Berner Fachhochschule
Haute école spécialisée bernoise
Bern University of Applied Sciences

EMPA
Materials Science & Technology

# Assessment and monitoring of the moisture content of timber bridges

**Bettina Franke**

Robert Widmann, Andreas Müller, Thomas Tannert

# Monitoring of timber road bridges

- Introduction
- Hygroscopic behaviour of wood
- Measuring method for moisture content
- Example for monitoring systems and projects
- Assessment and results for timber road bridges
- Conclusion and view

# Monitoring of timber road bridges

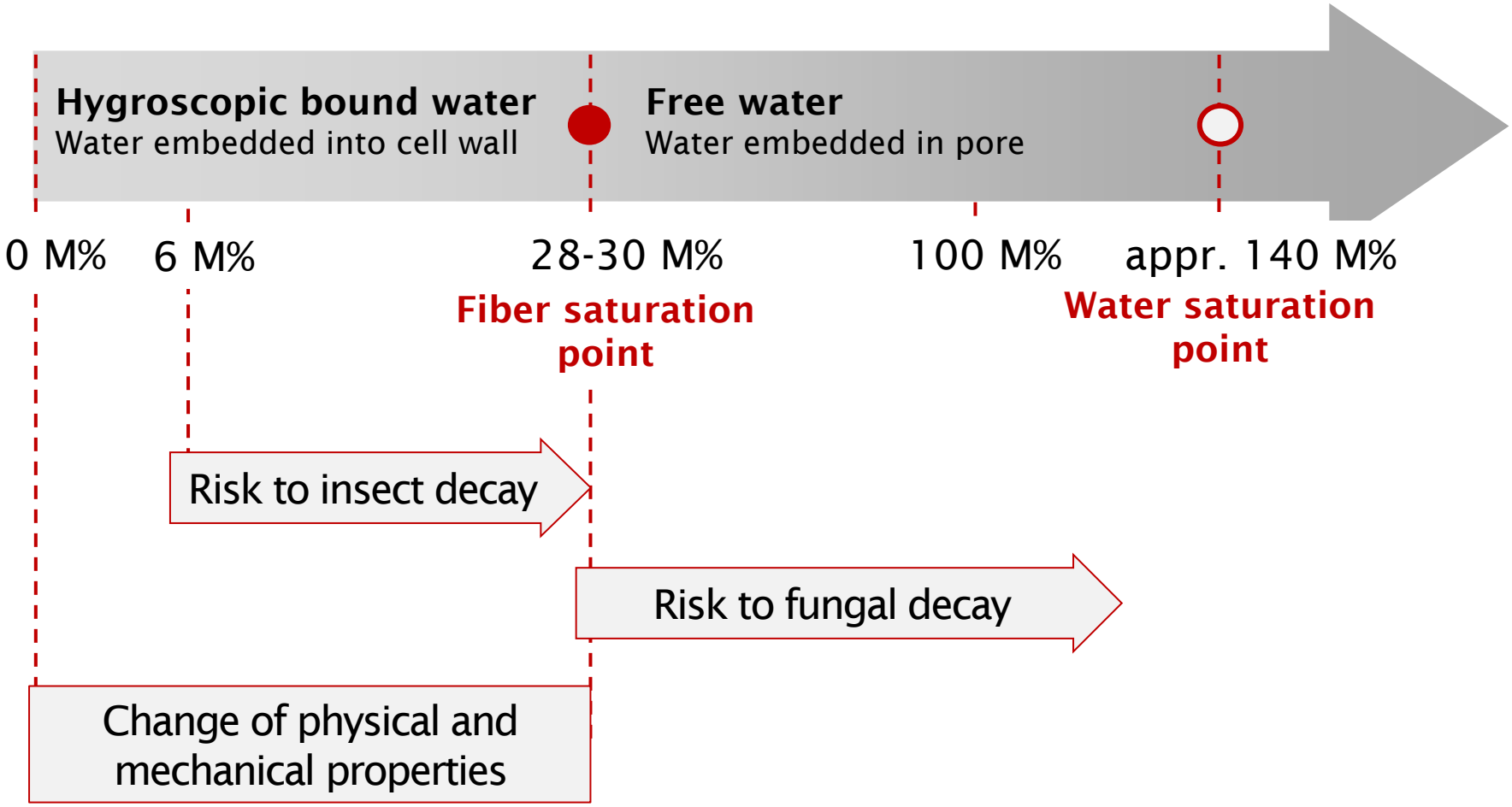
- Solid timber ⇒ Glued laminated timber ⇒ Block glued laminated timber
  - Increasing cross sections
  - Increasing differences of moisture content (out- and inside)

Pedestrian and bicycle bridge over Danube near Dietfurt

Timber road bridge near Bulle

# Monitoring of the moisture content

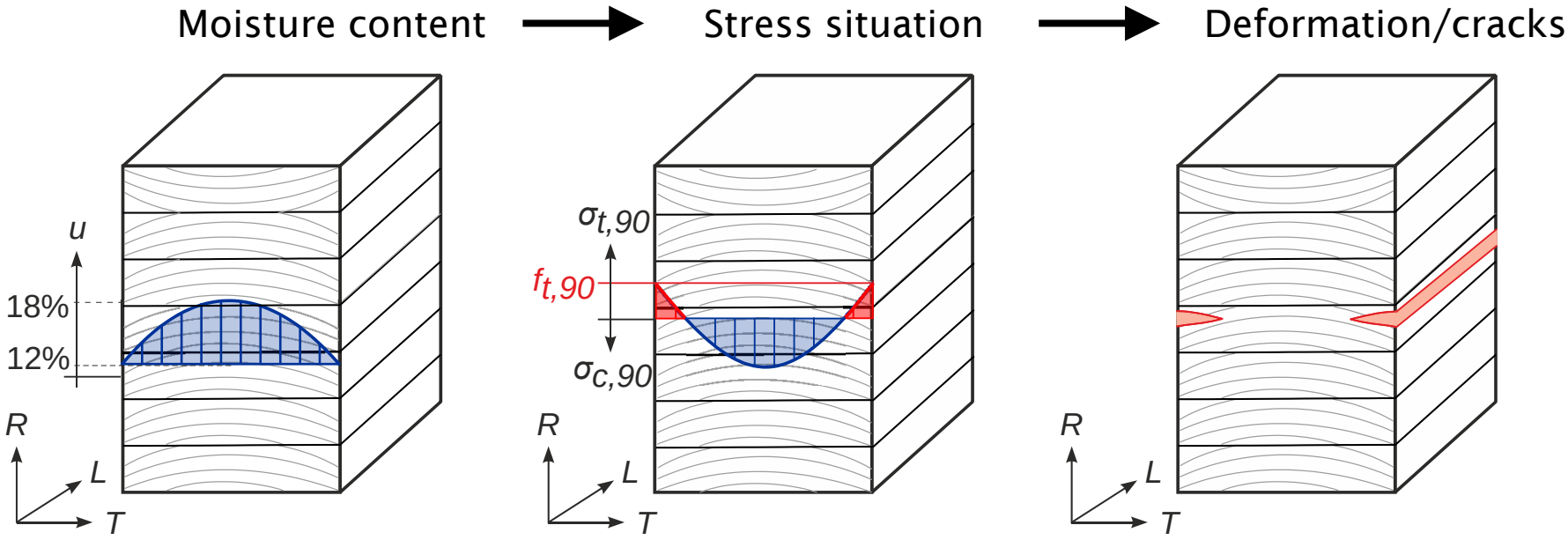
- Hygroscopic behaviour of wood



# Monitoring of the moisture content

- Hygroscopic behaviour of wood
  - Below the fibre saturation point
  - Change of physical and mechanical properties of wood
  - Swelling and shrinkage!

