Credit(s) earned on completion of this course will be reported to AIA CES for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

There are many requirements for the enclosure of a low energy building. Designers often grasp the importance of insulation and solar control but miss the impacts of thermal bridging, air leakage, and poor moisture management. John Straube will outline the physical principles and mechanisms involved, and describe durable, California-specific details for high-performance enclosures.

Learning Objectives

At the end of the this course, participants will:

1. Be able to list the performance requirements of an enclosure
2. Understand the three available strategies for rain penetration control
3. Be able to list the five requirements, performance metrics and means of testing air barriers
4. Recognize thermal bridges, understand their significance, and be able to describe solutions to blunt them

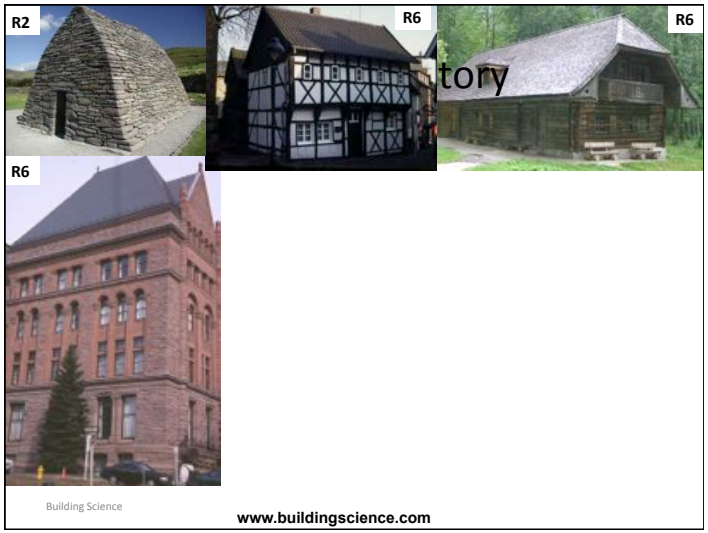
High Performance Enclosures

Dr John Straube, P.Eng.
Associate Professor
University of Waterloo
Building Science Corporation

