Boundaries and Barriers

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Overview of Presentation

- High Performance Enclosures
- Role of various layers
  - Structure
  - Rain
  - Heat
  - Air

High Performance Enclosures

Enclosure Requirements

- Support
- Control
  - Heat
  - Air
  - Rain
  - Vapor
  - Fire
  - Sound
- Finish

This talk

Enclosure Design Principles-1

- Design a complete load transfer path
  - structure, windows, ties, etc
  - All loads go to ground or it fails
- 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

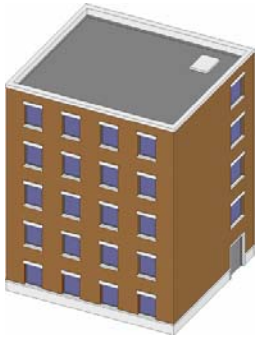
Enclosure Design Principles-2

- 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
  - vapour barriers are not "the" answer
- Accommodate movements and tolerances

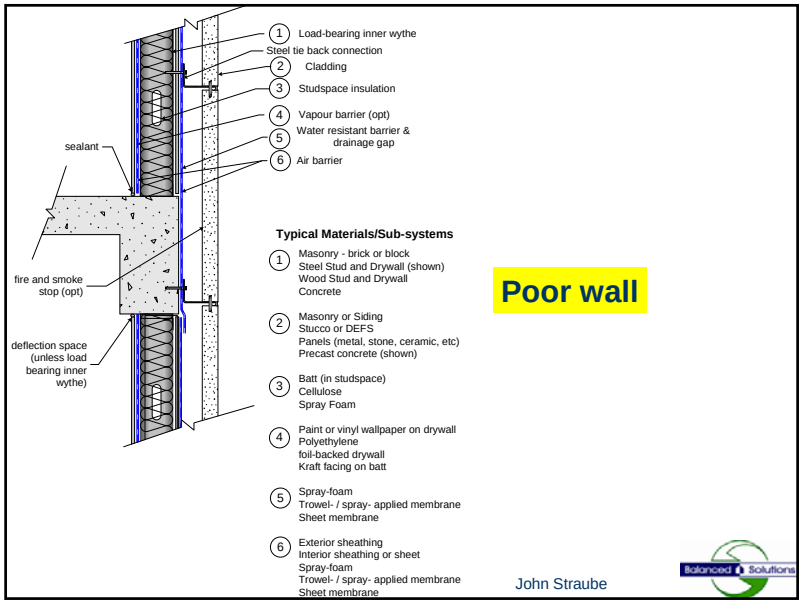
Practise: Continuous Layers

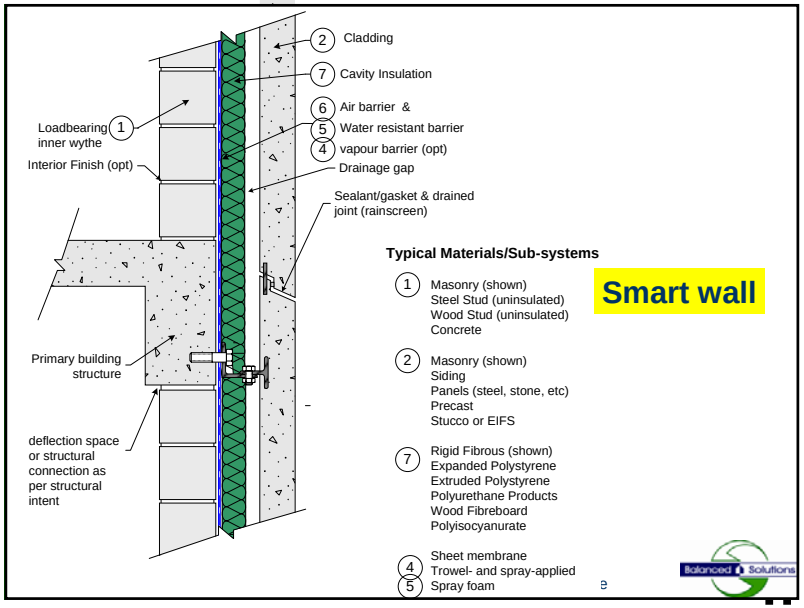
1. Structure
   - connect all parts together to foundation
2. Continuous Rain Control
   - Drainage plane, gap and flashing is needed
3. Continuous Insulation
   - Exterior insulation layer to slow heat flow, blunt cold spots (R>5)
4. Air barrier
   - Continuous air barrier to control air flow
   - Vapor retarder less important, may have holes

