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Paper 278

Vibration Control of Civil Engineering Structures using Magneto-Rheological Dampers

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Recent developments in civil engineering structures design and construction allowed the creation of slender and flexible structures such as towers, high-rise buildings and long span bridges. The structural properties of these structures, namely the low damping capability makes them vulnerable to strong wind or earthquake actions.

In recent decades various control systems based on passive, active, semi-active and hybrid devices have been proposed and different control strategies were developed and implemented for structural vibration control. Among these, the semi-active based control has become an important alternative to passive and active control methods as a result of its ability to gather some of the advantages of the passive control such as the reliability of these systems with the adaptability of the active control.

Magneto-rheological (MR) dampers are semi-active devices that can provide adequate vibration control of civil engineering structures as a result of their reliability and reduced power requirements. These devices have damping characteristics that can be modified in real time by adjusting the flow of a MR fluid with an applied magnetic field. Thus, a control algorithm that computes the required current level to adjust the MR damper damping force must be employed and several control strategies have been developed and validated for these semi-active devices.

A semi-active clipped-optimal control algorithm was proposed to reduce the structural response with a MR damper and has become a reference MR damper control approach. This is a model-based algorithm that commands the MR damper operating voltage or current by a linear optimal controller with a force feedback loop. The semi-active fuzzy control strategy is a robust control method that uses the fuzzy set theory to deal with input uncertainties or disturbances and has the ability to develop a controller without the exact mathematical model of the system. It also has the ability to compute the required current or voltage in order to generate the desirable damper force without measuring the generated damping force.

The research, described in this paper, investigates the semi-active control of a small-scale metallic frame equipped with a small MR damper. To implement a control system it is necessary to choose a numerical model to simulate the non-linear behaviour of the MR damper. Among the number of available models, the simple Bouc-Wen model was selected to simulate the MR damper response. An experimental program was carried out and the experimental data obtained with this program were later utilised to determine the parameters required to define the simple Bouc-Wen model.

In this research two vibration control approaches were selected to reduce the response of the scaled model frame: the clipped optimal algorithm and a fuzzy theory based control. The purpose of using these two control strategies is to compare their performance and efficiency to control the vibration induced by a simulated earthquake signal. A numerical model of the system was developed and one of the ElCentro records was used as the earthquake input signal. The performance of the two control systems is then compared with the results of similar response parameters of the uncontrolled structure and of several passive configurations of the MR damper.