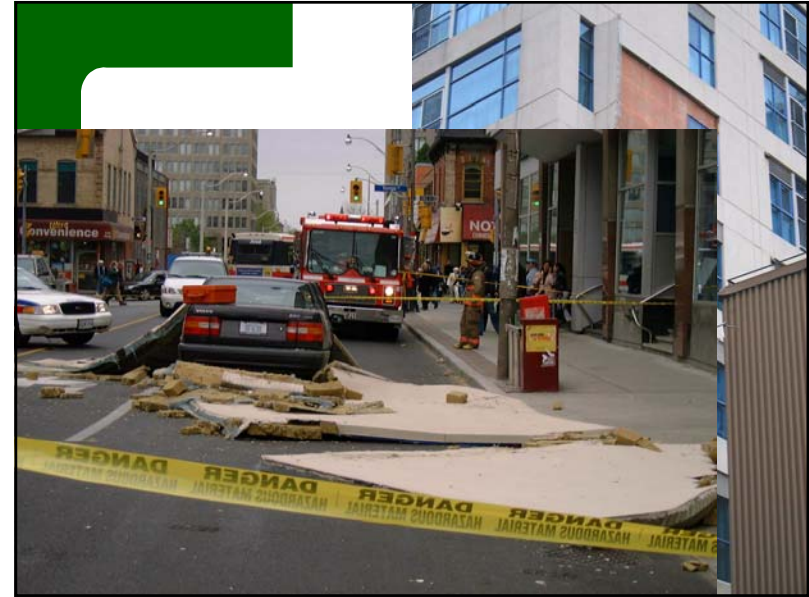


# Building Enclosure Design: EIFS

Dr John F. Straube  
Dupont Young Professor  
School of Architecture &  
Dept of Civil Engineering  
University of Waterloo  
Ontario, Canada



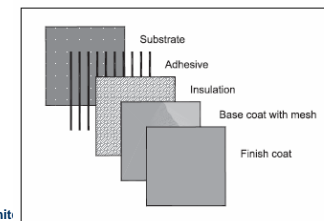
## Presentation Overview

- EIFS
- Building Functions
- Building Enclosures
- Rain Control Principles
- EIFS Applications



## EIFS

- Exterior Insulation and Finish System
- Not really a “cladding”
- This presentation will approach EIFS as a system
- Most principles are the same, only details vary



## EIFS History

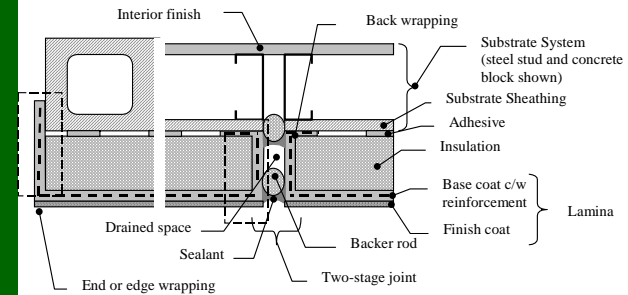
- 1930's Sweden
  - Lime stucco over rock wool
- Post WWII
  - Foam plastic and latex coatings over masonry
- 1970's
  - Dryvit enters American market
- Late 80's to early 90's
  - Explosive growth
- Mid to late 90's
  - leaks
- Today
  - Moisture managed rational approach?

