IAQ & Moisture

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BEG
Building Engineering Group

Fungal Growth

- Spores and toxins cause immuno-depression, allergic response
- LBL estimates US health and productivity losses at $30 to 100 billion/yr
- "Sick Building Syndrome"

Rain Penetration

Outline of Presentation

- Indoor Air Quality
  - What is it
- Mould, Moisture, and Temperature
- Surface Humidity
- Interior Moisture Loads
- Air barriers, rain control, plumbing

Fungi & Buildings

- We often make buildings of dead plants
  - sustainable
  - inexpensive and plentiful
- Fungi and termites have evolved to eat dead plants
- Dust mites eat the dust we produce (skin remnants, etc)
- We have a conflict of interest

IAQ

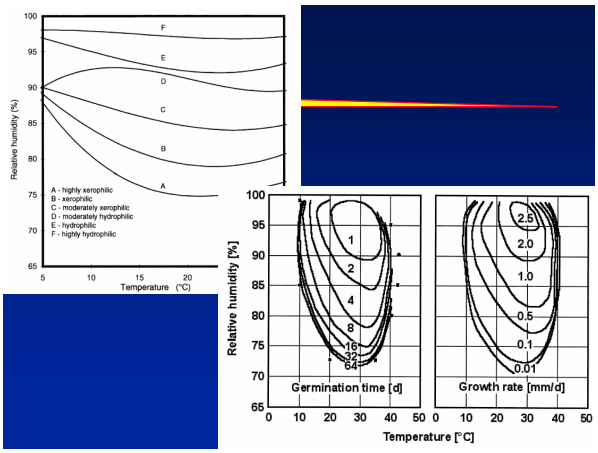
- Indoor Air Quality
- Particulates
  - Small particles of 1 to 10 microns
  - Smoke (candles) animal dander, dead mites and mold spores
- Airborne toxins
  - Mycotoxins
  - Volatile organic compounds
- Airborne bacteria and viruses
  - Require high humidity for long life

Fungi

- 1.5 million types -- only 400 cause disease
- fungi = mould + yeasts
- No photosynthesis
- Why avoid mould?
  1. staining
  2. illness - spores, mycotoxins, VOCs
  3. decay

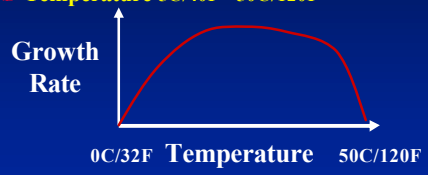
Mold

- Mold growth requires all of:
  1. Spores,
  2. temperature,
  3. nutrients,
  4. moisture
- Can't avoid 1, hard to avoid 2 or 3.
- Therefore, control moisture!
- Use radiation, alkalinity, biocides



Mold Growth On Surfaces

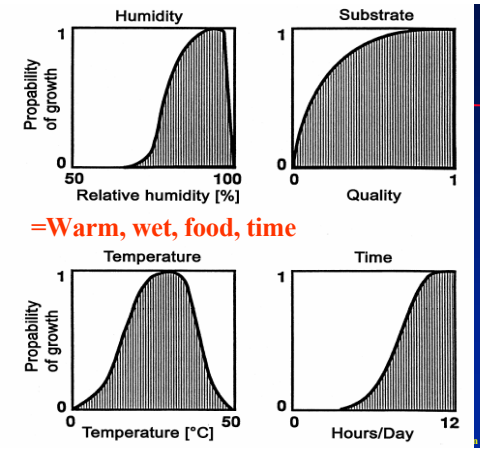
- *Surface* Humidity > 80%RH
- Temperature 5C/40F - 50C/120F



- Food Source (cellulose, soap, wood, oil)
- pH - usually less than 8 - 10

Dust mites

- Grow in carpets, bedding, stored clothing
  - Thrive in high humidity, generally over 60%RH
- Create allergenic response and particulates
- Eat dead skin and other organics



