Conference Proceedings 4th ICTB (2022)
https://doi.org/10.24451/t6nk-7h98

Climate and moisture monitoring in the timber wildlife bridge "Rynetel"

Sébastien Bonifacio[1], Marcus Schiere[2], Andreas Müller[3]

1 Introduction

With the first Swiss timber wildlife bridge 'Rynetel' over the A1 highway in Suhr (CH), timber is also introduced for the construction of wildlife crossings in Switzerland [1]. Approximately 70,000 vehicles pass through the structure daily. The construction was required to be durable and robust to allow a service life of 100 years, comparable to that of concrete structure [2]. The design was based on the first positive experience and knowledge gained from the four wildlife bridges built in Germany since 2005 [3][4]. For the wildlife bridges in Germany, wood species with a higher natural durability such as larch or Douglas fir were used. These are not available in sufficient quantities (regionally) in Switzerland for a structure of this type and size.

At the moment there is not enough knowledge about the prevailing climate conditions in a wildlife crossing over a highway to predict wood moisture and thus evaluate the use of native available spruce and fir ensuring the desired lifespan.

The project «Climatic conditions at timber overpasses for wild animals» aims to record and scientifically evaluate the general climate conditions thanks to a systematically monitoring of the structure. Special emphasis was also placed on the impact of traffic movements on the climate inside the structure. The timber construction is expected to be exposed to large volumes of water from spray carried inwards by traffic during rainfall. On the other hand, the traffic could also have a positive impact on air change (flow) in the structure and, hence, improve the drying capacity of the structure.

The impact of the cross-sectional shape and design of the tunnel-like bridge structure on the moisture levels and drying speed of the wood will also be analyzed in the future. This paper explains the properties of the implemented monitoring system to obtain all the data needed to perform the data analysis and achieve the project objectives mentioned above.

2 Measurement equipment

2.1 Wood moisture

Moisture content of the timber can generally be monitored either by performing local (spot) or global (surface) methods (Figure 1). To monitor a single spot, the electrical resistance measurement method, the sorption method and passive RFID are used. The electrical resistance measurement method is technically very simple and robust. The sorption method provides high accuracy and requires the installation of humidity and temperature sensors at the critical spot. [5]. One type of RFID tag measures the humidity in the immediate environment of the tag according to the principle of capacitive measurement. The use of RFID tags is low cost, and wireless [6].

[1] Sébastien Bonifacio, Bern Universitiy of Applied Sciences, Institute for Timber Construction, Structures and Architecture IHTA, currently: Projectingeneer, Timbatec Timber Construction Engineers Switzerland Ltd., Switzerland, sebastien.bonifacio@timbatec.ch
[2] Currently: Product Manager, Hupkes Wijma B.V., The Netherlands, mjs@hupkeswijma.com
[3] Bern University of Applied Sciences, Institute for Timber Construction, Structures and Architecture IHTA

https://doi.org/10.24451/t6nk-7h98

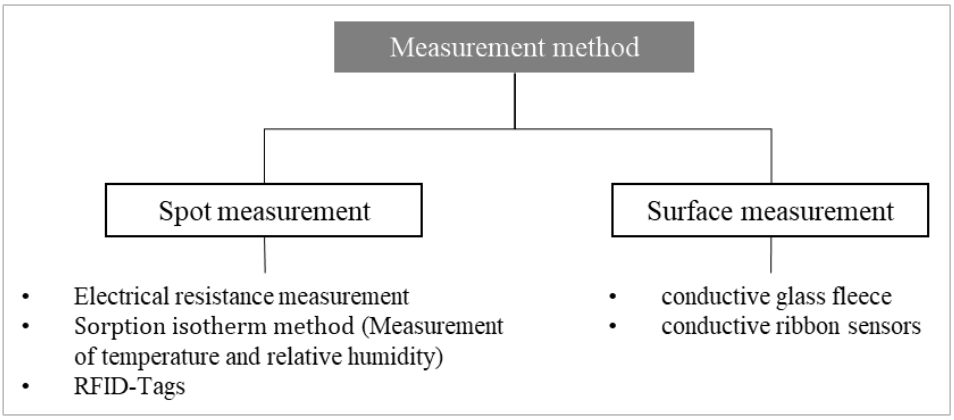

Figure 1 Overview of measurement methods used in monitoring systems in timber structures

With the surface measurement method, the moisture content of wood is measured over a large area. Surfaces can be reliably monitored with conductive glass fleece or with ribbon sensors. Both solutions are based on electric potential measurements. When the moisture changes or when water is present, the electrical potential changes. This way it is possible to monitor moisture over a wide area [6].

