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Building Science 2011

Environmental Separation



presented by www.buildingscience.com

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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Enclosures No. 2 /

Building Components

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

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Enclosures No. 3 /

Importance of the Enclosure

- Image
 - People see it!
- Building problems
 - Often heat, moisture and the enclosure
- Energy consumption
 - Driven by enclosure performance
- Durability often less than building
 - Roof 15-30 yrs, Windows 20-40 yrs
Sealants 5-25 yrs

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Enclosures No. 4 /

The Enclosure: An Environmental Separator

- The part of the building that physically **separates** the **interior** and **exterior** environments.
- 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.)

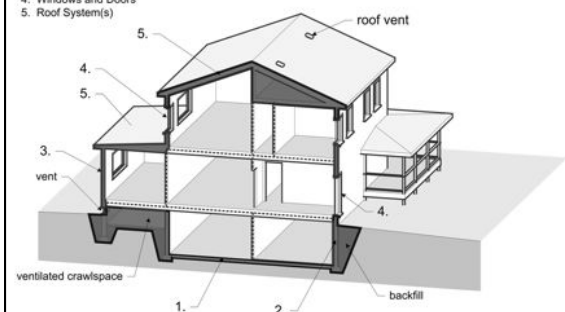
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Enclosures No. 5 /

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)

We will cover: roofs, walls, basements/slabs and windows



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Enclosures No. 6 /

Enclosure Loadings

- The separation function generates *loads*
- *Load*: any event, phenomenon or characteristic that can affect the enclosure
 - Heat, Air, Moisture
 - Fire, Sound
 - UV, Ozone
 - Gravity, impacts, abrasion
 - Insects
 - Etc...

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Enclosures No. 7 /

Loads: Climate / Site

- Design for
 - Climate zone
 - Site
 - Building height, shape, complexity



Seattle ≠ Sacramento
Miami ≠ Minneapolis
Edmonton ≠ Vancouver

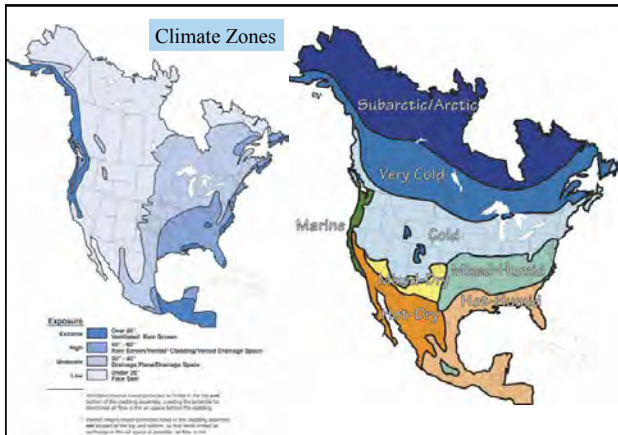
Marcus Vitruvius Pollio

These are properly designed, when due regard is had to the country and climate in which they are erected. For the method of building which is suited to Egypt would be very improper in Spain, and that in use in Pontus would be absurd at Rome: so in other parts of the world **a style suitable to one climate, would be very unsuitable to another**: for one part of the world is under the sun's course, another is distant from it, and another, between the two, is temperate.

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Enclosures No. 8 /

Climate Zones



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Enclosures No. 9 /

Climate Load Modification

- Building & Site (overhangs, trees...)
 - Creates microclimate
- Building Enclosure (walls, windows, roof...)
 - Separates climates
 - Passive modification
- Building Environmental Systems (HVAC...)
 - Active modification
 - Use energy to change indoor weather

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Enclosures No. 10 /

Evolution



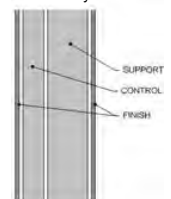
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Enclosures No. 13 /

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

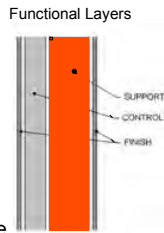


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Enclosures No. 14 /

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

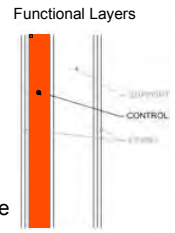


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Enclosures No. 15 /

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

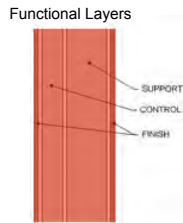


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Enclosures No. 16 /

Other Control Functions . . .

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



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Enclosures No. 17 /

History of Control Functions

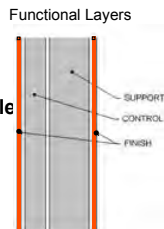
- **Older Buildings**
 - One layer does everything
- **Newer Building**
 - Separate layers, . . . separate functions



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Basic Enclosure Functions

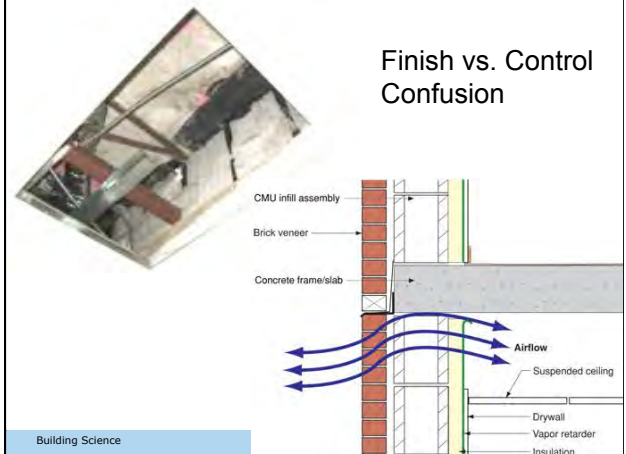
- **Support**
 - Resist & transfer physical forces from inside and out
- **Control**
 - Control mass and energy flows
- **Finish**
 - Interior & exterior surfaces for people
 - Color, speculance
 - Pattern, texture



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Enclosures No. 19 /

Finish vs. Control Confusion



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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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Enclosures No. 21 /

Enclosure Design Principles 1

- Design a complete structural load transfer path
 - Structure, windows, ties, etc
 - All loads go to ground
- Understand site, use, and climate *loadings*
 - Rain, sun, high rise or low-rise, pool, office, school
- 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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Enclosures No. 22 /

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 (mat'l'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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Enclosures No. 23 /

