Joseph Lstiburek, Ph.D., P.Eng

Building Science

Some Interesting Stuff on Slabs

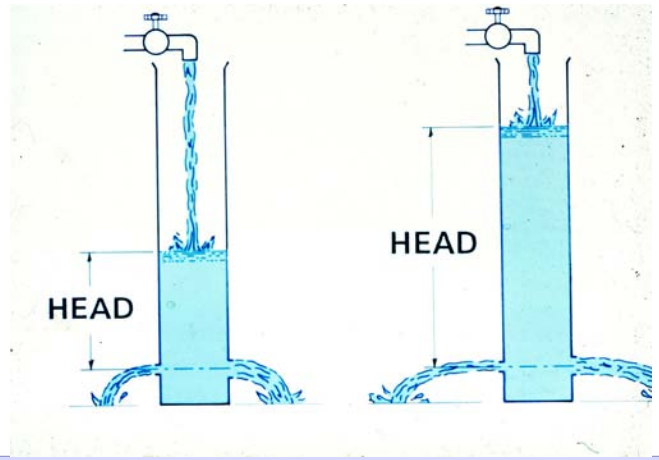
presented by www.buildingscience.com

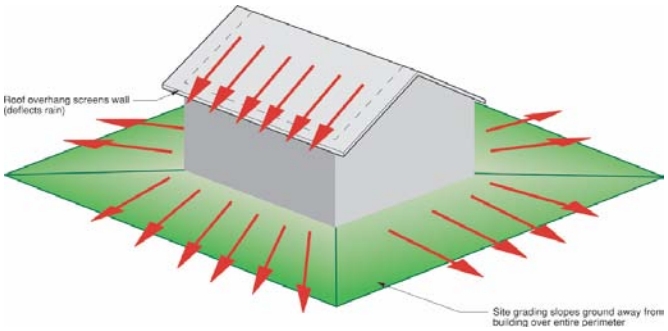
Water Flow Through Slab

- From under the slab
- From the edge of the slab
- From the slab itself

Mechanisms of Flow

• Liquid	Bulk	Hydrostatic Pressure
	Capillary	Concentration Gradient
	Osmosis	Concentration Gradient
• Vapor	Diffusion	Vapor Pressure
	Air Transport	Air Pressure





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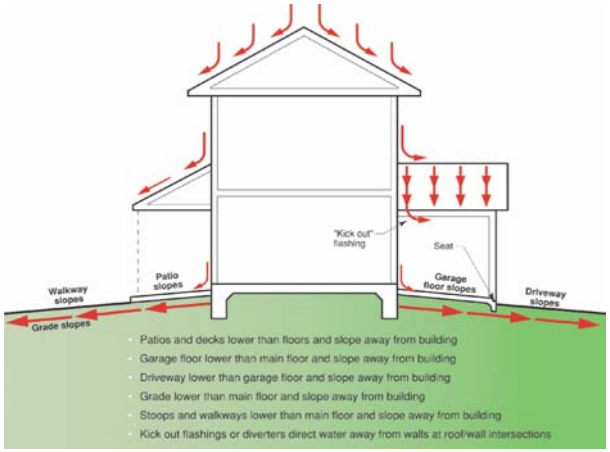

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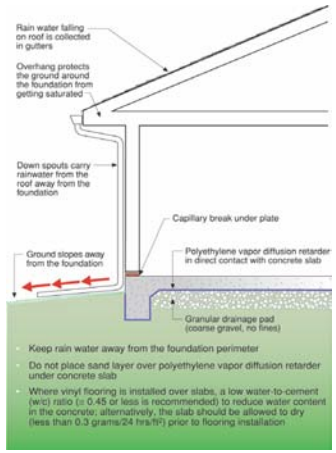

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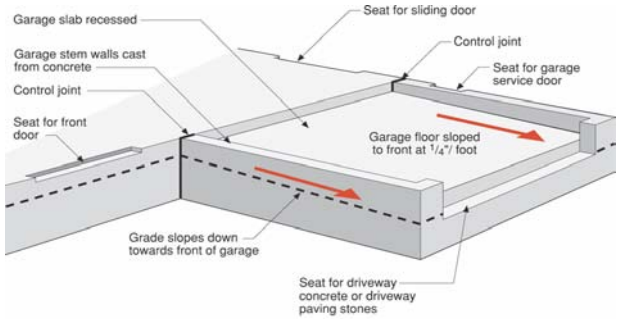

