Multi-objective Optimization of Seismic Vibration Control of Critical Equipments Isolated with Sliding systems

M. Faraji, N. Fallah, G. Zamiri
Department of Civil Engineering, University of Guilan, Rasht, P O Box 3756, Iran

Fallah@guilan.ac.ir

Abstract

Sensitive equipments as the secondary structures can be isolated from the floor vibrations caused by earthquakes using a proper isolation system. In this study the effectiveness of the sliding isolation system that is placed between the floor of the primary structure and the sensitive equipment is investigated under a group of earthquake records. In order to find the optimal values of the parameters of sliding isolator, namely: friction coefficient, damping coefficient and stiffness of restoring force device, a fast and elitist non-dominated sorting genetic algorithm (NSGA-II) method has been applied. The simultaneous minimization of acceleration and displacement of the secondary system are considered as objective functions. For the numerical study, the primary structure is considered as a ten-story shear frame with one lateral degree of freedom at each story level. The isolated equipment is considered at the fifth story of the primary structure. Results demonstrate the effectiveness of the considered isolation system in reducing the seismic vibration of the equipment. Also results reveal that the NSGA-II approach is strongly effective for evaluating the optimal values of parameters of the isolation system.

Keywords: secondary structures, sliding isolation system, multi-objective optimization, genetic algorithm, seismic vibration

1. INTRODUCTION

Protection of structures against earthquake vibrations is one of the main goals in a seismic resistant design that has a long history. In new earthquake design methodology, control systems are used as an effective strategy to protect the structures against dynamic forces. Control systems can be classified into passive, semi-active and active control mechanisms. Isolation system belongs to the passive control group is one of the most popular means of protecting a structure against natural forces like earthquake that has attracted considerable attention in recent years. The main performance of isolation systems is reducing the fundamental natural frequency of structural system to a value lower than the predominant frequencies of earthquake and also dissipating the seismic energies radiated by earthquakes [1-2].

In some designs, superstructures support the important and expensive non-structural components and equipments such as nuclear power plant, data center, internet facilities, telecommunication buildings and museums. Protection of these items against earthquake event is vital because the value of contents may be greater than the main structure. One of the main reasons that causes the housed equipment to be failed during the earthquake excitations is the large induced acceleration that imposes a huge inertia force while the primary structure itself may survive the event.

A number of research works have been conducted by employing isolation systems at the base of structures aiming to reduce the responses of secondary structures. In order to protect the internal sensitive equipments and facilities against the earthquake vibration, Fan et al. [3-4] used a number of conventional base isolation systems on the base of the main structure. Performing a parametric study, they found that using a properly designed base isolation system can significantly reduce the peak responses of secondary system. Young-sang kim et al. [5] studied the effectiveness of the base isolation system that is installed on the supports of the secondary structure. They demonstrated that using isolation system between secondary system and associated floor is more effective and economical than isolating the entire base of primary structure. Pranesh marnal et al. [6] used sliding isolation systems such as variable frequency pendulum isolator (VFPI), friction pendulum system (FPS) and pure friction (PF) system that were placed on the base of primary structure. They found that VFPI in comparison with other friction isolation systems is more effective in controlling the response of structure-equipment placed systems. M. Ismail et al. [7-8] proposed a new rolling-based seismic isolation bearing, named roll-n-cage (RNC) isolator, for motion-sensitive equipment protection. A multi-objective optimization of a PF system equipped with restoring force device