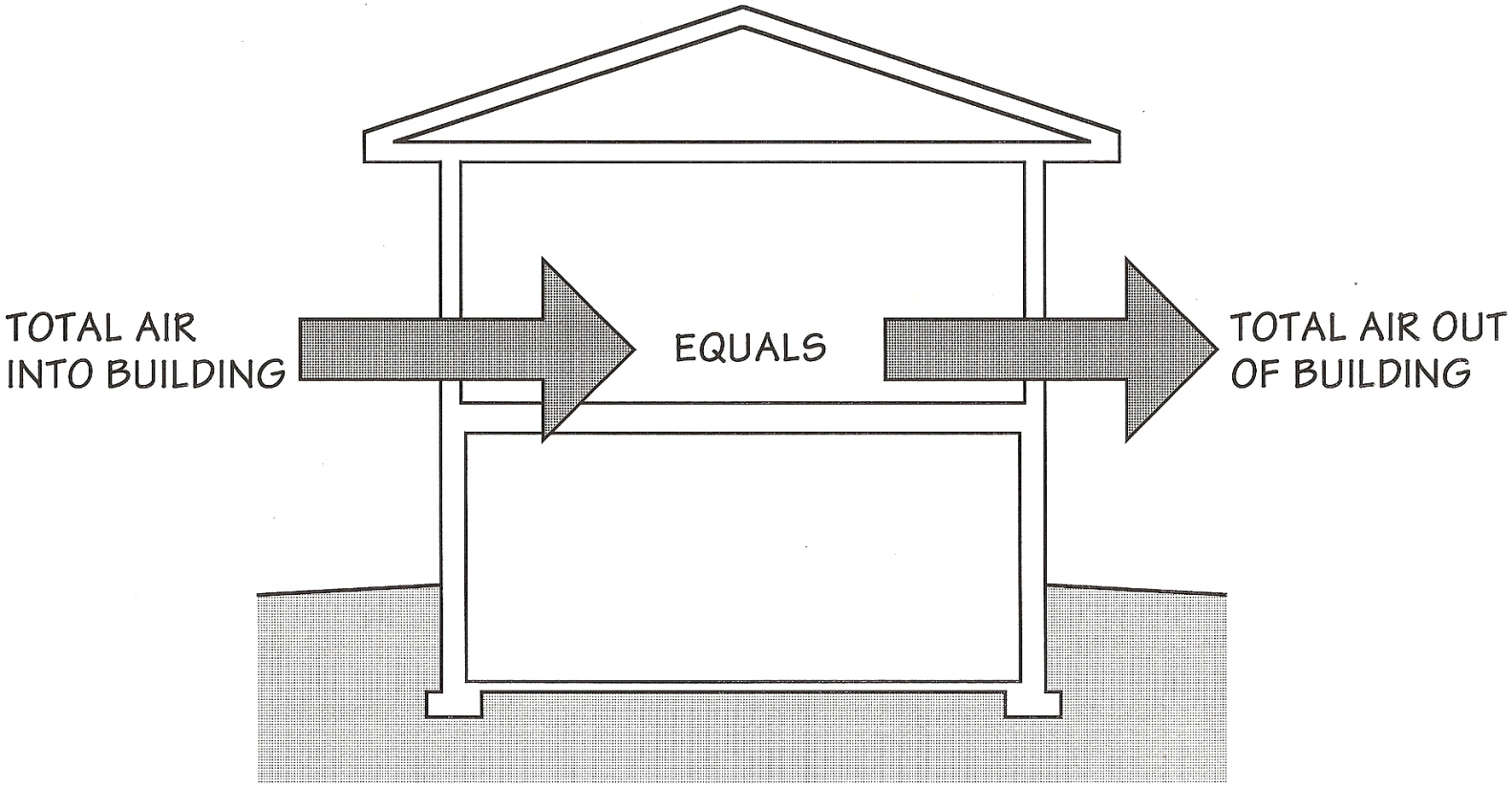
Advanced Building Science

- Infiltration & Ventilation (Air Exchange)
  - Basic concepts & terminology
  - Airflow around buildings
  - Moving towards calculating airflows

