Seismic Vibration Control of Strategic Equipments Using Semi-Active Sliding Isolation Systems

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ABSTRACT

Critical and sensitive non-structural components need to be protected against various types of earthquake excitations. For these purposes, using proper control strategies is inevitable for protecting them against the seismic vibrations. This study examines the performance of a semi-active control strategy for the equipments installed on the frictional isolator. In order to control the frictional resistance level at the interface of sliding system, the piezoelectric materials are used. The piezoelectric materials adjust this threshold force by providing varying compression axial forces. The LQR controller is used as the control algorithm. For a numerical simulation, a ten-story building frame with the equipment located at the middle story is considered. The main structure as the primary system is modeled as a shear frame that has one lateral degree of freedom at each story level and the equipment is modeled as the secondary system. Results demonstrate that piezoelectric based smart frictional isolator has significant effects in reducing the seismic responses of the secondary system in comparison with the passive frictional isolator.

Key Words: Semi-active control, sliding isolation system, Piezoelectric, LQR controller.

1 INTRODUCTION

The history of seismic resistant design indicates that in many well designed superstructures, the security of main structural components is unchanged during the earthquake vibrations while the non-structural components and critical equipments, including life-saving facilities in hospitals, data centers, high technology instrumentations, nuclear power plant, etc. may be failed and collapsed. Hence, the main structure may malfunction due to the fact that the collapse of these sorts of equipments may cause heavy economic loss and also limits the capability of authorities in providing urgent services during the earthquake events. In other words, when the ground acceleration is transmitted to upper floors it will be amplified. Therefore, the sensitive equipment mounted on upper floors is subjected to much stronger excitations than the base of main structure. This large induced acceleration imposes a huge inertia force on housed equipment during the earthquake excitations which leads to failure of them while the primary structure itself may survive the event. In this context, control systems are used as an effective strategy to protect the superstructures and their attached equipments against dynamic forces.

There are three classes of control strategies, categorized into passive, semi-active and active control mechanisms. Passive control systems are non-controllable and require no external power source to operate. Active control systems are controllable, but require significant power to operate. Semi-active control systems combines the advantages of both passive and active systems in that they are controllable but require little power to operate [1]. In the last two decades, the semi-active control strategies have attracted considerable attention in the field of vibration control of civil structures against dynamic forces like earthquake. This is because of its potential to provide the