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## EIFS Terminology

### • Special terms used



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## EIFS Terminology: Key points

- Lamina is the thin coating
- Made of
  - reinforced base coat (1.6 mm)
  - Finish coat (1.6 mm)
- Edges must be backwrapped

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## EIFS Benefits

- Continuous exterior insulation
  - Better thermal control
  - Better condensation control
- Lightweight
- Easy to recoat
- Many colours and textures
- Excellent retrofit solution

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## EIFS Limits

- **Combustibility**
- **Impact Resistance**
- **Rain Control?**
- **Durability over long term**
  - Hard to reseal

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## References

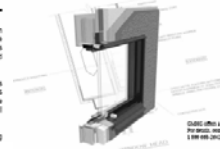
### Exterior Wall Design OAA Rain Penetration Control Practice Guide

**Summary**  
Several members of the OAA Council approved in principle a "Wall Design Exclusion" in order to prevent the indemnity Plan from the alarming number of claims related to some exterior wall systems. At the same time, Council saw the need to support its members by providing appropriate information, in the form of a comprehensive resource, which would assist architects and their practices to understand the underlying principles of rain penetration in walls. This resource is a valuable tool that will help members develop wall systems and details that conform to good practice techniques, resulting in the design and delivery of appropriate exterior wall assemblies. By so doing, many potential claims can be avoided. The resulting resource is called the OAA Rain Penetration Control Practice Guide. It accompanies and forms part of this Practice Bulletin.

#### BACKGROUND

1. This is the first in a planned series of Practice Bulletins on this issue. It is also the first Practice Bulletin in the "Technical" category. The OAA will continue to develop the OAA Rain Penetration Control Practice Guide and other information to assist architectural practices to deliver appropriate wall systems. This Bulletin and the Guide will be posted on the OAA web site, as are all Practice Bulletins. As the Guide is updated, the latest information will be posted. Please check the site at [www.oaa.on.ca](http://www.oaa.on.ca) periodically for the most current information.
2. The OAA Rain Penetration Control Practice Guide
3. building situations. It provides the basis for the design of many wall systems that are referred to in the indemnity Plan "Wall Design Exclusion", as otherwise provided in the Practice Bulletins issued by the Ontario Association of Architects.
4. The indemnity Plan "Wall Design Exclusion" affects all designs commenced on or after July 1, 2002. It is therefore important that all practices understand the issues and are able to deliver appropriate exterior wall systems.
5. Dr. John Straube, affiliated with the Civil Engineering

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## Buildings

- **Buildings are a major part of a countries infrastructure**
  - physical
  - economic
  - social
- **Buildings also part of the broader environment**
- **A "durable good"**
  - Running shoe (1 yr), car (10 yr), bldg (100yr?)
  - Requires more careful design

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## Building Function

- **"Durability, Convenience, and Beauty"**
  - Vitruvius 70BC
- **"Firmness, Commodity, and Delight"**
  - Sir Wotton 1684
- **"To Provide Desired Environment for Human Use and Occupancy"**
  - Straube 2002

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## Buildings

- “Provide space for human use & occupancy”
- Usually control the interior environment
  - 1. By passive means e.g. caves (the enclosure)
  - 2. By active means e.g., fire (services, HVAC)

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## Services

- Produce
  - Heat
  - cold
  - light
- Distribute
  - Energy
  - Fresh clean air
  - communications
  - people
- Become very important, e.g. NOT just Shelter

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## Building Enclosure

- Separates interior and exterior environment
- Passive environmental control
- Critical building component (*Seen from street, Vital Function, Physical Durability a problem*)
- Basic **Building Enclosure** Functions
  - Support
  - Control
  - Finish
  - Distribute services (sometimes)

Hierarchy  
of  
need

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## Building Enclosures

- **Definition (Part 5 of NBCC)**
  - Building element that separates indoors and outdoors: "Environmental Separator"
- Includes all of the parts that make up the wall, window, roof, floor, etc... from the innermost to the outermost layer.