www.BuildingScience.com

Insulation - History

tory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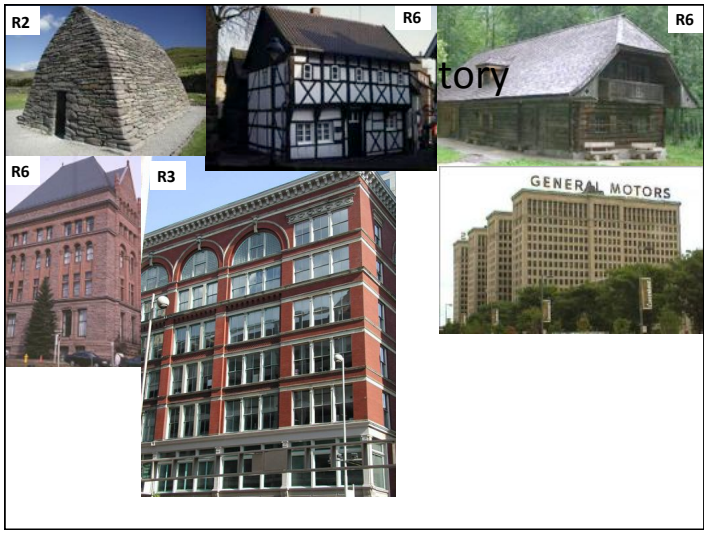
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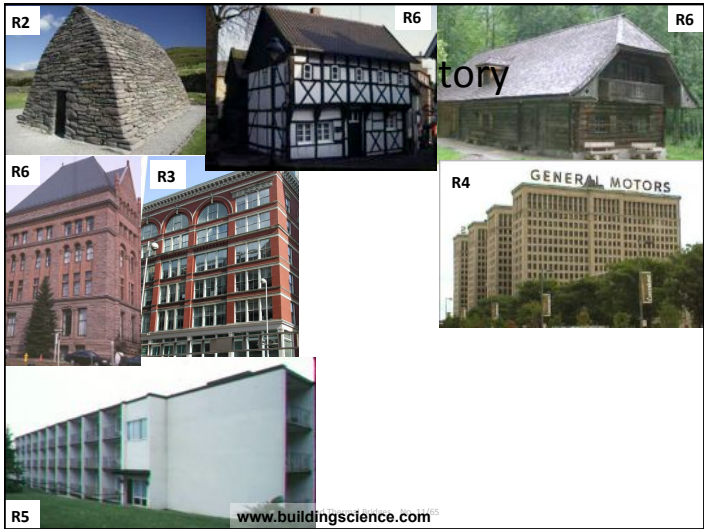
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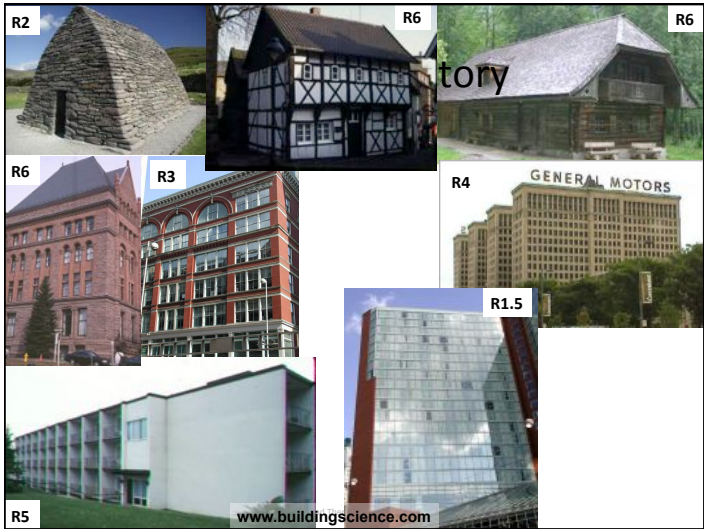
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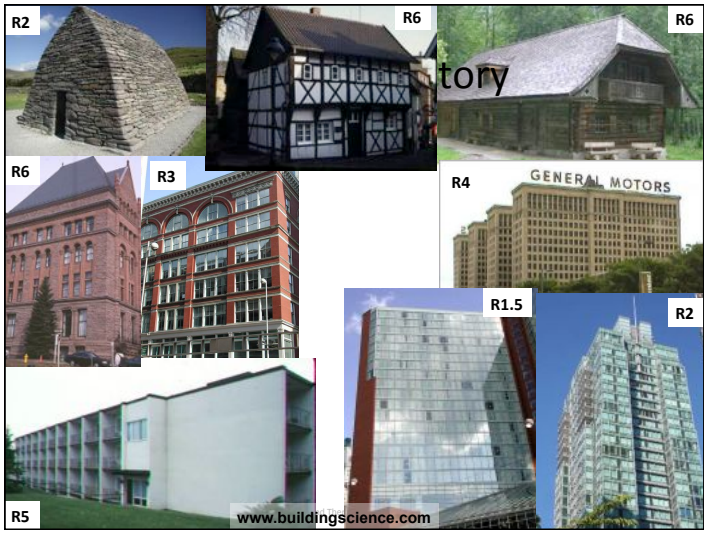


High Performance

- Insulate
- Airtighten
- Solar Control

Improve energy performance, air quality, and comfort

- But only after ….
  - No rain leaks
  - Damaging condensation

Insulation

- Thermal bridges of concrete and steel dramatically reduce performance
  - 6" steel stud, R20 batt = R5!
  - 6" wood stud, R20 batt = R14
- Windows have R-values of around 2-3. Huge heat loss
- ASHRAE 90.1-2010: U0.084 = R11.9 for CZ3
  - (Steel framed. R8 for CMU. Assumes <40%WWR)

