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Retrofits

John Straube, Ph.D., P.Eng
Building Science Corporation & University of Waterloo

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Choices

- **Changing mechanical systems is least invasive**
  - often near end of life (20 yrs)
  - 10% eff improvement = 10% operating savings = easy
- **Lighting and ventilation**
  - Many buildings have too many inefficient lights that are on for too long
  - Most buildings have too much ventilation with too little control
  - Can be major savings (30-50%)
- **MUST have clear idea of enclosure upgrades before deciding on mechanical!**

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Mechanical Retrofit

- **After enclosure upgrade**
  - Smaller quieter often different systems can be chosen
- **Air-based can be replaced with hydronic**
- **Steam-based can be replaced hotwater**
- **Low-temperature (more efficient) systems can be used**
- **For high ventilation load add HRV**
  - Schools, meeting rooms, etc
- **Variable speed fans and CO_2 controls**
- **Convert CAV to VAV**

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Enclosure Retrofit

- **Important target for many buildings**
  - Airtightness
  - Windows
  - Insulation
    - Roof
    - Walls
    - Basement
    - Slabs
- **Prioritize by Ease and Impact**

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Rational Retrofit Strategy

- **Eg a 125 ft x 50 ft 3 storey mill building**
- **12 ft flr to flr, 9 ft basement 40% window**

Component	Area (ft2)	U= 1 / R	Loss Btu/hr/F
Roof	6250	0.05 = 1/R20	312.5
Wall	7560	0.25 = 1/R4	1890
Windows	5040	1.0 = 1/1	5040
Air Leakage	0.3 ACH@ service		1400
Basement	3150	Dbl R (2*R3)	525
Slab	6250	Triple (3*1.5)	1388

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Choices

Always do exterior if you can follow perfect wall approach

But, if we have to, do interior beware floors, partitions, etc

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Exterior Insulation Retrofit

- Any reasonable level of insulation can be provided
  - Final R of 20, 30, 40, 50
- Almost all penetrations of air, heat, and rain can be improved
- Significant reductions in moisture risk

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Overclad Options

- **Drained EIFS**
- **Drained & Ventilated metal sheets, panels, fiber cement**
- **Horizontal Lap Siding**

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A wide range of aesthetics

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EIFS Application

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Drained EIFS: nice but not always needed

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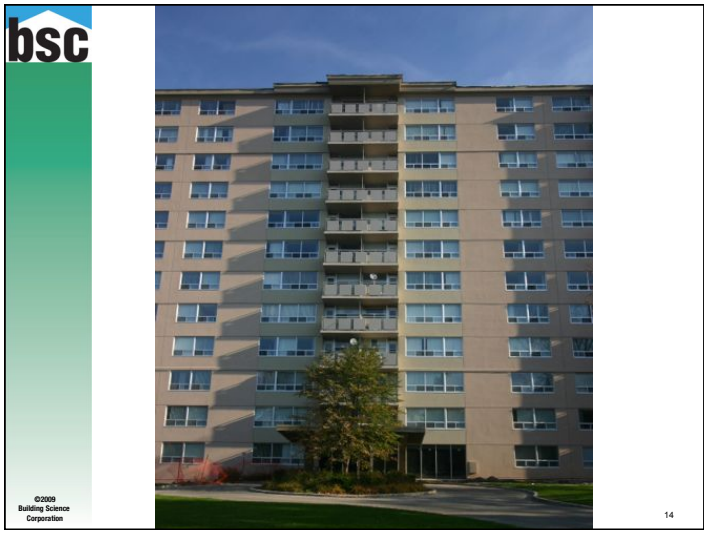
Suspended
Stages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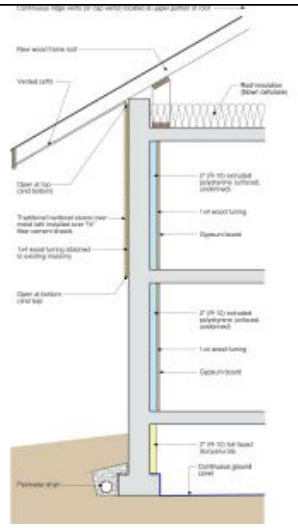
Drained ventilated cladding (no risk)

Require airtight parge



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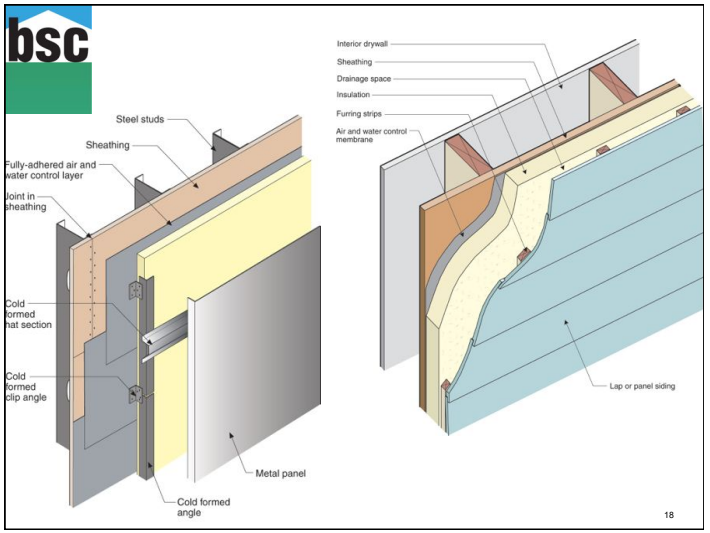

