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Fundamental Changes

and the need for systems thinking

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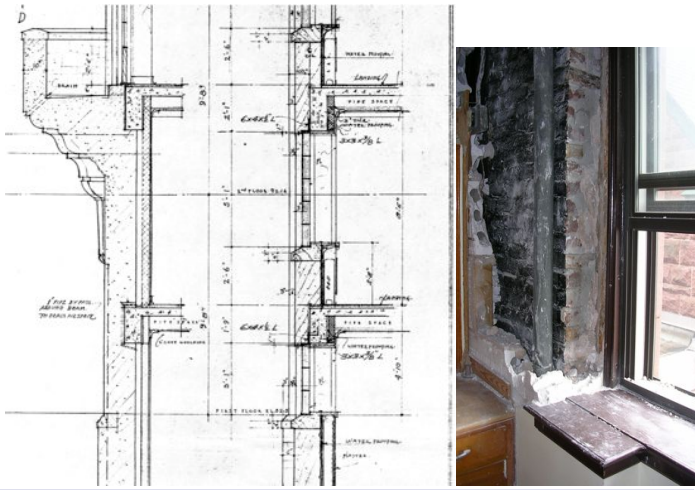
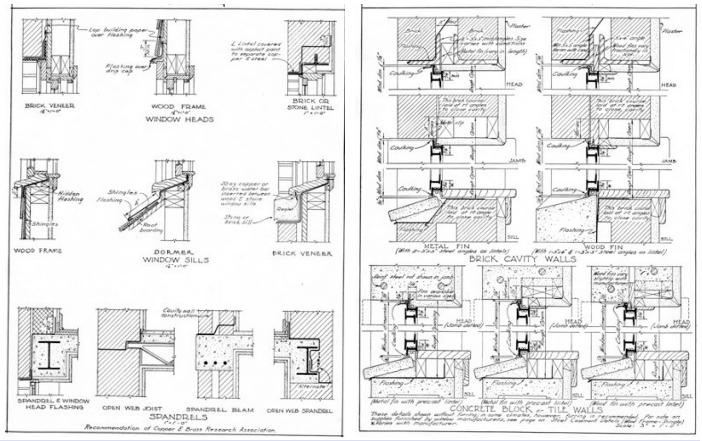
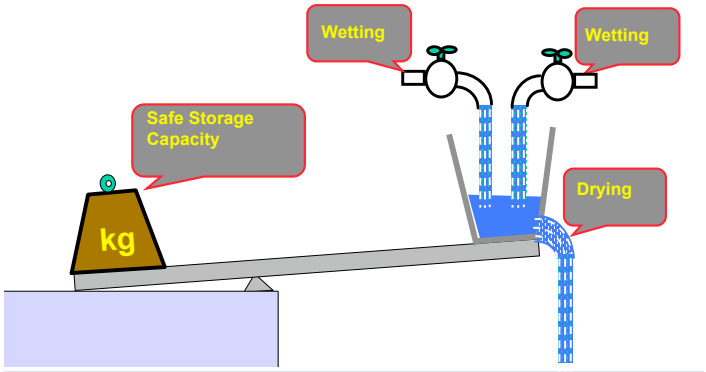




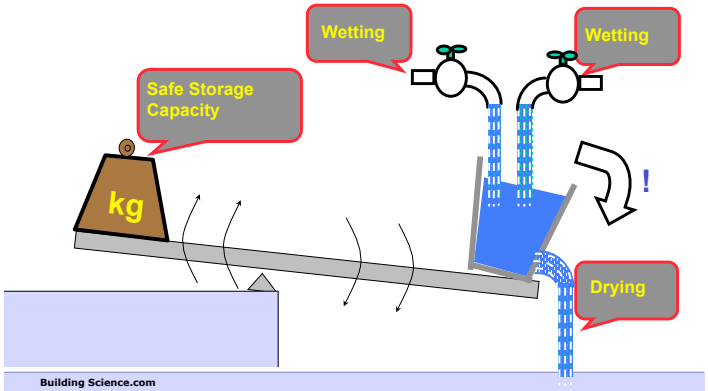
Pre-WWII Buildings

- Essentially no insulation
- Heating and some ventilation, but no air conditioning
- No vapor barriers
- Few explicit air-tightening or “draft-stopping” details
- Plaster is the dominant interior finish

Moisture Balance



Moisture Balance: Accumulation



Five Fundamental Changes

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

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

2. Permeability

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

3. Water/Mold Sensitivity

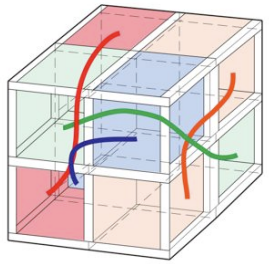
- Moisture= mold growth
- Wood products
  - New growth vs old
  - Processing: plywood, OSB, particle board
  - Paper, Veneers
- Finishes
  - Drywall, ceiling tile