Airtighten

- Airtightness becomes very important as enclosure insulation is increased
- Must increase airtightness
  - Improve air quality: where is it coming from?
  - Demand-controlled ventilation
  - Typical buildings leak energy
- Codes/ standard are beginning to demand it
- Can only really know tightness by testing
  - Must begin to test large buildings

Solar Control

- Can make little use of solar heat gain in enclosure-dominated large buildings in marine climates (insulate to keep heat in/out)
- Significant glass (WWR>30%) requires shade in marine climate buildings, esp. offices
- Glass area selection should be dominated by views and daylight, not solar heat gain

Durabilty

- Enclosures that control energy flow have reduce drying + increased wetting
- Must improve
  - Rain Penetration Control
  - Condensation control
  - Drying of construction moisture

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, caulked joint etc.
- Sometimes, interior partitions also are environmental separators (pools, rinks, etc.)

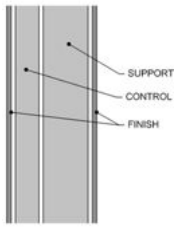
Climate Load Modification

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

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

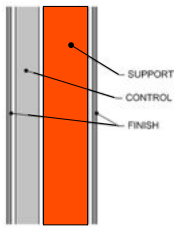
Functional Layers



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

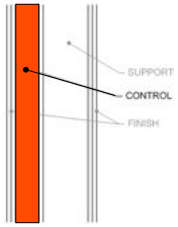
Functional Layers



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

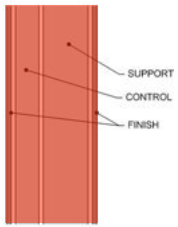
Functional Layers



Other Control . . .

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

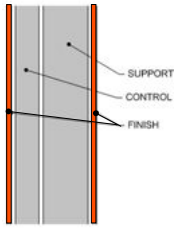
Functional Layers



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

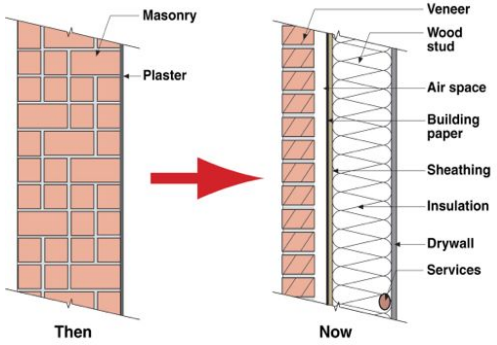
Functional Layers

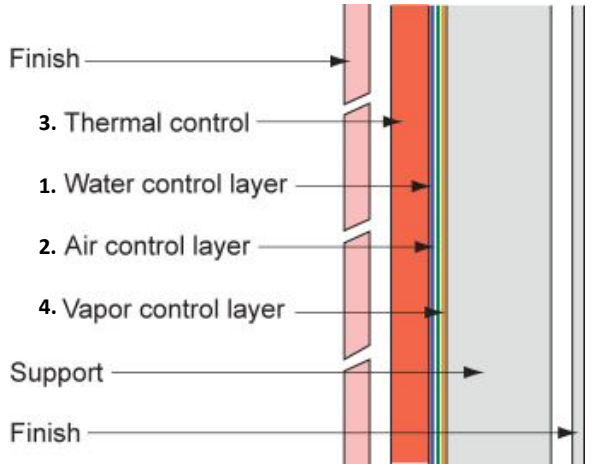


History of Control Functions

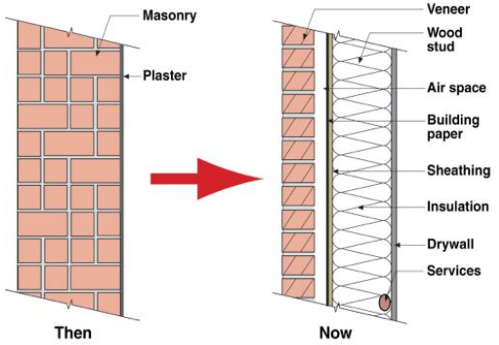
- Older Buildings
  - One layer does everything
- Newer Building
  - Separate layers,
    . . . separate functions