- Readings
  - HPE: Chapter 3.2
  - HPE: Appendix B.11 Air Flow Control in Buildings
  - HF: Chapter 24 => OK to “review” modeling

Infiltration & Ventilation (Air Exchange)

The Air Balance



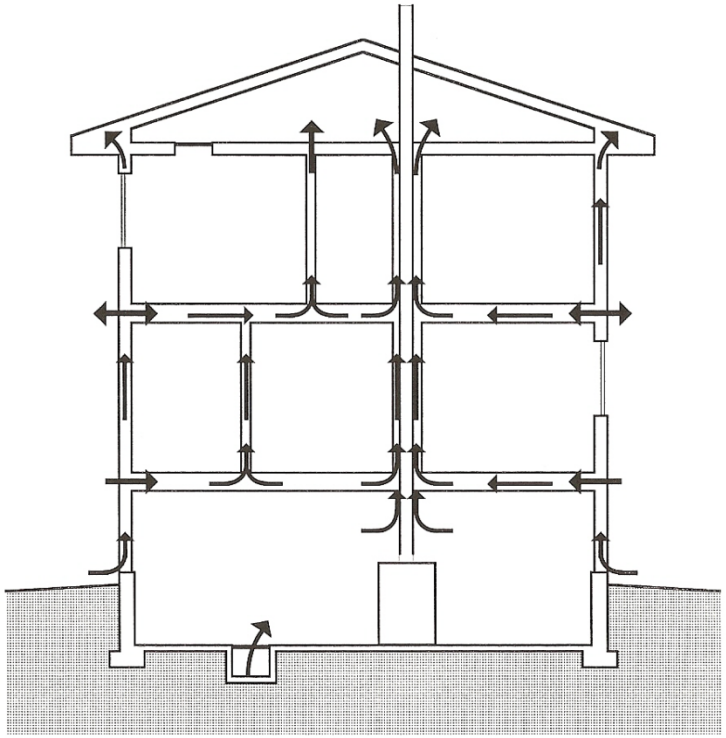
Infiltration & Ventilation (Air Exchange)

To Have Airflow, You Must Have:

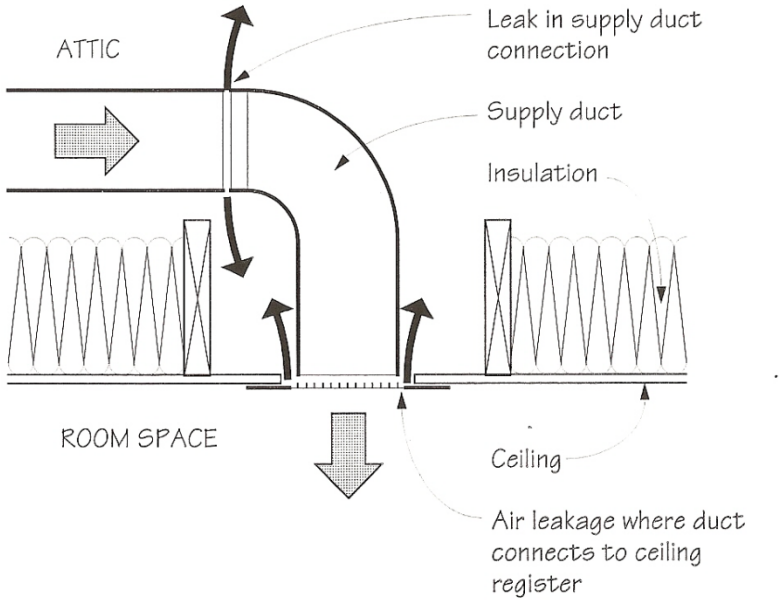
- Hole or path
  - random (leaks)
    - direct
    - indirect
  - intentional openings
- Pressure difference
  - outside pressures
    - airflow around buildings
    - temperatures (stack effect)
  - interior pressures
    - chimneys
    - mechanical systems

Infiltration & Ventilation

Air Leakage Pathways



Indirect through walls



Indirect through ducts

Infiltration & Ventilation

Air Flow is Driven by Pressure Differences

- These pressures can be created by natural conditions:
  - wind
  - temperature differences

