Building America U.S. Department of Energy Research Toward Zero Energy Homes

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Buildings Under Pressure
Air Barriers for Commercial Buildings

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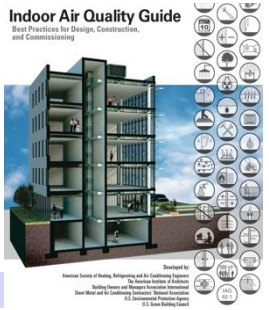
Air Barrier Systems

- Requirements for Airtightness are coming
- ASHRAE 189-2009
- ASHRAE IAQ Guide

ANSI/ASHRAE/USGBC/IES Standard 189.1-2009

Standard for the Design of High-Performance Green Buildings

Except Low-Rise Residential Buildings

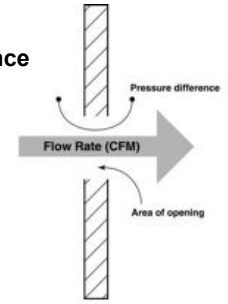


Airflow Control: Why

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

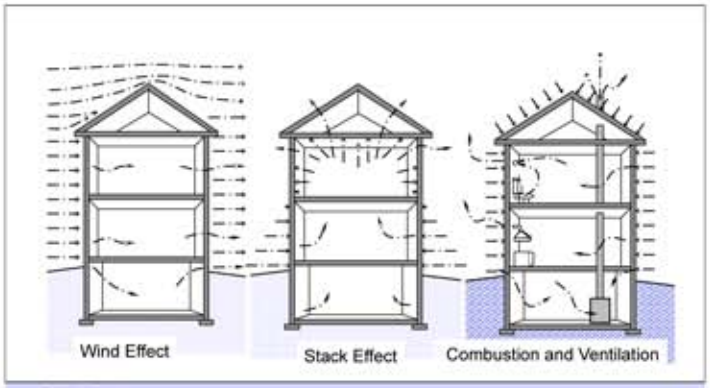
Air flow requires
•Pressure difference
•Hole



Air Flow

- Air flow depends on size of hole
- Air flow depends on pressure difference
  Flow = Area x $\sqrt{\Delta P}$ x Coefficient
- Air flows from higher pressure to lower pressure

3 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

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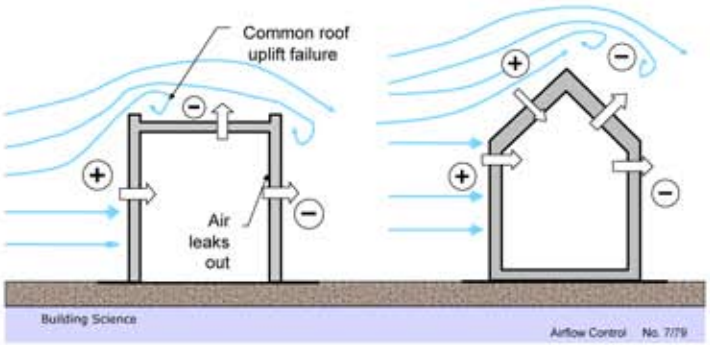
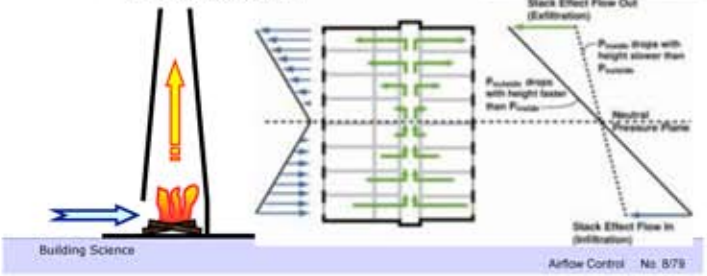
Wind Pressures / Flow Patterns

