

# Building Enclosures

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# Presentation

- Focus on the building enclosure
- Changes in the industry
  - Now and coming up ..

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# Building Functions

- Human needs... more than shelter  
(e.g. Location, Shelter, Utility, Comfort & Delight)
- ...function of a building:  
*“Provide the desired environment  
for human use and occupancy”*

*“Durability, Convenience, and Beauty”*  
Vitruvius, 70 BC

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# Building Components

- Buildings are made of several large systems
- The systems that make up a a building can be grouped in four categories
  - Superstructure
  - Enclosure
  - Service Systems
  - Fabric

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## The Enclosure: An Environmental Separator

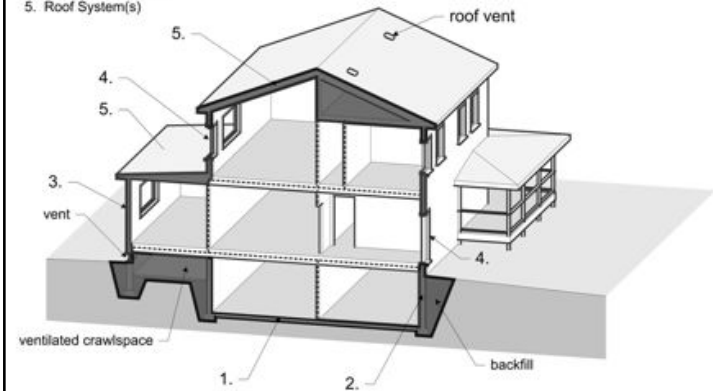
- The part of the building that physically **separates** the **interior** and **exterior** environments. (Part 5 of OBC)
- Includes all of the parts that make up the wall, window, roof, floor, etc... from the innermost to the outermost layer.
- Sometimes, interior partition also are environmental separators (pools, rinks, etc.)

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### Building Enclosure Components:

1. Basement Floor System(s)
2. Foundation Wall System(s)
3. Above Grade Wall System(s)
4. Windows and Doors
5. Roof System(s)



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Traditional Stucco Farmhouse



7 yrs old, non-traditional problems

What has changed?

## Mold, Rot, Corrosion, Decay, Recladding



## Enclosure Failures

- Problem causes:
  - 1. Material/system does not fill function
  - 2. Functionality not designed for
  - 3. Not built according to design (workmanship)
- Avoidance requires understanding each

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## 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

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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

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## 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

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## 3. Water/Mold Sensitivity

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



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## 4. Hygric Buffer Capacity

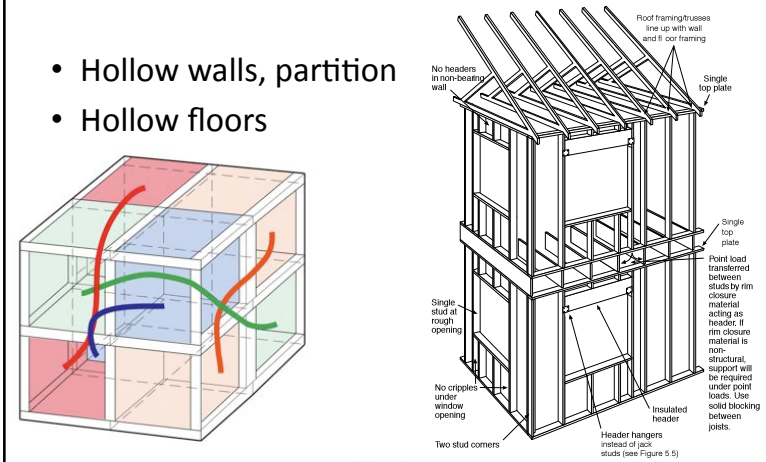
- Changing moisture storage
  - Concrete block / terra cotta
  - Rough cut wood / skip sheat
  - Steel stud with exterior gyps
- Orders of magnitude!
- But .. lightweight often low environmental impact



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## 5. Three-D Airflow Networks

