TOPOLOGY OPTIMIZATION OF STRUCTURES UNDER STOCHASTIC EXCITATIONS

Junho Chun[1], Junho Song[2] and Glaucio H. Paulino[3]

[1] Graduate Research Assistant and Presenting Author, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA. Email: jchun8@illinois.edu

[2] Associate Professor, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA. Email: junho@illinois.edu

[3] Donald B. & Elizabeth M. Willett Professor of Engineering, Department of Civil and Environmental Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA. Email: paulino@illinois.edu

One of the main goals in structural optimization is to achieve a structural design with the best performance while satisfying given design constraints. Among various applications of structural optimization, topology optimization based on mathematical programming and finite element analysis has recently gained great attention in the research community and structural engineering practice. This recent interest reflects the significance of time and financial resources dedicated by structural engineers to control the dynamic response of a structure under random vibrations caused by natural hazards or operations of non-structural components. In this regard, topology optimization of structures with stochastic response constraints is of particular interest and is meaningful in industrial applications. Despite rapid technological advances in this field however, computational challenges have prevented further development of its application, namely the actual incorporation of stochastic response of structures into topology optimization. In order to overcome such technical challenges in this field, this paper introduces a new method for incorporating random vibration theories into topology optimization in order to satisfy probabilistic constraints. This method uses a discrete representation method for stochastic processes to describe the stochastic response of a system subjected to random seismic excitations. Furthermore, a new formulation is developed for sensitivity of dynamic responses in order to use gradient-based optimization algorithms for the proposed topology optimization employing a discrete representation method. The proposed method is demonstrated by numerical examples of structures excited by random ground motion excitations.