John Straube, Ph.D., P.Eng

Building Science

Air Flow Control

presented by www.buildingscience.co

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

Building Science Airflow Control No. 2/79

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

Building Science Airflow Control No. 3/79

Airflow Control: What?

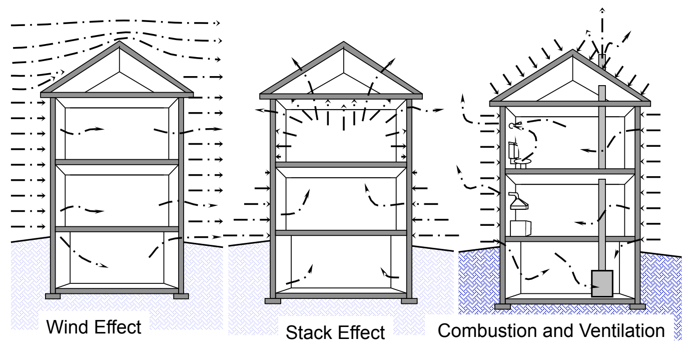
- Air flow through enclosure
  – Code requirement?
- Air flow within enclosure
  – Air loops inside enclosure
  – Air loop from interior and back
  – Air loop from exterior and back
- Therefore, CONTROL
  – = Limit or eliminate air flow through and within

Building Science Airflow Control No. 4/79

Driving Forces

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

Driving Forces

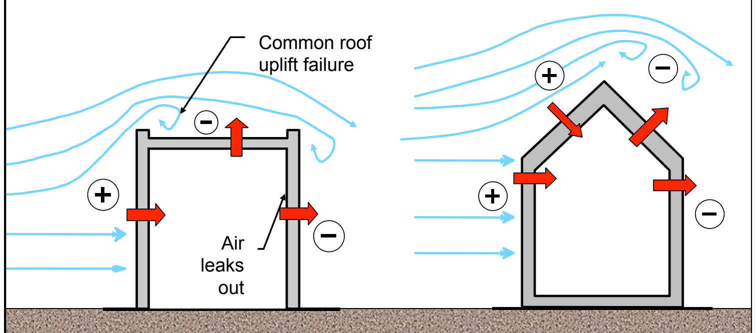


1. Wind

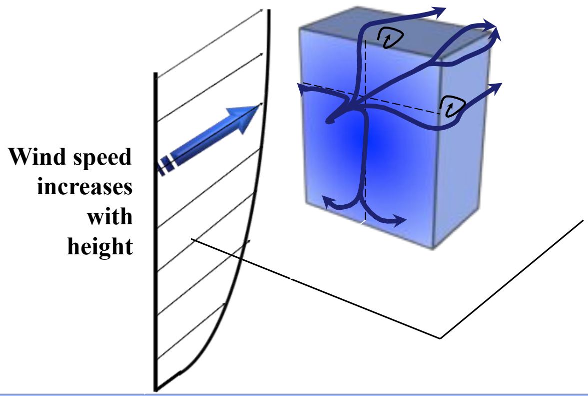
- Peak loads are high (>1000 Pa/20 psf)
- Average pressures much lower (<50 Pa)
- Wind Pressure Increases with Height
  - low-rise average pressure about 5 Pa
  - twenty story building about 40 Pa on normal day

Wind Pressures / Flow Patterns

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

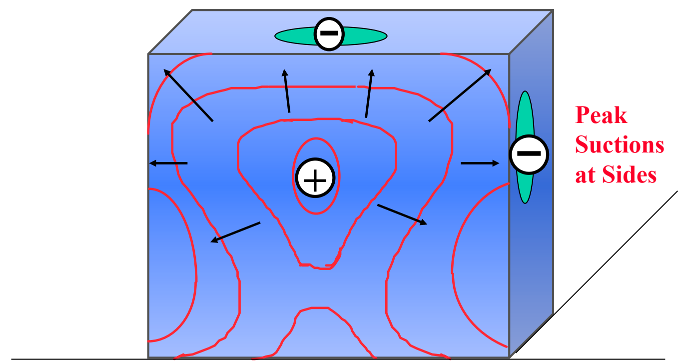


Wind Flow Patterns



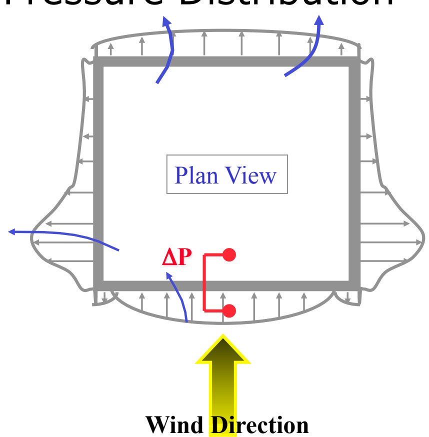
Building Science Airflow Control No. 9/79