The project's purposes can only be achieved with accurate and reliable data. The above listed surface measurement systems are suitable for a surveillance system of the waterproofing system but do not provide sufficient accuracy for the scientific evaluations. The presence of salt and other chemical elements as well as measurements at temperatures below zero affect negatively the accuracy of the measurements with the electrical resistance system. For these reasons it was chosen to use the sorption method for wood moisture measurement. The RFID system did not allow for continuous measurements and are typically used for occasional measurements and could not be used to measure changes in conditions with a frequency of 3 hours.

Wood moisture is monitored with sensors that measure temperature and humidity inside a cavity (Figure 2 and Figure 3). Using a sorption curve, wood moisture is calculated [5].

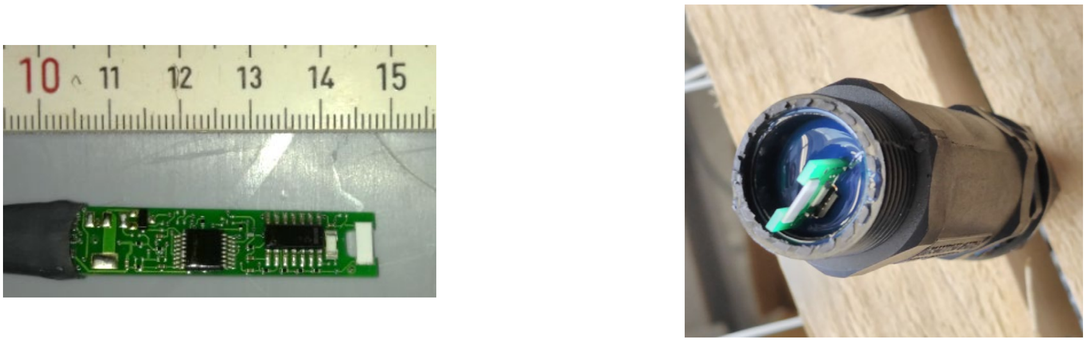

Figure 2 Air humidity and temperature sensor for measuring wood moisture by sorption method

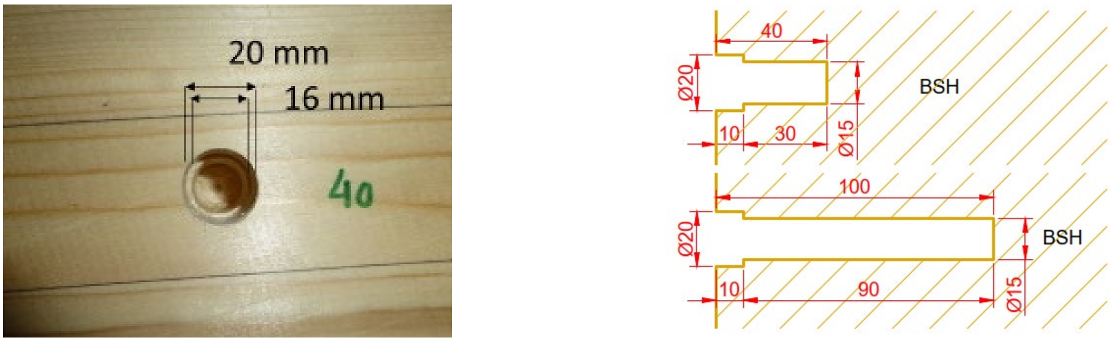

Figure 3 Preparation of holes in wood (left) and drawing for moisture measurement at 40 mm and 100 mm depth (right).

