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Abstract

Semi-active control algorithm and simulation analysis for structural protection using MR dampers

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Magnetorheological (MR) dampers are one of the most promising semi-active control devices for mitigating seismic response and so they have received significant attention in recent years. MR dampers have a number of attractive features. First, they are relatively inexpensive to manufacture because the fluids are not sensitive to impurities which are commonly encountered during manufacturing. Additionally, requiring only 20-50 watts of power, MR devices can operate with a battery, eliminating the need for a large power source or generator. Moreover, because the devices' forces can be adjusted by varying strength of the magnetic field, no mechanical valves are required, making a highly reliable device. Further, the fluid itself responds in milliseconds, which allows for the development of devices with a high bandwidth. Because of the inherent nonlinear behavior of MR dampers, however, one important challenge is to develop an appropriate control algorithm to take advantage of the unique characteristics of the device to achieve high levels of performance.

In this thesis, a semi-active control algorithm for civil structure with MR dampers is presented that is based on the nonlinearity present in the MR damper and the interaction between the control devices and the civil structure. The force produced by the MR damper can be increased or decreased by adjusting the value of the voltage applied to the MR damper. For this algorithm, the voltage is directly adjusted by the motion of the rod of the MR damper or the motion of the story where the MR damper is installed. Therefore, for this control method, full range of the voltage applied to MR damper can be available compared to various bang-bang control methods [1, 2, 3]; no reference active control forces need to calculate first to obtain the voltage through the clipped-optimal method [4, 5, 6]. Because the control strategy is based on the full state feedback and

only limited measurements are available, the Kalman filter is used in this thesis to estimate the full state of the structure. The main purpose of the proposed approach is to achieve a more robust performance for uncertain structural systems subjected to uncertain strong-motion excitations. The performance of the proposed approach is demonstrated through a simulated example of a ten-story building with MR dampers under random excitations and historical earthquake records with different magnitudes.