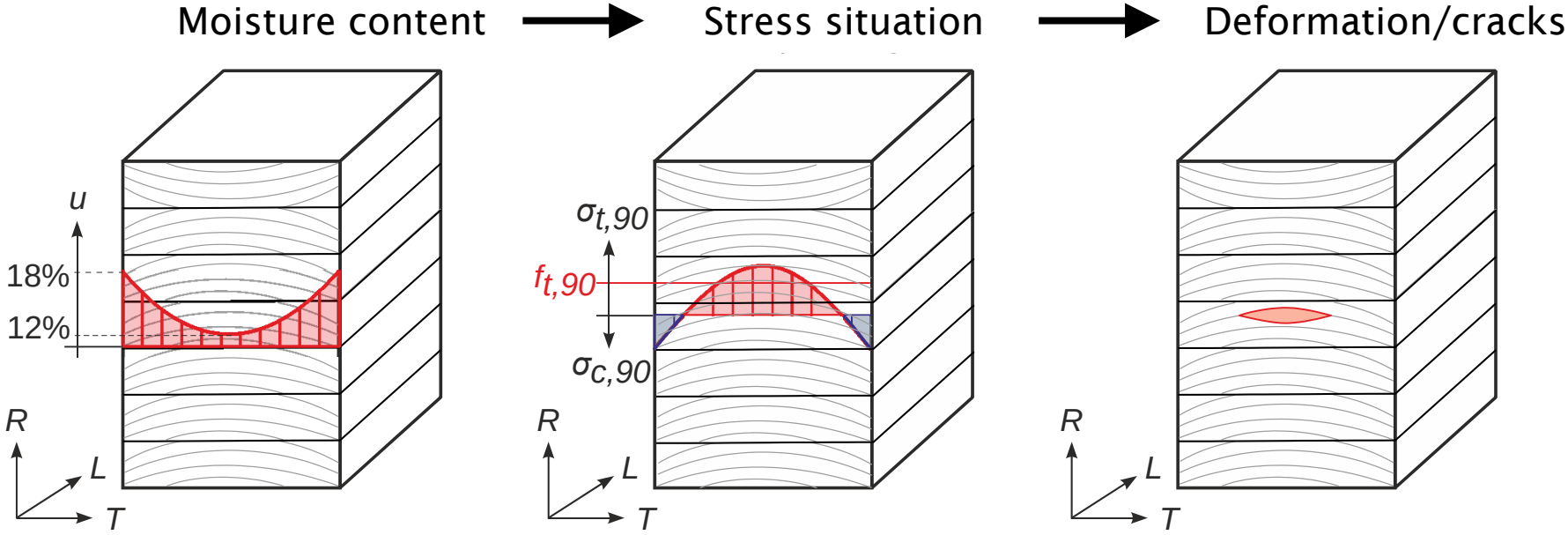
Desorption



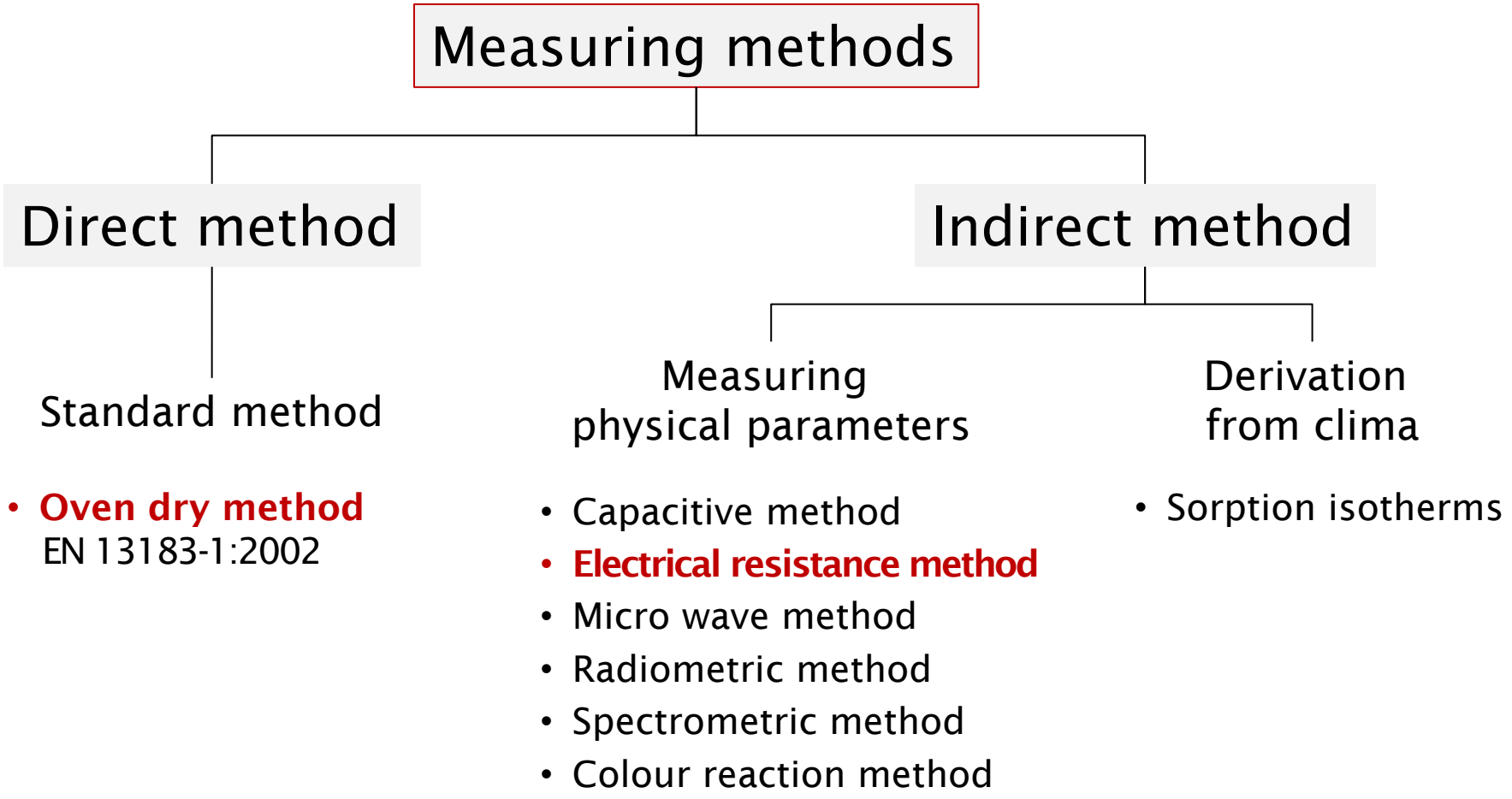
# Monitoring of timber structures

- Hygroscopic behaviour of wood
  - Below the fibre saturation point
  - Physical properties of wood
  - Swelling and shrinkage