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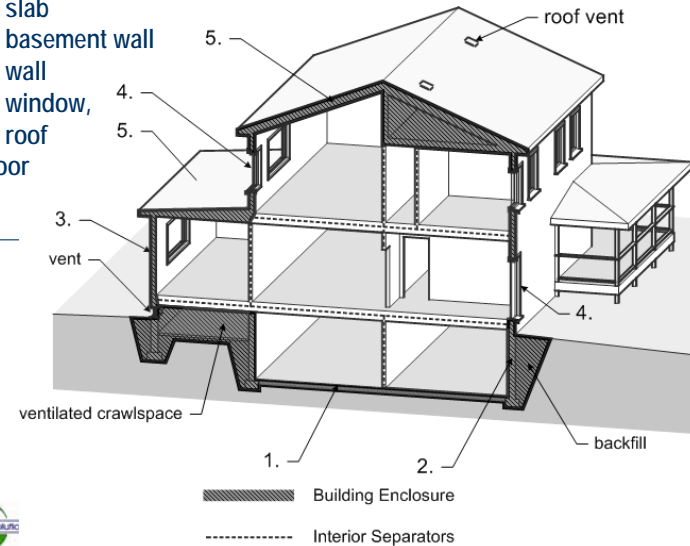
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## Components

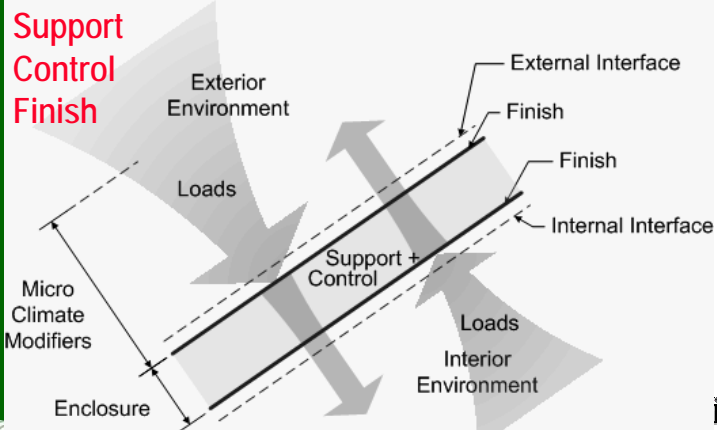
1. slab
2. basement wall
3. wall
4. window, door
5. roof



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## Building Enclosure Functions



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## Building Enclosure Functions

- **Basic Functions**
  - **Support**
    - Lateral (Wind Earthquake)
    - Gravity (dead, snow)
  - **Control**
    - Rheological (temp, moisture)
  - **Finish**
    - Impact
  - **Distribute (sometimes)**
    - Wear / Abrasion

**Support - resist and transfer physical forces from inside and out**

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## Building Enclosure Functions

- Basic Functions

- Support
- **Control**
- Finish
- Distribute (sometimes)

Heat  
Air  
Vapour  
Rain  
Sound  
Fire  
Insects  
Access

### Control - Mass and Energy Flows

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## Building Enclosure Functions

- Basic Functions

- Support
- Control
- **Finish**
- Distribute (sometimes)

Colour  
Texture  
Reflectance  
Pattern  
Speculance

### Finish - interior and exterior surfaces for people

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## Building Enclosure Functions

- Basic Functions

- Support
- Control
- Finish
- **Distribute (sometimes)**

Electricity  
Communications  
Plumbing  
Air ducts  
Gas lines  
Roof drains

### Distribute Services - a building function imposed on the enclosure

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## “Virtual” Enclosures

- Space can be formed by more than walls
- Climate can be modified by more than walls
- Multiple levels of control
  - climate
  - site
  - micro-climate
  - enclosure



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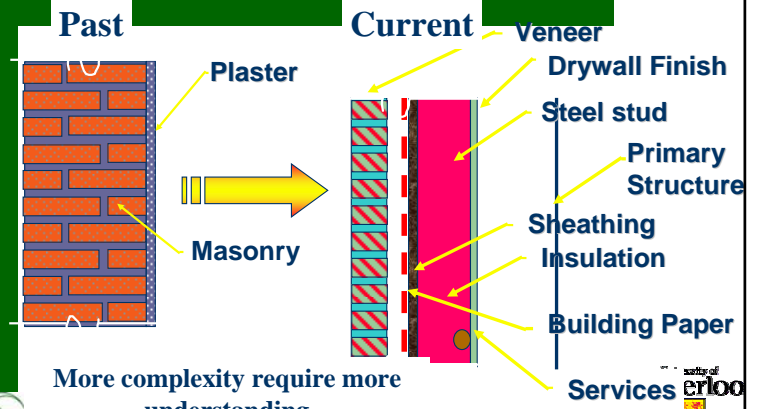