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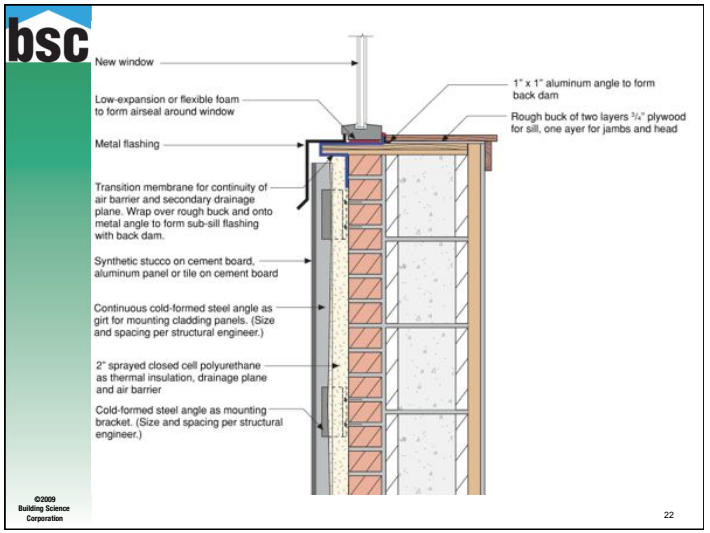
New window
Low-expansion or flexible foam to form airseal around window
Metal flashing
Transition membrane for continuity of air barrier and secondary drainage plane. Wrap over rough buck and onto metal angle to form sub-sill flashing with back dam.
Synthetic stucco on cement board, aluminum panel or tile on cement board
Continuous cold-formed steel angle as girt for mounting cladding panels. (Size and spacing per structural engineer.)
2" sprayed closed cell polyurethane as thermal insulation, drainage plane and air barrier
Cold-formed steel angle as mounting bracket. (Size and spacing per structural engineer.)
1" x 1" aluminum angle to form back dam
Rough buck of two layers ¾" plywood for sill, one ayer for jambs and head
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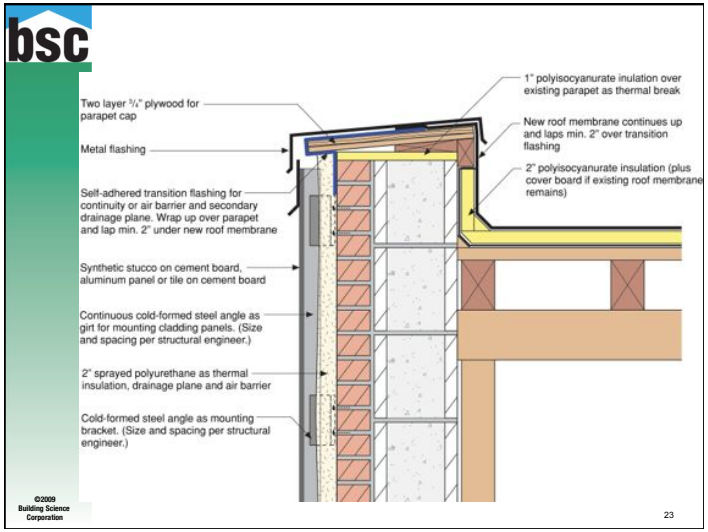
Two layer ¾" plywood for parapet cap
Metal flashing
Self-adhered transition flashing for continuity or air barrier and secondary drainage plane. Wrap up over parapet and lap min. 2" under new roof membrane
Synthetic stucco on cement board, aluminum panel or tile on cement board
Continuous cold-formed steel angle as girt for mounting cladding panels. (Size and spacing per structural engineer.)
2" sprayed polyurethane as thermal insulation, drainage plane and air barrier
Cold-formed steel angle as mounting bracket. (Size and spacing per structural engineer.)
1" polyisocyanurate inulation over existing parapet as thermal break
New roof membrane continues up and laps min. 2" over transition flashing
2" polyisocyanurate insulation (plus cover board if existing roof membrane remains)
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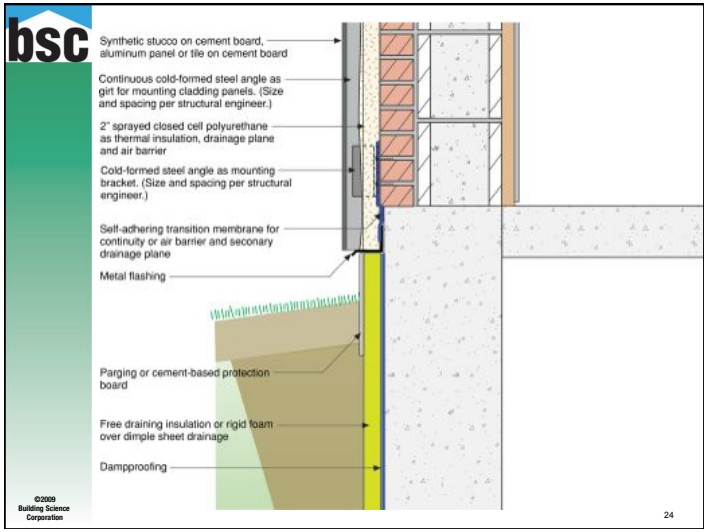
Synthetic stucco on cement board, aluminum panel or tile on cement board
Continuous cold-formed steel angle as girt for mounting cladding panels. (Size and spacing per structural engineer.)
2" sprayed closed cell polyurethane as thermal insulation, drainage plane and air barrier
Cold-formed steel angle as mounting bracket. (Size and spacing per structural engineer.)
Self-adhering transition membrane for continuity or air barrier and seconary drainage plane
Metal flashing
Parging or cement-based protection board
Free draining insulation or rigid foam over dimple sheet drainage
Dampproofing
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Interior Retrofits

