NSB 2011, 9th Nordic Symbosium on
Building Physics, 29 May – 2 June 2011
Tampere, Finland

Business from technology

Mould growth on building materials in laboratory and field experiments

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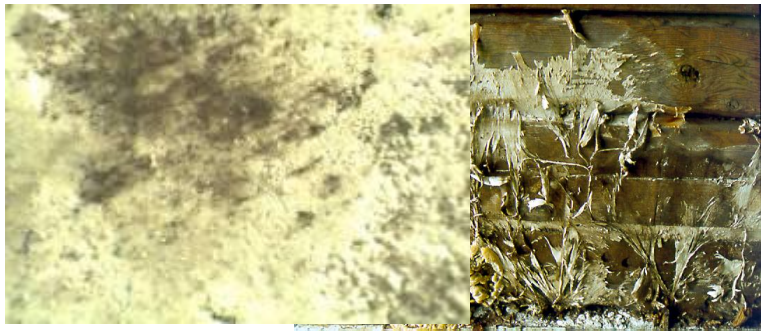
The present paper presents

- **Final results of a project on mould growth** on eight different building materials in controlled varied conditions.
- **The mould index** was used to verify the growth of mould fungi on surface of materials
- **Different mould sensitivity properties** of materials have been found varying **from resistant to very sensitive**.
- **Wood materials** were found to have the highest mould indexes
- The maximum mould indexes of **stone-based materials** were lower than that on wood-based materials.
- The harmful effects of mould growth on materials was not evaluated
  - **Present paper is a technical approach on humidity, temperature, time and type of materials (no health aspects)**

Mould growth as an indicator for performance of buildings

- **natural ageing (outdoor exposure)**
- grey wood
  - mould
  - indoor air
  - structures
    - VOCs
    - Aestetics
      - load exceeds tolerance
      - decay
      - **damage**

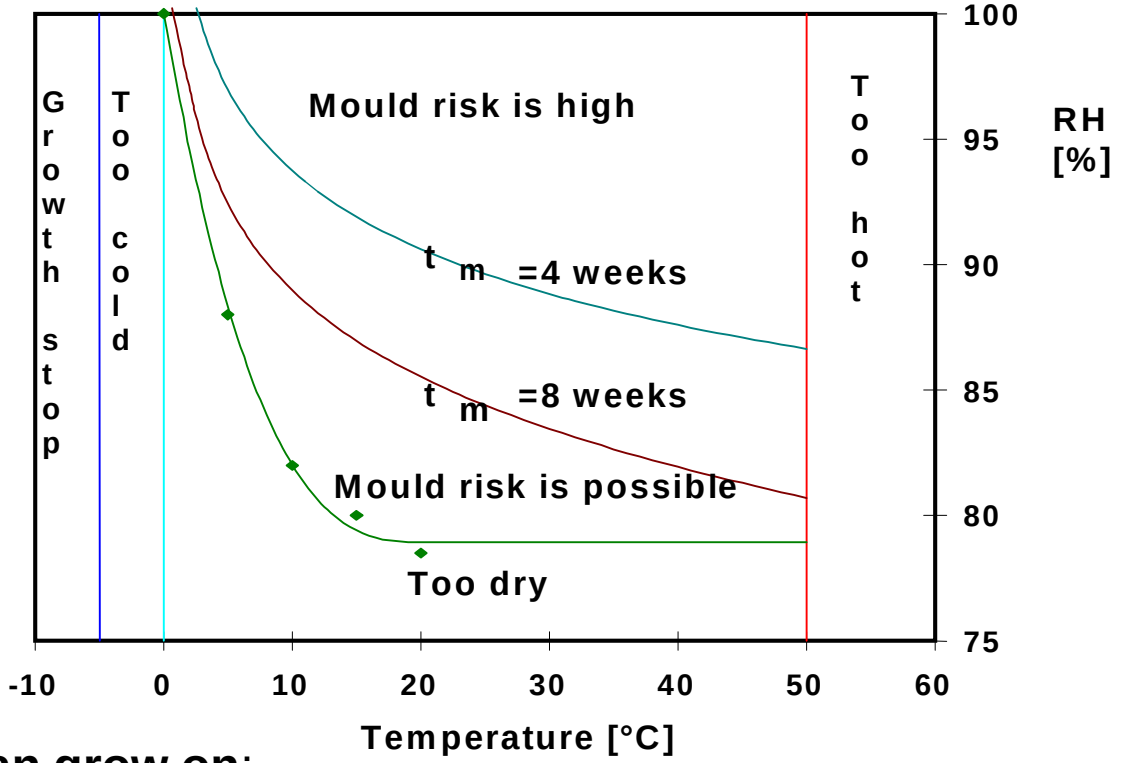
People spend more time indoors and are more depended on indoor air quality



Mould growth criteria based on previous laboratory work

Critical factors:

- Moisture
- Temperature
- Time
- Substrate
  Pine sapwood



Mould fungi and bacteria can grow on:

- Textiles, leather,
- coatings, paper, plastics,
- wood,
- brickwork and concrete.

Mathematical modelling of moisture behaviour and mould growth in building envelopes, VTT / TTY (Technical University of Tampere, 2005 – 2009. Test materials

Insulation materials

Glass wool
Polyester wool
EPS
PU

Stone materials

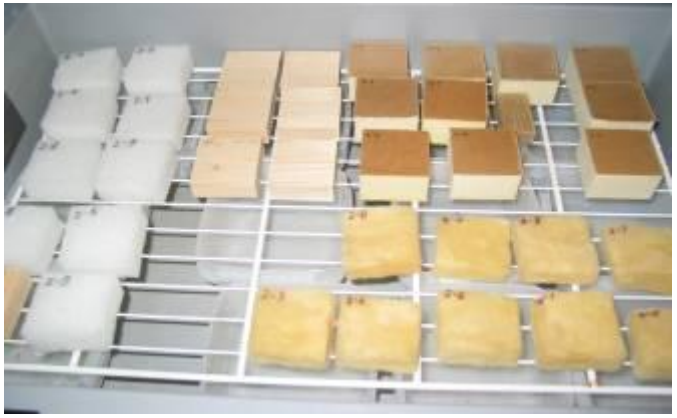
Concrete
Autoclaved aerated concrete
Expanded clay aggregate concrete

Wood materials

Edge glued spruce board
Pine sap wood (reference)

VTT & TUT research project for improved mould model – measurements

Materials in constant/periodic conditions



Constructions in laboratory

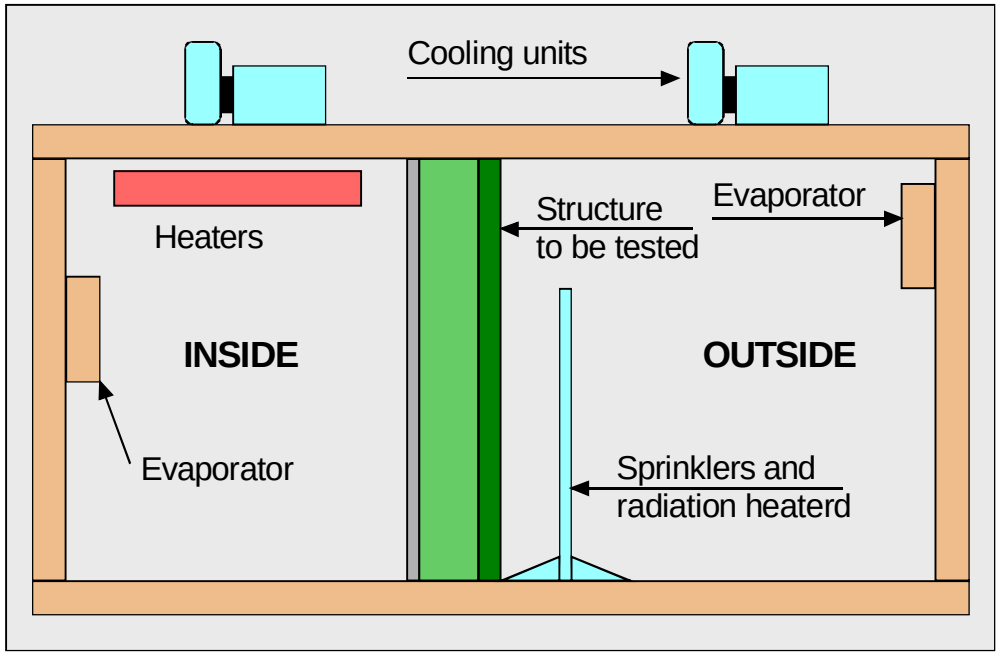
Material samples in outdoor conditions

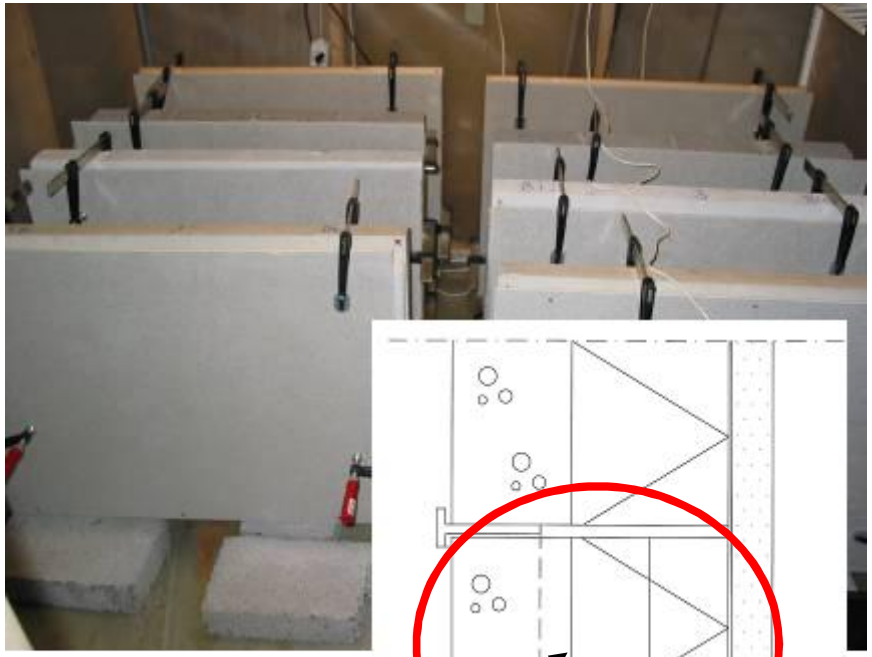
Constructions in outdoor conditions

MATERIAL EXPERIMENTS IN LABORATORY
Target conditions

Constant/cyclical conditions	Test condition 1	Test condition 2
Constant	97% RH / 22°C	
Cycle 4 – 8 weeks	97% RH / 22°C	97% RH / -5°C
Cycle 4 – 8 weeks	97% RH / 22°C	97% RH / -20°C
Cycle 4 – 8 weeks	97% RH / 22°C	50% RH / 22°C
Constant	97% RH / 5°C	
Constant	97% RH / -5°C	
Constant	90% RH / 22°C	
Constant	90% RH / 5°C	
Constant	97% RH / -20°C	