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



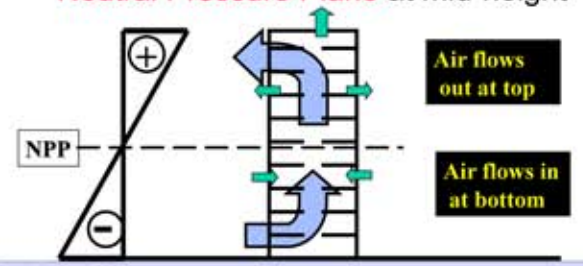
2. Stack Effect: Cold Weather

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



Stack Effect: Cold Weather

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



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Stack Effect

- When cold (20 F) outside
  - About 4.5 Pa per storey (12') 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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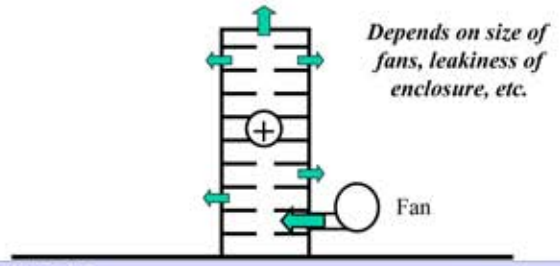
3. HVAC Pressurization

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



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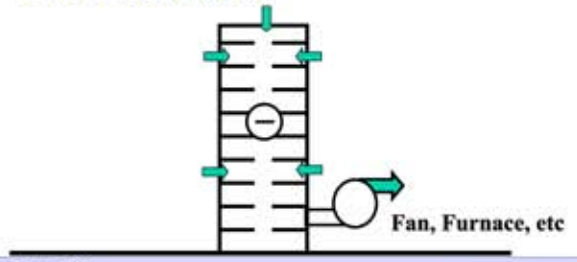
De-Pressurization

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



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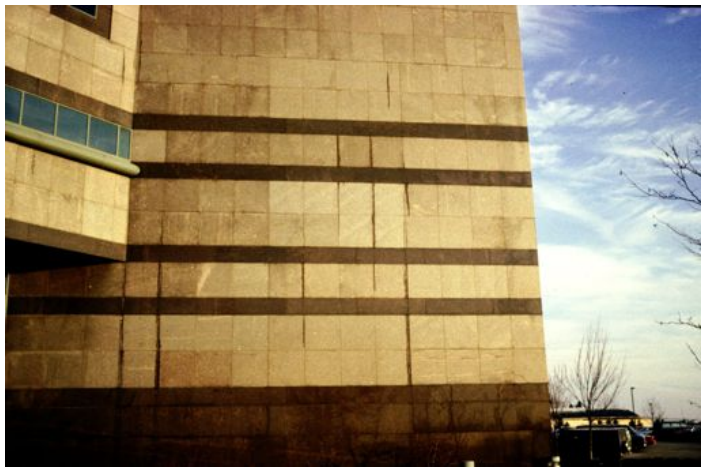
Problems with Pressurization

- Cant pressurize lobby in tall buildings in cold weather!
  - When it is 20F outdoors, 4.5 Pa/storey:
  - ten stories = 45 Pa (0.2 in wc)
  - Zero pressure at grade = massive exfiltration at roof, significant energy penalty
- Cant pressurize by sizing fans in design
  - Must know leakage first

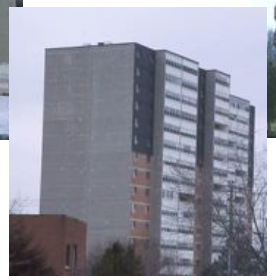
Air Leakage Condensation

- Controlling interstitial condensation is a major reason to control airflow
- If moist air contacts cool surface: Condensation occurs
- When
  - winter: cold outside surfaces
  - summer: cold inside surfaces
- Damaging airflow direction:
  - cold weather inside to outside
  - warm weather outside to inside



Building Science Pressurized Cold Climate Humdified Building and IAQ 17

Air Leakage
Condensation at top stories
•Wind +
•Stack +
•(Rain)



=Re-cladding

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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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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 : What

- Continuity & Strength are the key issues

The *continuous air barrier* shall have the following characteristics:

a. It shall be continuous throughout the envelope (at the lowest *floor*, exterior *walls*, and ceiling or *roof*), with all joints and seams sealed and with sealed connections between all transitions in planes and changes in materials and at all penetrations.
b. The air barrier component of each assembly shall be joined and sealed in a flexible manner to the air barrier component of adjacent assemblies, allowing for the relative movement of these assemblies and components.
c. It shall be capable of withstanding positive and negative combined design wind, fan, and stack pressures on the air barrier without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
d. It shall be installed in accordance with the *manufacturer's* instructions and in such a manner as to achieve the performance requirements.
e. Where lighting *fixtures* with ventilation holes or other similar objects are to be installed in such a way as to penetrate the *continuous air barrier*, provisions shall be made to maintain the integrity of the *continuous air barrier*.

