Numerical modelling of moisture related mechanical stress in wooden cylindrical objects using COMSOL:
a comparative benchmark

Henk Schellen

Jos van Schijndel

TU/e Technische Universiteit
Eindhoven
University of Technology

Walloon Church Delft

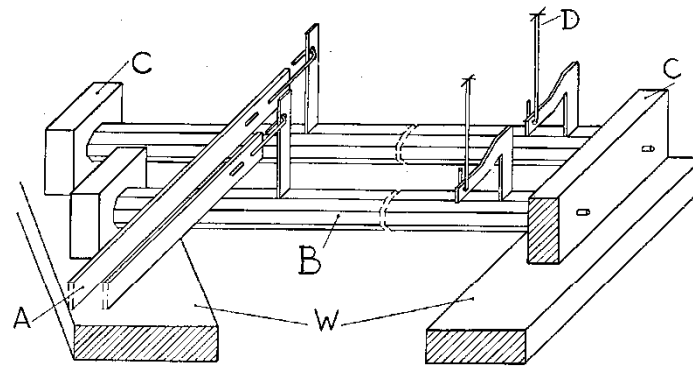TU/e Technische Universiteit
Eindhoven
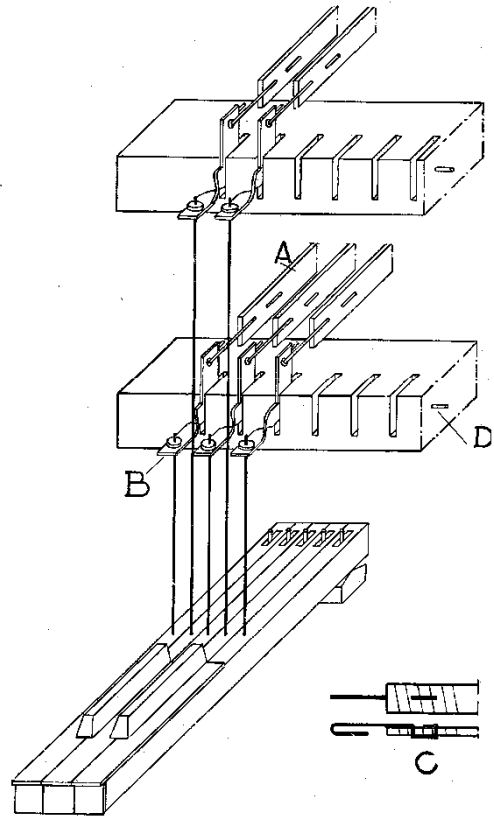University of Technology

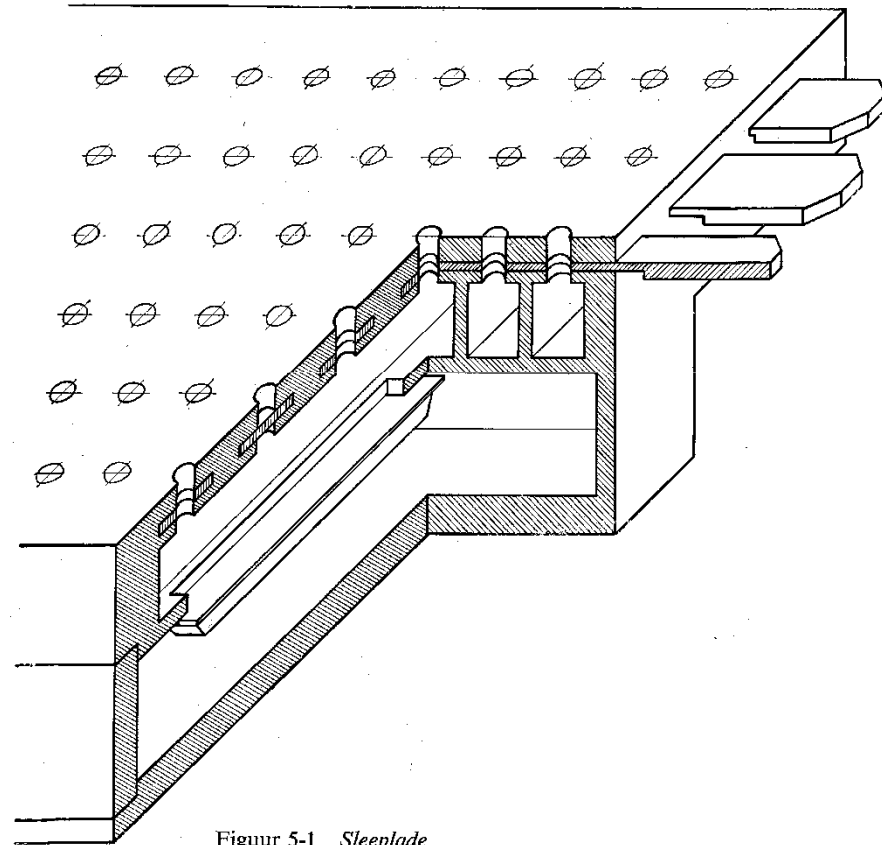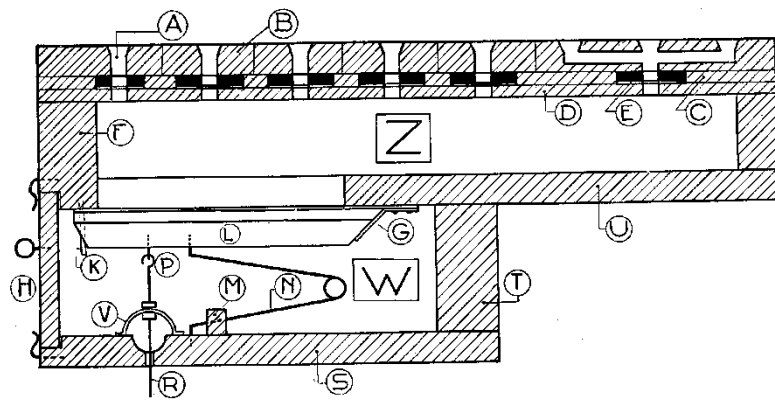# Walloon Church Delft

