Conference Proceedings 4th ICTB (2022)
https://doi.org/10.24451/5qga-vs74

ICTB 2021 PLUS
4th International Conference on Timber Bridges
Biel/Bienne, Switzerland, 9 -12 May 2022

Preliminary moisture-relevant monitoring results of a timber wild-life bridge 'Rhynetel'

Karim Ghazi Wakili[1], Jan Maurer, Andreas Mueller

1 Introduction

Wild-life bridges are of central importance for animal friendly habitats in densely populated regions where motorways and railways necessary for the connectivity between urban centres and the countryside cut the whole landscape into disconnected pieces. Central Europe and especially Switzerland represents such an environment in need of corridors and connections to help the animals overcome these obstacles.

The first wooden wild-life bridge in Germany has been built already in 2004 and first investigation results reported by M. Bauer [1]. In 2016 there were already 37 with tendency to much more. The first such wooden wild-life bridge in Switzerland has been built in 2019 by Timbatec [2]. This is the one we are investigating the influence of climatic and traffic conditions on the moisture behaviour on its different wooden elements for the first time with an elaborate monitoring procedure.

The following represents an initial evaluation of a selection of sensors used in this project over the period from around October 2020 to July 2021. Measurements from a total of three sources were available. The sensors for determining the wood moisture and wood temperature (90 measured values) from the company "terra", weather data from a weather station near the wildlife crossing (22 measured values) from Meteo-Swiss and traffic data (9 different vehicle classes) from the Swiss Federal Road Office FEDRO.

2 Material and method

A complete overview of the monitoring system installed in this construction is presented by Bonifacio et al. [3] at this conference and the measurement procedures explained elaborately.

For reasons of clarity, a representative selection of sensors was made from the large number of measuring probes mentioned above, with the main emphasis on «wood moisture», «climate» and «traffic». This was done in order to obtain an initial basis for investigating any correlations between these three parameters. In the course of the project, the remaining data will also be used to check and confirm these correlations.

Figure 1 shows an overview of the locations where temperature and humidity sensors are located on the inside of the wildlife crossing. A detail of the sensor positioning is shown in Figure 2.

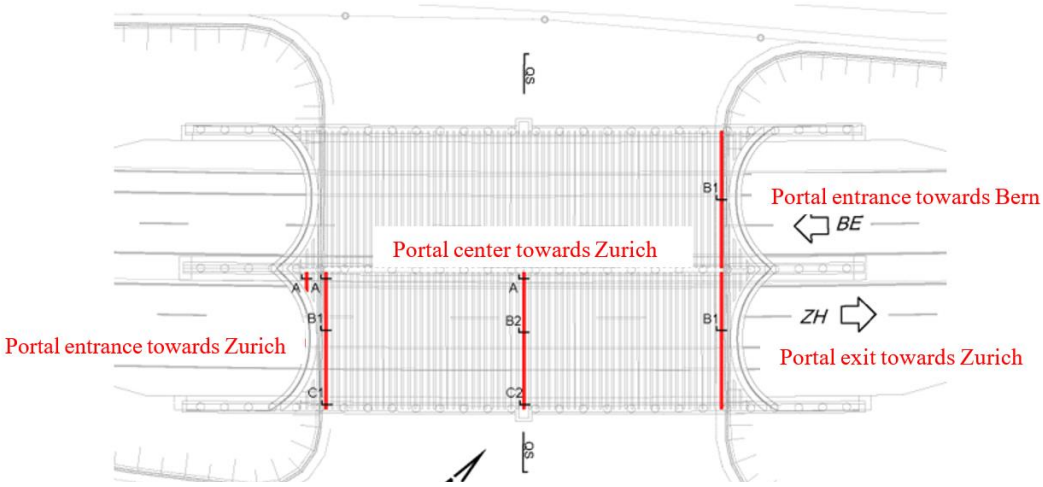

Figure 1. Drawing representing the top view of the timber wild-life bridge and the positions of the installed sensors

[1] Karim Ghazi Wakili, Senior Scientist, Institute for Timber Construction, Structures and Architecture, Bern University of Applied Sciences, Switzerland, karim.ghaziwakili@bfh.ch

Figure 2. Detail showing the position of the moisture sensors in the wooden elements (glue laminated timber).