Tests on assembles in laboratory





Detected interface

First test series	Second test series
light concrete + glass wool	light concrete + polyurethane
light concrete + polyester wool	light concrete + expanded polystyrene
edge glued spruce board + glass wool	edge glued spruce board + polyurethane
edge glued spruce board + polyester wool	edge glued spruce board + expanded polystyrene
expanded clay aggregate concrete + glass wool	expanded clay aggregate concrete + polyurethane
expanded clay aggregate concrete + polyester wool	expanded clay aggregate concrete + expanded polystyrene
concrete + glass wool	concrete + polyurethane
concrete + polyester wool	concrete + expanded polystyrene

Index for mould growth on materials

Previous scale only for wood based materials

0 = no growth

1 = some growth (microscopy)

2 = moderate growth (microscopy) (coverage > 10 %)

3 = some visually detected growth (thin hyphae found under microscopy)

4 = visual coverage > 10 %

5 = visual coverage > 50 %

6 = tight visual coverage 100 %

Microscopy only

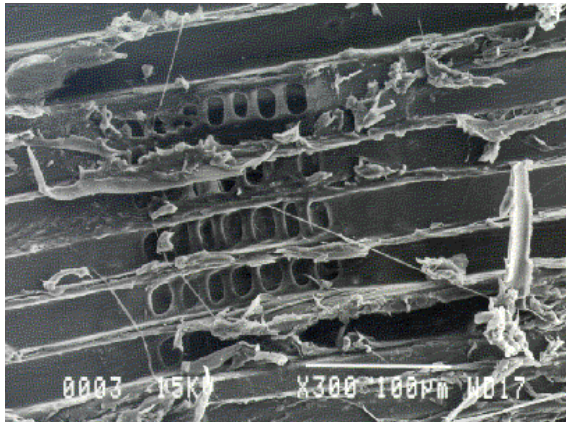
0 = no growth

1 = some growth

2 = moderate growth (coverage > 10 %)

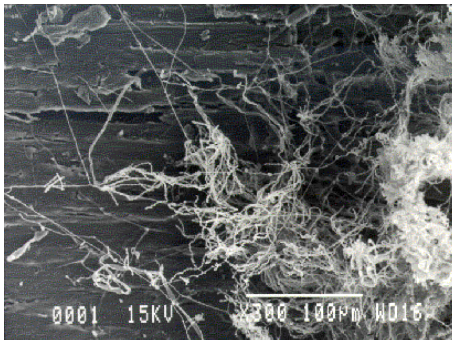
3 = coverage < 50 %

4 = coverage > 50 % (found under microscopy)

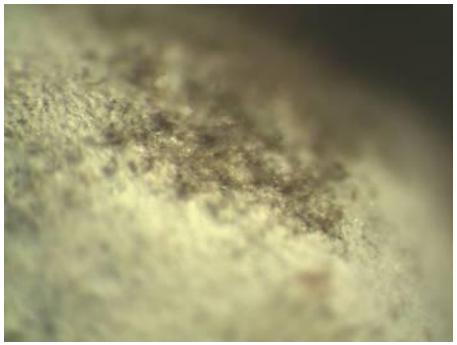


Index 1 (start of growth, wood)

