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SHAPE OPTIMIZATION METHOD FOR EIGEN FREQUENCY PROBLEM OF 3D STRUCTURE WITH INITIAL STRESS

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In the shape design of a linear elastic 3D structure, the natural vibration characteristic is one of the important performances for its dynamic design, hence, controlling it is strongly required. The natural vibration characteristic is influenced by the initial-stress such as self-weight or pre-stress. While the normal eigen equation consists of the stiffness and inertia terms, in the case under initial-stress condition, the geometric stiffness term should be added. When the negative geometric stiffness is dominant in the eigenvalue problem considering initial-stress, linear buckling occurs, where the buckling eigenvalue should be considered.

In this study, a solution to the shape design optimization problem of a 3D structure with initial stress is proposed, where a set of specified vibration eigenvalues with weighting coefficients is introduced as the objective functional. The eigen equation with geometric stiffness term and the volume are considered as the constraint functionals. The problem is formulated as a distributed-parameter shape optimization problem, and the sensitivity function with respect to the shape variation is theoretically derived using the Lagrange multiplier method, the material derivative method and the adjoint variable method. The optimal shape variation is determined by the H^1 gradient method [1], where the shape sensitivity function is applied as a distributed force to vary the shape. The repeated eigenvalue problem is also considered by switching the objective functionals. With the proposed method, the objective functional can be minimized without parameterization of the design variables, while maintaining the smoothness of the boundary shape.

The numerical design examples show that the proposed shape optimization method can control the vibration eigenvalues of a 3D structure with initial stress well. It is also confirmed that the optimal shape and its eigen frequencies are strongly influenced by the initial stress.

REFERENCES

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