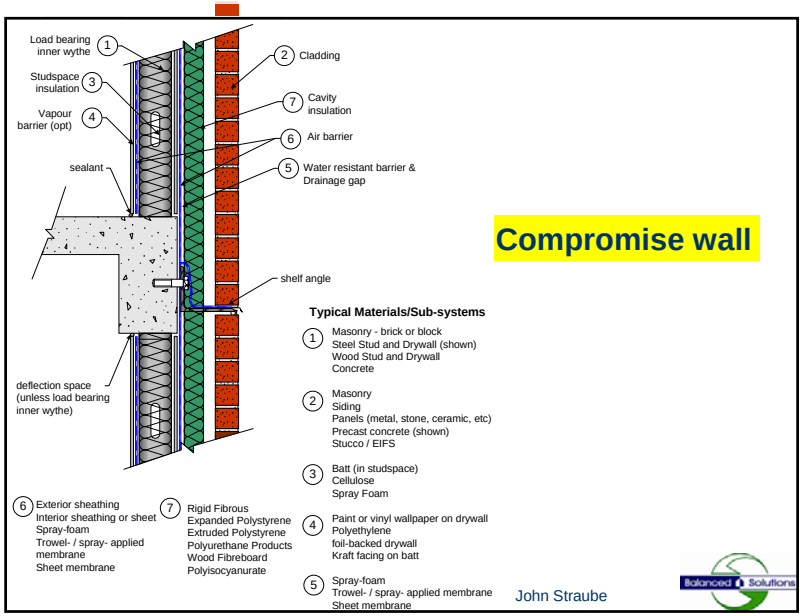
The Enclosure: Adding the Layers

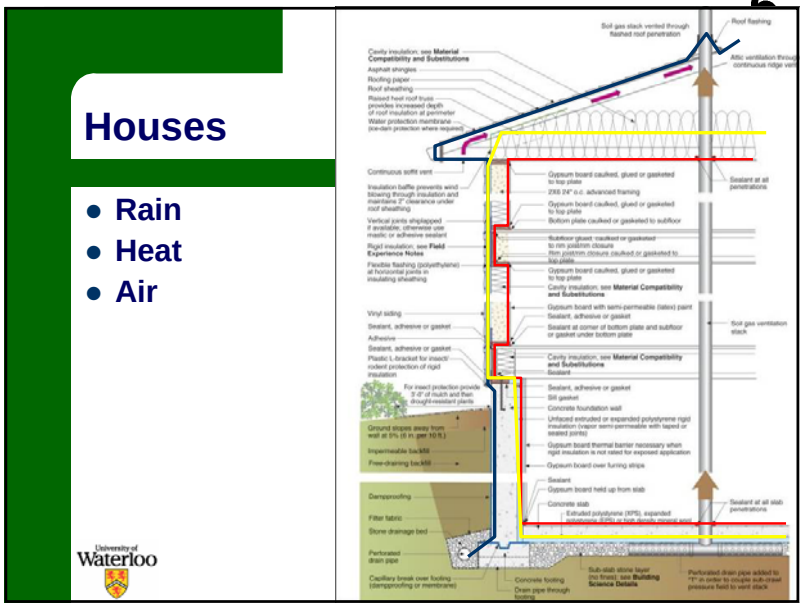


- Structure
- Air Barrier
- Insulation
- Rain Control
- Finish









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Vapor
5. Rain c
6. Air flo
Exterio
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1. Structure

Use resources efficiently to provide a safe structure

- **Connect**
  - **roof to wall,**
  - **windows and doors to wall,**
  - **wall to floors and foundation,**
  - **foundation to earth**

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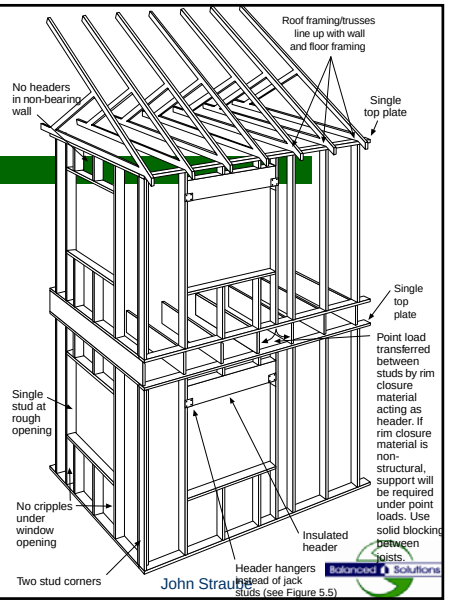
Advanced Framing System

- **Stack Framing**
- **Lintels where needed**

See Lstiburek's stuff buildingscience.com



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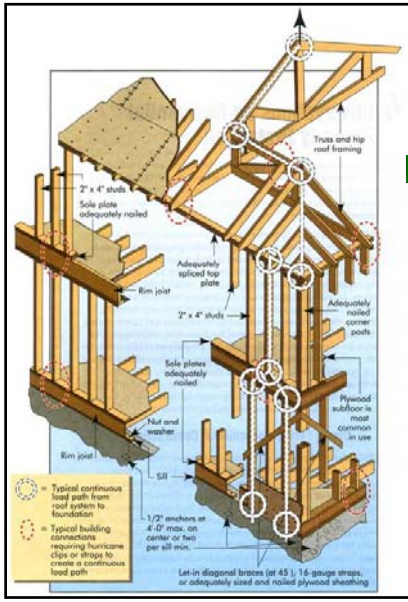

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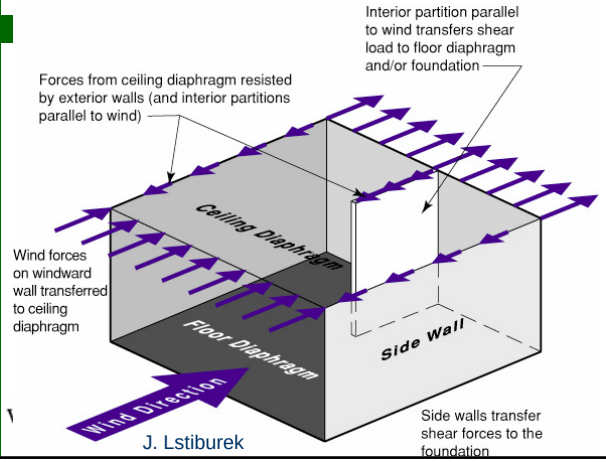
Load Transfers



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2. Continuous Rain Control

- Deflection Drainage Drying
- First reduce rain on building with details
- Stop rain penetration by Drainage (or Storage or Perfect Barrier)
  - Drainage plane continuous
  - Drainage gap continuous
  - Lead to flashing and weep holes