Walloon Church Delft

Playing mechanics
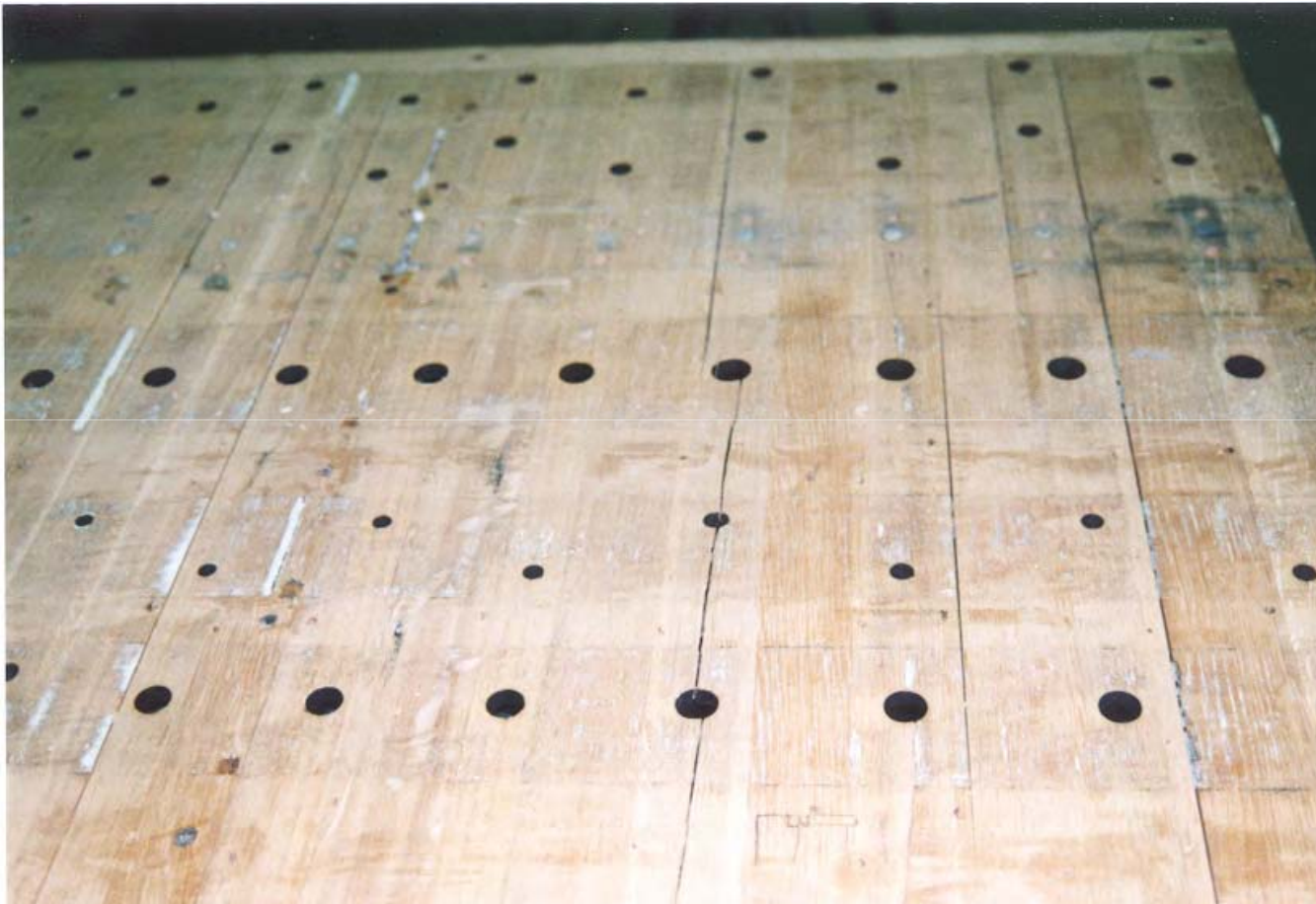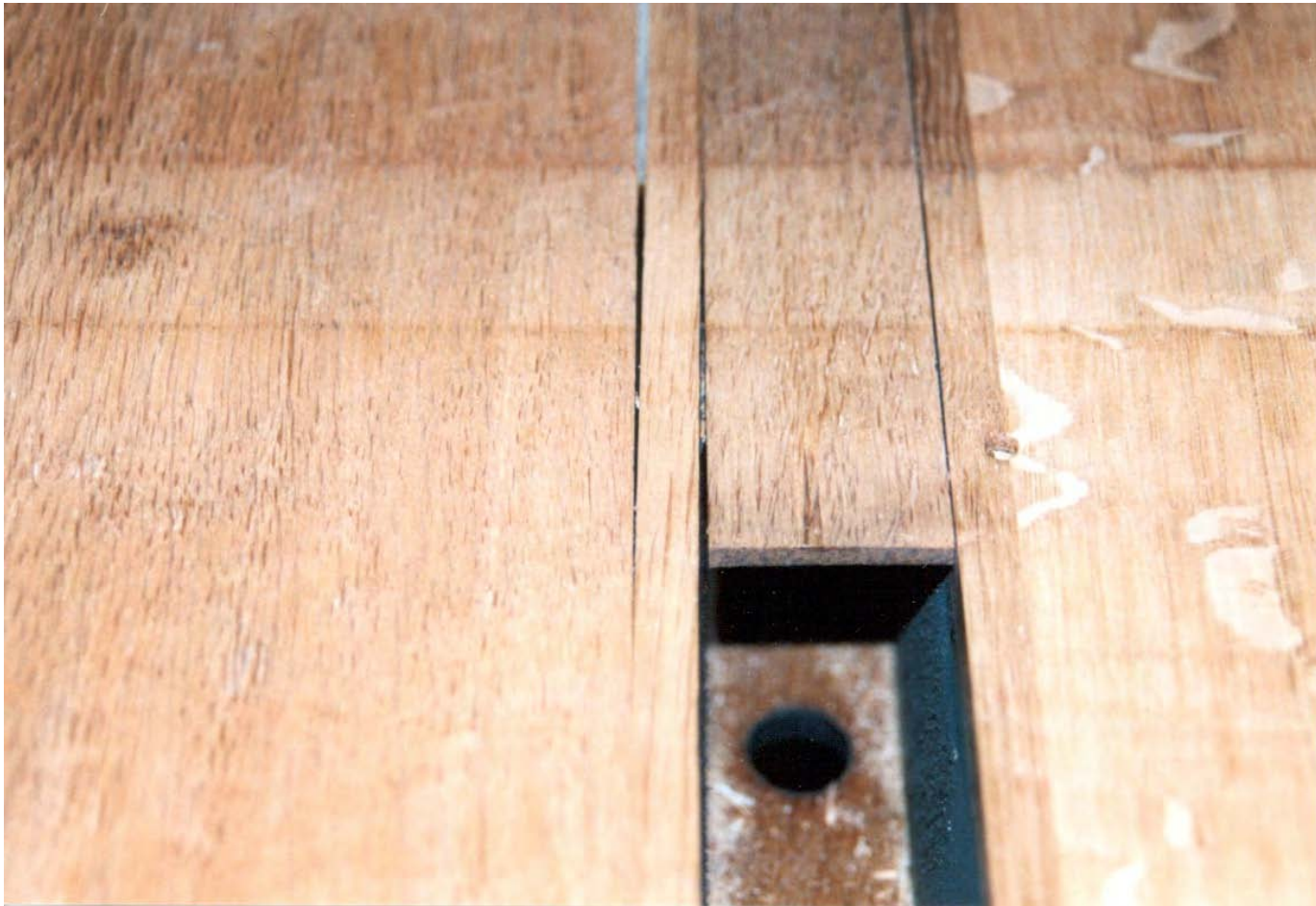
Wind drawer

Figuur 5-1   *Sleeplade*

Problem definition

- **Hot air heating**
- **Temperature stratification**
- **Organ damage**
- **Cracking of wood**

Cracking of wind drawers

Cracking of wind drawers
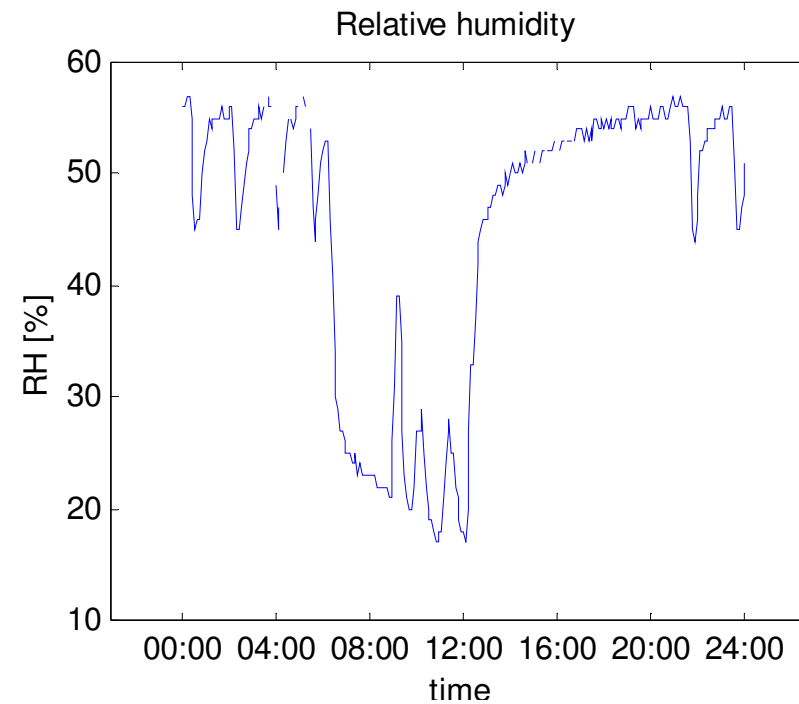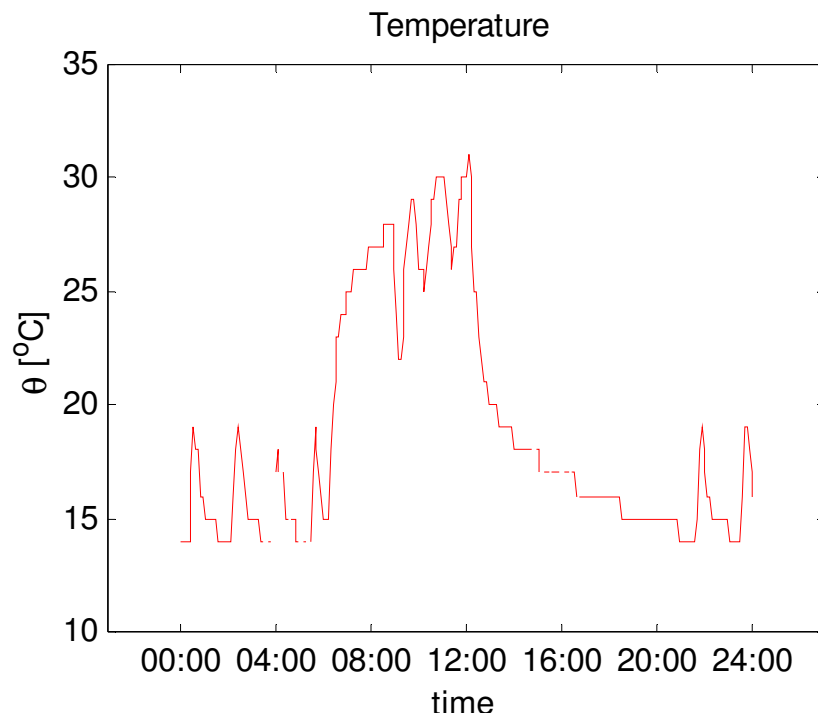
Deformation of wooden panels