Old Buildings  
= solid buildings



## Enclosures are Different Today



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## Enclosure Design Principles-1

- Design a complete load transfer path
  - structure, windows, ties, etc
  - All loads go to ground
- Respect the site and climate
  - rain, sun, wind, hill, valley, high rise or low-rise
- Continuous rain control plane
  - control with surface features and detailing
  - Drained, storage, or perfect barrier strategy
- Continuous plane of air barrier tightness
  - fastidious attention to detail 3-D

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## Enclosure Design Principles-2

- Provide a continuous plane of insulation
  - ideally separate structure from enclosure
  - Avoid thermal bridges
- Provide a moisture tolerant design
  - balance wetting, drying, and storage (matl's, climate)
- Use appropriate levels of vapour control
  - vapour barriers are not "the" answer
- Accommodate movements and tolerances

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## The Enclosure: Adding the Layers



- Structure
- Air Barrier
- Insulation
- Rain Control
- Finish

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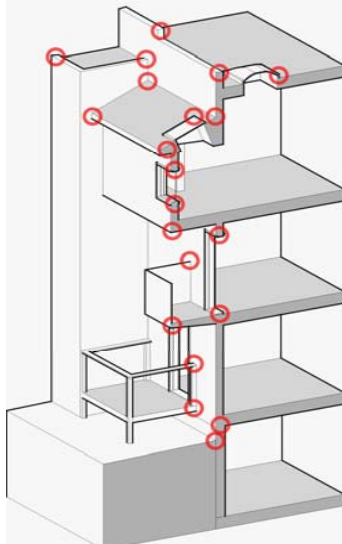
## Details

- **Layers are easy**
  - Still they are often not done
- **EIFS keep this simple**
  - Insulation, finish are separate
  - Air and water barrier can be
- **Connections, interfaces, penetrations**
  - challenging

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"House of Horrors"



**Details demand the same approach as the enclosure.**

**Scaled drawings required at** ○

## Building Enclosure Performance

- **Problems**
  - many relate to moisture!
  - Cracking, heat loss etc are also important
- **Common "Causes" - Design error**
- **Moisture Sources**
  - rain penetration
  - air leakage
- **Solutions**
  - case specific
  - **But ... fundamentals are general**

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## Moisture and Buildings

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

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## 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
- Practise: control *as many as possible*

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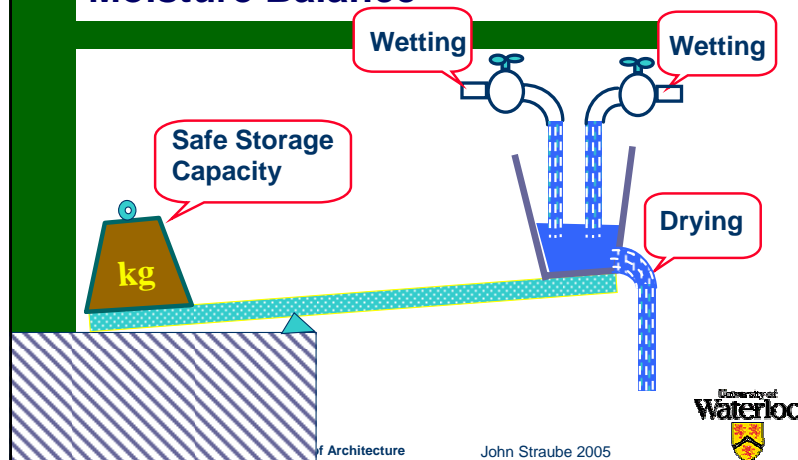


