Multi-objective optimization of seismically excited buildings using genetic algorithms and MR dampers

S. H. Shekarian[1], S. Pourzeynali[2]

1- M.Sc. Student, Dept. of Civil Engineering, The university of Guilan, Rasht, I.R. Iran
2- Associate Professor, Dept. of Civil Engineering, The university of Guilan, Rasht, I.R. Iran

s.hossein.shekarian@gmail.com
pourzeynali@guilan.ac.ir

Abstract

This paper presents multi-objective genetic algorithm optimization response control of a 3D 9-storey building frame using MR dampers. Equations of motion for the structure equipped with MR dampers have been established. Three appropriate objective functions have been chosen to perform the optimization process and the number and location of MR dampers have been optimized. Two different cases are studied as *passive off* and *passive on* in which the command currents of devices are set to minimum and maximum value, respectively. For each case, records from five ground motion data are applied to the building and GA is performed to determine the places where the dampers show their best performance. Then, an optimal force control strategy is employed to gain the full capabilities of the MR dampers. Results show that using the MR dampers in proper places can effectively reduce both the displacement and acceleration responses of the example building.

Keywords: Semi-active control, MR damper, Multi-objective optimization, LQR control theory.

1. INTRODUCTION

In recent years, many different approaches have been suggested by researchers to mitigate seismic hazards on structures. Through these methods in order to improve the reliability and safety of the structures against earthquake dynamic forces and to reduce the structural element damaging, the characteristics of stiffness, damping and effective mass of structure have been changed during earthquake, thus the dynamic response of structure is mitigated. These systems are called control systems and categorized into four main groups: active, passive, semi-active and hybrid control systems.

In active control systems, the structural response is controlled by applying the external forces on different locations according to feedback from structural responses. Despite adaption to different loading conditions, these systems are able to destabilize the structure, because of applying power to it.

Passive control systems reduce the structural vibrations according to structural responses during the earthquake, without using any external power. Since the characteristics of these control systems are unchangeable outside the system, they are sensitive to amplitude and frequency of excitation applied to structure and do not demonstrate adequate adaptability for different earthquake force conditions.

Semi-active control systems are designed to reduce the constraints exist in active and passive control systems. These systems have both adaptability to different loading conditions like active control systems and reliability of passive control systems. In this paper, application of magneteorheological damper control system for simultaneous mitigation of dynamic structural responses to earthquake is studied.

2. MAGNETORHEOLOGICAL DAMPER

Magnetorheological fluids (or simply "MR" fluids) belong to a class of controllable fluids that respond to an applied field with a dramatic change in their rheological behavior. The essential characteristic of MR fluids is their ability to reversibly change from free flowing, linear viscous liquids to semi-solids having a controllable yield strength in milliseconds when exposed to a magnetic field. Normally, this change is manifested by a very large change in the resisting force of devices in which MR fluid is used, called MR dampers.. These fluids are suspensions of micron-sized, magnetizable particles in an appropriate carrier liquid. In the presence of an applied magnetic field, the particles acquire a dipole moment aligned with the external field that causes particles forming linear chains parallel to the field. This phenomenon can solidify the suspension and restrict