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

Building Science

Foundations

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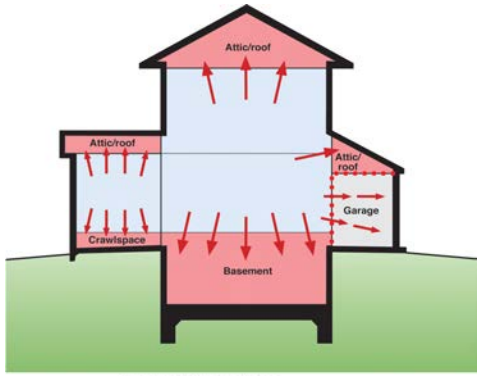

Expansion of Conditioned Space

- Conditioned space boundaries moving towards exterior surfaces of building
- Garage isolated from house by air barrier/pressure boundary
- Garage ventilated and conditioned independently of rest of conditioned spaces

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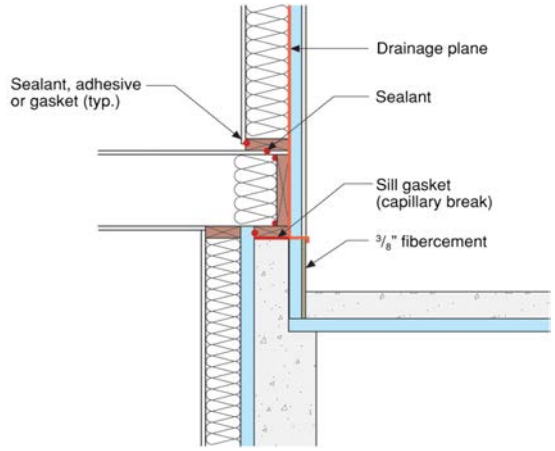

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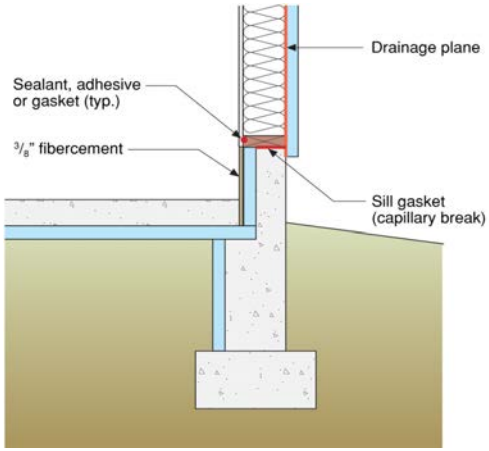

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Mechanisms of Flow

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

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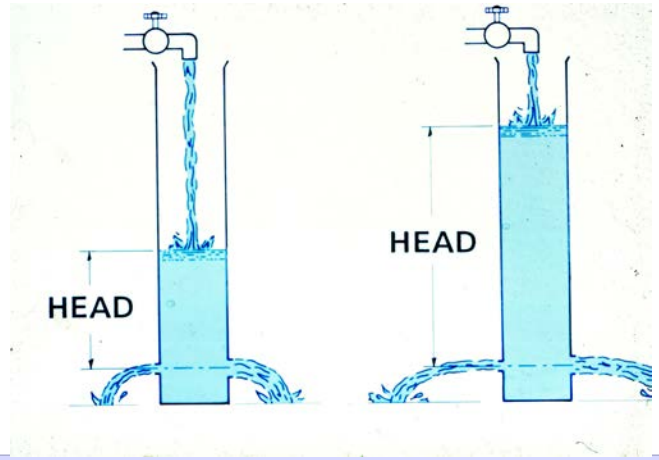

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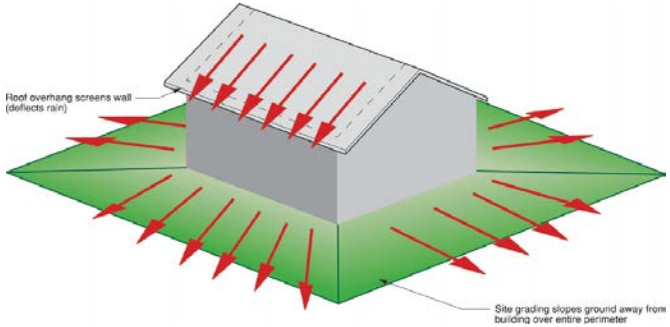

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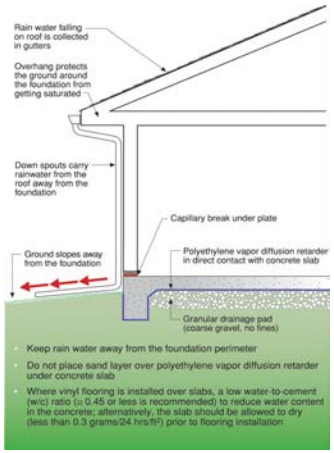

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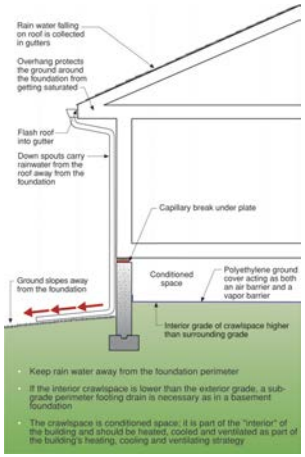