The Enclosure: Adding the Layers

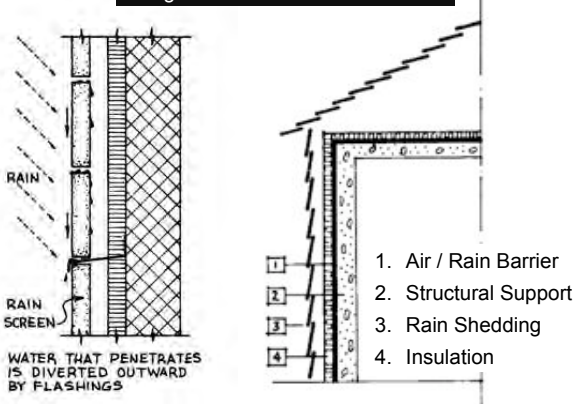


- Structure
- Air-Rain Barrier
- Insulation
- Finish

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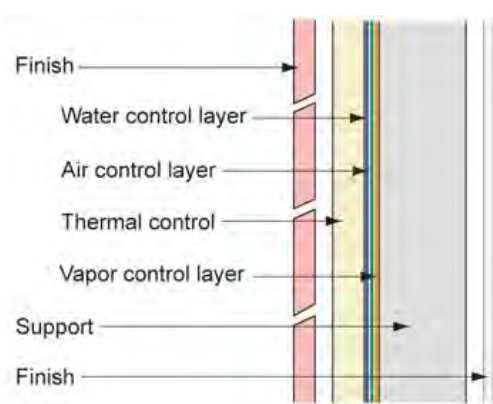
Enclosures No. 24 /

Design Information older than I am.



