Initial Shape Analysis of Cable-Stayed Suspension Bridge

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Summary

A cable-stayed suspension bridge is a hybrid structure that combines cable-stayed and suspension systems. This paper illustrates a novel method for determining the initial cable forces and target configurations of cable-stayed suspension bridges. The initial equilibrium states of a cable-stayed suspension bridge have not been investigated thus far. Hence, we propose an analysis method that involves the separation of the stay cable-supported and suspension cable-supported parts in order to analyze the initial equilibrium states of such a bridge. The analysis results for each part and suitable boundary conditions are employed to obtain the final cable forces and configuration of the entire system in the initial equilibrium state under dead loads. To verify the proposed method, an initial equilibrium state analysis is performed for a model of a cable-stayed suspension bridge having a total length of 4,000 m with a center span of 2,500 m. The results of this analysis indicate that the initial configurations and cable forces in the bridge model effectively satisfy the target design values.

Keywords: Cable-stayed suspension bridge; initial shape analysis; initial cable force

1. Introduction

The purpose of this paper is to propose a new method for determining the initial cable forces and shapes satisfying the design criteria of a cable-stayed suspension bridge. A cable-stayed suspension bridge is a hybrid system, simultaneously supporting the stiffened girders with two types of cables, i.e., stay cables and suspension cables. Specifically, the stiffened girders are supported near a tower using stay cables, whereas the center span is supported by suspension cables and hangers. Researches related to the problem of defining the initial shape in a cable-supported bridge have been steadily performed [1]. However, in the case of a cable-stayed suspension bridge, the initial cable forces and shapes cannot be determined using the previous methods because the two structural systems are combined into one system. Therefore, in this paper, algorithms are developed to analyze each part by separating the stay cable-supported and suspension cable-supported parts. Then, an example model of a cable-stayed suspension bridge is analyzed to verify the proposed method.

2. Schematic procedure of the proposed method

A schematic procedure to determine the initial shape of a cable-stayed suspension bridge is shown in Fig. 1. The initial tensile forces acting on the cable elements are calculated by separately analyzing the suspension cable-supported part (Fig. 1(b)) and the stay cable-supported part (Fig. 1(c)) in order to calculate the coordinates and tensile forces of the cables of the cable-stayed suspension bridge under a dead load. Then, the cable forces calculated in each part and the boundary conditions at the tops of the towers, as shown in Fig. 1(d), are employed to the entire model of the cable-stayed suspension bridge. A geometric nonlinear analysis is performed to calculate the reaction force R_H, which will be applied as cable force $R_H \cos\theta$ of the back-stay cable at the side span. Then, the displacements at the tops of the towers are checked, and the cable forces of the back-stay cables are modified (Fig. 1(e)).

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