Other effects

- Airborne bacteria and viruses survive longer in high humidity
  - Cadillac fever, humidifier fever
  - Legionnaires disease
- Low RH / moisture content can stress respiratory tract (infection)
  - Requires very low RH
- Some off gasing increases with higher humidity

Moisture

- Where does all the moisture come from?
  - Water vapor (indoors and out)
    - condensation
  - Rain penetration
    - Windows
    - Roofs
    - basements
  - Plumbing leaks
    - Washing machines, water connections
  - HVAC
    - Condensation in pans, humidifiers

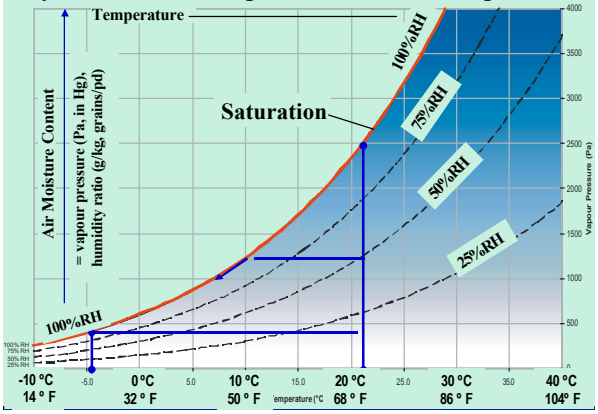
Surface Condensation

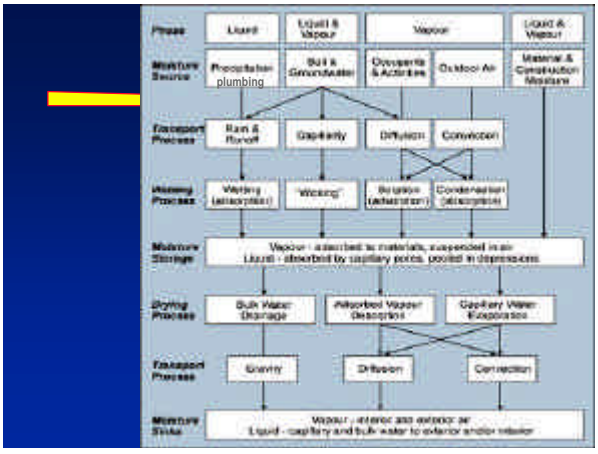
High interior humidity and low surface temps = high humidity

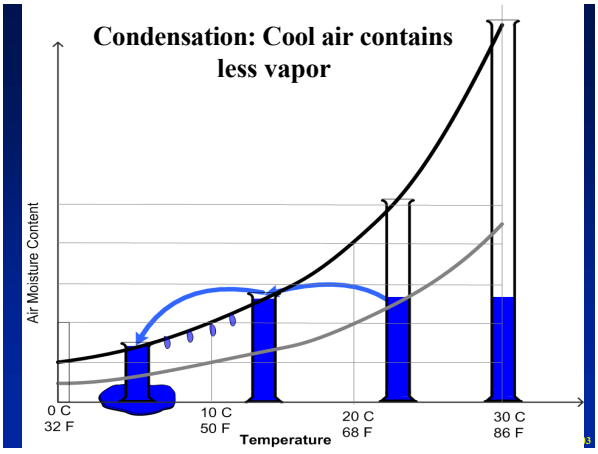
Wetting - Sources & Mechanisms

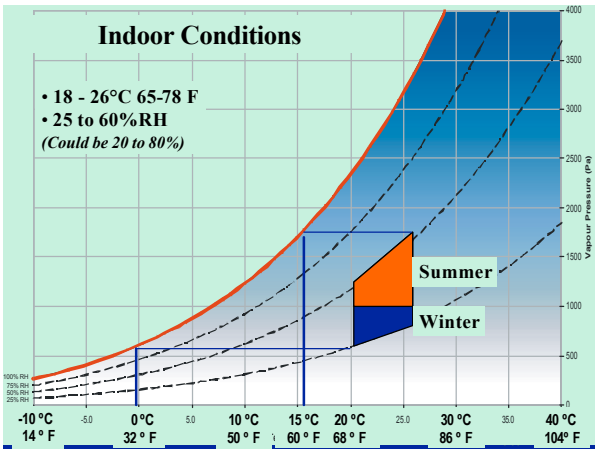
1. **Interior *and* Exterior Air (Vapour)**
   - by diffusion and air leakage *(convection)*
2. **Driving Rain (Liquid)**
   - by absorption ("wicking") and rain penetration
3. **Soil Moisture (vapour & liquid)**
   - by diffusion, absorption and liquid penetration
4. **Built-in Moisture (solid, liquid, vapour)**
   - not transported - *stored* in masonry/concrete, green lumber, cellulose insul, construction rain/snow