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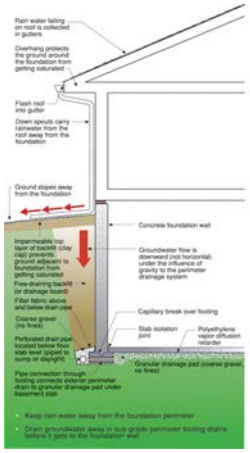

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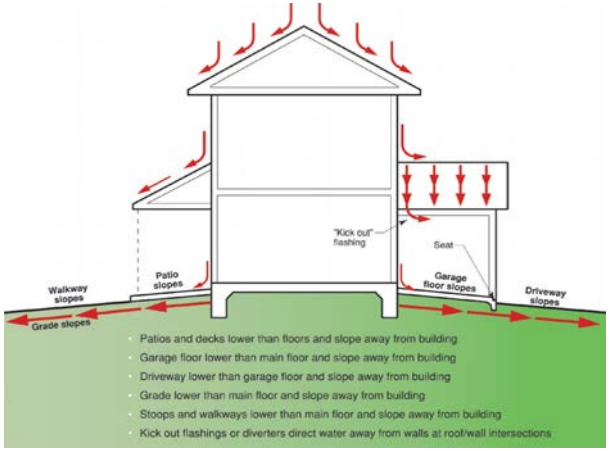

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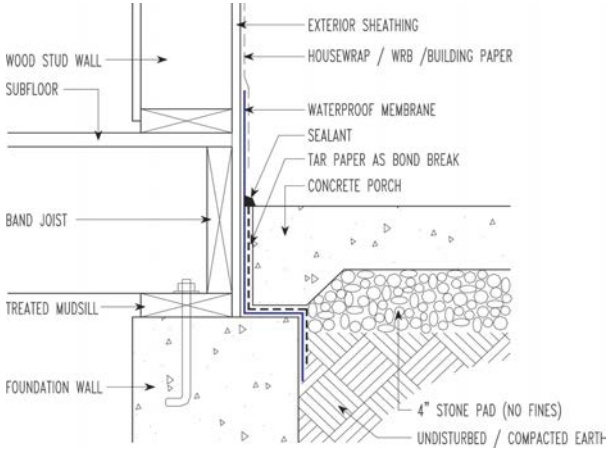

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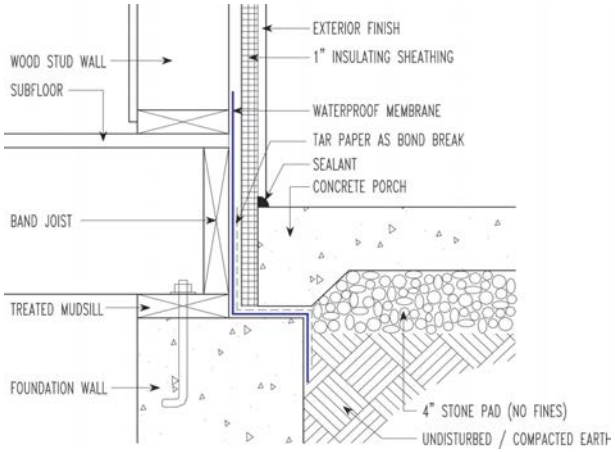

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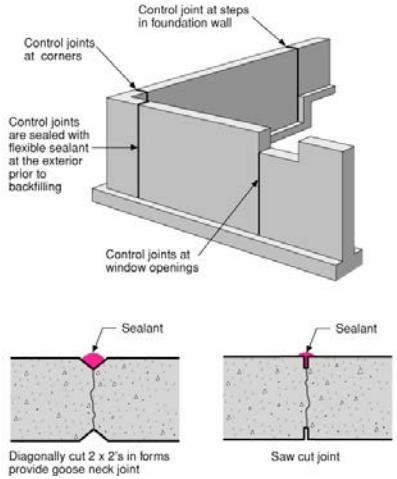

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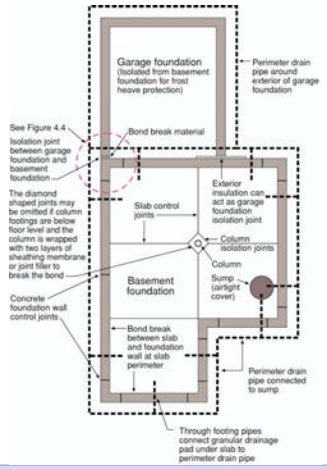

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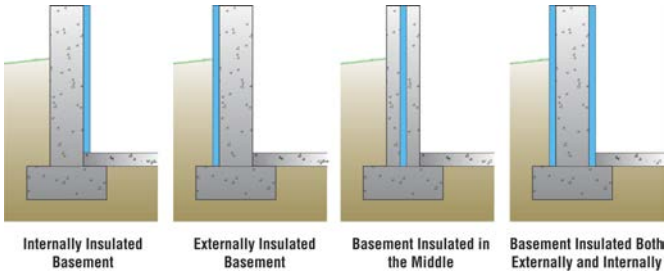