Pressure Distribution on Face



Building Science Airflow Control No. 10/79

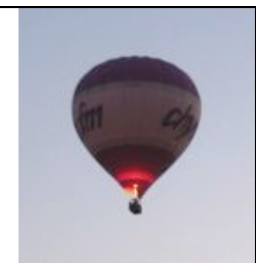
Wind Pressure Distribution

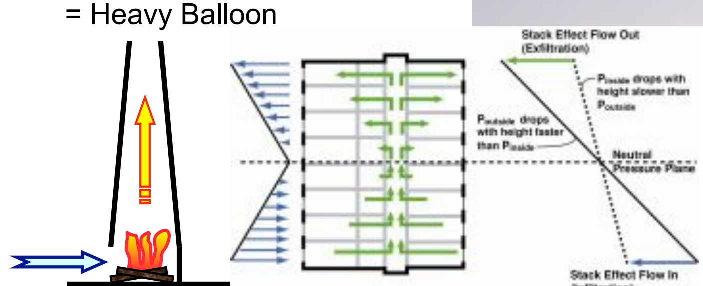


Building Science Airflow Control No. 11/79

2. Stack Effect: Cold Weather

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

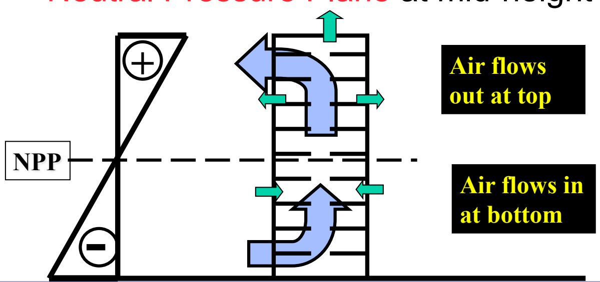




Building Science Airflow Control No. 12/79

Stack Effect: Cold Weather

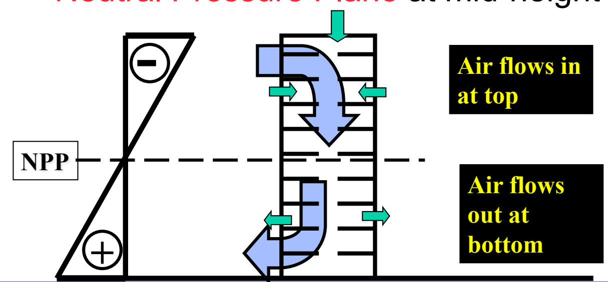
- “Perfect” Building equally leaky everywhere
- Neutral Pressure Plane at mid-height



Building Science
Airflow Control No. 13/79

Stack Effect: Warm Weather

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



Building Science
Airflow Control No. 14/79

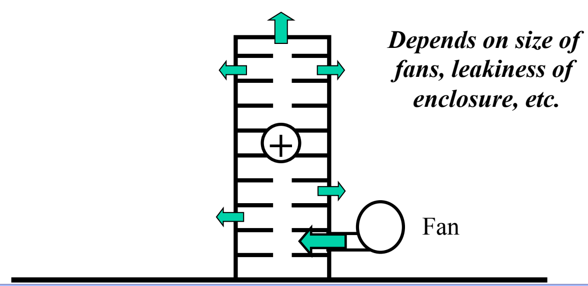
Stack Effect

- 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

Building Science
Airflow Control No. 15/79

3. HVAC Pressurization

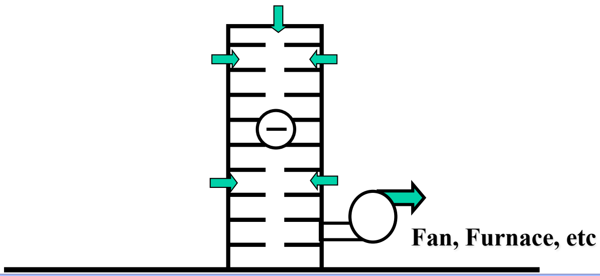
- More airflow forced into building than sucked out of building = Pressurization