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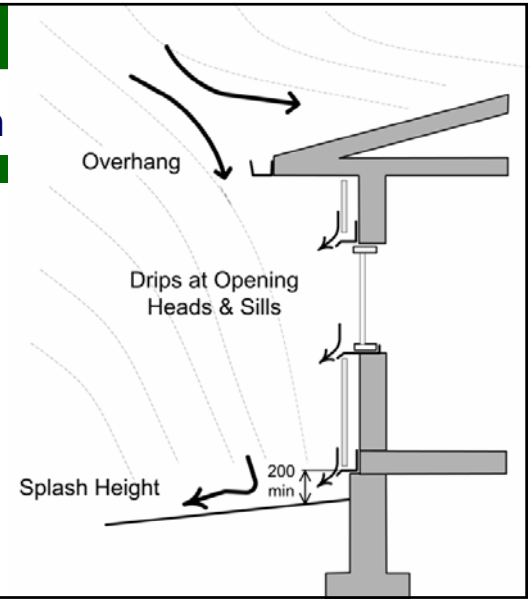
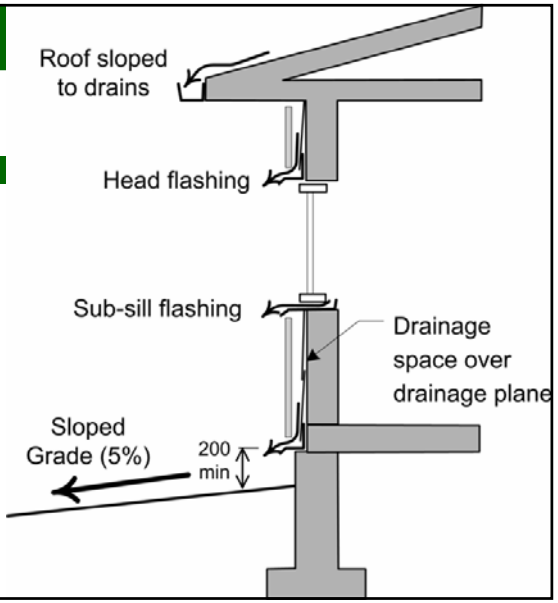
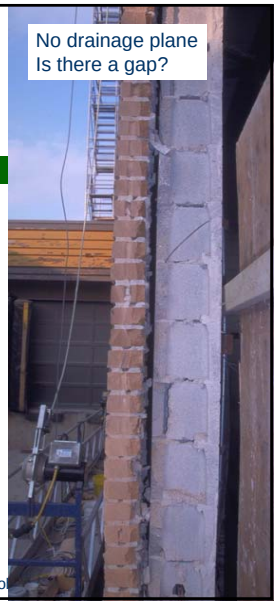
Deflection





Drainage

- Airspace often blocked
- Water can bridge over



Draining surface(s) vs drainage layer

- Drainage plane
  - Must be a capillary break
  - Must be durable when wetted
  - Must be lapped or continuous
  - Peel and stick, BP, Tyvek, spray applied
- Must lead to flashing (waterproof or steep slope) and weep holes

Types

- Format
  - Sprayed on
  - trowel applied
  - Sheet applied
- Desirable Attributes
  - Self sealing
  - Fully adhered
  - Vapor permeable

Housewrap Problems: materials& installation

Self Sealing

- Self sealing used in critical locations on houses or commercia buildings
- Needed to reduce the flow of even small amounts of water
- All existing products are vapor impermeable – this is a problem

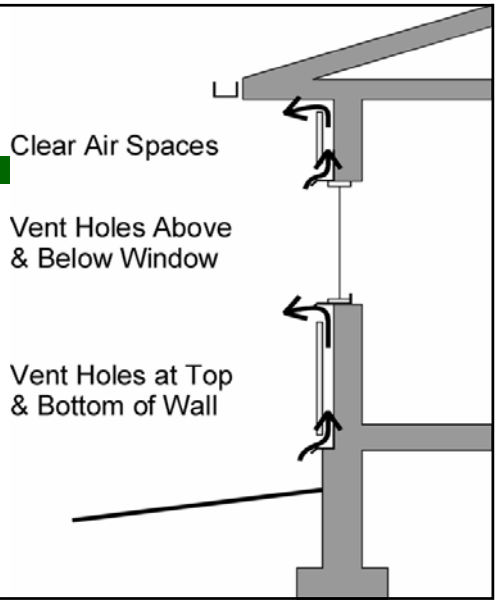
Role of the Gap / Airspace

- Capillary break (>1/16”)
- Drainage space (>1/16”)
  - No hydrostatic pressure
- Air Chamber
  - for ventilation drying (>1/2”?)
  - for pressure moderation (>1/4”)
- Finger Space (buildability)
- Adjustment and tolerances

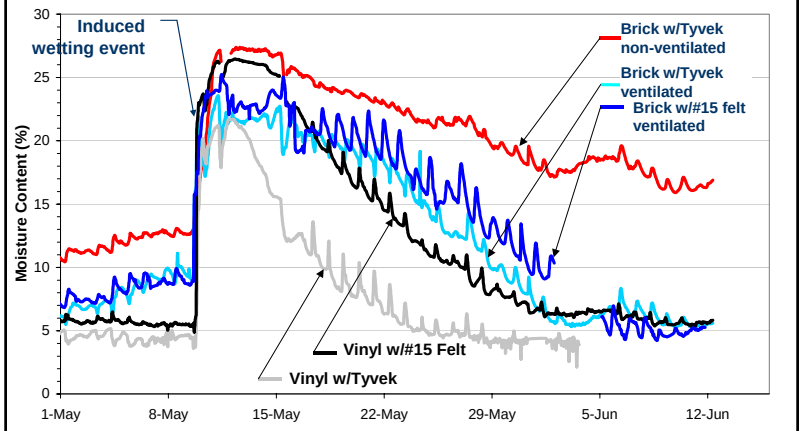
Water drains astonishingly well between sheets of building paper