Psych Chart: Air Vapour Content vs Temperature

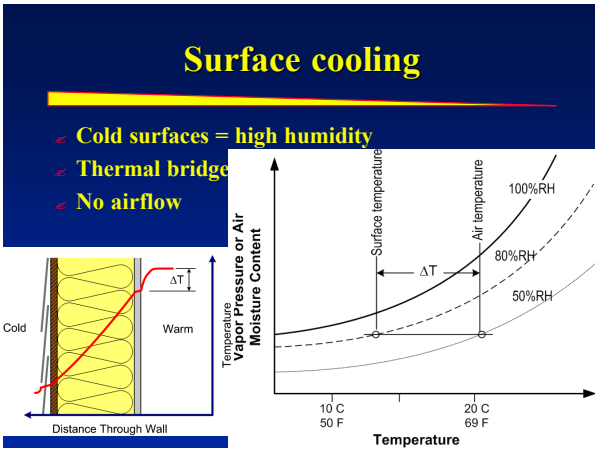




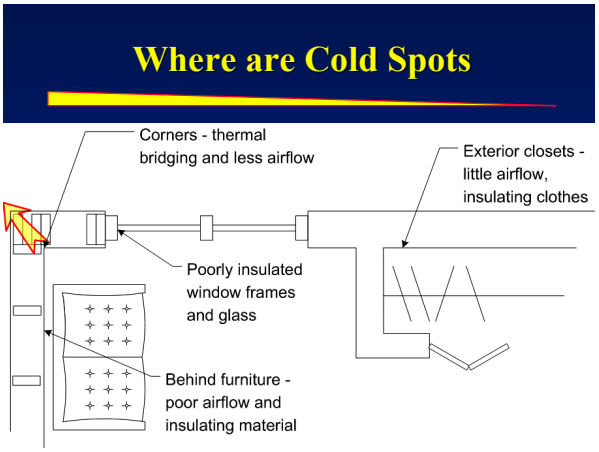


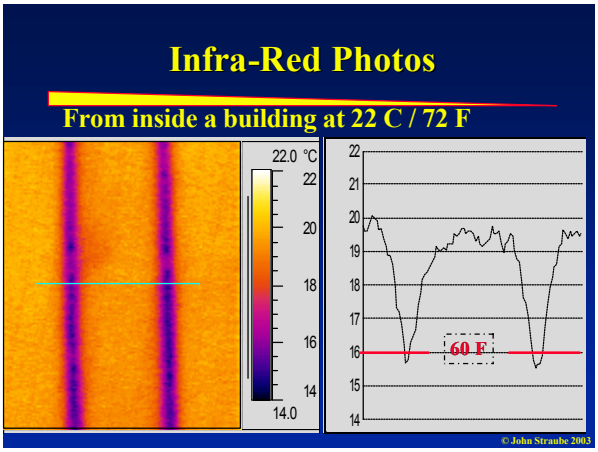

Indoor Conditions
• 18 - 26°C 65-78 F
• 25 to 60%RH
(Could be 20 to 80%)
Summer
Winter
Vapour Pressure (Pa)
-10 °C 14 ° F
0 °C 32 ° F
10 °C 50 ° F
15 °C 60 ° F
20 °C 68 ° F
30 °C 86 ° F
40 °C 104° F