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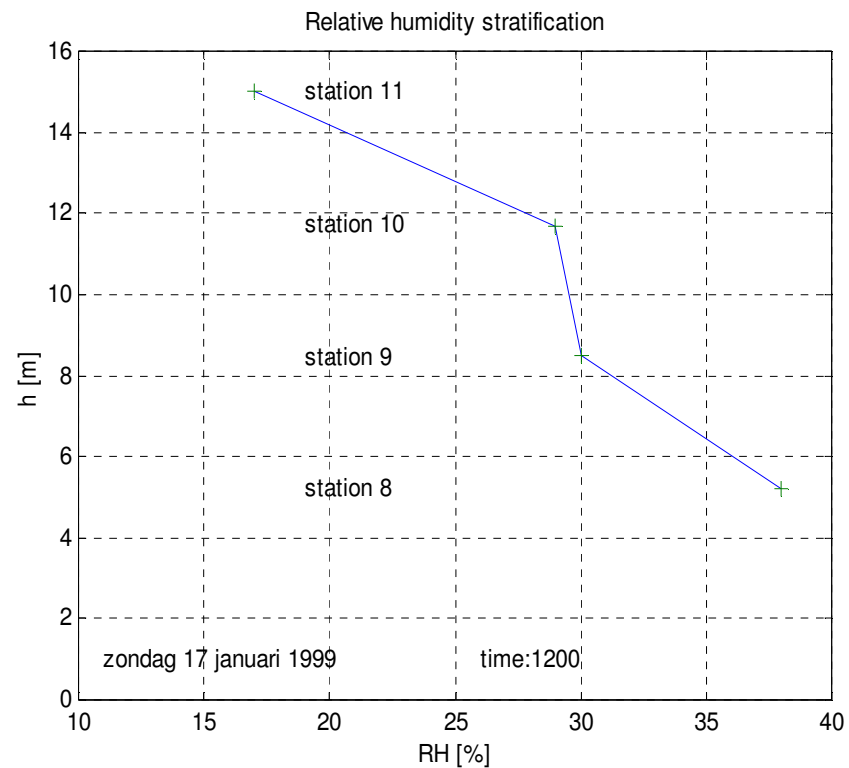University of Technology
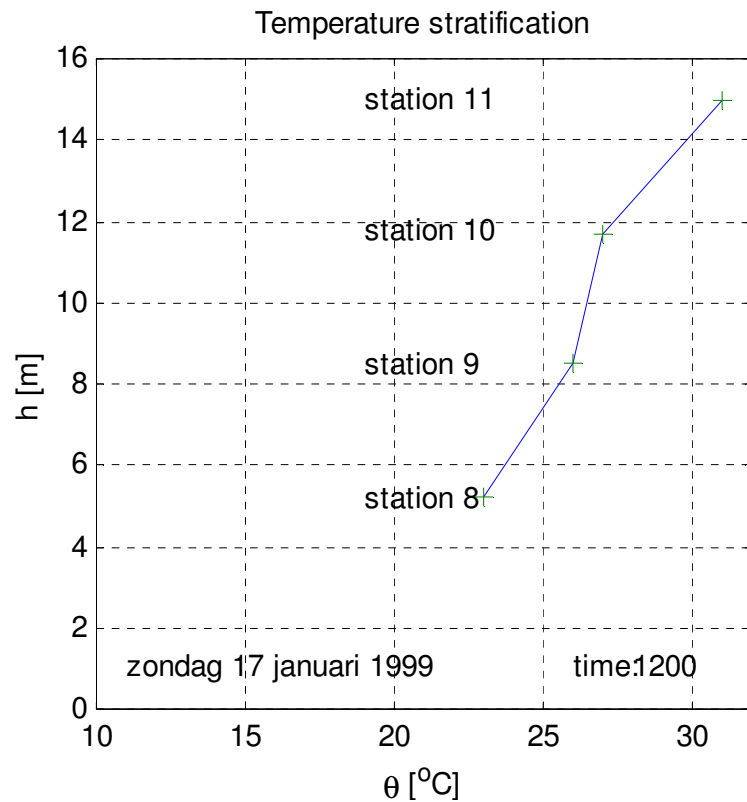
Wooden construction cracking

Flaking of paintings

Indoor air conditions near organ

Temperature and RH stratification

Temperature stratification

station 11

station 10

station 9

station 8

zondag 17 januari 1999   time:1200

h [m]

θ [°C]

