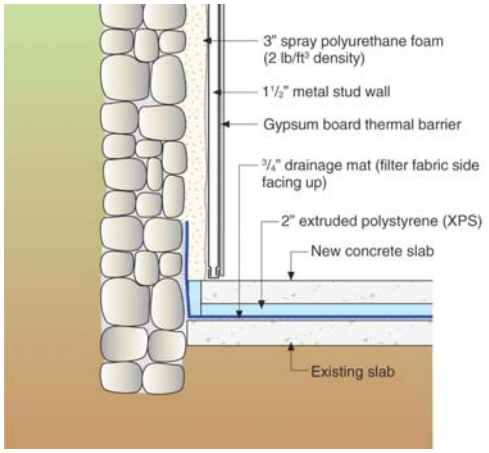

Remove demising wall
Crawlspace
Add column support
Remove windows and infill openings
Basement

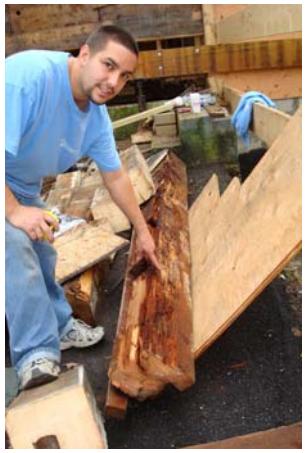


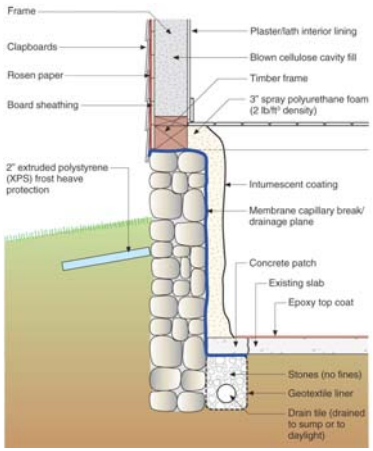

Frame
Clapboards
Rosen paper
Board sheathing
Plaster/lath interior lining
Blown cellulose cavity fill
Timber frame
3" spray polyurethane foam (2 lb/ft³ density)
Intumescent coating
Membrane capillary break/ drainage plane
Concrete patch
Existing slab
Epoxy top coat
Stones (no fines)
Geotextile liner
Drain tile (drained to sump or to daylight)

