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Building Science

Air Flow Control

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Overview of Presentation

- Why control airflow? Vapor flow?
- Review of Driving Forces
- Air Barrier Systems
  - Functions + Requirements
- Airflow Within Enclosures
  - convective loops, windwashing, pumping
- Air Leakage Condensation
  - Control Strategies
- Tall Buildings

Airflow Control: Why

1. Comfort and Health
   - Drafts
   - Odors, particles, gases
2. Moisture control
   - air leakage condensation
3. Energy
   - Heat transferred with air
4. Sound
5. Required by some codes

If you can't enclose air, you can't condition it

Airflow Control: what kind?

- Air flow through enclosure
  - Code requirement?
- Air flow within enclosure
  - Air loops inside enclosure
  - Air loop from interior and back
  - Air loop from exterior and back
- Therefore, CONTROL
  - = Limit or eliminate air flow through and within

- NII02.4.1 Building thermal envelope.
  The *building thermal envelope* shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped, or otherwise sealed with an air barrier material, suitable film or solid material .

1. All joints, seams and penetrations.
2. Site-built windows, doors and skylights.
3. Openings between window and door assemblies and their respective jambs and framing.
4. Utility penetrations.
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls.
7. Walls and ceilings separating the garage from *conditioned spaces.*
8. Behind tubs and showers on *exterior walls.*
9. Common walls between *dwelling units.*
10. Attic access openings.
11. Rim joists junction.
12. Other sources of infiltration.

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"A continuous air barrier shall be installed in the building envelope. Exterior thermal envelope contains a continuous air barrier. Breaks or joints in the air barrier shall be sealed. Air-permeable insulation shall not be used as a sealing material."
"The air barrier in any dropped ceiling/soffit shall be aligned with the insulation and any gaps in the air barrier sealed. Access openings, drop down stair or knee wall doors to unconditioned attic spaces shall be sealed."
"Corners and headers shall be insulated and the junction of the foundation and sill plate shall be sealed. The junction of the top plate and top of exterior walls shall be sealed. Exterior thermal envelope insulation for framed walls shall be installed in substantial contact and continuous alignment with the air barrier. Knee walls shall be sealed."
"The space between window/door jambs and framing and skylights and framing shall be sealed."
"Rim joists shall be insulated and include the air barrier."
"Insulation shall be installed to maintain permanent contact with underside of subfloor decking. The air barrier shall be installed at any exposed edge of insulation."
"Duct shafts, utility penetrations, and flue shafts opening to exterior or unconditioned space shall be sealed."
"Batts in narrow cavities shall be cut to fit, or narrow cavities shall be filled by insulation that on installation readily conforms to the available cavity space."
"Air sealing shall be provided between the garage and conditioned spaces."
"Recessed light fixtures installed in the building thermal envelope shall be air tight, IC rated, and sealed to the drywall."
"Batt insulation shall be cut neatly to fit around wiring and plumbing in exterior walls, or insulation that on installation readily conforms to available space shall extend behind piping and wiring."
"Exterior walls adjacent to showers and tubs shall be insulated and the air barrier installed separating them from the showers and tubs."
"The air barrier shall be installed behind electrical or communication boxes or air sealed boxes shall be installed."
"HVAC register boots that penetrate building thermal envelope shall be sealed to the subfloor or drywall."

Driving Forces

- 1. Wind Pressures
- 2. Buoyancy (or stack effect)
- 3. HVAC

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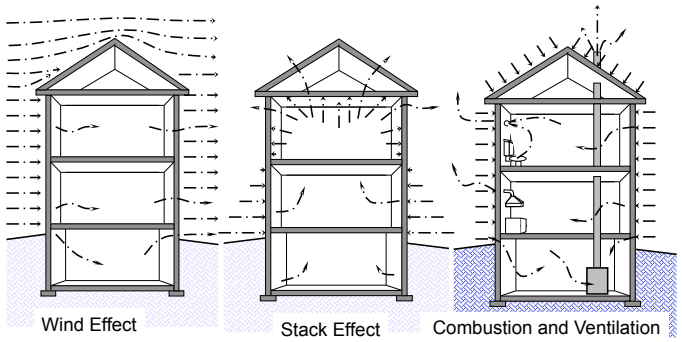
Driving Forces



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1. Wind

- Peak loads are high (>1000 Pa/20 psf)
- Average pressures much lower (<50 Pa)
- Wind Pressure Increases with Height
  - low-rise average pressure about 5 Pa
  - twenty story building about 40 Pa on normal day

