Structural topology optimization of bridge girders in cable supported bridges

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Abstract

This work applies a ultra large scale topology optimization method to study the optimal structure of bridge girders in cable supported bridges.

The current classic orthotropic box girder designs are limited in further development and optimization, and suffer from substantial fatigue issues. A great disadvantage of the orthotropic girder is the loads being carried one direction at a time, thus creating stress hot spots and fatigue problems. Hence, a new design concept has the potential to solve many of the limitations in the current state-of-the-art.

We present a design method based on ultra large scale topology optimization. The highly detailed structures and fine mesh-discretization permitted by ultra large scale topology optimization reveal new design features and previously unseen effects. The results demonstrate the potential of generating completely different design solutions for bridge girders in cable supported bridges, which differ significantly from the classic orthotropic box girders.

The overall goal of the presented work is to identify new and innovative, but at the same time constructible and economically reasonable, solutions to be implemented into the design of future cable supported bridges.

Keywords: innovative girder design; bridge girder; cable supported bridges; topology optimization; structural optimization; large scale topology optimization

1 Introduction

The current classic orthotropic steel box girder designs used in cable supported bridges since the 1950s [1] are limited in further development and optimization. The design principle, carrying load in one direction at a time, naturally leads to stress concentrations and thus significant fatigue issues. The fatigue issues are often the governing design driver in steel bridge girders [2]. Several initiatives have been taken to reduce these inherent problems in orthotropic girders. The focus has both been on the cut-out details in diaphragms around ribs, adjustment of the design/manufacturing process, optimizing dimensions and ratios between components and improving calculation methods. The evolution in the design of the closed-box bridge girder has mainly involved small iterative steps of alterations to the same basic design concept during the last decades [3]. No major design changes to overcome the fatigue issues or significantly increase span length and reduce weight (cost) has been introduced. This is not surprising due to the large cost and great risk of such major infrastructure projects. The small improvement