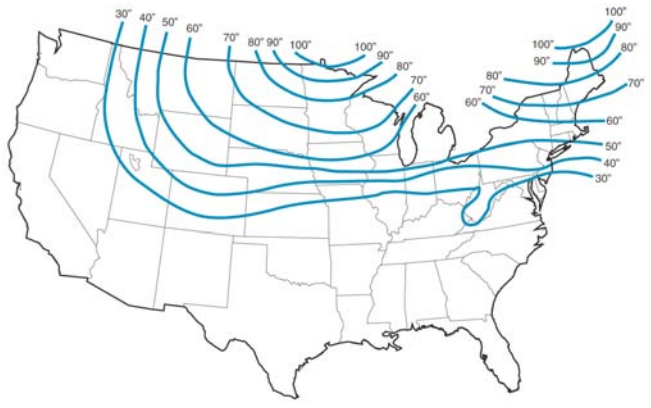

GRACE

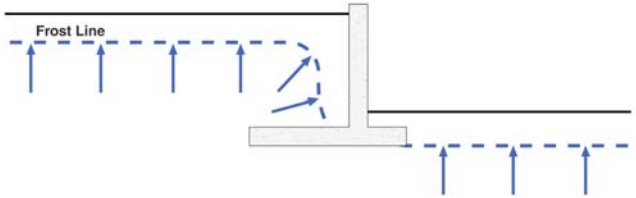

GRACE

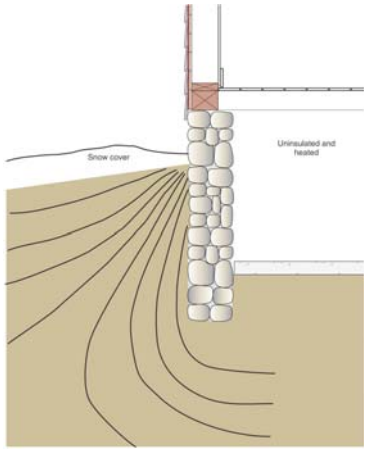

3" spray polyurethane foam
(2 lb/ft³ density)
1½" metal stud wall
Gypsum board thermal barrier
¾" drainage mat (filter fabric side
facing up)
2" extruded polystyrene (XPS)
New concrete slab
Existing slab

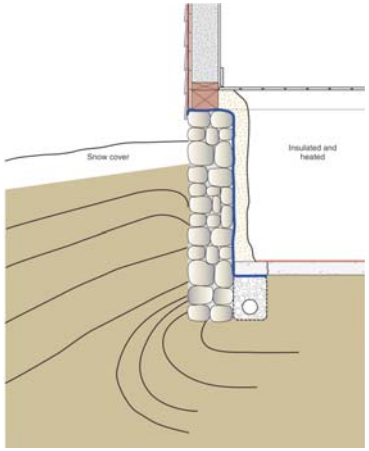


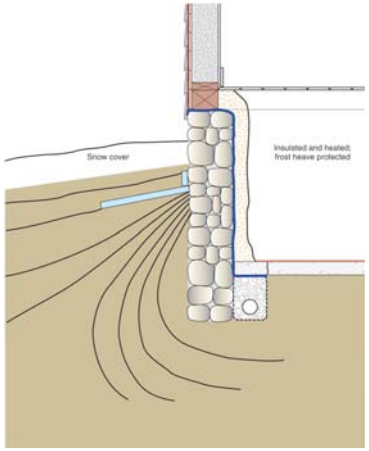

Frame
Clapboards
Rosen paper
Board sheathing
2" extruded polystyrene (XPS) frost heave protection
Plaster/lath interior lining
Blown cellulose cavity fill
Timber frame
3" spray polyurethane foam (2 lb/ft³ density)
Intumescent coating
Membrane capillary break/ drainage plane
Concrete patch
Existing slab
Epoxy top coat
Stones (no fines)
Geotextile liner
Drain tile (drained to sump or to daylight)

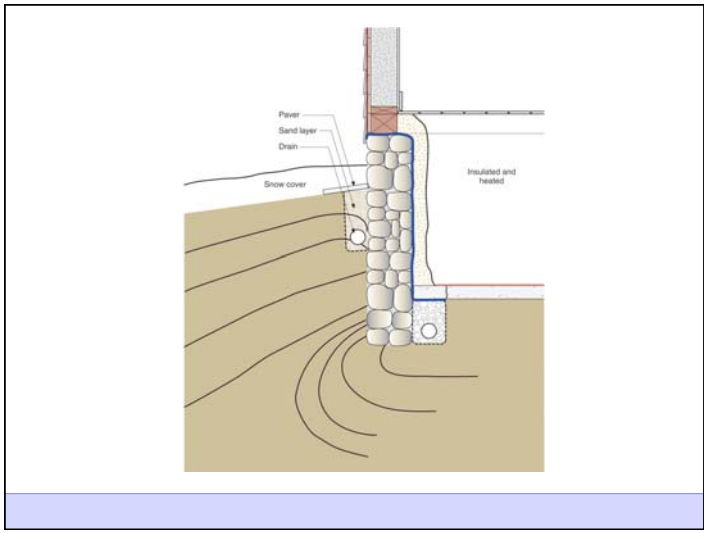

30"
40"
50"
60"
70"
80"
90"
100"
From the US Army Corps Engineers Extreme Frost Penetration
(in inches) based on state averages.

