Design of First Hybrid UHPC-Steel Bridge across the River Fulda in Kassel, Germany

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Summary
A 132 m long hybrid UHPC-steel bridge with 6 spans is currently being built across the river Fulda in Kassel, Germany. UHPC offers supreme durability characteristics and, hence, has been selected for the replacement of an existing, damaged timber structure. The novel structural concept consists of a hybrid steel – UHPC truss structure and precast UHPC plates for the bridge deck. The deck plates are glued to the upper chords of the truss structure. For the transfer of shear forces from the truss diagonals (steel tubes) to the UHPC chords, prestressed bolted friction connections are used. The paper describes the conceptual design, the final design, accompanying tests and the erection of the bridge structure. A monitoring system will be installed in order to gather practical experience with the new materials and the novel structural concept.

Keywords: Ultra-High-Performance Concrete (UHPC), durability, hybrid UHPC-steel structure, bridge design, glued connections, prestressed bolted connections, monitoring, precast elements, prestressing, posttensioning

1. Design and construction of first UHPC bridge structures in Germany
Ultra High Performance Concrete (UHPC) not only offers very high strength but also superior durability characteristics due to the low permeability for liquids and gases. Both, the very high strength as well as the significantly improved durability in comparison to normal and high strength concrete are a consequence of the extreme packing density of the cement matrix. At the University of Kassel, the mix design and optimization as well as the investigation of the characteristics of the hardened UHPC with values of the compression strength between 150 and 400 MPa have been in the focus of research since 1998 [1]. From this research work as well as from other investigations on UHPC [2] the required fundamentals for the design of UHPC structures are available.

The 132 m long Gärtnerplatz bridge across the river Fulda is the first multi span UHPC bridge in Germany. This project makes use of the experience gathered from the design and construction of

Fig. 1 Superstructure in longitudinal direction

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several small UHPC footbridges which have been built near Kassel [3]. These bridges consist of precast, prestressed UHPC elements with spans of 7,9, and 12m and have been built in 2005.

2. Innovations in design and construction of the new Gärtnerplatz bridge

The new Gärtnerplatz bridge is a 6 span hybrid UHPC-steel structure replacing a deteriorated timber bridge built in 1981. UHPC has been selected for this project since this new innovative material offers superior durability while enabling lightweight structures with filigree and elegant design. The cross section consists of precast prestressed UHPC deck elements on top of a three chord hybrid truss system. The upper chords are precast and prestressed as well as posttensioned slender beams made from UHPC (see Fig. 2). The lower chord and the diagonals of the truss system consist of steel tubes.

![Fig. 2 Cross section of hybrid three chord truss at midspan](image)

Since the cross sectional dimensions of the precast UHPC members are small (minimum deck plate thickness 8 cm), the application of mechanical connectors is difficult. Thus, gluing has been selected to connect the UHPC deck plates with the UHPC chords. Another innovation is the use of a prestressed connection using high strength bolts to ensure the shear force transfer between UHPC and steel members. A special case approval, based upon a test program on key elements of the structure, has been obtained. A monitoring system will be installed for this novel type structure to gather practical experience with this UHPC bridge during service life.

3. References