Building Science
Airflow Control No. 16/79

De-Pressurization

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

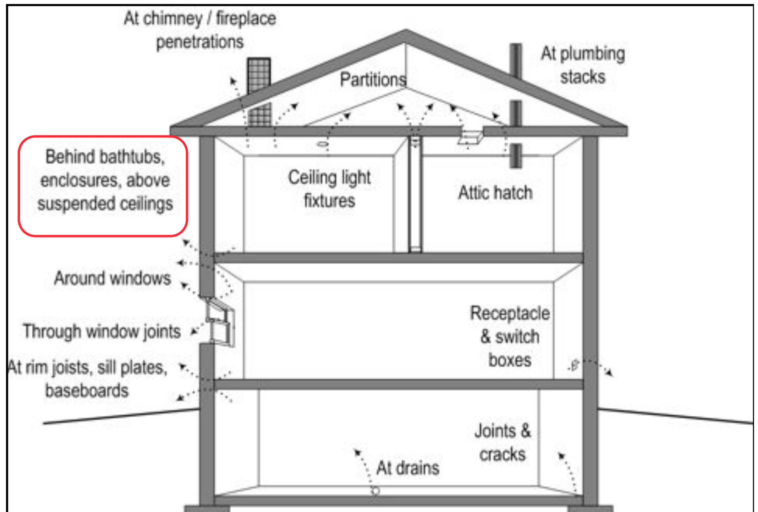


Driving Forces Summary

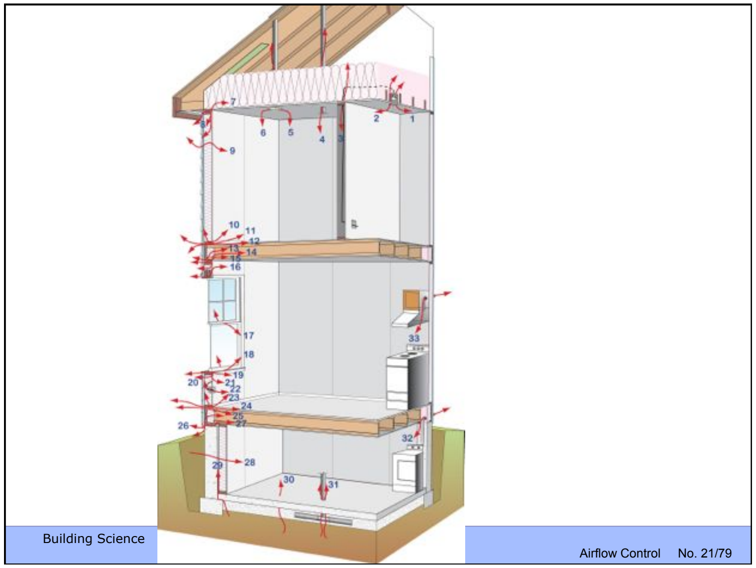
- Wind
  - Taller buildings see high pressures!
  - 2-10 Pa low bldgs, 30-200+ Pa tall buildings
- Stack Effect
  - Pressure increases directly with temperature difference and height
- HVAC
  - Depends on design and operation

Controlling Air Leakage

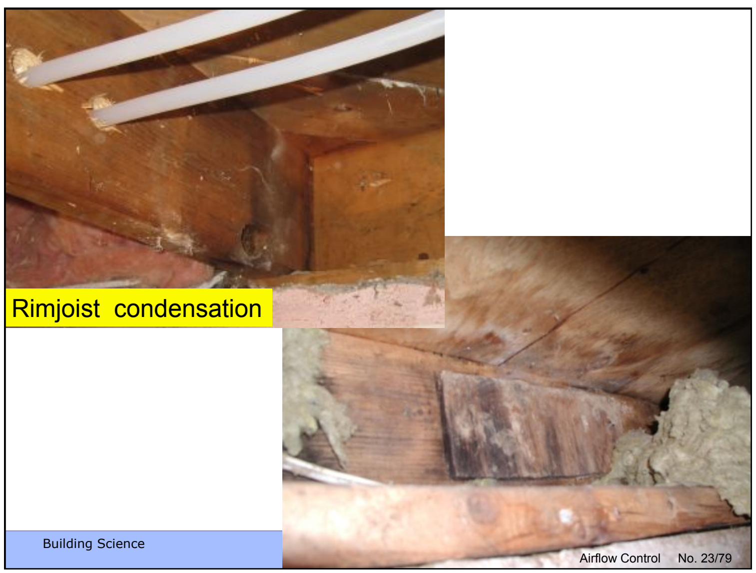
- Strategy
  - "Find the holes and plug them"
- This requires finicky attention to 3-D details.



