Form Optimized CFRP Reinforced and Post-tensioned Integral Concrete Bridge using Precast Girders

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Abstract

Numerous bridges in Germany are currently reaching the end of their lifetime. This is a chance for new bridge types and materials to be investigated. Concrete bridges with CFRP reinforcement – both prestressed and non-prestressed – have the potential to meet the current demands in terms of durability, robustness and economic viability. As part of the joint research project C³ - Carbon Concrete Composite, the Chair of Conceptual and Structural Design at the Technische Universität Berlin (TU Berlin) is conducting research on prestressed CFRP concrete bridges together with other research institutes and industrial partners. In this paper the conceptual and structural design of a concrete bridge using CFRP prestressed and reinforced precast girders is presented. According to the material characteristics of CFRP and the construction process, an optimized and unusual shape was conceived. As a result, the advantage of CFRP versus steel in terms of corrosion resistance and strength can lead to slender structures and material reduction.

Keywords: CFRP, post-tensioning, prestressing, concrete, precast girders, bridge, integral, conceptual design, *Baukultur*

1 Introduction

1.1 Current situation in Germany

Almost 40.000 federal road and highway bridges are located in Germany, of which 15.9 % have a span of about 30 m – 50 m [1]. Approximately half of all bridges have been built in the period between 1960 and 1985. These bridges are about to reach the end of their design life and many of them will need to be replaced in the near future. Furthermore, new highways are being built and others have to be expanded as traffic constantly increases. Therefore, large investments in infrastructure are expected in the upcoming years. This is a great opportunity for new building methods and materials, which can have better performance in terms of durability, robustness, safety, economy and appearance compared to existing solutions. Current conventional steel bridges and concrete bridges with steel reinforcement both have to deal with the problem of corrosion, which causes additional efforts in maintenance or short life expectancies.

1.2 CFRP prestressed concrete as an alternative

The use of CFRP (Carbon Fibre Reinforced Polymer, or simply "carbon") reinforcement and tendons in concrete bridges is promising in this context because the material does not corrode. Low unit weight, outstanding fatigue characteristics and, most essentially, very high tensile strength make CFRPs ideal, especially for prestressing. However, the lack of ductility requires a rethinking of design and safety issues and, due to the low transverse strength, new anchoring methods need to be developed. The high material costs have to be considered, as well.

The challenge for engineers is to use this material appropriately in order to reveal its potential and to utilize its advantages instead of simply accepting the drawbacks. Looking at prestressed CFRP concrete bridges built in the past, this was hardly

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