- And pressures can be created by mechanical equipment:
  - combustion venting
  - exhaust fans
  - exhaust devices
  - supply fans
  - forced air systems

Infiltration & Ventilation

- Types of Air Exchange
  - Infiltration and exfiltration
    - random leaks; natural forces
  - Ventilation (intentional openings)
    - natural
    - forced
    - other (chimneys & exhaust devices)

- Transfer (or circulation) air
  - Within the house

Infiltration & Ventilation

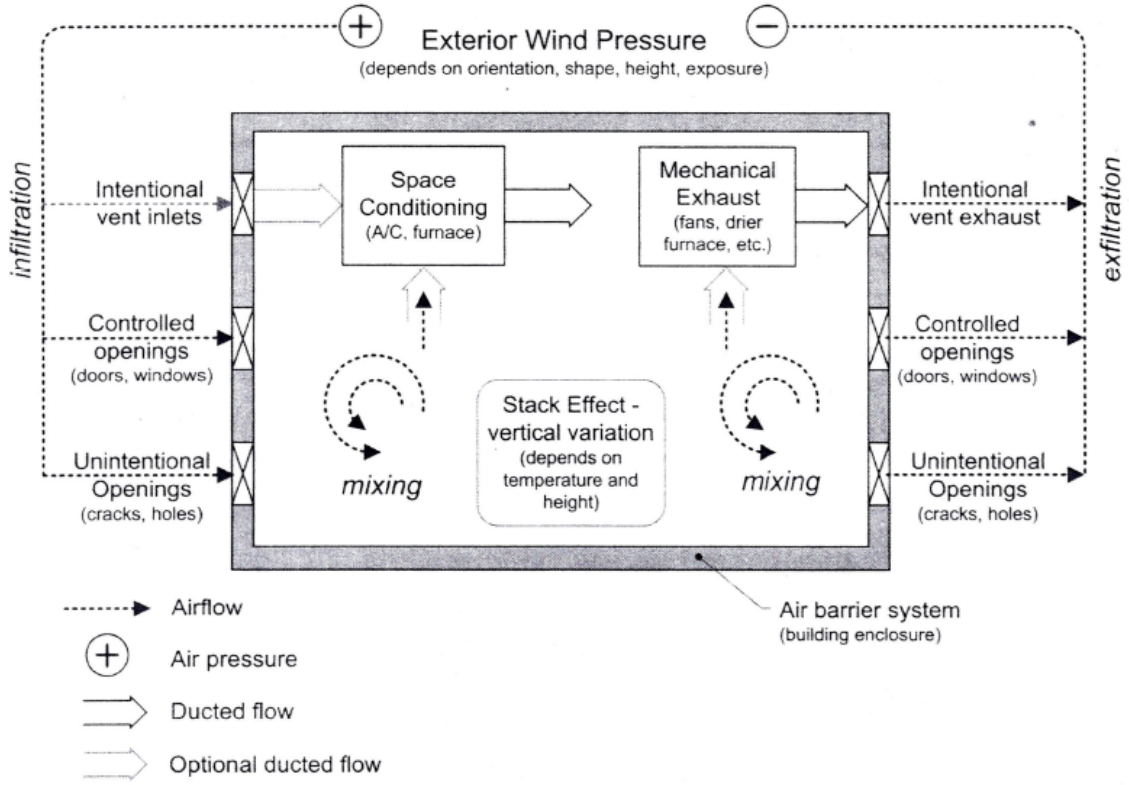


Figure 7.1: Examples of airflow processes within buildings and across enclosures

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 7

