Abstract

NON-LINEAR ANALYSIS OF STEEL BUILDINGS WITH OPTIMIZATION OF DAMPER PLACEMENT

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Controlling the dynamic response of structures is one of the challenges in the structural design of medium or high-rise buildings. The height of the structure tends to increase the flexibility and reduce the damping. In order to control the vibrations due to wind and seismic actions, various control techniques are developed. One of the common passive control systems is the tuned mass damper (TMD) that consists of a mass, spring, and dashpot that, when it is attached to a vibrating system, it damps its dynamic response.

This thesis investigates the mitigation of the excessive vibrations in multistory steel buildings using linear and nonlinear TMDs. Three types of stiffness mechanisms of TMDs were studied: linear, essential non-linear (without linear part), and non-linear (with linear part). The inelastic multistory 2-D steel buildings were numerically modeled, and the non-linear direct integration dynamic analysis was performed by a developed MATLAB code to obtain the damped and the undamped responses of the structures in terms of deflections, accelerations, and velocities at all stories. In addition, the energy transfer process of utilizing the dampers to enhance the dynamic behavior of inelastic structures to dissipate seismic input energy is studied. The structural behavior is assessed in terms of period elongation by making use of wavelet transform (WT) analysis which is one of the signal analysis methods.

An elastic-perfectly plastic material model with kinematic hysteretic type was utilized for modeling the inelasticity of the structures. In order to evaluate the effectiveness of dampers in suppressing the dynamic response, a set of eight earthquake events possessing a diverse frequency content were used. These events have been applied as an acceleration time-history at the base of the structure.

The minimum dynamic response of the structures for each seismic event was obtained by opting for the proper parameters of the damper. Thus, an optimization process via genetic algorithms (GAs) and particle swarm optimization (PSO) methods were adopted in this study to obtain the optimal parameters and location for each type of dampers. The effectiveness of each optimal damper designed for a specific earthquake is tested for the rest of earthquake events. Moreover, the effect of multiple earthquakes with different frequency spectrums is considered in the design of the dampers through the multi-input optimization (MIO) which uses the same concept of multi-objective optimization problems in which more than one objective, e.g., the minimization of maximum roof displacement, acceleration, minimize drift, or maximize energy dissipation, is involved to be optimized simultaneously.

Results showed that the optimally designed dampers by the proposed method are efficient in reducing the dynamic response of both elastic and inelastic structures, and (almost always) the best location of the damper is the top of the structure. It was observed that the efficiency of the dampers depends not only on the structural properties but also

on the characteristics of the earthquake excitation. Moreover, the MIO technique is more robust and reliable in the design of the damper.