INNOVATIVE FUZZY CONTROLLER FOR SEMI-ACTIVE BASE ISOLATION SYSTEMS

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Controlling algorithms development is one of the most challenging aspects of structural researchers with the aim of improving the behaviour of the building structures equipped with controllable devices under the seismic hazards. Base isolator of building structures can be designed for a specific magnitude earthquake level (Naeim, 1999). Obviously, the design is not optimal for all earthquake excitations (Chang and Spencer, 2010). In this paper, semi-active base isolation system is employed to enhance the performance of the base isolated structures under the several seismic conditions. A semi-active magneto-rheological (MR) damper works parallel with base isolation system. An innovative fuzzy controller is designed to control the applied voltage of the MR damper in accordance to the feedbacks of the structure. To investigate the performance of the controller in reducing the responses of the structure, a fourteen-story building structure is subjected to El Centro, Hachinohe, Kobe, Northridge and Tabas earthquake accelerations. The displacement and acceleration responses of the building's roof story with passive and semi-active base isolation devices is compared with that of the fixed base structure. The results have been showed the efficiency of the fuzzy controller in comparison with the passive base isolation system in various earthquake excitations.

In this study, according to the physical attributes of the base isolated building structure and the phase of the responses, fuzzy controller has been designed to reduce the responses under the earthquake excitations applied to the system. In conventional base isolation controlling algorithms the demanding force of the system is calculated according to the feedbacks and the applying voltage of the MR damper estimated by a filter (Yoshioka et al., 2002; Bo et al., 2014).

An innovative fuzzy controller is proposed that can directly apply the appropriate voltage to the MR damper to reduce the responses of the structure equipped with semi-active base isolation system. Inputs of the fuzzy controller are the velocity of the base story and the displacement and velocity responses of the top floor and the output is the command voltage of the MR damper.

Modelling of the system containing the structure and semi-active base isolator with MR damper device and fuzzy controller that estimates the applying voltage of the MR damper is planned by the SIMULINK environment of the MATLAB software (Figure 1). A Gaussian noise generator is employed to consider the imperfection of the sensors estimating the system responses. In addition, with a unit delay the postponed time of the applying MR damper force to the structure can be taken into account.

El Centro earthquake acceleration is implemented to this simulated model and the displacement time history response of the structure's top story is plotted and compared with that of the passive base isolated and fixed base building in Figure 2.

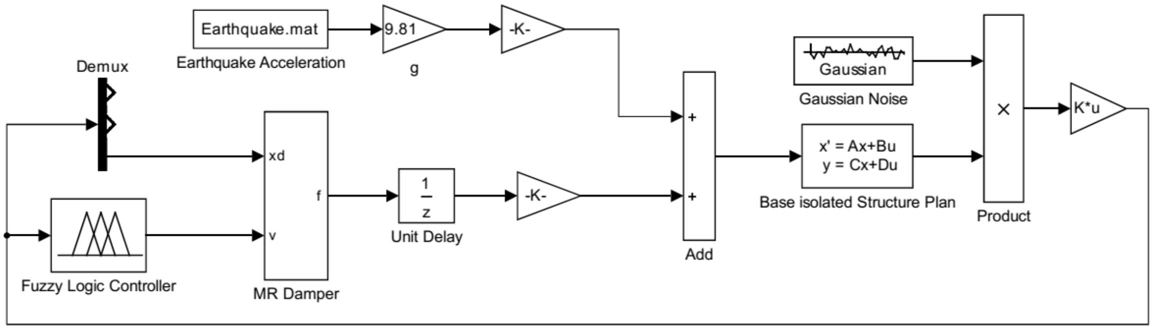

Figure 1. Simulink model of the controlled structure

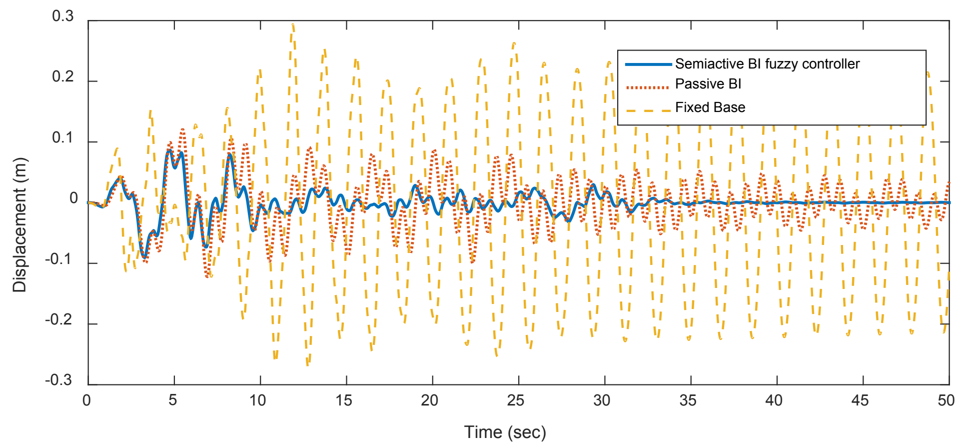

Figure 2. Top story displacement response under the El Centro excitation

The maximum and RMS (Root Mean Square) of the displacement response of the fixed base building under the El Centro excitation are 0.294 and 0.1528 m, respectively. The maximum and RMS displacement of the structure with passive BI are 0.1222 and 0.0405 m and those of the structure with semi-active BI by fuzzy logic controller are 0.0906 and 0.0207 m, respectively. The fuzzy controller is reduced the maximum and RMS responses of the passive BI about 26% and 49%. As can be seen, the semi-active fuzzy controller increased the performance of the system efficiently.

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