Relative humidity stratification

station 11

station 10

station 9

station 8

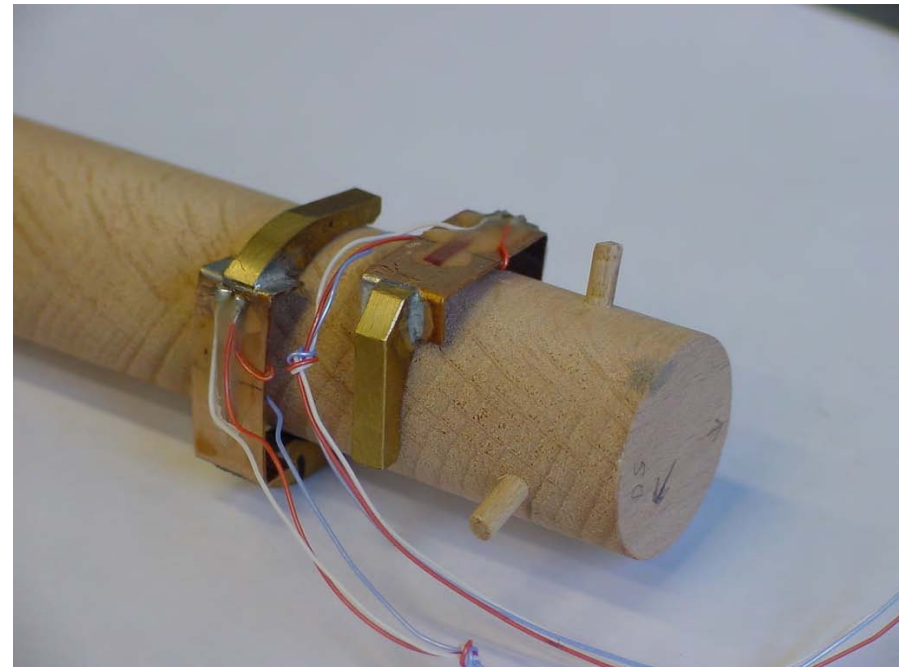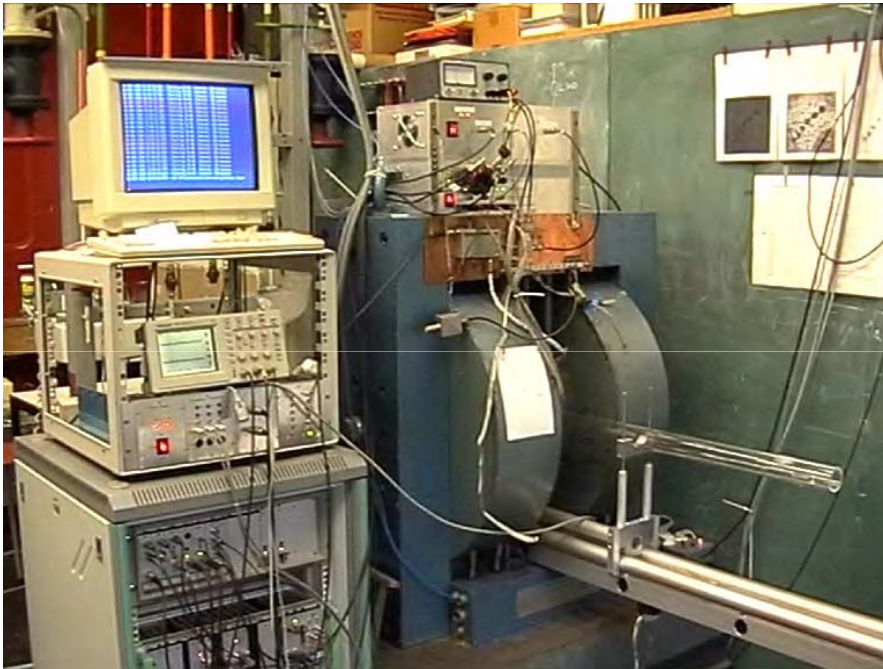zondag 17 januari 1999   time:1200

h [m]

RH [%]

Anisotropic material characteristics

1. Tangential   2. Radial   3. Axial

Moisture content measurements by NMR

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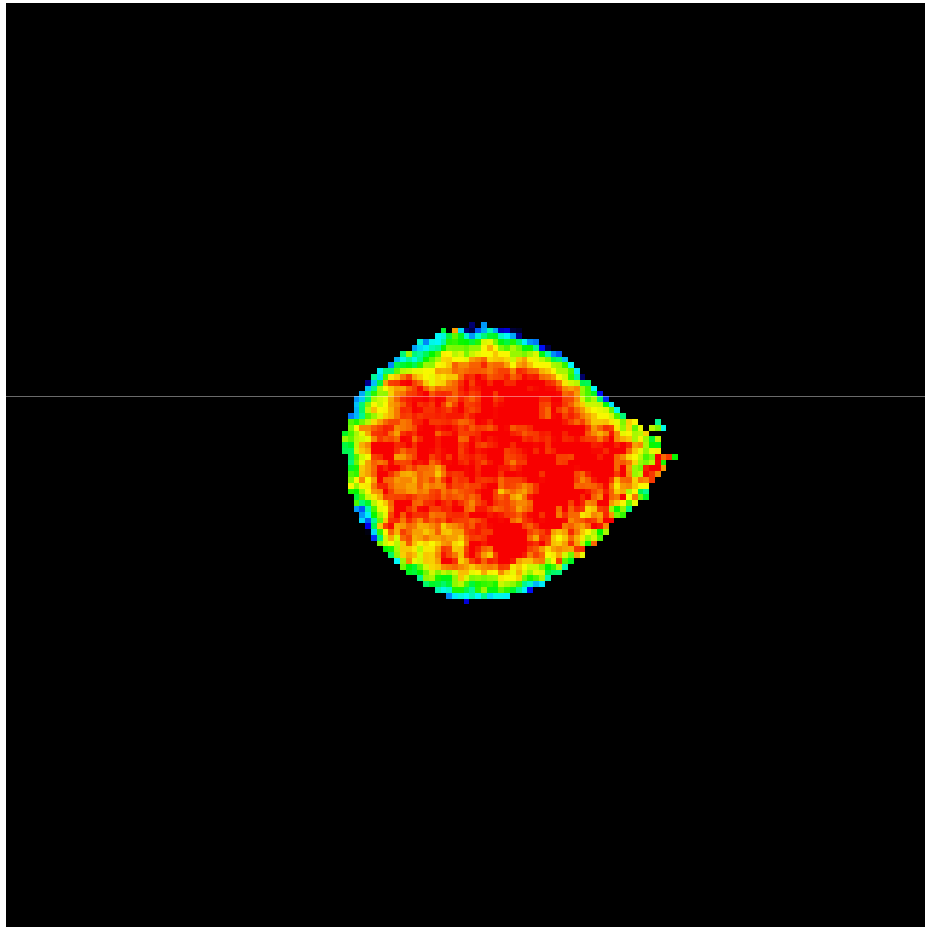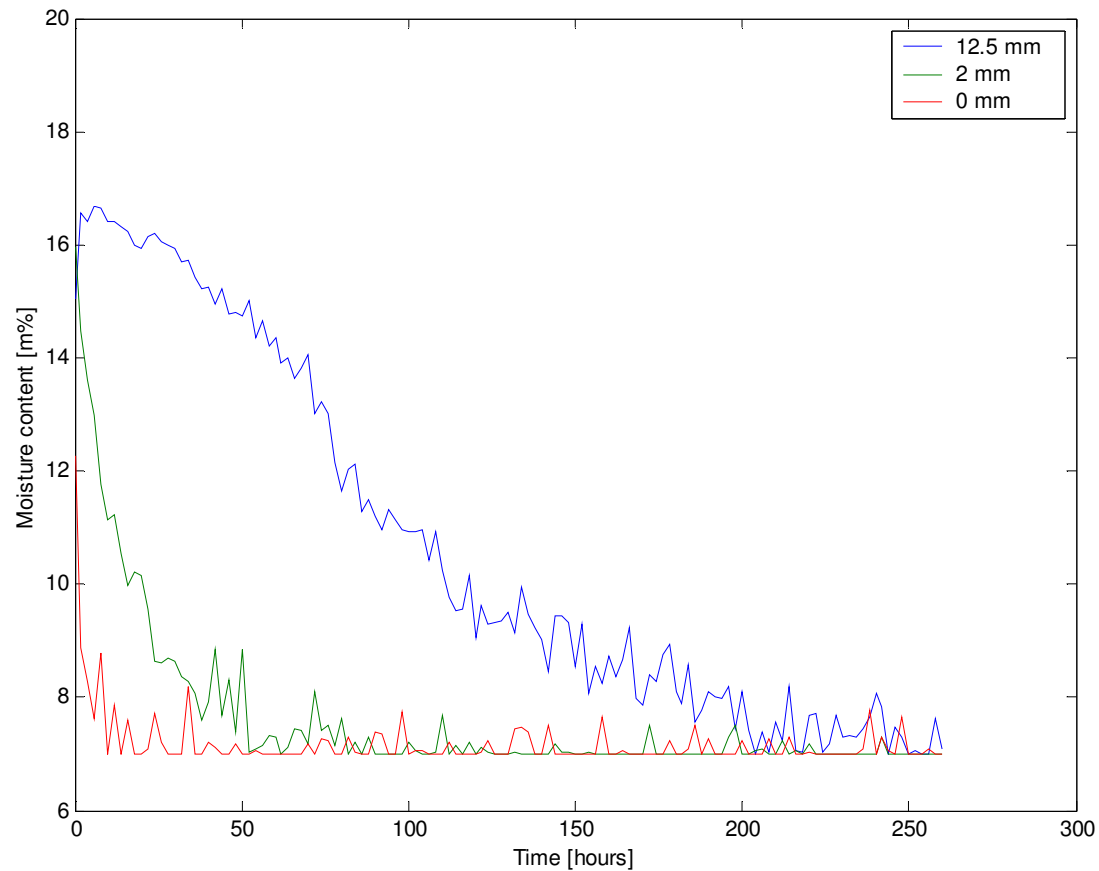
DOORSNEDE NMR-BUIS