Changes

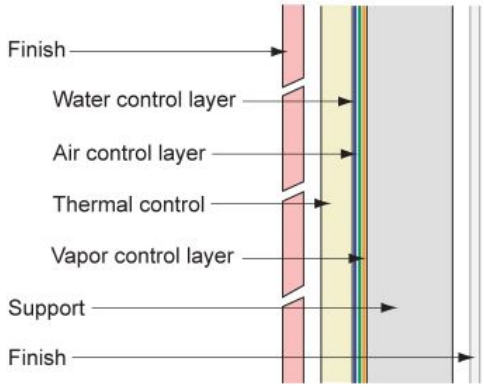




Changes



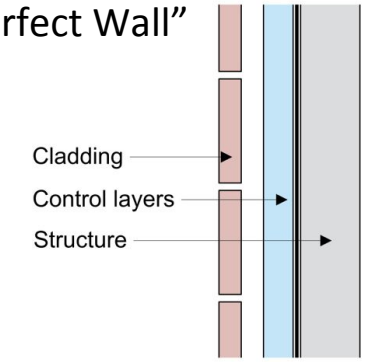
Enclosure Control Layers



The "Perfect Wall"

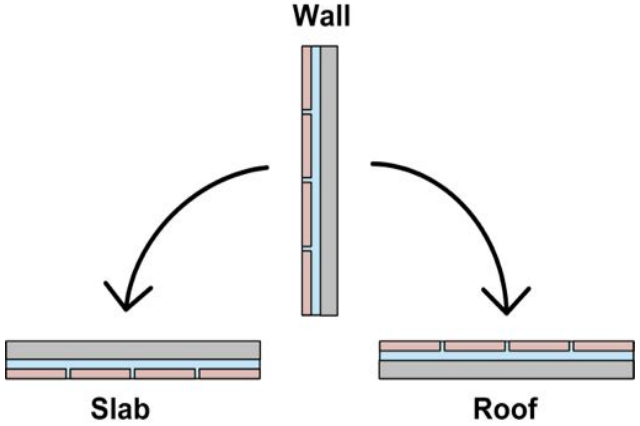
- Finish of whatever
- Control continuity
  - 1. Rain control layer
    - Perfect barrier
    - Drained with gap
    - Storage
  - 2. Air control layer
    - Air barrier
  - 3. Thermal control layer
    - Aka insulation, radiant barriers
  - 4. Vapor control layer
    - Retarders, barriers, etc
- Structure can be anything

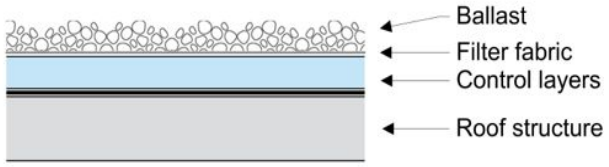
Fire Control may be needed
Sound Control optional

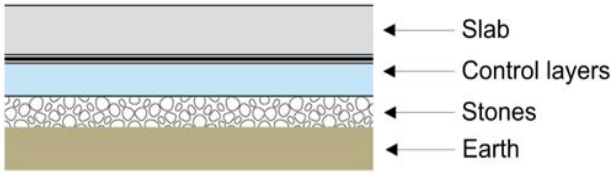


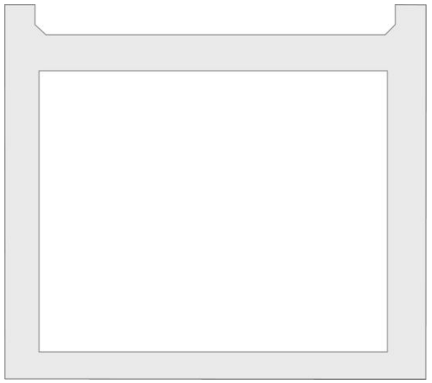
What is a high performance enclosure?