Three primary mechanisms generate the pressure differences required for air to

Infiltration & Ventilation

Natural Forces

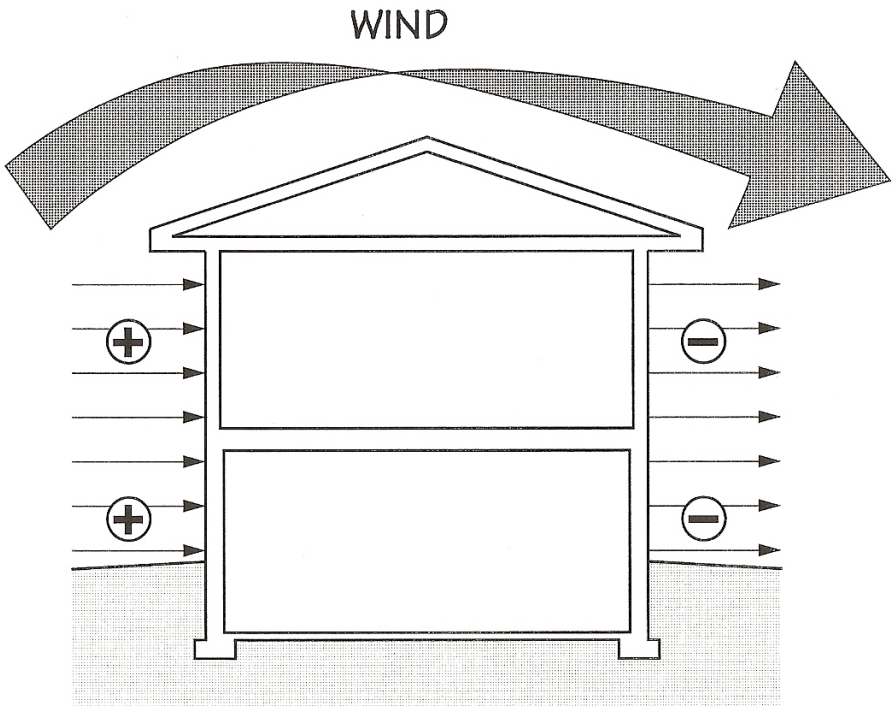
- Wind
- Stack (temperature-induced)

Infiltration & Ventilation

Wind drives air through openings

(either intentional or unintentional)

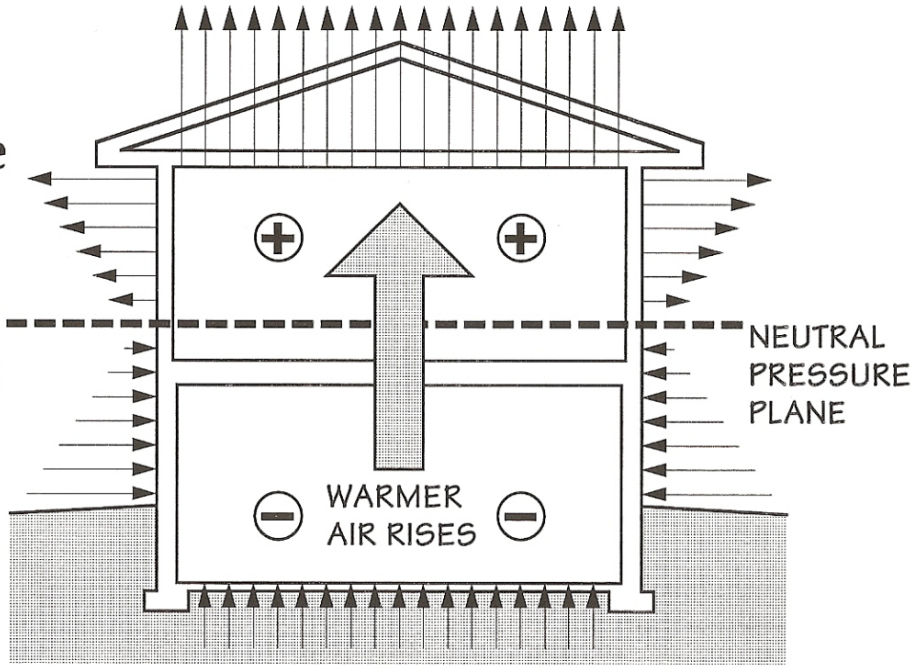
- Air is pushed inward on the windward side
- Air is sucked outward on the leeward side
- Flow in = Flow out



Infiltration & Ventilation

The stack effect

- Positive (outward) pressure is created above the neutral pressure plane
- Negative (inward) pressure is created below the neutral pressure plane
- Outward flow above the plane = Inward flow below the plane