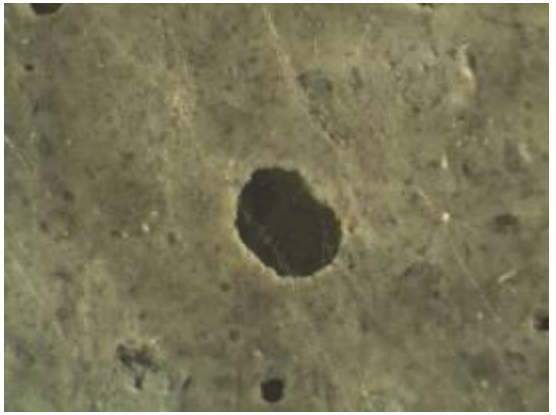
Index 6, wood



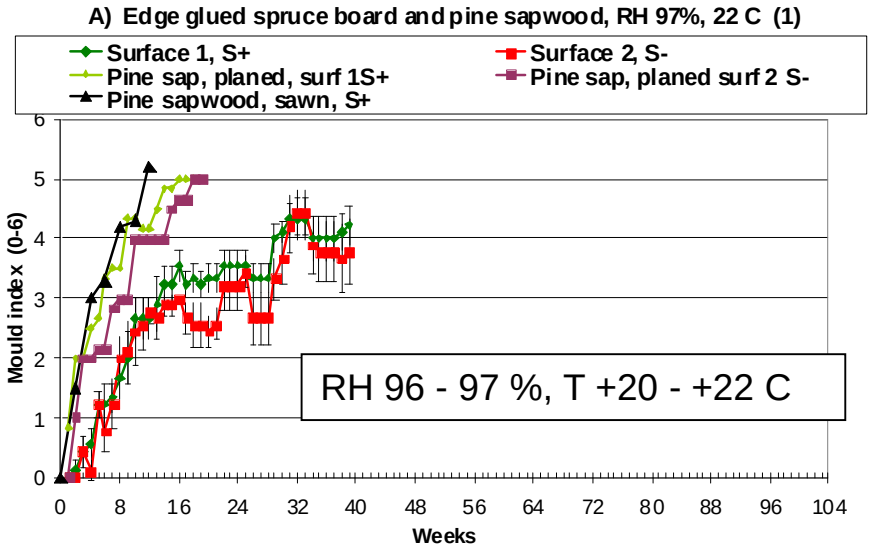
Index 4, wood,

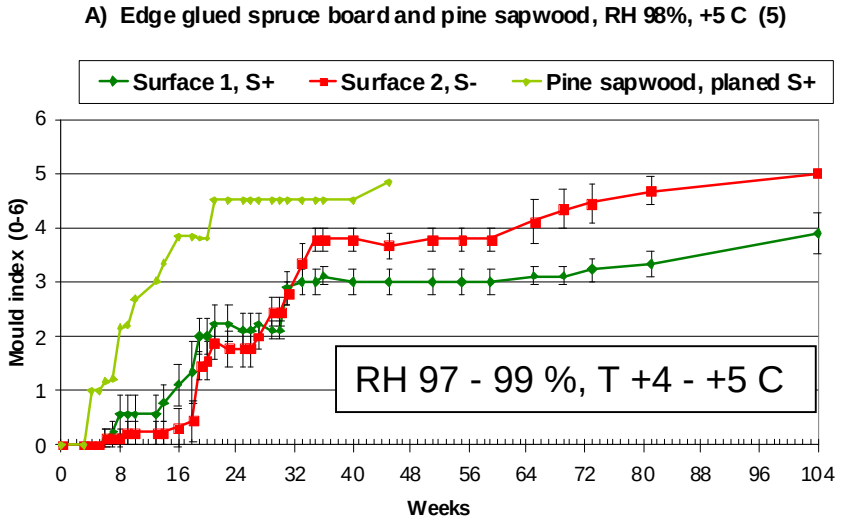


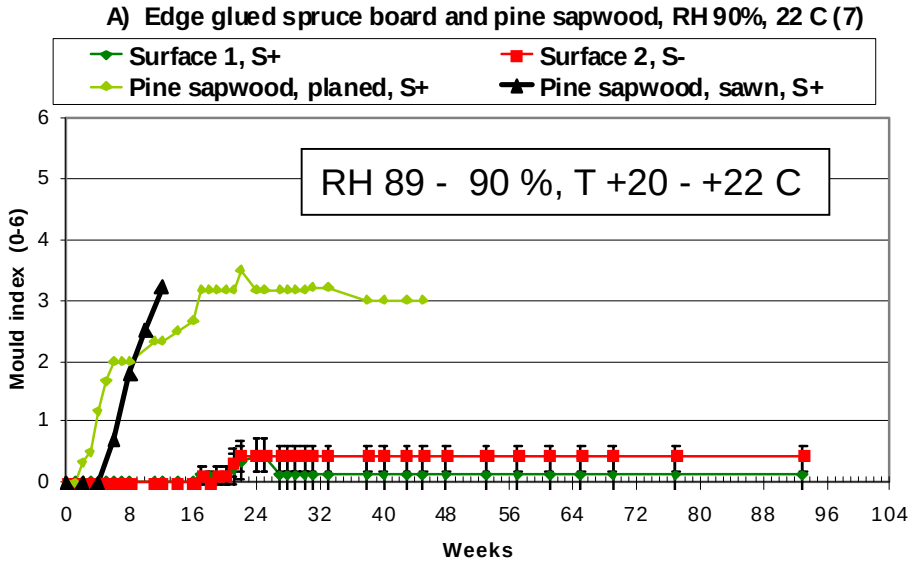
Index 3, concrete

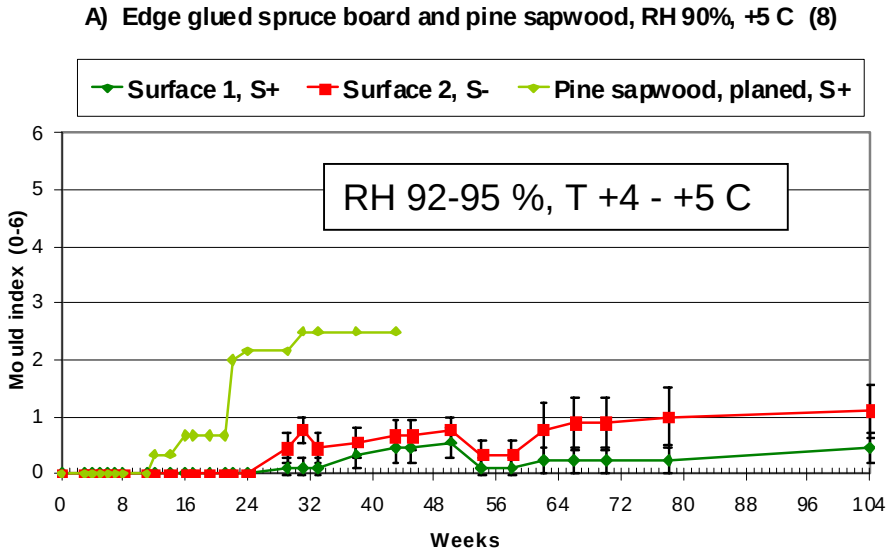


Index 2, concrete

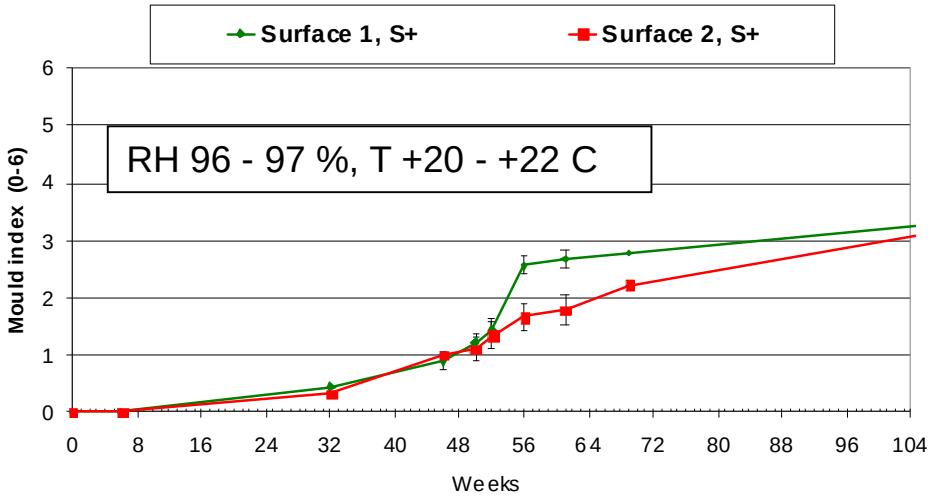

A) Edge glued spruce board and pine sapwood, RH 97%, 22 C (1)
Surface 1, S+
Surface 2, S-
Pine sap, planed, surf 1S+
Pine sap, planed surf 2 S-
Pine sapwood, sawn, S+
Mould index (0-6)
Weeks
RH 96 - 97 %, T +20 - +22 C


A) Edge glued spruce board and pine sapwood, RH 98%, +5 C (5)
Surface 1, S+
Surface 2, S-
Pine sapwood, planed S+
Mould index (0-6)
Weeks
RH 97 - 99 %, T +4 - +5 C

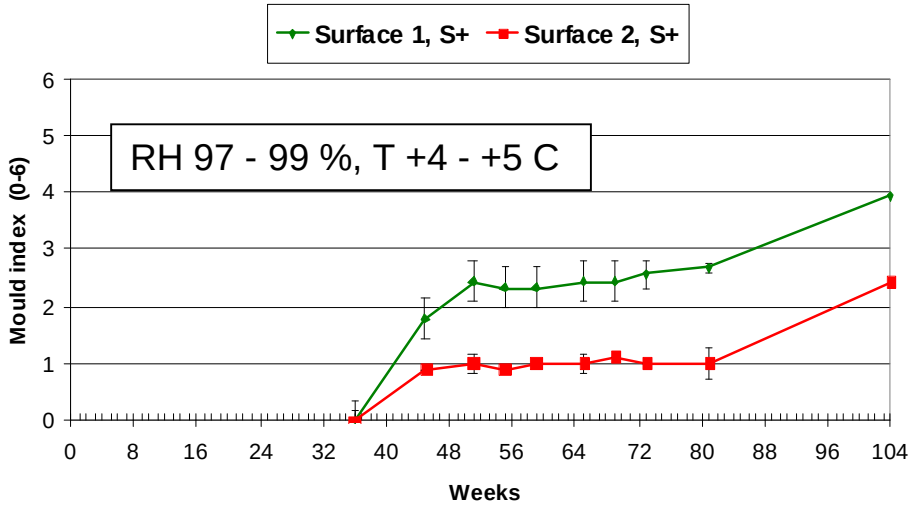

A) Edge glued spruce board and pine sapwood, RH 90%, 22 C (7)
Surface 1, S+
Surface 2, S-
Pine sapwood, planed, S+
Pine sapwood, sawn, S+
Mould index (0-6)
Weeks
RH 89 - 90 %, T +20 - +22 C


A) Edge glued spruce board and pine sapwood, RH 90%, +5 C (8)
Surface 1, S+
Surface 2, S-
Pine sapwood, planed, S+
Mould index (0-6)
Weeks
RH 92-95 %, T +4 - +5 C

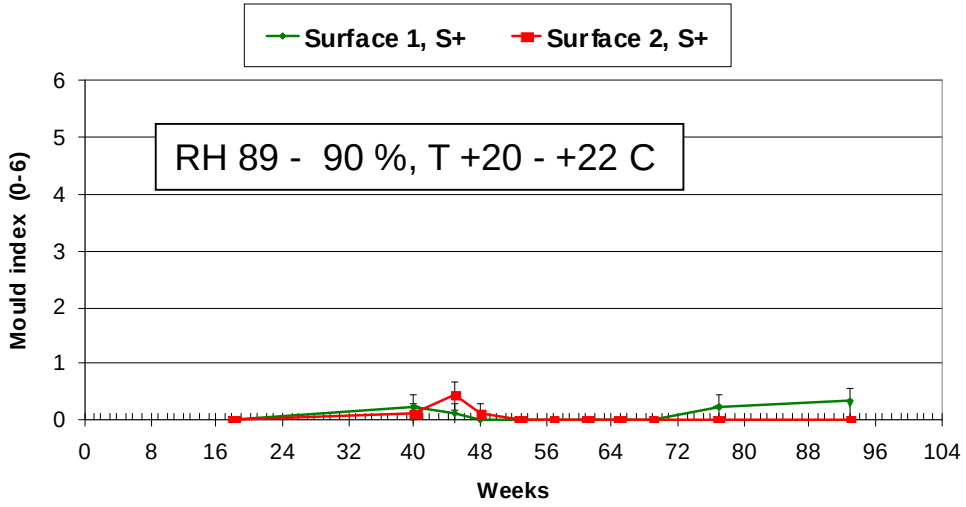
C) Concrete, RH 97%, +22 C (1)



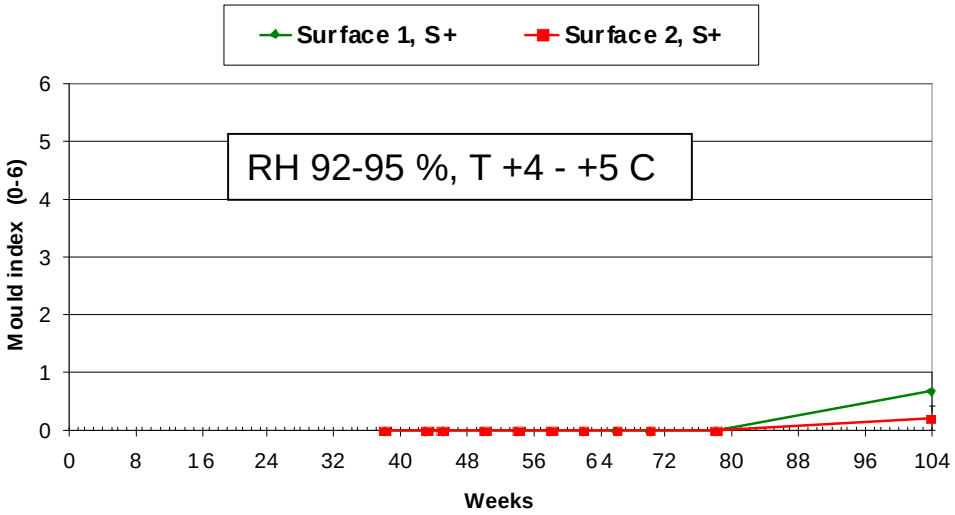
C) Concrete, RH 98%, +5 C (5)



C) Concrete, RH 90%, +22 C (7)