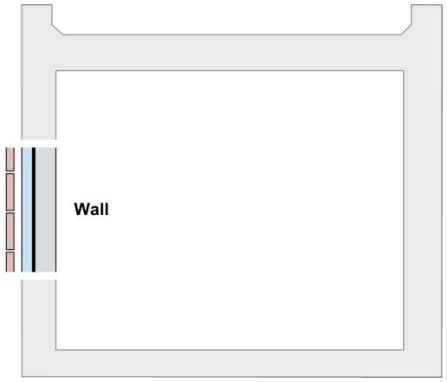
- One which provides high levels of control
- Poor continuity limits performance
- Poor continuity causes most problems too:
  - E.g. air leakage condensation
  - Rain leakage
  - Surface condensation
  - Cold windows
- This seminar: continuity + high levels

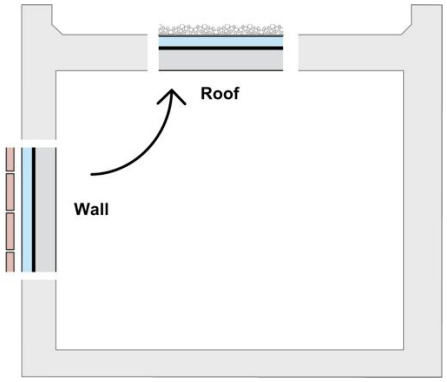

Wall
Slab
Roof

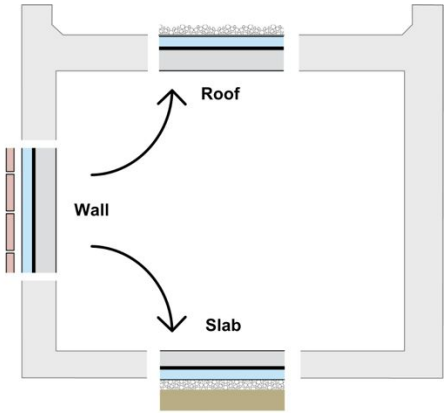

Ballast
Filter fabric
Control layers
Roof structure

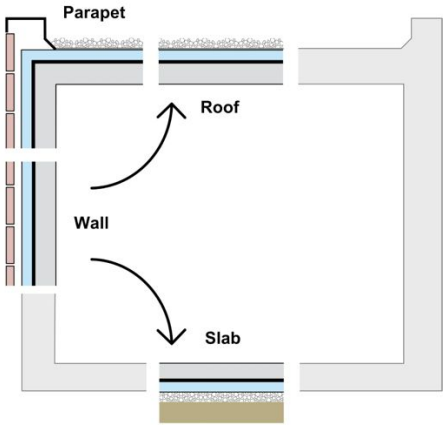

Slab
Control layers
Stones
Earth