- Garage floor lower than main floor and slopes away from building
- Garage door area recessed to prevent water entry
- Entry doors recessed to prevent water entry
- Stem walls cast from concrete, not constructed with masonry

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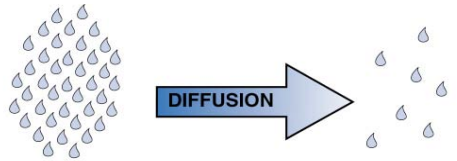

Higher Dewpoint Temperature
Higher Water Vapor Density
or Concentration
(Higher Vapor Pressure)
on Warm Side of Assembly

Low Dewpoint Temperature
Lower Water Vapor Density
or Concentration
(Lower Vapor Pressure)
on Cold Side of Assembly

Higher Air
Pressure

Lower Air
Pressure

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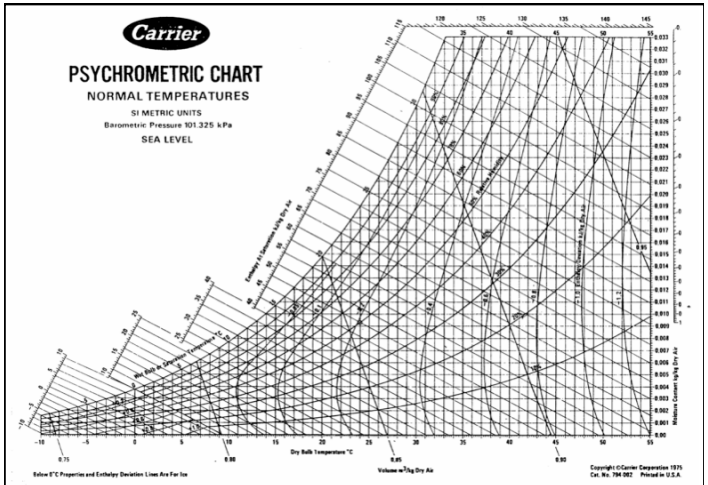

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Fick's Law (Fourier's Law) "direct functions"

Heat Flow
$Q = A \cdot u \cdot t \cdot \text{delta } T$

Vapor Flow
$M = A \cdot u \cdot t \cdot \text{delta } P_v$

A = surface area
u = thermal conductance
T = temperature
U = permeance
P_v= vapor pressure

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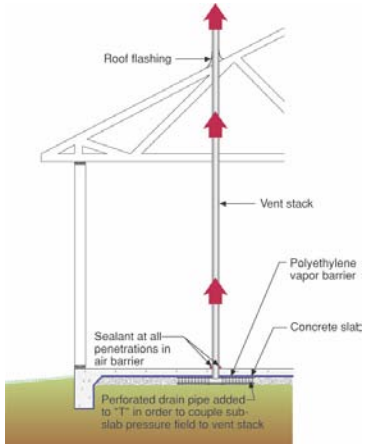

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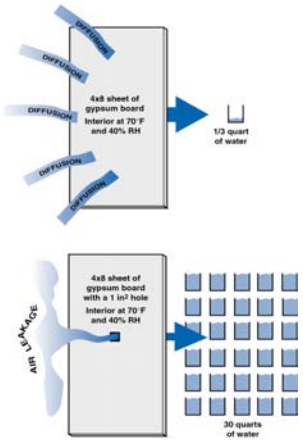

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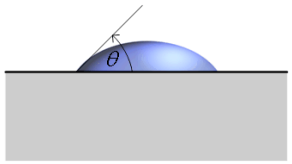
Surface Tension: Wettable

Water attracted to surface more than self

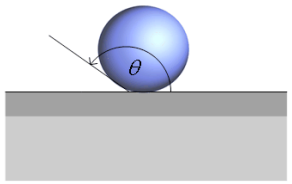
$\theta < 90^o$



normal material:
"wettable"

Water attracted to self more than surface

$\theta > 90^o$



hydrophobically treated:
"non-wettable"

