A prediction method for cable forces of cable-stayed bridges using fuzzy processing and Bayes estimation

Li Dong, Bin Xie, Dongli Sun, Yizhuo Zhang

Tianjin Municipal Engineering Design and Research Institute, Tianjin, CN

Contact: dongli1990@hotmail.com

Abstract

Cable forces are primary factors influencing the design of a cable-stayed bridge. A fast and practical method for cable force estimation is proposed in this paper. For this purpose, five input parameters representing the main characteristics of a cable-stayed bridge and two output parameters representing the cable forces in two key construction stages are defined. Twenty different representative cable-stayed bridges are selected for further prediction. The cable forces are carefully optimized through finite element analysis. Then, discrete and fuzzy processing is applied in data processing to improve their reliability and practicality. Finally, based on the input parameters of a target bridge, the maximum possible output parameters are calculated by Bayes estimation based on the processed data. The calculation results show that the average prediction error of this method is less than 1% for the twenty bridges themselves, which provide the primary data and less than 3% for an under-construction bridge.

Keywords: cable-stayed bridge; cable force; Bayes estimation; fuzzy processing.

1 Introduction

With the development of materials and design methods, the large-scale construction and promotion of cable-stayed bridges began in the second half of the 20th century, and the long-span composite cable-stayed bridges also developed rapidly [1]. At present, the composite cable-stayed bridge is still the most competitive type among the 200~600m span bridges.

As a result of a large number of cables and their adjustability, there are a variety of stress states of a completed bridge that meet the structural requirements. The appropriate completion states obtained by different optimization algorithms may be quite different. Most of the existing optimization methods can be divided into the following three categories [2, 3, 4]: critical position control method (such as the continuous rigid-support beam method), unconstrained optimization method (such as the minimum bending energy method), constrained optimization method (such as the minimum cable material method). There are many different genetic algorithms and particle swarm optimization algorithms to solve the cable force optimization problem [5]. It has become a trend to form a multi-objective optimization method to obtain better results [6].

Because the excellent cable force results of cable-stayed bridges are not unique, the complexity and versatility of various optimization methods with different control objectives are different. Based on existing cable force data, the method in this paper selects several specific representative main

https://doi.org/10.2749/ghent.2021.0644
Distributed by structurae