Typical Air Leakage Points

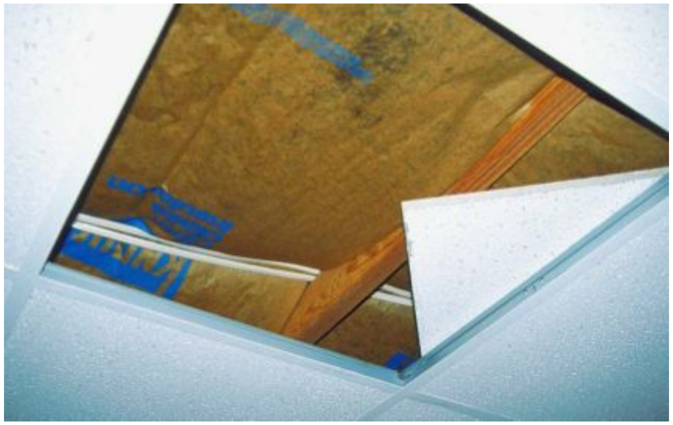

Building Science
Airflow Control No. 21/79


Rimjoist leakage

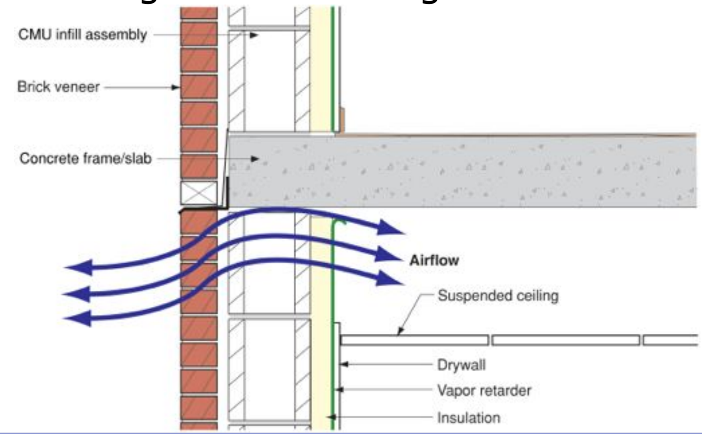

Rimjoist condensation
Building Science
Airflow Control No. 23/79


Building Science

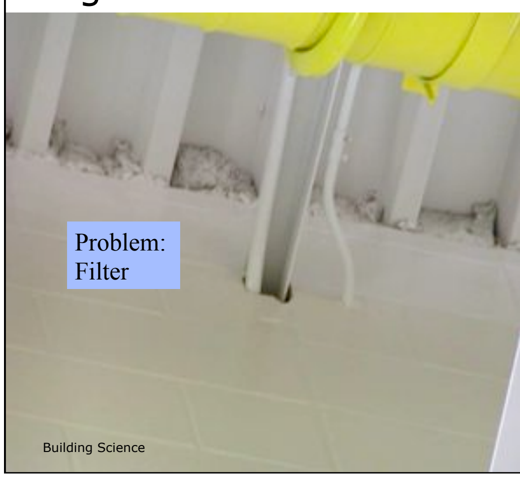
Bigholes

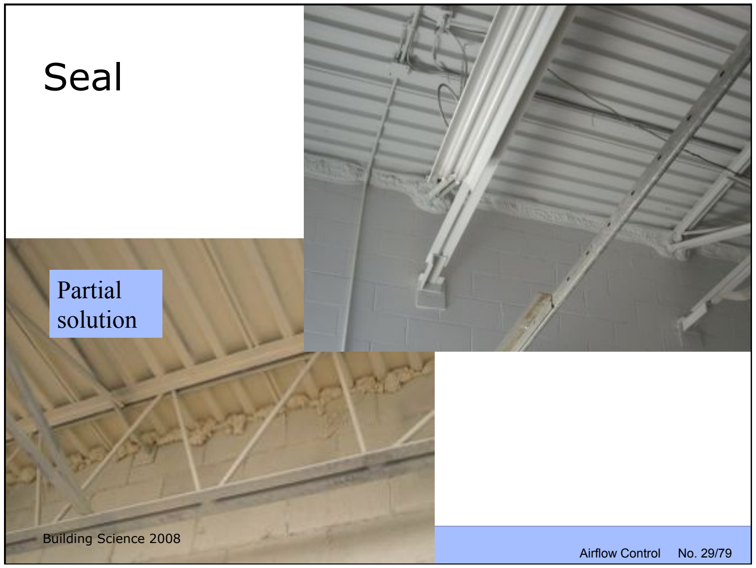


Leakage above ceilings

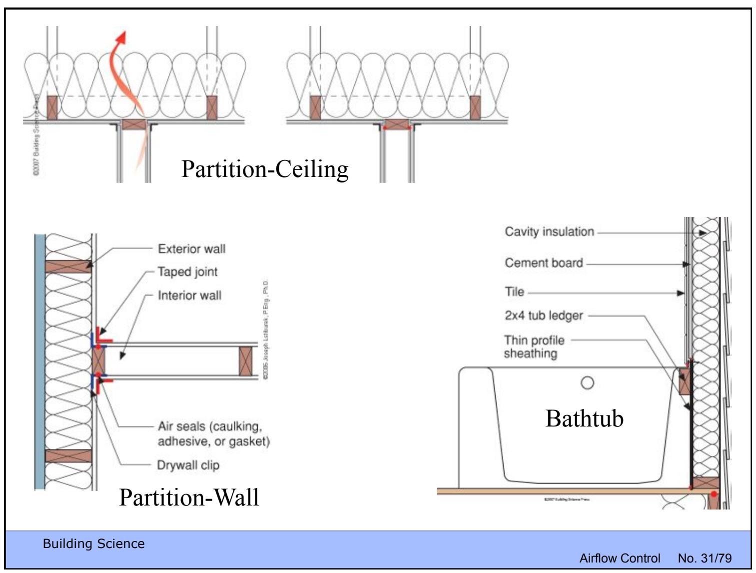


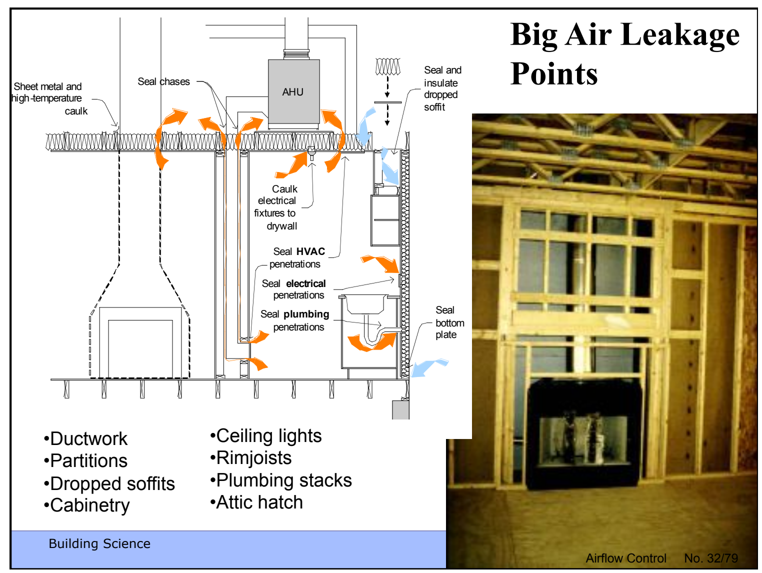
Bigholes




Seal
Partial solution
Building Science 2008
Airflow Control No. 29/79


If you can see daylight it is not sealed
Building Science 2008
Airflow Control No. 30/79


Partition-Ceiling
Exterior wall
Taped joint
Interior wall
Air seals (caulking, adhesive, or gasket)
Drywall clip
Partition-Wall
Cavity insulation
Cement board
Tile
2x4 tub ledger
Thin profile sheathing
Bathtub
Building Science
Airflow Control No. 31/79


Big Air Leakage Points
Sheet metal and high-temperature caulk
Seal chases
AHU
Seal and insulate dropped soffit
Caulk electrical fixtures to drywall
Seal HVAC penetrations
Seal electrical penetrations
