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Study of super long span cable-stayed bridges with CFRP components

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ABSTRACT

This paper introduces new types of cable-stayed bridges with carbon fiber reinforced polymers (CFRP) stay cables and/or a CFRP bridge deck. For each of the two CFRP components, namely, CFRP stay cables and CFRP bridge deck, the key design parameters and design strategies were determined and the appropriate value of each key design parameter was suggested. Using the suggested parameter values, six types of cable-stayed bridges with a main span length of 1400 m were selected and modeled with the finite element method, through which the procedures of designing composite cable-stayed bridges with CFRP components were presented in details. From a mechanical-behavior viewpoint (static and dynamic) a comparative study of composite cable-stayed bridges with different CFRP components was performed through numerical simulations. The economical behavior of each type of cable-stayed bridges was also comparatively studied considering the varying material price. With the high strength-to-weight ratio and other advantages of CFRP materials, it was proven in this study that the use of CFRP stay cables and CFRP bridge decks in super long span cable-stayed bridges is feasible and these types of composite cable-stayed bridges could become an excellent alternative to steel cable-stayed bridges where super long spans are desired.

1. Introduction

Carbon fiber reinforced polymers (CFRP) are increasingly making their way into the field of bridge engineering [1–5]. With this trend, the concept of composite cable-stayed bridges with CFRP stay cables and/or a CFRP bridge deck is also beginning to gain popularity in the bridge community. With light weight and superior strength, CFRP materials can be utilized to improve the load-carrying efficiency and extend the span length of cable-stayed bridges to over 1000 m. Also, the excellent durability and corrosion resistant behavior of CFRP materials make the CFRP cable-stayed bridges favorable in difficult environments such as those crossing straits and oceans. These features of CFRP materials may make them very attractive and favorable in designing cable-stayed bridges with super long spans [1].

The study of CFRP stay cables and CFRP bridge decks has recently attracted many researchers' attention; however, few studies have discussed the strategies for designing composite cable-stayed bridges with CFRP stay cables and/or a CFRP bridge deck [6–11]. There have been only a few field applications of the two CFRP components in short span cable-stayed bridges [10]. A comparative study of composite cable-stayed bridges with different CFRP components is desirable to fully understand the advantages and disadvantages of CFRP materials for their applications to stay cables and bridge decks.

To this end, in the present study six cable-stayed bridges with a main span length of 1400 m were selected. Finite element (FE) models of the six bridges were created and the design strategies for each bridge type were proposed. Five of them were composite cable-stayed bridges with CFRP stay cables and/or a CFRP bridge deck; the other one was a traditional steel–concrete cable-stayed bridge and was designed for the purpose of comparison. The key design parameter for each CFRP component was determined and appropriate value of each parameter was then suggested. The procedures of designing the proposed composite cable-stayed bridges with CFRP components were also presented in detail. Finally, from a mechanical-behavior viewpoint (static and dynamic) a comparative study of composite cable-stayed bridges with different CFRP components was performed through numerical simulations. The economical behavior of each type of cable-stayed bridge was also comparatively studied considering the varying material price. With the high strength-to-weight ratio

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