Adsorption



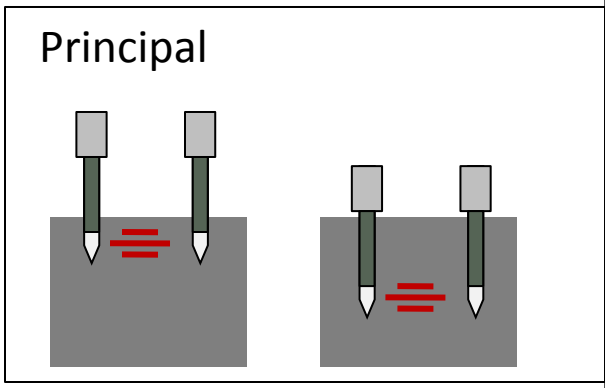
# Measurement methods of the moisture content



# Electrical resistance method

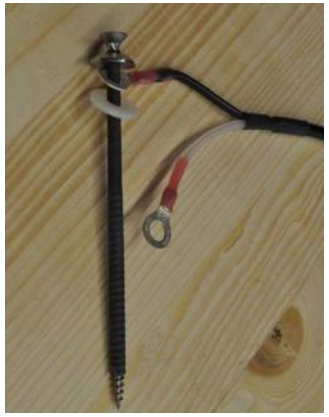
- Principal: Relation of the electrical conduction to moisture content of wood


- Non destructive and easy to use
- Two measuring sensors as pair needed and insertion perp. to grain
- Measuring range from 0 M% up to 90 M%
- Measuring accuracy 2 M%
  within the range from 6 M% - 25 M%
- Surrounding and wooden temperature range from 10 °C to 40 °C
- Measuring in different depths of the cross section → Detection of desorption and adsorption phase




# Electrical resistance method

- Measuring equipment
  - Classical instrument
  - Screws as sensors
  - Data loggers
  - Remote systems







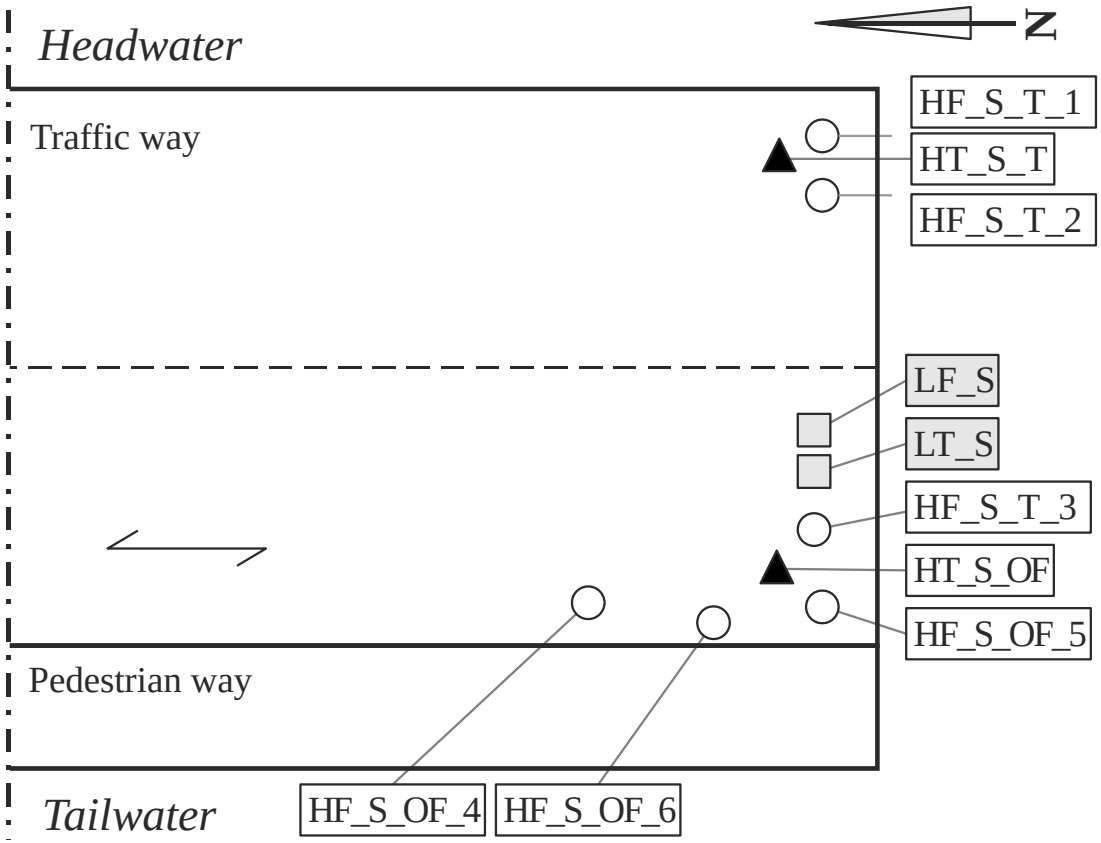
# Long-term monitoring of timber road bridges