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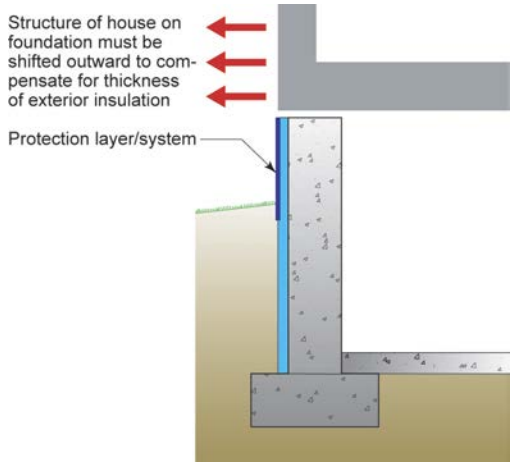

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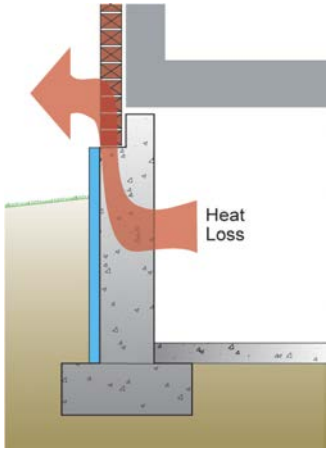

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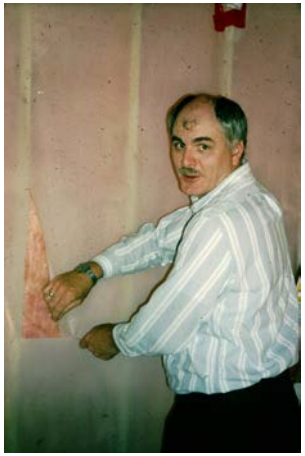

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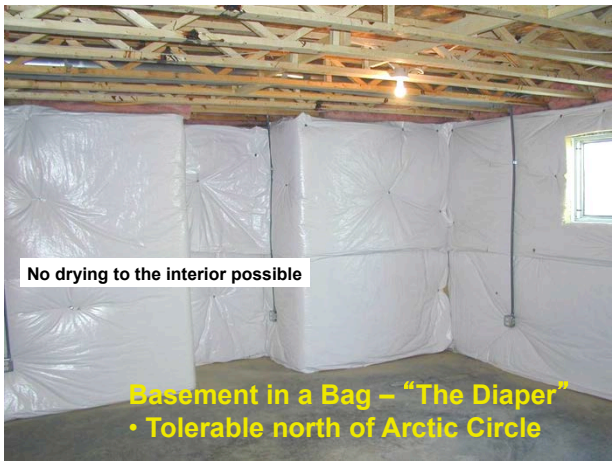
No drying to the interior possible
Basement in a Bag – "The Diaper"
• Tolerable north of Arctic Circle

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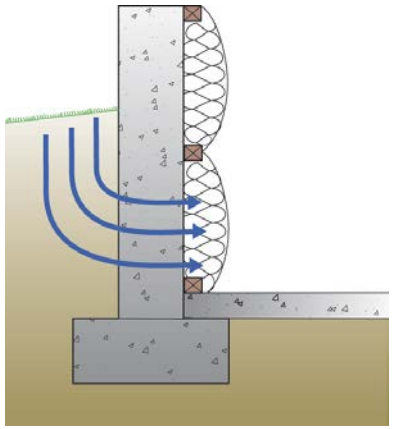

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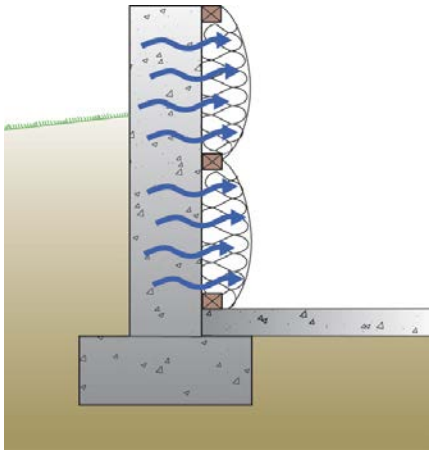

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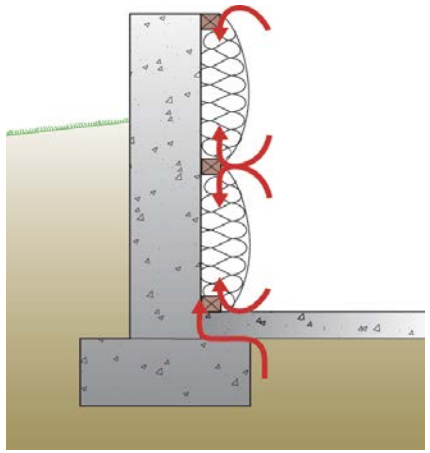

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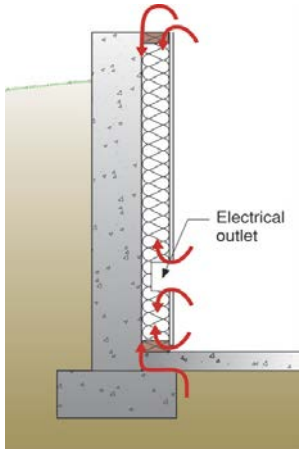

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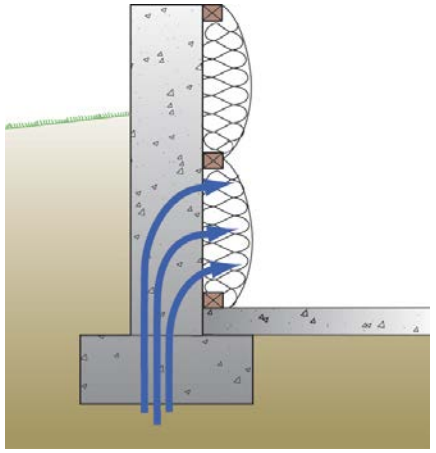

