Building Science

Historical Perspective

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This evolution thing……
Increased Thermal Resistance
Permeability of Enclosure Linings
Water And Mold Sensitivity of Materials
Hygric Buffer Capacity And Redistribution
Three Dimensional Air Flow Networks
Another take......
2x4 @ 16” o.c.

Double top plate

Taped and painted 1/2” gypsum wall board as interior finish

Fiberglass batt insulation in stud space

Plywood sheathing

Building paper

Wood clapboard siding
Freeze-Thaw Damage
Freeze-Thaw Damage
Freezing Temperatures
Water
Susceptible Brick
Susceptible Brick
Firing Temperature
Vitrification
Calculating capillary rise

\[ h = \frac{2 \sigma \cos \theta}{g \rho r} \]
Capillary rise versus diameter
Surface area vs. particle size
From Straube & Burnett, 2005
Figure 1c. Gypsum, hydrated from plaster of paris and water, porosity 30 per cent.

Figure 1b. Brick, sintered clay, porosity 40 per cent.
1. **Evaporation**
   - Water with salt in solution travels in porous material via capillary flow to surface where evaporation occurs.

2. **Salt buildup**
   - Salt is left behind as water evaporates; process leads to an ever-increasing concentration of salt as evaporation continues.

3. **Hypothetical process**
   - Water rushes to dilute concentration of salt leading to potential huge hydrostatic pressures.

4. **Surface breakage**
   - “Spalling” — Surface breaks apart and flakes when hydrostatic pressure due to “osmosis” exceeds cohesive strength of material.
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
Capillary break
Capillary break on exterior foundation wall

Capillary break under slab

Capillary break on top of footing
Wood floor framing embedded into masonry wall

Stainless steel cap flashing regletted into exterior wythe

Vapor impermeable layer to prevent evaporation or drying inward

1.5 \( \chi \)

Sacrificial layer

Wood floor framing embedded into masonry wall

Stainless steel cap flashing regletted into exterior wythe

3/4 \( \chi \)

Sacrificial layer

Vapor impermeable layer to prevent evaporation or drying inward

\( \chi \)
Multi-wythe masonry wall

Exterior wythe (repointed or coated with polymer cement slurry)

Embedded wood timber floor structure

Subfloor held away from wall

Timber decking cut back from wall

Spray applied foam insulation (2” closed-cell, high-density)

Uninsulated steel stud assembly

Gypsum board

Subfloor held away from wall

Timber decking cut back from wall

Plywood subfloor
Liquid applied membrane waterproofing

Flanged window

Trim closure

Concrete sill

2x6 wood buck

Exterior wythe (repointed or coated with polymer cement slurry)

Multi-wythe masonry wall

Air seal

1½” rigid insulation

Plywood spacer

1x2 backdam

2” spray applied foam insulation (closed-cell, high-density)

Uninsulated steel stud assembly

Gypsum board
Multi-wythe mass wall

- Interior lining (gypsum board)
- Interior framing
- Rock wool or Roxul rigid mineral wool insulation
- Fluid-applied water control layer (vapor semi-permeable)
- Cementitious rendering
Multi-wythe mass wall

Interior lining (gypsum board)

Cellulose or fiberglass cavity insulation

Wood frame wall (2x6)

Fluid-applied water control layer (vapor semi-permeable)
Multi-wythe mass wall

Interior lining (gypsum board)

“Strapped wall”; horizontal framing

Membrane “smart vapor barrier”

Cellulose or fiberglass cavity insulation

Wood frame wall (2x6)

Fluid-applied water control layer (vapor semi-permeable)

Cementitious rendering
1x4 wood furring attached through rigid insulation to 2x4 wood furring
2x4 wood furring mechanically attached to masonry wall
Fluid-applied water control layer and air control layer

Cladding
Joints offset horizontally and vertically with each layer taped
Masonry wall
Interior plaster and lath
2” semi-rigid mineral fiber insulation; seams offset horizontally and vertically

2x4 wood furring mechanically attached to masonry wall

Fluid-applied water control layer and air control layer

Metal hat channel

Fiber cement panel

“Reveal” in panel joint

Spacer/joint backer

1 1/2” semi-rigid mineral fiber insulation

Masonry wall

Interior plaster and lath
Stainless steel flashing

Trim

Paver

Waterproofing extended up wall to reglet

Drainage mat

Waterproofing
Stainless steel flashing

Reglet

Plaster “filler” for slope

Cladding “offset”
Parapet cap flashing sloping to interior with drip edges

Parapet flashing

Slope

Drip

Plaster "filler" for slope supporting flashing