A multi-objective genetic algorithm for optimal design of cable networks with external dampers and cross-ties

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Abstract

A hybrid technique combining cross-ties and external dampers has been successfully applied in several cable-stayed bridges. However, there is a lack of optimization design method in practical design of the hybrid system. Therefore, this study proposes an optimal design method to optimize the parameters of the cross-ties and external dampers for the cable vibration mitigation, using multi-objective genetic algorithm (MOGA). A two-cable hybrid system is studied in this paper and its characteristic equation is derived by using the complex modal analysis method. The optimal design method is introduced and its feasibility is demonstrated by analyzing a simple cable-damper system. Subsequently, the proposed method is used for optimal design of the cross-tie and external dampers of a two-cable hybrid system. The results indicate that the proposed method can be used for performance optimization of hybrid cable networks system in practice.

Keywords: Optimal design; hybrid cable networks; external damper; multi-objective genetic algorithm (MOGA).

1 Introduction

Due to the low levels of inherent damping and high transverse flexibility, cables in cable-stayed bridges are prone to vibrations induced by various types of excitations, including wind and rain. To mitigate their vibration, several useful countermeasures have been used in practice, e.g., mechanical dampers and cross-ties [1-3]. Mechanical dampers installed between cable and bridge deck can directly increase the cable damping, and the cross-ties interconnected adjacent cables can increase cables frequency by reducing the free length of cables. As cables are increasingly long in long-span cable-stayed bridges, a single measure may no longer meet the requirements of vibration control. Hence, the idea of combining cross-ties and external dampers into a hybrid system for cable vibration control was proposed, which combines the energy dissipation of damper and energy redistribution capability of networks formed using cross-ties [4-6]. This countermeasure has been successfully used in practice, such as, the Normandy Bridge in France, the Fred Hartman Bridge in USA.

However, up to now, the design of hybrid technique or cross-ties still relies on engineering experience and lacks effective optimization methods. Existing studies mainly focused on mechanism exploration and parametric analysis of the system [7-10]. Therefore, in this paper, a novel design approach based on MOGA is proposed to optimize the hybrid technique by taking a two-cable hybrid system as an example. Hence, the

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