The Concrete Dowel – A resource efficient Shear Connector.

Ingbert Mangerig
Professor
University of the German Armed Forces Munich,
Munich, Germany
Ingbert.Mangerig@unibw.de

Ingbert Mangerig, born 1950, received his PhD 1986 from the Ruhr.-Univ. Bochum. Since 1997 he is professor for steel, timber and composite structures at the University of the German Armed Forces.

Sascha Burger
Civil Engineer
German Railways
Munich, Germany
Sascha.Burger@bahn.com

Sascha Burger, born 1972, received his civil engineering degree from the Ruhr.-Univ. Bochum. From 2001 to 2006 he was working as a research assistant at the University of the German Armed Forces.

Robert Wagner
Civil Engineer
University of the German Armed Forces Munich,
Munich, Germany
Robert.Wagner@unibw.de

Robert Wagner, born 1978, received his civil engineering degree from the Technische Universität Kaiserslautern in 2006. Since 2007 he is working as a research assistant at the University of the German Armed Forces.

Summary

The concrete dowel is a new efficient shear connector for composite constructions. A composite girder based on concrete dowels consists of a welded T-type girder or a halved steel girder with slots in the web. The halved girder is a very cost effective version of the concrete dowel, because only one continuous oxygen-cut is needed to manufacture two beams. The composite is assembled by the steel strip which is embedded in the concrete slab. A verification procedure for the fatigue behaviour was needed, after a design concept for static loads was already elaborated, to expand the application range. The local concept was used for the research on the fatigue behaviour. The project led to a design procedure which allows a prediction of the achievable load cycles. The current research project pursues the research on fatigue behaviour. The knowledge of lifetime prediction is enlarged by a fracture mechanical approach. The fracture mechanic allows a definition of the stress intensity factor ΔK_{th} for the steel strip to avoid crack propagation.

Keywords: composite construction, composite girder, concrete dowel, shear connector, headed stud, fatigue behaviour, fracture mechanics

1. Introduction

The load bearing capacity of a composite system is strongly influenced by the construction and the arrangement of the shear connectors which have to transfer the longitudinal shear forces. There are different possibilities to connect the concrete slab and the steel girder. Several research activities in the area of composite construction lead to the concrete dowel. A composite girder based on concrete dowels consists of a T-type girder or a halved steel girder with slots in the web. The composite is assembled by the steel strip which is embedded in the concrete slab.

2. Design procedure

Based on the results of the experimental tests a compilation of influencing factors for the load bearing capacity of the concrete dowels was assorted. The characteristic features are the material properties of the steel and concrete, the geometry of the cut-outs, the reinforcement and the dowel topology. During the experimental tests different failure mechanisms were indicated. These mechanisms can be divided into three failure criteria. The failure criteria assume that the bearing capacity of the steel web between two concrete dowels is higher than the bearing capacity of concrete dowels. The elaborated design procedure in [1] differentiates between the three mechanisms of failure. Therefore during the dimensioning the proper failure mechanism with the related load bearing capacity has to be determined.

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3. Fatigue behaviour of concrete dowels

A verification procedure for the fatigue behaviour was needed to expand the application range. Therefore the researches on concrete dowels were pursued in [2]. The tests showed that there is no influence to the load bearing capacity by fatigue loads. Thereby a partition of the design procedure for static loads and the design procedure for fatigue loads [3] is possible. For the calculation of the fatigue behaviour of the steel slot the local concept was used.

At the beginning of the calculation the load sequence has to be defined. Further the cyclic strain-stress curve and the strain-Woehler-curve should be established. Next the component yield curve is elaborated. Therefore the stresses and the strains at the highest loaded point of the steel web are needed. For this a FEM calculation is most adequate. The results of the FE calculation establish an interrelation between the external load and the local strain behaviour. Hence a load-strain curve can be drained. With the help of some intermediate steps the design procedure results in a component Woehler-curve. This curve allows a prediction of the achievable load cycles until a crack occurs.

4. Crack propagation

The current research project pursues the research on fatigue behaviour. The knowledge of lifetime prediction will be enlarged by a fracture mechanical approach. The aim of this project is to control and avoid crack propagation in the steel web of the composite beam. As shown in [3] a prediction of the achievable load cycles is possible. For a prediction of the crack growth some basic data have to be elaborated. The experimental tests must be adjusted to the requirements of the civil engineering. Two different tests will be conducted. At first Woehler-curves at test specimens with different prefabrication will be elaborated to figure out its influence. The next step is to investigate the crack propagation in a real component. Therefore push-out tests will be used. Finally the influence of the cutting geometry to the crack propagation has to be covered by the tests. Tests with different cuts will be conducted.

In composite constructions the shear connectors are always covered by concrete so a visual inspection of these components is not possible. A crack in the steel web of the concrete dowel cannot be observed. Thus a requirement for investigations about the crack growth and the remaining life time of the components are given. Aim of the project is the definiton of a stress intensity factor ΔK_{th} which leads to a stop of the crack extension.

5. Conclusion

The aim of this paper is to present the concrete dowel as cost-efficient alternative to the headed stud in the field of composite construction. The prefabrication of the steel girders causes only low costs because two girders can be produced with only one cut in the steel web without nearly any slice. Furthermore oxygen-cutting and plasma cutting are fast and cost-saving cutting methods. In this context design procedures for static loads and cyclic loads are shown. Finally a fracture mechanical approach for the calculation of crack propagation is elucidated.

6. References

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