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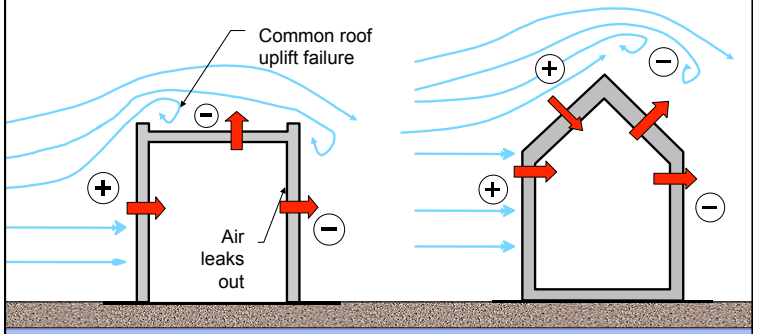
Wind Pressures / Flow Patterns

- **Pressure on windward side**
- **Suction on lee and sidewalls**



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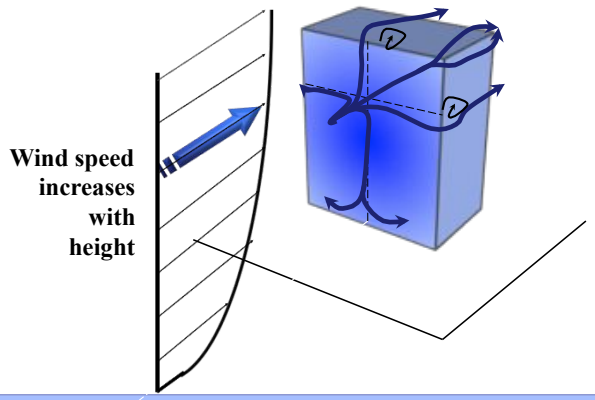
Wind Flow Patterns



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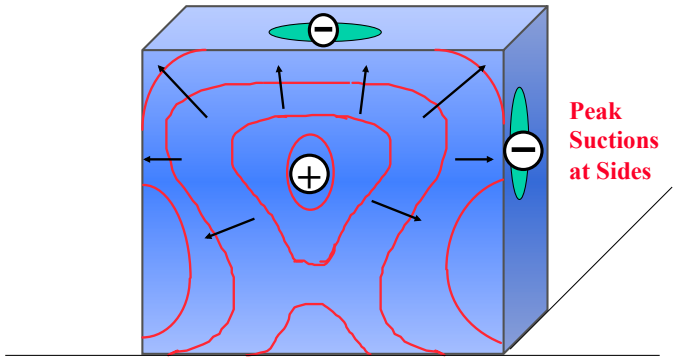
Pressure Distribution on Face



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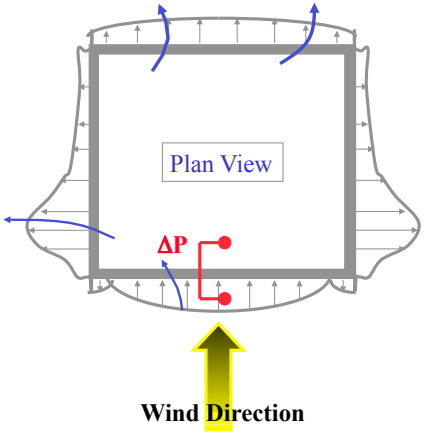
Wind Pressure Distribution



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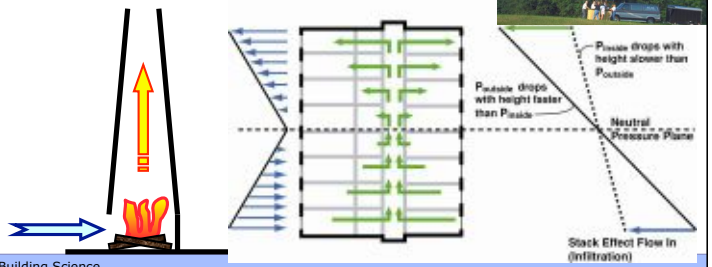
2. Stack Effect: Cold Weather

- Hot air rises
- Tall Building in Winter = Heavy Balloon



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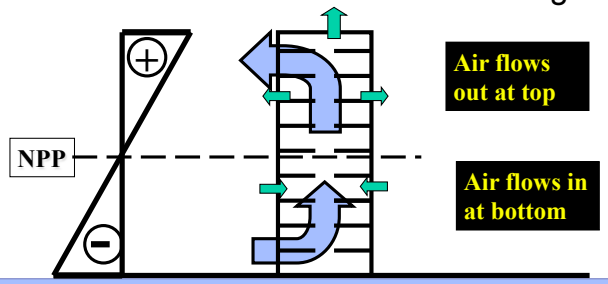
Stack Effect: Cold Weather

