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Fundamental Changes

and the need for systems thinking

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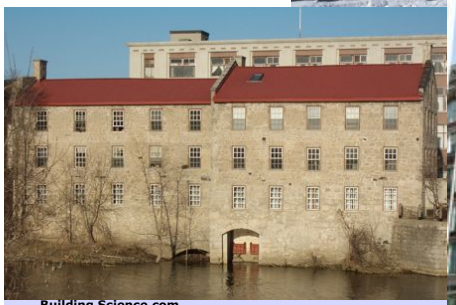
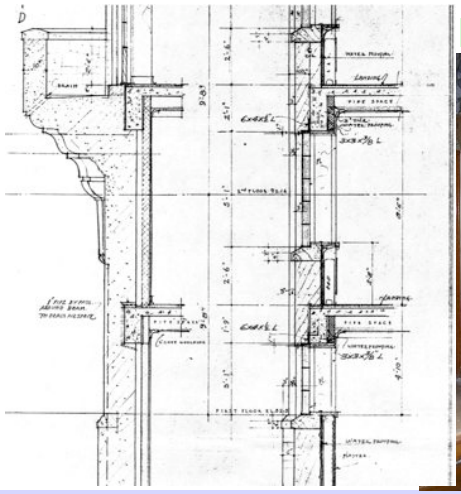
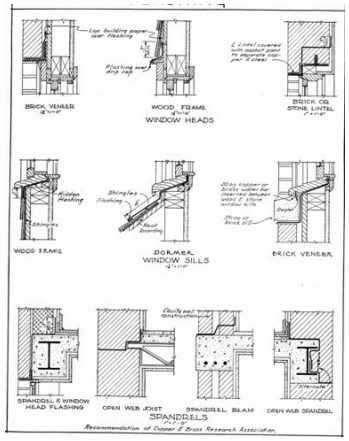
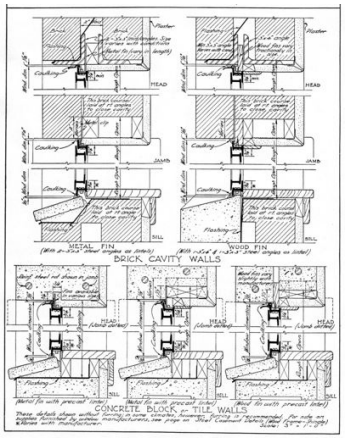
Solid masonry





Wet Applied Plaster





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Pre-WWII Buildings

- Masonry and old-growth solid timber structures
- Plaster is the dominant interior finish
- No added insulation (or very little)
- No vapor barriers
- Heating systems only, some natural ventilation
- No air conditioning
- Few explicit air-tightening details
- Few ducts, pipes, wires, controls, gas, cables,etc

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Five Fundamental Changes

1. Increasing Thermal Resistance
2. Changing Permeance of Enclosure Linings
3. Water/Mold Sensitivity of Materials
4. Moisture Storage Capacity
5. 3-D Airflow Networks

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1. Thermal

- Old buildings used energy leakage to dry materials and assemblies
- Increased airtightness
  - Reduces drying, interior RH increases
- Increased insulation = less drying
  - Colder exterior, colder interior
  - Wider swings
- White roofs, efficient lights, etc

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Energy Efficiency & Durability

- Better insulation means
  - Cold exterior and/or interior surface
  - More extreme variations at exterior
  - Colder surfaces mean
    - = more likely condensation
    - = higher RH = higher moisture content
- More insulation reduces durability!
- Air leakage dried as well as wets
  - Airtightness increases indoor humidity

2. Permeability

- Low permeance exterior layers
  - Metal panels, precast concrete
  - OSB and foam vs skip wood sheathing
- Low permeance interior layers
  - Polyethylene, vinyl wall paper
  - Vinyl sheet flooring

3. Water/Mold Sensitivity

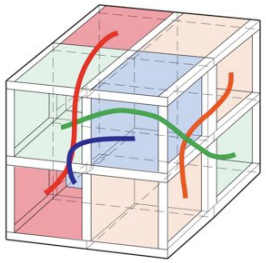
- Moisture= mold growth
- Wood products
  - New growth vs old
  - Processing: plywood, OSB, particle board
  - Paper, Veneers
- Finishes
  - Drywall, ceiling tile

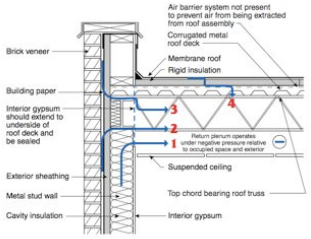
4. Moisture Storage Capacity

- Changing moisture storage
  - Concrete block / terra cotta
  - Rough cut wood / skip sheathing
  - Steel stud with exterior gypsum
- Orders of magnitude!
- Lightweight often low-impact