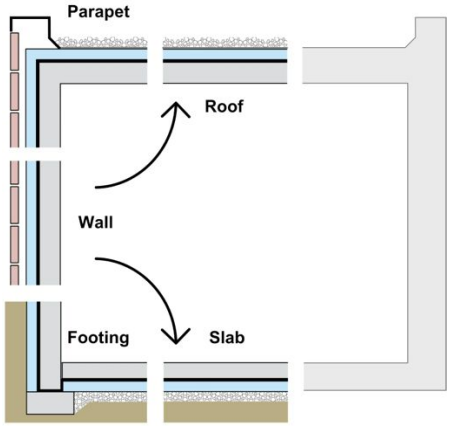


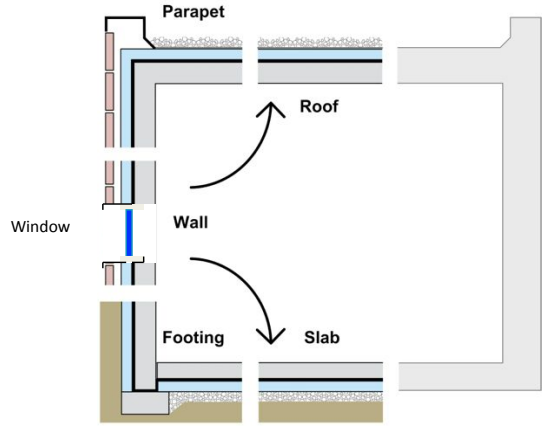

Wall


Roof
Wall

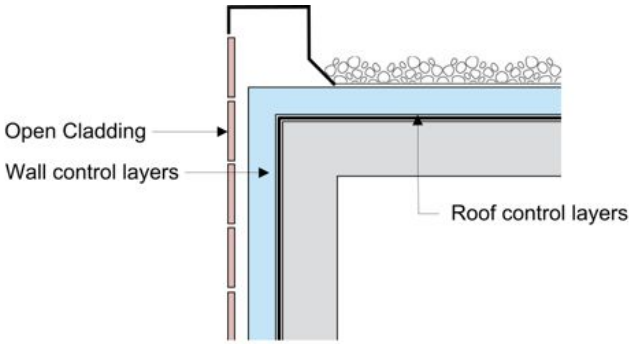

Roof
Wall
Slab


Parapet
Roof
Wall
Slab





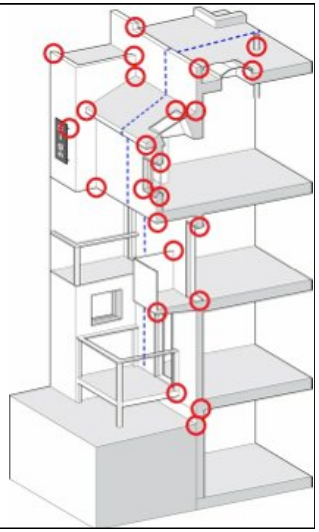
Connections: Who is in charge



Complexity increases detailing effort / risk of failure / cost reduces performance

Enclosure Design: Details

- Details demand the same approach as the enclosure.
- Scaled drawings required at ○
  - change in plane
  - change in material
  - change in trade



