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ESTIMATION OF THE GLOBAL OPTIMALITY FOR MULTIPLE TUNED MASS DAMPER SYSTEMS USING ORDER STATISTICS

Makoto Yamakawa[1], Susumu Yoshinaka[2], Yoshikazu Araki[3], Koji Uetani[4] and Ken'ichi Kawaguchi[5]

[1] Tokyo Denki University, 5 Senju-Asahi-cho, Adachi-ku, Tokyo 120-8551, Japan, myamakawa@mail.dendai.ac.jp
[2] Osaka City University, 3-3-138 Sugimoto, Sumiyoshi-ku, Osaka 558-0022, Japan, yoshinaka@arch.eng.osaka-cu.ac.jp
[3] Kyoto University, Kyotodaigaku-Katsura, Nishikyo-ku, Kyoto 615-8540, Japan, araki@archi.kyoto-u.ac.jp
[4] Setsunan University, 17-8 Ikeda-Nakamachi, Neyagawa, Osaka 572-8508, Japan, uetani@arc.setsunan.ac.jp
[5] Institute of Industrial Science, the University of Tokyo, 4-6-1 Komaba Meguro-ku, Tokyo 153-8505, Japan, kawaken@iis.u-tokyo.ac.jp

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Spatial structures generally possess little inherent damping. These structures tend to vibrate strongly in the normal direction of the curved roof. It has been reported that non-structural components, e.g., the plumbing, the ceiling systems and etc., were damaged by such vibrations, which caused the collapse and fall of the components, and injured and killed many people during the 2011 off the Pacific coast of Tohoku Earthquake [1]. It is known that passive tuned mass damper (TMD) can be effectively used for the vibration control. In particular, multiple TMD (MTMD) is robust when the system is excited by a wideband random disturbance [2]. This means that the effective use of TMDs enables to prevent or reduce such damages. The concept of the spatially distributed TMD system is illustrated in Fig.1.

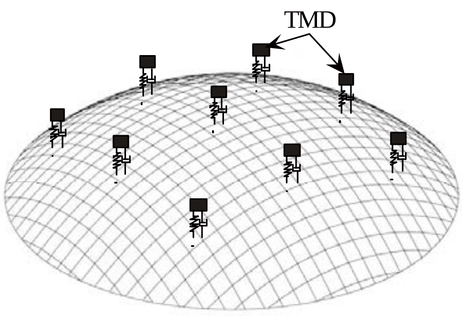

Figure.1 The spatially distributed TMD system for spatial structures

In this paper, we study an influence of placement of TMDs, i.e., MTMD systems, on the vibration control performance. We have to decide the both of a spatial arrangement and characteristics of the TMDs, which are frequency and damping characteristics. The possible locations for TMDs can be modelled as discrete variables, and the characteristics of the ones are treated as continuous variables. Thus, to find an optimum design of the MTMD system on the spatial structures is formulated as Mixed-Integer Programming (MIP) problem [3].

For solving this problems, some techniques are available. The ones are standard combinatorial optimization methods. In general, this type of the methods has rigorous mathematical backgrounds and can find exact global optimum solution; however, the methods need extremely high computational cost depending on the size of the problem. Heuristics are other choices; genetic algorithms and simulated annealing are representative ones in this category. It has been often reported that heuristics quickly find several near-optimal solutions and hence have become popular recently, e.g., [3]. This must be useful approach but we do not fully agree with the positive opinion because some of them lack mathematical backgrounds. How accurate and/or efficient the solutions are?

We attempt to mix two methods to design of the spatially distributed MTMD system. The one is enumeration method with deterministic procedures, which is used for decision on a spatial arrangement of TMDs. The other is random search method (RS) as a probabilistic approach [5][6], which is used for decision on characteristics of TMDs. The key concept of RS is prediction by order statistics. The method can guarantee the accuracy of a solution in terms of global optimality with a pre-assigned probability. The theoretical result indicates use of relatively small samples is enough to predict the large number of future samples. Thus, the proposed method is useful to estimate how accurate we obtain the solution in terms of global optimality. Through a numerical example, we investigate the applicability and effectiveness of the method to the design of TMD systems.

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