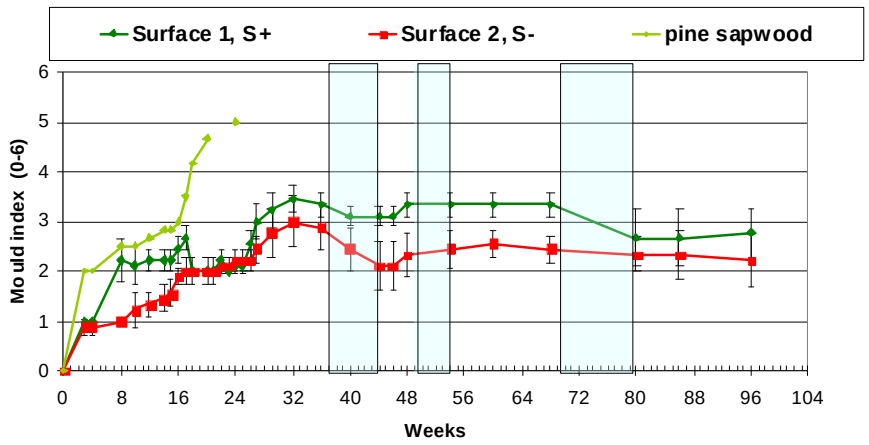


C) Concrete, RH 90%, +5 C (8)

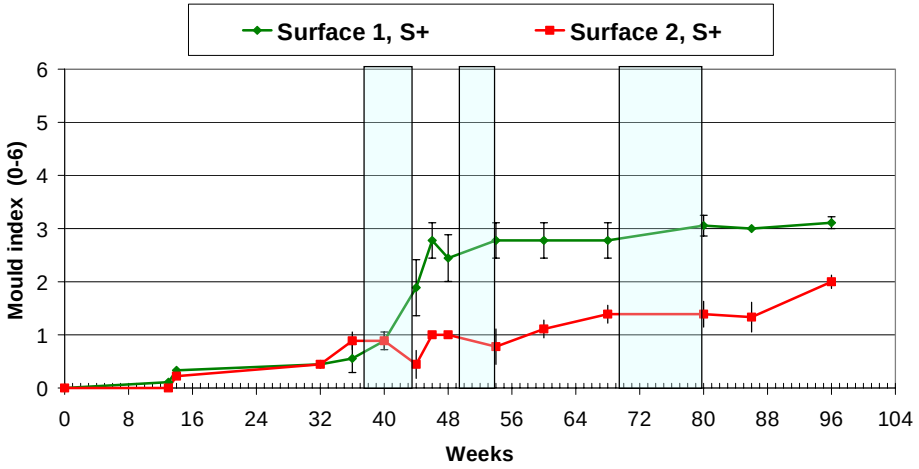


Effect of frost

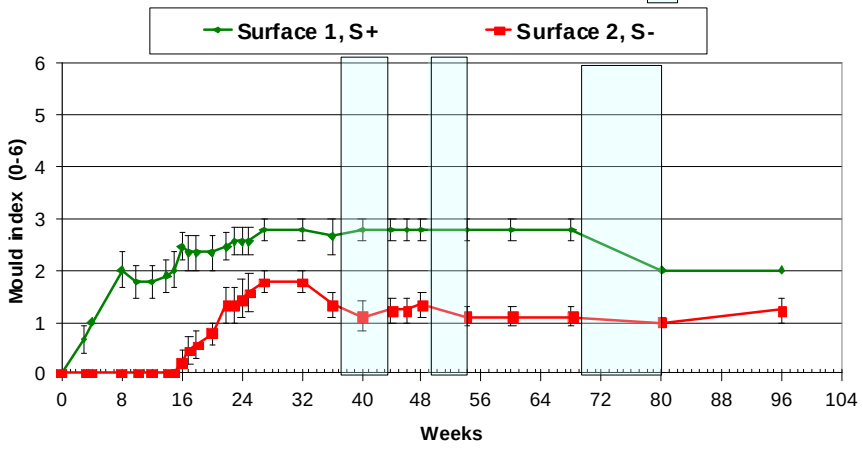
A) Edge glued spruce board and pine sapwood, RH 97%, +22 C, cycles at -20 C, weeks 37-44, 49-54, 69-80 (3)



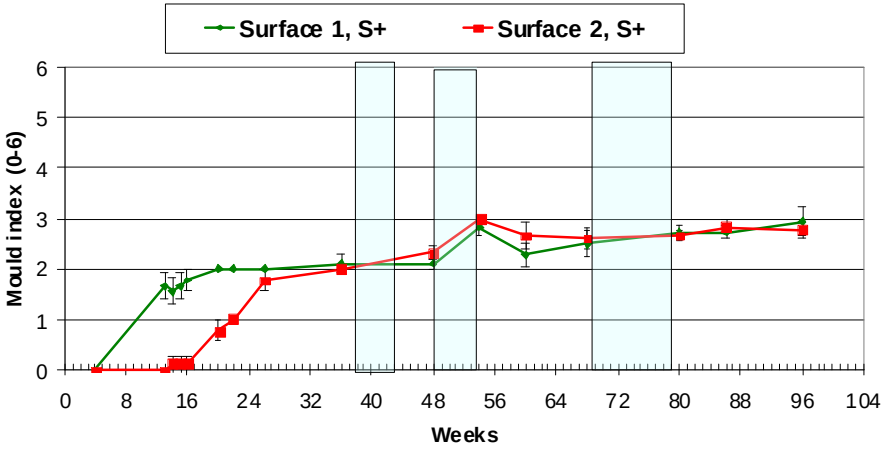
C) Concrete, RH 97%, +22 C, cycles at -20 C, weeks 37-44, 49-54, 69-80 (3)



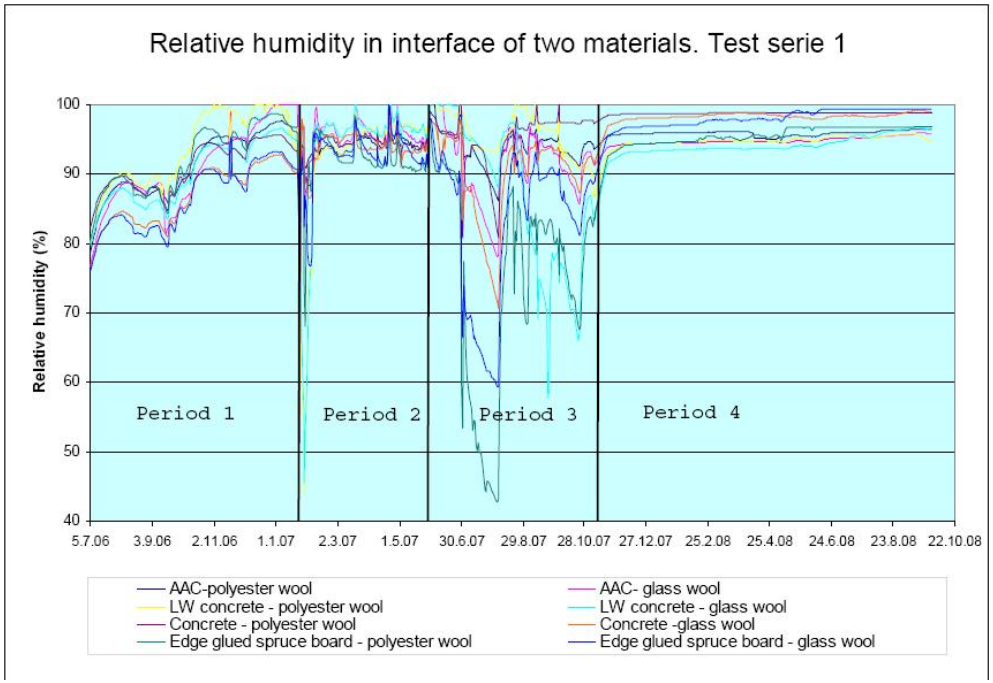
G) Glass wool, RH 97%, +22 C, cycles at -20 C, weeks 37-44, 49-54, 69-80 (3)