- Monitored timber bridges in Switzerland by BFH-AHB



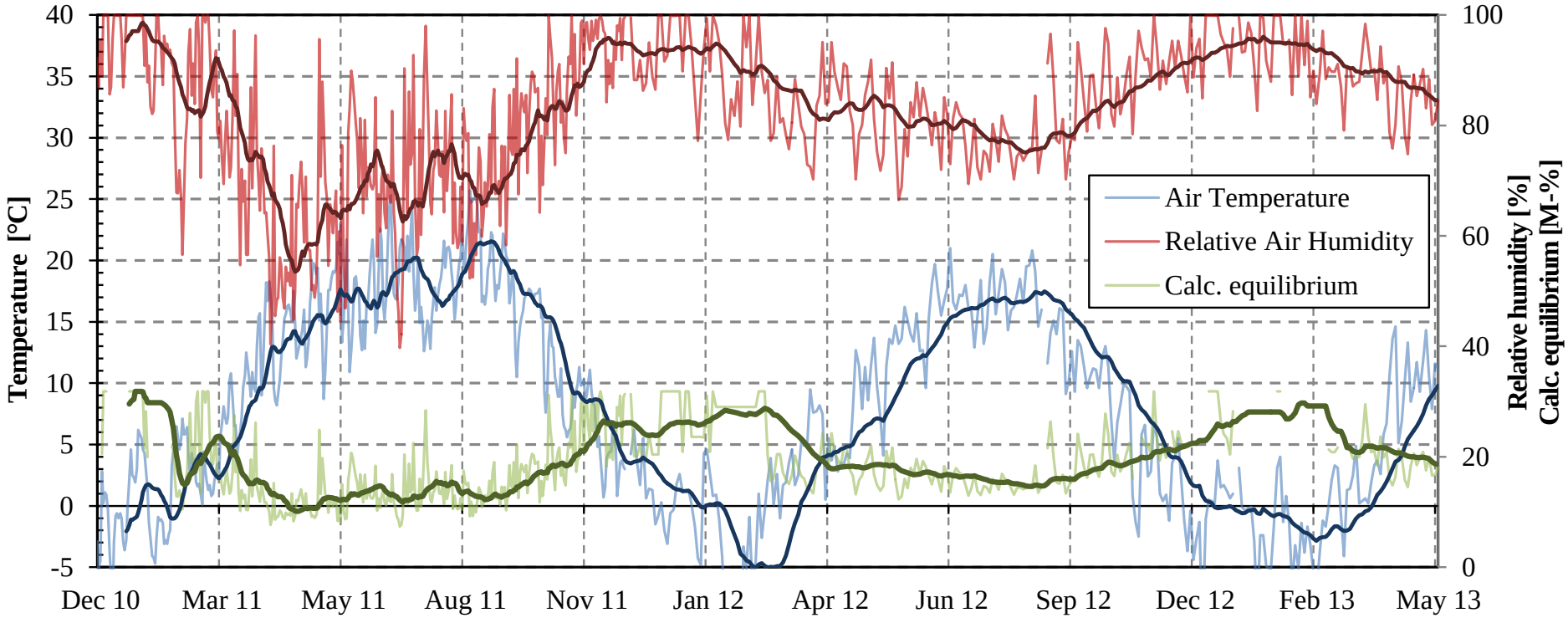

# Long-term monitoring of timber road bridges

- Measuring setup/plan of bridge Obermatt



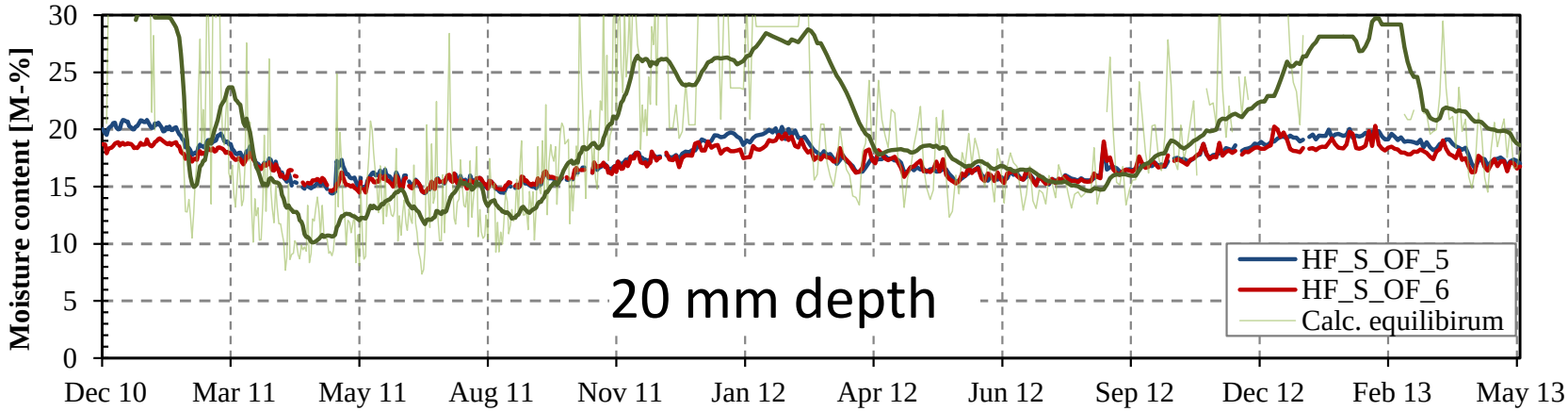
# Long-term monitoring of timber road bridges

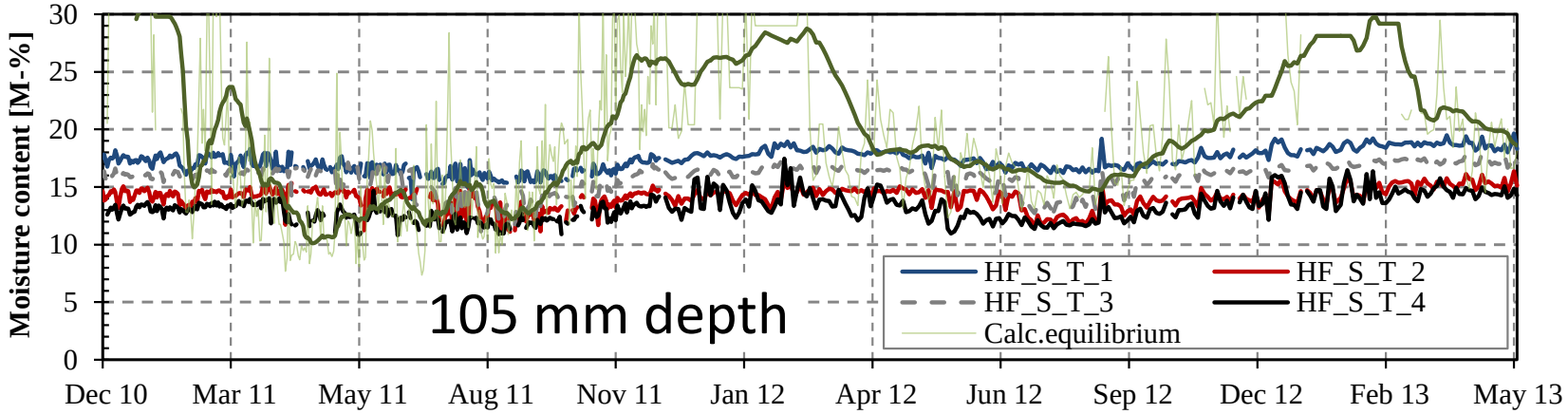
- Measuring results of Bridge Obermatt
  - Climate data
  - Corresponding calculated equilibrium moisture content



# Long-term monitoring of timber road bridges

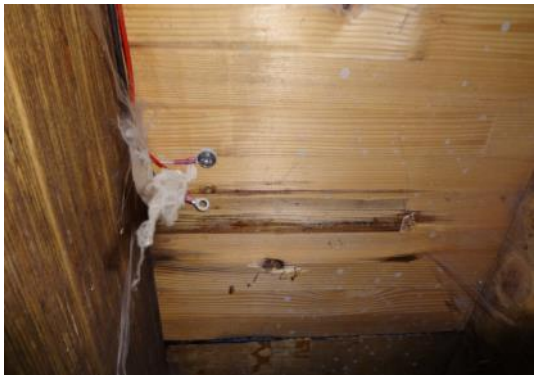
- Measuring results of Bridge Obermatt
  - Moisture content in different depths of the cross section

