A SEMI ACTIVE CONTROL STRATEGY FOR SEISMIC TORSIONALLY COUPLED BUILDING STRUCTURES

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It is well known that real response of plane-asymmetric buildings with irregular distributions of mass or stiffness can be affected by coupling of translational and rotational vibrations. This type of structures is likely to suffer more severe displacement demands at the corner elements under earthquake ground motions. Due to some architectural, employing traditional approaches to seismic control of these structures such as altering the stiffness and/or mass distributions is not usually practical choice. Structural control strategy represents a relatively new and smart approach to improve the performance of such systems. Accordingly, supplemental damping devices have attracted growing worldwide interest as an innovative approach to protect structures against natural extreme events by enhancing the structural energy dissipation capacity. Depending on the level of energy dissipation required and the sensitivity related to the band control, a control system can be broadly categorized into various strategies such as passive, active, semi active and hybrid systems. Although various devices have been proposed for these control systems, semi-active devices introducing the positive aspects of passive and active control devices have been given much consideration. However, most of the past experiences have been conducted on planar (symmetric-plan) systems, whereas there are a few studies that have considered the effects of control strategy on seismic response of asymmetric buildings (Yoshida and Dyke, 2005; Pnevmatikos, 2012; Mevada and Jangid, 2012). This paper addresses the effects of different semi-active control strategies on the seismic response of one-story, asymmetric-plan systems. The Magneto-Rheological (MR) dampers have been used as a semi-active control device in numerous researches both for symmetric and asymmetric buildings due to their attractive characteristics. However, one can show that the level of reduction in seismic torsional responses of asymmetric buildings is strongly affected by the asymmetric parameters of the building's plan. To examine the effect of asymmetry on the dynamic behavior of a controlled typical structure, a parametric study is performed using a mathematical model of a one-story building with an asymmetric stiffness distribution in one direction. The model is subjected to a uniaxial lateral disturbance, exciting both lateral and torsional motions. The equation of motion of this structure can then be written as follows:

$$M\ddot{u} + C\dot{u} + Ku = -M\Lambda\ddot{u}_g + \eta F \tag{1}$$

M, C and K represent mass, damping and stiffness of the structure, respectively. $u = \{u_x, \theta\}$ is the displacement vector, $\ddot{u}_g = \{\ddot{u}_x, 0\}$ is the earthquake acceleration and Λ is the influence vector with the order of 2×1 and each element is equal to 1. η is the vector of additional damper locations and F is the damper force vector. The performances of a variety of control algorithms including FLC and LQR used in the semi-active control of symmetric structures are examined. The peak responses of the system including lateral, torsional and edge displacements and their acceleration counter parts as well as dynamic eccentricity control are investigated under following some significant parametric variations such as static eccentricity ratio (e_y/r), ratio of uncoupled torsional to lateral frequency of the system ($\Omega_\theta=\omega_\theta/\omega_x$) and uncoupled lateral time period of system ($T_x=2\pi/\omega_x$) .

Due to the highly nonlinear dynamic behavior of MR dampers, existing uncertainty of seismic excitation and also torsional behavior of the systems, development of a robustness control algorithm is found as a significant challenge. Application of optimal strategy to create an admissible control algorithm and attain the desired level of performance isalso investigated in this study. In order to evaluate the effectiveness of the proposed methods, the performances of semi-active controllers are compared with some other control algorithms in a numerical example.

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