2.2 Outdoor climate sensor

The measurement of humidity and temperature is made with the same temperature and humidity sensor as the one with which the wood climate is determined. This is placed in a plastic box, which is connected to the outside air through a hole. The box is protected from radiation of heat/cold towards the underlying roadway by a steel plate.

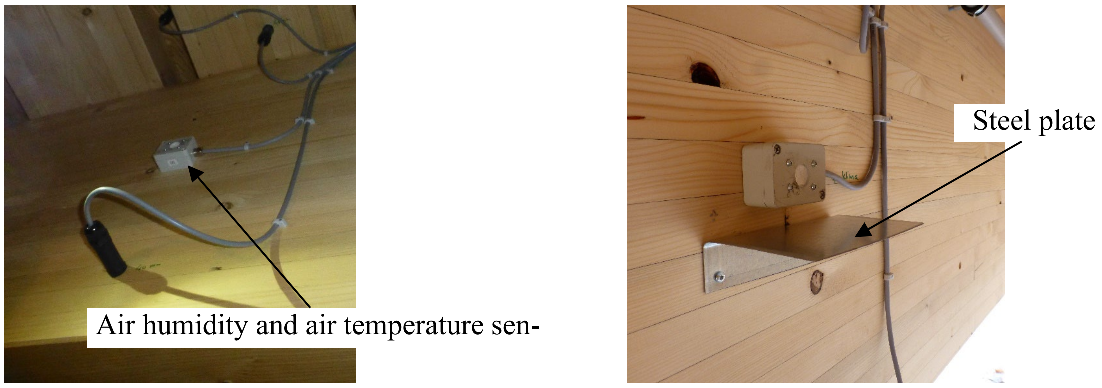

Figure 4 Air humidity and air temperature sensor (left) and steel plate as radiation protection (right).

2.3 Spray cloud and air exchange measurement

The measurement of spray cloud is carried out with rain sensors. If water lands on the surface of the beams, this is detected as spray cloud by the rain sensors. The air exchange due to the traffic in the structure is measured with a cup anemometer. Both systems were not calibrated and are used for qualitative comparisons of changes in the conditions within the wildlife bridge such as more are circulation, less air circulation.

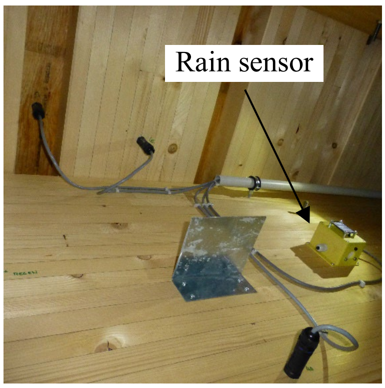

Figure 5 Rain sensor to detect spray cloud

Figure 6 Cup anemometer to detect movement of the air due to the traffic

3 Measuring points

The wildlife bridge (Figure 7) encloses the A1 highway with a double arch structure over a length of 50 meters. Wet roads and the combination of fast light traffic (left lane) and slow heavy traffic (right lane) can introduce water spray of varying heights and quantities into the structure. Due to the soil covering of the structure, larger temperature differences between the air in the structure and the adjacent, cooler timber structure are to be expected. This can lead to condensation on the timber members, the amount of which is estimated by measurements and calculation models.

Sensors were positioned in both the arch beams, the secondary structure, and the deck panels. Different points of the structure are monitored in order to detect differences between the area near the portals and the central area and differences between the two directions of travel (Figure 7). In addition to wood moisture, other parameters are measured such as climate, wood surface temperature, rain (spray cloud) and air velocity inside the wildlife bridge.

https://doi.org/10.24451/t6nk-7h98

In total, the following sensors have been installed: 26x wood moisture measurement with temperature and humidity sensors, 4x outdoor climate sensors, 2x rain sensors and 1x air velocity sensor. To collect the necessary data 33 sensors were installed throughout the structure.