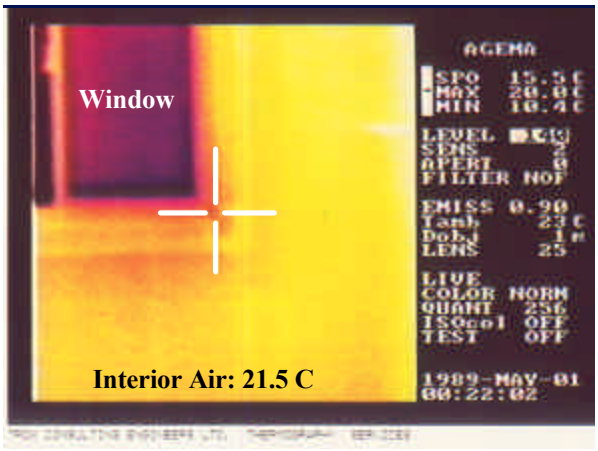

Find the thermal bridge


Surface cooling
Cold surfaces = high humidity
Thermal bridge
No airflow
Cold
Warm
ΔT
Distance Through Wall
Temperature
Vapor Pressure or Air Moisture Content
Surface temperature
Air temperature
100%RH
80%RH
50%RH
ΔT
10 C 50 F
20 C 69 F
Temperature

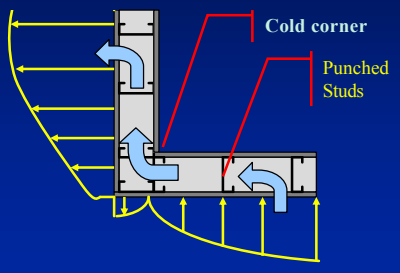

Find the thermal bridge


Where are Cold Spots
Corners - thermal bridging and less airflow
Exterior closets - little airflow, insulating clothes
Poorly insulated window frames and glass
Behind furniture - poor airflow and insulating material


Infra-Red Photos
From inside a building at 22 C / 72 F
22.0 °C
14.0
60 F
© John Straube 2003



Lateral Airflows



Interior Air at 22 C / 71.5F

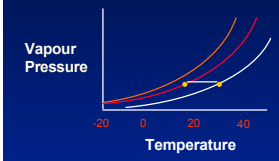
Surface temperatures cannot be less than:

Interior RH	Condensation Temperature	Temperature @80%RH
20	-2 / 29	1 / 33
40	8 / 46	11 / 52
50	11 / 52	14 / 57
60	14 / 57	17 / 63
80	18 / 64	22 / 72

Interior Moisture Loads

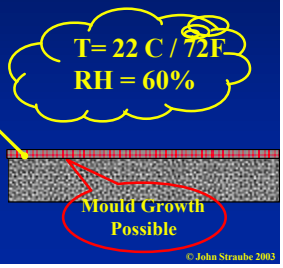
Why interior high humidity

Slab on Grade: Surface Humidity



T= 17C / 63 F, RH=80%
T=14 C / 57, RH=100%

Carpet on slabs is a bad idea everywhere

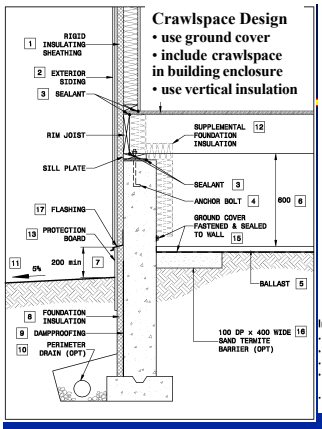


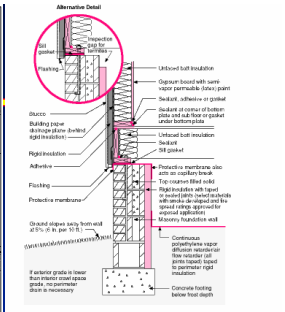
Internal Moisture Loads

- Mould grows well inside because it is always warm and no sun
- Interior mould is closer to occupants
- Hence, beware interior surfaces and hidden but connected spaces
- Keep interior spaces dry!