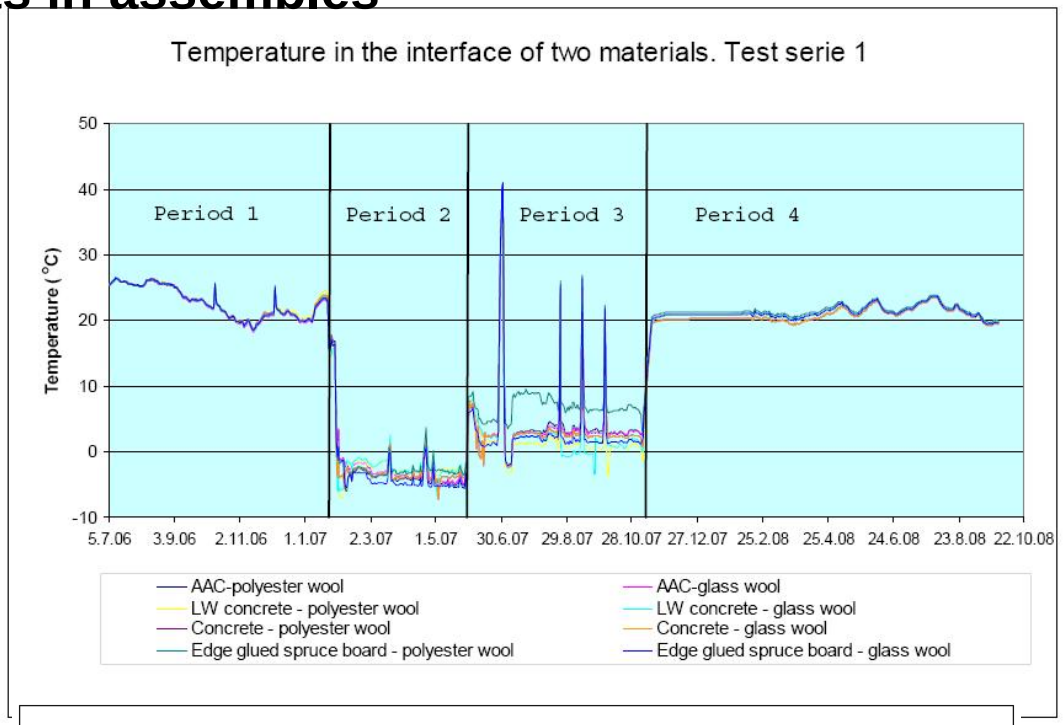


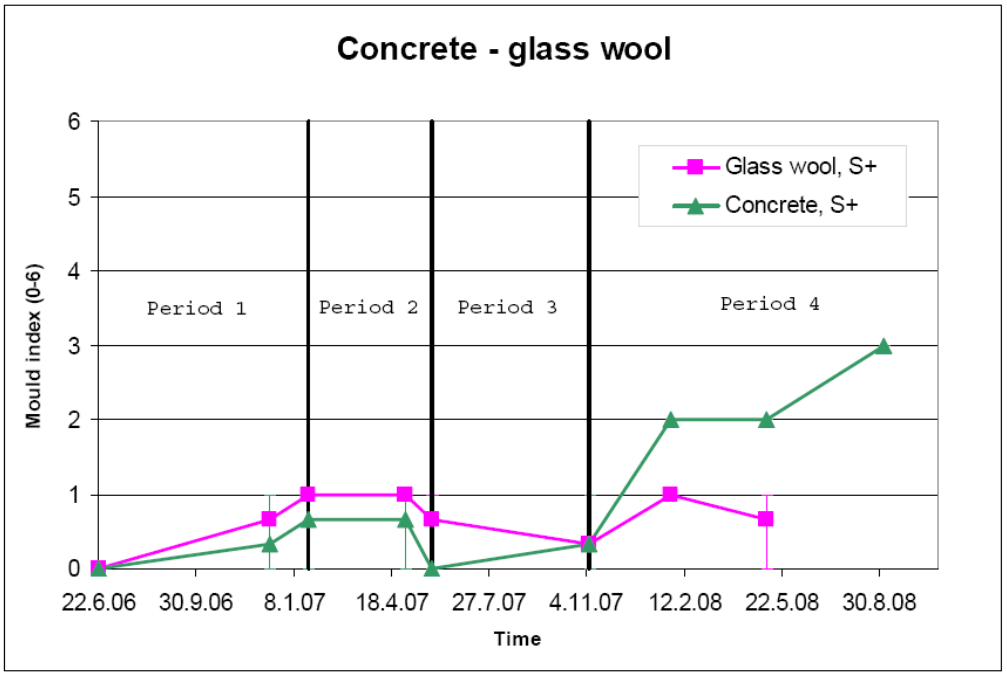
D) AAC, RH 97%, +22 C, cycles at -20 C, weeks 37-44, 49-54, 69-80 (3)

