Monitoring of a CFRP-GFRP-timber bowstring-arch bridge using novel sensing systems

Robert Widmann[1], Rolf Brönnimann[2], Urs Meier[3]

1. INTRODUCTION

The replacement of an existing pedestrian bridge at the Empa, Swiss Federal Laboratories for Materials Science and Technology in Dübendorf, Switzerland, gave the opportunity to head for a novel and experimental bridge design: a bowstring arch bridge. The bridge with a span of 12.0 m crosses a small pond and is made exclusively of glulam timber, glass fiber reinforced plastics GFRP and carbon fiber reinforced plastics CFRP (Figure 1).

As the bridge implements a novel combination of materials and techniques it was decided that selected performance - parameters should not be measured only at installation but also monitored over a longer period to observe the long-term behavior and performance of the structure. In the paper design features, the monitoring system and selected results are reported, this extended abstract only contains information about the monitoring system with the focus on a video based system.

Figure 1 – Situation of the ready assembled bowstring arch bridge that spans over a pond at the Empa site in Duebendorf, Switzerland. The bridge is made exclusively of glulam, CFRP and GFRP elements and apart of the installed multi-sensor monitoring system does not contain any metal part. On top of the timber bridge plate a GFRP-decking is installed.

[1] RobertWidmann, Wood Laboratory, Empa , Switzerland, robert.widmann@empa.ch
[2] Rolf Broennimann, Electronics, Metrology and Reliability Laboratory, Empa, Switzerland, rolf.broennimann@empa.ch
[3] Urs Meier, Empa, Switzerland, urs.meier@empa.ch

2. MONITORING SYSTEM

The bridge is being continuously monitored since its installation in spring 2007. With the help of numerous sensors of various types the following data are acquired (refer to Figure 2):

- Temperature and relative humidity at three different positions with standard temperature- / humidity sensors (TH1 to TH3).
- Shrinking and swelling deformations in the lateral direction of the deck using potentiometric displacement sensors with CFRP extension rods which are installed at the slabs underside (PA and PB).
- Tension in one of the six CFRP straps on base of the principle that a section of the straight strap is deflected and the necessary force to apply this deflection is being registered with a load cell (SK). An advantage of this system is its flexible handling as it can be easily removed and reinstalled, e.g. in the need of a re-calibration.
- Distributed deformations of the slab using a video camera monitoring system (Cam). This innovative system is used to monitor deformations at 12 target positions (3 targets in 4 rows, R1 – R4) at a time with only one single sensor, the camera. With the help of the analysis via an adapted software program resolutions depending on the targets distance to the camera of 0.05 mm to 0.20 mm can be reached.

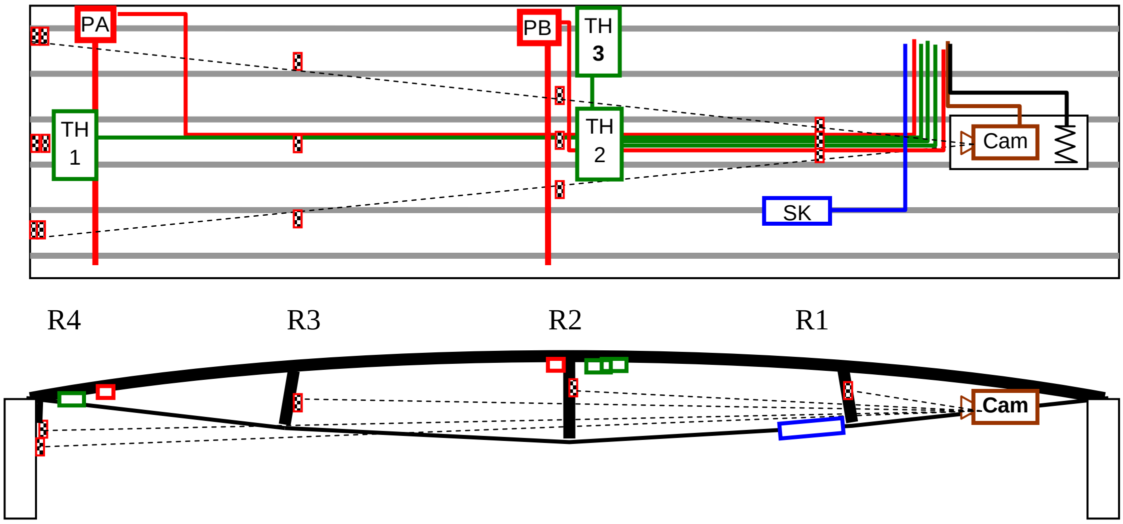

Figure 2 – Overview of the monitoring system. In the top-view and side-view the positions of the various sensors are shown. The wiring of the system is mainly housed in the spacing between timber plate and the GFRP decking and leads to a PC which is placed in the basement of the adjacent building.

3. RESULTS AND CONCLUSION

A load test confirmed the expected performance of the bridge. The installed monitoring system has been collecting valuable data for over three years. Especially adapted sensors for the system perform well, with the exception of the sensor for the strap tensions.

The video surveillance system delivers reliable data and could be even used to validate results from other sensors. A big advantage of the system is that deformations at several positions of the structure can be measured and monitored at the same time with using only one sensor – the camera. This camera also gives the opportunity to visually check the structure to a certain degree. For example accumulations of dirt and/or intensive growth of plants under the bridge slab can be detected easily and thus could indicate necessary maintenance of the structure.

There are three requirements that have to be met, if such a video system should be installed for monitoring purposes: a constant source of energy to power the camera, enough (day)light for the detection of the targets and a safe position for its installation in order to protect it from vandalism.Considering the possibilities of the video system, further development can be expected.