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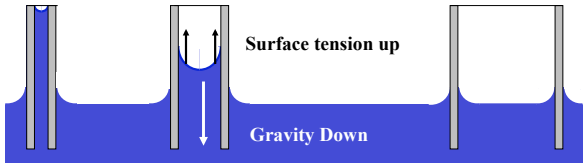
Capillary Pressures

- Result of surface tension = attraction to surfaces
  - pressure varies with pore size
  - e.g., height rise in a glass tube



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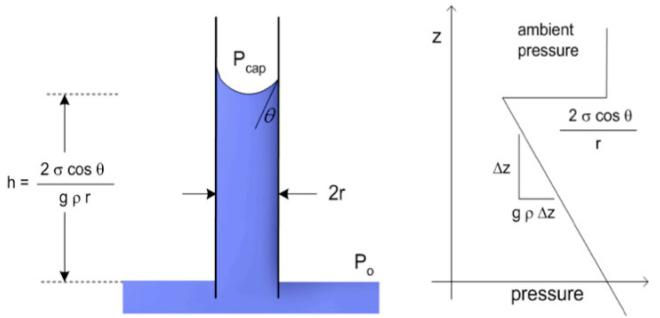
Calculating capillary rise



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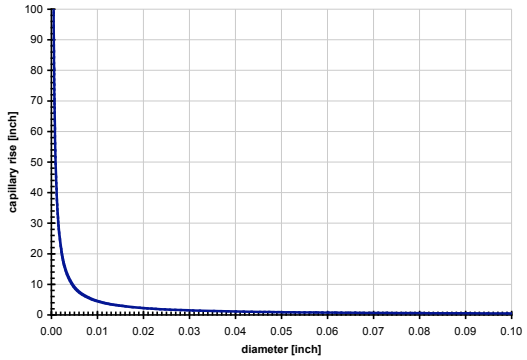
Capillary rise versus diameter



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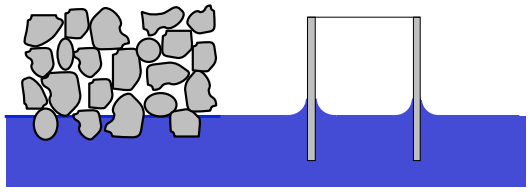
Capillary Flow

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



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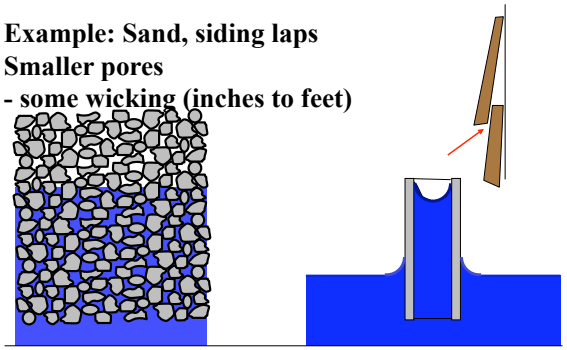
Capillary Flow

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



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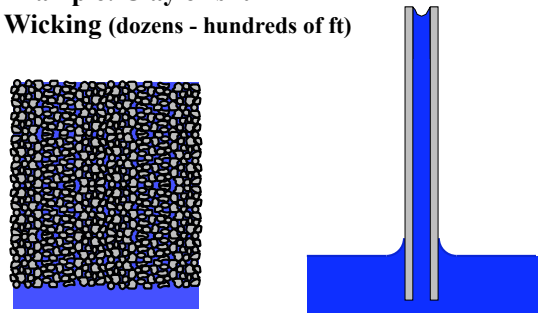
Capillary Flow- concrete sucks

Example: Clay or silt
Wicking (dozens - hundreds of ft)



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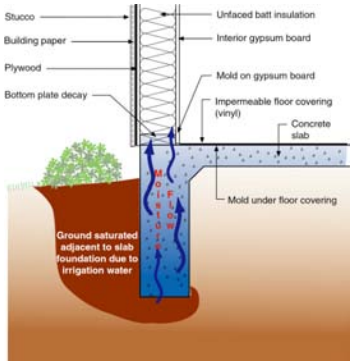
Capillary Moisture Flow