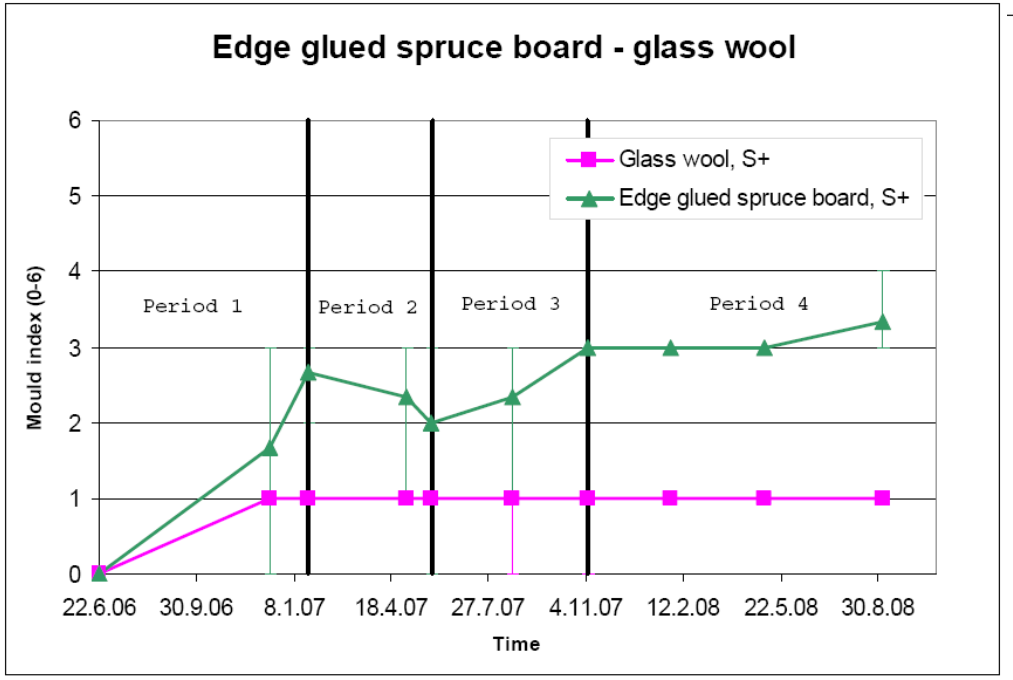


Results in assembles









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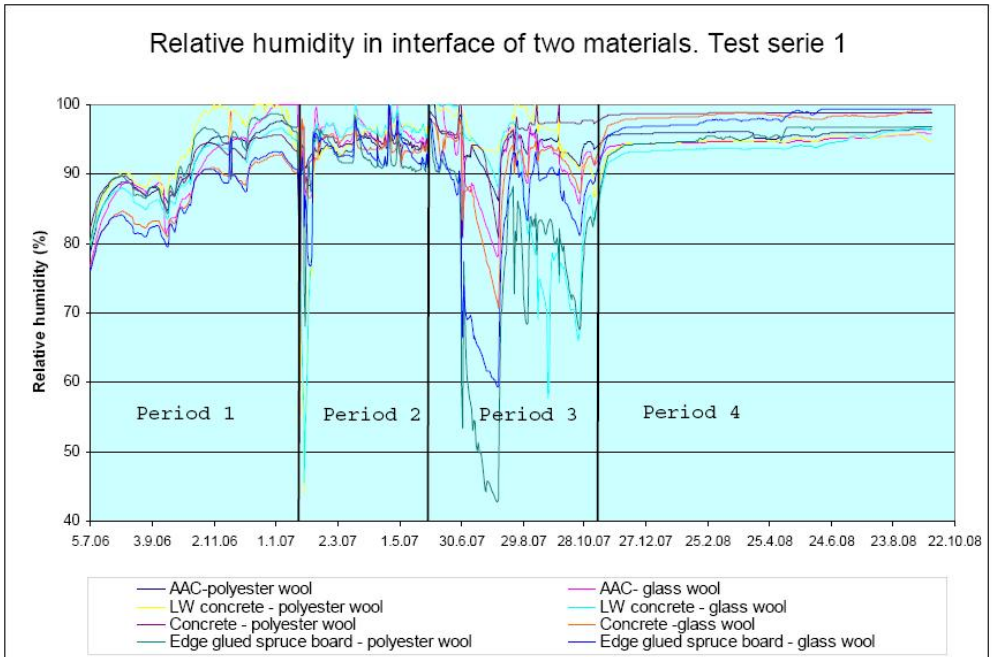
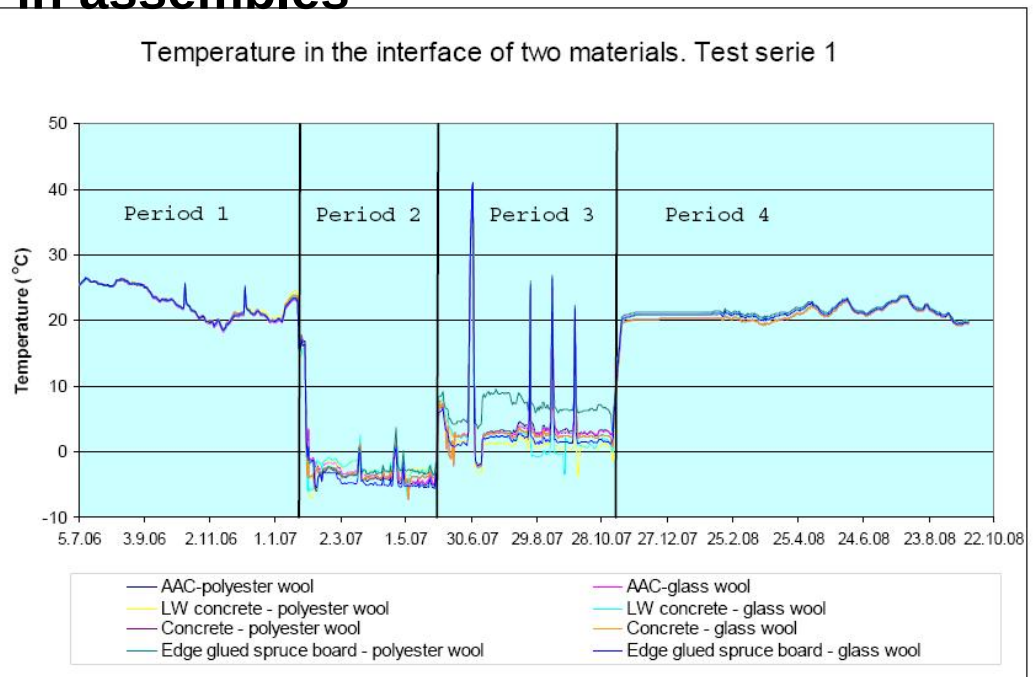
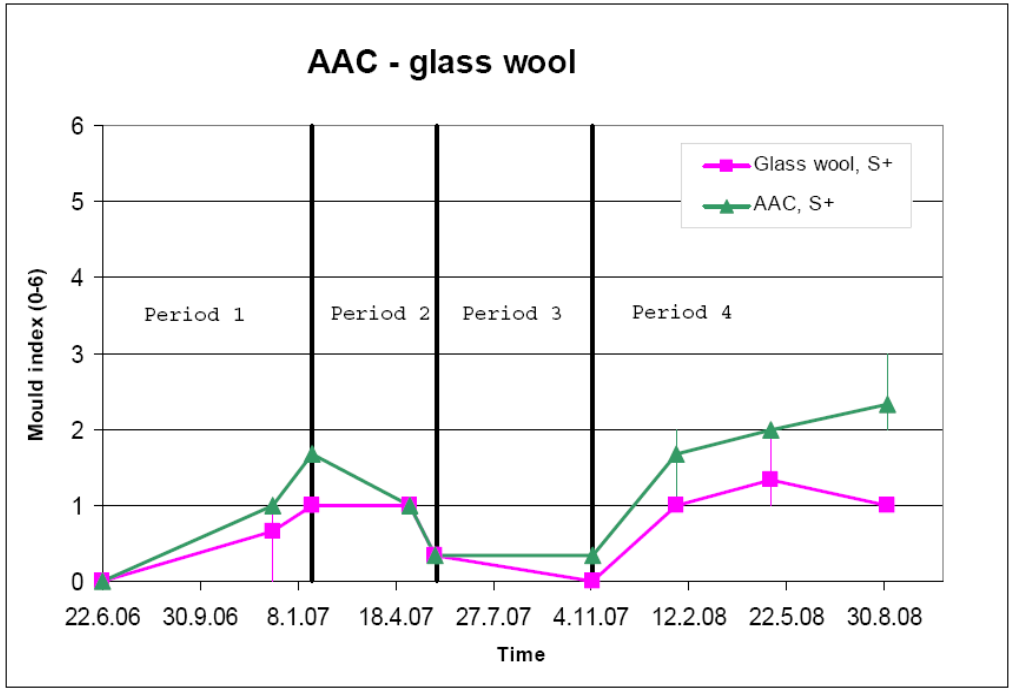
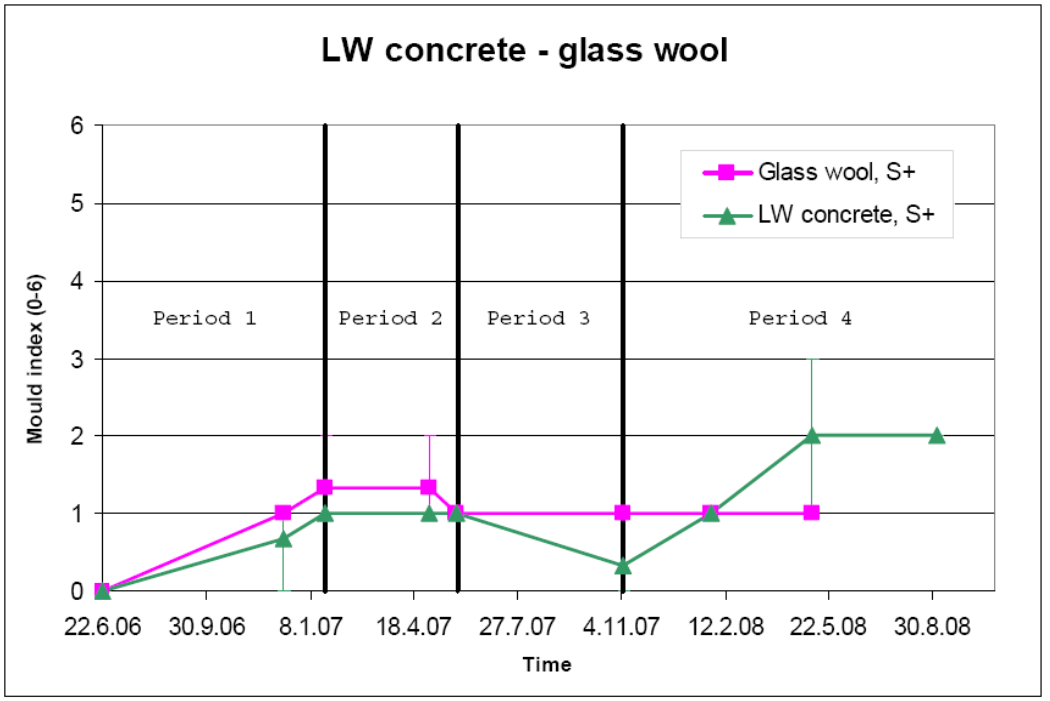
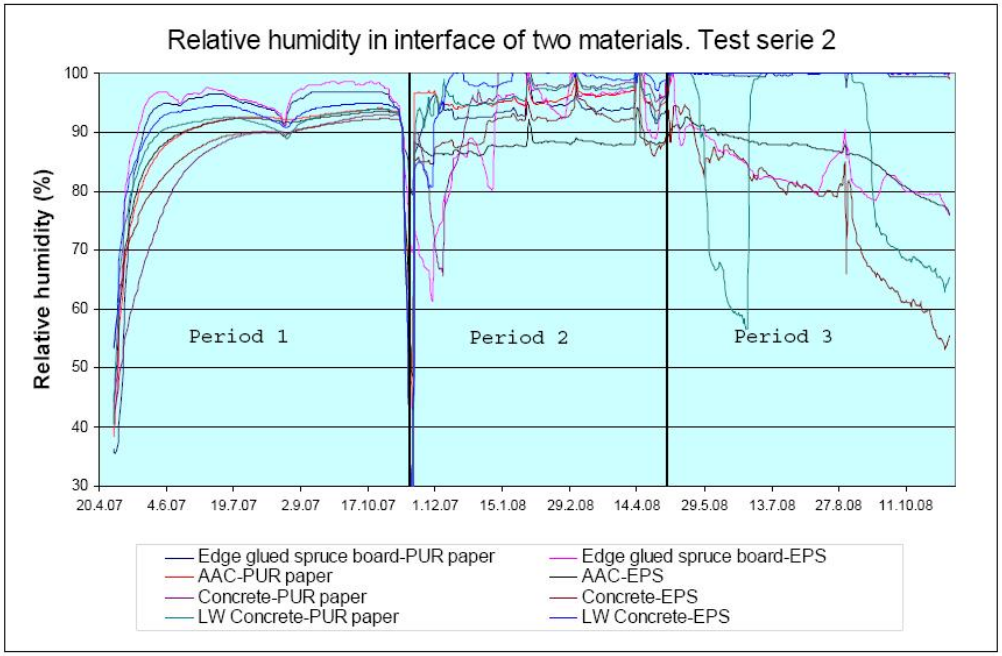