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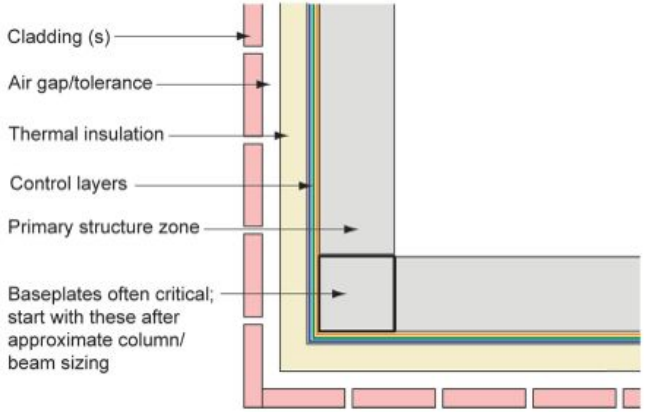
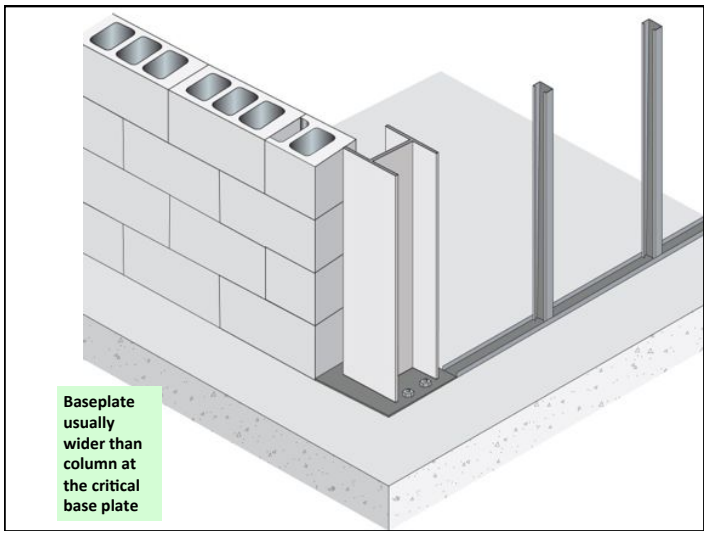
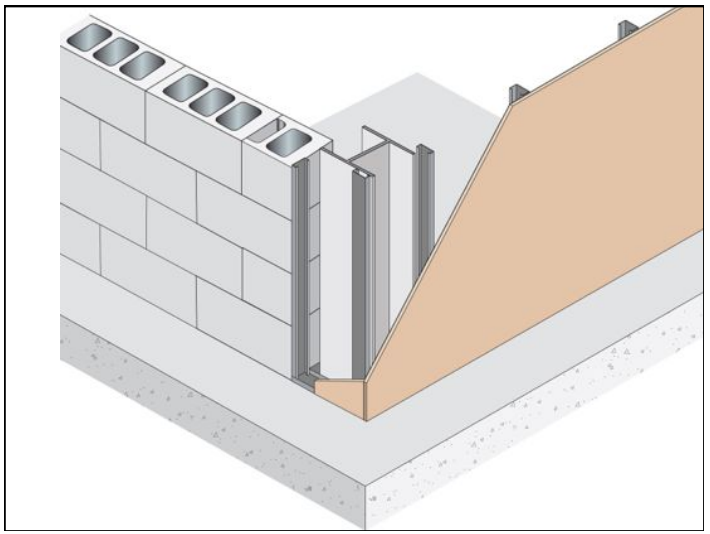
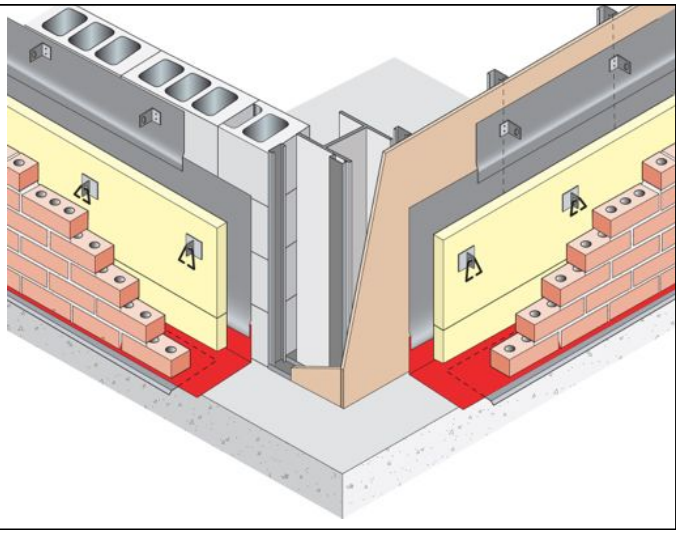
Early stage planning



