Accepted Manuscript

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Ersin Aydin, Baki Öztürk, Maciej Dutkiewicz

PII:	S0022-460X(18)30616-3
DOI:	10.1016/j.jsv.2018.09.031
Reference:	YJSVI 14382
To appear in:	*Journal of Sound and Vibration*
Received Date:	01 February 2018
Accepted Date:	11 September 2018

Please cite this article as: Ersin Aydin, Baki Öztürk, Maciej Dutkiewicz, Analysis of efficiency of passive dampers in multistorey buildings, *Journal of Sound and Vibration* (2018), doi: 10.1016/j.jsv.2018.09.031

Analysis of efficiency of passive dampers in multistorey buildings

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Abstract: In this study, optimum design of viscous dampers under different mode behaviors are investigated for structures exposed to earthquakes. The structure is modeled as a shear frame and considered as linear. The upper and lower limit values of the dampers are defined as passive constraints, while the damping coefficients of the dampers placed in each storey are considered as the design variables. The use of these technological tools in construction has caused a serious cost increase. It is therefore important to use minimum of these elements. For this reason, the sum of the damping coefficients of the dampers is regarded as the objective function and is minimized as an indication of the capacities of the dampers placed in the building stories and thus their costs. It is well known that the addition of dampers to the structure increases the damping ratio of the structure. A new active constraint is included in the optimization problem as the target damping ratio. The equation required for the calculation of the value of the target damping ratio corresponding to any mode is also derived. The simple optimization problem is solved using three different optimization algorithms: Simulated Annealing, Nelder Mead and Differential Evolution algorithms. Optimum designs are found to minimize the cost function and provide all constraints. In the shown numerical example, the effect of the variation of the building period and the changes of the target damping ratio on the optimization is investigated. Furthermore, earthquake behavior of the structure corresponding to these optimum designs is investigated using El Centro Earthquake (NS) record and examined in terms of period and additional damping ratios of the maximum displacements to the floors. In addition, the proposed method finds the optimum damper distribution considering the first two modes. The proposed optimum damper design method is very simple and it is a method which reaches the optimum designs in different mode behaviors. As a result, it has been shown in the numerical examples that the optimum damper design can be changed according to the variations of the designer's constraints.

1. Introduction

There are three main periods of structural design. The first is the classical era, in which only vertical loads are considered in the design of the structures. The second is the modern era, in which dynamic loads have been used in design, the third is the postmodern era when energy is damped by active, passive or mixed systems using technological tools and methods. Damping systems can be used both for natural hazard mitigation, and for rehabilitation of aging or deficient structures. For the last four decades, the remarkable interest has been taken to develop the structural control devices, especially in order to minimize the wind and earthquake induced structure vibrations. The reduction of structural vibrations can be provided by various technological methods such as modifying rigidity, mass, damping and by using passive, active or semi active reverse forces. The systems that realize the structural control have different working principles and different classifications according to their mechanisms. Passive energy dissipation systems include a set of materials and tools for increasing damping, stiffness and strength. They cannot exhibit a variable attitude towards the variability of external influences and do not need a number of sensors and computer systems. However, there are also systems with a number of sensors and computer mechanisms that are variable, self-adjusting, depending on the external force, reducing structural response by applying counteracting control forces externally, creating reactive internal forces, and these are called as active control systems.

This work focuses on the design of viscous dampers as passive control systems building structures. Damping is one of many different ways for allowing a structure to reach the best performance when it is exposed to wind, earthquake and blast or other type vibration external effects. Application of supplemental dampers has transitioned from protection related structures to commercial applications on building structures and bridges exposed to seismic or wind loads. Fluid damping technology has been proven to be thoroughly reliable and robust for implementation to structures. A fluid