Assessment and monitoring of the moisture content of timber bridges

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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
  - **Hygroscopic bound water**: Water embedded into cell wall
  - **Free water**: Water embedded in pore

  - 0 M% to 6 M%: Fiber saturation point
  - 28-30 M%: Risk to insect decay
  - 100 M%: Change of physical and mechanical properties
  - appr. 140 M%: Water saturation point

- Risk to fungal decay
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

Moisture content → Stress situation → Deformation/cracks
Monitoring of timber structures

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

Adsorption

Moisture content  ➔  Stress situation  ➔  Deformation/cracks
Measurement methods of the moisture content

Measuring methods

- Direct method
  - Standard method
    - Oven dry method
      - EN 13183-1:2002

- Indirect method
  - Measuring physical parameters
    - Capacitive method
    - Electrical resistance method
    - Micro wave method
    - Radiometric method
    - Spectrometric method
    - Colour reaction method
  - Derivation from clima
    - Sorption isotherms
Electrical resistance method

- Principal: Relation of the electrical conduction to moisture content of wood
- Non-destructive and easy to use
- Two measuring sensors as a pair needed and insertion perpendicular 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

![Diagram of bridge Obermatt with labeled parts: Headwater, Traffic way, Pedestrian way, Tailwater, various points labeled as HF_S_T_1, HT_S_T, HF_S_T_2, HF_S_OF_5, etc.](image-url)
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

![Graph showing moisture content over time for two different depths: 20 mm and 105 mm.](image-url)
Long-term monitoring of timber road bridges

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

![Image of monitoring setup]

![Graph showing moisture content over time for different sensors]

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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

![Graph showing temperature, relative humidity, and moisture content over time with selected dates for Measuring group 2.](image)
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!

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