- Hollow walls, partition
- Hollow floors

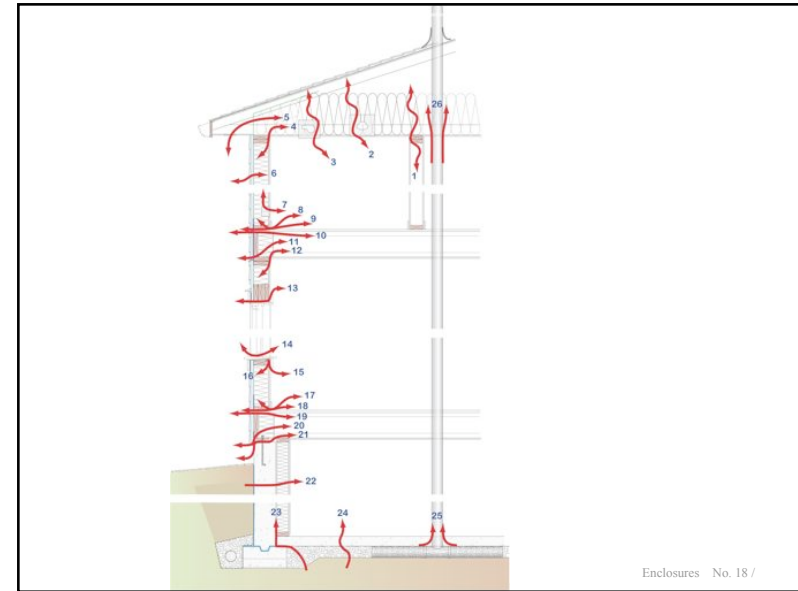
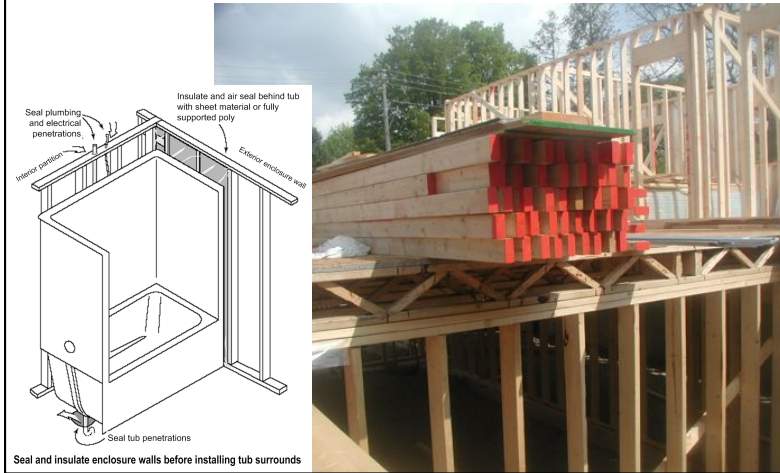


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## Hollow Walls, Floors etc



## 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
  - The code cant keep up
  - CCMC cant protect, but they could help

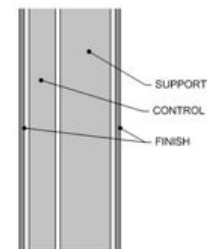
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## Basic Functions of the Enclosure

- 1. Support
  - Resist and transfer physical forces from inside and out
- 2. Control
  - Control mass and energy flows
- 3. Finish
  - Interior and exterior surfaces for people
- Distribution – a building function

Functional Layers

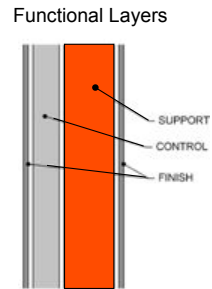


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## Basic Enclosure Functions

- **Support**
  - Resist & transfer physical forces from inside and out
    - Lateral (wind, earthquake)
    - Gravity (snow, dead, use)
    - Rheological (shrink, swell)
    - Impact, wear, abrasion
- **Control**
  - Control mass and energy flows
- **Finish**
  - Interior and exterior surfaces for people

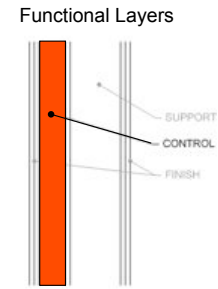


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## Basic Enclosure Functions

- **Support**
  - Resist & transfer physical forces from inside and out
- **Control**
  - **Control mass and energy flows**
    - **Rain** (and soil moisture)
      - Drainage plane, capillary break, etc.
    - **Air**
      - Continuous air barrier
    - **Heat**
      - Continuous layer of insulation
    - **Vapor**
      - Balance of wetting/drying
- **Finish**
  - Interior and exterior surfaces for people

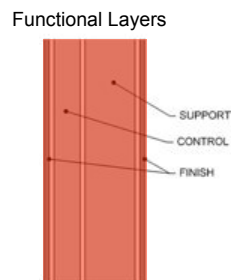


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## Other Control . . .