Ventilation

- Often useful



Ventilation Drying Field Results: ASHRAE RP1091



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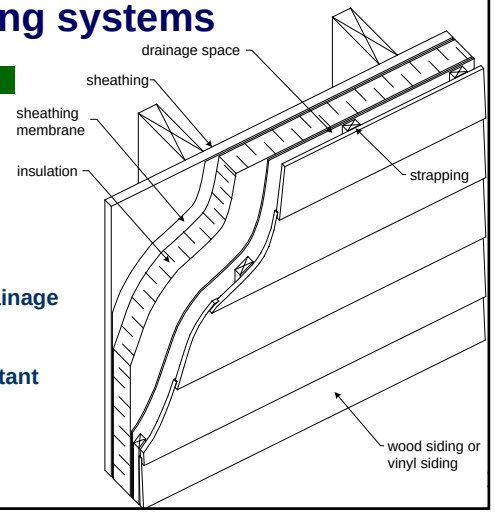
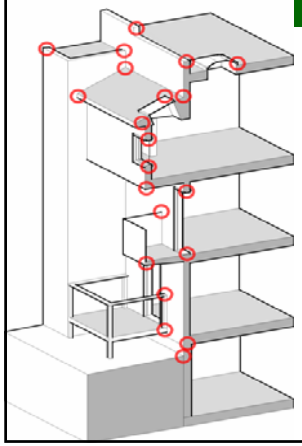
Light cladding systems

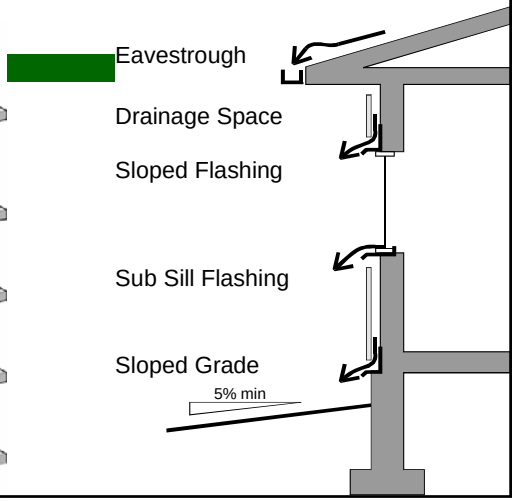
- Can perform well
- Cladding leaks a lot
- Battens ensures drainage occurs and provides ventilation drying
- Flashing very important



Flashing: Details

"House of Horrors"





3. Continuous Insulation

Protect the structure and interior with a continuous blanket of insulation

- Aim for min. R5 everywhere
- Keeps structure warm
  - = dry!
  - Avoids interstitial condensation
  - Accelerates drying
- Covers thermal bridges
  - True R-value

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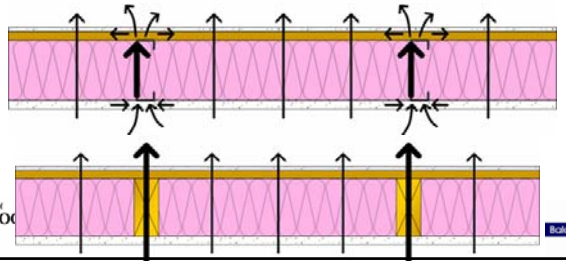
Thermal Bridging

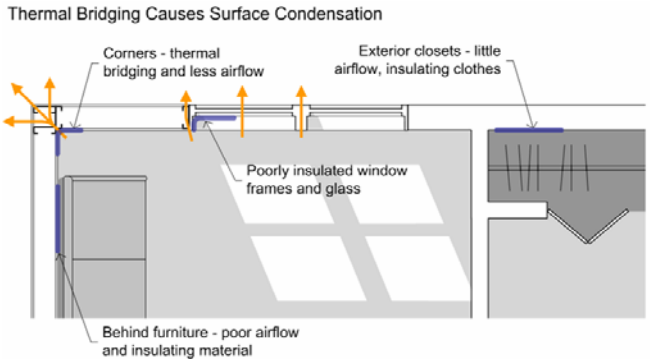
- Heat flows more easily through studs
  - Wood R6 vs R20. Steel R0.4 vs R20
  - What about double, triple studs, rim joists?



Thermal Bridging

- Major losses thru steel
- Result:
  heat loss
  moisture problems

Thermal Bridging: Common Problems



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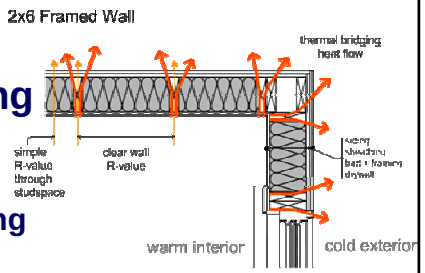
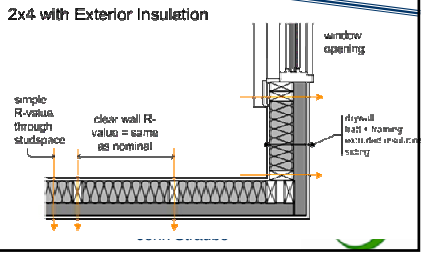
Thermal Bridging

Solution

- Insulated sheathing
- Even 1" is big deal





Windows are thermal bridges

- Most windows are R2, good windows are R3
- Curtainwalls rarely over R3
- These are thermal bridges!
- Need to try for R4 or 5!