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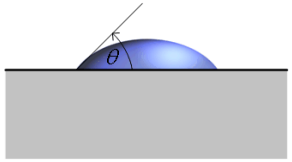
Surface Tension: Wettable

Water attracted to surface more than self

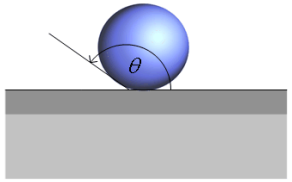
$\theta < 90^o$



normal material:
"wettable"

Water attracted to self more than surface

$\theta > 90^o$



hydrophobically treated:
"non-wettable"

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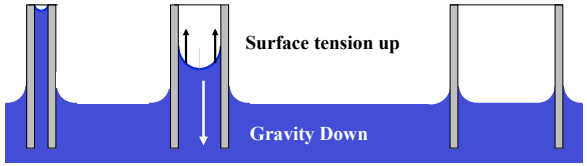
Capillary Pressures

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



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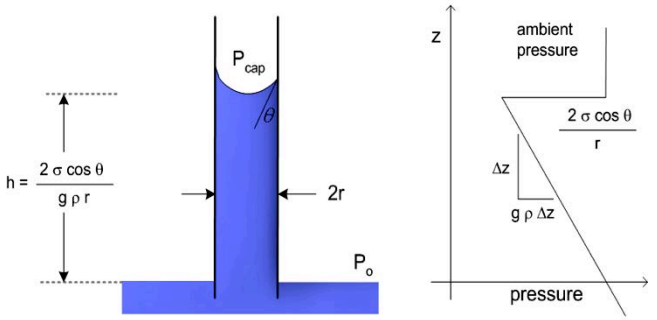
Calculating capillary rise



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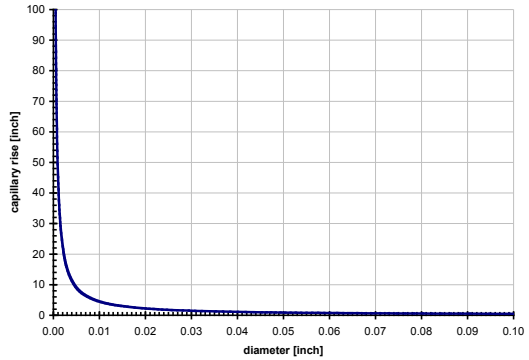
Capillary rise versus diameter



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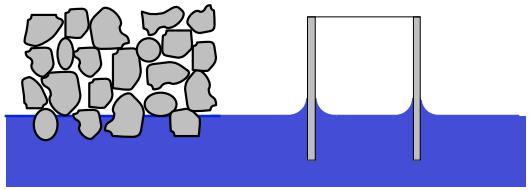
Capillary Flow

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



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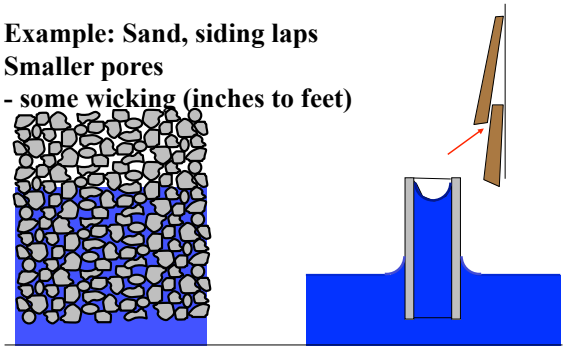
Capillary Flow

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



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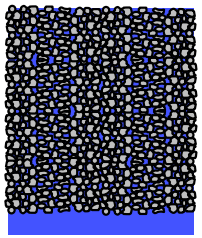
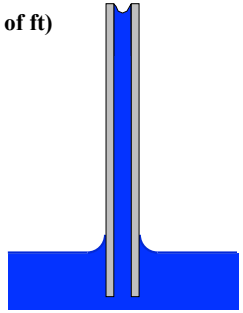
Capillary Flow- concrete sucks

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





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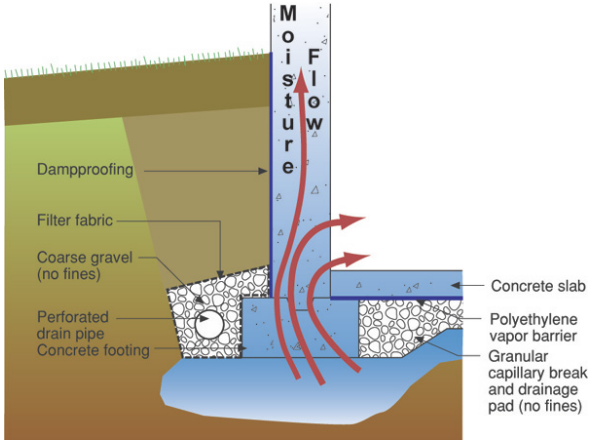