- "Perfect" Building equally leaky everywhere
- Neutral Pressure Plane at mid-height



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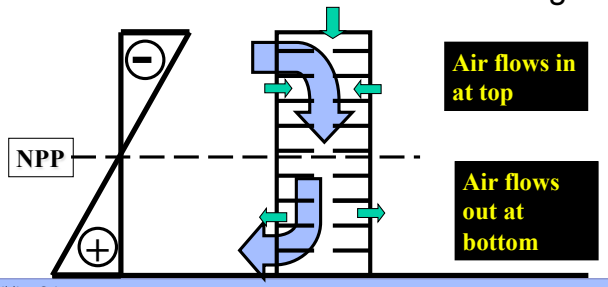
Stack Effect: Warm Weather

- "Perfect" Building equally leaky everywhere
- Neutral Pressure Plane at mid-height



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Stack Effect

- When cold (20 F) outside
  - About 4 Pa per storey (10') of height
- When hot (95 F) outside
  - About 1.5 Pa per storey (10') of height
- Result
  - Revolving doors
  - We suck air from below in cold weather

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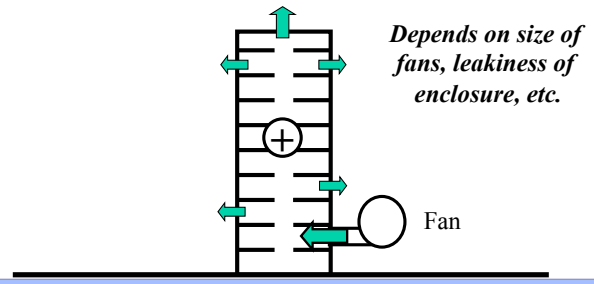
3. HVAC Pressurization

- More airflow forced into building than sucked out of building = Pressurization



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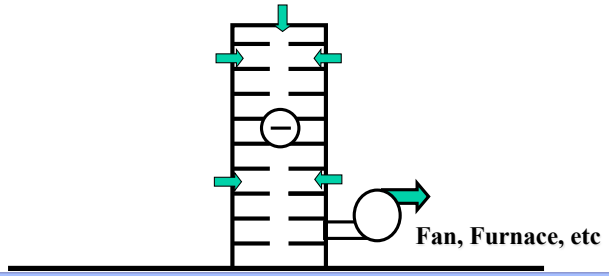
De-Pressurization

- More airflow forced out of building than forced into building = De-Pressurization



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Driving Forces Summary

- Wind
  - Taller buildings see high pressures!
  - 2-10 Pa low bldgs, 30-200+ Pa tall buildings
- Stack Effect
  - Pressure increases directly with temperature difference and height
- HVAC
  - Depends on design and operation

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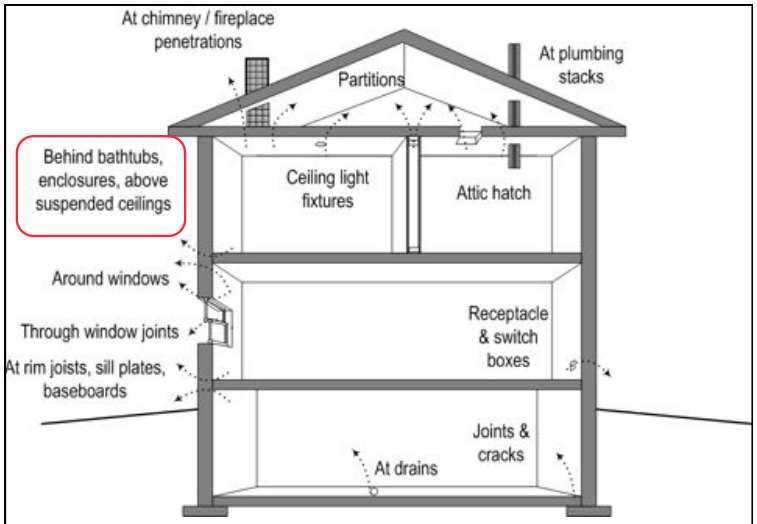
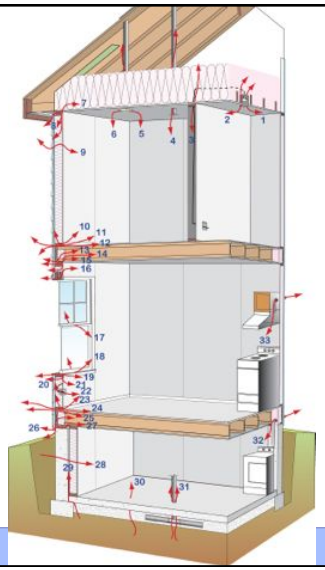
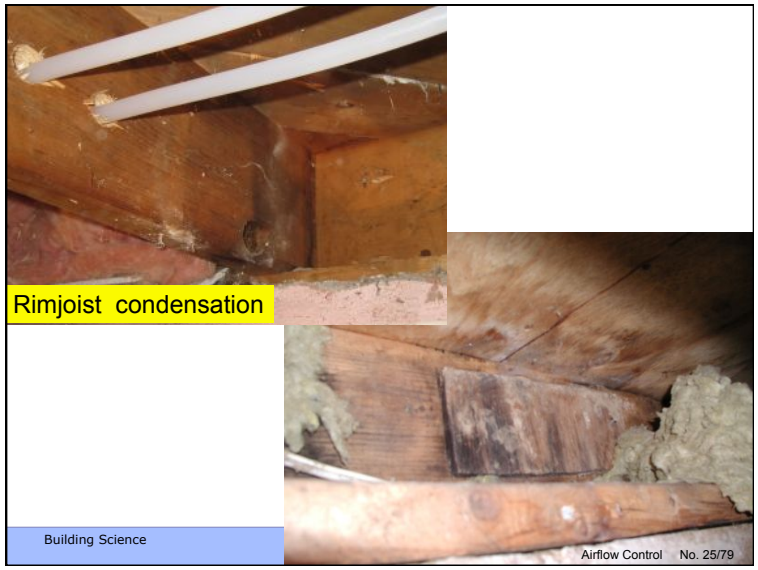
Controlling Air Leakage

