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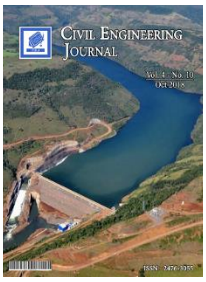

Effect of Soil and Structure Nonlinear Interaction on the Efficiency of Tuned Mass Damper

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Abstract

In this paper, three 10, 15, and 20-story two-dimensional concrete structures have been used with a moment frame bearing system as models under analysis. First, using various time history analyses by the OpenSees software, the optimal parameters of the tuned mass damper (TMD), including frequency and mass, were obtained. Structures controlled with and without TMD were modelled on three soft, moderate, and hard soil types classified according to Code 2800. The models were analyzed in terms of time history by 7 ground motions. In order to take into account the nonlinear interaction of soil and structure, the model of the beam on nonlinear Winkler foundation has been used. The results show that nonlinear interaction in most cases reduces the efficiency of TMD. Moreover, as the soil becomes softer, the efficiency reduction of the mass damper increases.

Keywords: Tuned Mass Damper; Soil and Structure Nonlinear Interaction; Winkler Model; Time History Analysis.

1. Introduction

The soil and structure interaction has a significant effect on the efficiency of passive control systems, especially the tuned mass damper (TMD), which is highly sensitive to the frequency considered for it regarding the frequency of mode or modes of the structure. Due to the fact that, the soil and structure interaction is non-linear in reality, in this paper the changes in the TMD efficiency have been studied by taking into account structures with and without TMD on different soils [1-3].

These control systems are known as tuned mass dampers or TMDs. The initial ideas and general concept for controlling vibration by mass were first introduced in 1909 by Frahm [4]. The basis of the behavior of the balanced mass dampers on the structures is rooted in the performance of dynamic vibration absorbers studied by Frahm. His objective was to reduce the rotational motion of the ship around its longitudinal axis, and, after its development, called it dynamic vibration absorber. Years after the idea of Frahm, Ormondroyd and Den Hartog proposed the first theory which was fully including the damping tool [5]. In the book Mechanical Vibrations by Den Hartog, calculation of the optimal parameters of a tuned mass damper system has been presented. Ormondroyd and Den Hartog developed a more complete model of the idea of shock absorbers [6]. In his book, Den Hartog presented the theory of shock absorbers in the case where the main structure was without damping [7]. Chaojin and Spyrako conducted a research on the seismic analysis of towers and their uplift. In this study, factors like soil hardness, ratio of tower height to foundation width, and the rate of foundation uplift from soil were considered. Furthermore, they investigated the effects of soil hardness on the seismic response of short towers compared to long ones. Their research showed that in an unusual foundation uplift, the seismic

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