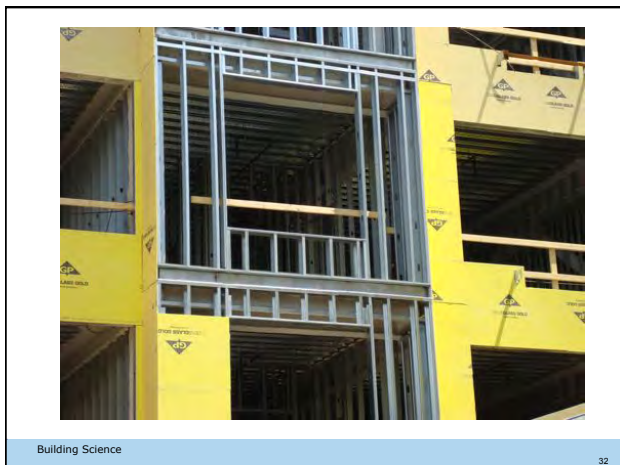
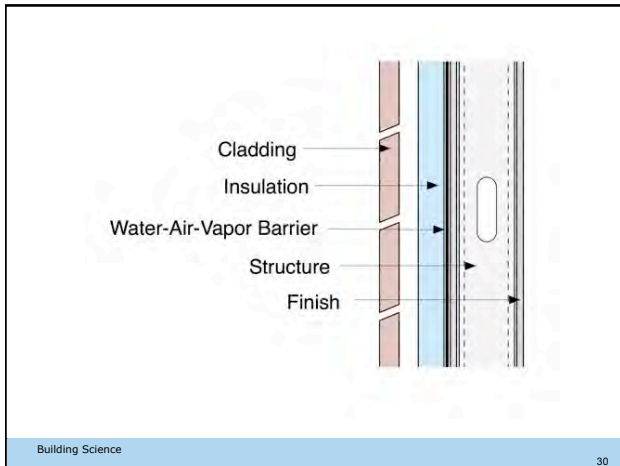
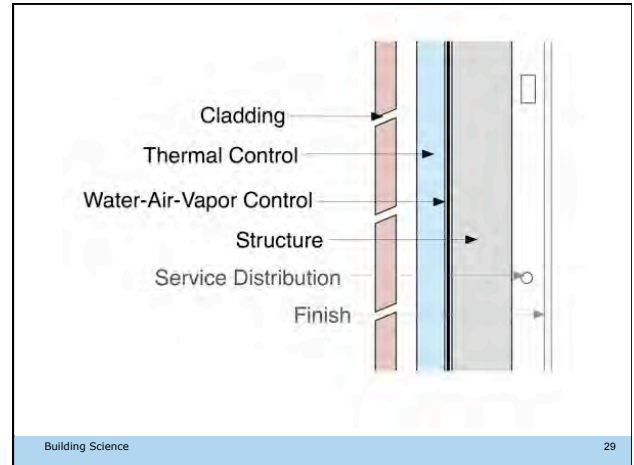
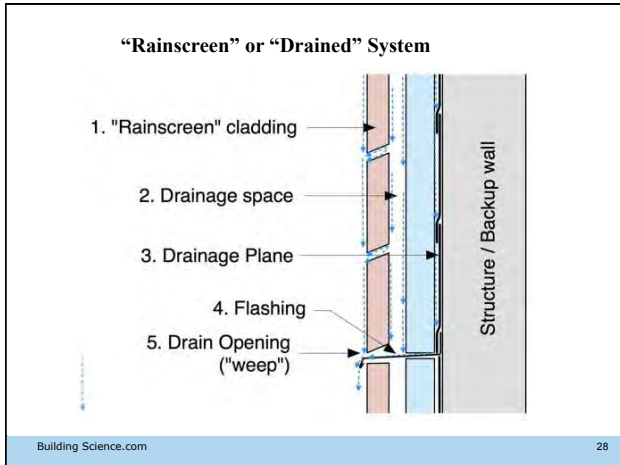
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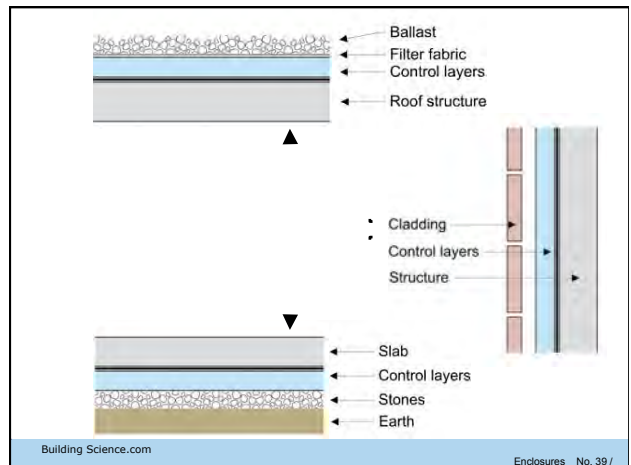
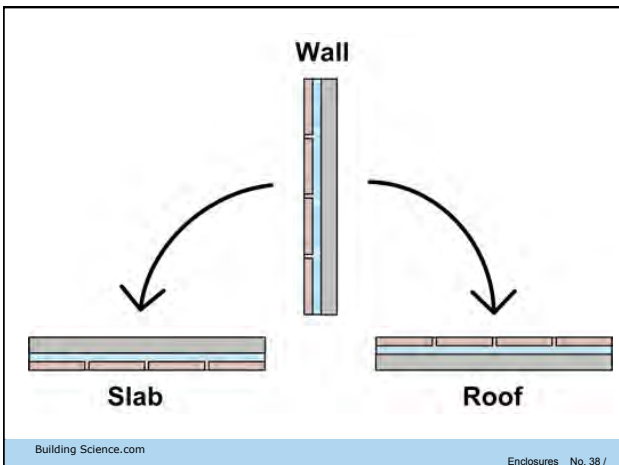
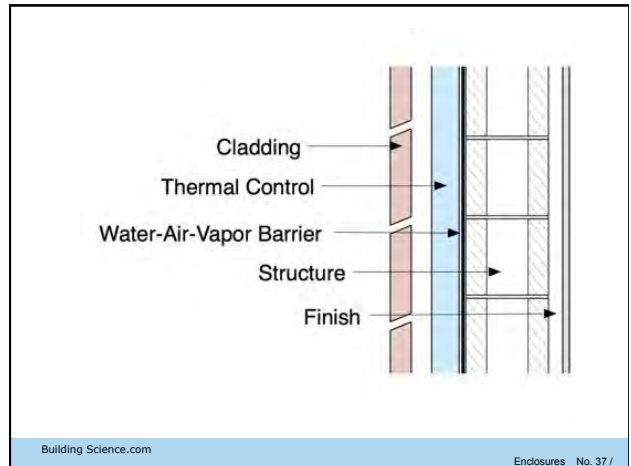
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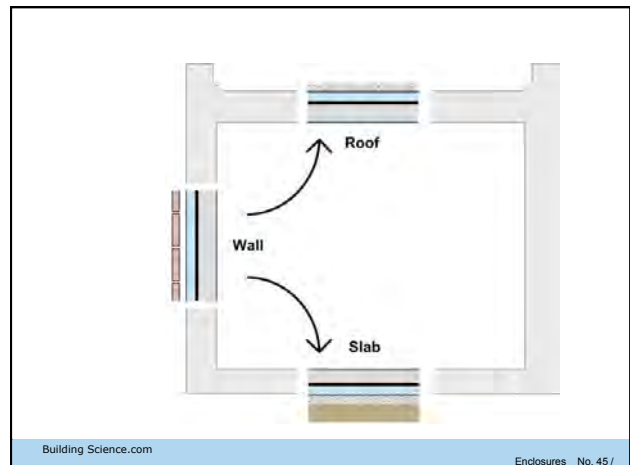
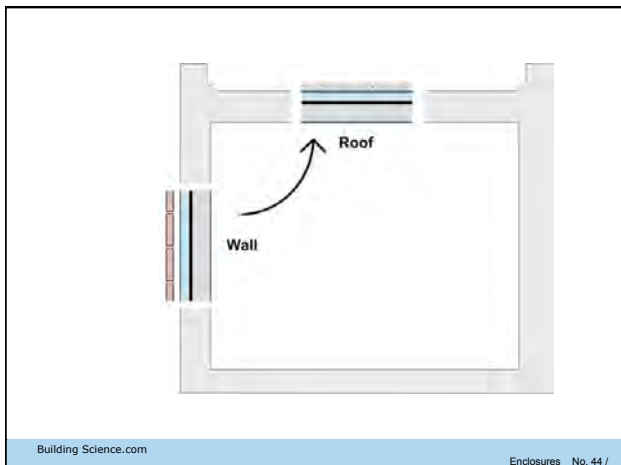
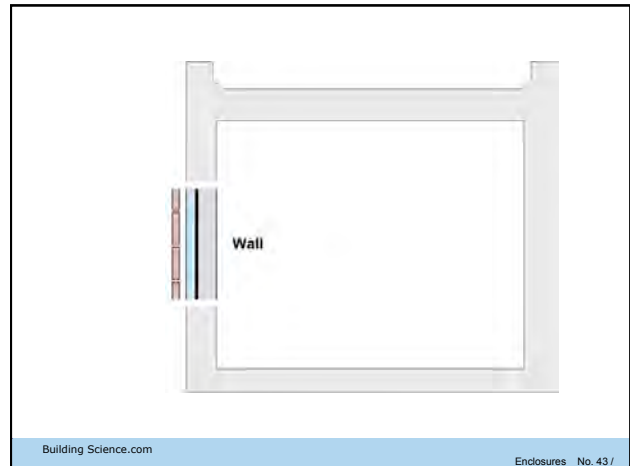
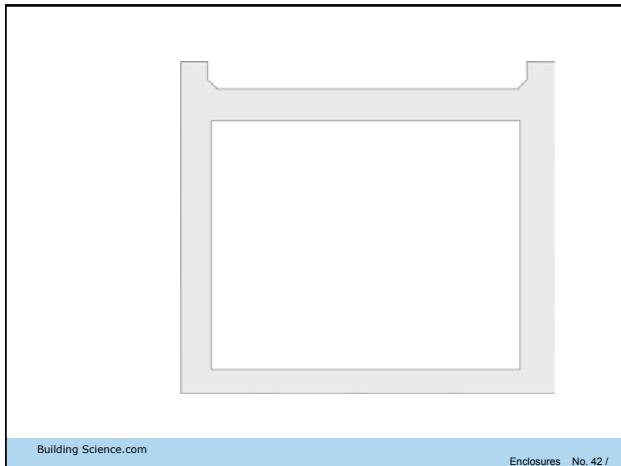
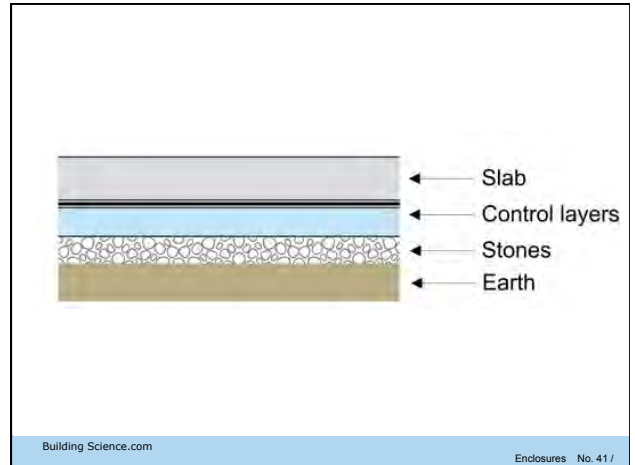
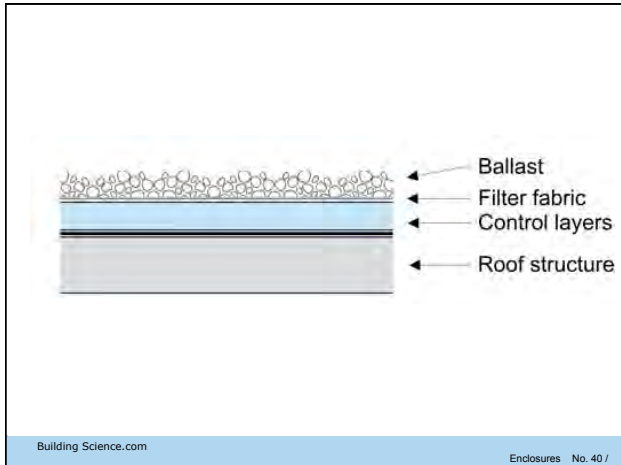