Interior retrofits can be relatively low risk for frost durable exterior enclosures

E.G.

Brick block cavity walls

Tiltup concrete, solid concrete, precast concrete

Use Air-impermeable insulation to prevent air loops that can cause condensation

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- **interior**

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Solid Masonry: Interior Retrofit

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Solid masonry

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Load Bearing Solid Masonry

- **Large stock of desirable buildings**
- **Downtown**
- **Attractive**
- **Good bones**
- **Flexible Program**

- **Most want to keep brick exterior**

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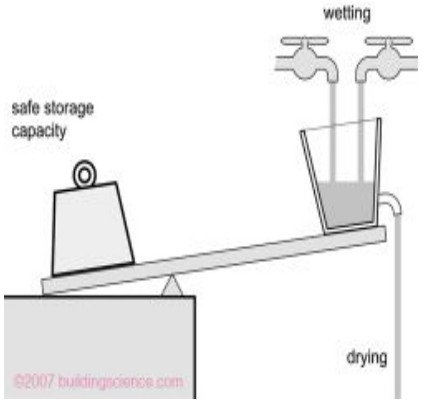
Moisture Balance



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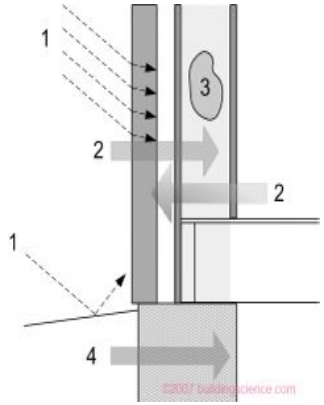
Wetting



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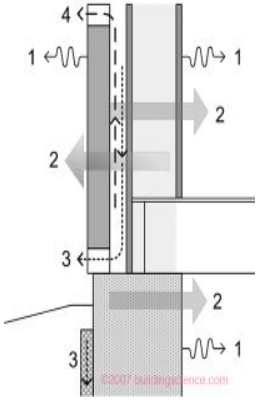
Drying



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Durability

Insulating makes in/out face of enclosure cold
Gypsum board / OSB in summer/winter normal walls
Condensation occurs on cold surfaces
Drying occurs slowly from cold materials
Ergo... Insulating makes things wetter and stay wetter longer!

Air & water vapor moves through fiberglass rockwool and cellulose
Foam stops air and slows vapor

Building America U.S. Department of Energy Research Toward Zero Energy Homes

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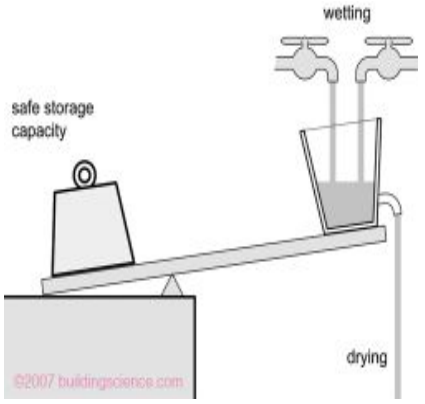
Moisture Balance



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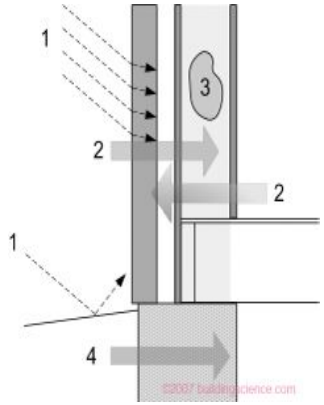
Wetting



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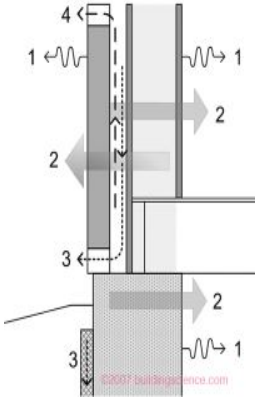
Drying



