Fatigue of Prestressed Concrete Beams with low Shear Reinforcement Ratios – Experimental Investigations

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Summary

The demands on the load-carrying capacity of existing bridges increased over the last decades due to higher traffic loads. In this context, the shear resistance is of special interest. As part of a research project, tests on single span I-shaped prestressed concrete beams with low shear reinforcement ratios (ρ_w = 0,15 % and 0,22 %) under cyclic loading have been performed. The test beams and investigated load regimes refer to the conditions of existing bridges. The cyclic loading led to gradually stirrup fractures accompanied by a redistribution of forces between adjacent stirrups and increasing deformations and crack widths. Furthermore, a direct compression strut contributing to the shear carrying capacity developed. Due to an overestimation of the stress range by the common design approach for shear fatigue, the stirrups were able to resist more load cycles than predicted. In some stirrups the tensile strength was exceeded after previous fatigue failure of adjacent stirrups.

Keywords: fatigue; shear; bridge; prestressed; post-tensioning.

1. Introduction

Bridges are an important element of the infrastructure within the road network. The demands on the load-carrying capacity of bridges increased over the last decades due to higher traffic volume, especially concerning heavy good vehicles. Many existing bridge structures in Germany were designed in the 1960s and 1970s according to former codes which do not represent the expected traffic loads. Due to the comparable low shear reinforcement ratios which were required based on the old design codes [1],[2], the shear resistance is of special interest.

As part of an extensive research programme, the number of load cycles until failure and the failure announcement of prestressed concrete beams under cyclic shear load have been investigated at the Institute of Structural Concrete at RWTH Aachen University. Altogether 21 tests were performed on I-shaped and T-shaped beams without shear reinforcement [3] and low shear reinforcement ratios. Within the test programme, the influence of the shear reinforcement ratio, the prestressing, the maximum load and the load range was investigated.

The test beams were designed referring to the conditions of existing bridges. A review of bridges built in the 1960s and 1970s was carried out to determine typical structures of the German highway network. This concerns especially the cross section geometry, the degree of prestressing and the longitudinal and transversal reinforcement ratio. For these identified structures static calculations with different load models were performed in order to obtain reasonable load regimes. The present paper describes the results of twelve tests on beams with low shear reinforcement ratios (ρ_w = 0,15 % and 0,22 %). The results should be incorporated in existing guidelines for survey and redesign of bridges in order to assess the capacity of existing bridges.

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