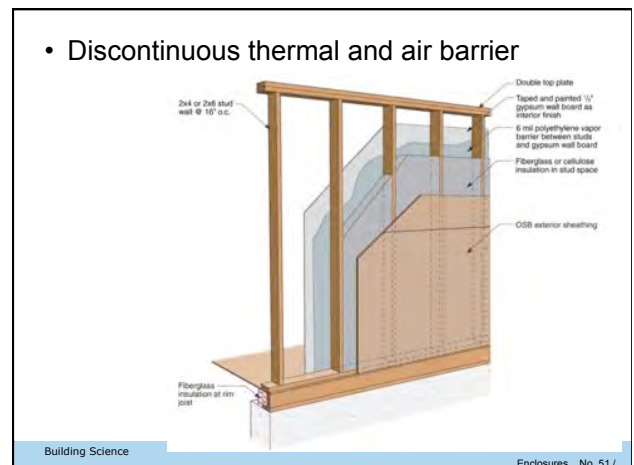
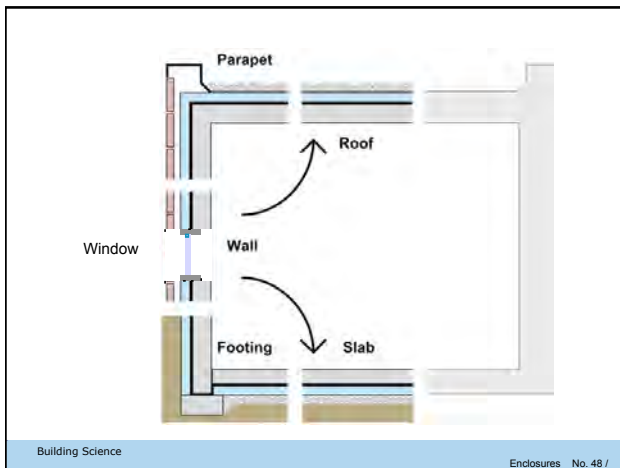
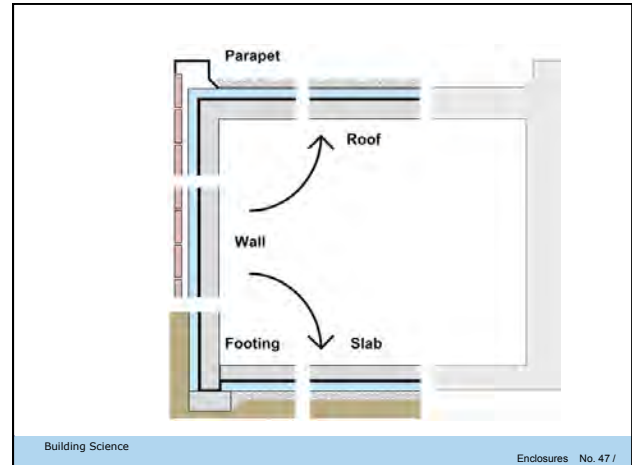
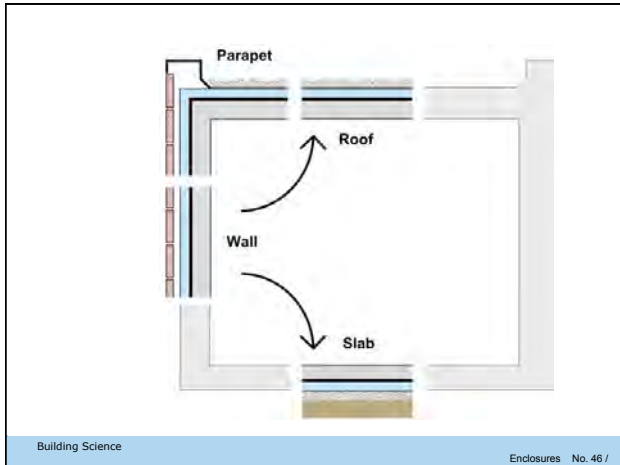
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Mom's Rules of Building Science

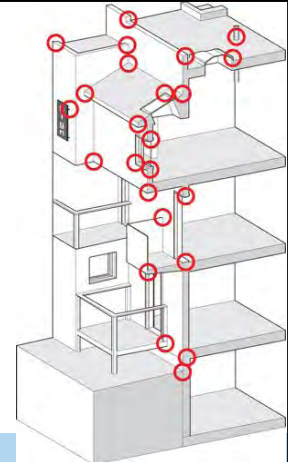
- Close the window / door / fridge
 - Airtightness matters
- Wear a hat
 - Sunshade, rain shelter
- Don't tuck pants into boots
 - Drainage and shingling
- Wear your jacket, sweater, mittens
 - Insulate on the outside

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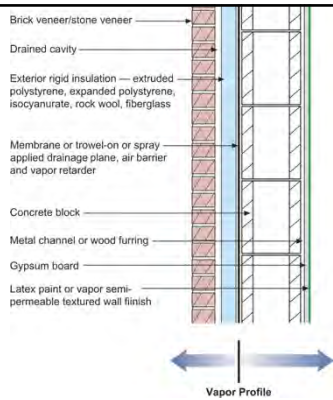
Enclosures No. 52 /