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## Moisture Balance

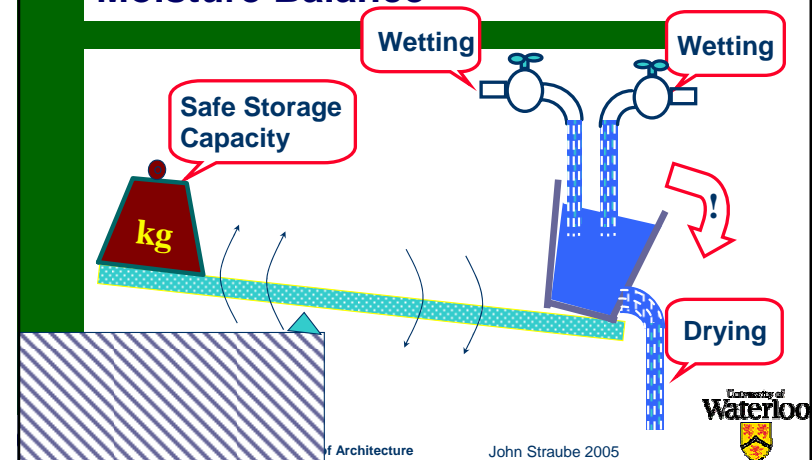


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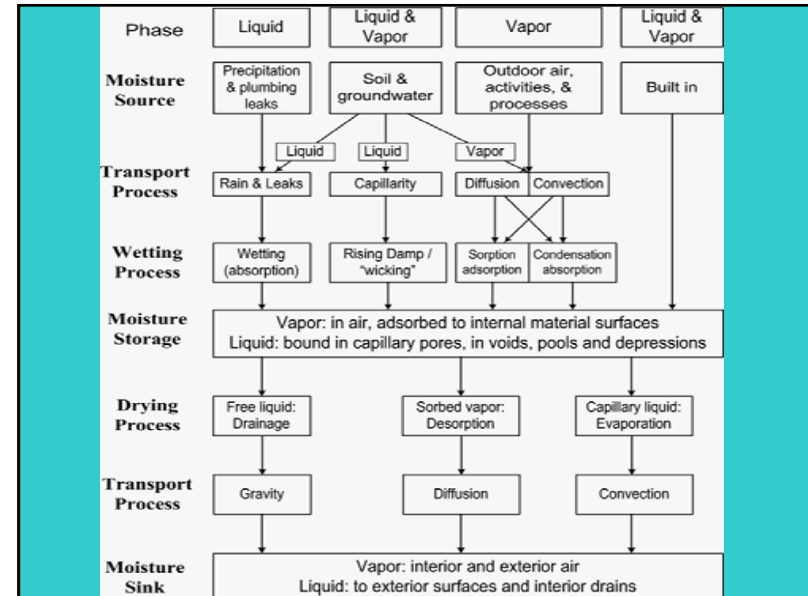
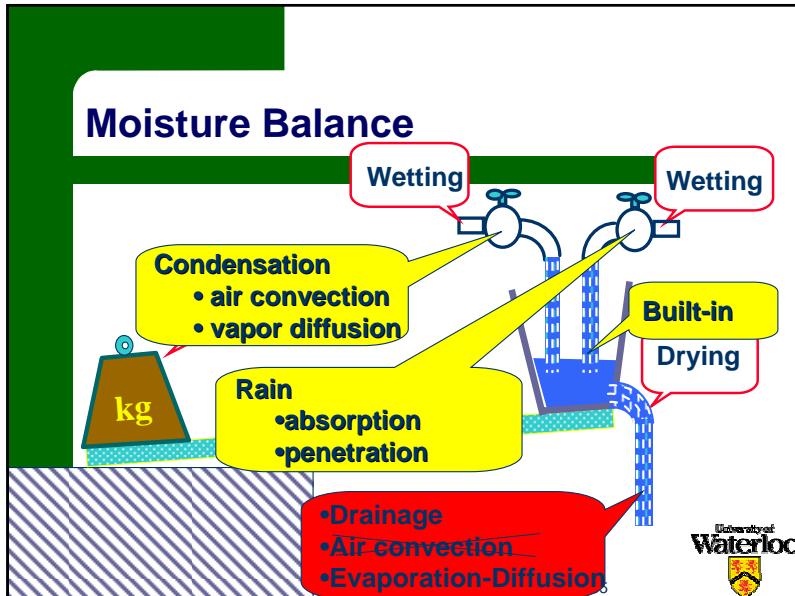
## Moisture Balance