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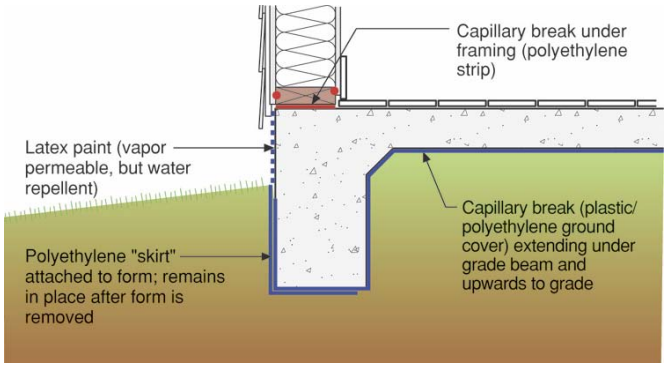

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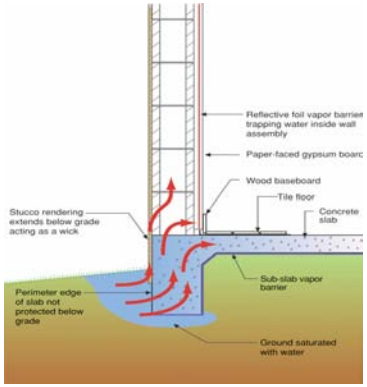

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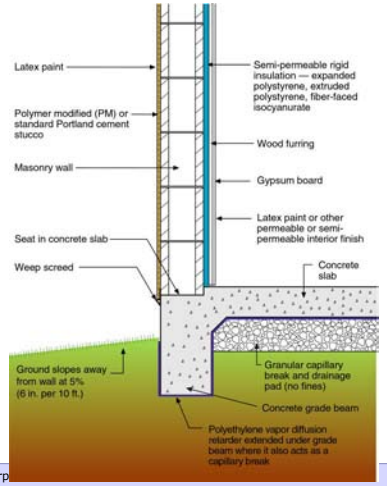

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Capillarity + Salt = Osmosis

- 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

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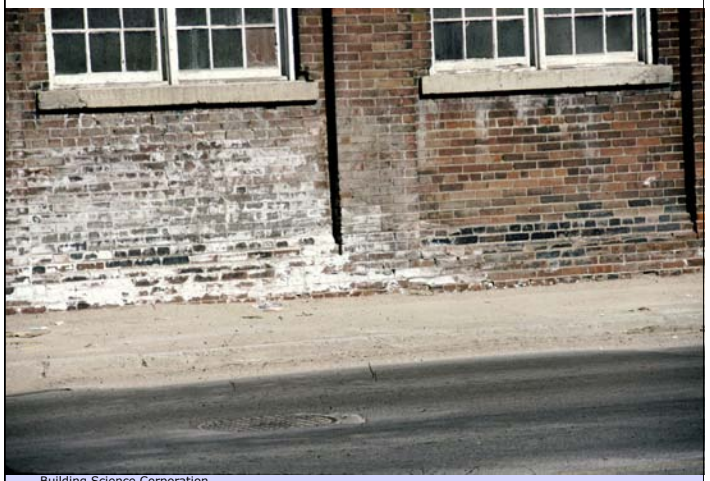

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Diffusion + Capillarity + Osmosis = Problem

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

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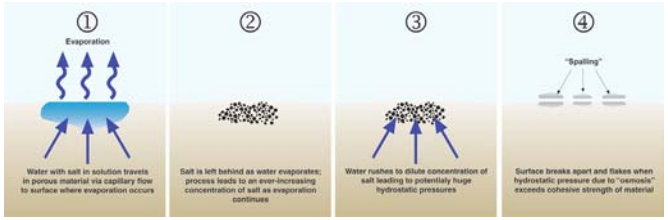

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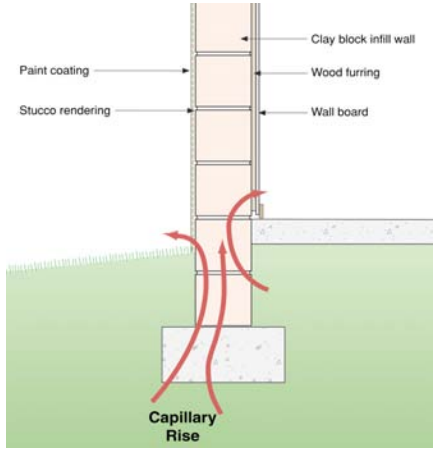