- **Support**
- **Control**
  - **Fire**
    - Penetration
    - Propagation
  - **Sound**
    - Penetration
    - Reflection
  - **Light**
    - Diffuse/glare
    - View
- **Finish**

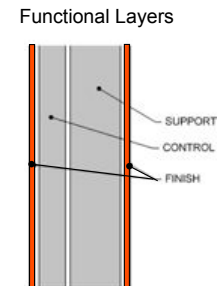


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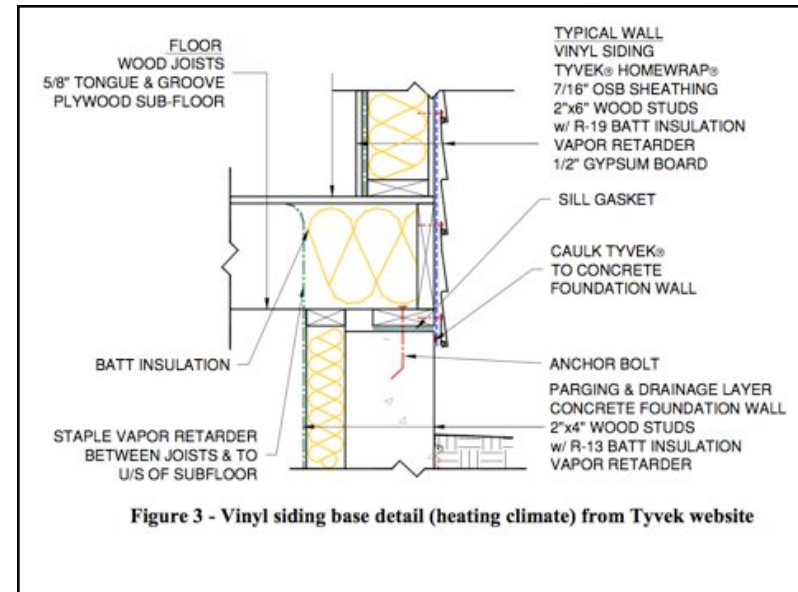
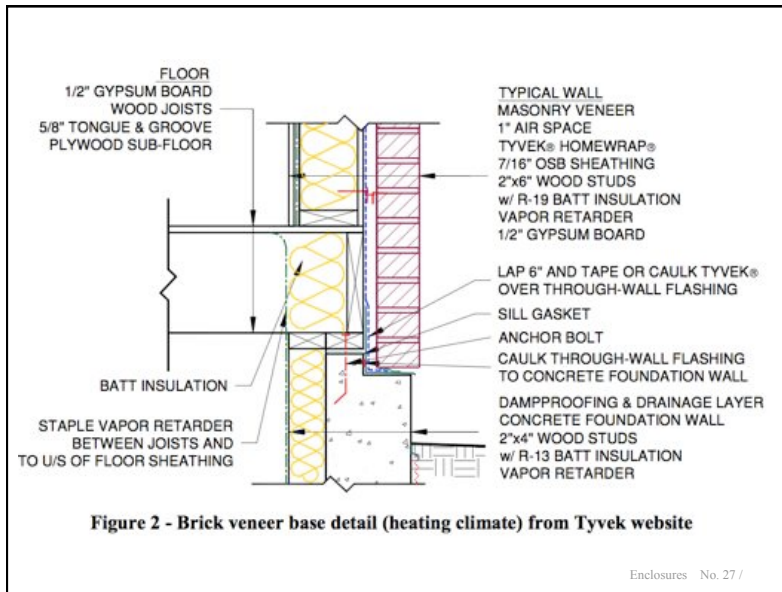
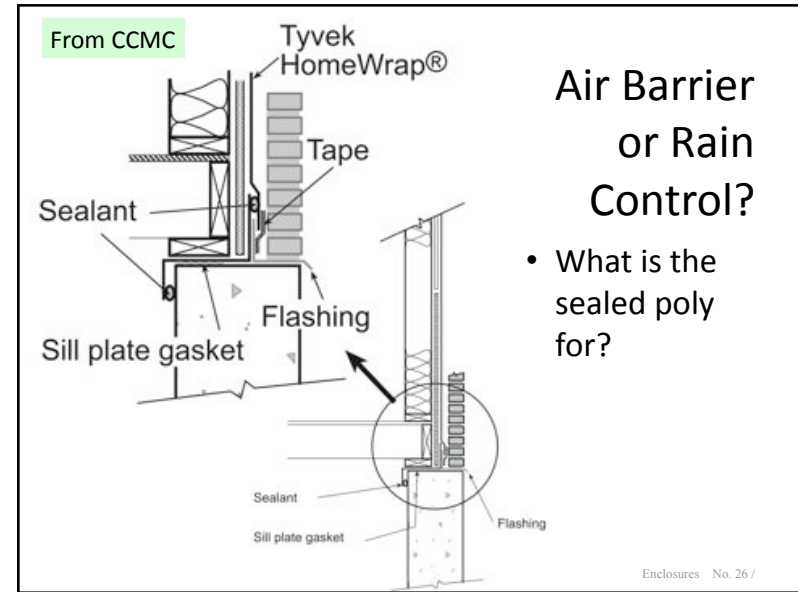
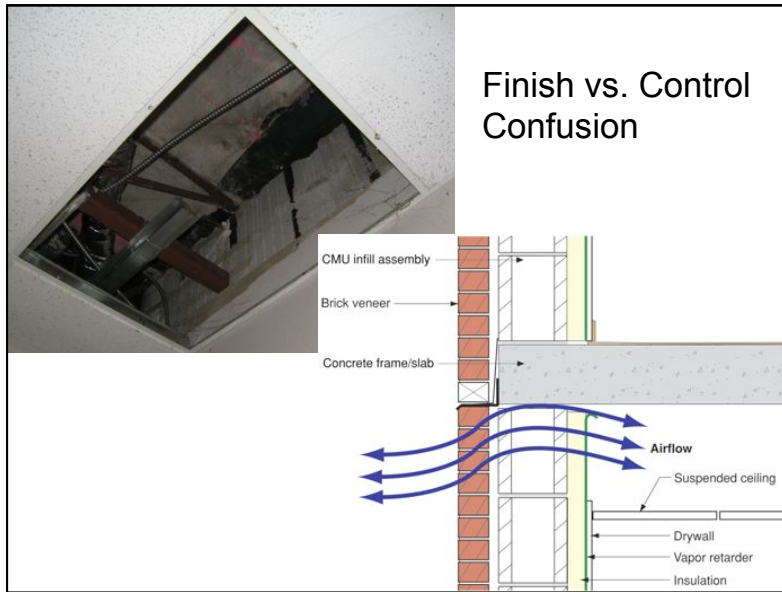
## Basic Enclosure Functions

- **Support**
  - Resist & transfer physical forces from inside and out
- **Control**
  - Control mass and energy flows
- **Finish**
  - **Interior & exterior surfaces for people**
    - Color, speculance
    - Pattern, texture



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## Distribution

- A ***Building*** Function imposed on enclosure
- Distribute services or utilities to from through, within, the enclosure, e.g.,
  - Power
  - Communication
  - Water (Potable, sewage, etc.)
  - Gas
  - Conditioned air ←
  - Cold or hot water ←

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## History of Control Functions

- Older Buildings
  - One layer does everything
- Newer Building
  - Separate layers,  
... separate functions



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## Enclosure Design Principles 1

- Design a complete structural load transfer path
  - Structure, windows, ties, etc
  - All loads go to ground
- Respect the site and climate
  - Rain, sun, wind, hill, valley, high rise or low-rise
- Continuous rain control plane
  - Control with surface features and detailing
  - Drained, storage, or perfect barrier strategy
- Continuous plane of air barrier tightness
  - Fastidious attention to detail 3-D

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## Enclosure Design Principles 2

- Provide a continuous plane of insulation
  - Ideally separate structure from enclosure
  - *Avoid thermal bridges*
- Provide a moisture tolerant design
  - Balance wetting, drying, and storage (matl's, climate)
  - Use appropriate levels of vapour control
    - No cold vapor barriers, allow drying
- Accommodate movements and tolerances
- Draw all of the Details!