Enclosure Design: Details

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



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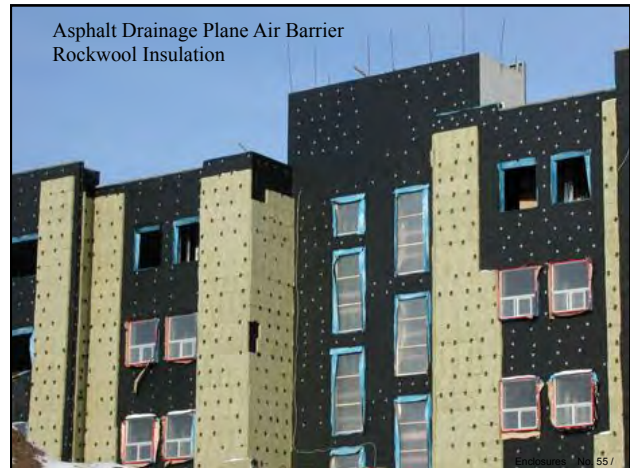


The "Perfect" wall: High Performance

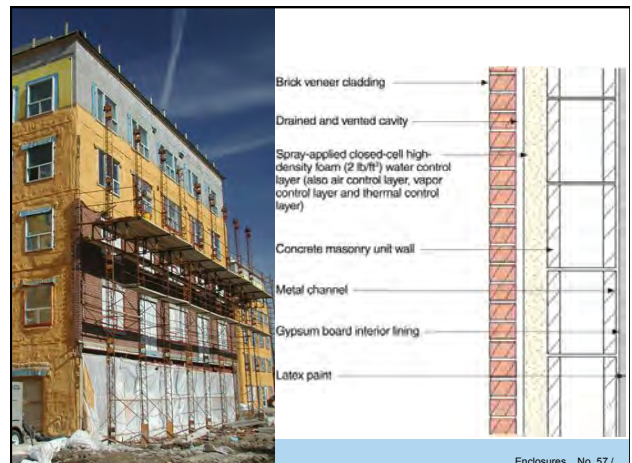
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Enclosures No. 54 /

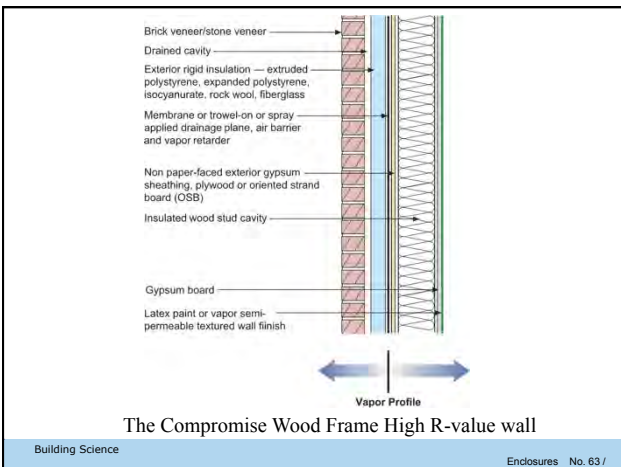
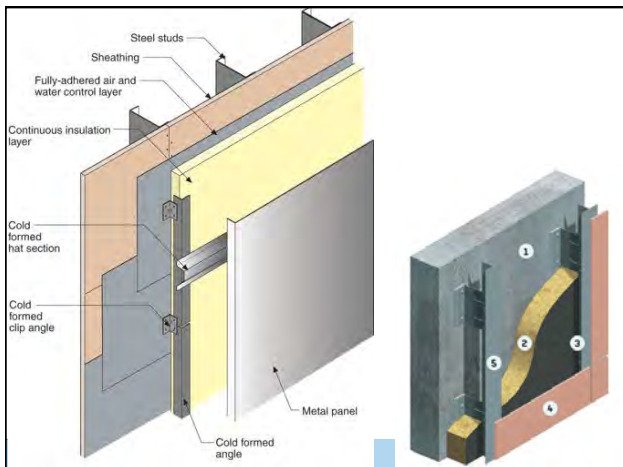
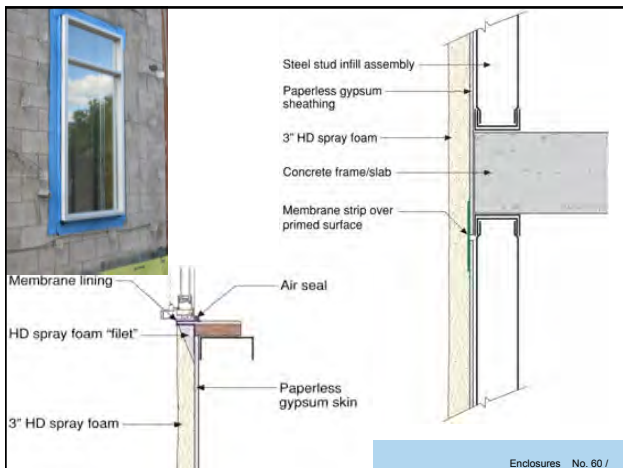
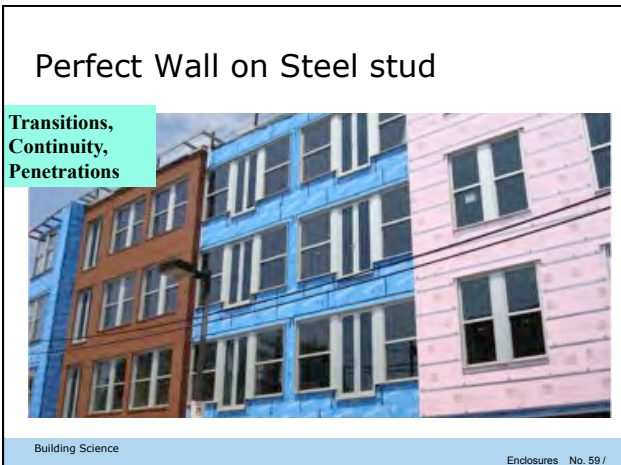
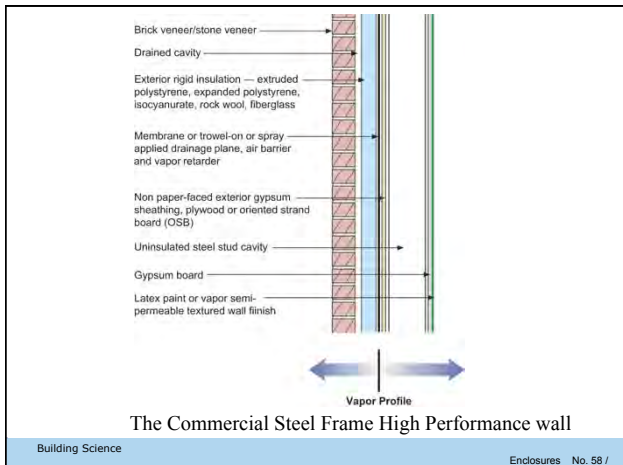
Asphalt Drainage Plane Air Barrier Rockwool Insulation