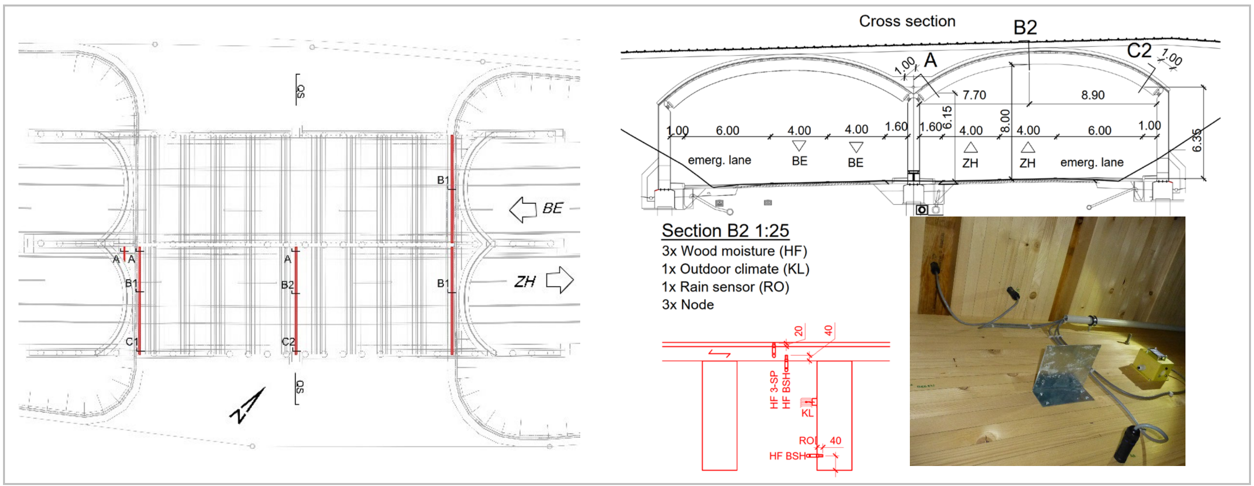

Figure 7 Wildlife bridge plan with monitoring sections indicated (left) and section with detail and photo sensor equipment point B2 (right)

4 Monitoring system

The sensors installed in the wood structure are connected to nodes for data transmission. The nodes are connected to a gateway that is linked to a web interface (swissMon©) from terra vermessungen Ltd (Figure 8). The monitoring system measures since October 2020 and provides the data in real time.

Figure 8 System design and data flow (swissMon©)

The data measured by the measuring system mounted on the wildlife bridge are supplemented with data from weather stations from the Swiss Federal Office MeteoSwiss and vehicle counting points from the Swiss Federal Roads Office FEDRO. These data together with the data measured by the monitoring system form the basis for the analyses that will be carried out in the duration of the project.

5 Wood moisture and conclusion

Measured values show that wood moisture in the various elements in timber varies with the seasons. Some elements show greater fluctuations while others have a more or less constant moisture content. The following picture shows the wood moisture (monthly average) at three different points: (1) slow lane, entrance area (2) slow lane, central area (3) emergency lane, central area. In correspondence of these three points the wood humidity of the glumal 760/240 beam is shown. In the central zone, slow lane, the humidity of the LVL is also shown.