Drying of a cylinder of wood

Drying of a cylinder of wood

Determining of diffusion coefficient

Optimal diffusivity: 5.8884e-010 m^2.s^{-1}

$$\frac{\partial w}{\partial t} = \nabla \cdot (D_v \nabla w)$$
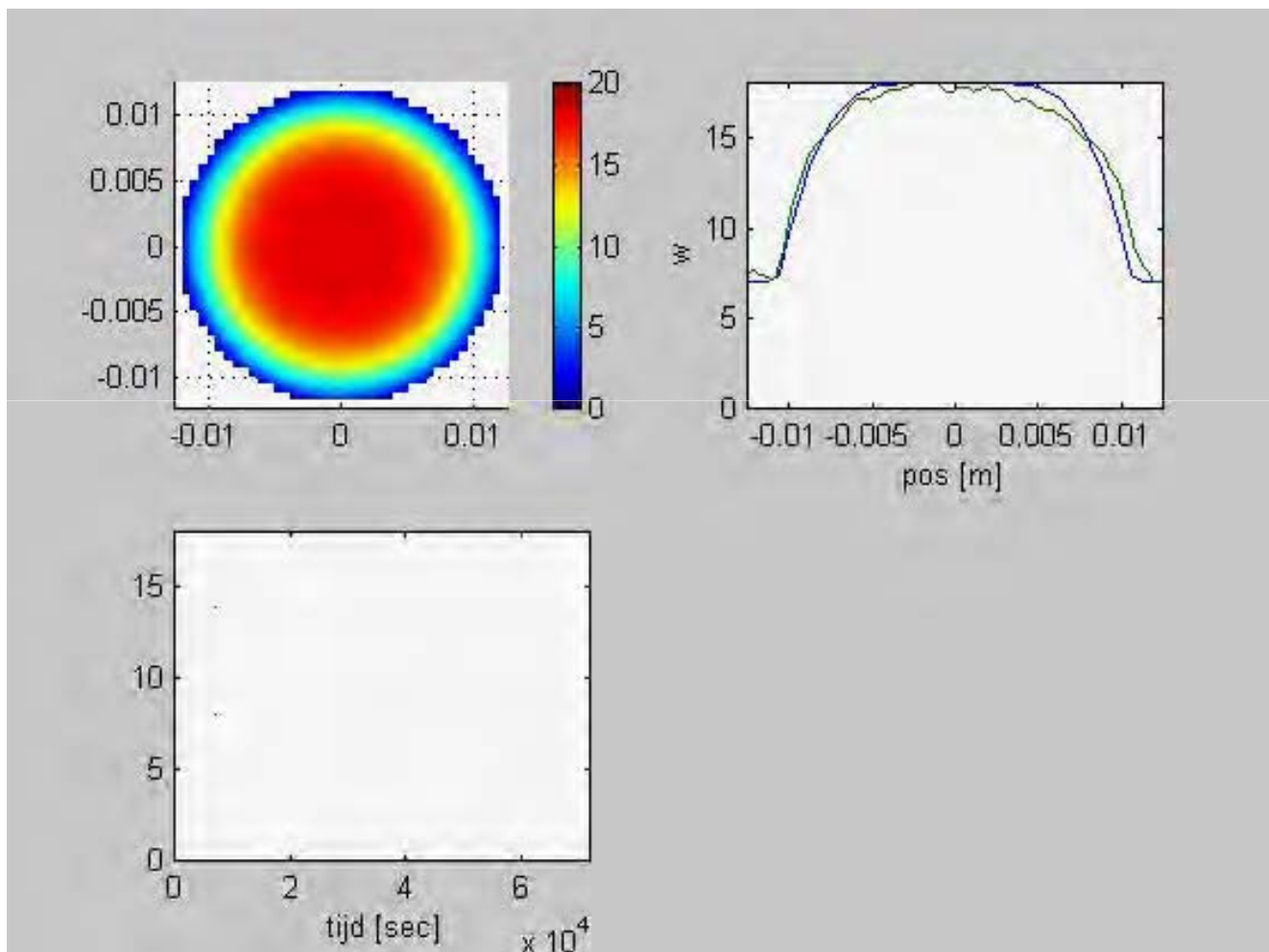
where

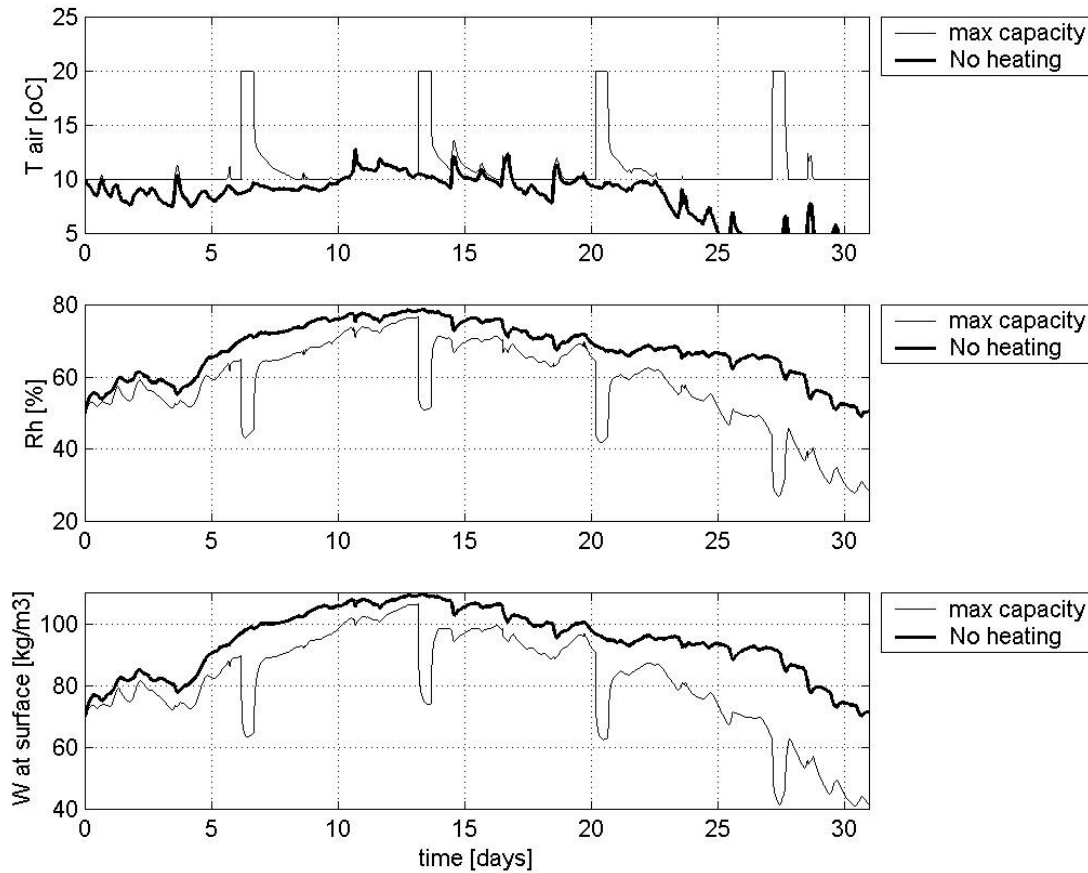**w = moisture content [kg/m3]**
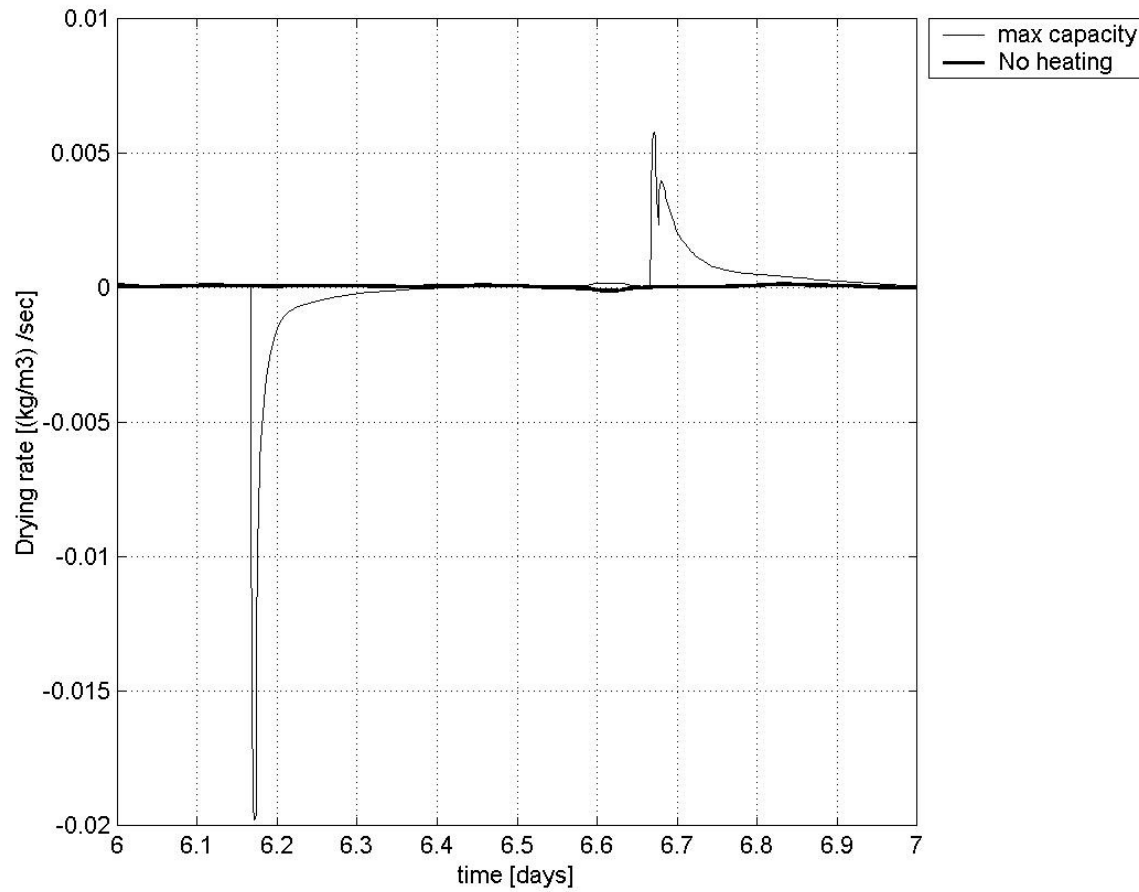
D$_v$ = vapor diffusivity [m2/s]