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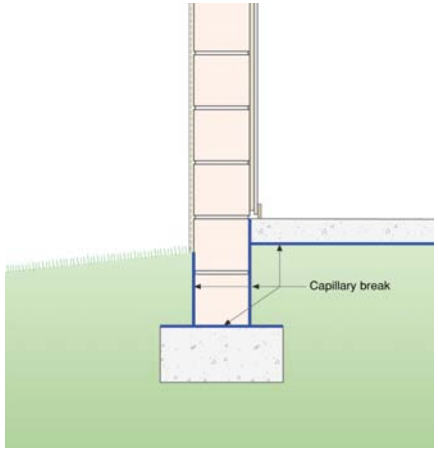

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Sand Layer = Problem

- Desiccates slab
- Creates reservoir
- Prevents drainage
- Exacerbates capillary wicking
- Negates vapor barrier

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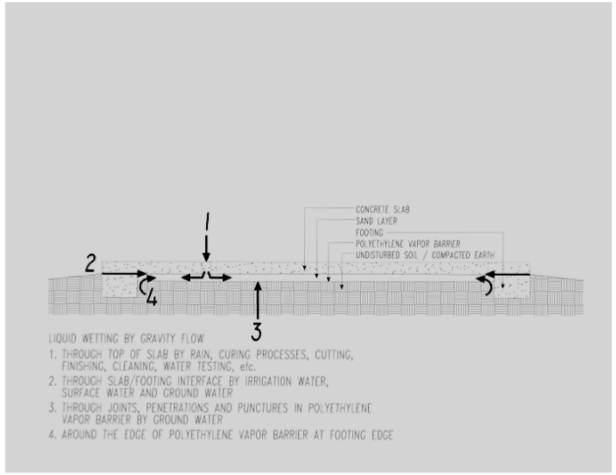

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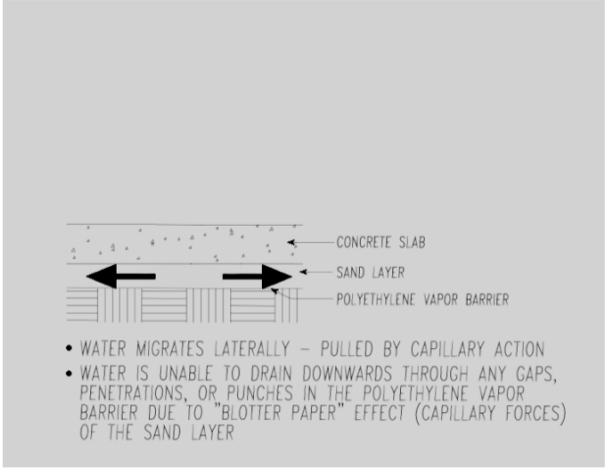

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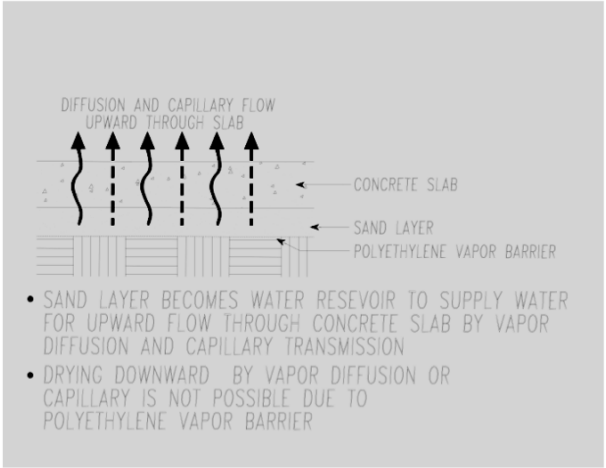

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Sand Layer = Never Needed It

