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. Introduction

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. Furthermore, the behaviour of UHPC elements in bending and shear has been studied intensively [1]. This research, mainly founded by the DFG (Deutsche Forschungs-Gemeinschaft / German Research Foundation), has encouraged the authors to start with some UHPC-projects for bicycle and pedestrian bridges.

With respect to the conceptual design and design verifications for structures made of UHPC, the following principal conclusions could be drawn from the research work (compare also [2, 3]:

- For elements subject to bending or bending and normal force, the tensile strength of UHPC with fibres can be used, since due to the fibres, a ductile behaviour in tension can be ensured. Reduction factors accounting for the inhomogeneity of the spatial distribution of the fibres and their orientation should be introduced. For thin elements, the dominating fibre orientation can be observed to be parallel to the formwork.
- For rectangular cross sections, failure due to shear forces could only be observed for very low or no fibre contents. For UHPC without fibres, the shear force resistance can be calculated well by the model according to Zink [4] which is mainly based on the bearing capacity of the compression zone.

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