Optimal Performance-Based Design of Non-Linear Stochastic Dynamical Systems

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ABSTRACT

Performance-based design, or Performance-Based Engineering (PBE), is currently well accepted as a proper methodology for assessing risk and designing facilities which can be subject to continuous levels of damage caused by extreme responses under various hazards of varying magnitudes. However, the difficulties in assessing probabilities associated with different hazard and performance levels, especially when nonlinearity is considered in dynamically excited structural systems, have been a limiting factor for incorporating PBE into design optimization. This paper advances the state-of-the-art by incorporating PBE into the optimal design of non-linear/hysteretic stochastic dynamical systems. The approach combines a statistical linearization technique with time-variant reliability analysis concepts, in order to formulate a total expected life-cycle cost optimization problem. As a numerical example, reinforced concrete buildings modeled as MDOF Bouc-Wen hysteretic systems subjected to wind excitation are studied. Optimal transversal stiffness of the buildings columns are obtained both for the linear and the nonlinear cases, as well as for various design life values. Optimal stiffness values determined herein consider the initial costs but also expected losses over the lifetime of the structure, for several wind hazard magnitudes and displacement response levels of the structure.