Major Sources of Interior Moisture

- Occupant Activity
  - Total for Family of 4:
    5 to 20 kg/day (11 to 44 pds per day)
- Wet basements and crawlspaces
  - Major source of liquid and vapor
- Leaky plumbing
  - Water source
  - Blown hoses





Internally Insulated Masonry Crawl Space — Stucco

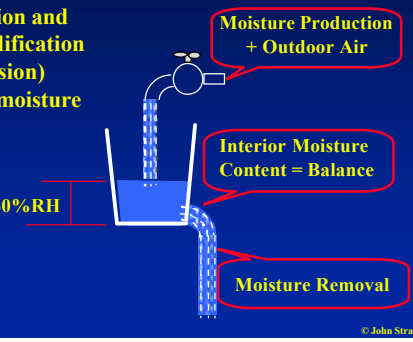
- Masonry wall cold, can dry to exterior; low likelihood of mold
- Protective membrane acts as termite barrier
- Rigid insulation must be fire-rated if it is left exposed on the interior
- Building paper installed shingle fashion acts as drainage plane located behind rigid insulation
- Cold concrete wall must be protected from interior moisture-laden air in winter and in summer

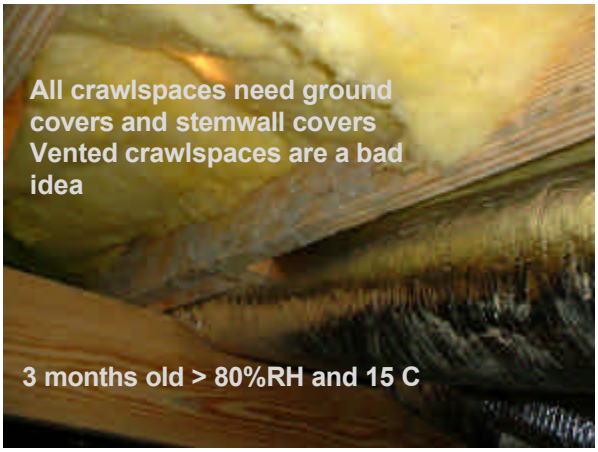
Lstiburek
Builders Guide

Basements & Crawlspaces

Interior Air Moisture

- Ventilation and dehumidification (& diffusion) remove moisture

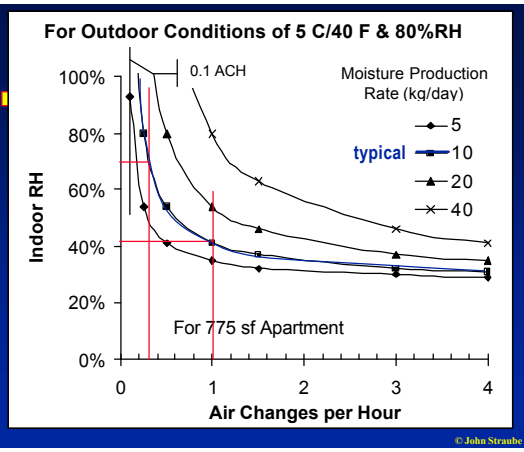




Sources of Moisture Within Buildings

Source	Strength kg per day
People - evaporation per person	0.75 (sedate) to 5 (heavy work)
Humidifier	2-20+
Hot tub, Whirlpool	2-20+
Firewood, per cord	1-3
Washing floors, counters, etc.	0.2
Dishwashing	0.5*
Cooking for four	0.9 to 2 (3 with gas range)*
Defrosting (frost free) Fridge	0.5*
Typical bathing/washing per person	0.2 to 0.4*
Shower (ea)	0.5
Bath (ea)	0.1+
Uncovered Crawlspace	0.5 / m^2
Unvented Gas Appliance (ea)	1
Seasonal Desorption	3-8 depends on the type of construction
Plants/Pets	0.2 - 0.5 (five small plants or one dog)
Total (Typical Family of 4)	**About 10 , but potential ranges 3 to 40**