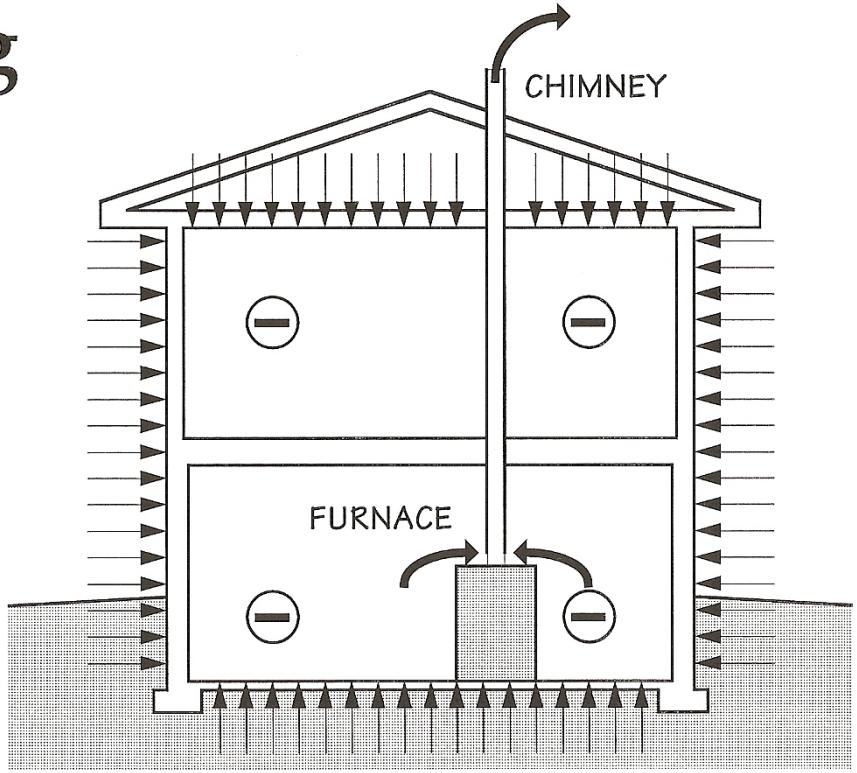
Infiltration & Ventilation

- Mechanical Forces
  - Combustion exhaust
  - Ventilation (exhaust fans)
  - Exhausting devices
  - Supply devices
  - Forced-air systems

Infiltration & Ventilation

Combustion venting (the chimney effect)