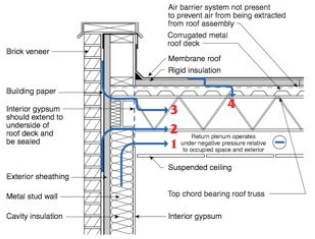
4. Hygric Buffer Capacity

- 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





1 Air is pulled from exterior wall cavity into return plenum since interior gypsum does not extend to underside of roof deck

2 Air is pulled from exterior through gaps in building paper and exterior sheathing

3 Air is pulled from exterior through gaps between corrugated metal roof deck and structural steel

4 Air is pulled from under roof membrane through gaps in rigid insulation and metal roof deck

Hollow Buildings

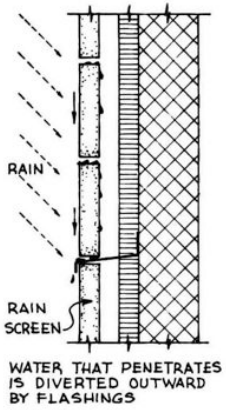
Five Fundamental Changes

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

Addressing these changes

- Get back in balance
- Provide better moisture control
  - drainage, airtight, construction control
- Allow diffusion drying of moisture
  - Use vapor barriers with care
- Compartmentalize
  - Air seal within buildings as well

- Follow the rules

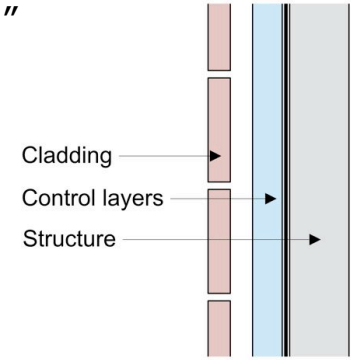


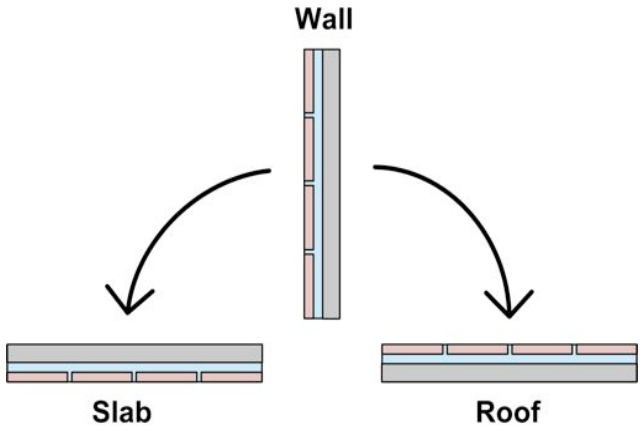
Commercial Enclosure: Simple Layers

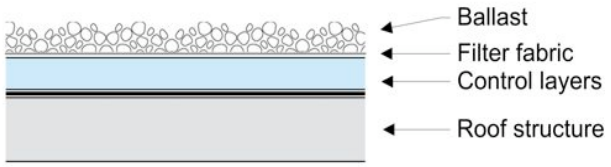
- Structure
- Rain/Air/Vapor
- Insulation
- Finish

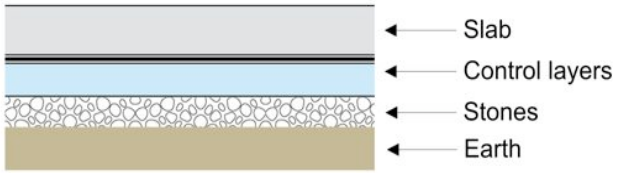
The "Perfect Wall"

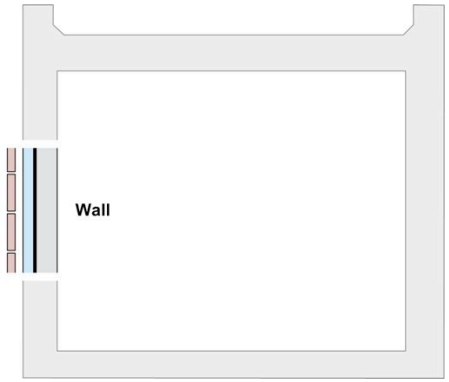
- Finish of whatever
  - May need ventilation
- Control continuity
  - Drainage gap + plane
  - Air barrier
  - Insulation
  - Vapor control
- Structure can be anything

