Resistance to fatigue and prediction of lifetime of wire tendons cast into concrete up to 10^8 cycles

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Abstract

Usually for verification of compliance, the fatigue resistance of prestressing steel is determined from tests of naked specimens at 2 million cycles. However, for design the fatigue resistance of tendons cast into concrete, is substantially lower. To verify the resistance of existing older prestressed concrete bridges and for the design of new bridges, S-N curves of prestressing steel in curved steel ducts embedded into concrete are needed. In bridges, the load cycles due to heavy vehicles may rise up to about 10E8 cycles or even more. Previous tests with curved tendons in steel ducts primarily cover a range of up to about 20 million cycles. Thereby no real endurance strength has been estimated jet. Hence the S-N curves given in Eurocode 2 and Model Code 2010 are defined hypothetically for a range from 10^6 up to 10^8 and are not based on test results. The reason is that experimental investigations in a range up to 10^8 cycles are very expensive and also demand a very long duration.

Essential progress results from the development of an optimized test setup that allows a frequency of 10Hz for the applied load cycles. Therewith, the experimental investigations up to 10^8 cycles have been done by means of prestressed concrete beams with embedded curved tendons in steel ducts.

Furthermore, procedures to also forecast the lifetime in the case of very low stress ranges respectively the remaining lifetime of a running test had been developed in conjunction with an interdisciplinary research project. The procedures are based on refined statistical analysis of the extensively measured data including increase of crack width, strains, sound emission etc. Additionally the analysis of the latter leads to some interesting new perceptions.

Keywords: post-tensioning; concrete beams; fatigue behaviour; endurance strength; large-scale test; cyclical load; S-N curves;

1 Introduction

Today the maintenance of existing buildings is gaining more and more importance compared to the construction of new buildings. The current design codes have been developed over decades, always adapting new design approaches current at that time. Therefore, recalculations of older existing buildings often lead to deficiencies concerning durability, strength and performance capability. Moreover, the external impacts became more extensive, complex and intense.

In essence, two major influences substantially contribute the time dependent loss of load bearing. Firstly there is the influence of material corrosion, which can be caused, by e.g., chlorides or similar external impacts. Also, material fatigue may cause a slowly progressing material damage, due to frequently recurring cyclical loads. Cyclical loads may occur at, e.g., offshore-structures,

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