- Negative (inward) pressure is created in the building



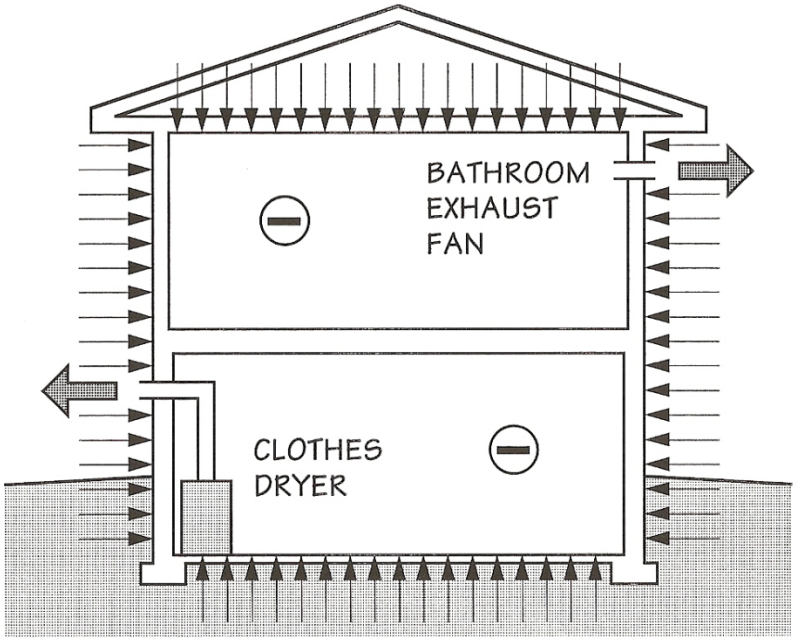
Infiltration & Ventilation

Exhausting Devices

- Clothes dryers also create negative (inward) pressure in the building

Mechanical Ventilation

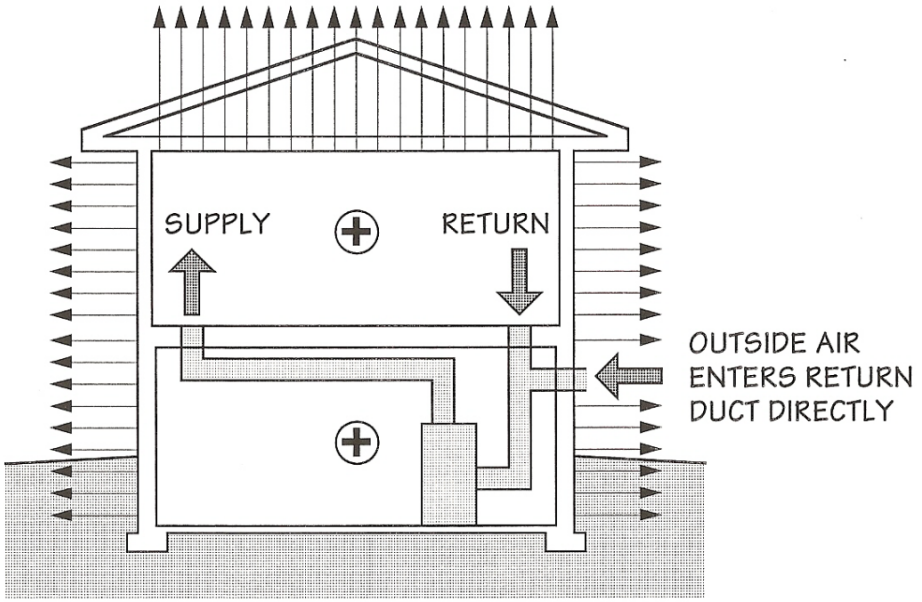
- Bath and kitchen fans create negative (inward) pressure in the building



Infiltration & Ventilation

Supply devices

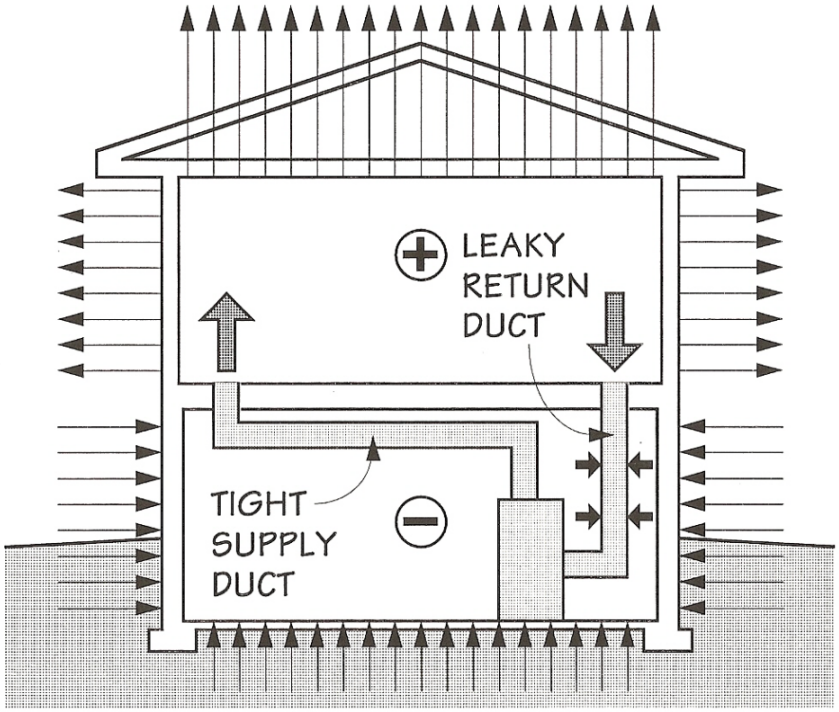
- Outside air supply directly connected to the HVAC system creates positive (outward) pressure in the building