Total family of four:
3 - 21
7 – 90
pds/day



Interior Humidity

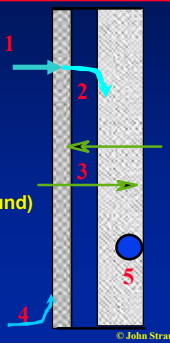
- In hot-humid weather
  - Need proper AC design
  - Cold deep coils
  - Good double sloped drain pans
- May need to add dehumidifier in some climes

Interior Humidity

- Fewer air changes = higher interior humidity
- More moisture production = higher interior humidity
- More airtight construction = interior RH is more sensitive to moisture production rate
- Solution: Controlled Ventilation

Within Wall/Roof Wetting

1. Rain Absorption
2. Rain Penetration
3. Water Vapour
   i) Diffusion
   ii) Convection
4. Splash/ Wicking (from ground)
5. Plumbing Leaks



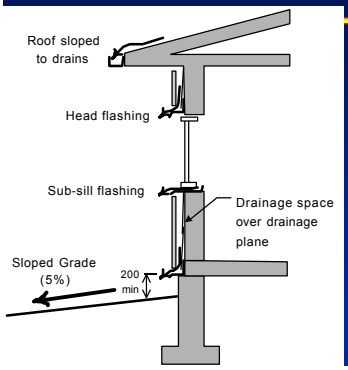
Interior Humidity

- Interior humidity arehigher in summer and spring/fall than winter
- But ... interior surface temperatures lowest in winter
- Insufficient ventilation *will* encourage mould growth in many cases

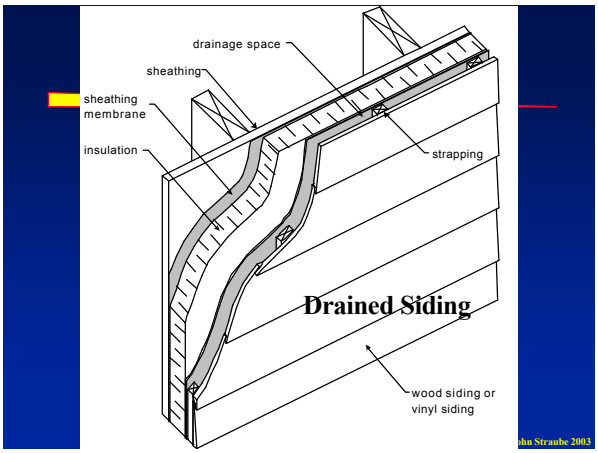
Rain Control

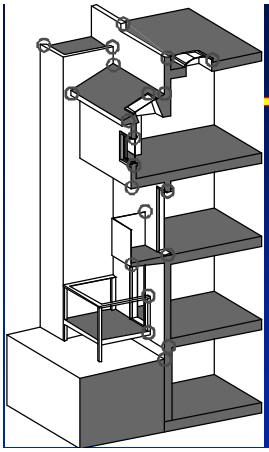
- Often largest source of moisture
- A large topic in its own right
- Maintenance and repair important
- Use overhangs, drips, etc.
- Usually causes mould inside enclosure
- Solar driven vapour can cause *interior* wetting