- Control of cracking by soaking up excess mix water (use less water)
- Control of slab curl by soaking up excess mix water (use less water)
- Protects poly by reducing punctures (punctures don't matter if air flow doesn't occur - use concrete as air barrier)
- Allows finishing to occur faster by soaking up excess mix water (use less water)

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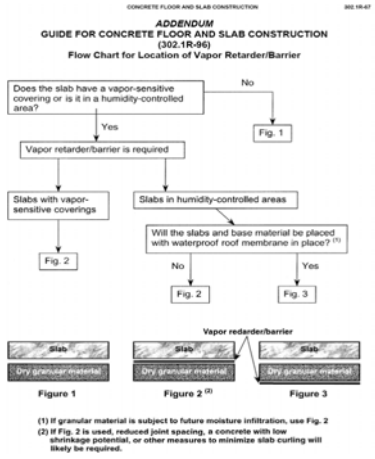

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Less Water in Concrete, No Sand Layer, Polyethylene Wrapped Around Slab Edge and Polyethylene Capillary Break Under All Plates

- Water-to-cement ratio of 0.45
- Mid range water reducer (Polyheed, Daracem, Mira)
- Fly ash is recommended - actually required in many regions for sulfate resistance and corrosion resistance ("Type F" up to 30 percent may be used)
- Good things happen
- Lower permeability
- Increased sulfate resistance
- Reduced shrinkage and cracking
- Reduced curl
- Increased corrosion resistance
- Strength can be used as a surrogate for w/c ratio (4,000 psi) for field verification

Continuous Wet Cure For 72 hours -When You Need It You Don't Always Need It - Pick Your Spots

- Necessary for dry windy hot months out west - June through October for CA, AZ, NV
- Dam the slab - pond water on top of slab
- Use burlap and keep it wet - can be covered with polyethylene
- Nothing is better than a continuous wet cure - nothing, nothing, nothing
- Curing compounds don't work - the good ones were banned
- Consider also using control joints or polypropylene mesh to control shrinkage cracking
- To get low water-to-cement ratio, don't just add cement - just adding cement increases shrinkage cracking
- Use combination of mid-range water reducer, increased cement content and fly ash
- Fly ash replaces cement and doesn't react immediately so that sufficient water is available to finish slab - finishing slabs becomes very difficult with w/c ratios below 0.45 - the fly ash kicks in later

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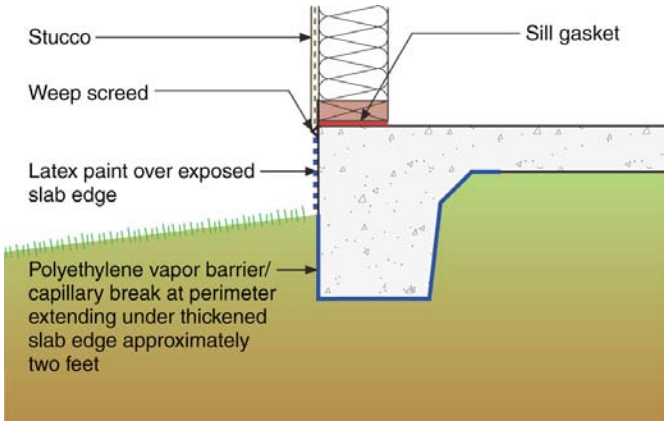

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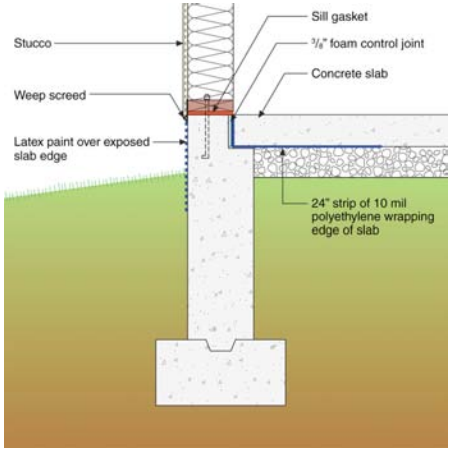

