Damage Detection Methods for Shear Structures by
Using Damage Indices Consisting of Limited Number of
Natural Frequencies

Keio University
Graduate School of Science and Technology
School of Science for Open and Environmental Systems

Student ID Number ___________ Name __ HoThu, Hien ___________

Thesis Advisor __ Professor __ Name __ Mita, Akira ___________

Keio University
Graduate School of Science and Technology
September 2014
# Thesis Abstract

**Registration Number:** □ "KOU" □ "OTSU"  
*Office use only*  
**Name:** Ho Thu, Hien

**Title of Thesis:**

Damage Detection Methods for Shear Structures by Using Damage Indices Consisting of Limited Number of Natural Frequencies

**Summary of Thesis:**

This dissertation presents new damage indices for damage detection (DD) methods of structures using the changes in the first several natural frequencies. For that method, only two accelerometers are needed, or even one acceleration sensor is enough to obtain the natural frequencies.

First, a method of detecting the location of damage in shear structures by using only the changes in the first two natural frequencies is proposed. This DD method can determine the damage location in a shear building by using a Damage Location Index (DLI) based on two natural frequencies for undamaged and damaged states. The uncertainty associated with system identification methods for obtaining natural frequencies is also carefully considered. Some simulations and experiments on shear structures were conducted to verify the performance of the proposed method.

Second, a method for detecting damage to shear structures by using Support Vector Machines (SVMs) and only the first three natural frequencies is proposed. During training, they require data from the undamaged and damaged structure. Based on the shifts in the first three natural frequencies, damage location indicators (DLIs) are proposed, and used as new feature vectors for SVMs. Simulations of five-story, nine-story and twenty-one-story shear structures and experiments on a five-story steel model were used to test the performance of the proposed method.

Third, a DD algorithm is proposed for multi-story shear structures that only need the first two or three natural frequencies. The method is able to determine the location and severity of damage on the basis of damage location indices (DLI) and damage quantification indices (DQI) consisting of the changes in the first several squared natural frequencies of the undamaged and damaged states. The uncertainty associated with system identification methods for obtaining natural frequencies is also carefully considered. The method is accurate and cost-effective means only requiring the changes in the natural frequencies.

Finally, the conclusion is given. The main scope of this dissertation is to establish the general DD procedure for multi-story shear structures by using the changes in the first several natural frequencies only. The DD methods with the new definitions of damage indices based on the changes in the first several natural frequencies were proposed. They can detect, localize and quantify the damage in multi-story shear structures accurately with a limited number of sensors. The contributions of this thesis were summarized and the possible direction of the future research was also pointed out.