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# Design Checklist & Functions

## Building Enclosure Concept Design Stage Checklist

### SUPPORT

1. **Support** mechanical loads
  - Sufficient strength and stiffness (from structural engineer)

### CONTROL

2. **Heat Flow Control** (Temperature and Energy)
  - avoid thermal bridges, reasonable insulation: HVAC energy + capital cost savings
  - control air leakage,
  - excessive glazing = winter discomfort and summer overheating (esp. west glass)
3. **Condensation Control**
  - surface condensation, i.e. thermal bridges, corners, etc.
  - interstitial condensation (summer & winter) by vapour diffusion and air leakage
4. **Air Flow Control**
  - air barrier systems, compartmentalization, convection loops in batts
  - IAQ, control of stack effect, HVAC, and wind-induced air flows, odor, dust

### 5. Rain Control

- climate, site, building orientation, shape
- deflection, surface drainage, drying, and enclosure rain control strategies

### 6. Crack/Movement control

- control of cracking and movement are complementary
- consider creep, sag, shrinkage, swelling, both moisture and temperature movement

### 7. Fire and Smoke Control

- fire resistance rating, flame spread, smoke produced, toxins generated
- special situations, often involved in design decisions (e.g., combustible vs non-combustible)

### 8. Sound and Vibration Control

- airborne sound reflection, transmission, and impact borne sound transmission
- special situations are sometimes important, always needs some consideration

### FINISH

9. **Finish**
  - colour, pattern, texture, etc of interior and exterior interfaces
  - architecture and interior designers

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# Design Checklist & Functions

## Building Enclosure Concept Design Stage Checklist

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Continuous Air Barrier

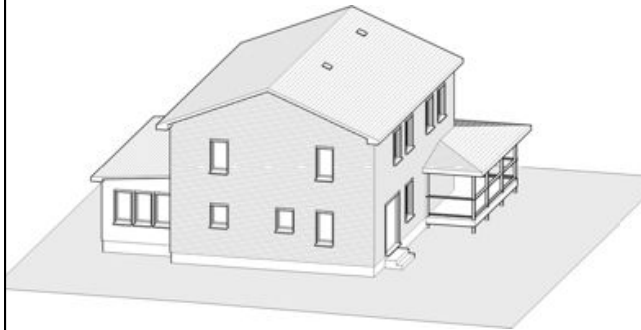
Continuous Insulation

Continuous Rain Control Layers

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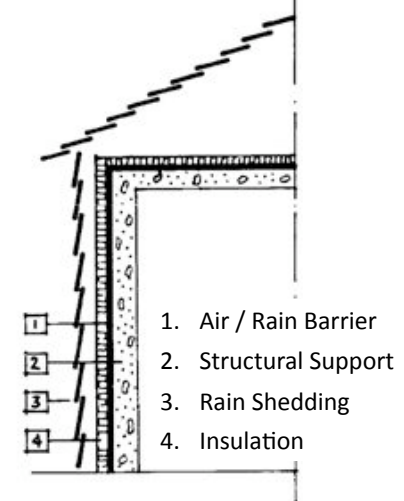
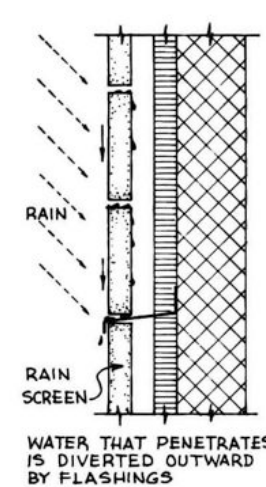
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## Framed Enclosures: Adding the Layers