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Vapor Profile

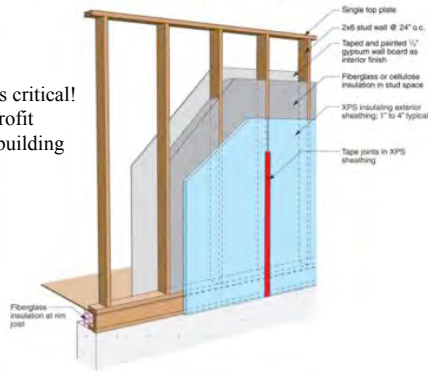


Enclosures No. 57 /



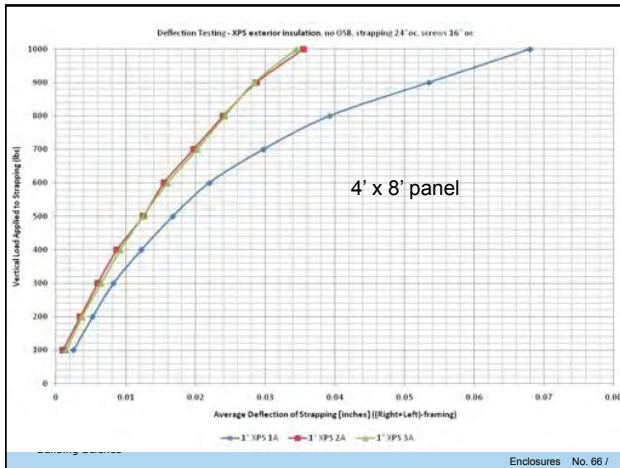
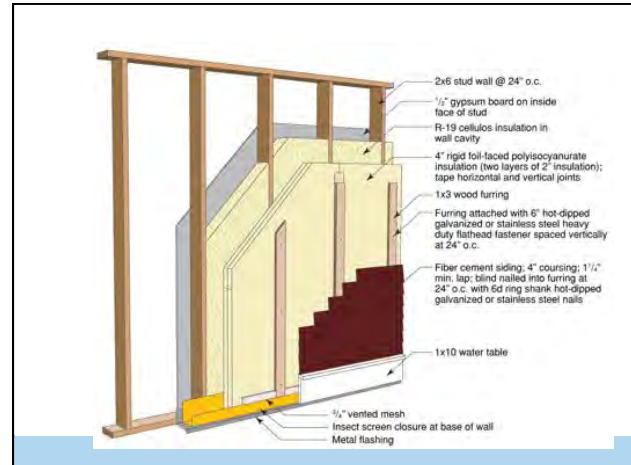
• Perfect Residential Compromise

- Ratio of R-values critical!
- This can be a retrofit of a wood frame building

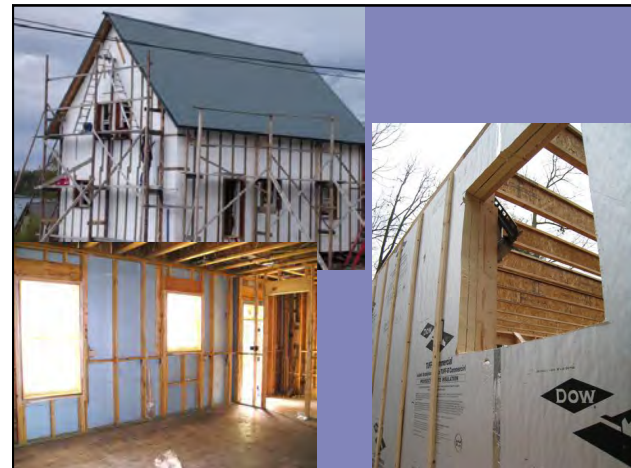


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Enclosures No. 64 /



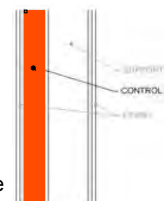
Enclosures No. 66 /



Recall: 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

Functional Layers

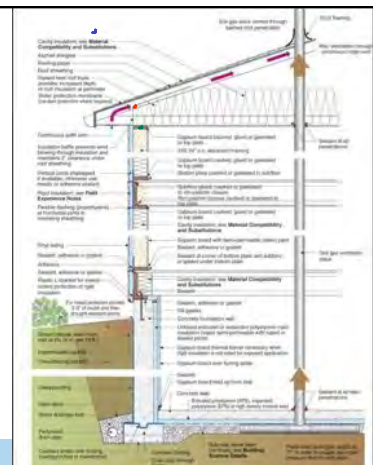


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Enclosures No. 68 /

Houses

- Rain
- Heat
- Air



Enclosure Types

- Typically define enclosure by
 - Finish, e.g. “brick veneer, granite” etc
 - Support e.g., “steel stud, concrete block” etc.
- Should define by what we use and where we put:
 - insulation,
 - water and
 - air barriers
- And where they are located relative to structure

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Enclosures No. 71 /

Brick Veneer/Steel Studs

- Very common system
- Steel studs are thermal bridging nightmare
- Brick is Drained system
- Beware drainage/flashing
- Detail air barrier
- Insulate on exterior
 - Beware balcony/canopy



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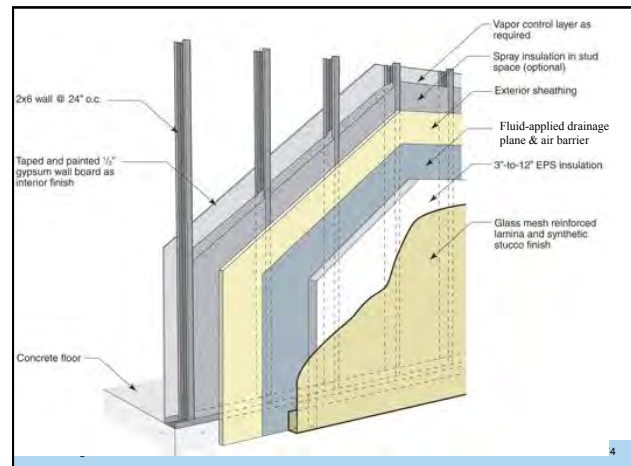
Enclosures No. 72 /