t   = time   [s]

Measurement vs Simulation

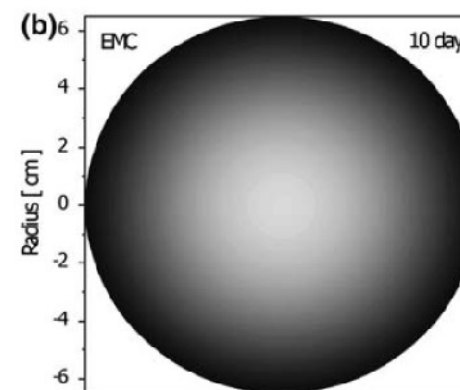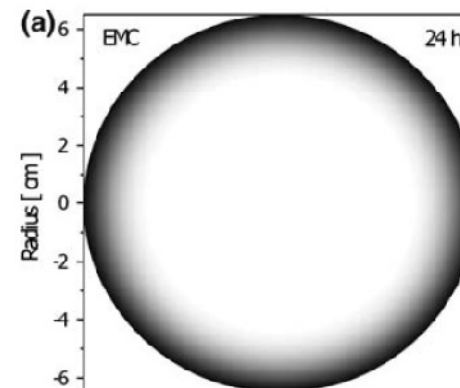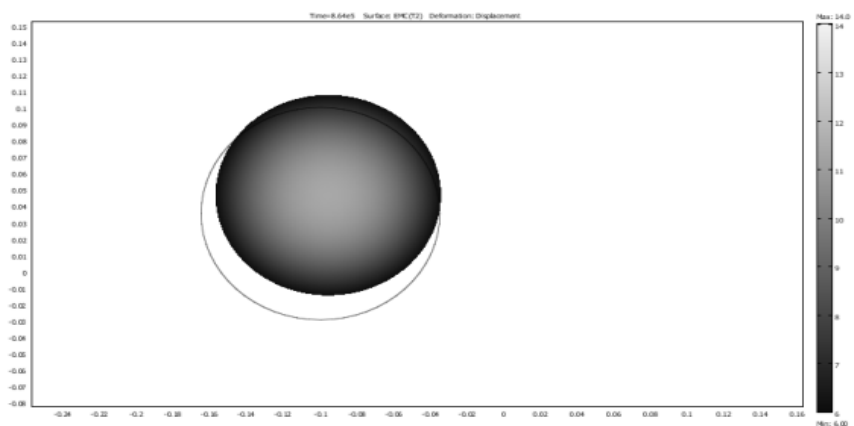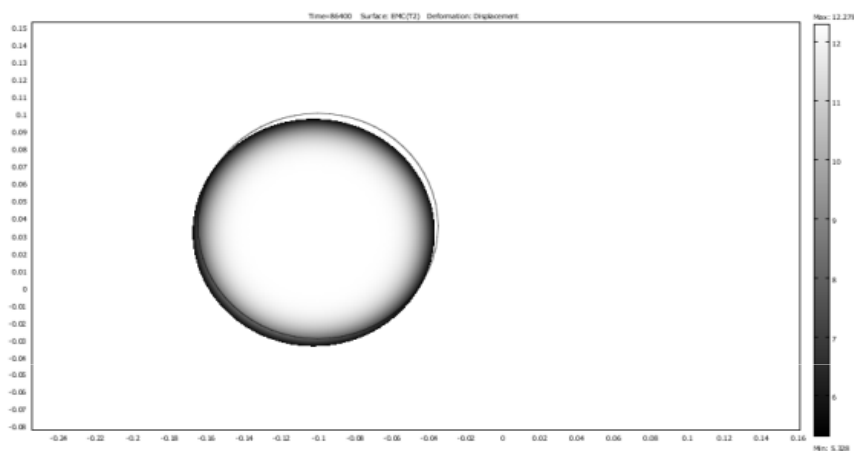# Results