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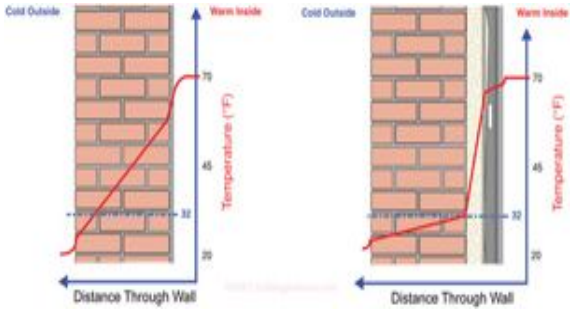
Interior Insulation



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Risks

- **Freeze-thaw**
- **Salt and Osmosis**
- **Rot of embedded wood**
- **Damage to interior finish**

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Freeze-thaw

For a damaging F-T cycle one needs

- A temperature drop below about -5 C / 20 F
- Nearly saturated moisture content
- Porous, brittle material

For brick, degree of saturation of 0.80 to 0.95

Insulating reduces masonry temperature

Therefore keep MC below 80% of saturation during cold weather

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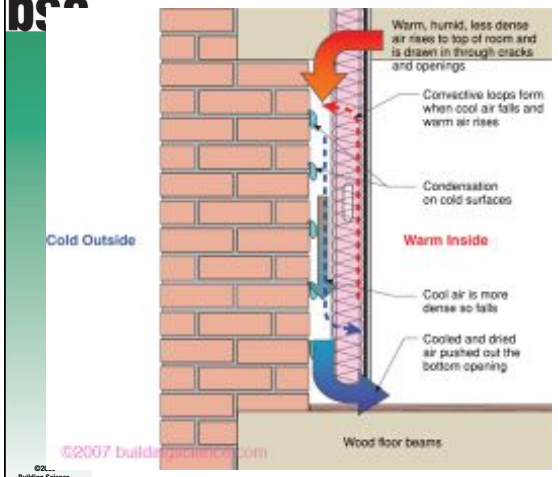

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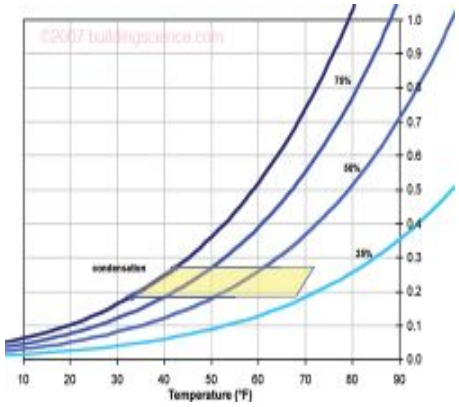

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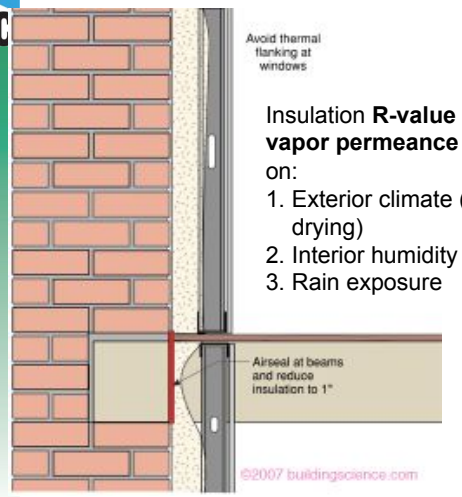

Insulation **R-value** & **vapor permeance** depend on:

