



## Investigations and modified approaches regarding the shear capacity of existing pre-stressed concrete bridges



Name: **Sebastian Felix Gehrlein**  
E-Mail: **sebastian.gehrlein@tum.de**  
Supervisor: **Univ.-Prof. Dr.-Ing. Dipl.-Wirt.-Ing. Oliver Fischer,**  
**Chair of Concrete and Masonry Structures**  
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### Motivation

Due to the increased traffic and, in particular, increasing heavy goods transportation, as well as the evolution of codes and regulations, more than 60.0% of the existing pre-stressed concrete bridges in Germany show relevant or severe deficits when being re-analysed according to current design standards [1]. More than 56.5% of the bridges with deficits exhibit an insufficient shear capacity as different standards applied at the time of construction of these bridges. However, the existing bridges in Germany hardly show any damage which indicates an insufficient shear capacity as only a few corresponding cracks can be detected on the bridges. There are also no known shear failures of bridges in the final state of construction. Therefore, several major research projects have been initiated to close the gap between calculation and experience recently. One step in this approach for more realistic models regarding the shear capacity was taken by carrying out in-situ full-scale tests on an existing bridge.

### In-Situ Full-Scale Tests

In the summer of 2017 these experimental load-to-failure tests took place at a 64-year-old, 163.0 m long pre-stressed concrete bridge near the town of Hammelburg in Bavaria. The continuous road bridge over the Franconian Saale river was chosen because of the relatively large number (seven) of bridge spans (see Fig. 1) and the small amount of shear reinforcement. The primary objective of the field test was to determine the shear capacity of existing bridges with a construction time before 1966 (year of implementation of minimum shear reinforcement in German standards).

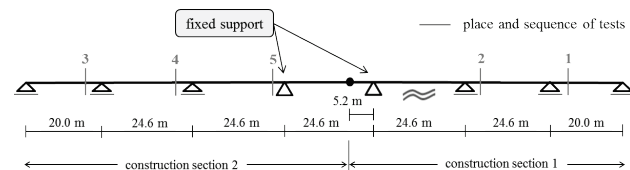


Fig. 1: Structural system of Saalebrücke Hammelburg and test positions.

To realise the planned loading concept, a 31.65 m reaction girder was designed and mounted above the bridge (please refer to Fig. 2). By means of this girder, it was possible to introduce the necessary loads via six hydraulic cylinders (see Fig. 3). Due to the unfavourable ground conditions and the repeated use of the loading equipment in several positions on the bridge, the steel girder was temporarily fixed to the bridge piers via massive steel rods and crossbeams. To carry out five tests in five different positions on the bridge (as shown in Fig. 1), the whole system was also designed to be moveable by using hydraulic pushing cylinders, as well as heavy-duty rollers, rails and sliding plates.



Fig. 2: Reaction girder with reinforcement frames

To measure the imposed loads and resulting stresses as well as to record the load-bearing behaviour of the tested bridge sections, extensive quantities of measurement equipment were installed on the bridge. In addition to conventional measurement techniques, such as inductive displacement transducer, cable-controlled potentiometer, load-cells and strain gauges, an innovative fibre optical measurement system [2] was applied on a large scale. In all five tested spans, the aim of the experiments, a shear force failure of the investigated beam with corresponding, massive oblique shear cracks, was reached. By means of an extensive quantity of measuring techniques, the load-bearing behaviour and the crack pattern of the investigated middle

beams was precisely gauged. These exceptional full-scale in-situ tests will therefore help in gaining a better understanding of the load-bearing mechanism as regards the shear force within pre-stressed concrete beams with little to no shear reinforcement. Furthermore, the validation and potential for the quantification of scale effects occurring with laboratory tests is possible.

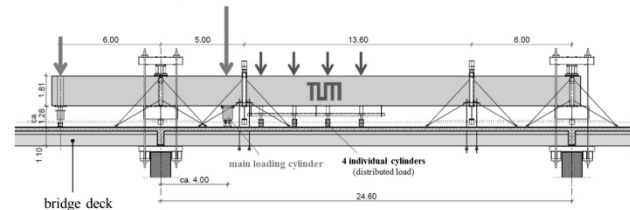


Fig. 3: Schematic sketch of the loading equipment with hydraulic cylinders in testing position

### Further Scope of Research

As the field tests at the Hammelburg bridge were completed by the end of 2017, the extensive measurement data is currently being evaluated. Comprehensive numerical re-calculations and parameter studies of the investigated bridge are being carried out, too. In 2018, there will also be two more experimental tests with a comparable cross-section using the substructure technique which is available at the laboratory of the Chair of Concrete and Masonry Structures of TUM.

### References

- [1] Fischer, O. et al.: *Nachrechnung von Betonbrücken – Systematische Datenauswertung nachgerechneter Bauwerke, Bericht B 124 der Bundesanstalt für Straßenwesen*, 2016
- [2] Schmidt-Thrö, G., Scheufler, W., Fischer, O.: *Kontinuierliche faseroptische Dehnungsmessung im Stahlbetonbau. Beton- und Stahlbetonbau*, 111 (2016), p. 496-504