Building Enclosure Design: EIFS

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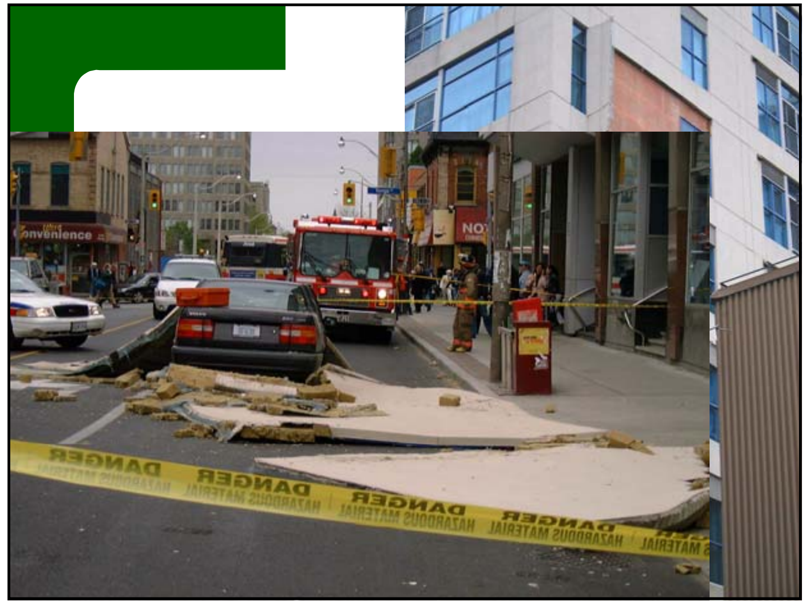


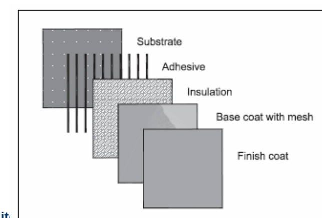
Presentation Overview

- 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

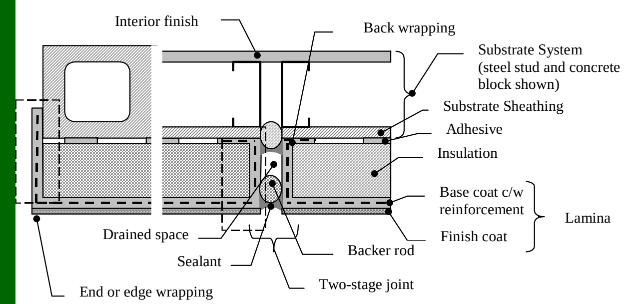


EIFS History

- 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?

EIFS Terminology

- Special terms used



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

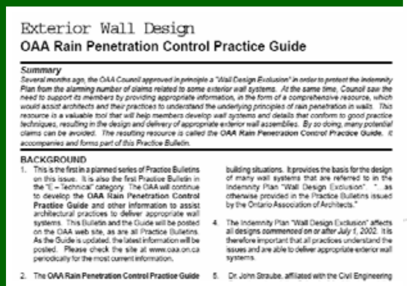
EIFS Benefits

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

EIFS Limits

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

References



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

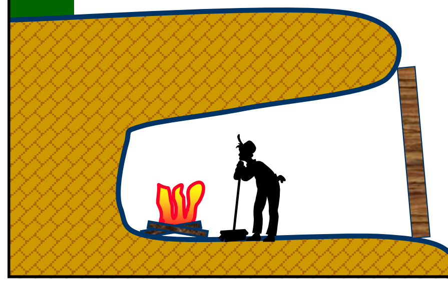
Building Function

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

“Primitive Hut”

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)

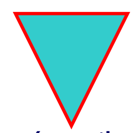


Services

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

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)