Infiltration & Ventilation

Forced air systems– ducts in basement

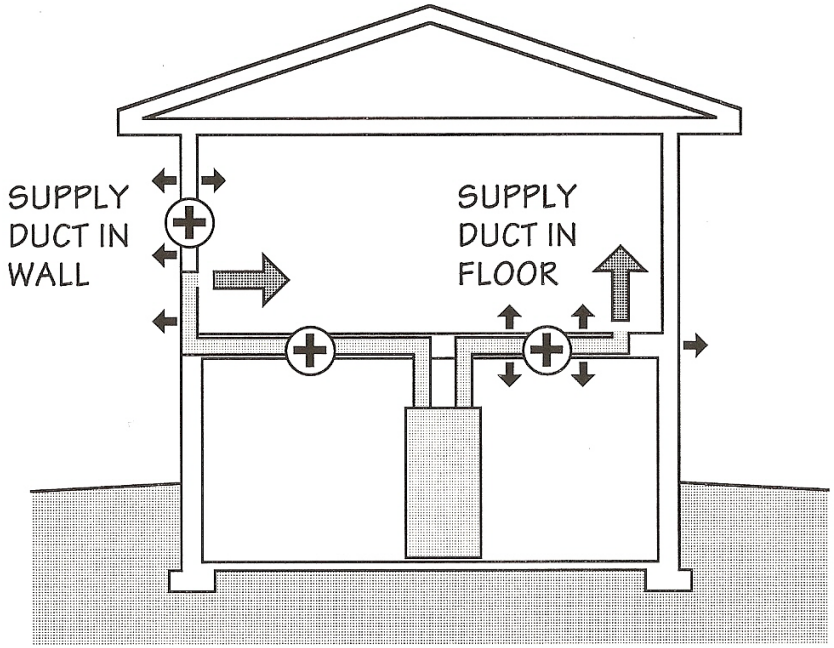
- Leaky return ducts cause the basement to be depressurized while the above grade space is pressurized



Infiltration & Ventilation

Forced air systems–supply ducts within walls and floors

- **Leaky supply ducts can pressurize cavities causing air leakage**



Airflow Around Buildings

Wind Data

- See Chapter 14 (ASHRAE Handbook Fundamentals 2013) for wind design data
- Hourly vs. Annual
- Frequency distribution
- Vertical wind profile

Airflow Around Buildings

- Flow Patterns
  - Building height
  - Building shape
- Zones of Interest
  - Stagnation
  - Recirculation
  - Upwash & downwash
  - Ground conditions

Airflow Around Buildings

Wind Pressures

- Local pressure coefficients for a tall building
  - with varying wind angle

- Local pressure coefficients for low-rise (walls & roof)

Airflow Around Buildings

Effects on System Operation

- Wall openings
- Impact of mechanical ventilation/exhaust
- Building pressure balance

Airflow Around Buildings

Scale Modeling Simulation and Testing

- Simulation
  - CFD is tedious and very expensive
- Physical modeling
- Field evaluations
- Boundary layer wind tunnel
  - can be expensive, but a great tool

Types of Air Exchange in Buildings

1. Air Infiltration and Exfiltration
   - Random leaks
   - Natural driving forces (wind/temperature)
2. Natural Ventilation
   - Intentional openings (windows)
   - Natural driving forces (wind/temperature)
3. Chimneys
   - Intentional openings (flue)
   - Thermally (or mechanically) driven
4. Exhaust Devices
   - Intentional openings (vents)
   - Mechanically driven (fans, etc.)
5. Mechanical Ventilation
   - Intentional openings (vents or grills)
   - Mechanically driven (fans, etc.)

In Summary

Questions and Discussion

Preview for Next Class

- Air Exchange => All about the Math!
  - Calculating airflows
  - Superposition
    - wind & stack
    - balanced and unbalanced
  - Simplified air exchange models

- Readings
  - HF Chapter 16.1 – 16.25
  - HF Chapter 24 => OK to “review” modeling