From ASHRAE 189.1-2009

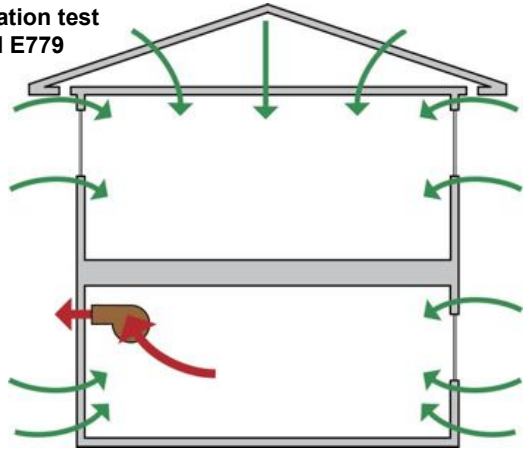
Air Barrier Requirements

- Air impermeability
  - Material: 0.02 lps/m² @ 75 Pa 0.004 cfm / ft² at 0.3" wg
  - Component: 0.2 lps/m² @ 75 Pa 0.04 cfm / ft² at 0.3" wg
  - Building: 2.0 lps/m² @ 75 Pa 0.4 cfm / ft² at 0.3" wg
- *Building* requirement most important for energy, interior RH, IAQ
- *Component* requirement *may* matter for air leakage condensation control

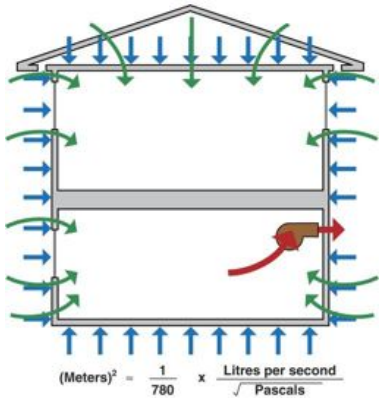
Measuring Airtightness

- Targets (GSA, Army Corp, ASHRAE 189)
- Measured using ASTM E779 (usually)
- May use building airhandler if flow can be measured accurately
- Buildings up to 800 000 sf have been tested to date

Infiltration test
ASTM E779



$$ELA = C \times \frac{\text{Rate of flow}}{\sqrt{\text{Pressure difference}}}$$



$$(\text{Meters})^2 = \frac{1}{780} \times \frac{\text{Litres per second}}{\sqrt{\text{Pascals}}}$$

Air Barrier Examples

- – Drywall, caulked/sealed/gasketed
- – Exterior sheathing
- – Sitecast or Precast concrete
- – Spray foam insulation
- – Fully-adhered roofing membranes
- – Steel sheets
- All need careful joint sealing!

Spray/Trowel Applied Air/water

- Semi-permeable

Details

- Air & water & vapor transition membranes

Insulation, Air barrier, WRB

- Fully adhered air barrier drainage plane and insulation

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Commercial Air-Water Barriers

- Drainage plane/air barrier
- Format
  - Sprayed on
  - trowel applied
  - Sheet applied
- Desirable Attributes
  - Self sealing
  - Fully adhered

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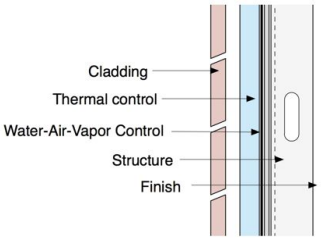
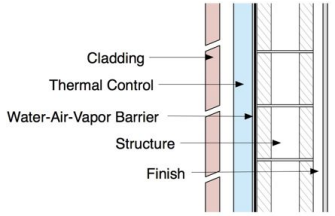
Example applications