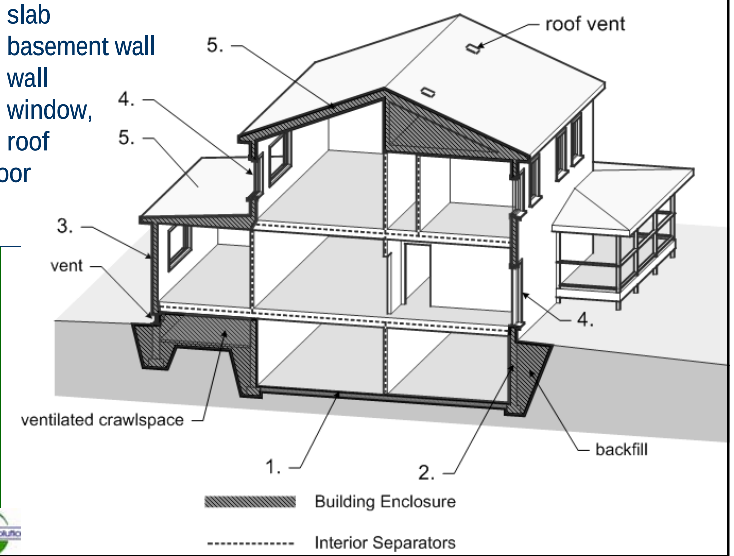
Hierarchy of need

Building Enclosures

- **Definition (Part 5 of NBCC)**
  - **Building element that separates indoors and outdoors: "Environmental Separator"**

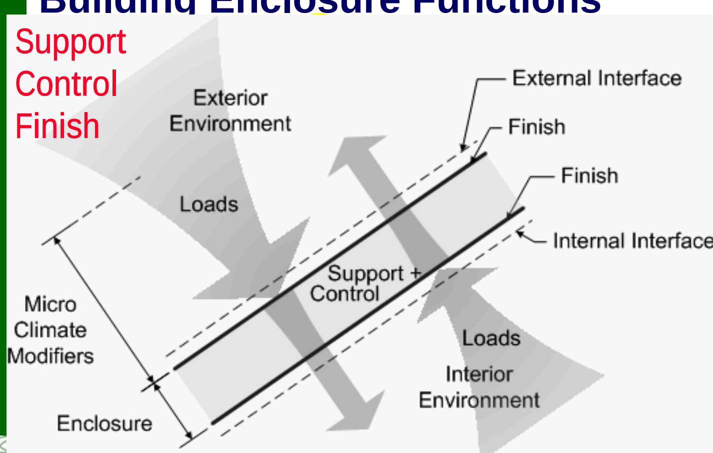
- **Includes all of the parts that make up the wall, window, roof, floor, etc… from the innermost to the outermost layer.**

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



Building Enclosure Functions

Support
Control
Finish



Building Enclosure Functions

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

Lateral (Wind Earthquake)
Gravity (dead, snow)
Rheological (temp, moisture)
Impact
Wear / Abrasion

Support - resist and transfer physical forces from inside and out

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Control: Heat, Air, Vapour, Rain, Sound, Fire, Insects, Access

Control - Mass and Energy Flows

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Finish: Colour, Texture, Reflectance, Pattern, Speculance

Finish - interior and exterior surfaces for people

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

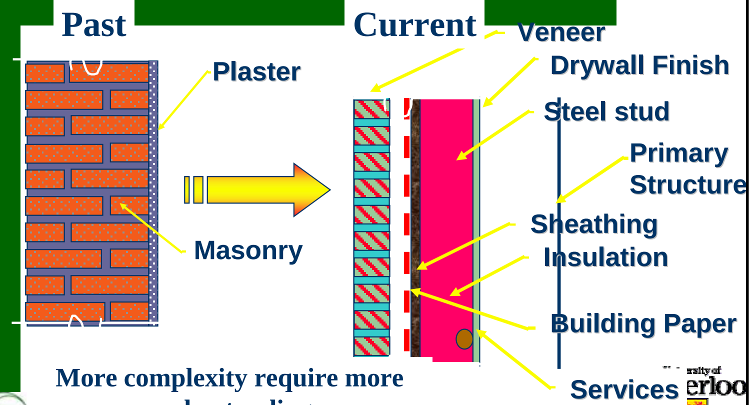
Distribute: Electricity, Communications, Plumbing, Air ducts, Gas lines, Roof drains