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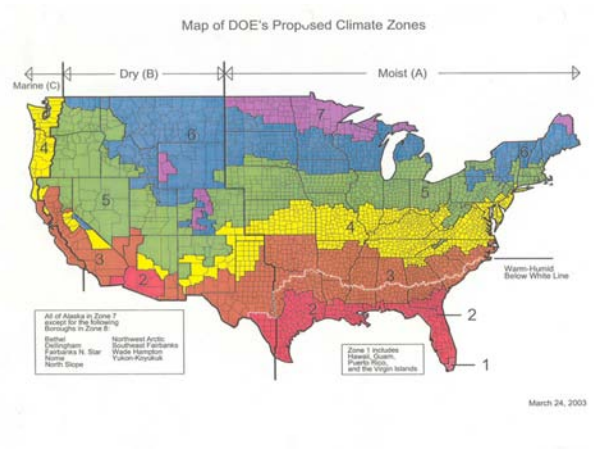

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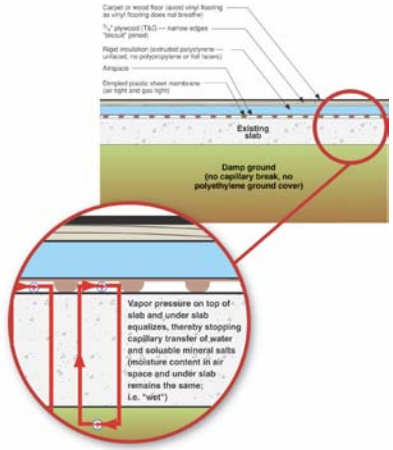

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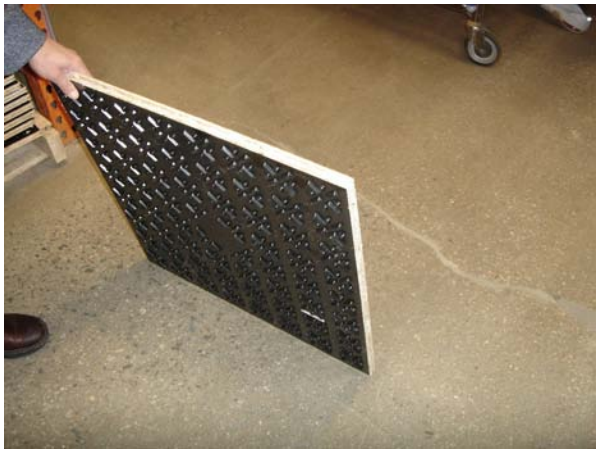

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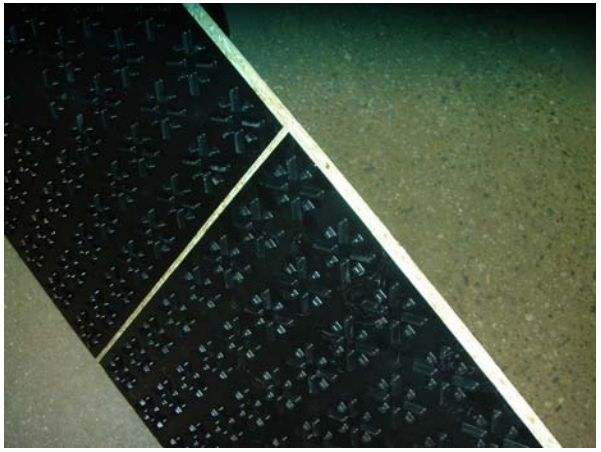

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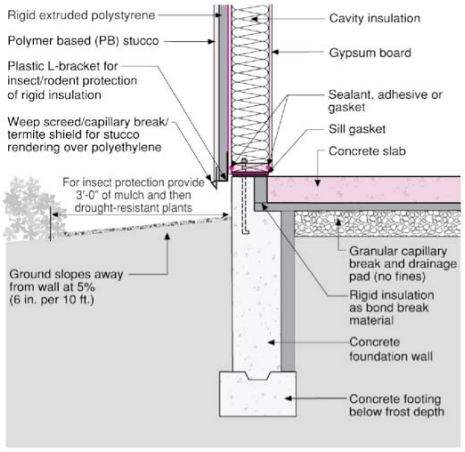