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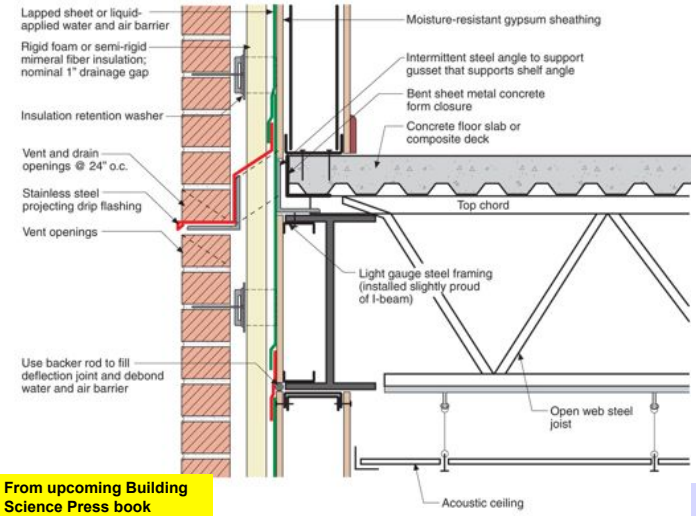
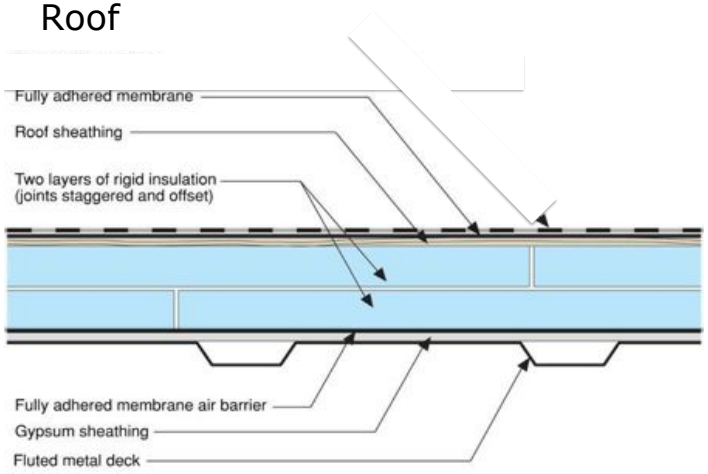
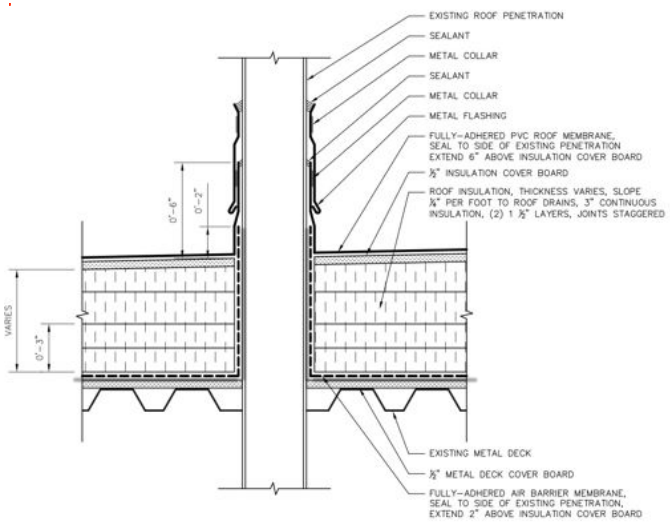


From upcoming Building Science Press book

Roof





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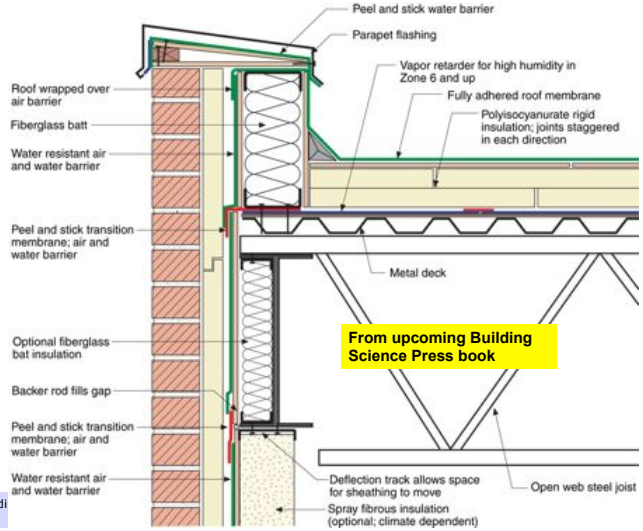

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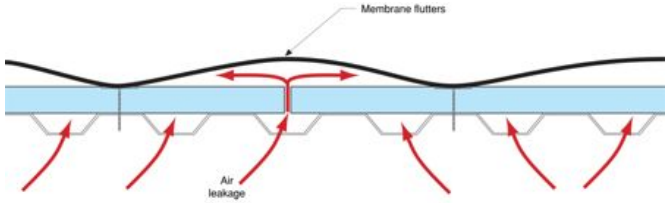
Pumping Airflow and Adhered Membranes