Distribute Services - a building function imposed on the enclosure

“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

Enclosures are Different Today



More complexity require more understanding

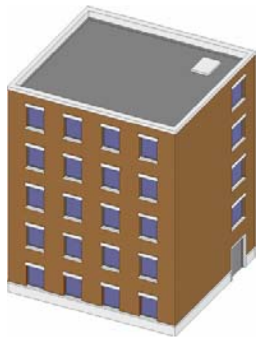
Enclosure Design Principles-1

- 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

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

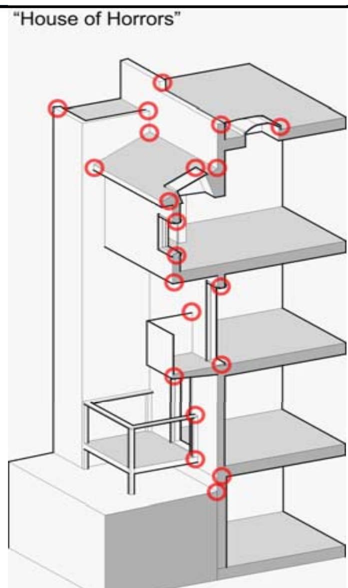
The Enclosure: Adding the Layers



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

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



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

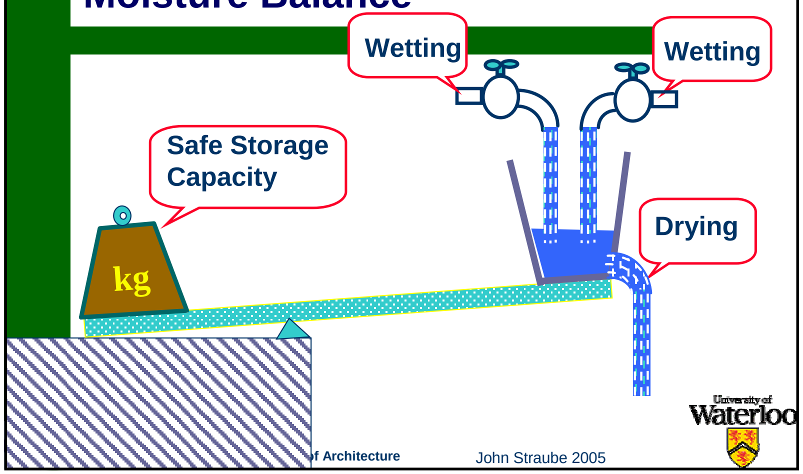
Moisture and Buildings

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

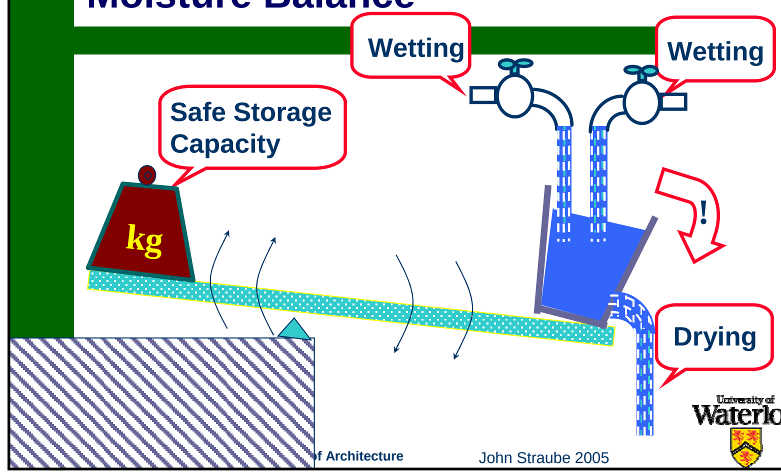
Moisture Control

- 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*

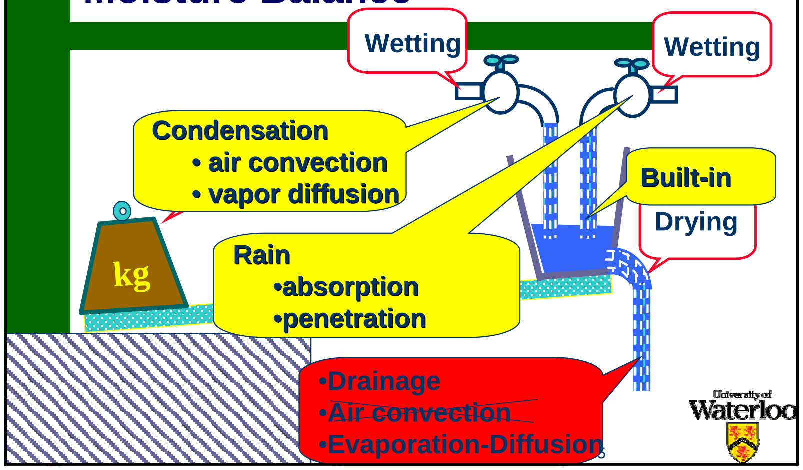
Moisture Balance

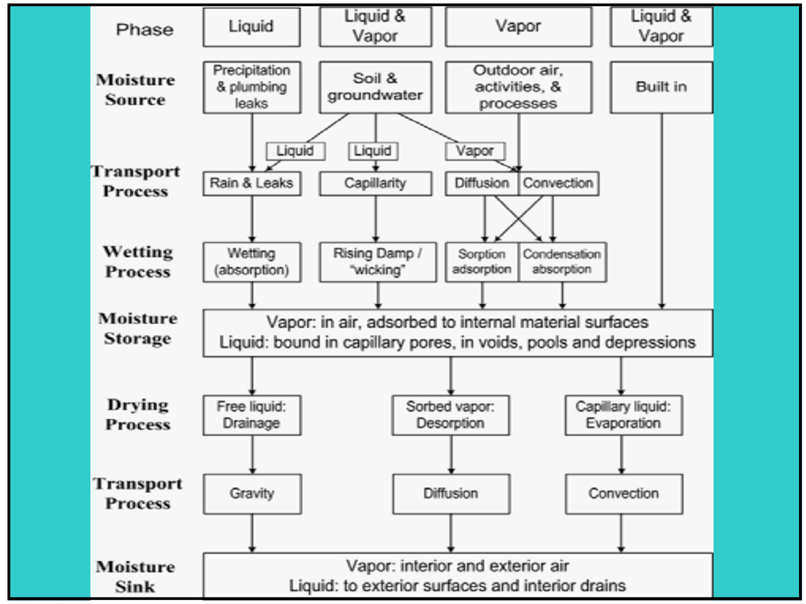


Moisture Balance



Moisture Balance





Design Choices