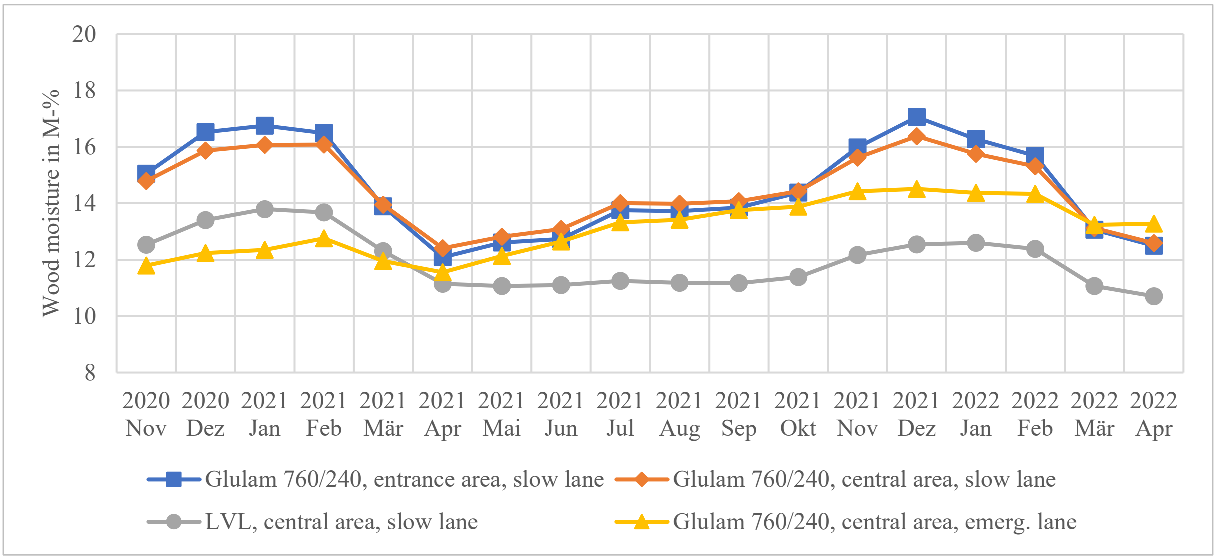

Figure 9 wood moisture (monthly average) from opening to traffic in November 2020 through April 2022

Since the opening of the wildlife bridge in November 2020 until today, in over one year period, there are no noticeable trends that indicate an increase in moisture and furthermore the maximum values are 17 M-%. The parts with higher moisture content are located above the slow lane. The moisture content of the LVL in contact with the soil has a lower moisture content than the glulam 760/240 beam. Above the emergency lane there is less moisture fluctuation than in the area above the slow lane, probably due to less spray cloud. The measurements carried out in the last 1.5 years confirm the correct choice of the type of structure and the use of wood for wildlife bridges.

The data collected from the monitoring system will be analyzed with special attention to the influence of traffic: (1) Due to water spray carried along by traffic during rainfall outside the wildlife bridge, the timber structure is exposed to larger amounts of water than a regular protected structure. (2) On the other hand, traffic could have a positive effect on the air exchange (flow) in the structure and on the drying capacity of the structure. These influences on the wood moisture content and wood moisture fluctuations will be quantified by two years of monitoring and simulations. Subsequently, the use of native spruce and fir as a load-bearing material in wildlife bridges will be further investigated. Simulations and further data analysis will allow prediction of wood moisture for other types of structures as well. All results will be published in the final report of the research project.

Acknowledgement

The research is performed in the scope of grant “2020.08 Klimabedingungen bei Wildtier-überführungen in Holzbauweise” by Federal Office for the Environment FOEN, Wald- und Holzforschungsförderung Schweiz (WHFF-CH). The project partners Timbatec Holzbauingenieure Schweiz AG, Häring AG, Roth Burgdorf AG, terra vermessungen AG and Lignum accompanied the project.

References

[1] Ingenieurgemeinschaft 2B (2918) UEF Wildüberführung Rynetal (AG 6) Suhr, Detailprojekt 2018.
[2] Müller A., Bonifacio S. (2019) Fachliche Stellungnahme zu der geplanten Wildtierüberführung über die A2 in Tenniken/Dietgen und deren Gebrauchstauglichkeit über 100 Jahre vom 27.9.2019, Institut für Holzbau, Tragwerke und Architektur, Berner Fachhochschule AHB.
[3] Bauer M. (2016) Erfahrungsbericht über die Grünbrücke bei Luckenwalde, 4. Internationale Holzbrückentage IHB 2016.
[4] ProTimb (2019) Wartungshandbuch - Prüfplan, Erfurt Deutschland.
[5] Bonifacio S. (2020) Untersuchung der Grundlagen zur Messung des Raumklimas in einen Holzgebäude, Berner Fachhochschule Architektur, Holz und Bau, Schweiz
[6] Berner Fachhochschule, IMP Bautest AG, Aeschlimann AG, Asphaltbeläge auf Holzbrücken - Untersuchung der schubfesten Fahrbahnaufbau-ten für Holzbrücken, Forschungsprojekt ‘Abdichtungssysteme und Bitumenhaltige Schichten auf Brücken mit Fahrbahnplatten aus Holz’