

A new reliability based optimization of tuned mass damper parameters using energy approach

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Abstract

In this work a reliability based optimization (RBO) strategy of Tuned Mass Damper (TMD) parameters is presented. The strategy is based on an energetic approach. The strategy consists to optimize the TMD parameters so that we minimize the failure probability (objective function) characterized by the exceedence of the power dissipated in the primary structure of a certain threshold value during some interval time. The evaluation of the objective function is carried out using the classical Rice's formula. The strategy is, firstly, applied to linear single-degree of freedom (SDOF) system, subjected to seismic motion, and then extended to linear multi-degree of freedom (MDOF) system. The use of the Rice's formula requires the knowledge of the joint probability density function (PDF) of the considered processes; to this end, exact expression of the joint PDF is presented for the SDOF system and an approximation is presented for the evaluation of the failure probabilities for the MDOF system. By making use of the obtained joint PDF, for the SDOF system, as the a priori joint PDF, the approximation of the joint PDF, for the MDOF system, has been performed using the Minimum cross-entropy method (MinxEnt).

To highlight the good effectiveness of the proposed strategy, a ten-story shear building, subjected to different earthquakes, is considered. The obtained results are compared with other from literature, and it has been shown the superiority of the proposed strategy.

Keywords

Reliability based optimization of TMD, energy approach, joint PDF of non-Gaussian processes, Rice's formula, minimum cross-entropy

1. Introduction

Many researchers have shown interest in passive control using tuned mass damper (TMD) in randomly driven linear structure in recent years (Li et al., 2010; Marano and Greco, 2010; Marano et al., 2007, 2008; Morga and Marano, 2013; Tigli, 2012; Yu et al., 2013; Zuo, 2009; Mishra et al., 2013b; Xiang and Nishitani, 2014; Casciati and Giuliano, 2009). The interest is particularly focused on the optimization of the TMD parameters when the primary structure is subject to Gaussian stationary stochastic loadings. In most works, the TMD optimization is carried out by minimizing some objective function explicitly related to the displacement response of the primary structure (Adam and Furtmüller, 2010). In the literature, among the existent optimization strategies (see for example

Marano et al., 2010 and Mrabet et al., 2015), one can cite: (1) the stochastic structural optimization problem (SSO), where the root mean square displacement of the primary structure is minimized (Chakraborty and

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