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Keynote Paper

Topology Optimization of Building Structures subject to Stochastic Dynamic Loads

Fernando Gomez[1)] and *Billie F. Spencer, Jr.[2)]

[1), 2)] *Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, 205 North Mathews Avenue, MC-250, Urbana, IL 61801, USA*
[2)] *bfs@illinois.edu*

ABSTRACT

Topology optimization provides a general approach to obtain optimal material layout in a prescribed domain according to some cost function and subjected to given design constraints; however, most approaches only accommodate deterministic loads although many of the most severe dynamic loads that civil structures withstand are stochastic in nature. In contrast, this study accounts directly the stochastic excitation, by modeling it as a zero-mean filtered white noise; when combined with the equations of motion for the structure, an augmented state space representation is formed, whose only input is an uncorrelated white noise; and the stationary covariances of the structural responses of interest are obtained by solving a large-scale Lyapunov equation. The optimization problem is formulated with a general objective function defined in terms of the covariances of the structural responses, a volumetric constraint, and design variables as the relative densities of the elements. A gradient-based method is used for the update of the design variables, and the sensitivities are computed using an efficient adjoint method that requires the solution of an adjoint Lyapunov equation. Additionally, this study implements the following details in the topology optimization of stochastically excited buildings: additional floor masses, gravity boundary elements, diaphragm constraints, and ground motion stochastic models. To illustrate the framework, topology optimization of the lateral resisting system of a mid-rise building under lateral seismic excitation is performed. The results show the opportunities of topology optimization of stochastically excited structures.

REFERENCES

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[1)] Doctoral Candidate
[2)] Nathan M. and Anne M. Newmark Endowed Chair in Civil Engineering