- Strategy
  - "Find the holes and plug them"
- This requires finicky attention to 3-D details.

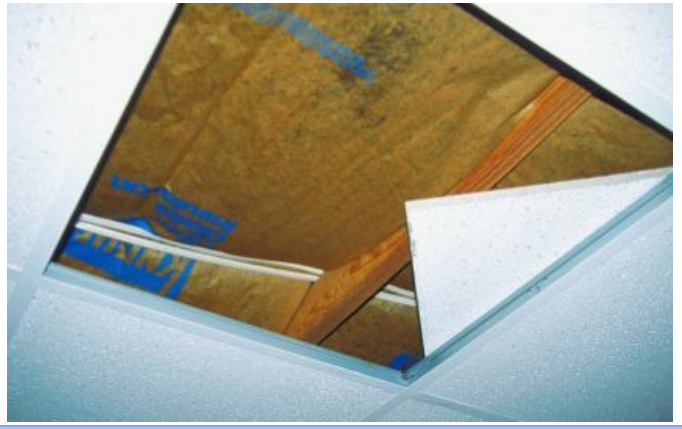


Typical Air Leakage Points





Bigholes



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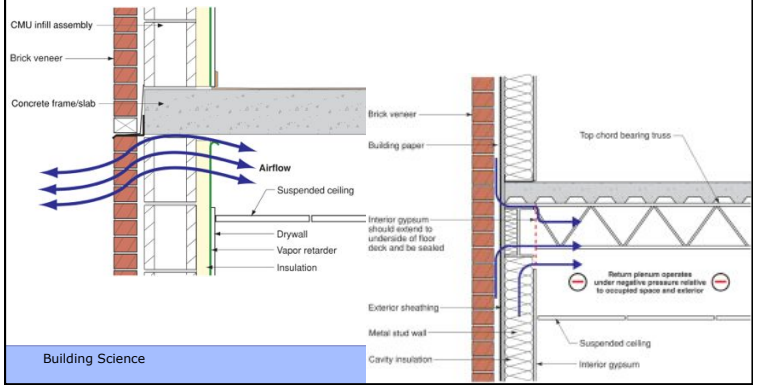
Leakage above ceilings