Cladding “Types”

- Masonry veneer, adhered veneer
- Architectural precast
- EIFS and stucco
- Panel systems: Metal, fibre cement, glass, natural stone
- Windows, curtainwalls, storefronts
- Lap siding, board and batten
-are all just cladding, not enclosures

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Enclosures No. 73 /



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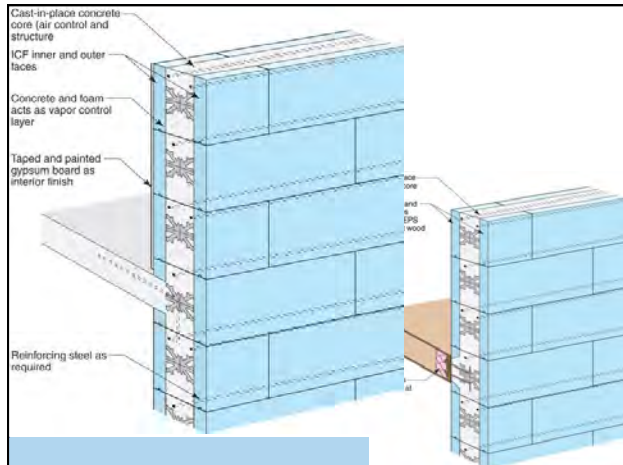
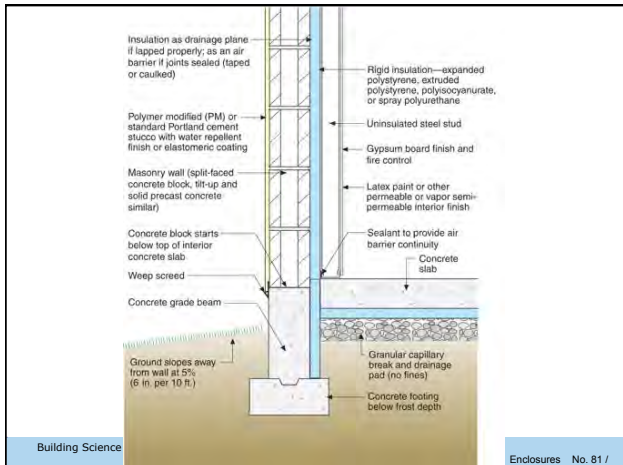
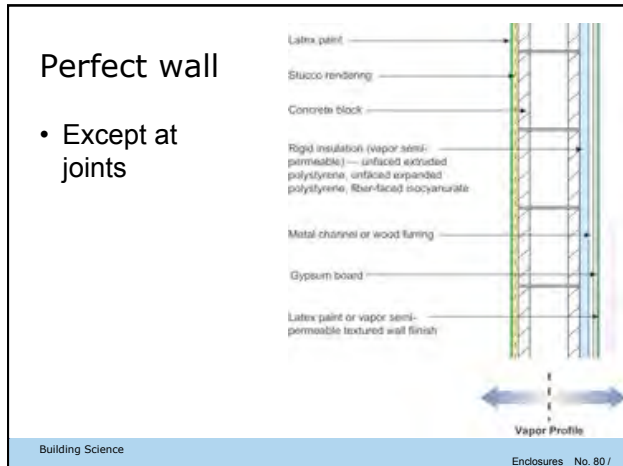
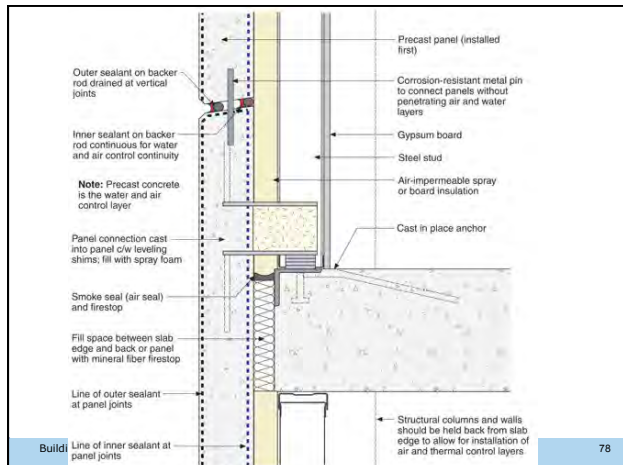
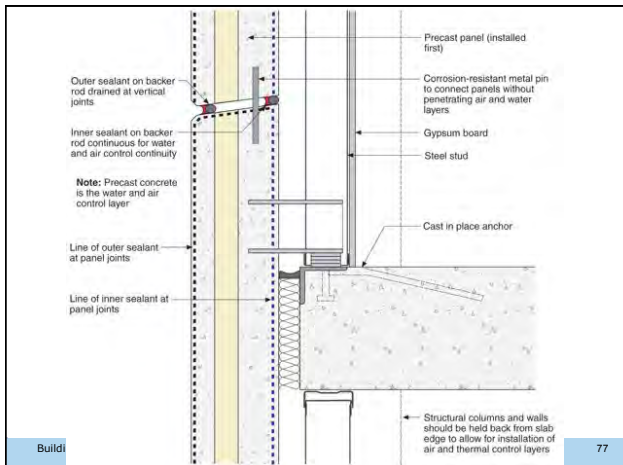
Metal Panels

- Lightweight, durable
- Should be drained & vented system
 - Some are not!
- Have high performance potential
- High tech look



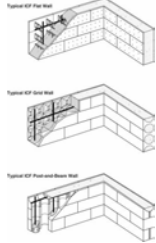
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Enclosures No. 76 /



Insulated Concrete Forms

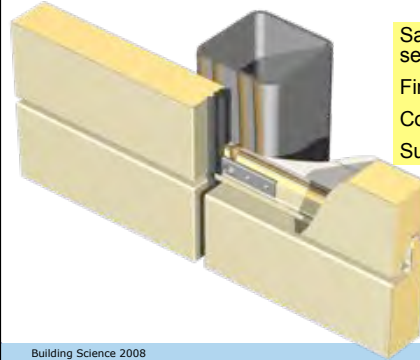
- Excellent enclosure system
- Concrete acts as air barrier
- No vapor barrier needed
- Expensive, but high performance