Drainage



Drain site
Drain walls
Drain windows
Flash
Flash
Flash
Repeat

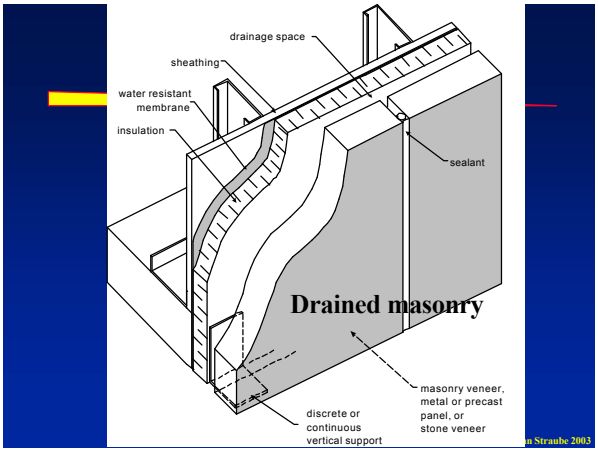




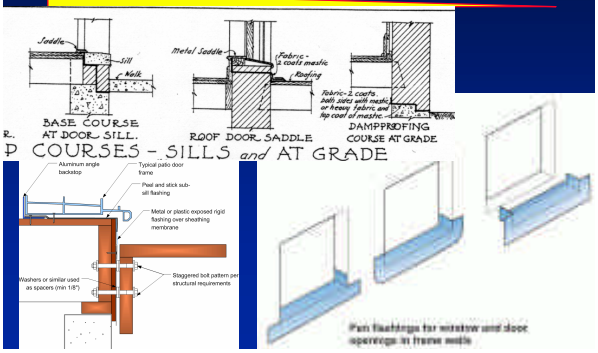
Drained Joint details needed where problems occur

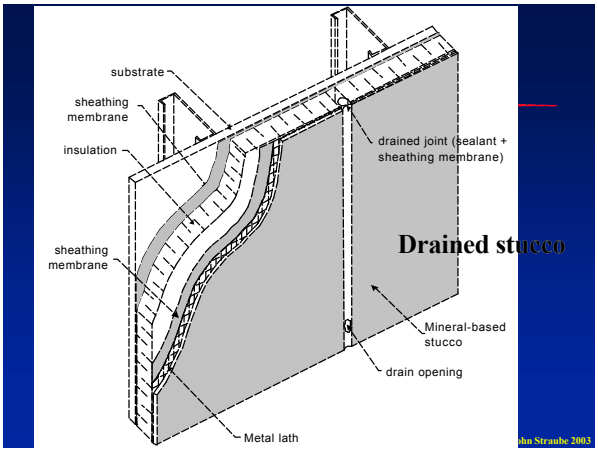
- Windows / Doors
- Balconies
- Wall to roof
- Penetrations