3 Results

3.1 Temperature and moisture in the wooden elements

Figure 3 shows the measured surface values for the moisture content on the wooden elements [3] parallel to the lanes and covering the curved glue laminate timber elements (HF, red, blue, and yellow lines) in mass percent on the left y-axis. The amount of rain in mm/h (green line) is also shown on this axis. The right y-axis shows a dual value of 0 or 1 meaning no rain and rain. The time on the x-axis stretches over the period between October 9th, 2020, and July 7th, 2021. The dotted pink line corresponds to a preliminary hygrothermal simulation of the moisture content. This will be discussed in a future investigation comparing measured and simulated values.

The moisture contents fluctuate mainly between 10 and 15 mass percent of moisture which is not critical, and their mean value shows an increase from the starting point until March 2021 and decreases slightly afterwards. This is most probably the initial condition of a quasi-steady-state behaviour. There seems no immediate correspondence with the Amount of rainfall. This is not unusual as the moisture movement by diffusion is a slow transient process. No moisture accumulations have been detected for this period.

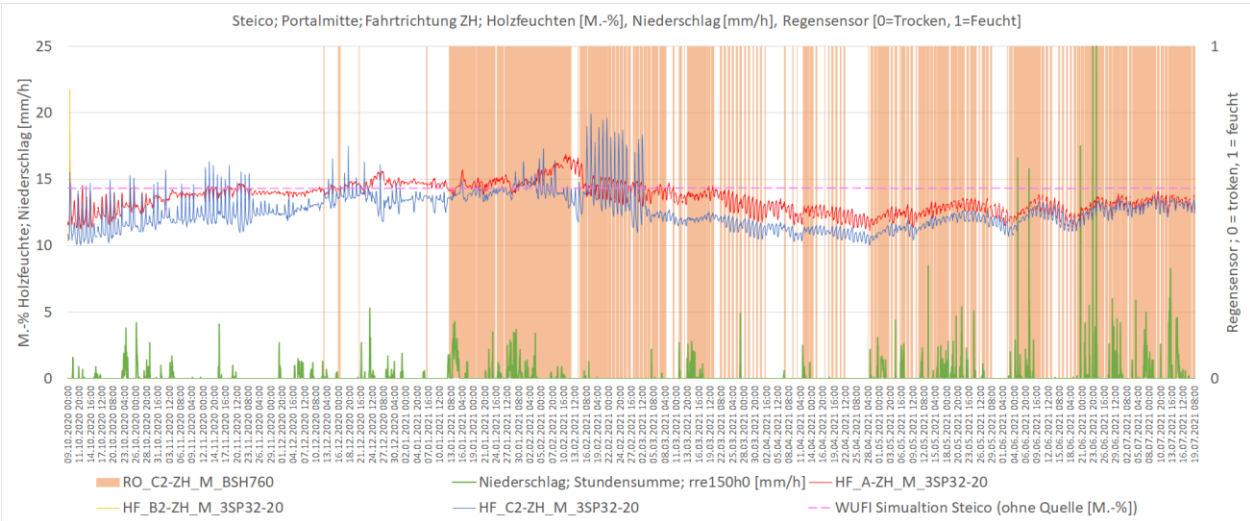

Figure 3. Measured moisture content in wooden elements at the center on the Zurich Lane, amount of rain and rain sensor (right y-axis).

An example of the spot moisture measurements [3] in two different depths in a curved laminated timber element is shown in Figure 4 together with the amount of rain (green line). The lines in yellow and blue (both 40 mm depth) show slightly higher variations in the measured period (the same as in Figure 3) compared to the grey line corresponding to a depth of 100 mm. The moisture contents are sub-critical and do not show an immediate correlation with the amount of rain as well.

