MULTI-OBJECTIVE OPTIMIZATION OF SEISMICALLY BASE ISOLATED BUILDING WITH TUNED MASS DAMPER

Ebrahim NAZARIMOFRAD
Bu Ali Sina University, Faculty of Engineering, Hamedan, Iran
enazarimofrad@gmail.com

Saeed PIRGHOLIZADEH
Shahroud University, School of Civil & Architectural Engineering, Shahroud, Semnan, Iran
saeedpgz@gmail.com

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The main objective of the paper is to find the optimal values of the parameters of the base isolation and the tuned mass damper system, using genetic algorithms (GAs), to simultaneously minimize the displacement of the building's top story and that of the base isolation system. There are six unknown parameters as variables: stiffness and damping ratio of the base isolation and mass, stiffness, damping and location of the tuned-mass damper that should be optimized. In order to simultaneously minimize the objective functions, a fast and elitist non-dominated sorting genetic algorithm (NSGA-II) approach is used to find a set of Pareto-optimal solutions. Through the numerical simulation of an eight-storey base-isolated building subjected to El Centro earthquake records, it was found that better location of tuned mass damper is between one and three storey.

Figure 1 shows the idealized mathematical model of the N-story, base-isolated, building structure with tuned mass damper that considered in the present study. For the system under consideration, the governing equations of motion are obtained by considering the equilibrium of forces at the location of each degree of freedom. The Equations (1-3) are derived and combined from Naeim and Kelly, 1999 and Connor and Laflamme, 2014.

$$M\ddot{u} + C\dot{u} + Ku = -MR(\ddot{u}_g + \ddot{u}_b) + \Gamma(k_t u_t + c_t \dot{u}_t) \tag{1}$$

$$\sum_{i=1}^{n} m_i \ddot{u}_i + m_t \ddot{u}_t + (\sum_{i=1}^{n} m_i + m_b + m_t)\ddot{u}_b + k_b u_b + c_b \dot{u}_b = -(\sum_{i=1}^{n} m_i + m_b + m_t)\ddot{u}_g \tag{2}$$

$$m_t \ddot{u}_t + k_t u_t + c_t \dot{u}_t = -m_t(\ddot{u}_g + \ddot{u}_s) \tag{3}$$

Where M, C, and K are the structural mass, damping, and stiffness matrices, respectively, and u is the displacement vector of the building stories relative to the base slab; and R is the influence vector of üg that is the earthquake ground acceleration, and a dot denotes the time derivative. Also mb, cb, kb are the base isolation mass, damping, and stiffness, respectively and mt, ct, kt are the tuned mass damper, respectively. In Equation (1) parameter Γ specifies the location of TMD on desired storey.

For numerical evaluation of the isolation systems with TMD and effectiveness of GA optimizers proposed in this investigation, an eight-story building is selected. Properties of the building are summarized in the Table 1. In the table the interval of six variables that should be optimized has been introduced. A functional code was written in the MATLAB software with six input and two objectives as output that were the displacement of the building's top story and the displacement of the base slab. The code was based on Equations (1-3). By running algorithm (NSGA-II) a graph were plotted as pareto (Figure 2). By increasing displacement of base slab, displacement of the building's top story decrease.

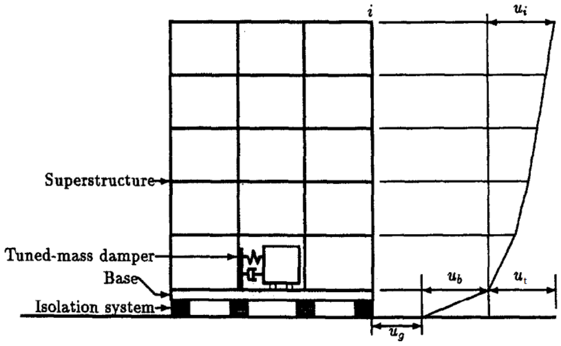

Figure 1. Base isolated building with tuned mass damper

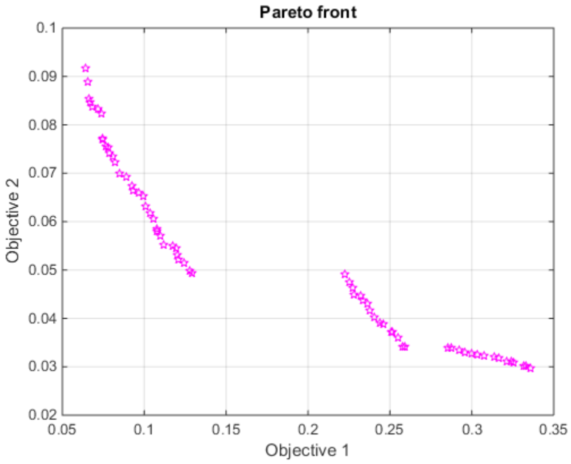

Figure 2. Pareto front of two objectives

Table 1. Properties of the building

			min	max
Mass of each storey (Kg)	110000	interval of mt (Kg)	480	60000
Stiffness of each storey (N/m)	145350000	interval of kt (N/m)	1360000	15000000
Damping of building	0.05	interval of ct	2500	14300
		interval of kb (N/m)	2988400	27680600
		interval of ξb	0.1	0.3
		interval of location of TMD	1	8

As the results the best location of TMD is between story 1 and 3. That shows when TMD is used in isolated building, should be installed on the first floors. As example, one of the results from optimization is as Table 2 that its corresponding response is in Figure 3. The displacement dissipation is 63 percent.

Table 2. One on results from optimization

Max Disp mb	Max Disp m8	mt	ct	kt	ξb	kb	TMD Loca.
0.228	0.046	7828	5392	1450683	0.299	5274100	2

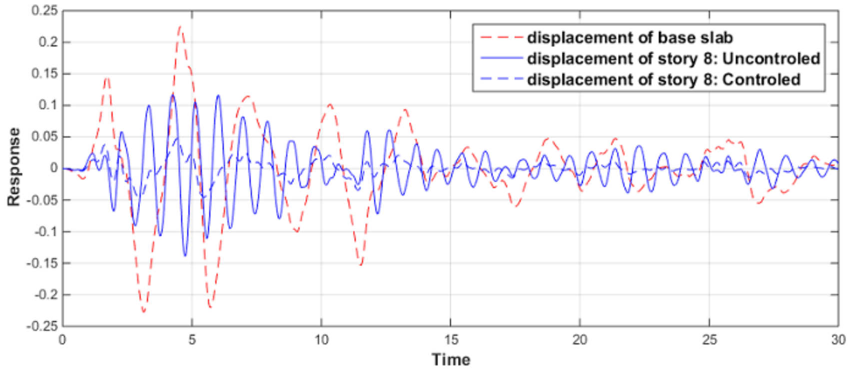

Figure 3. Pareto front of two objectives

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