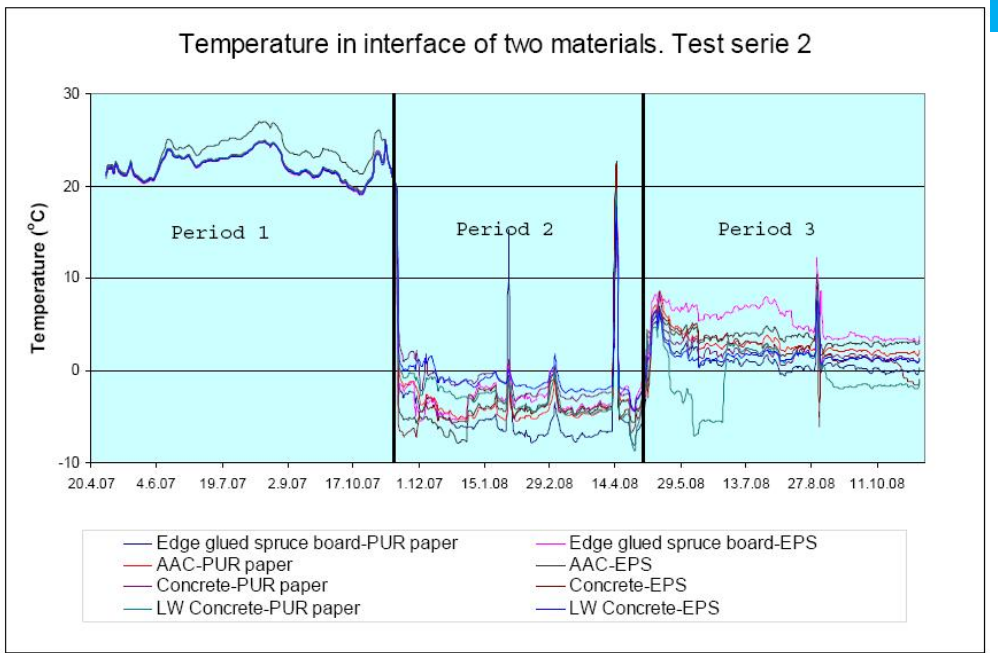


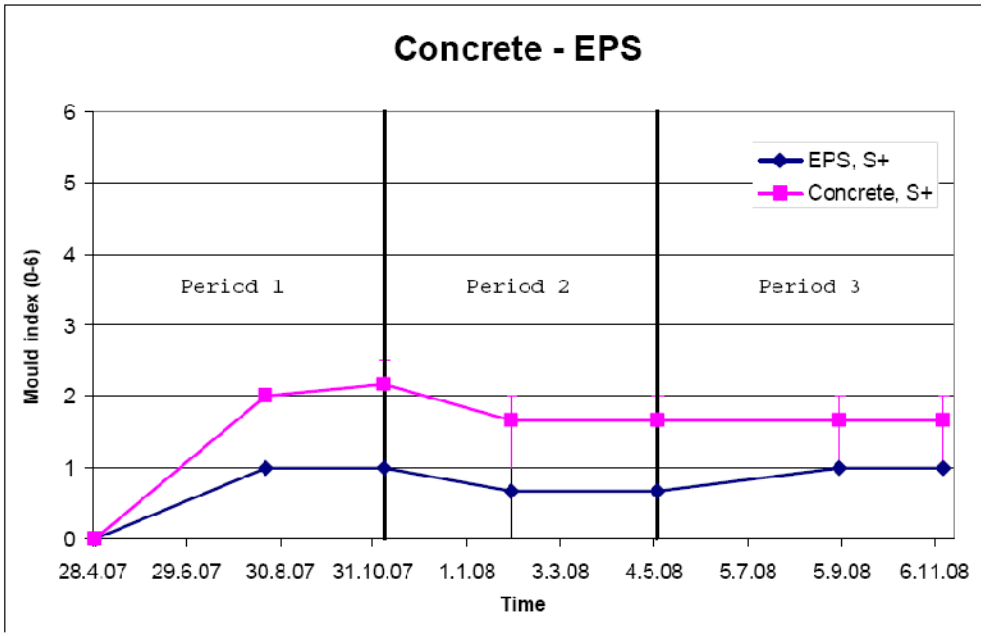


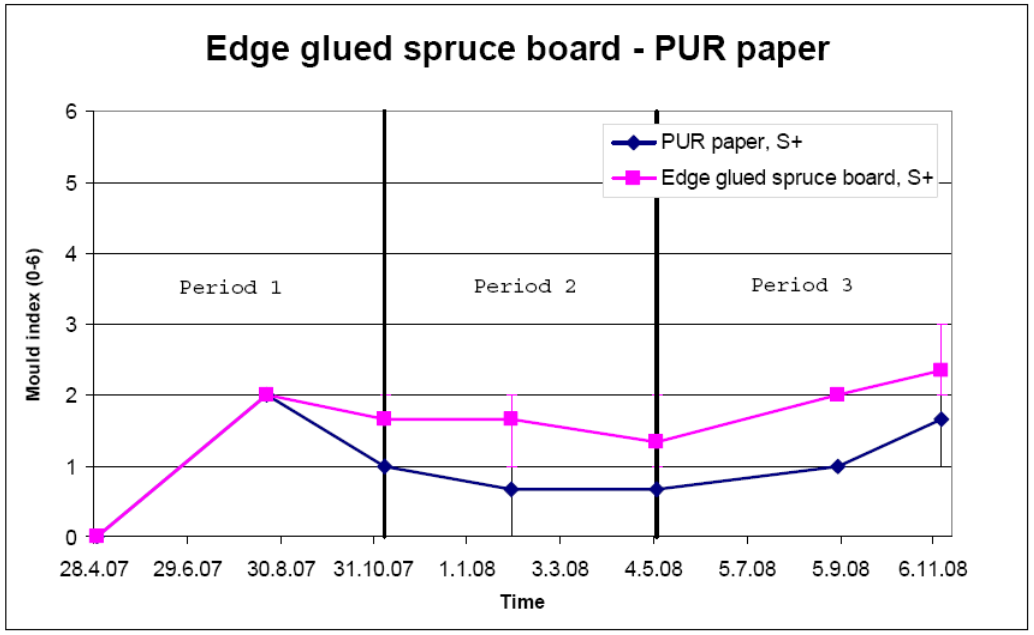


Results in assembles

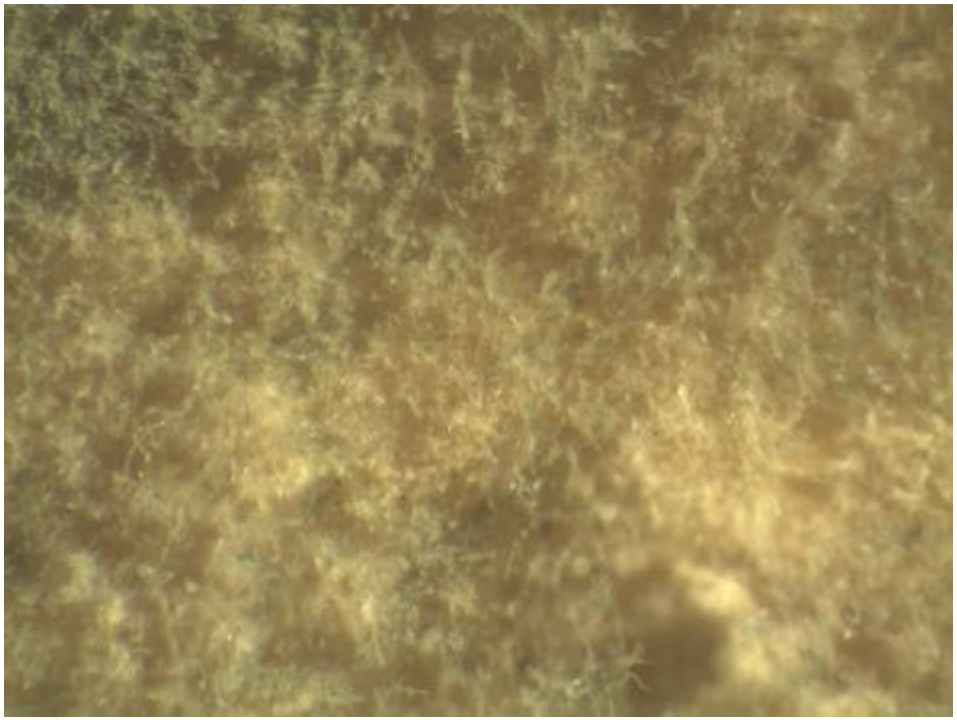




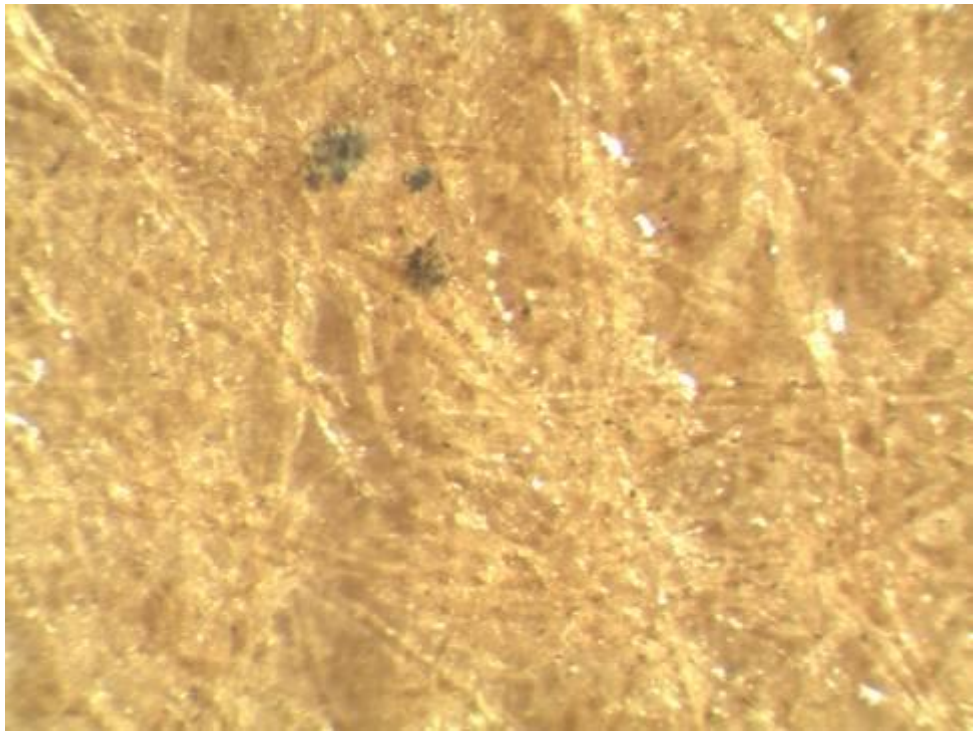




Mould growth on different materials (1)