Structure  
Air Flow  
Control  
Insulation  
Rain  
Control  
Finish

## Design Information older than I am.




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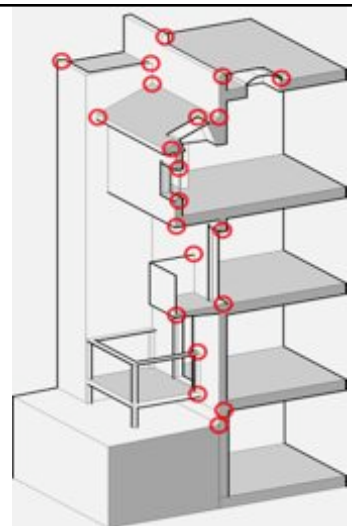
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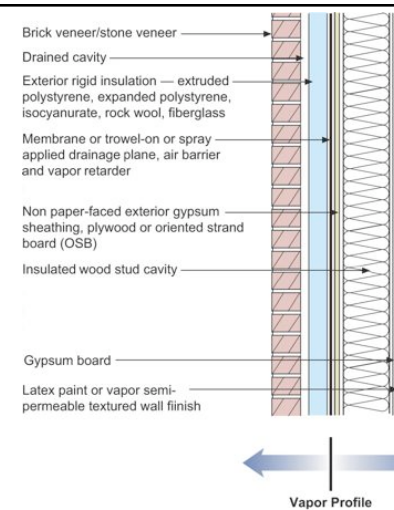
## Enclosure Design: Details

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



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The Wood Frame High R-value wall

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## Issues

- Rain Control - constant effort
  - Leaks, rot, stain, peeling paint
- Air Control – new products
  - Rot and mold, Comfort, noise, health
- Vapor Control – new walls, new challenges
  - Condensation, rot and mold
- Heat Flow Control – new products
  - cold spots, comfort

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## Rain



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## Drain the Rain



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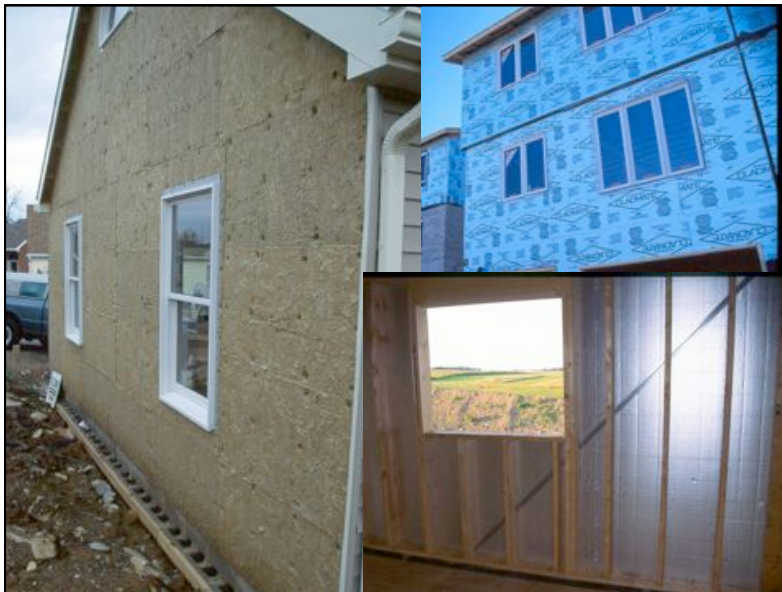


# High R-value Walls

## Case Studies

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### Lowell Habitat for Humanity Bedford, MA

1400 sq. ft. @ \$80/sq. ft.