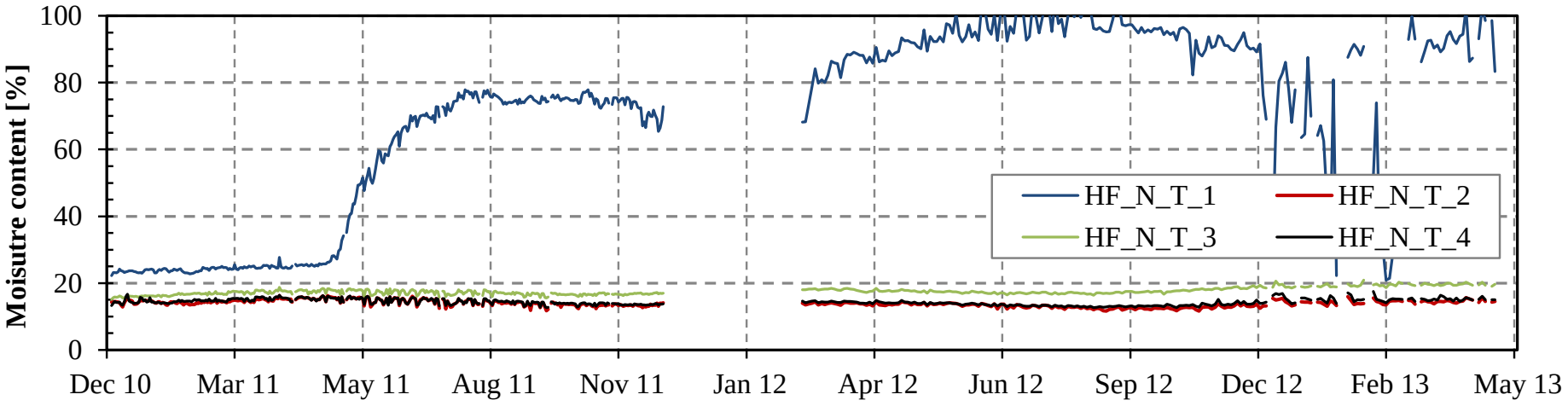


# Long-term monitoring of timber road bridges

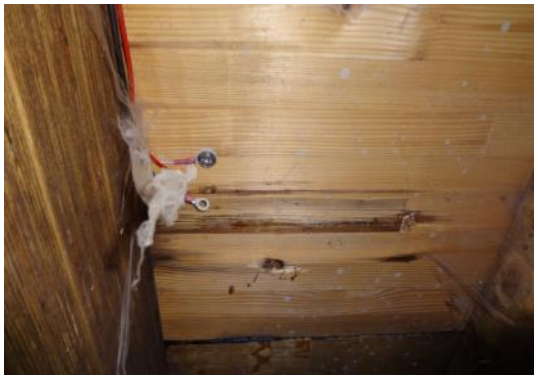
- Measuring results of Bridge Obermatt
  - Irregular change of moisture content



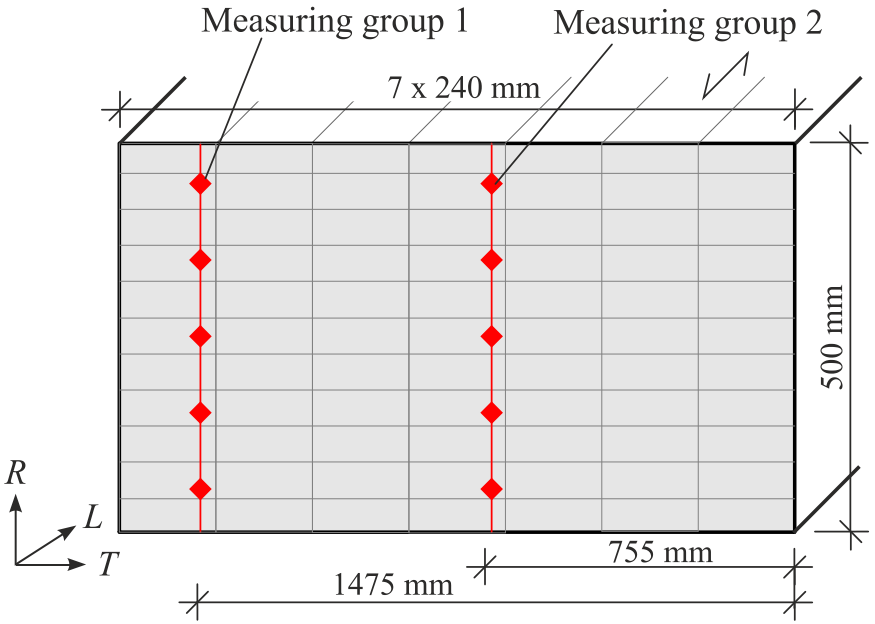
# Long-term monitoring of timber road bridges