1. Exterior climate (temp / drying)
2. Interior humidity levels
3. Rain exposure

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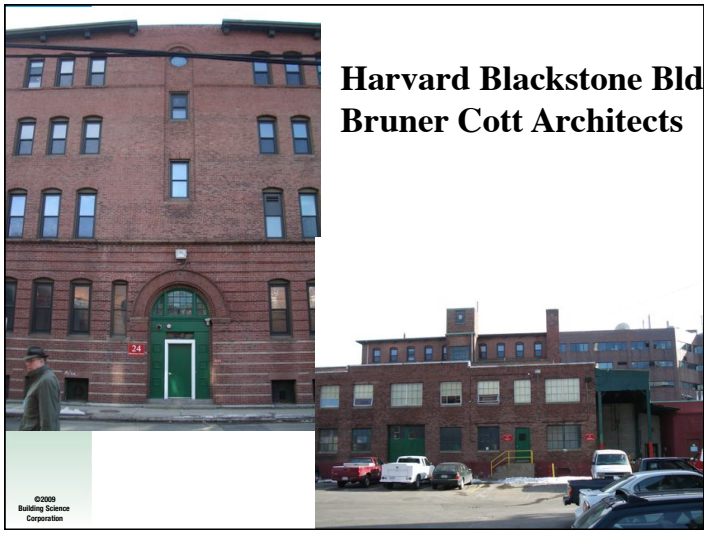
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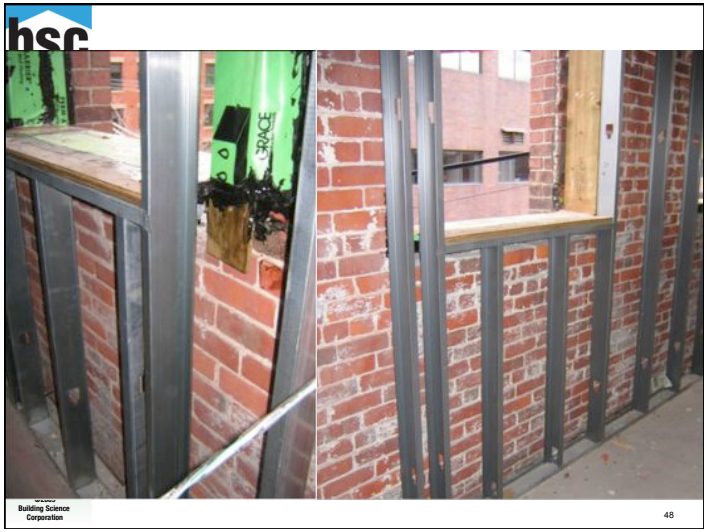
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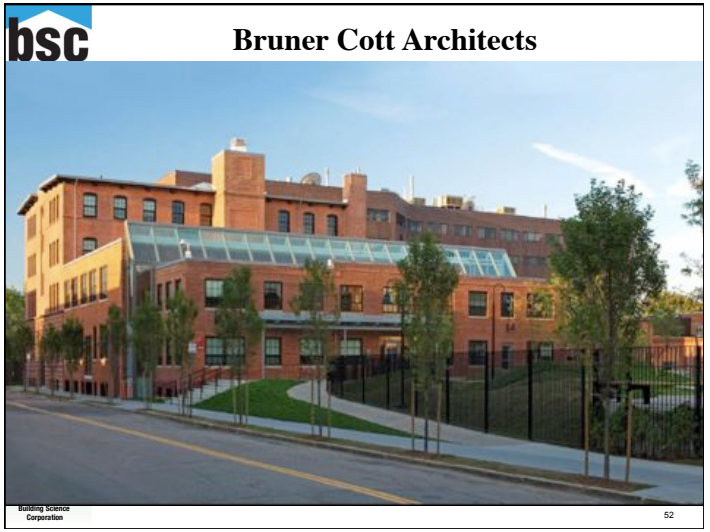
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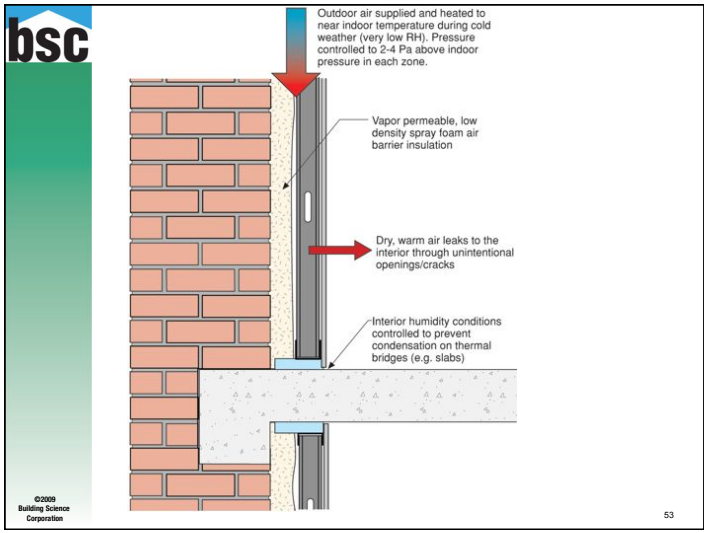
Outdoor air supplied and heated to near indoor temperature during cold weather (very low RH). Pressure controlled to 2-4 Pa above indoor pressure in each zone.
Vapor permeable, low density spray foam air barrier insulation
Dry, warm air leaks to the interior through unintentional openings/cracks
Interior humidity conditions controlled to prevent condensation on thermal bridges (e.g. slabs)
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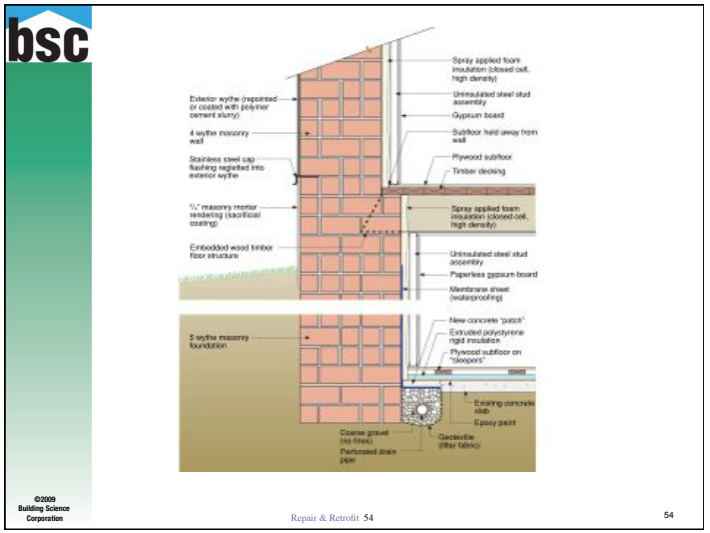
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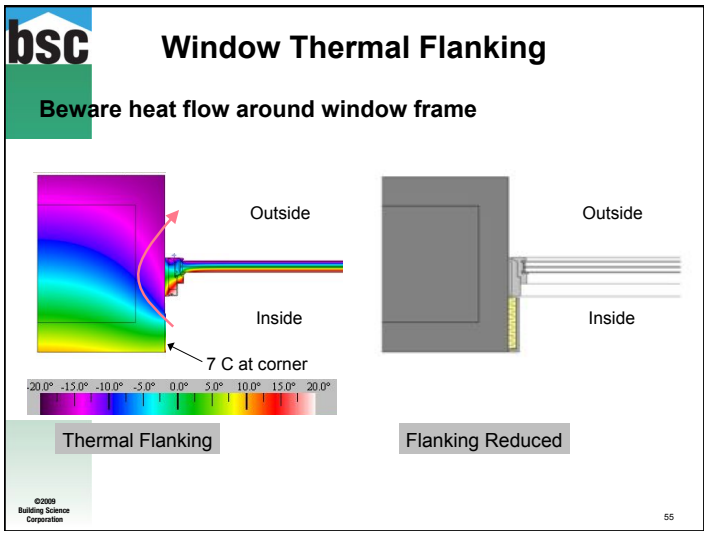
Window Thermal Flanking
Beware heat flow around window frame
Outside
Inside
7 C at corner
-20.0° -15.0° -10.0° -5.0° 0.0° 5.0° 10.0° 15.0° 20.0°
Thermal Flanking
Outside
Inside
