Shear resistance of existing prestressed concrete bridges under static and cyclic loading

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Summary

The demands on the load-carrying capacity of bridges have increased over the last decades due to higher traffic volume. In the future, an even further increase of traffic loads is expected. Many existing bridge structures in Germany built in the 1960s and 1970s were designed for lower traffic loads applying the principal tensile stress criterion for shear. These structures typically feature a high degree of prestressing and low shear reinforcement ratios. In addition to the verification of the shear strength under static loading in the ultimate limit state, the shear fatigue resistance under service loads must be proved to account for the increased fatigue loads. This paper presents alternative design approaches developed at the Institute of Structural Concrete at RWTH Aachen University for the static and fatigue verification considering the provided shear reinforcement. The application to a typical bridge structure of the German road network is presented.

Keywords: prestressed concrete; bridge; assessment; shear; fatigue design.

1. Introduction

A large part of existing bridges in Germany was built in the 1960s and 1970s whereas mainly prestressed and non-prestressed concrete structures were used. Since opening of these structures to the public, the traffic volume and weight have increased significantly. Furthermore, in the course of time the design and construction rules for concrete bridges changed in some parts. This especially concerns the shear design so that the shear resistance of many older bridges cannot be verified applying the current standards.

The shear resistance of older bridges under static loading was originally determined based on the principal tensile stress criterion. In order to reduce the required shear reinforcement, the structures typically exhibit a high degree of prestressing. Applying the strut and tie models of the current standards often leads to more shear reinforcement than provided in the webs. In addition to the static shear strength, the shear resistance under cyclic loading also has to be verified according to current standards. This is mainly to account for the increased loads and the extended service life. Since the approaches for shear fatigue make use of the static shear strength, the calculated deficits in the static strength also concern the shear fatigue evaluation. As a shear failure of the existing structures has not been observed so far, they are apparently able to carry the current loads.

In order to assess the bearing capacity of older bridges more accurately and to account for the respective characteristics the German Federal Ministry of Transport, Building and Urban Development published the “German Structural Assessment Provisions for Older Road Bridges” [1] in 2011. It contains modifications of the design approaches of the current standards as well as alternative design procedures. Considering the first experiences made with the practical application of the current guideline and taking into account new research results the publication of a revised guideline is

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