LARGE STRUCTURAL DYNAMICS MODELS WITH NONLINEAR DAMPING: SIMULATION VIA REDUCED ORDER MODELS

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The objective of this work has been to develop reduced order modeling schemes that can be used to conduct efficient simulation studies of very large structures having nonlinear damping. We report results for both smooth and non-smooth damping properties that may be isolated at a few locations in the structure or that may be distributed throughout the structure. The model reduction employed is an "exact for the linear case" version of the Guyan reduction that produces an approximate reduced order model for a nonlinear system. The advantages of this method are computational simplicity and efficiency and the retention of the original functional form of any non-smooth nonlinearities in the reduced order model. We present results for simple structural systems having several thousand degrees of freedom for which reduced order models having five to twenty degrees of freedom are used to simulate decay of free oscillation and steady state response to harmonic excitation. The reduced order models are shown to produce simulated responses that are in very good agreement with simulations obtained using the original models. Because reduced order models can produce inaccurate simulations for static nonlinearities, we have investigated the reasons for the good agreement in cases of nonlinear damping by studying the nonlinear normal modes in a two degree of freedom system with smooth nonlinear damping. This analysis shows that the linear based reduction may be expected to produce accurate renderings of damping effects even if the damping is quite strong. The methodology presented should be useful for complex structures with joints, dry friction, and other damping mechanisms for which the nonlinear nature of the damping needs to be taken into account in order to obtain valid simulation results.