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Experimental test of asymmetrical cable-stayed bridges using MR-damper for vibration control

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ABSTRACT

In this paper, a semi-active control by MR-damper is researched; its purpose is to effectively control vibration of asymmetrical cable-stayed bridges when earthquake is loaded on the type of bridge. For an experimental study, a model of 10.2 m high and 28 m long asymmetrical cable-stayed bridge structure was built being similar to a real one in size and function. A MR damper was also designed in proper size suitable for the control of the model. The experiment was performed in the way in which three piers were fixed on three shaking tables with 30% of El-centro earthquake wave, and a control device was placed on the lower part of its upper deck for horizontal control. As for control algorithms, Lyapunov and Clipped-optimal control algorithms were applied. The effectiveness of the semi-active control with MR damper for the asymmetrical cable-stayed bridge was measured under five control conditions: Uncontrol, Passive-off, Passive-on, Lyapunov Control, Clipped-optimal Control. The experiment showed that the semi-active control applying Lyapunov and Clipped-optimal algorithms effectively increased controllability almost in double, and decreased displacement 75% compared with the condition of passive-off. Therefore the semi-active method suggested in this paper is proven effective in controlling asymmetrical cable-stayed bridges.

1. Introduction

Almost all structures are commonly exposed to unexpected and uncertain loads like moving traffic, typhoon, earthquake, and other natural disasters. Specially, cable-stayed bridges are even more vulnerable to such devastating loads for their structural flexibility. In spite of their vulnerability, cable-stayed bridges continue to be built by virtue of their beautiful appearance. For the reason, many researches are being done on how to control the harmful vibration of the bridges to secure their safety and effective long-term maintenance [1–4].

Among various methods to control the vibration of bridges, the semi-active control method is particularly being studied in terms of control device or control algorithm. As for the researches on control device, they study on MR (Magneto-Rheological)-damper, orifice fluid damper, controllable friction damper, smart tuned mass damper, etc. Specially, since MR developed by Carlson at Lord was introduced into civil engineering, its application has been studied for the control of structural vibration [5–7].

Although MR damper may not function well due to MR fluid's inherent viscosity when it is not used for a long time, the MR-damper applied semi-active control is highly effective with minimum power by making it possible to receive fast control response. Also its mechanical simplicity and sturdiness is found very useful for the vibration control of large-scale structures, and so it is consistently being researched [8–10].

In order to control the vibration of structures with the semi-active method and also eventually develop a unified control system, a choice of proper algorithm is very important. Spencer and Dyke et al. performed a research of contrasting and comparing various control algorithms and control devices in terms of strength and shortcoming, and also an interpretative research for criteria for their evaluation [11,12]. Anat et al. presented an ideal interpretation of MR damper along with its frictional and viscous quality, and performed an experiment on the semi-active control method with MR damper of Lord (RD-1005-5-2) applying two kinds of control algorithm and inflicting a repeated load on a connected three-span structure which was 1 m in length and was 0.49 m in height [13]. Besides that, there were many other researches most of which were numerical and interpretative ones [11,14], and only a few were experimental. Even those experimental researches focused merely on the constitution of wireless system and its evaluation rather than on control algorithm and effective control device. And their target structures were mostly buildings rather than bridges [15].

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