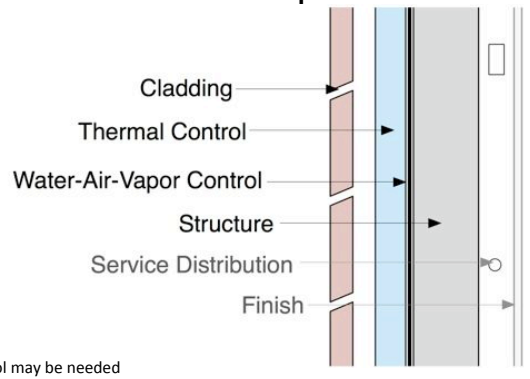


Baseplate usually wider than column at the critical base plate





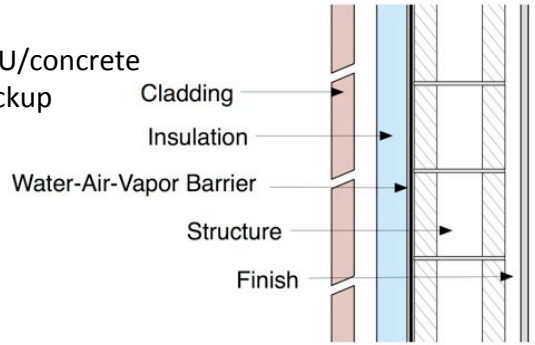
Perfect Wall expanded



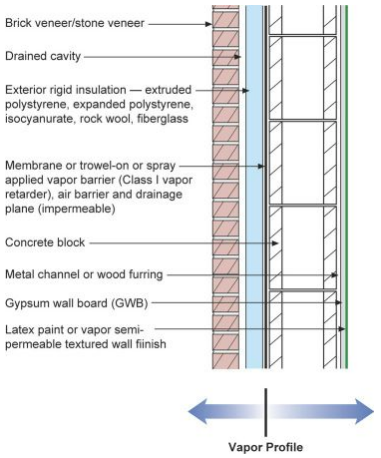
Fire Control may be needed
Sound Control optional

Perfect Wall

- CMU/concrete backup

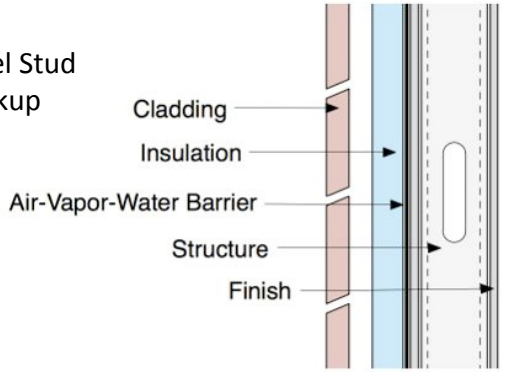


Any R-value, e.g.
2" PIC=R15
2"XPS =R18
3"MFI=R16

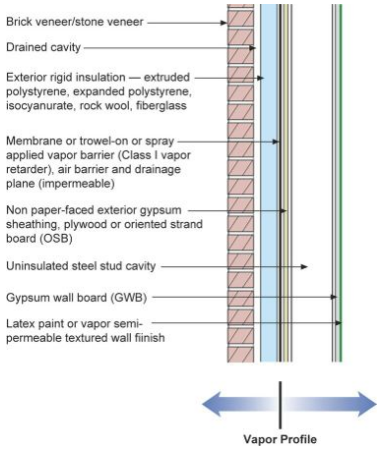


Perfect Wall

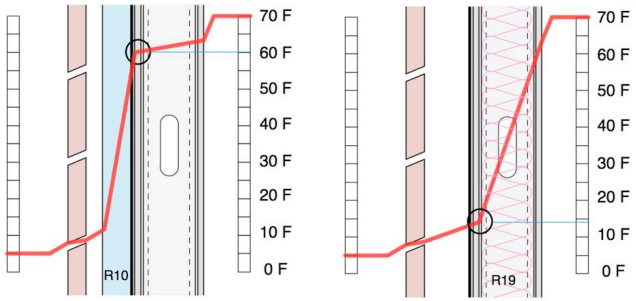
- Steel Stud Backup



Any R-value, e.g.
2" PIC=R15
2.5"XPS =R15
3"MFI=R15

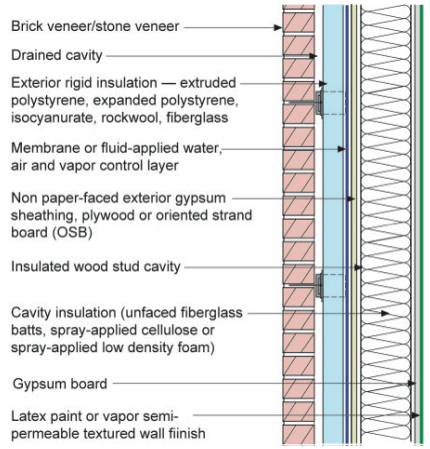


Condensation & Drying



Ratio: $\frac{\text{Exterior R-value}}{\text{Studbay R-value}}$ controls risk of condensation

Compromise



Steel studs compromise the thermal performance Wood studs, not so much

Any R-value, e.g.
6" wood stud+
2" PIC= R30
3"XPS= R32
4"SPF= R40

BSD-163