Seal plumbing penetrations
Seal bottom plate
•Ductwork
•Partitions
•Dropped soffits
•Cabinetry
•Ceiling lights
•Rimjoists
•Plumbing stacks
•Attic hatch
Building Science
Airflow Control No. 32/79

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

Building Science Airflow Control No. 34/79

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)

Building Science .com Airflow Control No. 35/79

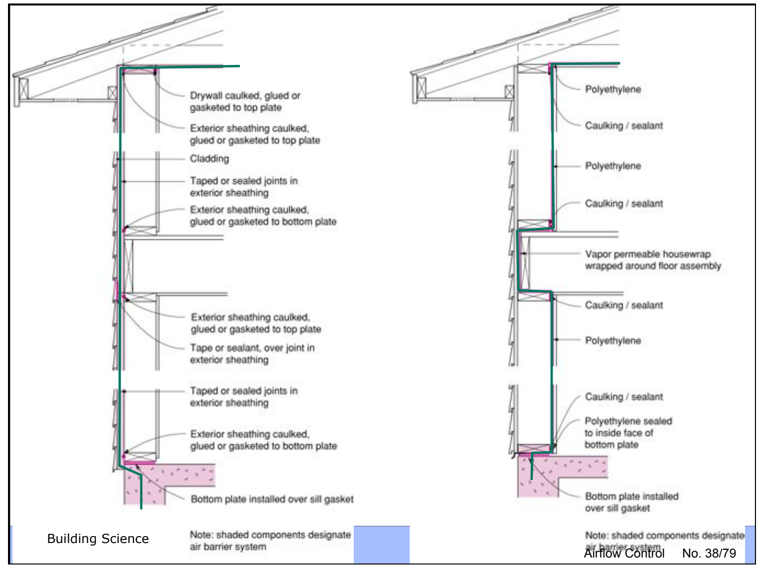
Air Barrier Requirements

- 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

Building Science 2008 Airflow Control No. 36/79

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

Building Science



Building Science

Airflow Control No. 38/79

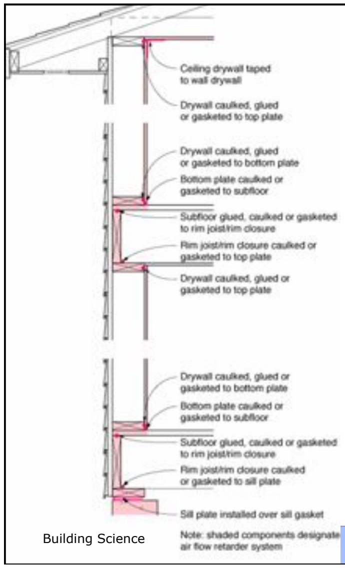
Building Science

Airflow Control No. 39/79

Poly can be (?) an air *and* vapour barrier
But
BEWARE Air Conditioning
Definitely not in South

Building Science 2008

Airflow Control No. 40/79



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 Airflow Control No. 41/79

Airflow Within Enclosures

More than just air barriers!