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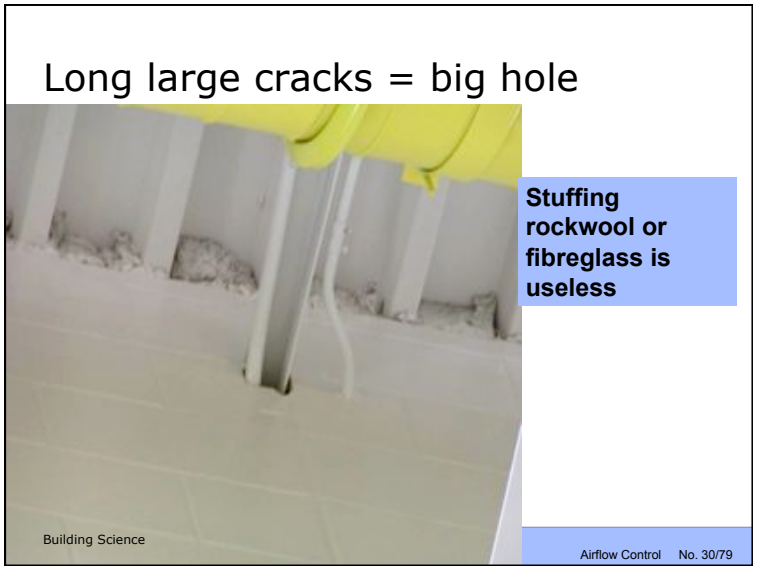
Long large cracks = big hole
Stuffing rockwool or fibreglass is useless
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Seal

Partial solution: air can still flow above deck

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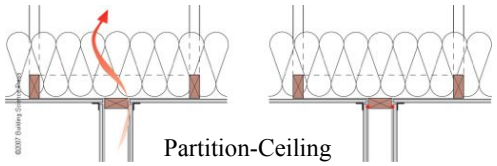
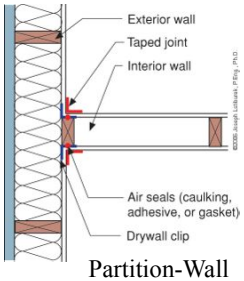
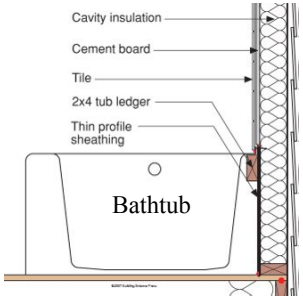
Airflow Control No. 34/79



Partition-Ceiling



Partition-Wall



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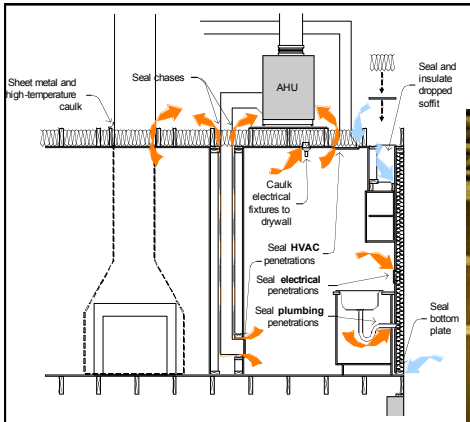
Big Air Leakage Points



- Ductwork
- Partitions
- Dropped soffits
- Cabinetry
- Ceiling lights
- Rimjoists
- Plumbing stacks
- Attic hatch

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Air Barrier Systems

- Function: to stop airflow through enclosure
- ABS can be placed anywhere in the enclosure
- Must be strong enough to take wind gusts (code requirement)
- Many materials are air impermeable, but most systems are not airtight

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Codes are coming …

- IRC 2009 Defintion: AIR BARRIER. Material(s) assembled and joined together to provide a barrier to air leakage through the building envelope. An air barrier may be a single material, or a combination of materials.

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Air Barrier Systems: Requirements

- Continuous
  - primary need, common failure
- 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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Air Barrier Requirements

- Air impermeability
  - Material: 0.02 lps/m^2 @ 75 Pa 0.004 cfm / ft^2 at 0.3" wg
  - Component: 0.2 lps/m^2 @ 75 Pa 0.04 cfm / ft^2 at 0.3" wg
  - Building: 2.0 lps/m^2 @ 75 Pa 0.4 cfm / ft^2 at 0.3" wg
- *Building* requirement most important for energy, interior RH, IAQ
- *Component* requirement *may* matter for air leakage condensation control

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- **Cellulose in not an air barrier**
- **DensePack (>3.5 pcf) can slow airflow**
- **Improves horrible buildings, does not achieve good or great**