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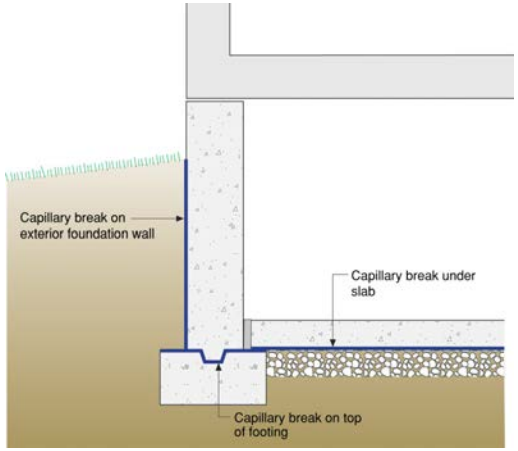

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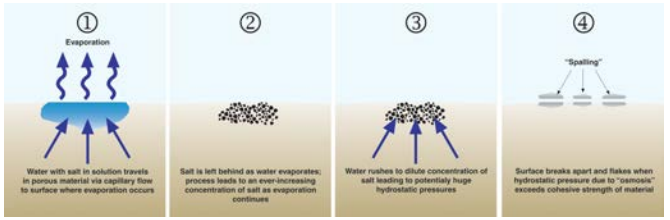
Capillarity + Salt = Osmosis

- 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



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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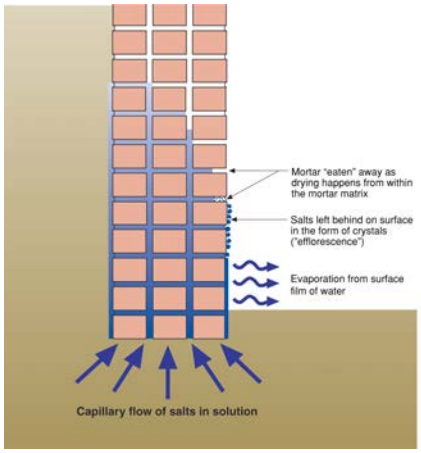

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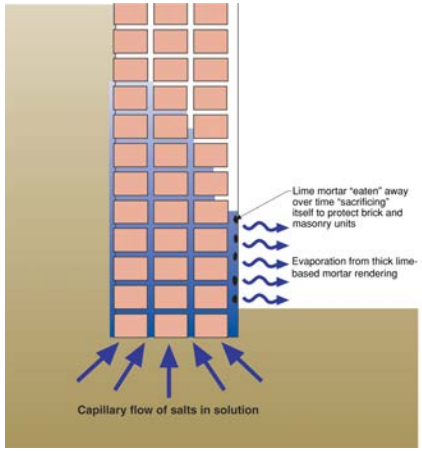

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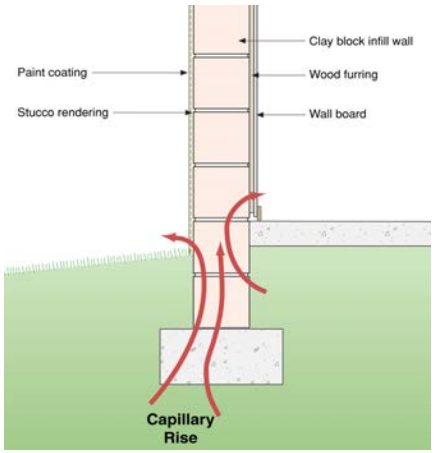

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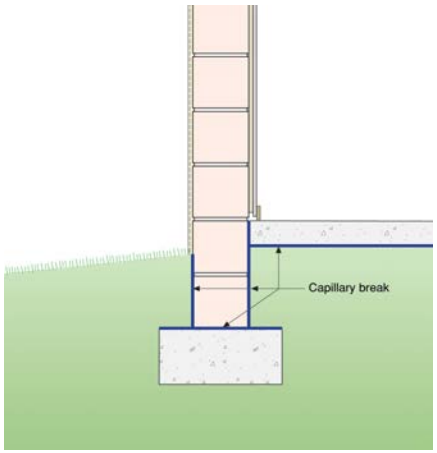

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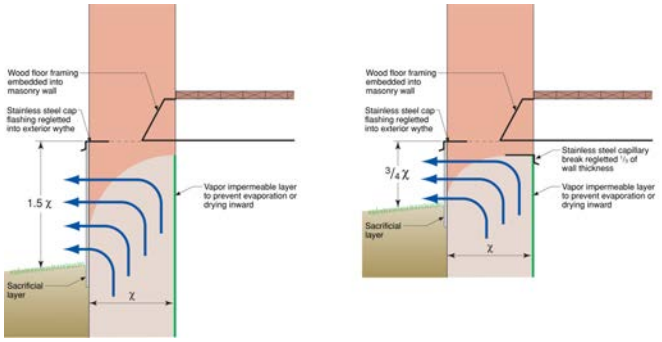

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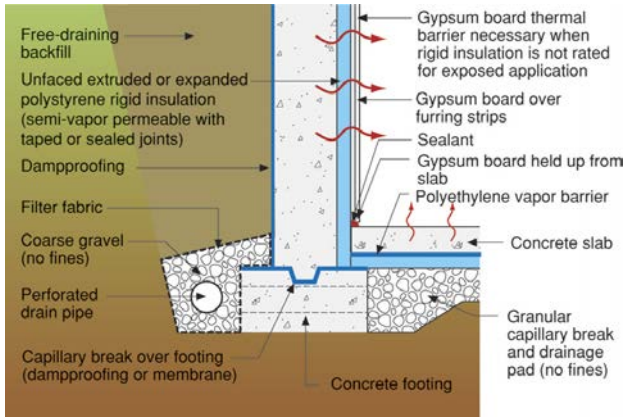