Gas = \$50/month @ \$1.50 /therm

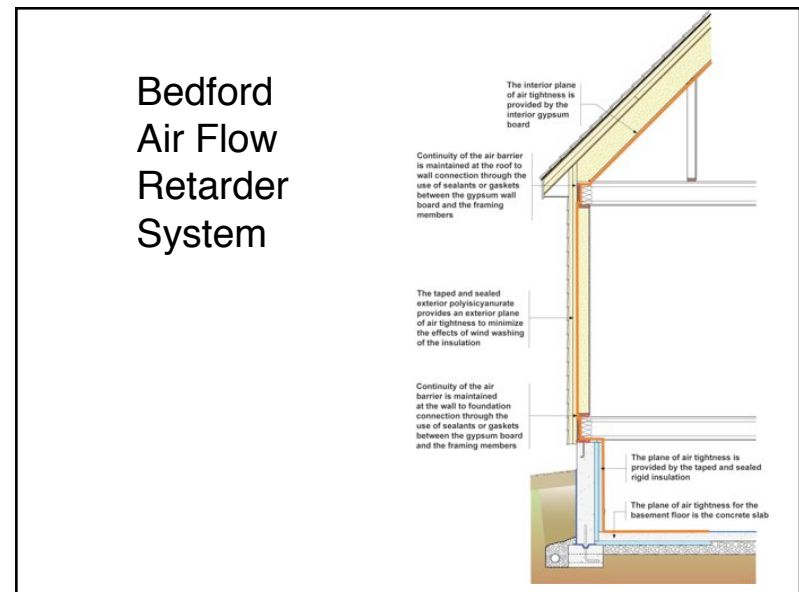
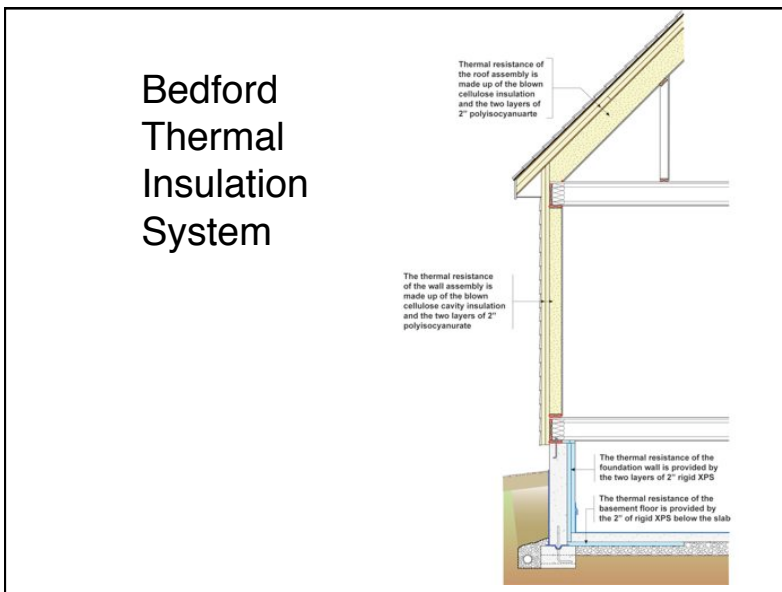
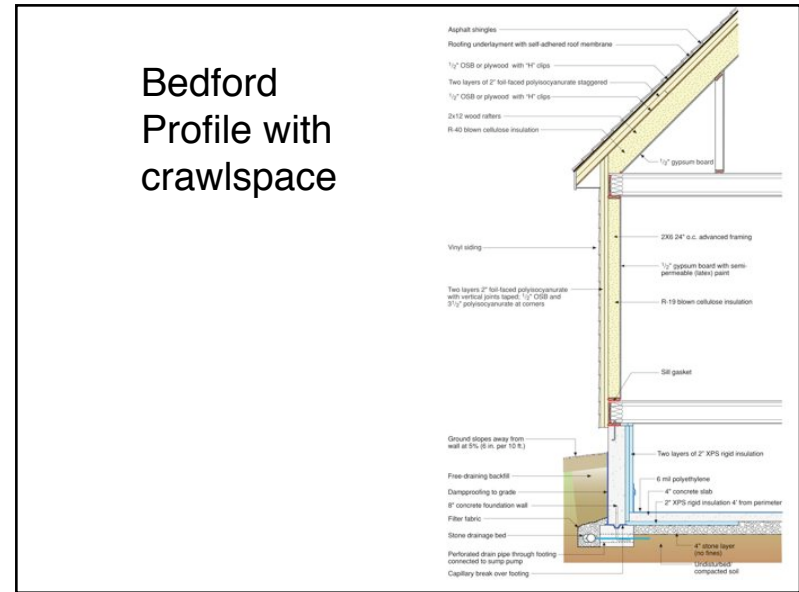
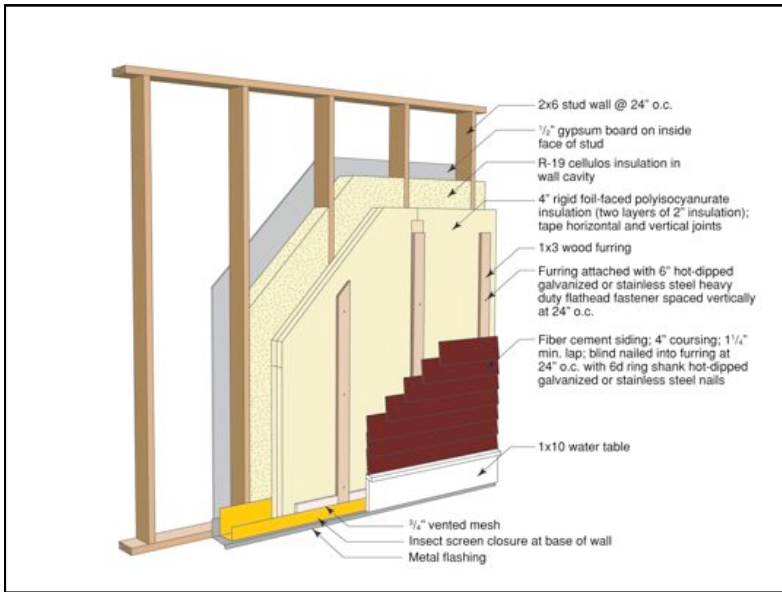
Electric = \$50/month @ \$.15/kWh    Average = \$3.30 per day

