Parametric Analysis and Performance Evaluation of Tuned Mass Damper Inerter (TMDI) to Mitigate the Vortex-Induced Vibration of a Long-Span Bridge

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Abstract

In this paper, an inerter is incorporated into the conventional TMD system, and the performance of the novel inerter-based system, namely tuned mass damper inerter (TMDI), for the VIV mitigation of long-span bridges has been studied. A suspension bridge is taken as a numerical example to verify the performance of TMDI, and the optimal parameters of TMDI are determined by the genetic algorithm. A parametric analysis of the control effect of TMDI is conducted to investigate the influence of the mass ratio and inertance ratio of TMDI on its static deformation, control effect, stroke and control force. The results show that with the same mass ratio, TMDI is slightly less effective than TMD, but it can still significantly reduce the vibration amplitude of the bridge deck. The static deformation and stroke of TMDI are much smaller than that of TMD, which saves installation space and makes it more suitable for the vertical vibration control of long-span bridges.

Keywords: long-span bridge; vortex-induced vibration; tuned mass damper inerter; vibration control.

1 Introduction

With the technical advancement of bridge construction, long-span bridges become more and more flexible, thus the abnormal vibration of bridges occurs frequently at low wind velocity. Vortex-induced vibration (VIV), a typical wind-induced vibration, has a great influence on driving comfort and safety, and a lot of control schemes have been devoted to the problem. Tuned mass damper (TMD) is one of the most effective schemes and has been widely adopted in long-span bridges due to its reliability. However, the application of TMD on the vertical low-frequency VIV control of bridges is limited since the static deformation is excessive.

Recently, a novel two-terminal device named inerter was applied to the vibration control of engineering structures. Smith [1] first proposed the concept of inerter in 2002. Ikago et al. [2] proposed a new seismic control device, tuned viscous mass damper (TVMD), and derived a closed-form optimum design for the TVMD vibration control system. Garrido et al. [3] proposed a rotational inertia double-tuned mass damper (RIDTMD) by replacing the viscous damper in conventional TMD with the TVMD. They demonstrated that RIDTMD is more effective at the same mass ratio, especially near the resonant frequency, and the suppression band is wider than TMD. Marian and Giaralis [4] introduced inerter into TMD to achieve enhanced performance in mitigating the response of the primary structure subjected to white noise

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