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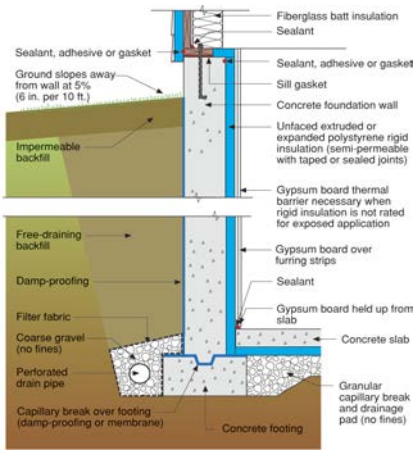

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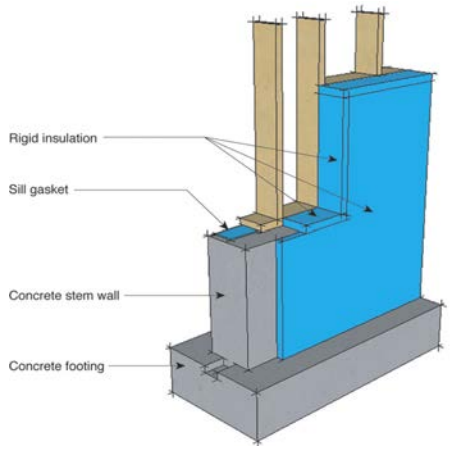

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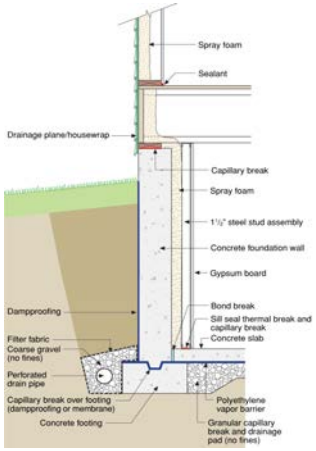

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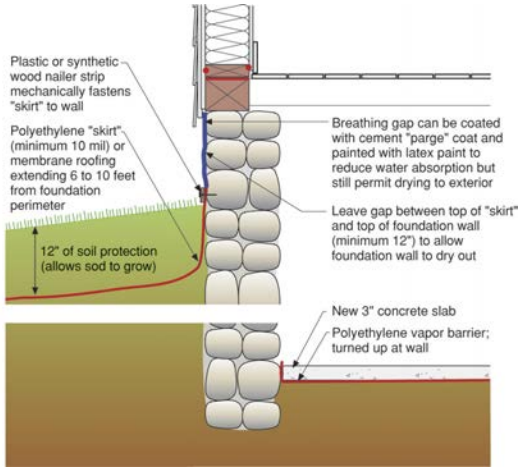

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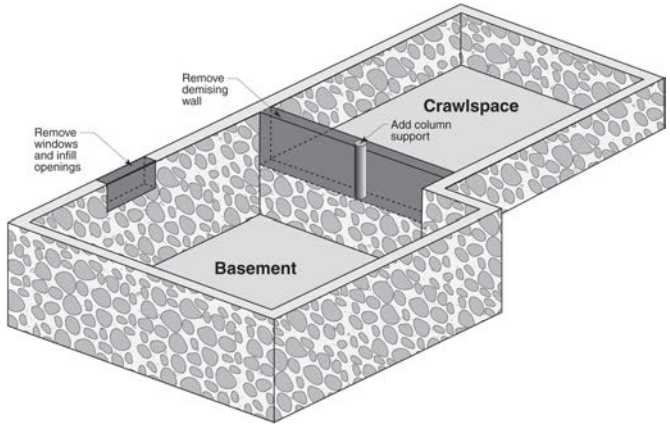

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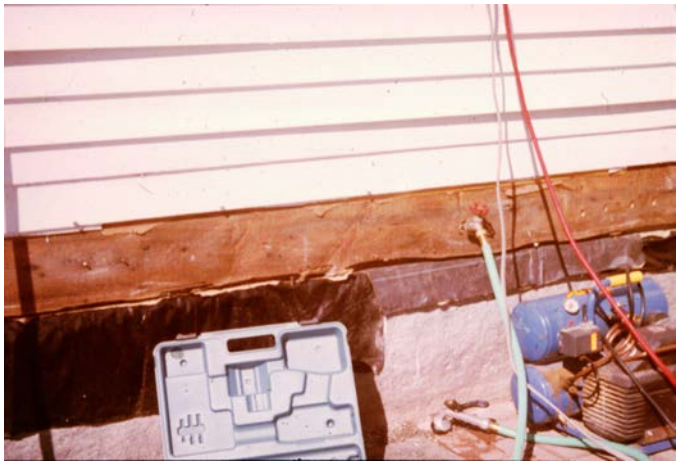

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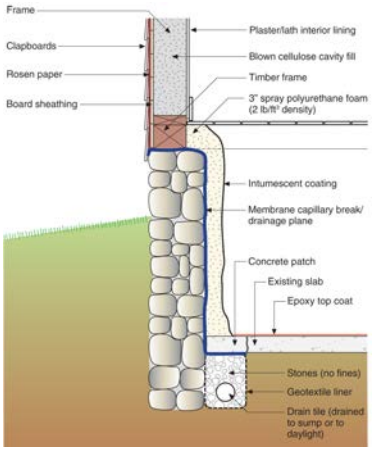