Drying rate

New model in Comsol

- **Hygrothermal model**
  - **thermal transport**
  - **hygric transport**
- **Linear elastic mechanical model**
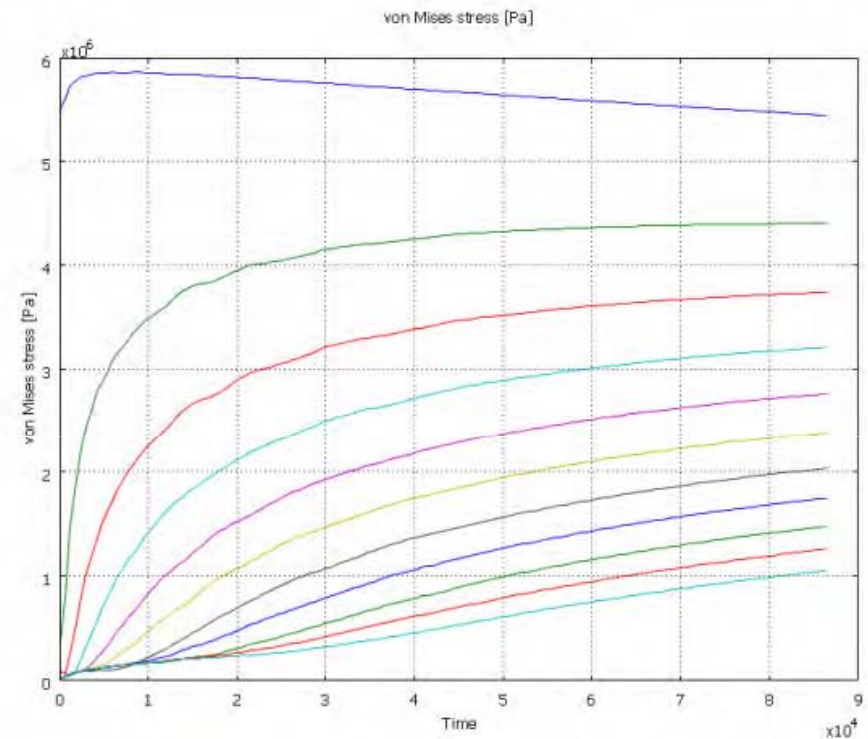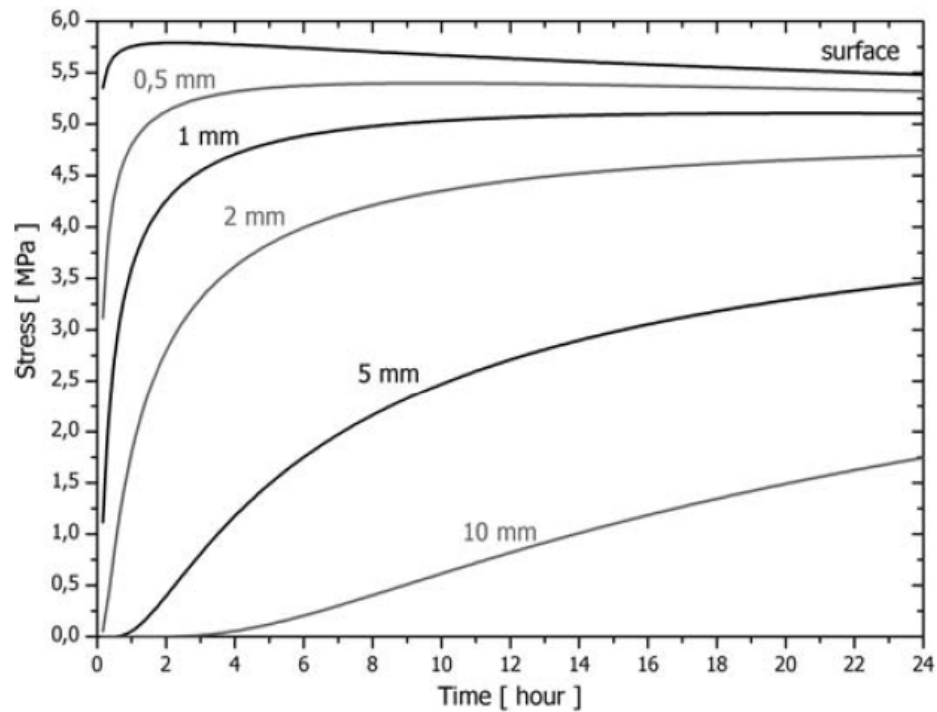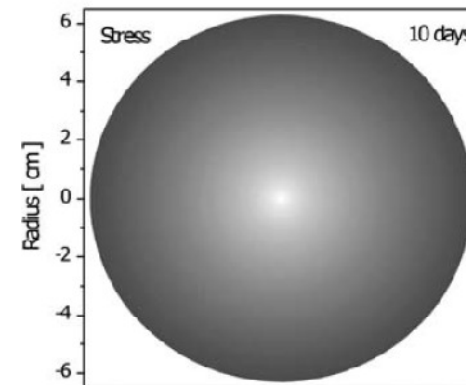- **Results compared to Jakiela et al.**

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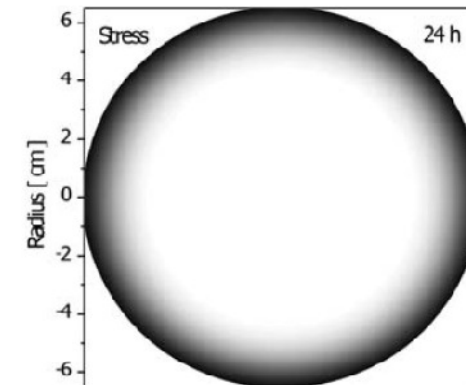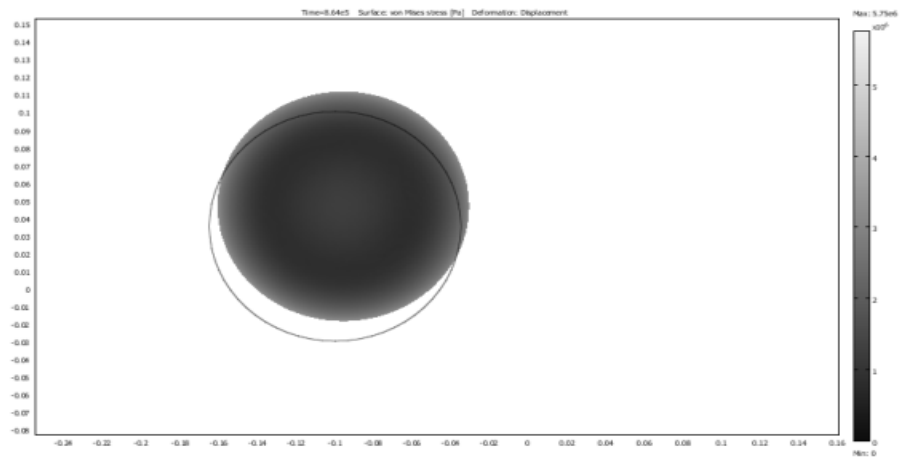**Eindhoven**
University of Technology
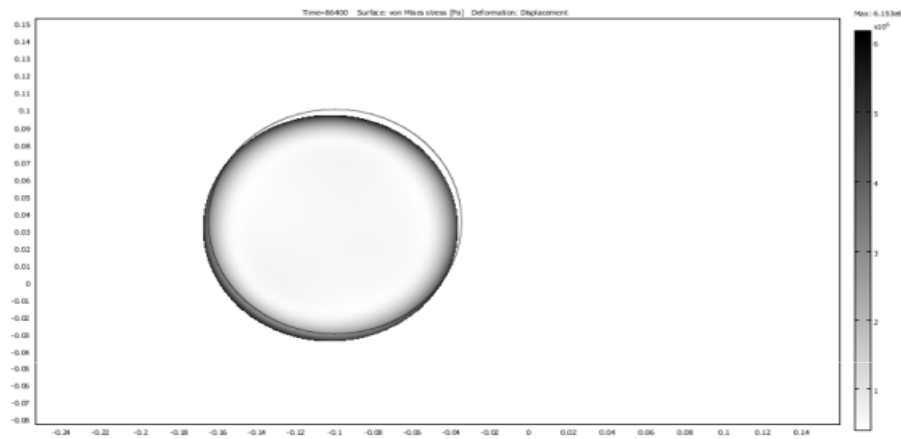
Moisture distribution