- Measuring results of Bridge Obermatt
  - Irregular moisture contents



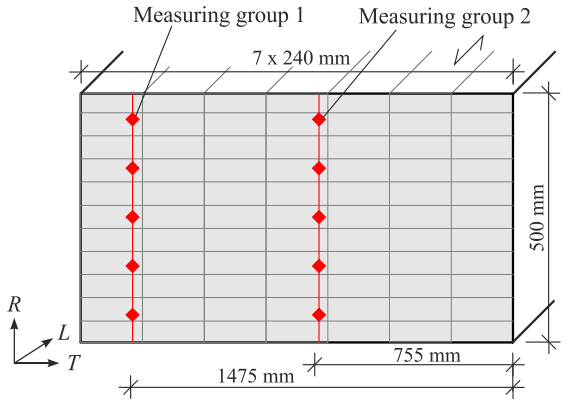

# Long-term monitoring of timber road bridges

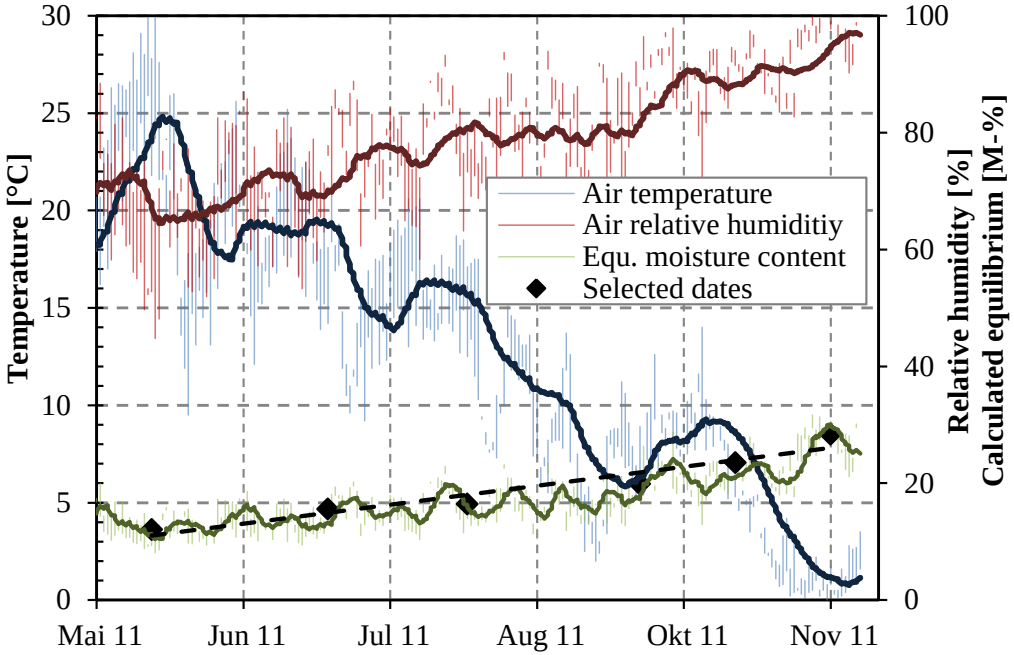
- Measuring setup/plan of bridge Horen

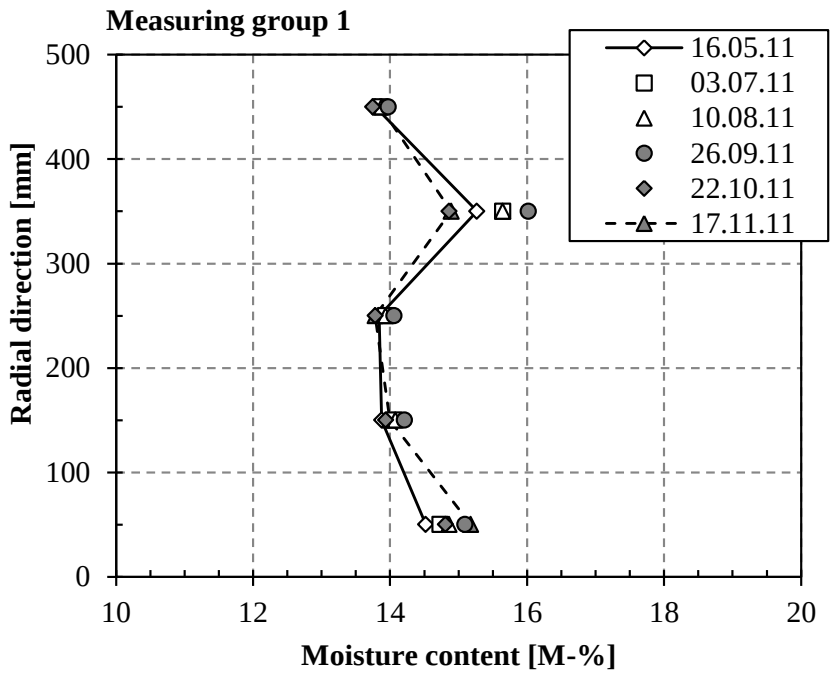


# Long-term monitoring of timber road bridges

- Measuring results of Bridge Horen
  - Adsorption period
  - Almost no differences for both measuring lines (changes are within the measuring accuracy)

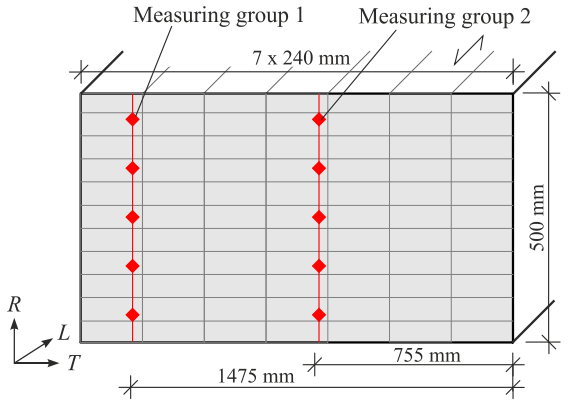


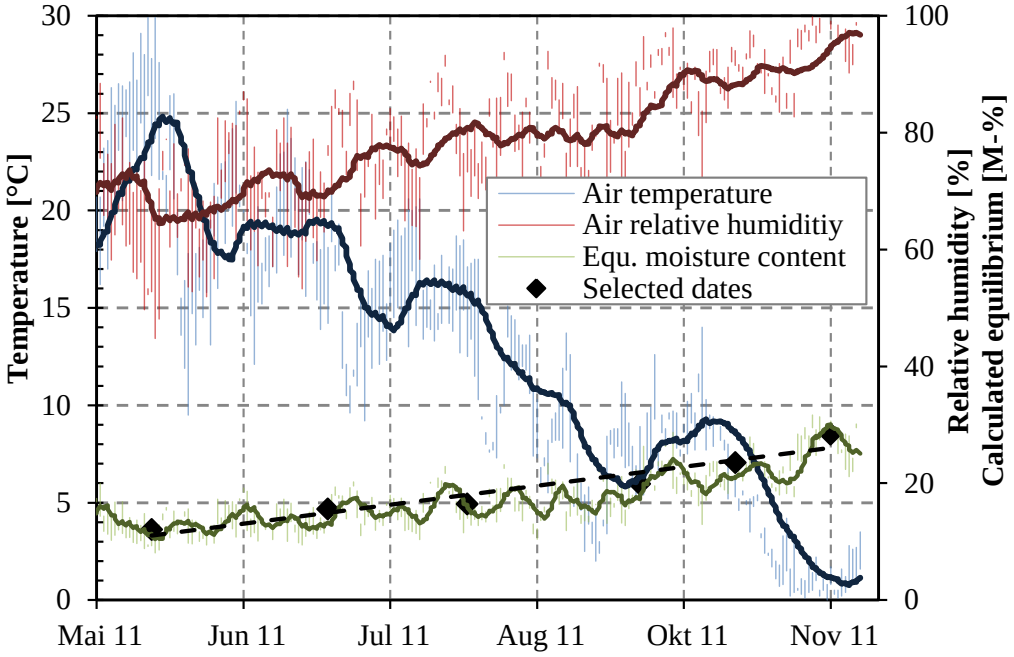



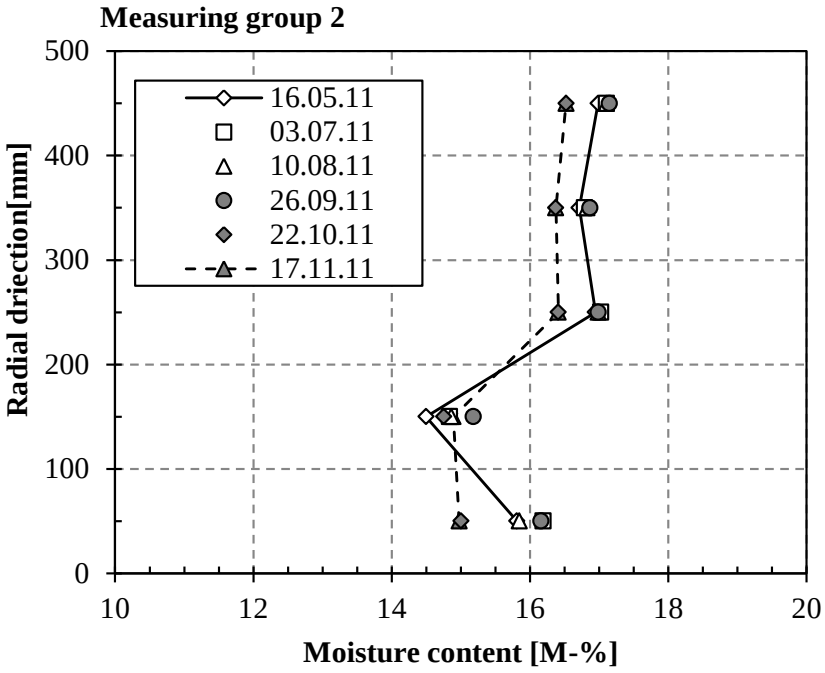



# Long-term monitoring of timber road bridges

- Measuring results of Bridge Horen
  - Adsorption period
  - Almost no differences for both measuring lines (changes are within the measuring accuracy)