With 4 kW PV and 94 sq. ft. solar hot water    \$105/sq.ft.

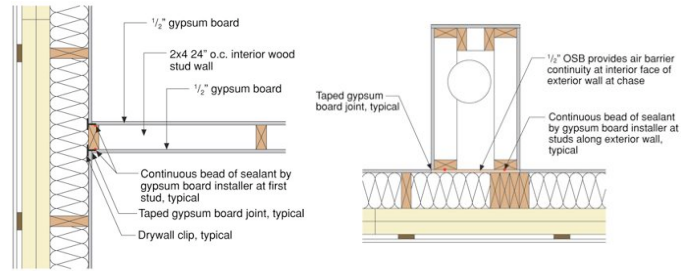
Electric = \$0    Gas = \$37.50/month    Average = \$1.25/day



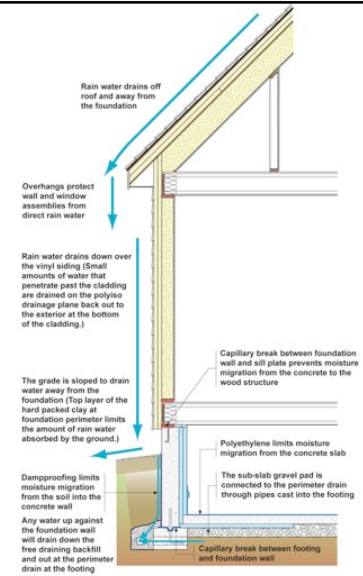




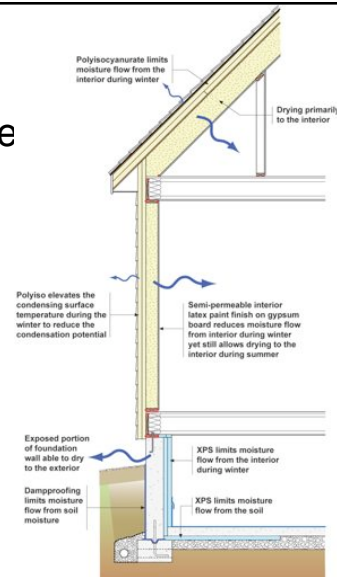
## Airtightness details at penetrations



## Bedford Water Management System



## Bedford Vapor Retarde System



## Conclusions

## Advanced Framing Details