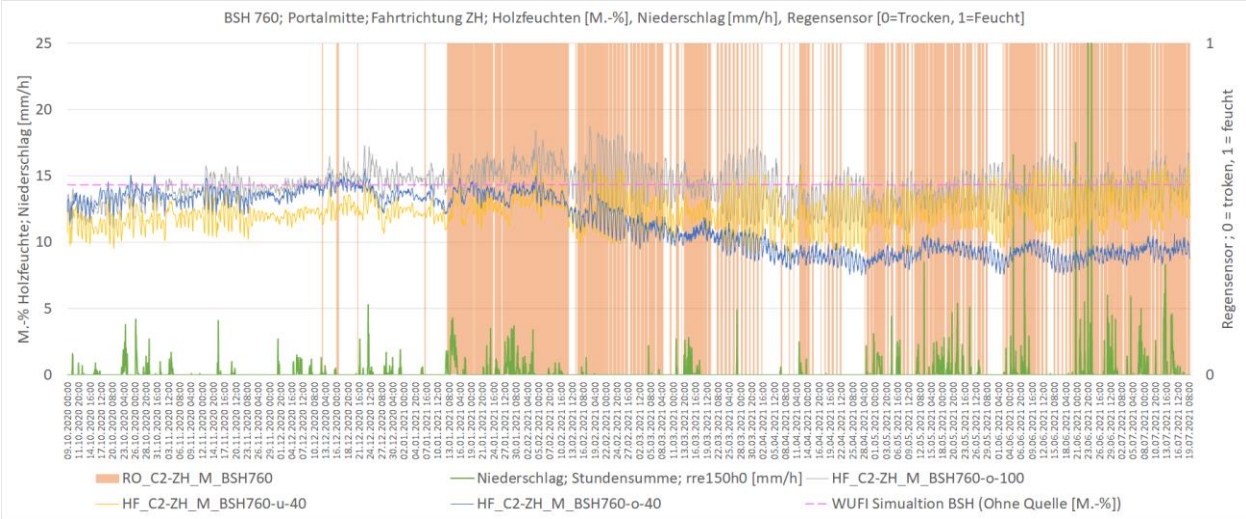

Figure 4. Measured wood moisture in two depths of 40 and 100 mm in a glue laminated timber element at the point C2 portal centre on the Zurich Lane, the measured precipitation, and the rain sensor (right y-axis).

3.2 Relative humidity of the air

The next two figures (Figs. 5 and 6) compare the measured air temperature and humidity (both yellow lines) in the space beneath the wild-life bridge (four measuring points) and the values obtained from the nearby meteorological station. During the colder season (Nov. 2020 to Feb. 2021), a slightly cooler temperature and correspondingly higher relative humidity is measured at some points in the space beneath the wildlife bridge. The use of these different climate data in a hygrothermal simulation will provide information about the effect of these differences on the wood moisture content (measured and simulated).

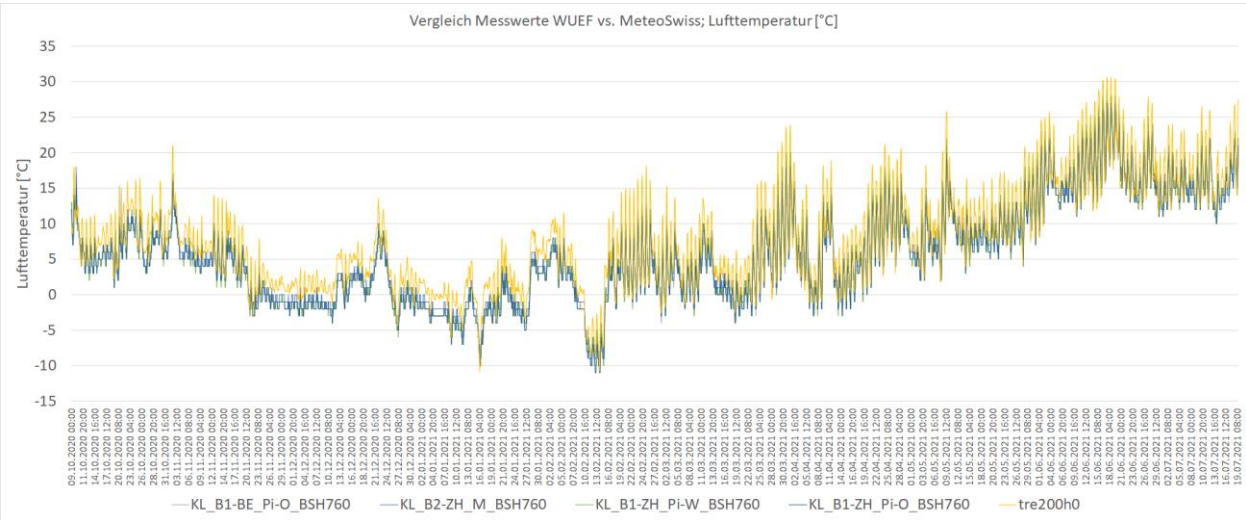

Figure 5. Measured air temperature in the space beneath the wildlife bridge and the nearby Meteo-Schweiz weather station (2m above ground).