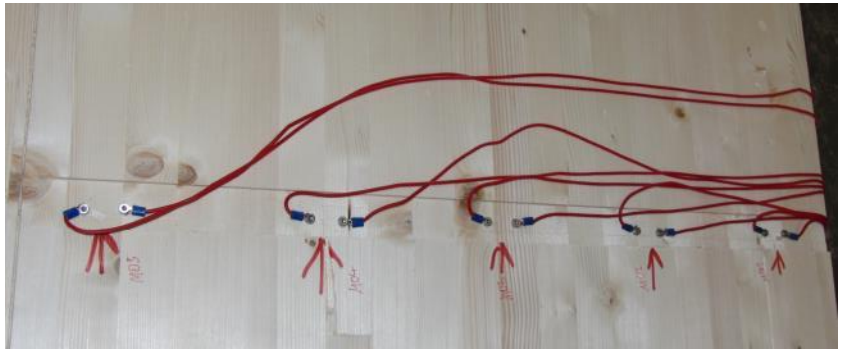


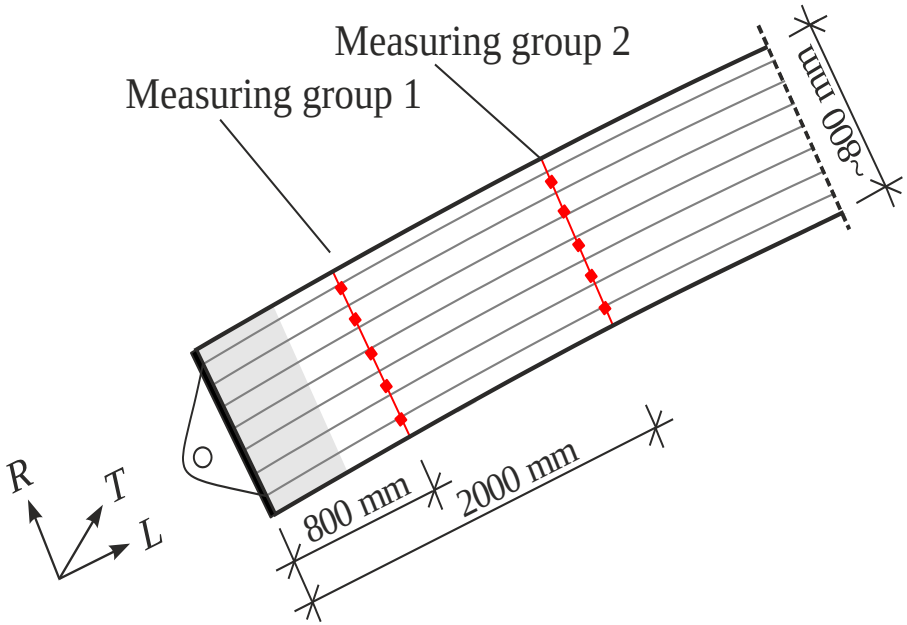



# Long-term monitoring of timber road bridges

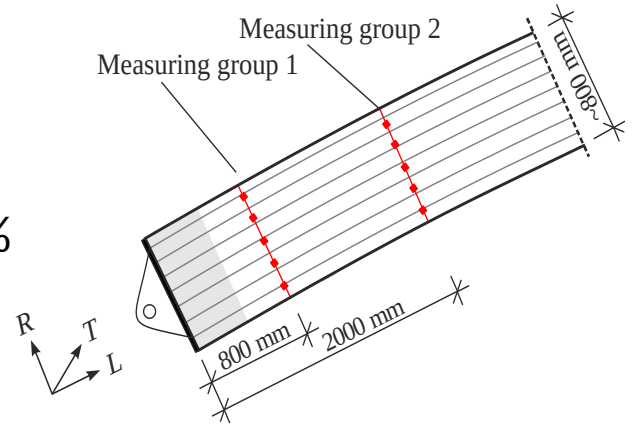
- Measuring setup/plan of bridge Muotathal

