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

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

If you can’t enclose air, you can’t condition it
Driving Forces

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

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

Wind speed increases with height

Pressure Distribution on Face

Peak Suctions at Sides

Wind Pressure Distribution

Plan View

Wind Direction

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

Air flows in at bottom
Air flows out at top

Stack Effect: Warm Weather

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

Air flows in at top
Air flows out at bottom

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

3. HVAC Pressurization

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

 Depends on size of fans, leakiness of enclosure, etc.
De-Pressurization

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

![Diagram](image)

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.
Bigholes

Problem:
Filter

Leakage above ceilings

CMU infill assembly
Brick veneer
Concrete frame/slab

Airflow
Suspended ceiling
Drywall
Vapor retarder
Insulation
Seal

Partial solution

Solution:

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If you can see daylight it is not sealed

Airflow Control     No. 30/79
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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

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)

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
• Cellulose in not an air barrier

• DensePack (>3.5 pcf) can slow airflow

• Improves horrible buildings, does not achieve good or great

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

Airflow Within Enclosures

More than just air barriers!
1. Convective Loops
2. Wind washing
3. Pumping

These can cause comfort, condensation, and energy problems

Convective Loops

- Gaps in batt insulation on both sides

Steel studs are even “better”

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

A common performance problem
Internal Stack Effect

- Gaps in batt insulation on both sides
- Closed circuit
- Energy cost
- Cold surfaces

*Cold air = heavy*

Result: Air Flow

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Air movement (Stack Effect)

- Warm Weather
- Cold Weather

*Cold Surface*

Air Barrier

More Vapor

Condensation if more vapour

Air Flow

More Vapor

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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

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Pressure Distribution

Plan View

ΔP

Airflow Control     No. 49/79
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Pressure Distribution

Plan View

ΔP

Airflow Control     No. 50/79
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Lateral Airflows

Cold: moldy interior corner
Hot: Condensation on back

This costs energy, promotes condensation, causes comfort problems

Punched Steel Studs

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Using Exterior Sheathing to Control Wind washing

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**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

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**Pumping**
Roof air barrier

Deck level vapor control membrane rarely required if closed cell foam is used.

Fully adhered roof membrane

Non-adhered, vapor permeable = modest performance

Supported flexible membrane is better
Air & Vapor Barrier, Water Barrier

Fluid-applied products avoids laps

Fully-adhered air-water barrier

Vapor Permeable!
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

Air sealing around components:
- Complex Air-sealing is often required, especially in retrofit

Commercial Buildings: Often exterior air barrier is only practical solution
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)
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