4. Air Barrier

Provide a continuous barrier to air flow over the whole building

Air Barriers vs Vapor Barriers

- *Vapour Barriers Control Vapour Diffusion*
  - **Why? 1. Moisture wetting and drying**
- *Air Barriers Control Air Leakage*
  - **Why? *Six* reasons.**
  - **Heat (for 1. comfort & 2. energy considerations)**
  - **3. Moisture**
  - **4. Sound 5. Smoke & 6. odours and dust**

Air barriers

- **Stop the flow of air**

  Equals
- **Stop**
  - **Moisture (condensation)**
  - **Drafts**
  - **Energy**
  - **Noise**
  - **Dust**
  - **Odors and smoke**

Vapor barriers = drying retarders

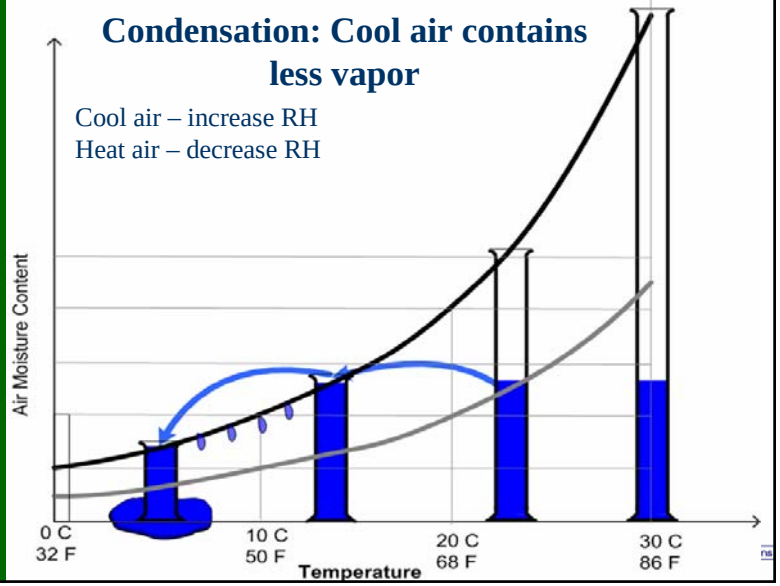
- **Vapor diffusion is a slow process**
- **Uniform action = small holes don't matter**
- **Use as needed, not more**

Air Barriers are Systems (not materials)

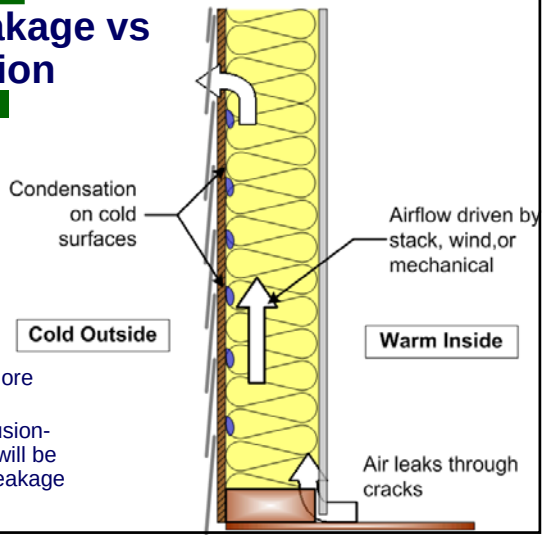
- **Air barrier systems are required to stop airflow through enclosure**
- **ABS can be placed anywhere in the enclosure**
- **Must be strong enough to take wind gusts**
- **Air barrier systems must be continuous They leak at joints, interfaces, penetrations**
- **multiple air barrier planes are useful for redundancy**

Condensation: Cool air contains less vapor

Cool air – increase RH
Heat air – decrease RH

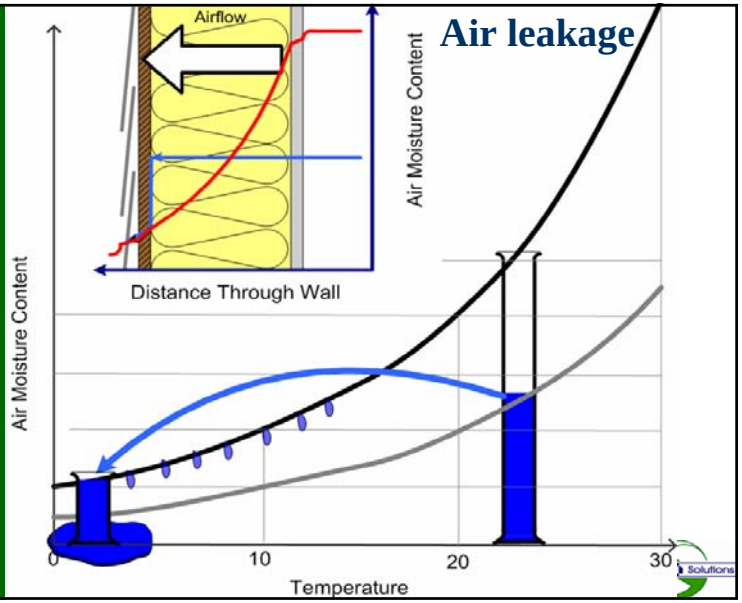


Air leakage vs Diffusion

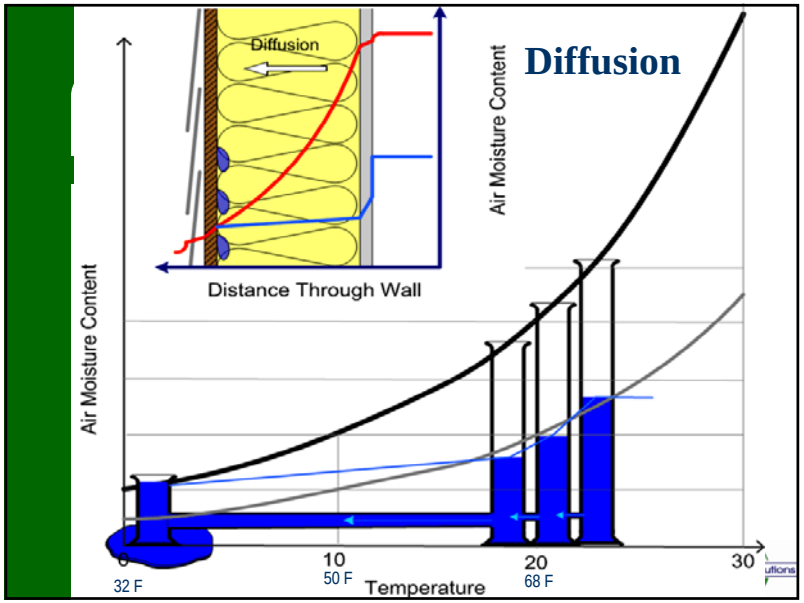


- Air leakage is much more critical
- Walls sensitive to diffusion-related condensation will be more sensitive to air leakage