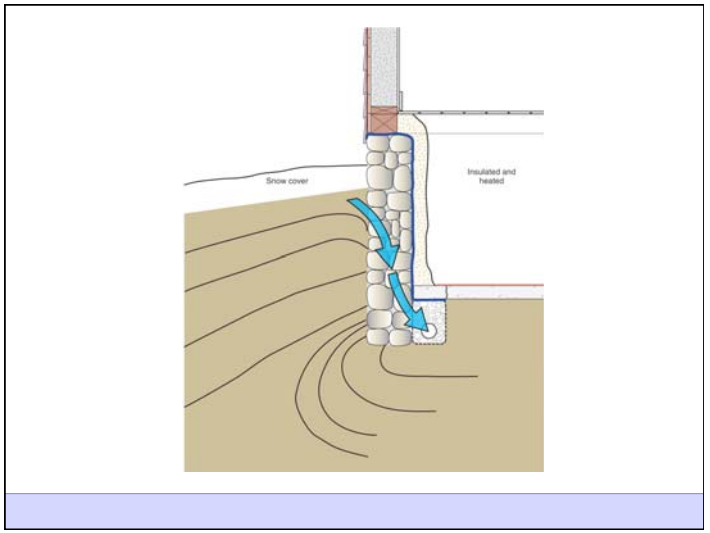

Frost Line

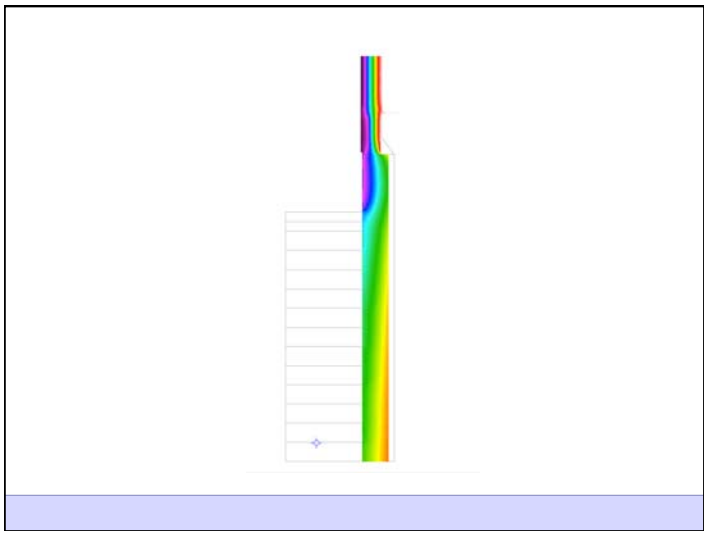

Snow cover
Uninsulated and heated

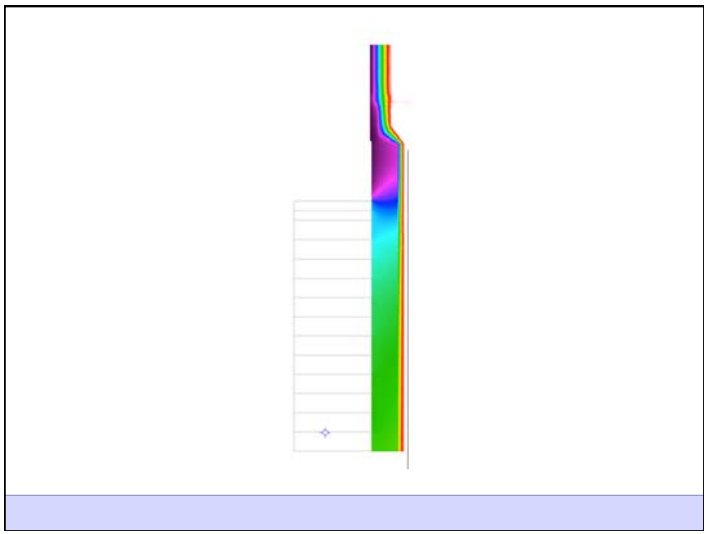

Snow cover
Insulated and heated


Snow cover
Insulated and heated; frost heave protected


Paver
Sand layer
Drain
Snow cover
Insulated and heated


Snow cover
Insulated and heated



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