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

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

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

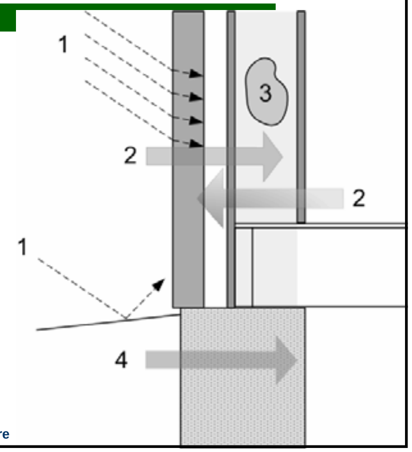
Wall Wetting Mechanisms

1. Rain
- absorption
- penetration
- splash and drips

2. Water Vapour
- Diffusion
- Convection (air leaks)

3. Built-in
- vapor, liquid

4. Ground
- capillary, diffusion



Wetting means we need drying

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

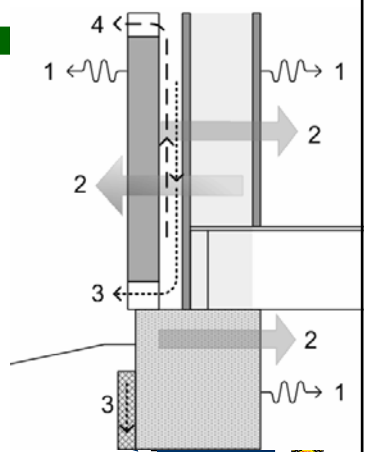
Drying - Where to and How

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

Wall Drying Mechanisms

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



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*)

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

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"

Enclosure Design for Durability

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

Material Performance Thresholds

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

Performance of What?

