Prediction of Aerodynamic Coefficients using Artificial Neural Network in Shape Optimization of Centrally-Slotted Box Deck Bridge

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Abstract

Aerodynamic shape optimization of bridge deck is a very important task in the wind-resistant design of long-span bridges and often carried out via wind tunnel tests of sectional model or CFD simulation, both of which commonly need heavy workload, thus are time-consuming and costly. In this paper, an artificial neural network (ANN) model was developed to predict aerodynamic coefficients of a central-slotted box deck of a 1600m main span cable-stayed bridge during the aerodynamic shape optimization to enhance its performance of wind-induced static stability. The ANN model was built and trained with a data set of aerodynamic coefficients obtained from limited cases of wind tunnel tests. The effect of neuron numbers in the hidden layer on prediction accuracy was discussed. The results show that the built ANN model can accurately predict the aerodynamic coefficients and significantly reduce the workload of wind tunnel tests.

Keywords: long-span bridge; centrally-slotted box deck; aerodynamic shape optimization; aerodynamic coefficients; artificial neural network.

1 Introduction

Over the last decades, with the application of new materials and the progress of construction technology, the span length of modern bridges has considerably increased. The demand for super long-span bridges with a main span of 1500 -3500 meters is growing. There are many super-long span bridges under construction or design in China, including Jiangsu Zhangjinggao Yangtze Bridge, Nanjing Wenjin Yangtze Bridge, Nanjing Xianxin Yangtze Bridge, Lingdingyang Shenzhen bridge, Changtai Yangtze Bridge, Hutong Yangtze River Bridge, with expect to be finished with five years. With the increasing span length, modern long-span cable-supported bridges become more and more susceptible to strong wind, and the wind-induced static instability and flutter are considered as critical factors that control the construction and design of bridges.

Flutter is generally treated as a sudden aeroelastic instability phenomenon caused by negative aerodynamic damping. Once the wind speed exceeds the critical wind speed, the system damping will be negative, and the structural vibration diverges rapidly with the increase of

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