Flanking Reduced
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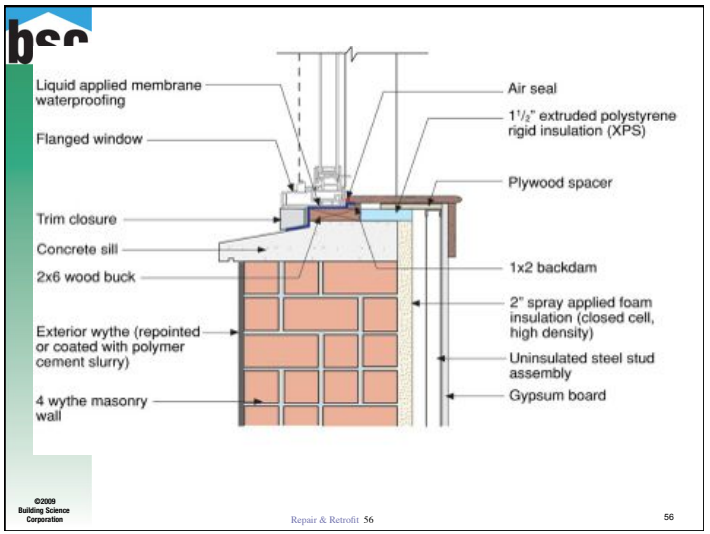
Liquid applied membrane waterproofing
Flanged window
Trim closure
Concrete sill
2x6 wood buck
Exterior wythe (repointed or coated with polymer cement slurry)
4 wythe masonry wall
Air seal
1½" extruded polystyrene rigid insulation (XPS)
Plywood spacer
1x2 backdam
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board
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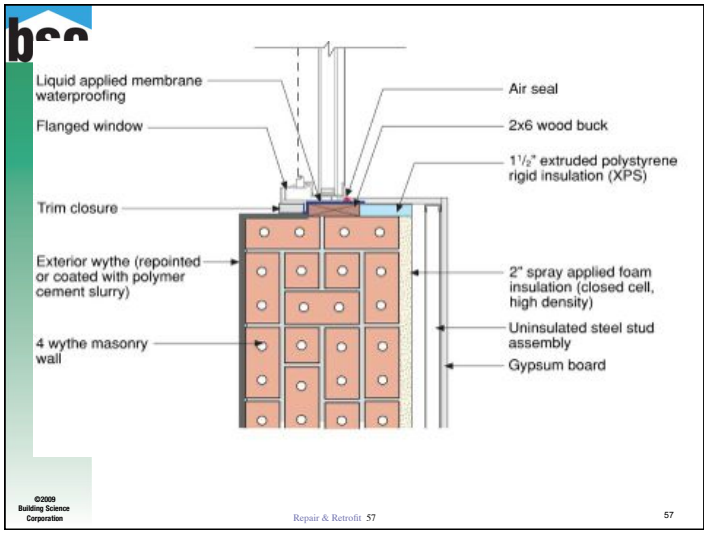
Liquid applied membrane waterproofing
Flanged window
Trim closure
Exterior wythe (repointed or coated with polymer cement slurry)
4 wythe masonry wall
Air seal
2x6 wood buck
1½" extruded polystyrene rigid insulation (XPS)
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board
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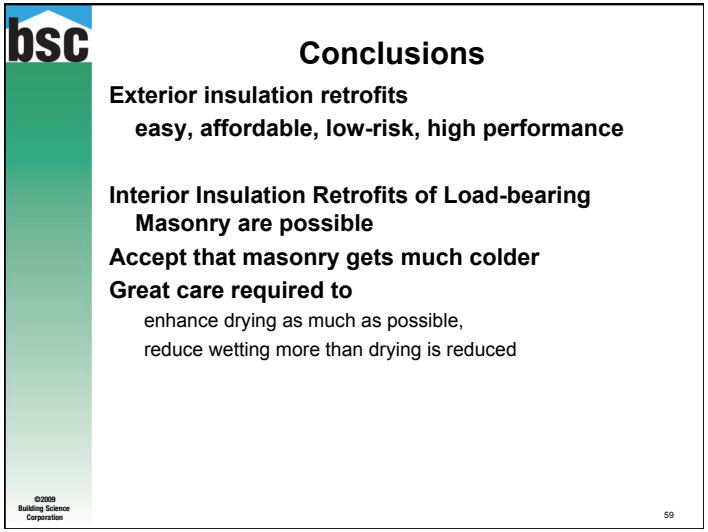
Conclusions
Exterior insulation retrofits
easy, affordable, low-risk, high performance
Interior Insulation Retrofits of Load-bearing Masonry are possible
Accept that masonry gets much colder
Great care required to
enhance drying as much as possible,
reduce wetting more than drying is reduced