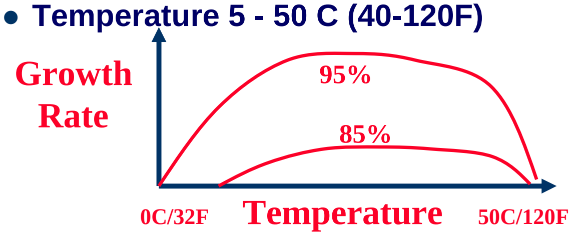
- Materials - asphalt, paper
- Layers - building paper
- Sub-assembly - lapped, between airspace/sheathing
- Assembly - drained stucco over steel stud
- Enclosure - wall, joints, window
- Building - 12 storey apartment bldg
- Site - seashore or sheltered
- Climate -Miami or Minneapolis

Steel Corrosion

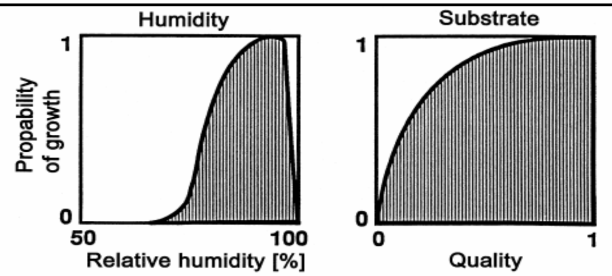
- Electrochemical Process - oxygen + electrolyte
- Can begin if RH>80%, mostly RH>95%
- Coatings protect
- Zinc galvanizing is sacrificial
- Factors
  - Temperature (Arhenius Law)
  - Time of Wetness (TOW)
  - pH of environment
  - Salinity

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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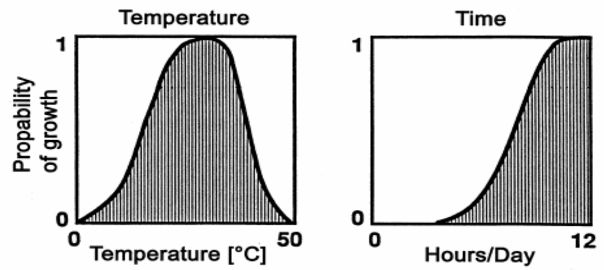
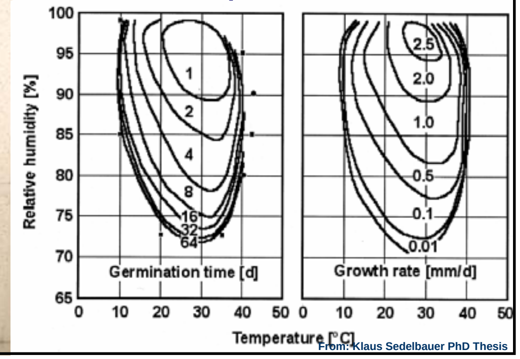


Germination & Growth

- Time for spore germination
- Rate of Growth
- Plots for perfect food source

Brampton stripmall



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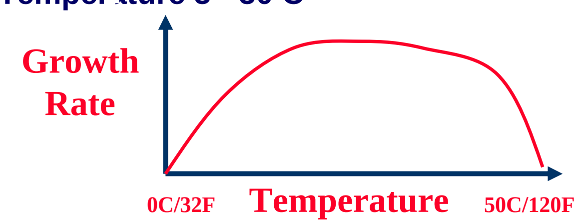
Decay

Wood Decay

- Surface Humidity > 95%RH, MC>30%
- Temperature 5 - 50 C



- Highly species, sample, exposure dependent