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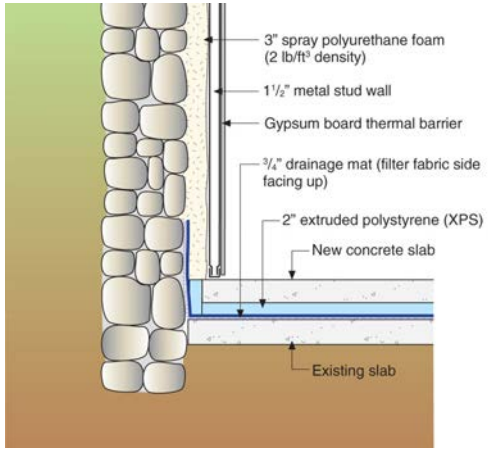

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Joseph Lstiburek – Foundations 91

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Joseph Lstiburek – Foundations 97

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Joseph Lstiburek – Foundations 98

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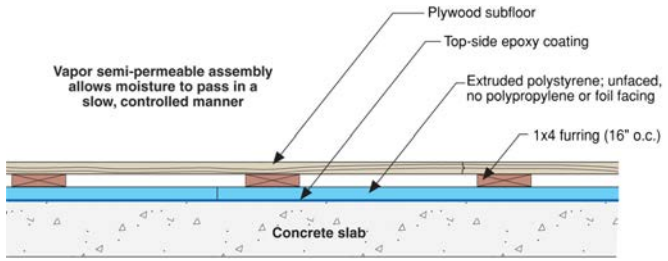

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Joseph Lstiburek – Foundations 102

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Joseph Lstiburek – Foundations 103

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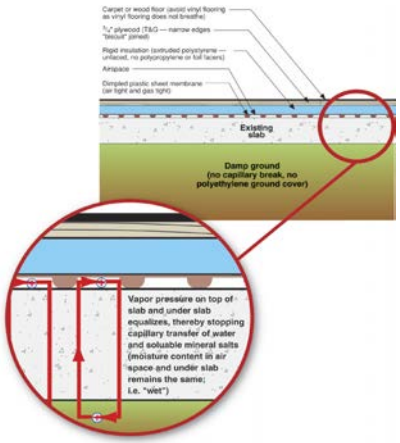

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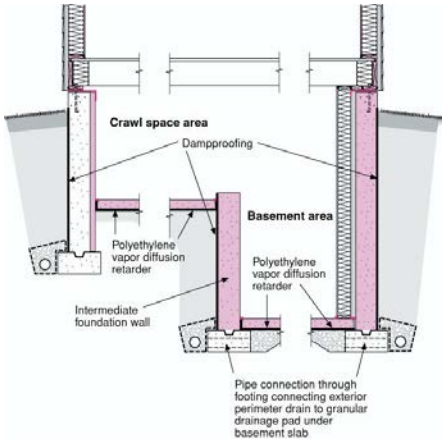

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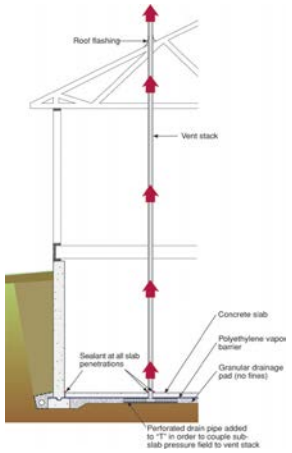

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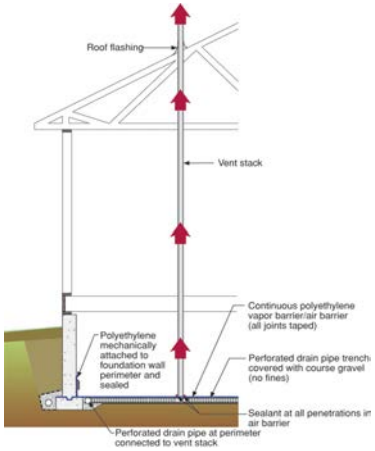

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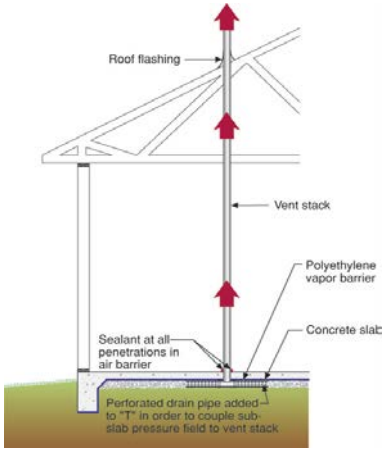

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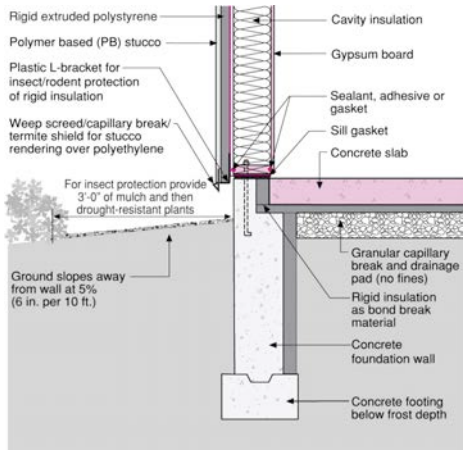