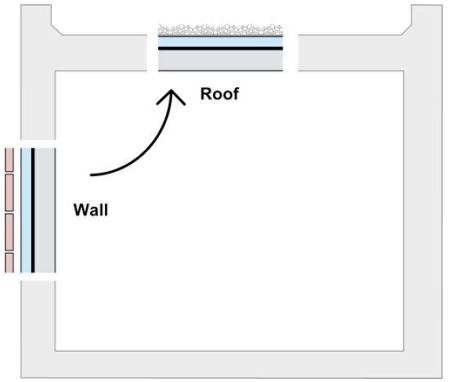


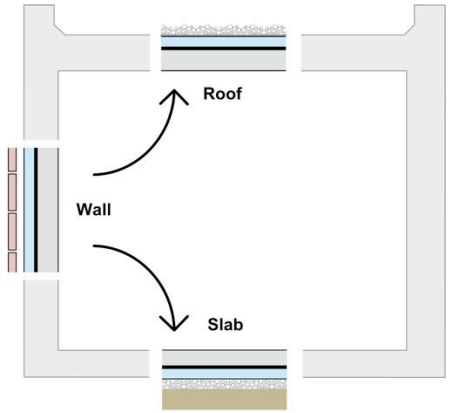


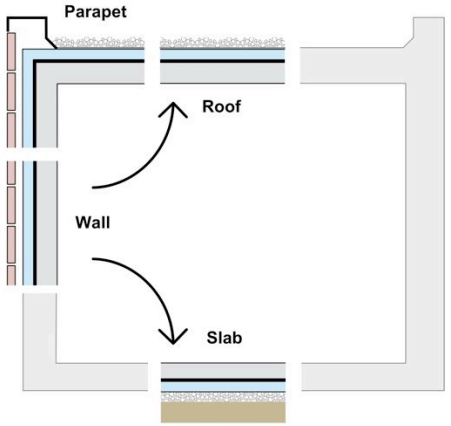


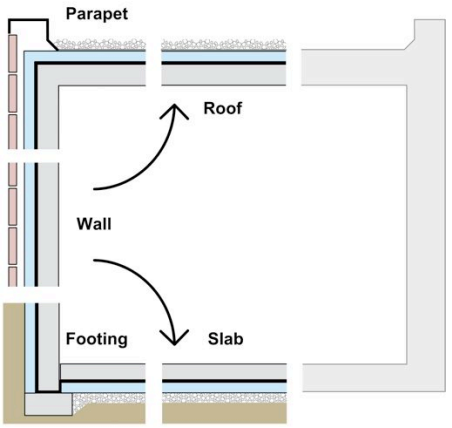

Slab
Control layers
Stones
Earth

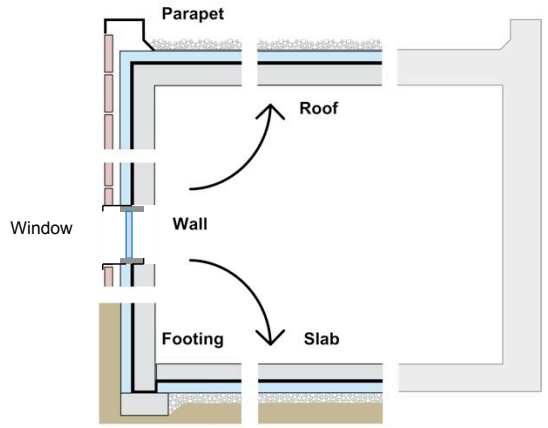

Wall


Roof
Wall

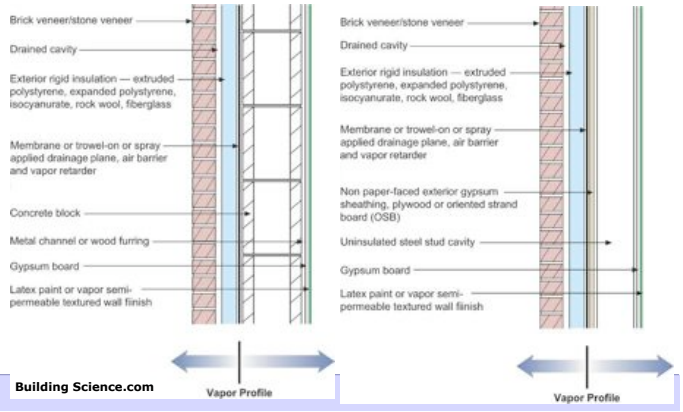

Roof
Wall
Slab


Parapet
Roof
Wall
Slab


Parapet
Roof
Wall
Footing
Slab

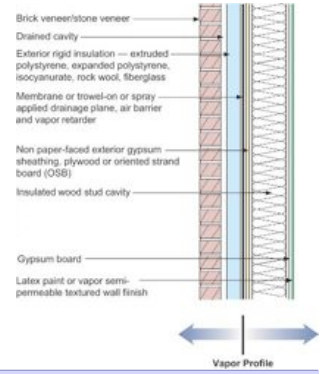

Parapet
Roof
Window
Wall
Footing
Slab

The perfect wall



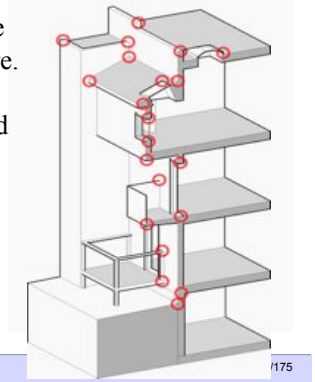
More challenging …

- Compromise
  - Wood studs
    - Wood insulates
  - High R-value steel
    - R40+
- The future?
  - Net-zero
  - Carbon neutral



Enclosure Design: Details

- Details demand the same approach as the enclosure.
- Scaled drawings required at ○



Conclusions

- The world has changed
- We have changed our construction materials
- We need to adapt our design to accommodate
- More change is coming . . .