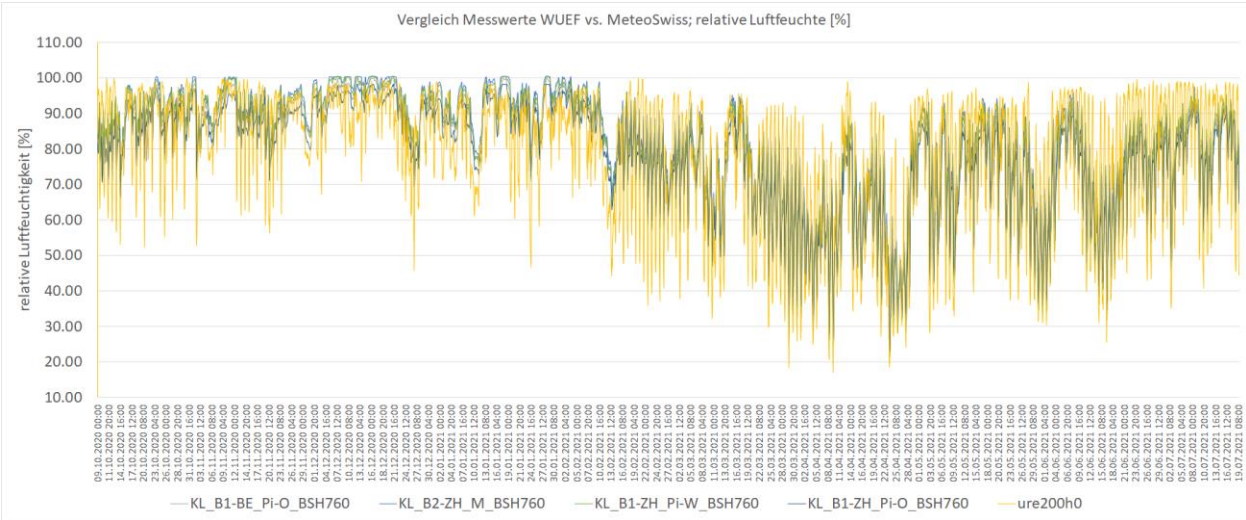

Figure 6. Measured air humidity (rel.) in the space beneath the wildlife bridge and the nearby Meteo-Schweiz weather station (2m above ground).

The relative humidity in the space beneath the wildlife bridge shows much smaller diurnal fluctuations which can be expected as the Meteo-Data are measured in an open field in contrast to the relatively closed space beneath the wildlife bridge. This explanation holds also for the lower temperature during the summer period (Apr. to Jul. 2021) The whole time period on the x-axis the same as in the previous figures.

3.3 Traffic data

According to the FEDRO guideline for traffic counters, the data for all vehicle classes was available individually. From these, however, the LW-like vehicles (types 1, 8, 9 and 10 see Table 1) were combined and summarized for the direction of travel in Figure 7. The reason is that these vehicles, due to their size, can spray the rainwater much more and much higher water, enable the formation of haze and can thus influence the moisture content in the wooden structure.

For the sake of clarity, the sum over a whole year of the counted vehicles (Figure 7) is divided into 6 periods of 4 hours each. This means that the first part in Figure 5 (top left) shows the total for the first 4 hours of the day (0, 1, 2 and 3) and the subsequent parts each show the total for the 2nd, 3rd, 4th, 5th and last 4 hours of the day correspondingly.

Table 1: Vehicle types according to 'Swiss 10' of FEDRO

Type	Vehicle
1	Bus 
8	Truck 
9	Truck with Trailer 
10	Articulated Lorry 

As mentioned above the diffusion of water is a slow process and a quasi-steady state would only be reached after 1-2 years depending on the climatic boundary conditions. An evaluation of moisture content in the wooden elements needs monitoring data for a corresponding period. This will also serve for robust hygro-thermal simulations to enable an extrapolation to longer time periods including and forecasting the impact of climate change.

