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An innovative design method for nonlinear tuned mass damper

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Abstract. The commonly used TMD design method in the project assumes the TMD has pure linearity. However, in real engineering TMD will exhibit nonlinear behaviors. Without considering the nonlinearity of TMD, the control effect of the TMD that is designed by the linear design method, may be worse and even enlarge the structural response. In this paper, based on the previous study results of nonlinear TMD, the improved design method for engineering application is proposed. The linear design method and the improved design method are compared. Taking the best parameter obtained by the improved design method is less than or equal to 90% of that obtained by the original design method as the dividing line. The critical nonlinear coefficient, reaching which value the improved design method needs to be used, is given. Finally, numerical simulations on two engineering examples are conducted to proof the results.

Keywords: TMD; engineering design; nonlinearity; improved design method; critical coefficient

1. Introduction

Tuned Mass Damper (TMD) has been widely used in civil engineering due to its simple structure, no external energy consumption and good stability. Up to now, the working principle of TMD has been basically improved (Den Hartog 1947, Yao 1972, Warburton 1982, Tsai and Lin 1993, Zuo and Nayfeh 2004, Kareem and Kline 1995, Wu and Chen 2000, Kwok and Samali 1995). It has been widely recognized that TMD can control structural vibration induced by wind loads. The John Hancock building in Boston, the Sydney TV Tower in Australia, and the Chiba Port tower in Japan all installed the TMD device to reduce the vibration of the structure (Kwok and Samali 1995).

Linear TMD has the above advantages and is widely used, but there are still limitations, such as small control frequency range. In order to improve the performance of linear TMD, nonlinear TMD has been proposed and studied. Nonlinear Energy Sinks (NES), as one of the nonlinear TMD, has been proved to have wider control frequency bandwidth than linear TMD (Bert *et al*. 1990). Gendelman *et al*. (2011) proposed that NES with multi degree of freedom has wider effective control frequency range. NES can distribute the input energy from lower mode to higher order mode (Quinn *et al*. 2012). However, there is also instability phenomenon and amplification of the structural response amplitude in the nonlinear TMD. Djemal *et al*. (2015) have proved that the nonlinear TMD has a jump phenomenon by experiments. Alexarder and Schilder (2009) pointed

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