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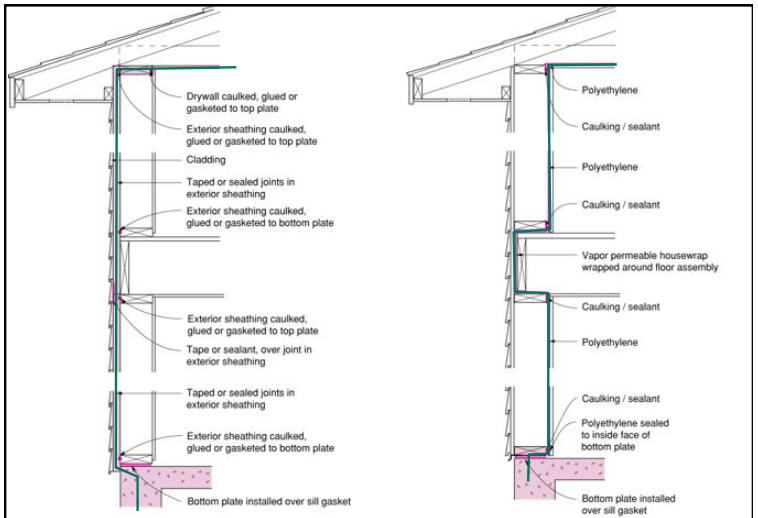
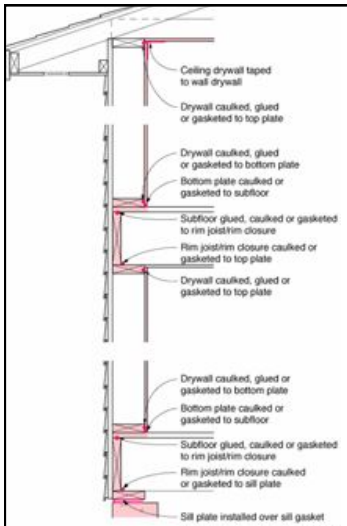


Building Science Note: shaded components designate air barrier system Note: shaded components designate air barrier system Airflow Control No. 43/79



The Airtight Drywall Approach

Use drywall, framing members

- **Seal with sealant, gaskets, etc.**
- **Is stiff, strong**
- **Often easier to ensure quality**
- **Widely applicable to all forms of commercial, residential**
- **Allows choice of vapor permeance**

Building Science Note: shaded components designate air flow retarder system Airflow Control No. 44/79


Poly can be (?) an air
and vapour barrier
But
BEWARE Air
Conditioning
Definitely not in South
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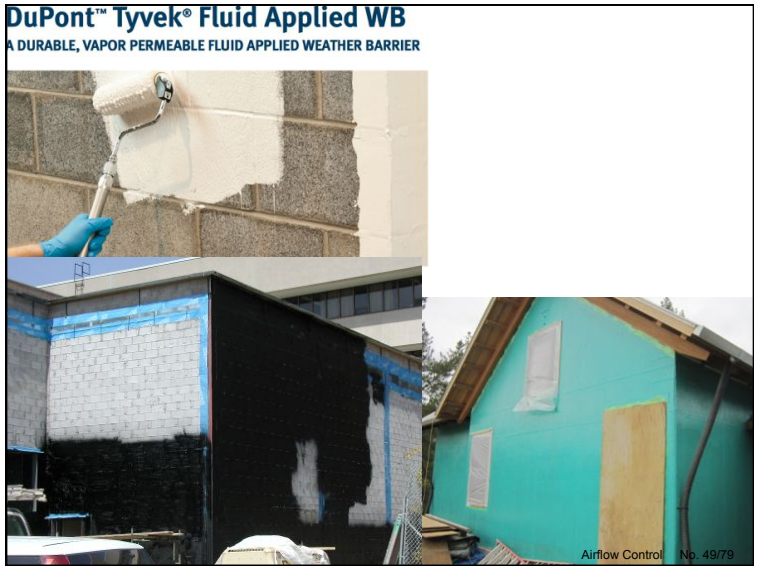
Loose-membranes
require good support
Tyvek
Building Science
Airflow Control No. 46/79

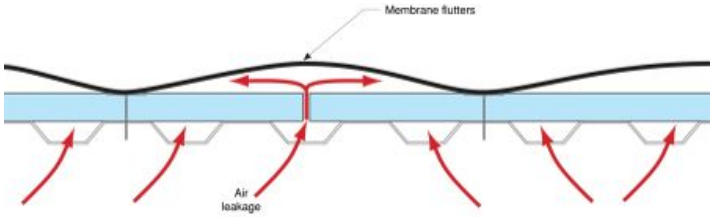

Non-adhered, vapor
permeable
=modest performance
Supported flexible
membrane is better
Tyvek
www.BuildingScience.com


Fully-adhered Air+Water Barrier is BEST
(Note: Vapor barrier shown)



Pumping Airflow and Adhered Membranes

- Membrane is continuous and airtight but …
  - It may not control airflow if not fully adhered or supported
  - E.g. roofing, housewraps, poly



