Computational Assessment of Prestressed Concrete Bridges

Gregor BORKOWSKI
Civil Engineer
Lucerne University of Applied Sciences and Arts, Horw, Switzerland
gregor.borkowski@hslu.ch

Gregor Borkowski (1979) received his civil engineering degree from Hamburg University of Technology in 2006.

Viktor SIGRIST
Professor
Hamburg University of Technology, Germany
sigrist@tu-hamburg.de

Viktor Sigrist (1960) received his university degrees from ETH Zurich, worked as a structural engineer and is Head of the Institute of Concrete Structures at TUHH since 2002.

Summary

A current challenge for engineers is the conservation of existing structures which includes maintenance, assessment and, if necessary, strengthening. For the evaluation of the load carrying capacity and the remaining service life, detailed knowledge of material properties is required and a structural model should be used, with which the stress state can reliably be analysed. In this paper, concrete hollow box girder bridges (single and multi-cell cross sections) are examined.

First, on the basis of a case study it is shown how eccentrically arranged traffic loads are introduced into the system. For this, a 3d finite element model with the assumption of linear elastic material behaviour is used. The results are compared to those of a beam based calculation where, regarding the shear forces, considerable differences are found.

Second, the influence of the reduction of the stiffness due to cracking of the concrete is discussed. Finally, the effect of the decrease of prestress as a result of damaged coupling joints is outlined.

Keywords: concrete bridges, coupling joints; prestressed concrete; structural assessment.

1. Introduction

The construction of prestressed concrete bridges started in the 1940s and reached its peak in the 1960s. By that time, the need for new bridges was very large and it was extensively taken advantage of the prestressing technology. Today, higher traffic loads and serious durability problems require regular inspections of the bridges. Since the intended service life of most of these bridges is not reached, rather than replacing them it is often more economic to maintain and, if necessary, strengthen them.

First problems with the new construction method occurred in the 1970s. The bridges were usually built in sections i.e. a new section was attached to an older one whose concrete has already hardened. As in these coupling joints the concrete tensile strength is lower than in other areas, they were located in regions which are almost not stressed in tension due to permanent loads. Typically, the joints were located at a distance of approximately 0,2L from an intermediate support, where L is the length of one span. At these joints the prestressing tendons are coupled too, which causes an additional weakening of the cross section (Fig. 1). In the 1970s, cracks in the coupling joints of young bridges were detected and after the collapse of a bridge a special regulation was published in 1977 [1], in which the dimensioning and construction of the coupling joints is specified. The main causes for the defects at the coupling joints were seen in oversimplified statical systems, insufficient consideration of temperature effects and neglect of additional forces due to the deformation of the cross section.

In [2] by means of an idealized bridge model it was shown that additional forces due to the deformation of the cross section occur if one web of a hollow box is directly loaded with a line load or a single load in the middle of the span. In this case the additional forces can be determined analytically as e.g. demonstrated in [3] and [4]. Using a 3d finite element model it was further demonstrated that if the loads are located close to the support and not directly above the web no

https://doi.org/10.2749/222137912805111078
Distributed by structurae