- 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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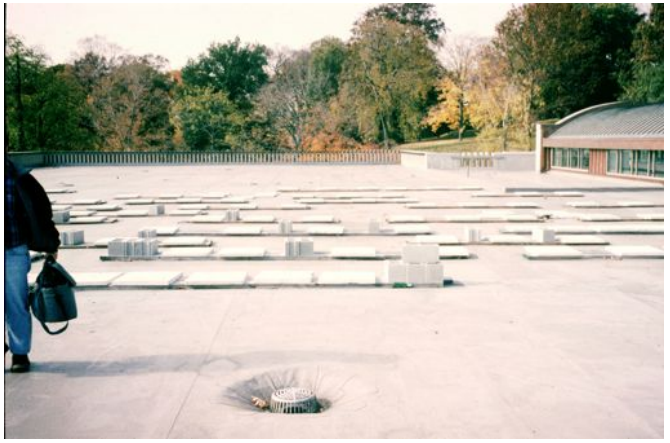
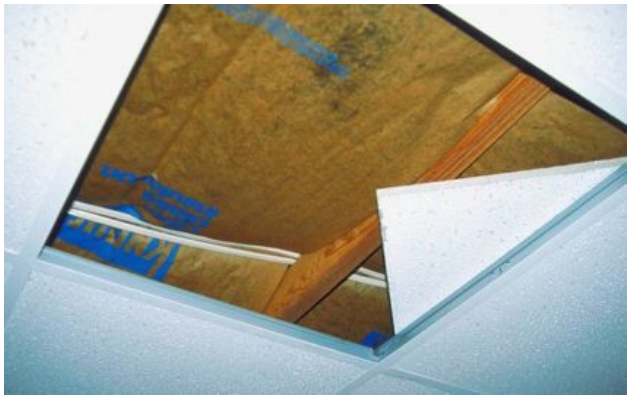
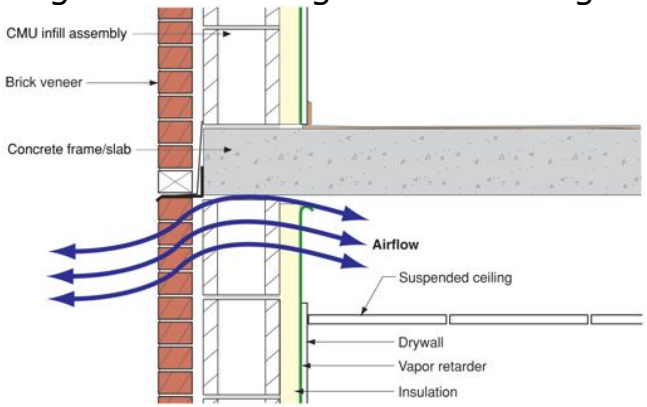


Roof in Motel: Bigholes



Big Holes: Leakage above ceilings



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Bigholes

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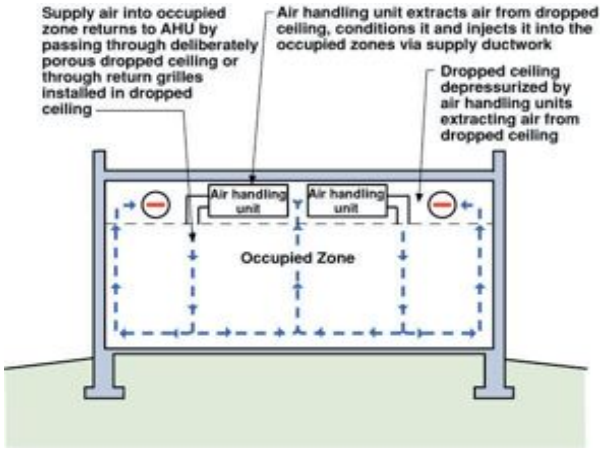

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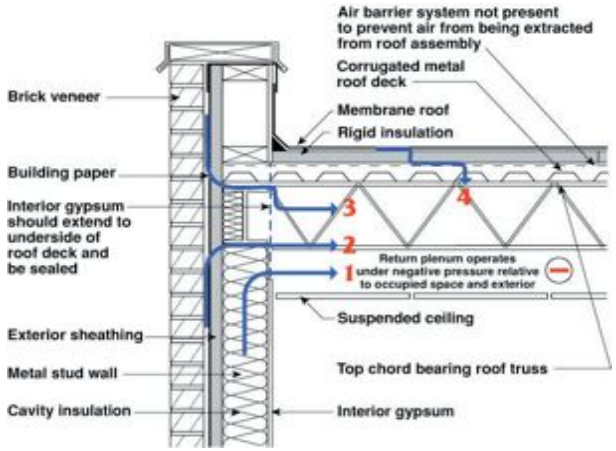
– Air Flow, Pressures and IAQ 47