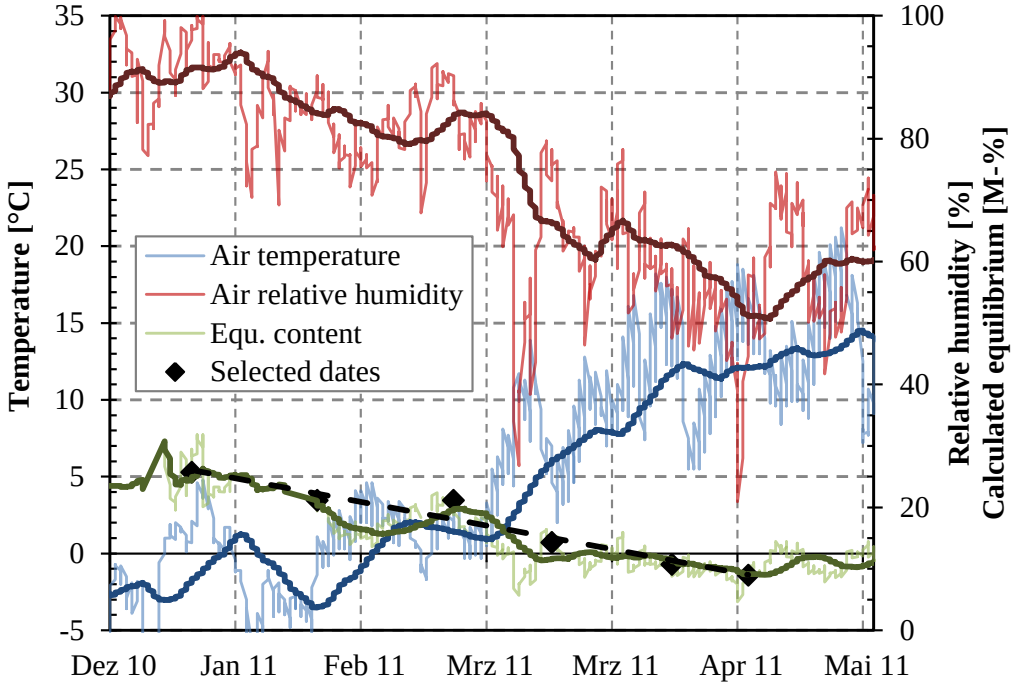


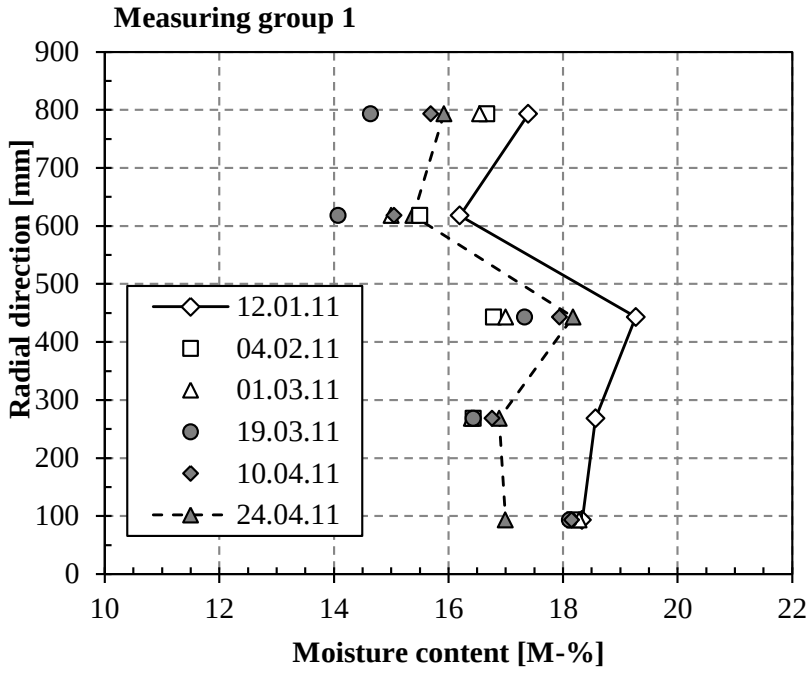


# Long-term monitoring of timber road bridges

- Measuring results of Bridge Muotathal
  - Desorption period,
    theoretical decrease from 25 M% to 9 M%
  - Less reaction for both measuring lines

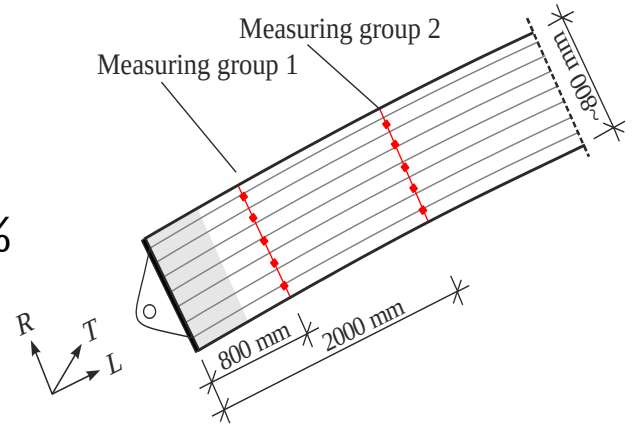


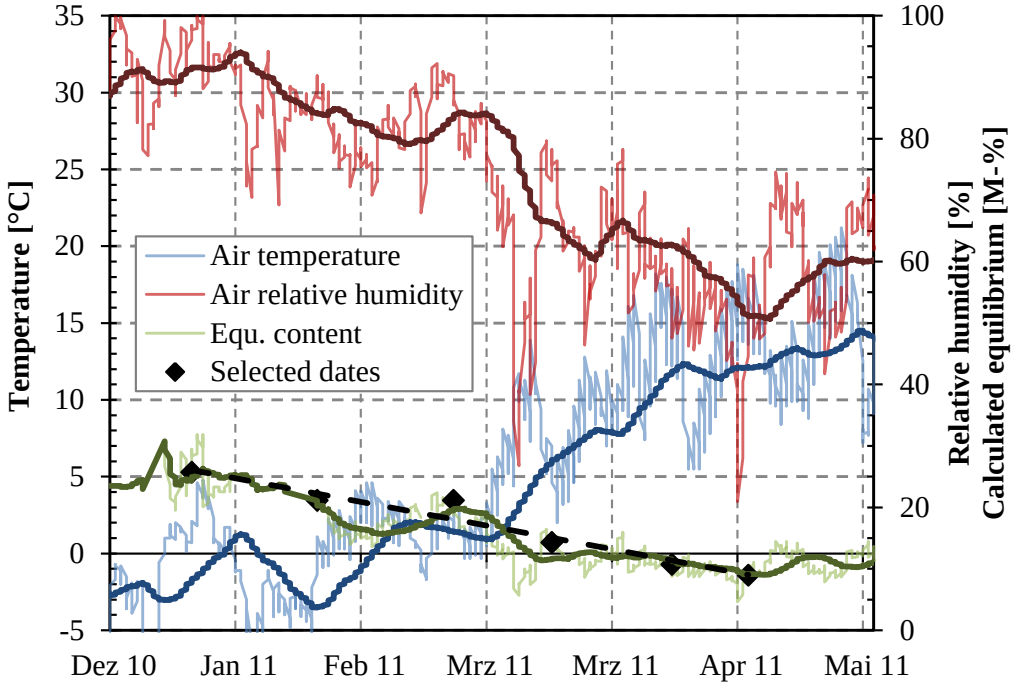



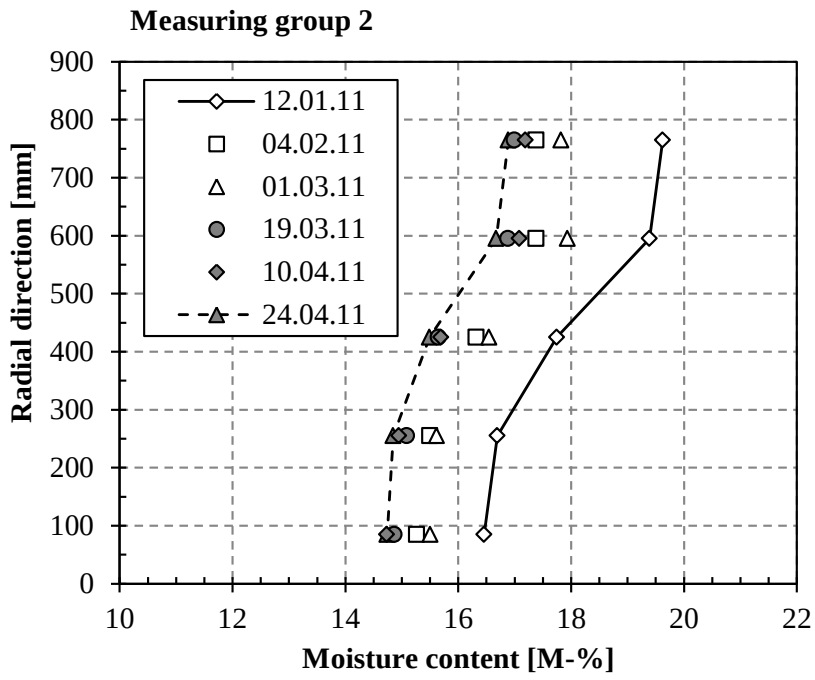



# Long-term monitoring of timber road bridges

- Measuring results of Bridge Muotathal
  - Desorption period,
    theoretical decrease from 25 M% to 9 M%
  - Less reaction for both measuring lines



# Long-term monitoring of timber road bridges

## Conclusion and outlook

- Long term monitoring gives the possibility to observe extensive and unusual moisture accumulations at an early stage to avoid decay/fungal development
- Electrical resistance measurement method was used in several case studies and proofed its capability to determine the moisture content
- Change of moisture content in the timber members is delayed and with less variation depending on the distance to the surface against the calculated equilibrium moisture content
- The moisture content in the timber varies between about 12 M% and 22 M% for outdoor climate conditions
- No major differences could be detected between the positions of the measuring sensors (too large distances used)
- Further investigations with smaller distances needed

# Thank you for your attention!

**Robert Widmann**
Bettina Franke
bettina.franke@bfh.ch

www.ahb.bfh.ch