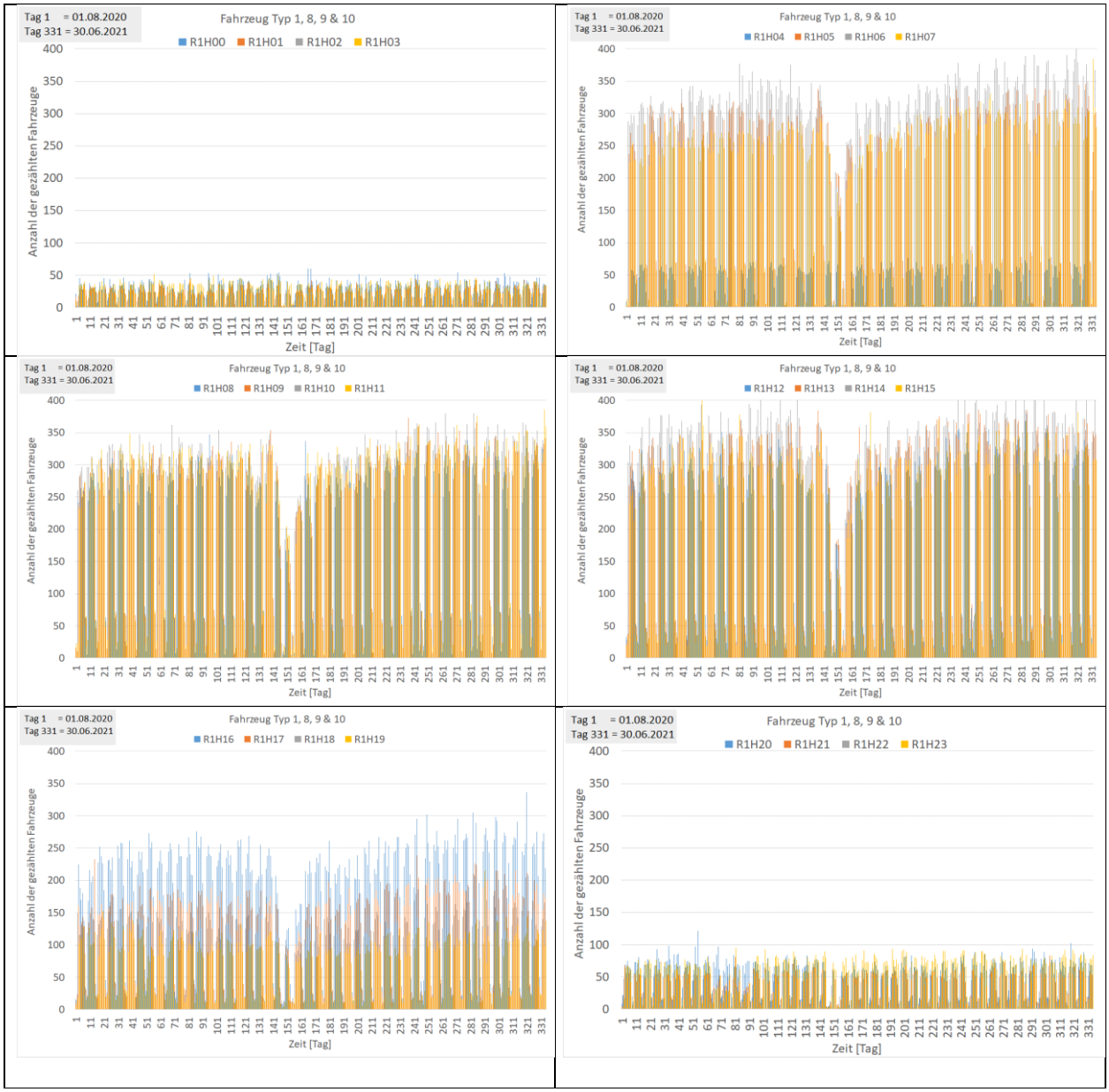

Figure 7. Number of counted large vehicles (types 1, 8, 9 and 10) in the direction of Zurich (R1) from July 2020 to June 2021. For the sake of clarity, summarized in 6 parts of 4 hours each.

4 Acknowledgement

The project has been financed by the grant “2020.08 Klimabedingungen bei Wildtier-überführungen in Holzbauweise” by the Swiss Federal Office for the Environment FOEN, Wald- und Holzforschungsförderung Schweiz (WHFF-CH). The support of the project partners “Timbatec”, “Häring AG/Roth Burgdorf”, “terra vermessungen “ and Lignum Switzerland is greatly appreciated.

5 References

[1] Bauer M. (2016) Erfahrungsbericht über die Grünbrücke bei Luckenwalde. In: 4. Internationale Holzbrückentage IHB 2016 , 8-9 June 2016, MPA Stuttgart.
https://www.forum-holzbau.com/pdf/14_HBS_2016_Bauer.pdf

[2] Timbatec (2020) First Swiss wildlife bridge made of wood
https://www.timbatec.com/en/aktuelles/meldungen/8087175055-Rynetel.php

[3] Bonifacio S., Schiere M., Mueller A. (2022) Climate and moisture monitoring system in the timber wildlife crossing ‘Rynetel’, ICBT 2021 PLUS, 9-12 May 2022, Biel, Switzerland.