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Insulated metal panels

Same material fulfills several functions
 Finish (paint)
 Control (metal, foam)
 Support (metal+foam)

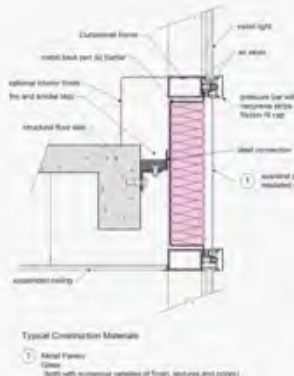


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Enclosures No. 84 /



Curtainwall

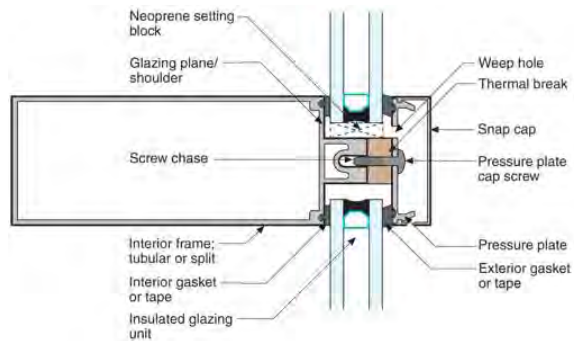


Geometrically complex & require detailed analysis. Should be drained! ("rainscreen"?)

1. Structure
2. Exterior Screen / finish
3. Interstitial heat flow control system
4. Vapor diffusion control system
5. Rain control system
6. Air flow control system
7. Exterior continuous heat flow control
8. Interior Finishes
9. Service Distribution

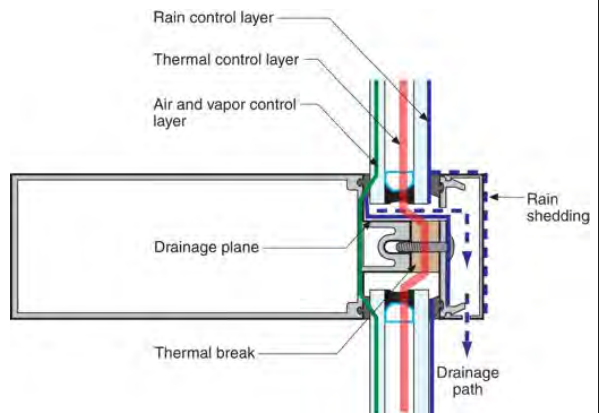
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Enclosures No. 86 /



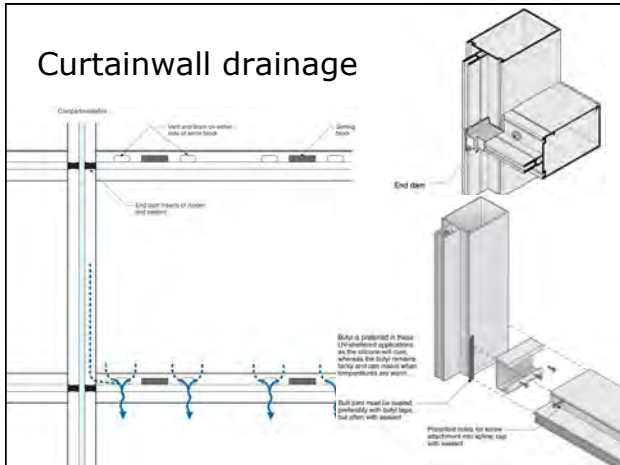
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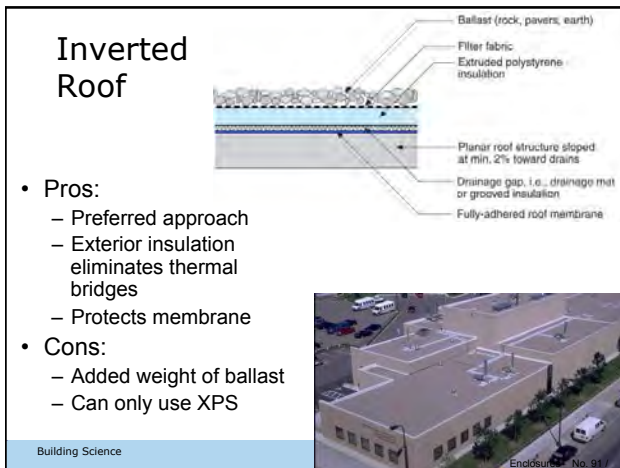


Roofs

- Roofs are significant proportion of the area of low-rise buildings
 - Significant to total cost
 - Major area for heat loss / gain
 - Low-slope membranes usually need replacement in every 15-25 yrs.
- Wide range of membrane choices
- Insulation on top *or* bottom of membrane
- Green roofs = organic ballast

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Enclosures No. 90 /



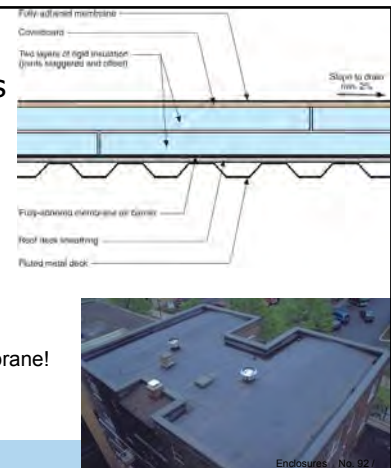
- Pros:
 - Preferred approach
 - Exterior insulation eliminates thermal bridges
 - Protects membrane
- Cons:
 - Added weight of ballast
 - Can only use XPS

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Enclosures No. 91 /

Exposed membranes

- Pros:
 - Lightest weight
 - Wide variety of insulation and membranes
- Cons:
 - Exposed membrane!



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Enclosures No. 92 /

Windows

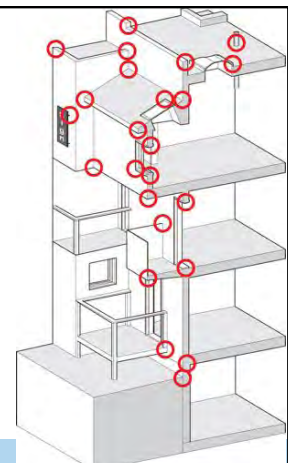
- Same functions as rest of enclosure
 - Support, control, finish
- Windows are often poorly insulated and air leaky
 - Must specify frames, spacers, fills, coatings
- Windows dominate solar gains

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Enclosures No. 93 /

Enclosure Design: Details

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



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