Air leakage

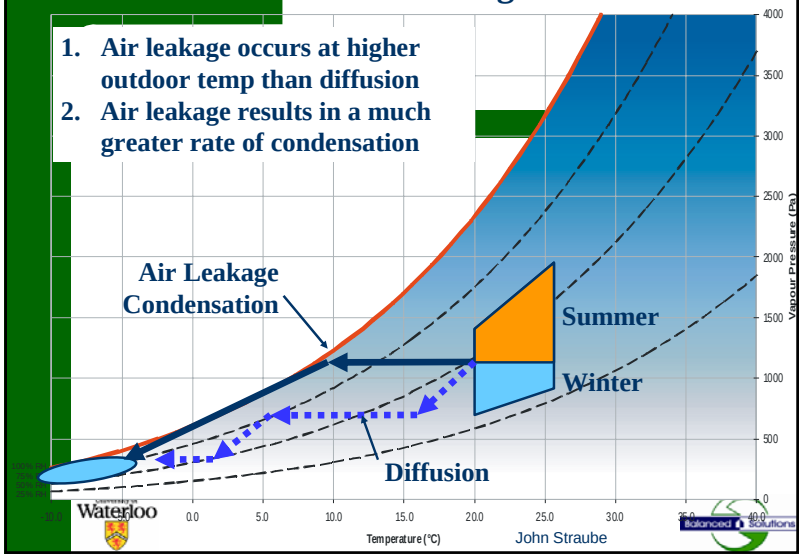


Diffusion



Air Leakage vs Diffusion

1. Air leakage occurs at higher outdoor temp than diffusion
2. Air leakage results in a much greater rate of condensation



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Vapor diffusion control

- Provide low permeance on the interior in Vermont
  - Not freezer warehouses and arenas!!
- Low permeance means 0.5 to 3 perms
  - Depends on interior RH, exterior permeance
- Adding insulating sheathing means you don't need poly
- Add enough ins. sheathing and nothing
- Vapor barriers are drying retarders

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Air Barrier System Requirements

- Continuous
  - primary need
- Strong
  - designed for full wind load
- Durable
  - critical component - repair, replacement
- Stiff
  - control billowing, pumping
- Air Impermeable
  - (may be vapour permeable)

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Airflow Control: Where

- Stop airflow anywhere
- Can locate anywhere in enclosure
- Should be protected if possible
- Multiple layers are good
- Important in all climates

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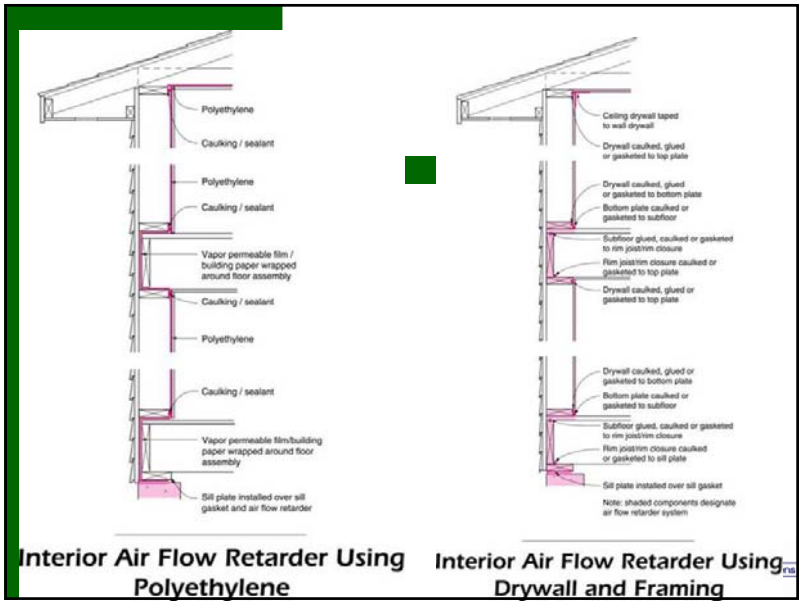
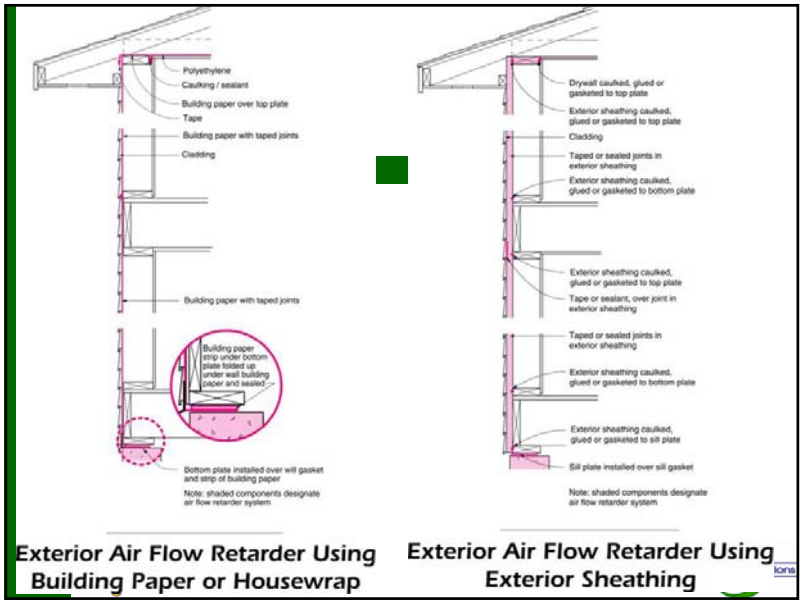