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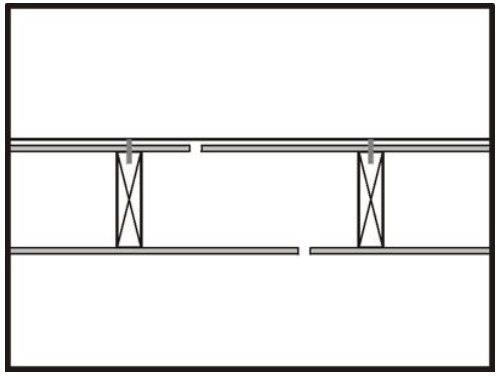
Pumping



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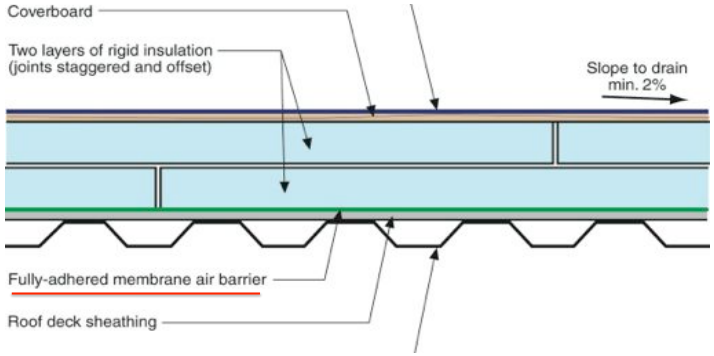
Deck level vapor control membrane rarely required if closed cell foa

Roof air barrier



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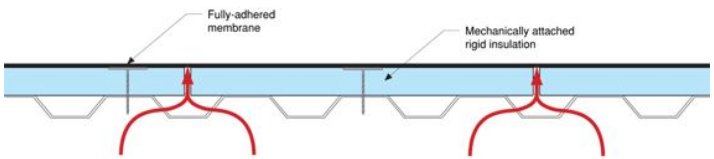
Fully adhered roof membrane



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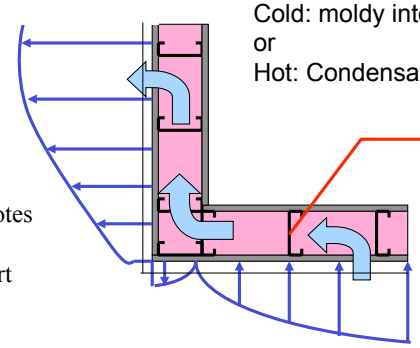
Lateral Airflows



Cold: moldy interior corner
or
Hot: Condensation on back

Punched Steel Studs

This costs energy, promotes condensation, causes comfort problems

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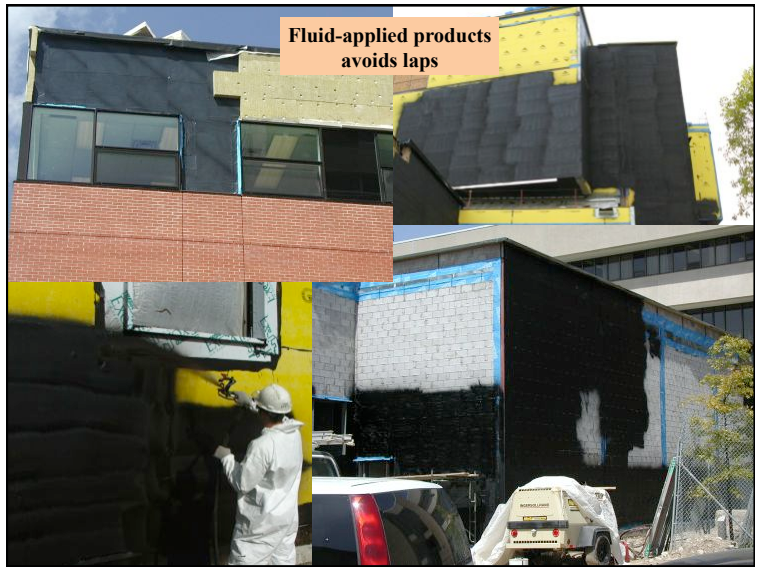
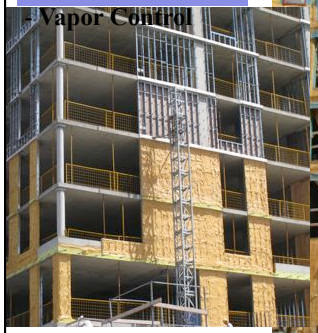


Fully-adhered air-water barrier

Vapor Permeable!

www.BuildingScience.com

Closed-cell spray polyurethane foam: ccSPF
-Rain control
-Air Control
-Thermal Control
Vapor Control



