STEEL-CONCRETE COMPOSITE BRIDGES SUBJECTED TO FATIGUE LOADING

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Summary

In current national and international standards of composite structures of steel and concrete the determination of the ultimate load capacity and the fatigue life of headed shear studs takes place with separate and independent verifications at the ultimate limit state, serviceability limit state and fatigue limit state. The effect of pre-damage due to fatigue loading is not considered. This paper deals with the results of a comprehensive program of experimental work with more than 90 standard EC4-push-out test specimens and two full scale-beam tests which consider the crack propagation through the stud foot and the local damage of concrete surrounding the studs as relevant consequences of high cycle loading. Based on the results of the push-out tests, new design methods were developed to predict the fatigue life and the residual strength of headed shear studs after high cycle loading. Considering the interaction between the local damage and the behaviour of the global structure, these research results were taken as the basis to simulate the cyclic behaviour of composite beams.

Keywords: steel-concrete composite beams, cyclic behaviour, headed shear studs, high-cycle fatigue, experiments, damage accumulation, numerical simulation

1. Introduction

As a result of the benefits of combining the advantages of steel and concrete, steel-concrete composite beams are today widely used for bridges and industrial buildings. The transfer of longitudinal shear forces at the interface between both components is mostly realized by headed shear studs. Especially in bridges due to the enormous increase in traffic loads these shear studs are subjected to a steadily rising number of high-cycle loadings, which may result in fatigue failure during the lifetime of the structure. In current national [1] and international [2, 3] standards the determination of the ultimate load capacity and the fatigue life of headed shear studs takes place with separate and independent verifications at the ultimate limit state, serviceability limit state and fatigue limit state. The fatigue resistance is verified comparable to steel structures, based on nominal stresses concept and linear damage accumulation according to Palmgren-Miner and effects of pre-damage due to high-cycle loading are neglected. From recent investigation [4] it is known, that cyclic loading of headed shear studs leads to a decrease of static strength, so that the assumptions for independent limit states are not given. Because the design life of cyclic loaded headed shear studs is characterized by a significant change in deformation behaviour and deterioration in strength the reliability index of steel-concrete composite structures subjected to faitgue loading may fall below the target values in codes. On this background a comprehensive program of more than 90 standard EC4-push-out test specimens and two full-scale beam tests were developed, considering the crack propagation through the stud foot and the local damage of the concrete surrounding the studs as relevant consequences of high-cycle loading.

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