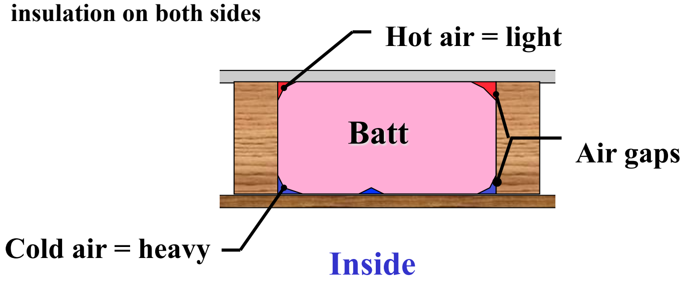
1. Convective Loops
2. Wind washing
3. Pumping

These can cause comfort, condensation, and energy problems

Building Science Airflow Control No. 42/79

Convective Loops

- Gaps in batt insulation on both sides

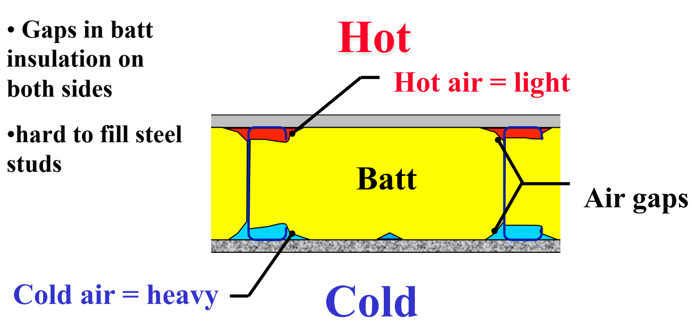


A common performance problem

Building Science Airflow Control No. 43/79

Steel studs are even "better"

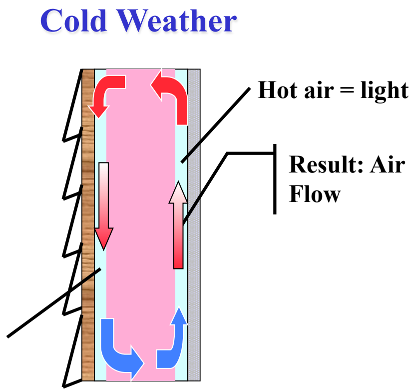
- Gaps in batt insulation on both sides
- hard to fill steel studs



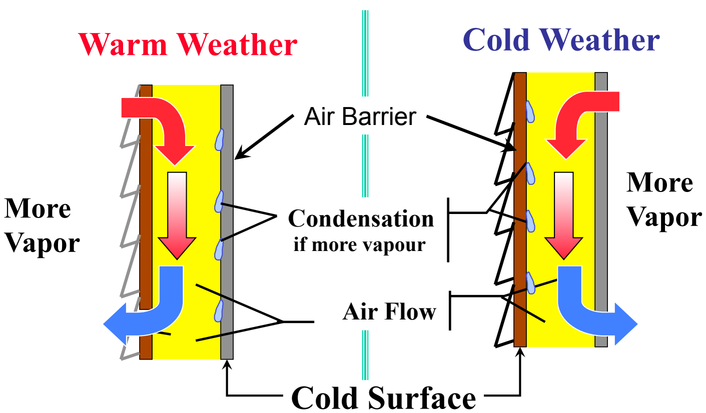
Building Science Airflow Control No. 44/79

Internal Stack Effect

- Gaps in batt insulation on both sides
- closed circuit
- energy cost
- cold surfaces



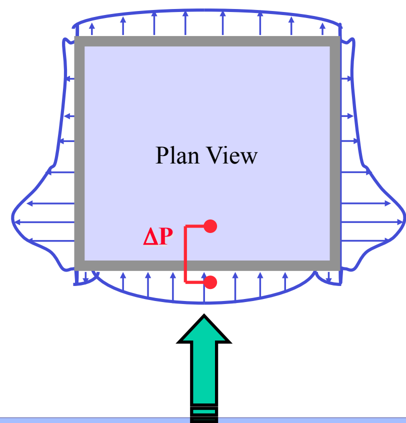
Air movement (Stack Effect)



Windwashing

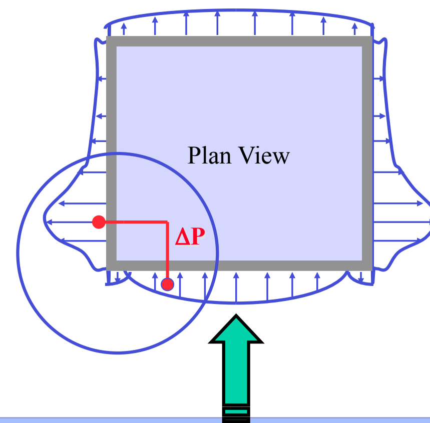
- Need some airtightness outside air permeable insulation
- Sealed housewrap, attached building paper
- Sheathing sealed with tape
  - both OSB and insulated sheathing
  - high density MFI?
- High density cavity insulation
  - some foams, maybe dense cellulose

