Fatigue-resistant design of modular bridges made of precast concrete elements

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Abstract

Modular construction with precast concrete has been becoming increasingly important for years. While the advantages of conventional precast construction have already been used for decades, modular structures go one step further due to the fact that no in-situ concrete or mortar is required. One way of transferring forces is to activate surface friction by post-tensioning. While shear bearing capacity is largely dependent on static friction, flexural capacity is linked to the decompression of dry joints. Two primary fields of application are bridge structures and wind turbines. Both groups of structures are stressed by non-static loads. In order to design them fatigue-resistant, an in-depth knowledge of this discontinuity zone is required. For this reason, experimental investigations, finite element analysis and probabilistic calculations were coupled in this study. The goal is a design proposal that allows the fatigue-proof design of dry joints.

Keywords: precast concrete, modular bridges, dry joints, post-tensioning, cyclic loading, fatigue

1 Motivation

The ubiquitous requirements for (bridge) structures can be reduced to stability, serviceability, aesthetics and cost efficiency. The latter point in particular is often decisive in the awarding of contracts. In times of climate change and resource scarcity, a rethink is also taking place in the construction industry towards a lifecycle-oriented view of structures. In this context, the concept of sustainability is a commonly known buzzword. It describes the ecological, economic and technical optimization of structures with the aim of conserving resources [1]. A technical optimization is represented by the modular construction method, which extends the advantages of conventional precast elements by the following points [2]:

- reduction of construction time due to elimination of curing times of fillers/adhesives
- expansion and adaptation to changed utilization concepts and capacities
- exchange of individual modules in case of damage
- non-destructive dismantling of existing structures

With 86.2 % of all road bridges, the reinforced and prestressed concrete is predominant in road bridge construction in the Federal Republic of Germany [3]. Since bridges are essential/critical parts of infrastructure with a planned service life of 100 years, the flexibility of modular construction plays a major role, as it allows the operator to respond to changing requirements during life cycle. Precast concrete structures can be designed to be adaptable by avoiding non-reversible connections such as transverse reinforcement, grouting joints