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Comparison on different approaches for robust optimum design of tuned mass dampers

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ABSTRACT

This study investigates the effects of structural uncertainties on design and performance evaluation of passive tuned mass dampers (TMD) used for vibration control. A robust optimal design methodology is presented in which are assumed time-invariant uncertain structural parameters. Unlike conventional TMD designs, based on the implicit assumption that all parameters involved are deterministically known, a robust approach is considered in the proposed design which properly accounts for uncertainties in load and structural models. In comparison to a conventional method, the solution must be able not only to minimize a performance but also to limit its variation induced by uncertainty in system parameters. The importance of structural uncertainties is demonstrated by applying the methodology to a single degree of freedom structure subjected to a stationary white noise. The problem is treated characterising all uncertain parameters by a nominal mean value and a variance. It is also assumed that all these parameters are statistically independent. Three kinds of methods are compared: the single-objective conventional optimization and the single and the multi-objectives robust optimization ones. With reference to this last, a Pareto evolutionary algorithm is used to identify a number of optimal solutions that are distributed along the Pareto front. It is found that the consideration of structural uncertainties improves substantially the robustness of the TMD design. Also, multi-objective robust TMD-design methodology induces a significant improvement in performance stability and furnishes a better control on the design solution chosen.

REFERENCES

[1] Coello Coello C. A., “Handling Preferences in Evolutionary Multiobjective Optimization: A Survey”, IEEE Neural Networks Council (ed.), Proceedings of the 2000 Congress on Evolutionary Computation (CEC 2000) Vol. 1, IEEE Service Center, Piscataway, New Jersey, pp. 30 -37.

[2] Doltsinis I, Kang Z. Robust design of structures using optimization methods. Comput Methods Appl Mech Eng 2004;193:2221–37.

[3] Fonseca C. M. & Fleming P. J., "Genetic Algorithms for Multi-Objective Optimization: Formualtion, Discussion and Generalization", Genetic Algorithms: Proceedings of the 5th International Conference (S. Forrest, ed.) San Mateo, CA: Morgan Kaufmann, July 1993

[4] Igusa T, Kiurghian AD. (1988) "Response of uncertain systems to stochastic excitation". J Engng Mech, ASCE;114:812–32.

[5] Kicinger R., Arciszewski T. and De Jong K., "Evolutionary computation and structural design: A survey of the state-of-the-art", Computers and Structures 83 (2005) pp. 1943-1978.

[6] Lagaros N.D., Fragiadakis M., Papadrakakis M. and Tsompanakis Y., "Structural optimization: a tool for evaluating seismic design procedures", J. of Engrg. Str., (to appear), 2006.

[7] Langley, R. S.; (2000) "Unified approach to probabilistic and possibilistic analysis of uncertain systems", Journal of Engineering Mechanics, Vol. 126, No. 11, November, 2000, 1163–1172

[8] Luh G. C. & Chuen C. H., "Multi-Objective optimal design of truss structure with immune algorithm", Computers and Structures, 82 (2004) pp. 829-844.

[9] Lutes L.D., Sarkani S., (2001), "Random Vibrations", Butterworth-Heinemann, Oxford (UK).

[10] Marano G.C., Greco R., Trentadue F. and Chiaia B., (2007) "Constrained reliability-based optimization of linear tuned mass dampers for seismic control", International Journal of Solids and Structures, accepted for pubblication

[11] Nigam, N.C., (1972), "Structural Optimization in random Vibration Environment" , AIAA, 551-553.

[12] Siddall JN. (1984) A new approach to probability in engineering design and optimisation. ASME J Mech, Transmiss, Autom Des 1984;106:5–10.

[13] Papadimitriu, C., Beck, J. L., Katafygiotis, L.S., "Asymtotic expansion for reliability and moments of uncertainly systems, Journal of Engineering Mechanics (ASCE), Vol 123, No 12, 1997, 1219-1229

[14] Papadrakakis M., Tsompanakis Y., Lagaros N.D. and Fragiadakis M., "Reliability based optimization of steel frames under seismic loading conditions using evolutionary computation", Special Issue of the Journal of Theoretical and Applied Mechanics on Computational Intelligence in Mechanics, Vol. 42, No 3, pp. 585-608, 2004.

[15] Srinivas N. & Deb K., "Multi-objective Optimization Using Nondominated Sorting in Genetic Algorithms", Journal of Evolutionary Computation, Vol. 2, No. 3 (1994), pp. 221-248.

[16] Zang C. , Friswell M.I., Mottershead J.E., A review of robust optimal design and its application in dynamics, Computers and Structures 83 (2005) 315–326