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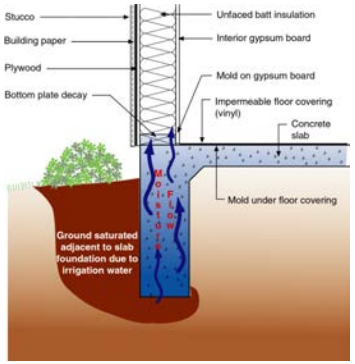
Capillary Moisture Flow



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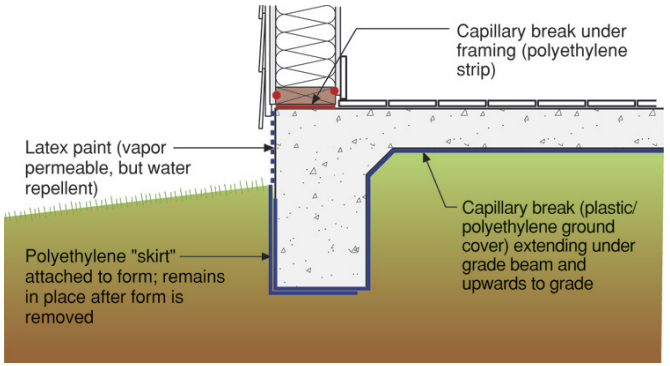

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Joseph Lstiburek – Foundations 135

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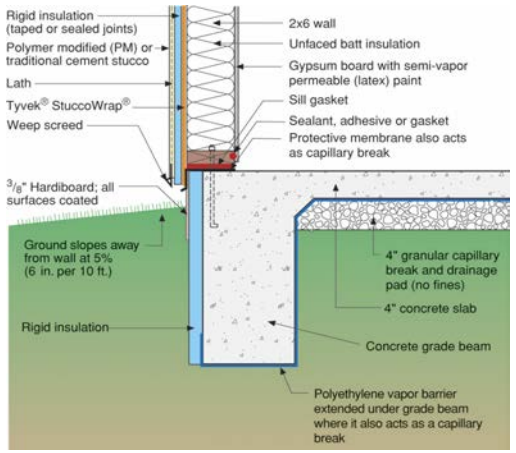
Joseph Lstiburek – Foundations 139



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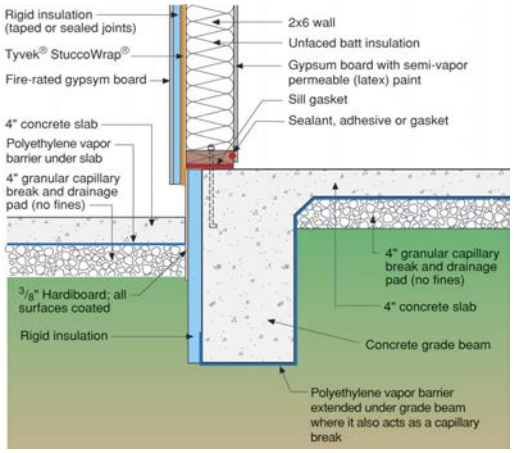

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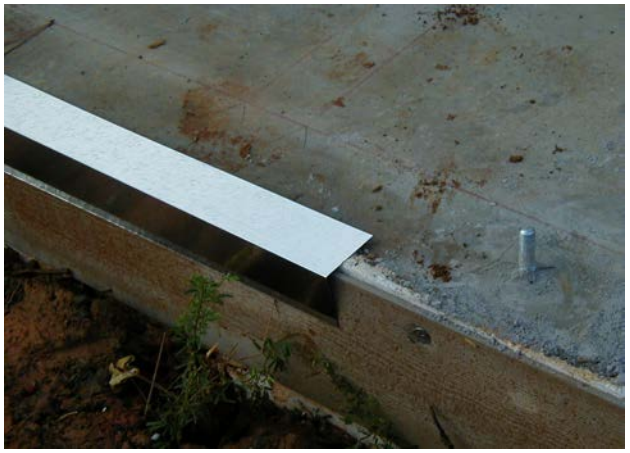

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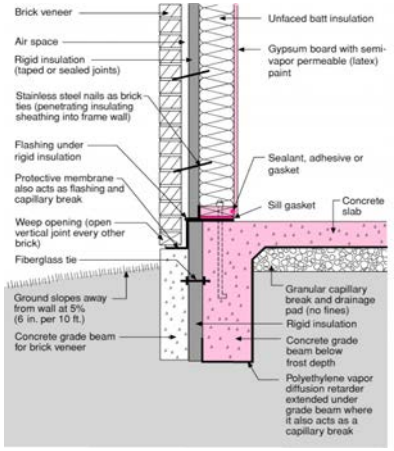

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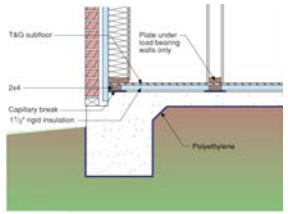

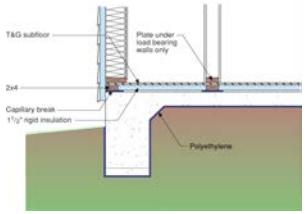

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