Interior Air Flow Retarder Using Polyethylene

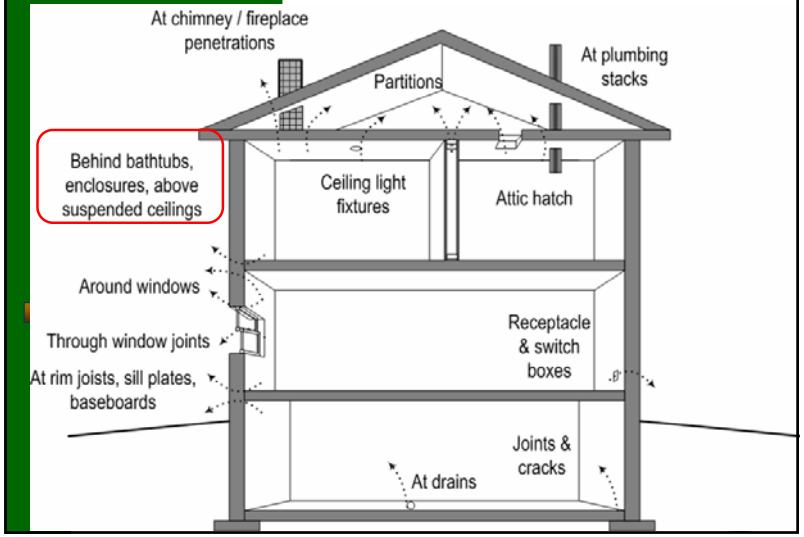
Interior Air Flow Retarder Using Drywall and Framing



Exterior Air Flow Retarder Using Building Paper or Housewrap

Exterior Air Flow Retarder Using Exterior Sheathing

As for rain, it is all in the details



Poly can be (?) an air and vapour barrier

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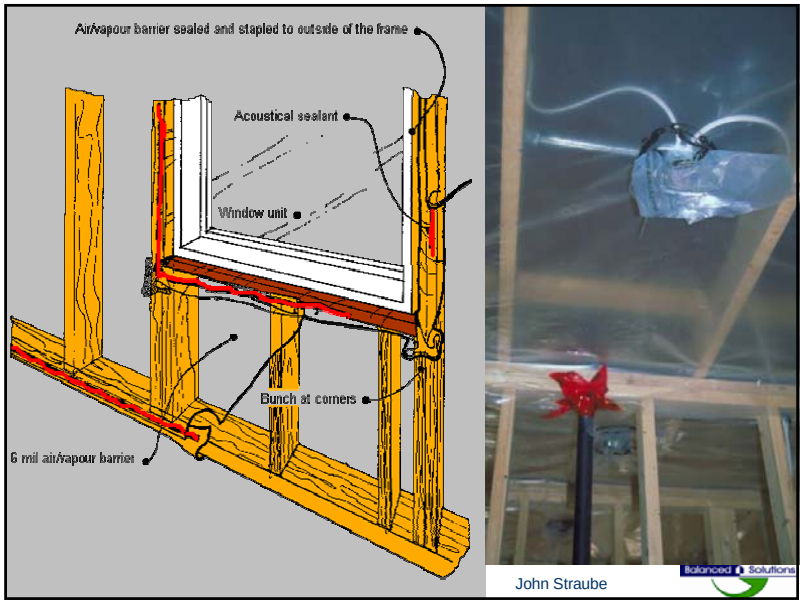

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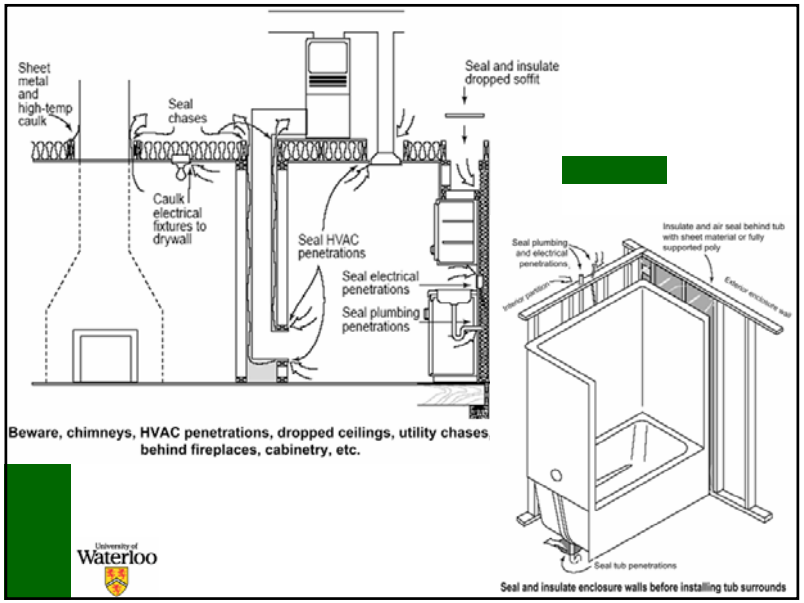
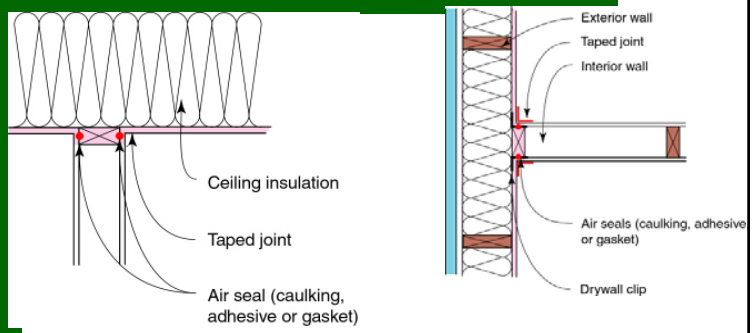