Pressure Distribution



Building Science 2008 Airflow Control No. 49/79

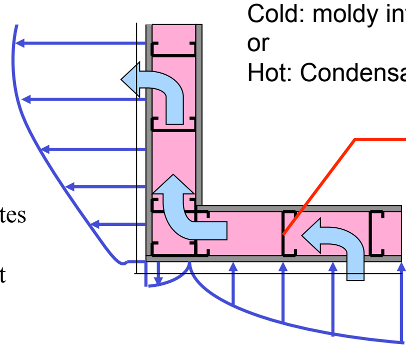
Pressure Distribution



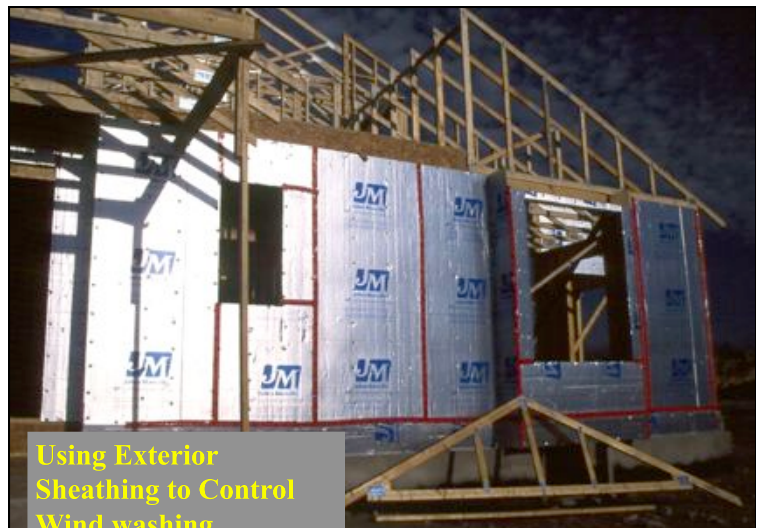
Building Science 2008 Airflow Control No. 50/79

Lateral Airflows

This costs energy, promotes condensation, causes comfort problems



Building Science 2008 Airflow Control No. 51/79

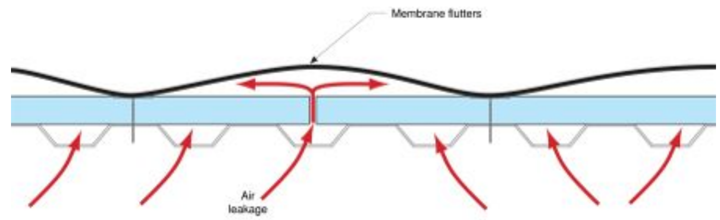


Building Science 2008 Airflow Control No. 52/79

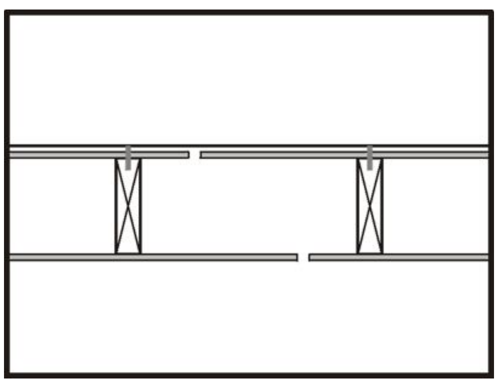
Windwashing Drainage plane not an air barrier as installed

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



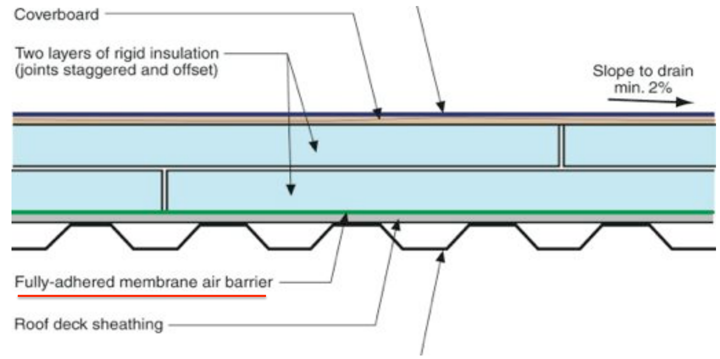
Pumping



Building Science .com 57

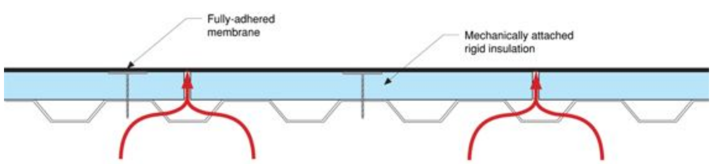
Deck level vapor control membrane rarely required if closed cell foa