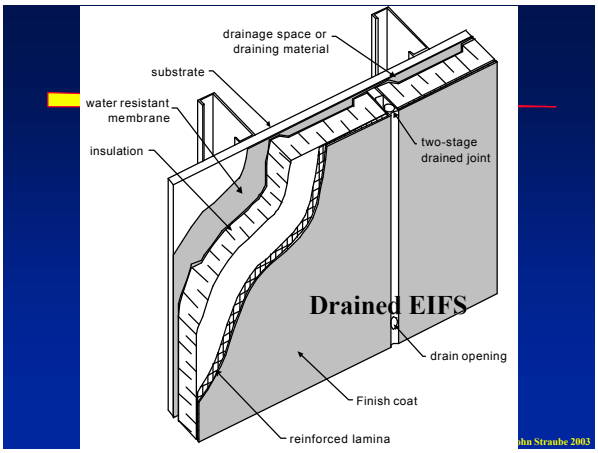
Really flash

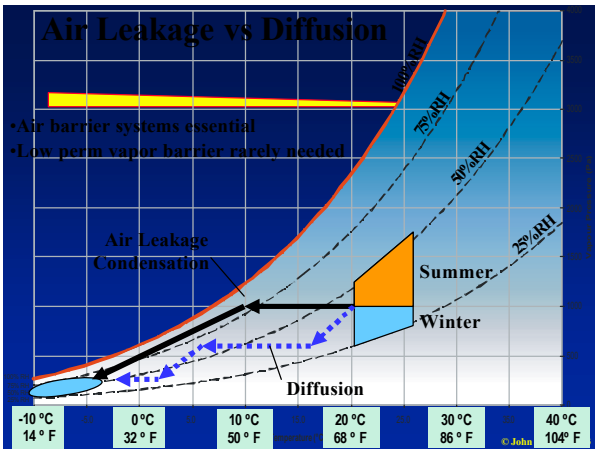


Drained Windows and Doors



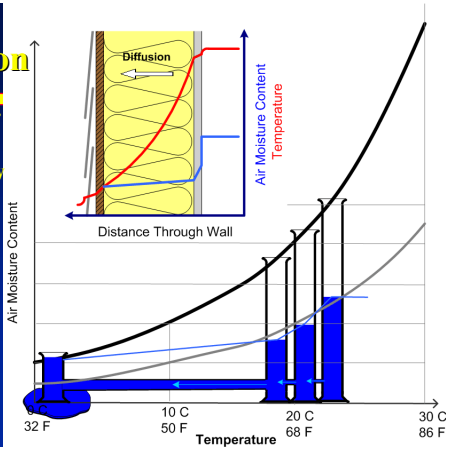




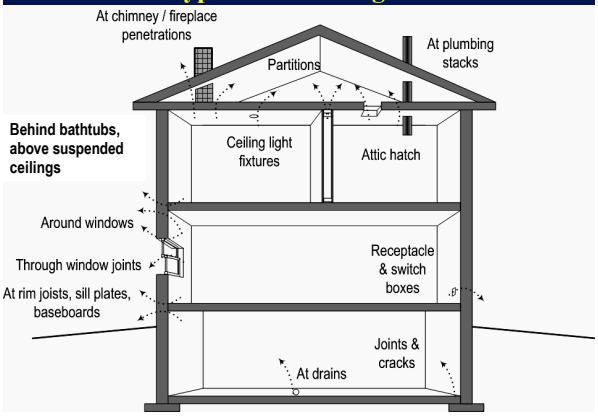


Diffusion

- Each layer reduces vapor flow

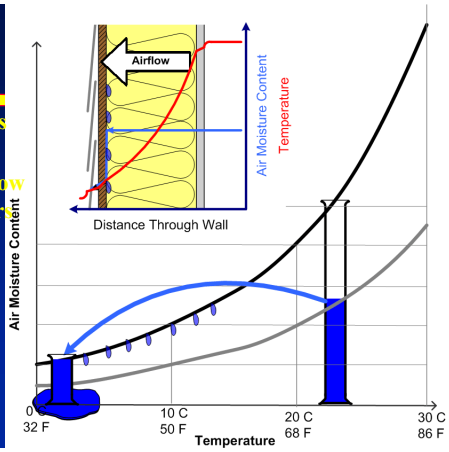


Typical Air Leakage Points



Airflow

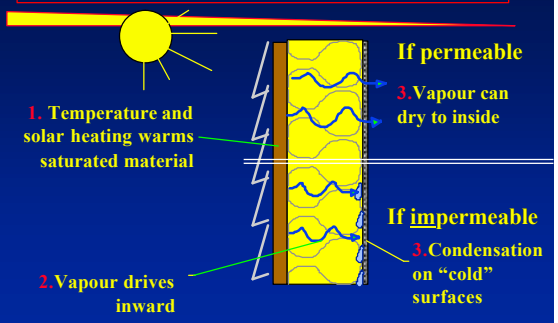
- Vapor flows with air
- Constant flow across layer



Air Barrier Systems

- Air barrier systems (ABS) control air flow
  - ABS prevent air leakage condensation
- Not the same function as vapor barriers
  - vapor barriers rarely important
- Interior air barriers protect occupants from mould growth within the enclosure
- A good ABS requires careful detailing
- "Build Tight, Ventilate Right"

Inward Diffusion Drying



Solutions

- Materials are not a simple answer
- *But*, paper-faced gypsum and ceiling tiles can not be allowed to get wet!
- Painted concrete block, plaster, exposed ceilings are *definitely* more moisture tolerant

Solutions

- *Control humidity*: ventilation /dehumidification
  - Keep RH under 60% all the time in hot
  - Keep RH under 40% in winter (25% in cold)
- Provide *timely* maintenance and repair
  - all leaks and disaster
- Accept that plumbing leaks can happen and design to tolerate
  - Disaster pans, accessible plumbing

Vinyl wallpaper in hot-humid

Conclusions

- Mould Control = Moisture Control
- Moisture Control includes
  - interior humidity
  - rain penetration
  - plumbing leaks
  - maintenance activities
- Choose materials for expected conditions
- Controlled ventilation and drying is important