Air Sealing Details



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Air sealing Details

- Seal ALL penetrations to the outside

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Air Sealing Details

- Airtight electrical boxes in exterior walls and ceilings

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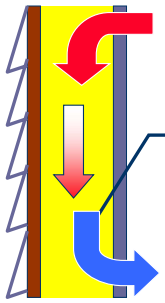
Convection Barrier (Control Stack Effect)

Cold Weather



Hot air = light

Result: Air Flow

Cold air = heavy

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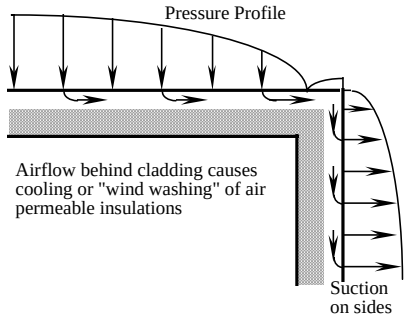
Control windwashing (lateral flow)



Solution: Add a "wind barrier" to exterior

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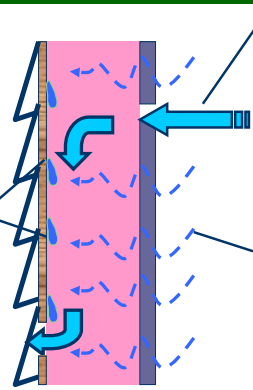
Wall w/o Insulated Sheathing



Air leakage

Cold = Condensation

Vapour Diffusion

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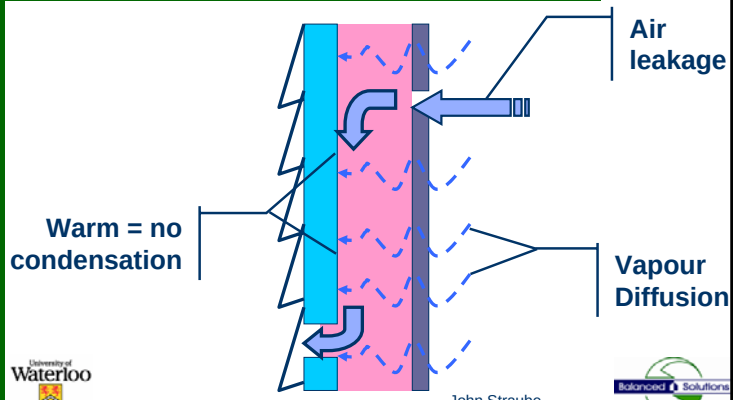
Wall with Insulated Sheathing



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Examples

- Some typical and odd examples

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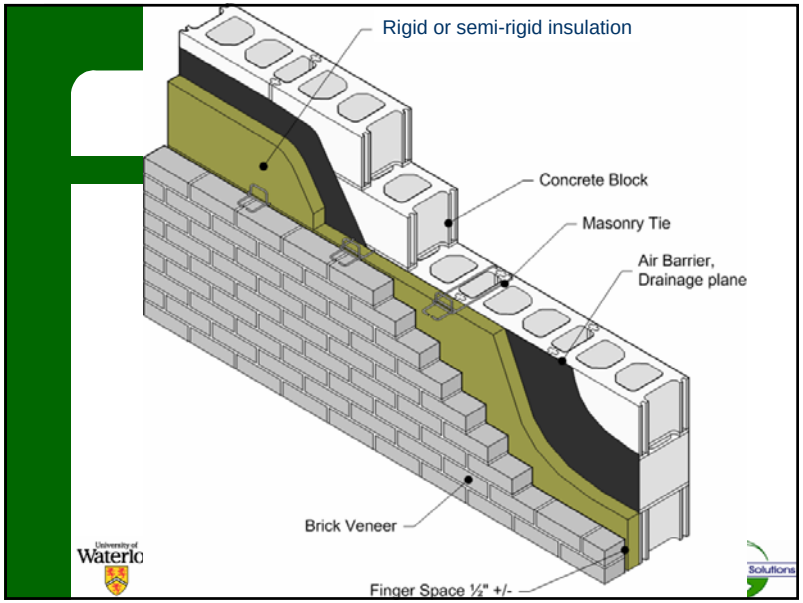


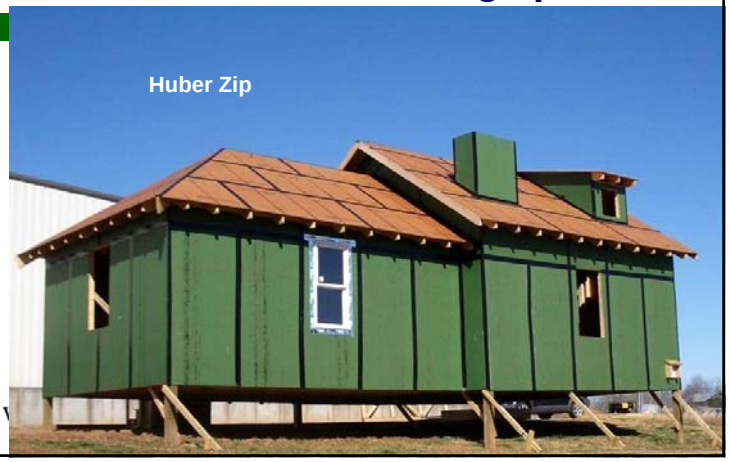
Combined air, vapor, drain, insulation

ICF – concrete is air barrier …

Drainage planes

Trowel applied air and water barrier

Combined air and drainage plane



SPF air barrier, polyiso drain plane

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  - fastidious attention to detail 3-D

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Building Science Textbook at

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