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## Design Choices

- Avoid wetting
- Provide enough drying to accommodate wetting
- Provide enough storage
- The balance has shifted over time

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## 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 water vapor condensation problems
  - Allow drying of built-in and accidental moisture – beware drying retarders

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## Wetting - Sources & Mechanisms

1. Interior and Exterior Air (Vapour)
  - transport by **diffusion** and **air leakage (convection)**
2. Driving Rain (Liquid)
  - Absorption (“wicking”) and Liquid Penetration
3. Soil Moisture (Vapour & Liquid)
  - Diffusion, Absorption and Liquid Penetration
4. Built-in Moisture (solid, liquid, vapour)
  - not transported - stored in masonry/concrete, green lumber, construction rain/snow

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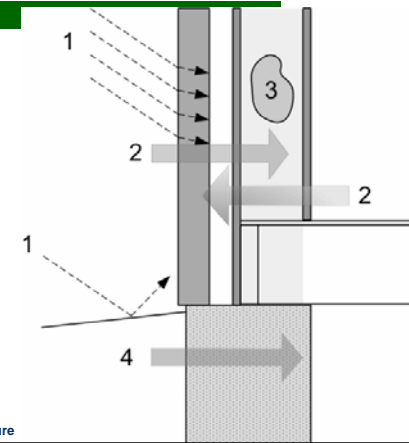
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## Wall Wetting Mechanisms

1. Rain
  - absorption
  - penetration
  - splash and drips
2. Water Vapour
  - Diffusion
  - Convection (air leaks)
3. Built-in
  - vapor, liquid
4. Ground
  - capillary, diffusion



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## Wetting means we need drying

- We are not perfect.
- Our buildings are not perfect.
- Therefore, our buildings get wet
- So provide drying



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## Drying - Where to and How

### To Exterior (liquid)

- drainage *free liquid water only*
- stops leaving materials saturated

### To Exterior or Interior Air (vapour)

- first, evaporation then:
  - air leakage (convection)
    - ventilation (e.g. for vapour resistant cladding)
  - diffusion
    - vapour barriers slow drying

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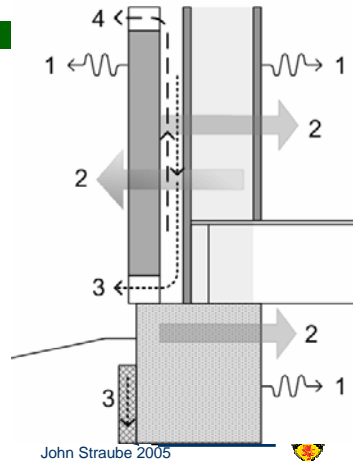
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## Wall Drying Mechanisms

1. Surface Evaporation
2. i) Diffusion  
ii) Convection
3. Drainage
4. Ventilation



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## Storage

- Bridges gap in time between wetting and drying
- **How much moisture** for **how long** before damage
- **Safe** storage
  - mold, rot, freeze-thaw, corrosion
- **Amount** of storage
  - e.g. steel stud, vs wood stud vs concrete block
  - 1: 10 : 100+
- **Basic mechanisms**
  - capillary pores (*bound liquid*)
  - sorption (*vapour*)
  - pools and puddles (*free liquid*)