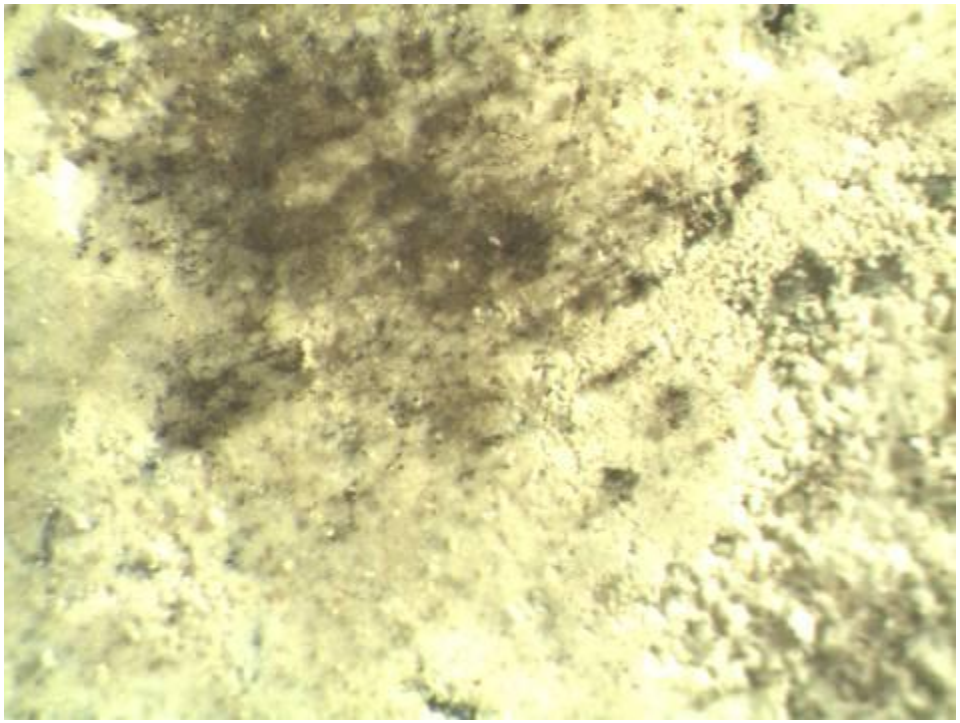


Mould on sawn surface of pine sapwood

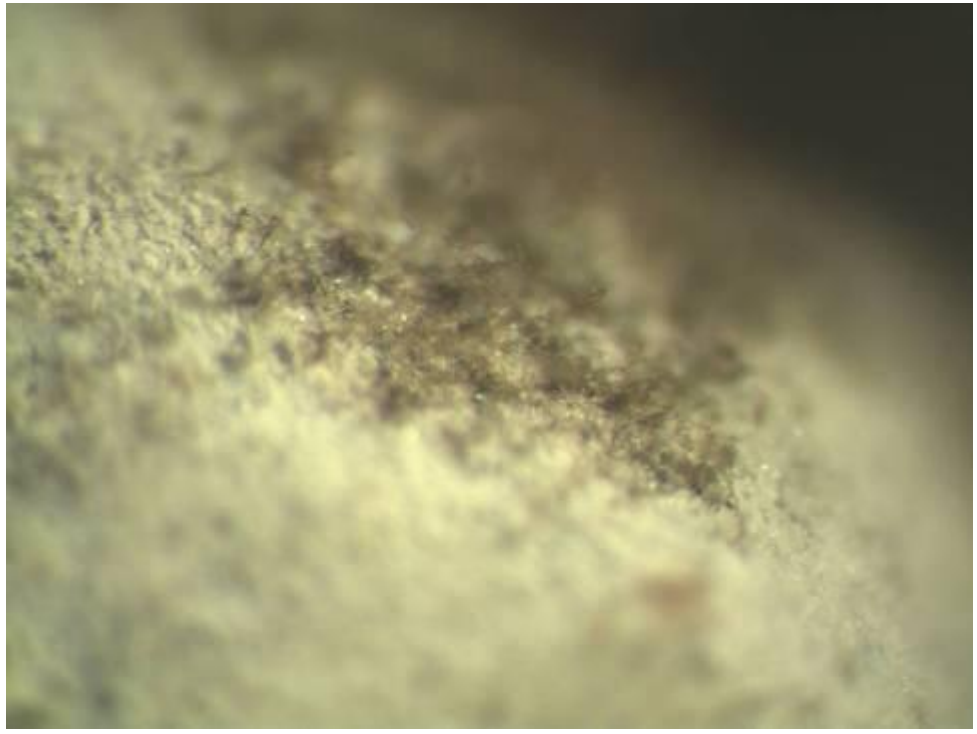


Mould on paper surface of PUR

Mould growth on different materials (2)

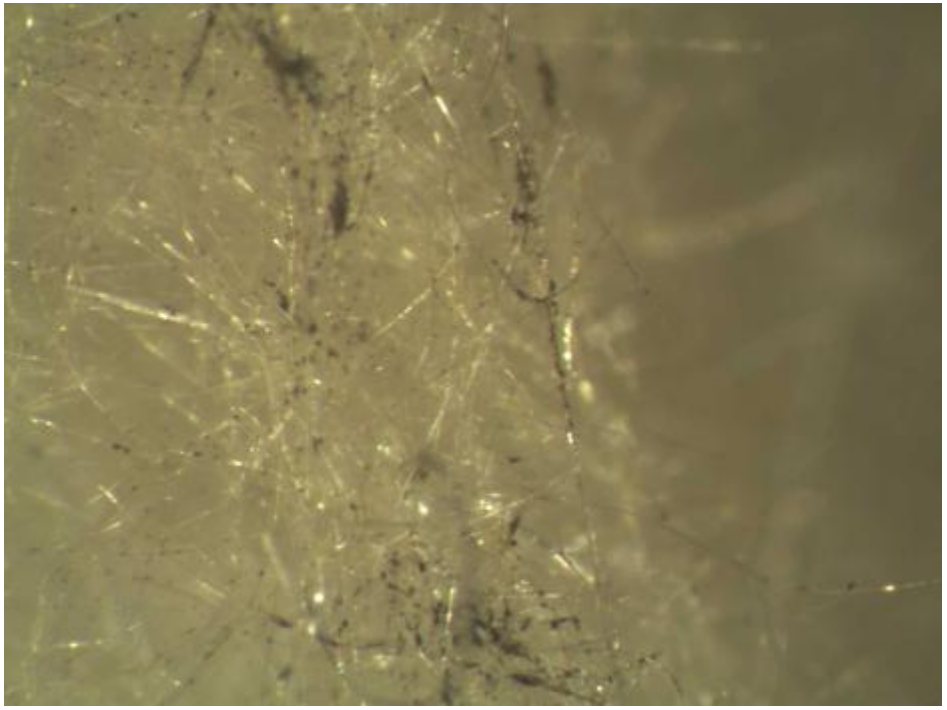


Mould on concrete

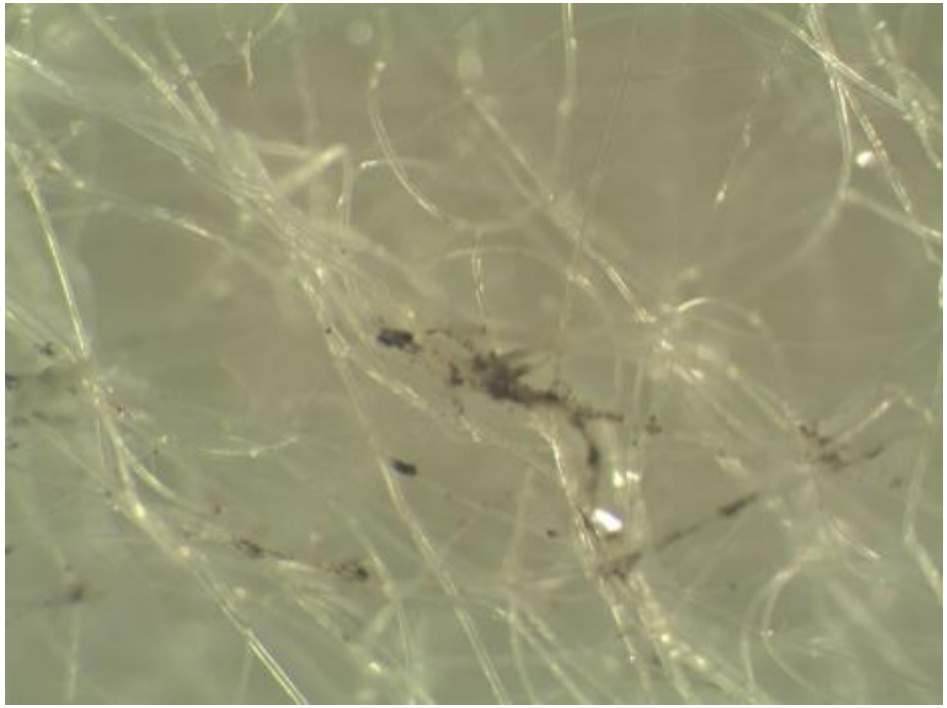


Mould on ACC

Mould growth on different materials (3)



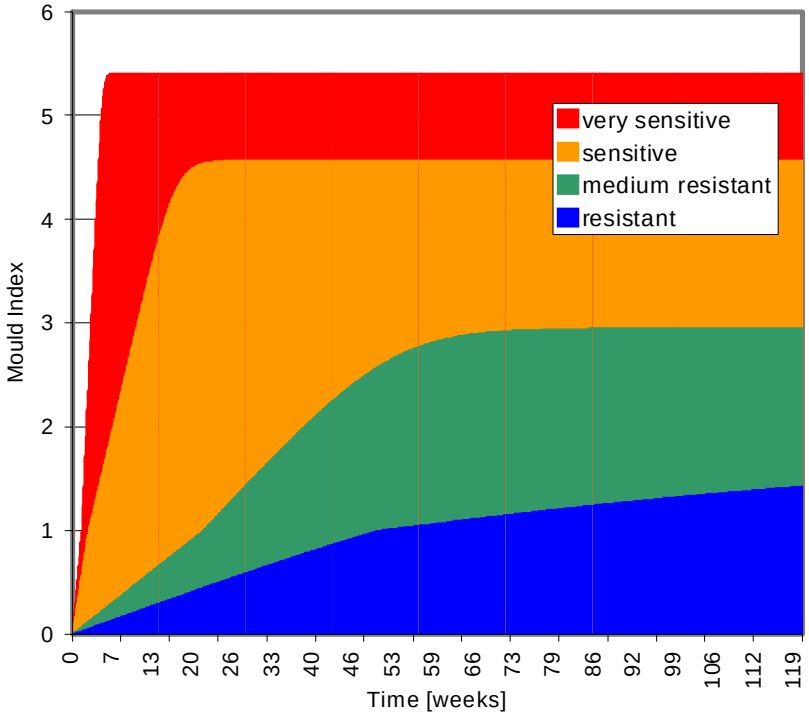
Mould on fibers of glass wood



Mould on fibers of polyester wool

Mould growth sensitivity classes and some corresponding materials in the present research. The figure in table illustrates the predicted mould growth for the established sensitivity classes for constant conditions at 97 % RH and 22 C

Sensitivity class	Materials
Very sensitive	Pine sapwood
Sensitive	Glued wooden boards, PUR with paper surface, spruce
Medium resistant	Concrete, aerated and cellular concrete, glass wool, polyester wool
Resistant	PUR polished surface



Conclusions

- At exposure of high relative humidity, mould growth was detected in all materials, and faster than at other tested conditions
- Low temperature (+4…+5 ˚C) affected on the mould growth activity, but less ín high humidity conditions (RH above 97 %)
- Highest mould growth acitivity was found on wood materials and paper-coated materials
- Lower response of mould growth was found on stone based and insulation materials
- At lower humidity (RH 89 – 90 % / 20 -22 ˚C) mould growth was limited (exception of pine sapwood)
- Decline of mould growth was found caused by longer periods of frost and dry conditions

ACKNOWLEDGMENTS

- This paper is a part of the project **“Modelling of mould growth”** financed by Tekes, Industry and VTT.

  Project team
  - **TTY**: Juha Vinha (project leader), Kimmo Lähdesmäki, Kati Salminen, Tomi Strander
  - **VTT**: Hannu Viitanen, Tuomo Ojanen, Ruut Peuhkuri, Leena Paajanen, Hanna Iitti, Liisa Seppänen
  - Industrial partners

- The model and work performed in the ”Mould Modelling” project will be continued and applied in the project **”Enersis”**

  - Concept Ensuring High Indoor Environment Quality and Structure Moisture Performance in Energy Efficiency Renovations

    for Built Environment Research Programme 2010
    financed by the Finnish National Technology Agency (Tekes).