Resistance of Concrete Members without Stirrups to Fatigue Loads

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Summary

Currently the fatigue strength of a structure limits its lifetime more and more; particularly that of concrete members without shear reinforcement, which are stressed by dynamic loads. Even though designing structures to fatigue is extremely important, only a rather limited number of dynamic tests and investigations were conducted so far. Thus, the knowledge in this field is rather limited.

Therefore an extensive literature review has been conducted to establish a database of fatigue tests. This database is used to check the current design approach acc. to Eurocode 2 (short EC2-1-1) and to demonstrate its imprecision. Furthermore, concrete beams were tested with up to 4 million cycles at the University of Hamburg (TUHH) to study their behaviour. In contrast to static loads, the test specimens did not show any brittle failure. Derived from these tests, it can be concluded that the compression zone is primarily responsible for the shear bearing capacity.

Keywords: fatigue strength, concrete members without stirrups, database, shear bearing mechanisms

1. Introduction

The lifetime of concrete members without shear reinforcement stressed by high dynamic loads is often limited by its fatigue strength. Examples amongst others to mention are deck slabs of concrete bridges, slender towers, maritime structures or footings of wind energy plants. Their sustainability can be strongly reduced, if the fatigue strength becomes relevant.

An extensive literature review shows that only a few dynamic tests of concrete members without shear reinforcement have been conducted so far, worldwide. In total 160 tests were found, which were used to form a database; this number contains specimens, which collapsed by concrete or rebar failure, as well as specimens, which did not fail (run-outs) and were tested again.

Within this paper it will firstly be presented that the current design approach of EC2-1-1 [1] reveals an extreme scatter in the shear capacity of the various concrete beams. Some tests specimens failed in the permitted range, whereas others did not fail in the non-permitted range of EC2-1-1. As the design formula in EC2-1-1 is connected to the shear bearing capacity $V_{Rd,c}$ (eq. 1) a new approach for $V_{Rd,c}$ (eq. 2), which was developed by VU [2] at the Institute of Concrete Structures at the University of Hamburg (TUHH), will also be presented and confirm the uncertainties in fatigue design. Due to these studies it has to be considered, that more reliable design models are needed.

Therefore, as the first step to a new design model, a test series of 10 single-span concrete members without transverse reinforcement under static and cyclic loads is conducted at TUHH. This series and its first interesting results will be presented in the second part of this paper.

https://doi.org/10.2749/222137912805111393