Air sealing around components:

e.g., windows and walls other Openings and penetrations

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Complex Air-sealing is often required, especially in retrofit

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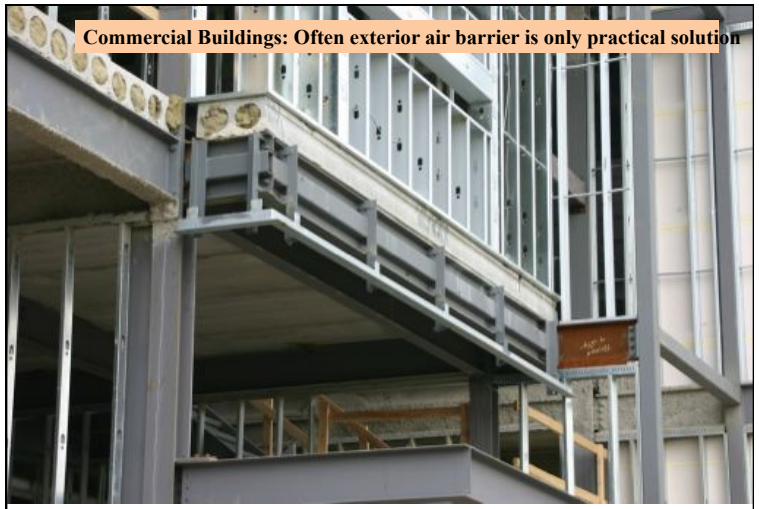

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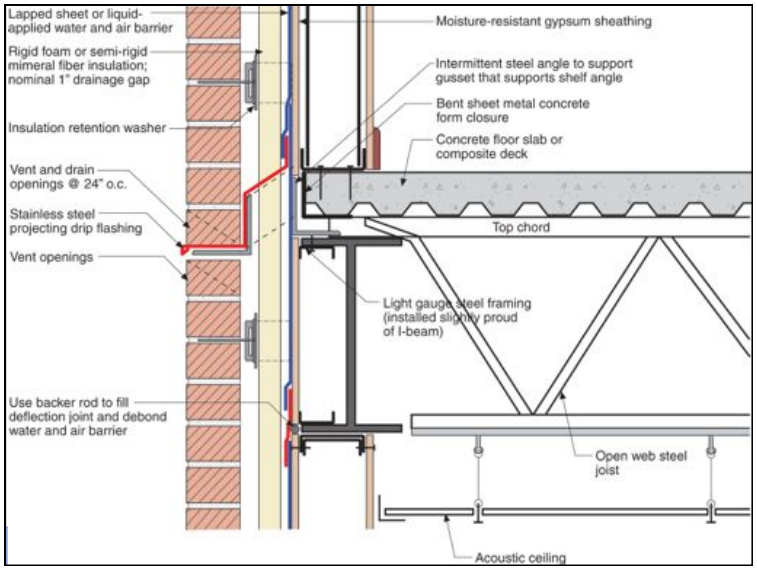

Review Air Barrier : Requirements

- Continuous
  - primary need, common failure
- 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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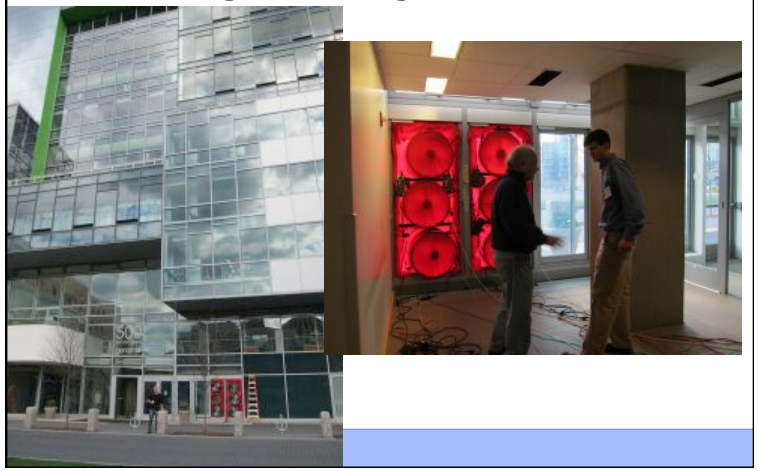
Air Leakage Testing

Air Leakage Testing



Air Leakage Testing

Conclusions

- Design, draw and spec a continuous air barrier!
- Some airtightness on both sides of air permeable insulation!
- Control driving forces
  - pressurization
  - temperature (insulated sheathing)
- Beware flow within enclosures/buildings
  - compartments, stiff air barriers

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