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Damage Detection Method in Non-Destructive Testing Based on Topology Optimization and Eigenvalue Analysis

Takafumi Nishizu[1], Akihiro Takezawa[2], Mitsuru Kitamura[3]

[1] Hiroshima University, Hiroshima, Japan, d145208@hiroshima-u.ac.jp;
[2] Associate Professor, Hiroshima University, Hiroshima, Japan, akihiro@hiroshima-u.ac.jp;
[3] Professor, Hiroshima University, Hiroshima, Japan, kitamura@hiroshima-u.ac.jp;

Abstract

Non-destructive testing detects damage according to a difference in a physical phenomenon between a normal structure and damaged structure. However, the accuracy of such damage detection typically depends on the skill of the engineer. As a solution, a numerical method of detecting damage to a structure based on a dynamical numerical model such as a finite element model was proposed. This method automatically derives a structure with a response that is equal to that of a damaged structure employing an optimization algorithm. The procedure can be applied to not only non-destructive testing but also automatic structural health monitoring. Among structural optimization methods, topology optimization can optimize the structure fundamentally by changing the topology and not just the shape of a structure. We thus employ topology optimization for structural optimization. Damage detection using topology optimization based on frequency response analysis has been suggested. However, the eigenvalue-based technique that is traditionally used in damage detection has not been integrated with topology optimization. The present study thus examines a damage detection method using topology optimization based on eigenvalue analysis. Our method derives a structure that has the same eigenvalues as a damaged structure employing topology optimization and can identify a damaged structure.

Keywords: topology optimization; eigenvalue analysis; non-destructive testing; sensitivity analysis.