Optimising material use and pedestrian comfort for the design of a hybrid steel-FRP bridge

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Abstract

In an ongoing project in Gothenburg, Sweden, challenging soil conditions necessitated a lighter bridge than the design with the originally planned steel deck. To address this, a hybrid structure with a steel support beam and a Fiber-Reinforced Polymer (FRP) deck was proposed. The steel structure was designed by Systra AB in Sweden, while the FRP deck was designed by Royal HaskoningDHV in the Netherlands. This cooperation on vital structural components called for a collaborative model. A parametric coordination model was created using Rhino/Grasshopper, thereby facilitating the generation of calculations in SOFiSTiK and drawings in Tekla Structures. This streamlined workflow was accessible to all involved parties, ensuring they worked with the most up-to-date design version at all times. The dynamic behavior of the bridge emerged as a significant design challenge during the project. Human-induced vibrations posed limitations on pedestrian comfort, influenced by the interaction between the steel and FRP elements. Initial calculations indicated that merely increasing the bridge's dimensions would not sufficiently address this vibration issue. Leveraging the parametric model, a variation study involving over 200 design variants was conducted. This approach allowed for the retrieval of relevant data, enabling design exploration to select the optimal variant. The chosen bridge design achieved the dual objectives of minimizing material usage while adhering to pedestrian comfort and other design criteria. Through this collaborative and innovative methodology, the project successfully enhanced the efficiency of the bridge design while ensuring optimal collaboration between the two companies.

Keywords: Parametric, vibrations, pedestrian bridge, design exploration, hybrid, FRP, steel, coordination model, collaboration

1 Introduction

In Gothenburg, for the first time in 100 years, a new bridge over the canal is being built. It is a bike and pedestrian bridge designed by architect Malin Mirsch of Systra AB. An impression of the bridge is shown in Figure 1. After considering various options for the bridge, a construction with a steel "arch" was chosen, which supports the deck at two points at approximately 1/3 and 2/3 of the span. The end of the deck is supported on concrete abutments.

Originally, a steel deck was considered. Due to poor soil conditions in the area a lighter Fiber-Reinforced Polymer (FRP) deck was chosen. Dennis Schakel of Systra AB took the FRP course at TU Delft and had previously been in contact with Kees van Ijselmuijden of Royal HaskoningDHV about FRP

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