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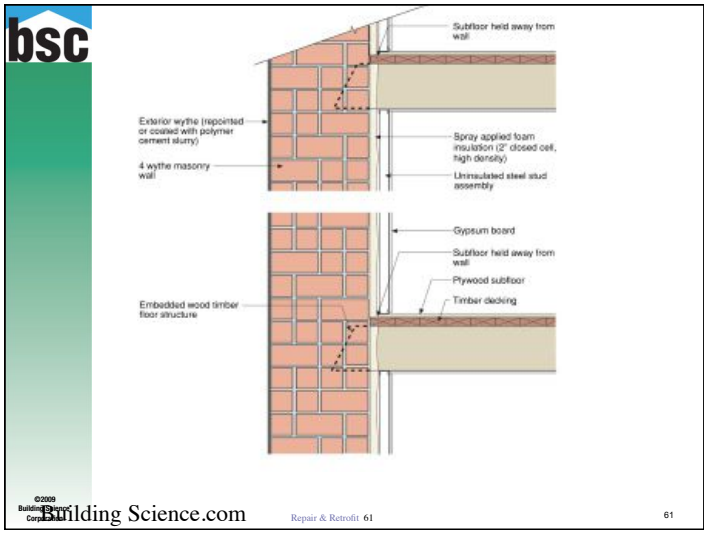
Subfloor held away from wall
Exterior wythe (repointed or coated with polymer cement slurry)
4 wythe masonry wall
Spray applied foam insulation (2" closed cell, high density)
Uninsulated steel stud assembly
Gypsum board
Subfloor held away from wall
Plywood subfloor
Timber decking
Embedded wood timber floor structure
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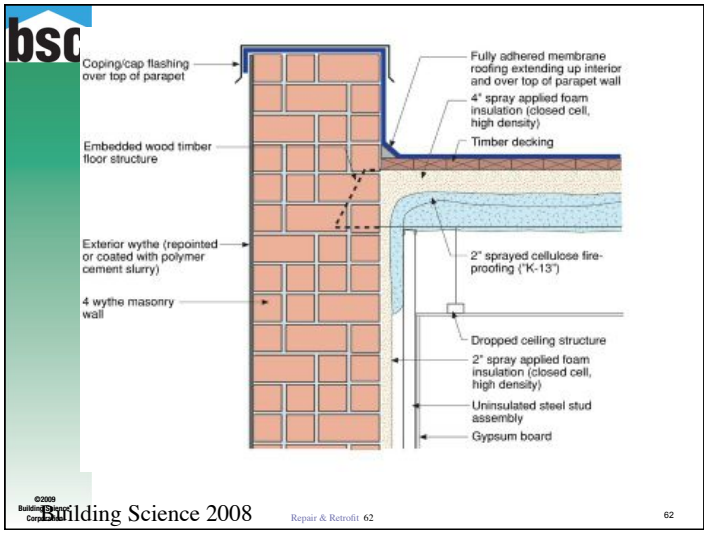
Coping/cap flashing over top of parapet
Fully adhered membrane roofing extending up interior and over top of parapet wall
4" spray applied foam insulation (closed cell, high density)
Timber decking
Embedded wood timber floor structure
Exterior wythe (repointed or coated with polymer cement slurry)
4 wythe masonry wall
2" sprayed cellulose fire-proofing ("K-13")
Dropped ceiling structure
2" spray applied foam insulation (closed cell, high density)
Uninsulated steel stud assembly
Gypsum board
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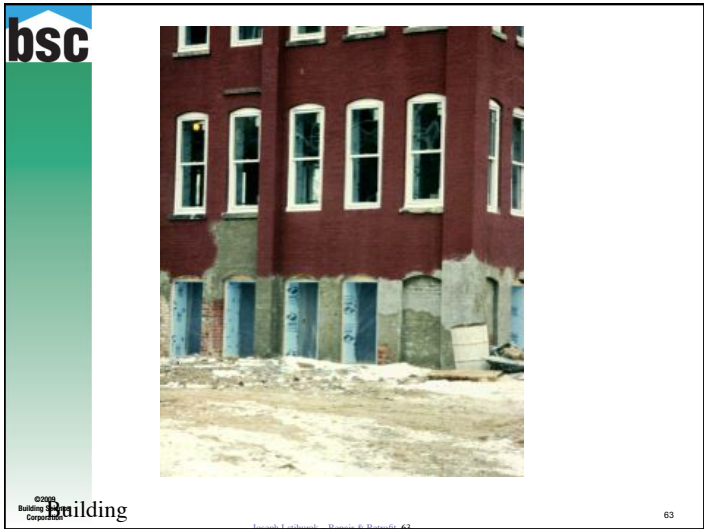
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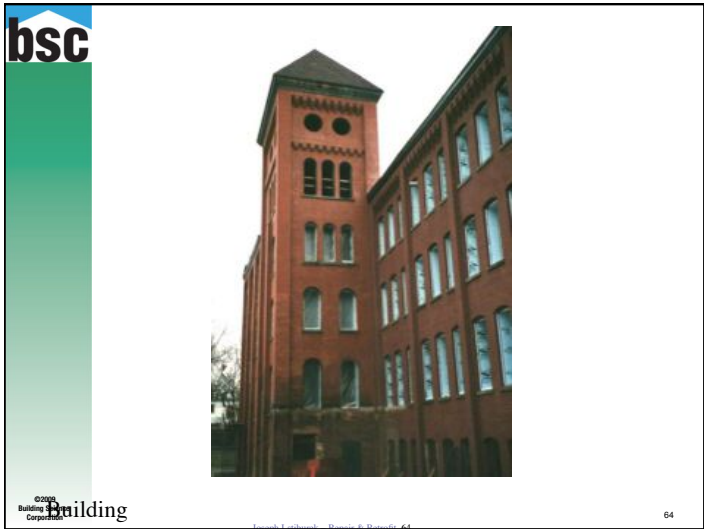
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Basements