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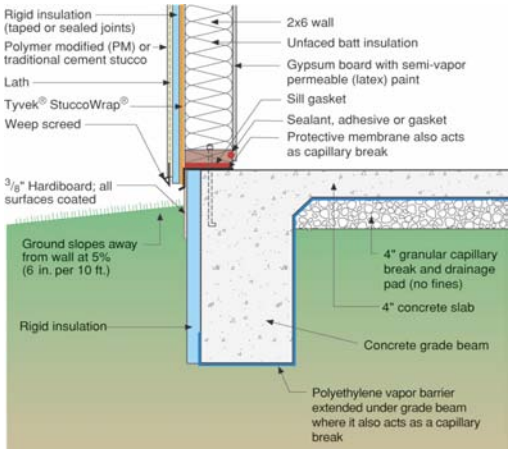

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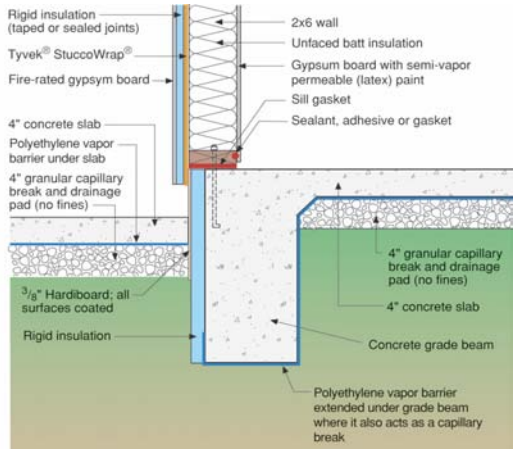

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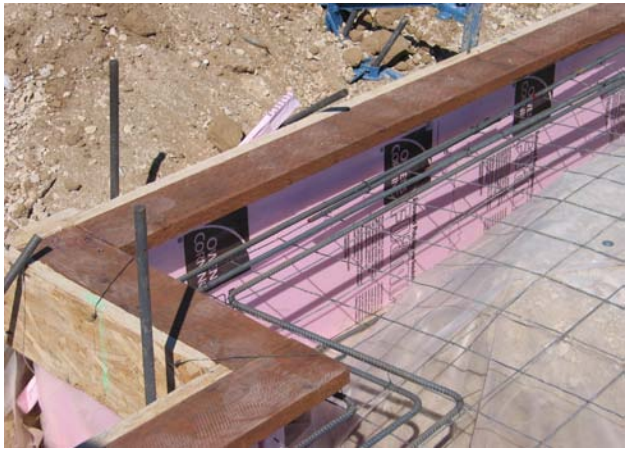

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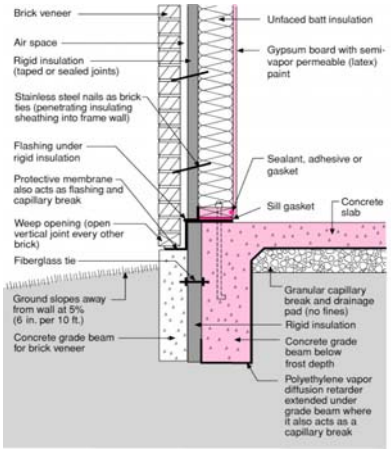

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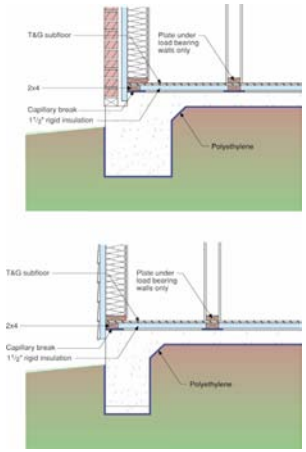

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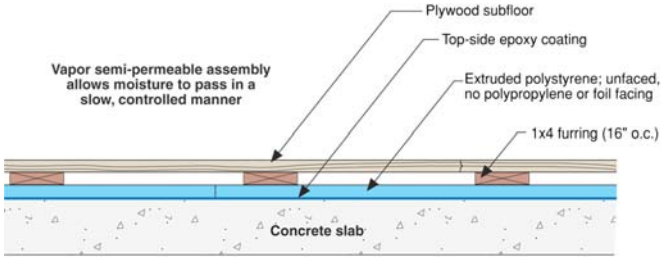

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