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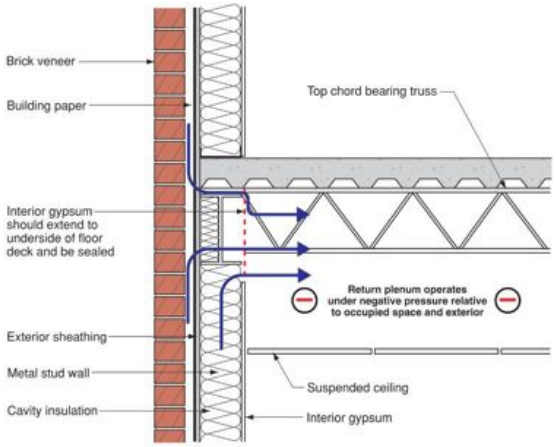

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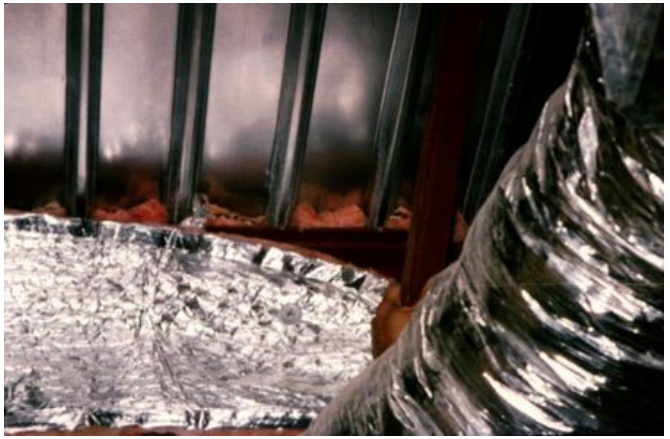
Air Flow, Pressures and IAQ 49



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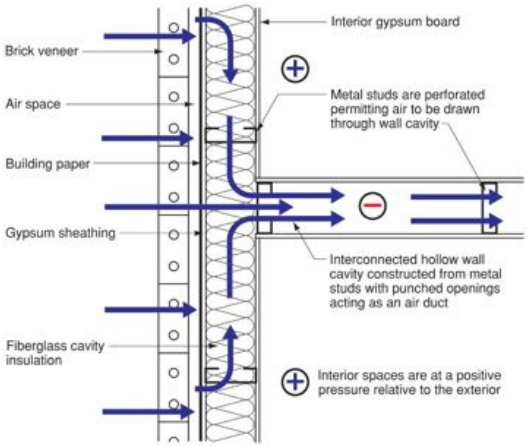
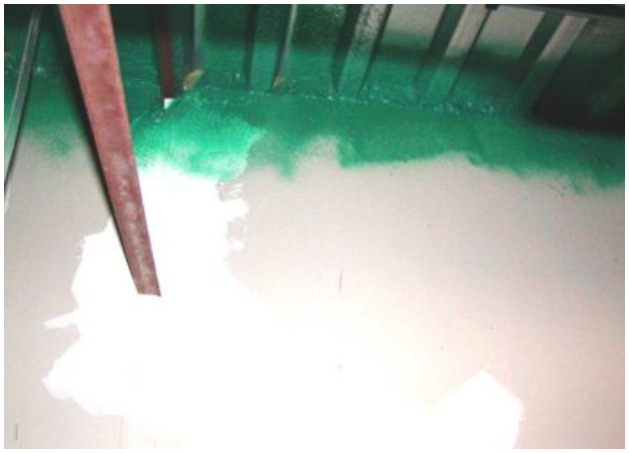

Interior gypsum board
Brick veneer
Air space
Building paper
Gypsum sheathing
Fiberglass cavity insulation
Metal studs are perforated permitting air to be drawn through wall cavity
Interconnected hollow wall cavity constructed from metal studs with punched openings acting as an air duct
Interior spaces are at a positive pressure relative to the exterior



Conclusions

- Air Barrier Systems will become mandated or required
- Mechanical engineers need to manage pressures better
- Knowing airtightness allows for better mechanical system designs

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