- Easy to retrofit and improve from the interior
- Ceiling height is the big restriction for slab solutions

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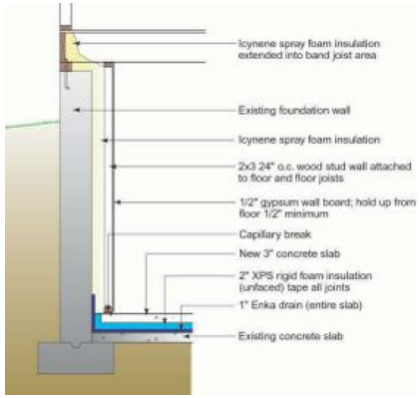

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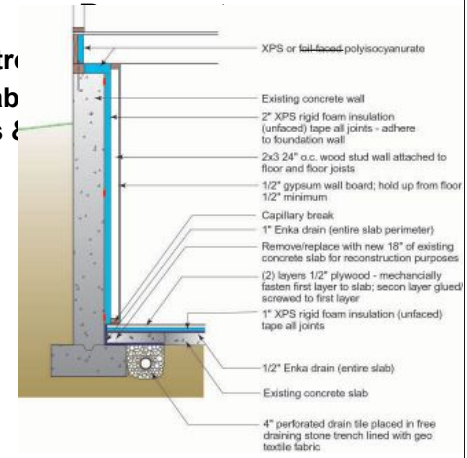
New or retr

Solves slab wetness & cold



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Retrofit Slab, drainage and sump before wall insulated
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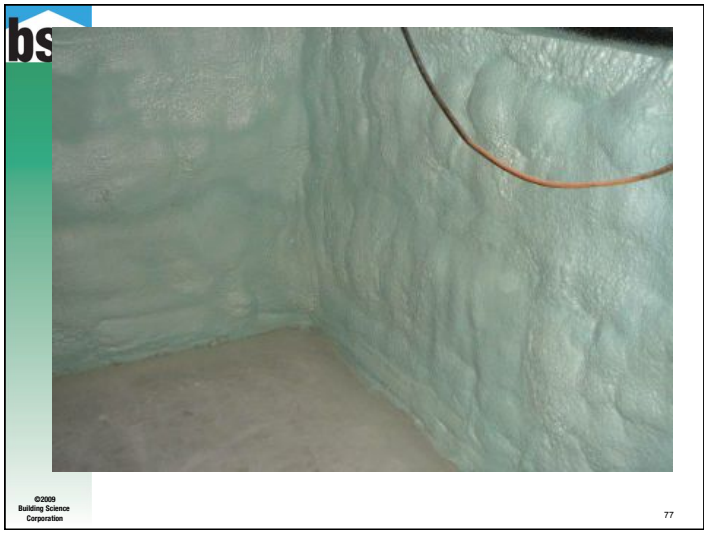
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