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## Safe Storage Capacity

- Different materials react differently
- Primary environmental variables
  - temperature, time of wetness, RH (=MC)
- **Approximate Thresholds**
- Mould, fungi, corrosion, etc.:
  - Over 80%RH, > 5 C “for some time”
  - Generally need liquid (100%) and warm (>15 C)
- Freeze-thaw, dissolution:
  - from 100%RH to saturated

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## Material Performance

- How to predict performance?
- We test materials or layers and are interested in enclosure system?
- Must know loads, microclimate=exposure
- **“No Bad Material,  
Just Materials Used Badly”**

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## Enclosure Design for Durability

- Balance wetting, drying and storage potentials
- Durability:
  - choice of materials and
  - their arrangement for
  - the microclimates expected

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## Material Performance Thresholds

- Corrosion
- Mould
- Decay
- Freeze-thaw
- Dissolution/Dissociation
- Shrinkage/Swelling
- **All are temperature and moisture**

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## Performance of What?

- Materials - asphalt, paper
- Layers - building paper
- Sub-assembly - lapped, between airspace/sheathing
- Assembly - drained stucco over steel stud
- Enclosure - wall, joints, window
- Building - 12 storey apartment bldg
- Site - seashore or sheltered
- Climate - Miami or Minneapolis

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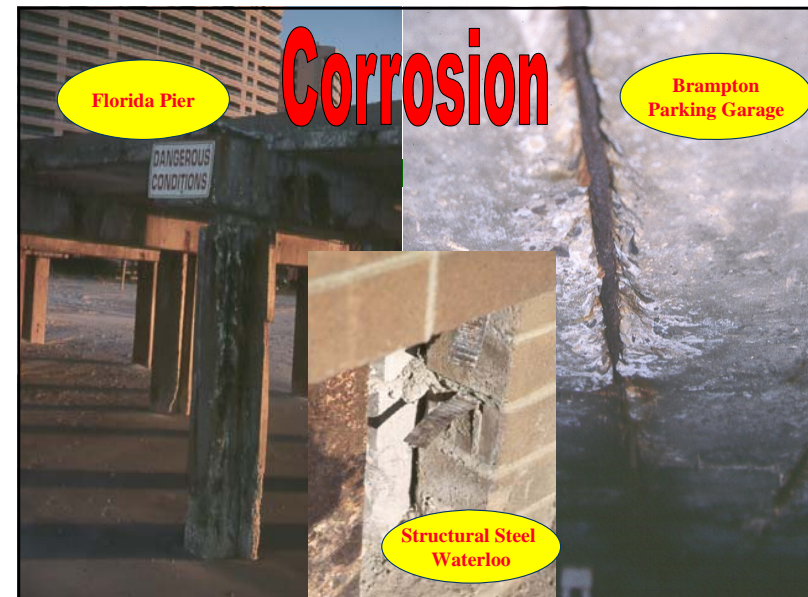
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## Steel Corrosion

- Electrochemical Process - oxygen + electrolyte
- Can begin if RH>80%, mostly RH>95%
- Coatings protect
- Zinc galvanizing is sacrificial
- Factors
  - Temperature (Arrhenius Law)
  - Time of Wetness (TOW)
  - pH of environment
  - Salinity

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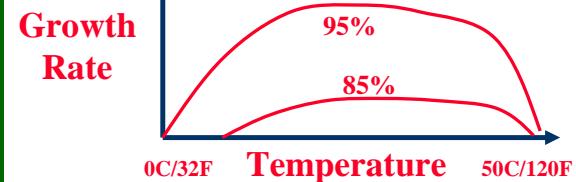
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## Mould Growth On Surfaces

- **Surface** Humidity > 80%RH, 95-100%
- Temperature 5 - 50 C (40-120F)



- Food Source (cellulose, soap, wood, oil)
- pH - usually less than 4 - 8

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