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Crack widths in portal frame bridges subjected to restraint effects

Erik GOTTSÄTER
PhD student
Lund University
Lund, Sweden
erik.gottsater@kstr.lth.se

Erik Gottsäter works with thermal actions and cracking due to restraint effects in his PhD-project.

Oskar LARSSON IVANOV
Assistant Professor
Lund University
Lund, Sweden
oskar.larsson_ivanov@kstr.lth.se

Oskar Larsson Ivanov works with climate change impacts and maintenance strategies on bridges.

Mario PLOS
Associate Professor
Chalmers University of Technology
Gothenburg, Sweden
mario.plos@chalmers.se

Mario Plos works with design and assessment of bridges and other concrete structures.

Contact: erik.gottsater@kstr.lth.se

1 Abstract

Restraint stresses appear in structural parts which are prevented from adjusting their shape when subjected to e.g. shrinkage or thermal actions. If the restrained stresses are large, cracking might occur, which can affect the durability of the structure. In the case of restraint effects, the reinforcement required in a bridge to limit the crack widths can be difficult to determine, as the magnitude of the restraint stresses depend on the stiffness of the structure. If cracking occurs, the stiffness is reduced and thereby also the stresses. For this reason, in structural parts affected by restraint effects, it can be hard to estimate both the number of cracks that will appear and the resulting restraint stress that governs the crack widths.

In this study, crack widths in a portal frame bridge subjected to thermal actions and shrinkage were investigated using non-linear FE analysis. A bond-slip relation was used for concrete-reinforcement interaction, as the resulting crack spacing was unknown. Corresponding analysis was performed using linear elastic material models and hand calculations of crack widths, for two different thermal load cases, and relations between the results from the different methods are presented. The result can lead to the development of a more accurate design model, which would lead to more efficient use of reinforcement.

Keywords: Restraint, thermal actions, shrinkage, cracking, crack width, FE-analysis, portal frame bridge

2 Introduction

Restraint effects can cause cracking in reinforced concrete structures. However, as the magnitude of restraint stresses depend on the stiffness of the structure, the restraint stresses will decrease when cracking occurs [1]. The resulting restraint stresses, which govern crack widths, are hard to predict as they depend on the magnitude of cracking.

Portal frame bridges can be subjected to both thermal actions and shrinkage. These load effects often cause restraint stresses to appear in the bridges, as the structural parts are rigidly connected to each other. In design of bridges, finite element (FE) models using a linear elastic material model for concrete are often used. The tensile stresses resulting from the calculations are then used to determine the required reinforcement amounts. However, in the main Eurocode document regarding design of concrete structures [2], the methodology for crack width calculation is based on the non-restraint case, where the stresses are independent of the cracking. If the stiffness reduction due to cracking is not considered in any other way, the resulting reinforcement amounts required for e.g. crack width limitation will be overestimated.

In Sweden, differences in shrinkage due to casting of portal frame bridges in stages, combined with the

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