Reliability-based topology optimization under random vibrations

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Keywords: Finite Element Method, computational mechanics, topology optimization, uncertainty quantification, structural reliability, probability of failure.

1) Context of the study

Topology optimization is an approach, that aims for achieving lightweight structure and high-performance requirements such as strength, stiffness, natural frequency, or buckling. Moreover, this methodology allows topological changes as well as structural shapes, thus can produce valuable designs for new structural functions. Furthermore, topology optimization has changed the way we think about designing structures. Topology optimization was developed in the 90s by Bendsøe and Kikuchi [1]. Since several works related to theories and techniques have been proposed to make topology optimization more efficient [2-8].

Actually, the field of topology optimization is undergoing important academic development. it is now being successfully used for the design of several components concerning stiffness and strength, and several methods are proposed to take into account buckling constraints [6], and eigenfrequency constraints [4-5]. However, the topology optimization is based on a deterministic approach which does not take into account the variability of input parameters and the uncertainties related to design loading, and material properties.

On the other hand, the Reliability-Based Design Optimization (RBDO) has been developed to consider uncertainties in the design optimization procedure, while the safety requirements are fulfilled [11-14]. It consists of finding the best design with optimal cost and safety assurance, based on structural reliability theory to take into account uncertainties. Thus, a more rigorous approach to topology optimization should consider the uncertainties arising from the random nature of the loading fluctuations, the material properties, and the geometrical dimensions. The integration of the reliability concepts into the topology optimization led to the so-called *Reliability-Based Topology Optimization.* At now, several works focus on developing efficient RBTO formulations or considering buckling-constrained topology optimization [15-17]

However, RBTO under random vibrations remains academically challenging. This work aims to develop an efficient approach to the new RBTO tool which allows considering the random vibration constraints. To be successful, the spectral approach for the random vibrations should be preferred, because of their efficiency and robustness.

2) Objective and content of the thesis

This PhD project will be carried out at the LMN: Laboratoire de Mécanique de Normandie under the supervision of Dr. Leila Khalij and Dr. Younes Aoues;

The LMN is a research laboratory with strong expertise in uncertainty propagation in mechanical and multi-physical models, quantification, Reliability-based design, topology optimization, multicriteria design optimization, random vibration, multiaxial fatigue criteria, etc.

Important tasks of this thesis project are:

- Development of the topology optimization under static and eigenfrequency constraints.
- Integrating the random vibration constraints in the deterministic topology optimization.
- Integration of the reliability requirement in the topology optimization under the random vibration constraints.

3) Profile and requirements

Engineering school or Master in Mechanical or Applied Mathematics solid background in mathematics and solid mechanics, Finite element method, probability theory, and probabilistic approaches.
Experience in numerical simulation on dedicated software (for example ANSYS, COMSOL, NASTRAN, etc.)
Good programming experience, Matlab, Python, or C ++.
Good communication in English (read and write)

4) References

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