Moisture and Buildings

- Moisture is involved in almost all building envelope performance problems
  - In-service .... Durability
- Examples:
  - rot,
  - corrosion,
  - mould (IAQ)
  - termites, (!),
  - staining
  - etc.

Moisture Damage

- Damage caused by
  - Very high humidity for a long time
  - Wet (100%RH) for a shorter time
- Time required depends
  - on material
  - Temperature
- Temperature
  - Accelerates slows or stops process
**Moisture Control**

- **Moisture-related Problems**
  1. Moisture must be available
  2. There must be a route or path
  3. There must be a force to cause movement
  4. The material must be susceptible to damage

- **Theory:**
  - eliminate any one for complete control

- **Practice:**
  - control as many as possible
Moisture Balance

- Wetting
- Drying
- Safe Storage Capacity

Moisture Balance: Accumulation

- Wetting
- Safe Storage Capacity
- Drying

Moisture Balance

- Wetting
- Condensation • air convection • vapor diffusion
- Flood
- Built-in
- Rain • absorption • penetration
- Drainage • Air convection • Evaporation-Diffusion

Design Choices

- Either avoid wetting
- Or, provide enough drying to accommodate wetting
- Depending on the storage provided

The balance has shifted over time
- Amount of storage has changed over last 100 yrs
  - e.g. steel stud vs wood stud vs concrete block
  - 1: 10 : 100+
- Wetting is usually less
- Drying is often much less
Design Solutions

- **Balance** wetting, drying, and storage
- **Practical Rules**
  - Provide a *continuous* plane of *rain* control including each enclosure detail
  - Provide *continuous air barriers* and *insulation* to control condensation problems
  - Allow *drying* of built-in and accidental moisture – beware drying retarders

The Water Molecule

- Asymmetrical = *polar*
- Small: one billion = one foot

The Polar Molecule

- Hydrogen end is “more” positive
- Oxygen end is “more” negative

Surface Tension: Wettable

- Water attracted to *surface* more than
- Water attracted to *self* more than *surface*

*θ* < 90°

*θ* > 90°

- normal material: “wettable”
- hydrophobically treated: “non-wettable”
Capillary Pressures

- Result of surface tension = attraction to surfaces
  - pressure varies with pore size
  - e.g., height rise in a glass tube

Surface Tension

Water: Liquid vs Vapor

- Vapor is a single molecule
- Liquid is molecular clumps, 60 or more
- Tyvek vs asphalt
Vapor Pressure: water as a gas

Water vapor in Air

Water vapor in Air
Water vapor in Air

0 C 32 F
10 C 50 F
22 C 72 F 50%RH
35 C 95 F 25%RH

Dewpoint Temperature

0 C 32 F
10 C 22 C
50 F 100%RH
72 F 50%RH
95 F 25%RH

Cold weather condensation

0 C 32 F
1/2
10 C 22 C
50 F 100%RH
72 F 50%RH
95 F 25%RH

Control interior RH

0 C 32 F
10 C 21 C
10 F 50%RH
21 F 70%RH
95 F 12%RH

Powerful means of controlling condensation in cold climate buildings
Warm weather condensation

Dehumidification

Psych Chart: Air Vapour Content vs Temperature

Psych Chart: Air Vapour Content vs Temperature
**Indoor Conditions**
- 68 – 78°F (20-26°C)
- 25 to 60% RH
  (Could be 20 to 70%)

**Outdoor Conditions**
- Summer / Winter
  - January 10-30°F / -10°C & 80-100%
  - July 75-95°F / 24-35°C & 50-90%

**Indoor vs Outdoor Conditions**
- Inward drive bigger than outward
- Tighter control of T/RH increases drive
- Vapour Pressure Difference

**Water Vapour Transport**
- **Air Convection** (like heat convection)
  - more to less air pressure
  - flow through visible cracks and holes
  - vapour is just along for the ride
- **Vapour Diffusion** (like heat conduction)
  - more to less vapor
  - No air flow
  - Flow through tiny pores
Air leakage

- Much more vapor can be carried on back of air flow than diffusion
- Condensation only happens if air flows towards cold surface
Valid for Diffusion of Air Leakage (Convection)

The inside face of the insulating sheathing is the first condensing surface.

- Vinyl or aluminum siding
- R-10 rigid insulation
- R-19 cavity insulation in wood frame wall
- Gypsum board

Warm Sheathing Approach

$$T_{\text{back of sheathing}} = T_{\text{interior}} - (T_{\text{interior}} - T_{\text{exterior}}) \frac{R_{\text{batt}}}{R_{\text{total}}}$$
No exterior insulation

Keep it real dry . . .

R7.5 Exterior Insulation

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Conclusions

• Air can store much more water vapor as temperature increases
• Water vapor moves in two modes
  – Diffusion (vapor control)
  – Air Leakage (air control)
• Vapor control is less important
• Air control requires all holes sealed