Moisture distribution

Stress distribution
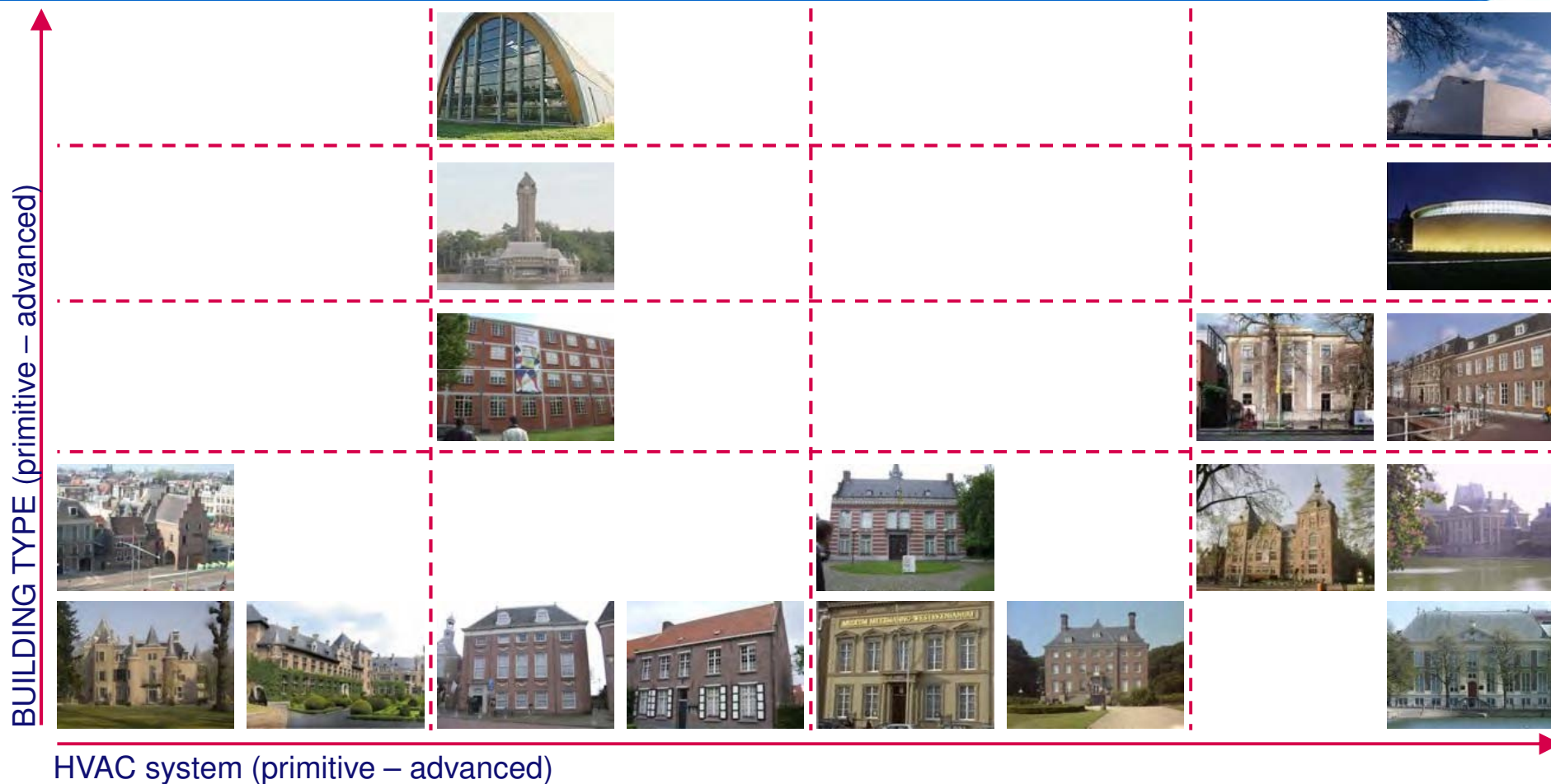
Stress distribution

PhD work Marco Martens

BUILDING TYPE (primitive – advanced)

HVAC system (primitive – advanced)

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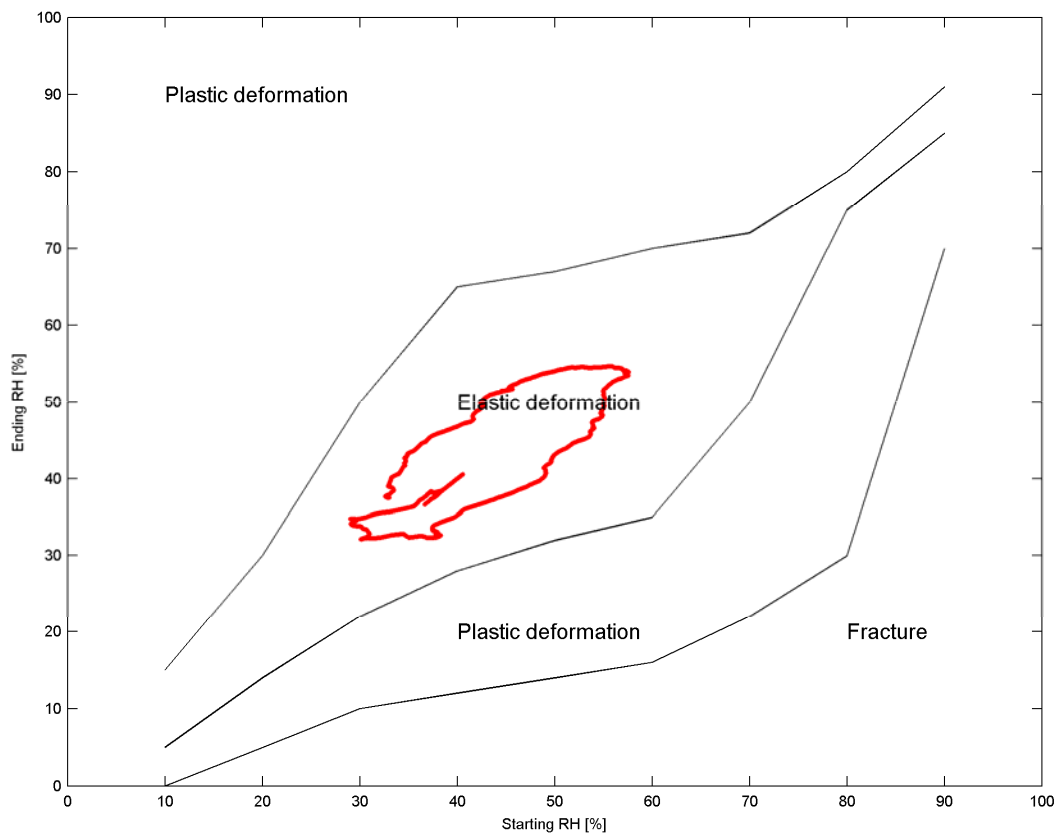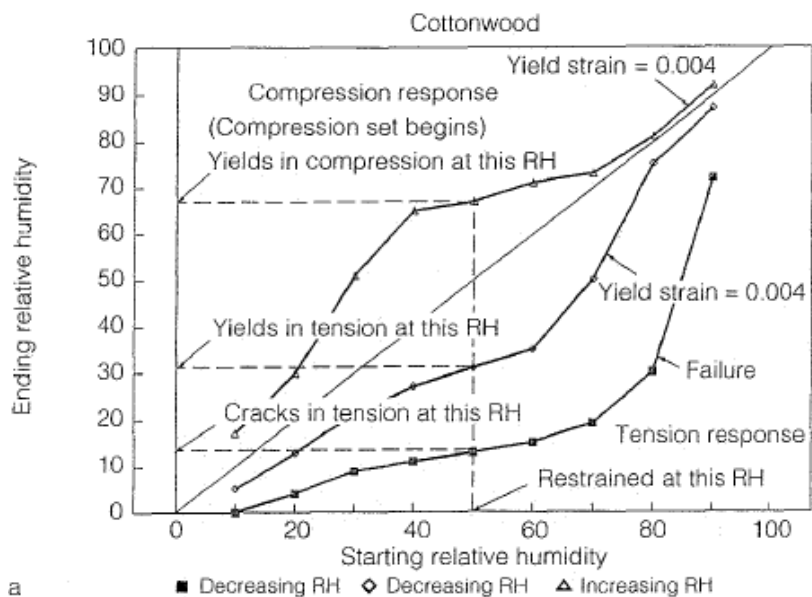University of Technology

WP 4,5:OBJECT METHOD: MECHANICAL

- **Gradient in wood (difference surface – bulk)**
- **Structural response (bulk over time)**

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WP 4,5:OBJECT METHOD: MECHANICAL

- **Gradient:**
  - Mecklenburg

Conclusions

Current results

- **COMSOL model for combined dynamic thermal and moisture transport**

- **Linear elastic stress calculation**

Future work:

- **Linkage to existing integrated Simulink model with building model and Simulink controller**

- **Dynamic stress calculations with measured and simulated indoor boundary conditions**

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