ABSTRACT

In this dissertation, a new method to design multiple tuned mass dampers (multiple TMD's) for minimizing excessive vibration of structures was developed using a numerical optimizer. It is a very powerful method by which a large number of design variables can be effectively handled without imposing any restriction before the analysis. Its framework is highly flexible and can be easily extended to general structures with different combinations of loading conditions and target response quantities. The developed method has been applied to searching of optimal TMD's for a wide range of structures, from simple SDOF lumped-mass systems to continuous beams and floor structures with multi-mode structural responses, under wide-band excitations. For SDOF structures, the optimally designed multiple TMD's have non-uniform frequency distribution and unequal-and-low damping ratios. This optimal configuration of TMD's was different from the earlier analytical solutions and was proved to be the most effective. A robustness design of multiple TMD's was also conducted where the system parameters were uncertain and modeled as independent normal variates. For a simple beam with widely-spaced natural frequencies, the results confirmed that multiple TMD's can be adequately designed by treating each structural vibration mode as an equivalent SDOF system. Next, for the control of a beam structure with two closely-spaced frequencies, the results showed that the most effective multiple TMD's have their natural frequencies distributed over a range covering the controlled structural frequencies and have low damping ratios. Furthermore, a single TMD can be made effective in controlling two modes with closely spaced frequencies by a newly identified control mechanism, but the effectiveness will be greatly impaired when the loading position changes. Finally, a realistic design problem of 10 TMD's for a large floor structure with 5 closely spaced frequencies was presented. The acceleration responses at 5 positions on the floor excited by 3 wide-band forces were simultaneously suppressed. The obtained TMD's were very effective and robust. Extensive numerical verifications of control effectiveness of TMD's were shown, both in time and frequency domains, which confirm advantages of the approach.