Roof air barrier



Building Science.com 58

Fully adhered roof membrane

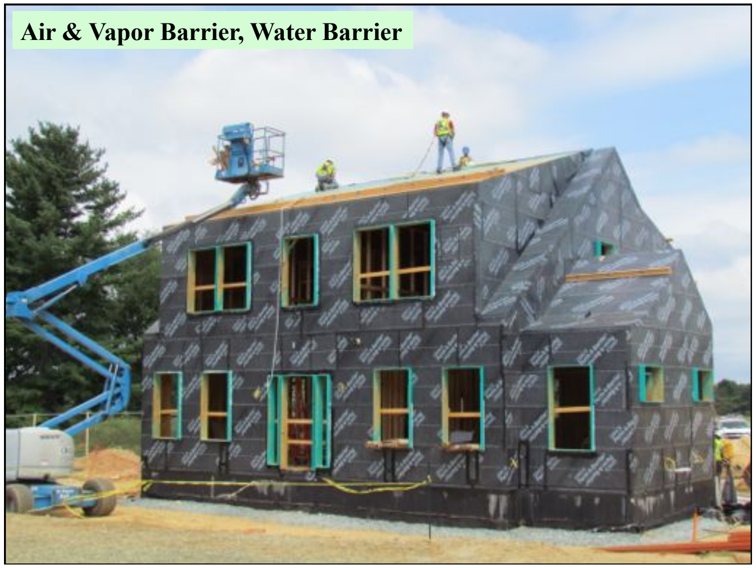


Building Science .com 59

Non-adhered, vapor permeable =modest performance

Supported **flexible membrane is better**

www.BuildingScience.com


Air & Vapor Barrier, Water Barrier


Air & Vapor Barrier, Water Barrier


Fluid-applied products
avoids laps


Fully-adhered air-water barrier
Vapor Permeable!
Self-adhered– no staple holes
and tears that allow air and
moisture to pass through walls
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

Building Science .com

Airflow Control No. 66/79

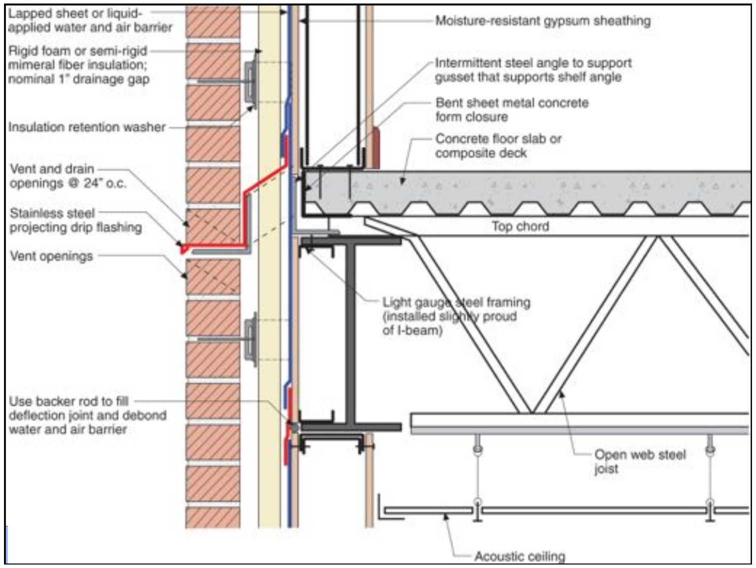
Complex Air-sealing is often required, especially in retrofit

Building Science

Airflow Control No. 67/79

Commercial Buildings: Often exterior air barrier is only practical solution

Building Science.com



Review Air Barrier : Requirements

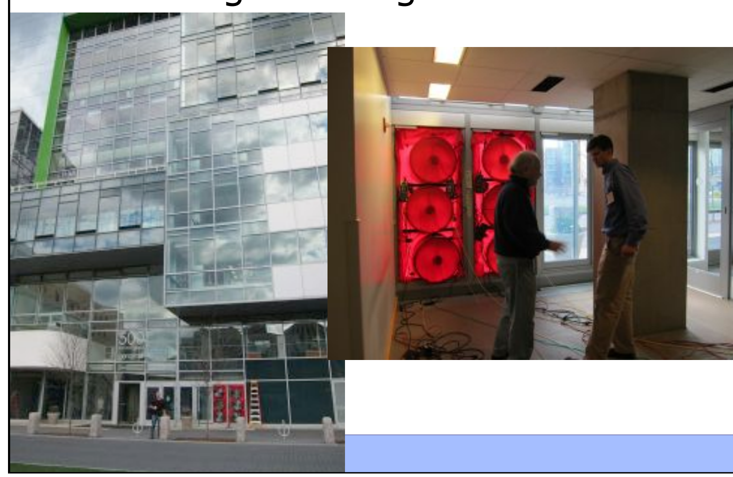
- Continuous
  - primary need, common failure
- Strong
  - designed for full wind load
- Durable
  - critical component - repair, replacement
- Stiff
  - control billowing, pumping
- Air Impermeable
  - (may be vapour permeable)

Building Science 2008

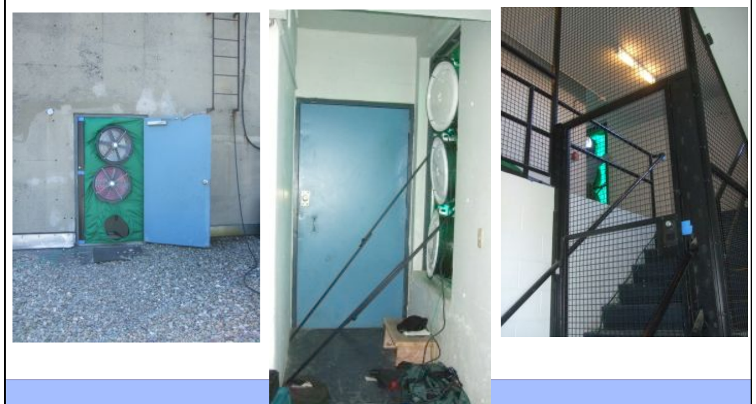
Airflow Control No. 70/79

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