ICCES, 2023, vol.27, no.1
DOI: 10.32604/icces.2023.09388

PROCEEDINGS

Robust Shape Optimization of Sound Barriers Based on Isogeometric Boundary Element Method and Polynomial Chaos Expansion

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ABSTRACT

As an important and useful tool for reducing noise, the sound barrier is of practical significance. The sound barrier has different noise reduction effects for different sizes, shapes and properties of the sound absorbing material. Liu et al. [1] have performed shape optimization of sound barriers by using isogeometric boundary element method and method of moving asymptotes (MMA). However, in engineering practice, it is difficult to determine some parameters accurately such as material properties, geometries, external loads. Therefore, it is necessary to consider these uncertainty conditions in order to ensure the rationality of the numerical calculation of engineering problems. In this study, based on isogeometric boundary element method, a robust optimization design method for the shape optimization of the sound barrier is proposed. The uncertainties of the wavenumber of the acoustic wave and the coefficient of the sound absorbing material are considered. The uncertainty of the surface admittance of the sound absorbing material is described by a random field, and the expansion optimal linear estimation (EOLE) method is used to discretize it into a series of uncorrelated random variables. Meanwhile, the stochastic response of the structure is calculated with the polynomial chaos expansion (PCE) method and isogeometric boundary element method. The sensitivity of the stochastic response is also obtained by the PCE method. The weighted sum of the mean and standard deviation of the stochastic response is set as the objective function for the robust design optimization. Finally, the optimization problem is also solved by MMA. Numerical examples show that the results of the proposed robust optimization method are more suitable in the situation whose parameters of the material and load are uncertain than the results of the deterministic optimization.

KEYWORDS

Robust optimization; isogeometric analysis; boundary element method; polynomial chaos expansion

Funding Statement: This study was financially supported by the National Natural Science Foundation of China (NSFC) under Grant No. 12172350.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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