ABSTRACT

In order to obtain a significant reduction for seismic responses of structures using tuned mass dampers (TMDs), optimization is a mandatory process. A music-inspired metaheuristic algorithm called harmony search is employed in the proposed method for optimum design of TMDs implemented on structures considering soil-structure interaction (SSI). The present approach considers time domain analyses conducted for several earthquake excitations. The optimum design variables, such as mass, period, and damping ratio of TMD are searched for an optimization objective (the maximum displacement of structure) and a design constraint (the maximum scaled stroke capacity of TMD). The proposed method was investigated with a 40-storey high-rise structure for different soil characteristics and the optimum results were compared with a previously developed metaheuristic approach. Results show that the proposed method is feasible and more effective than the compared method.
INTRODUCTION

In the passive structural control of structures by using tuned mass dampers (TMDs), optimum parameters are depended to several factors such as excitations, soil characteristics, support conditions and TMD stroke capacity. Since wind and earthquake excitations cannot be exactly predicted, the structural model may include soil-structure interaction (SSI) effects of a realistic design.

Metaheuristic algorithms have been employed in order to find the optimum parameters of TMDs for structures. Genetic Algorithm (GA) is employed by Hadi and Arfiadi (1998) for optimum design of TMDs for multiple degree of freedom (MDOF) seismic structures. Also, Marano et al. (2010) optimized TMD parameters including the mass ratio by using a GA based method. Additionally, GA has been employed in several TMD optimization methods for torsionally irregular structures (Singh, Singh, & Moreschi, 2002; Desu, Deb, & Dutta, 2006). For optimization of active tuned mass dampers, metaheuristic methods such as GA (Pourzeynali, Lavasani, & Modarayi, 2007) have been employed. Another metaheuristic method employed for the TMD design is Particle Swarm Optimization (PSO) and it was employed for the TMD problem in order to obtain several closed form expressions (Leung & Zhang, 2009). Steinbuch (2011) used bionic optimization for tuning of mass dampers for earthquake resistance of structures. Harmony Search (HS) is another metaheuristic algorithm employed used in the optimum design of TMDs (Bekdaş & Nigdeli, 2011) including providing a ductile response (Nigdeli & Bekdaş, 2013). The parameter tuning of TMD by considering soil-structure interaction (SSI) have been investigated by Farshidianfar and Soheili (2013a; 2013b; 2013c) for different approaches based on several metaheuristics such as ant colony optimization, artificial bee colony optimization and shuffled complex evolution. Since the vibrational energy of the structure is directed to the soil through the foundation, dynamic response of structures is very different than fixed based structures when SSI effect is taken into account. Thus, SSI effects are dominantly effective on optimum TMD parameters. Xu and Kwok (1992) proved the influence of SSI effect on the effectiveness of TMDs by investigating the wind-induced motion of tall and slender structures. Wu et al. (1999) investigated SSI effect for seismic performance of TMDs and found that TMD becomes less effective when the soil shear wave velocity decreases. Wang and Lin (2005) investigated the application of TMDs for torsionally coupled irregular buildings including SSI effects. Lui et al. (2008) developed a mathematical model based on time-domain analyses of high-rise structures with SSI and TMD. In several studies, active tuned mass dampers have been investigated for asymmetric structures considering soil-structure interaction effects (Li, Yu, Xiong, & Wang, 2010; Li 2012). Stroke capacity of TMDs is a limitation for practical applications. The stroke capacity is effective on optimum design variables of TMDs. Tributsch and Adam (2012) indicated that a TMD with a damping coefficient larger than the optimum one can only reduce maximum deflection of the TMD spring. For that reason, the stroke capacity can be considered as a constraint in the optimization process. Recent studies about TMD design of structures are also mentioned in this section. A damping maximized TMD design was proposed by Miranda (2012). Tigli (2012) developed close-form design formulas for random loads. Lin et al. (2013) proposed a semi active TMD utilizing magnetorheological (MR) dampers. Salvi and Rizzi (2015) developed a method called Minimax optimization for TMD design. Daniel and Lavan (2015) proposed an optimality criteria based seismic design for multiple TMDs controlling irregular structures. Matta (2015) investigated the seismic effectiveness of TMDs by using a life-cycle cost criterion. Quaranta et al. (2016) investigated linear TMDs on inelastic structures and tested the system by using pulse-like excitations. Pourzeynali et al. (2016) proposed a robust multi-objective optimization method for TMDs reducing structural vibrations.