5. Three-D Airflow Networks

- Hollow walls
- Taller buildings





Hollow Buildings

- Inter-connected voids

Hollow Buildings

Interconnected interstitial voids

Five Fundamental Changes

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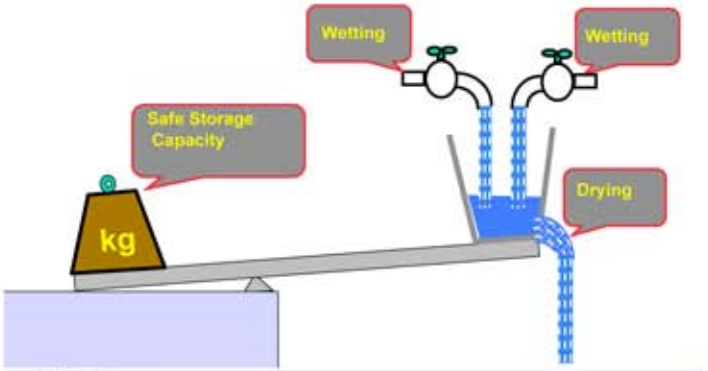
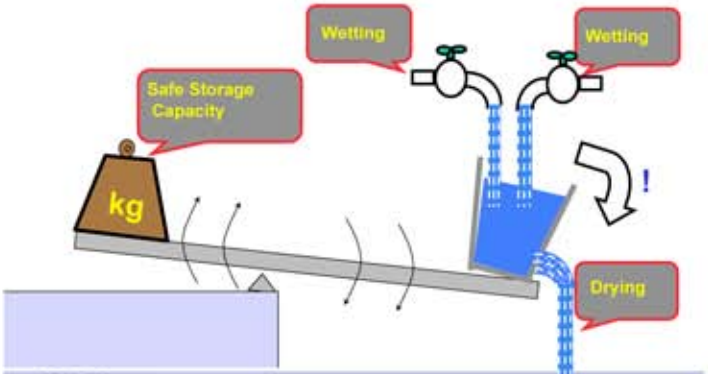
Moisture Balance



Moisture Balance: Accumulation



Addressing these changes

- Get back in balance
  - . . . and we need more insulation
- Provide better moisture control
  - drainage, airtight, construction moist. control
- Allow diffusion drying of moisture
  - Avoid vapor barriers
- Compartmentalize
  - Understand airflow in buildings

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- Need to understand what we are doing from *first* principles
- Cant "learn by trying"
- Building Science can guide us

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The Rules

Heat Flow Is From Warm To Cold

Moisture Flow Is From Warm To Cold

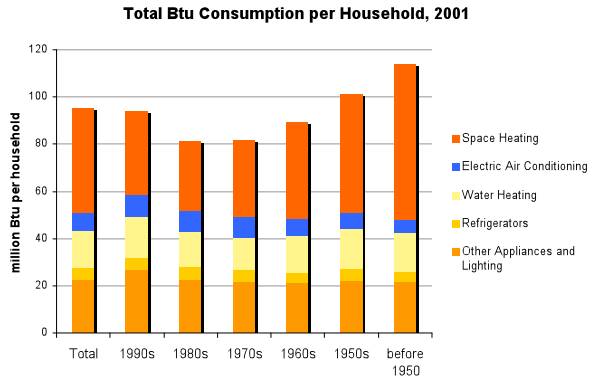
Moisture Flow Is From More To Less

Air Flow Is From A Higher Pressure To A Lower Pressure

Gravity Always Acts Down

Issues of Energy

How Old and New Houses Use Ene



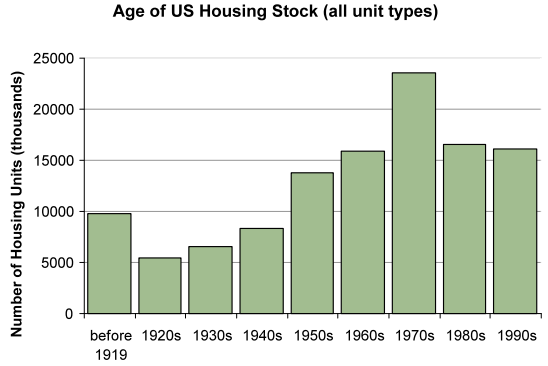
Source: US Census Bureau, Annual Housing Survey: http://www.census.gov/hhes/www/housing/ahs/ahs.html

Existing US Housing

- Total Housing Units in 2001 (millions):
- Single-Family Homes 73.7
- Apartments (all buildings) 26.5
- Mobile Homes 6.8
- Constructed since 2001 about 10
- Approx Existing Units: **115 million** units[1]

1. Energy Information Administration, Residential Energy Consumption Survey, 2001 data: www.eia.doe.gov/emeu/recs
2. EIA, Annual Energy Review, 2001 data: www.eia.doe.gov/emeu/aer

Existing Housing Stock



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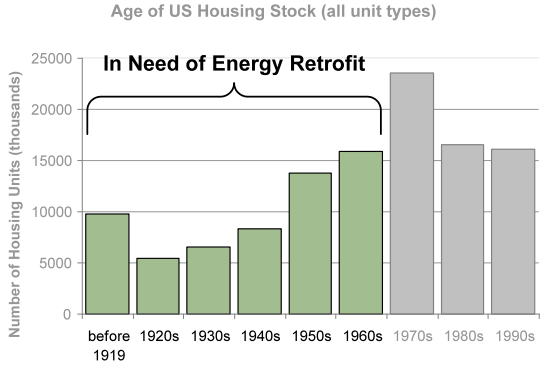

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