DISSERTATION INFORMATION

INTRODUCTION

Dissertation title:	**Development of modal strain energy method for structural damage identification in plate-like structures**
Major:	**Civil Engineering**
Major code:	**9580201**
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ABSTRACT

Plate structures are essential components of civil engineering projects. However, these structures are susceptible to defects and damages during construction and operation, which can reduce their load-bearing capacity. Therefore, it is necessary to regularly and continuously monitor the structure to detect structural loss early and ensure the safety and regular operation of the structure. The combination of strain energy method and genetic algorithm can determine the occurrence, location, and extent of damage within plate structures. However, the effectiveness of this method in detecting structural deterioration is still limited, particularly in cases involving multiple damages, minor damage and damages located at the boundaries. Therefore, the aim of this research is to develop an improved strain energy method for efficiently diagnosing the occurrence, location, and extent of damage in plate structures.

The essential improvements of the doctoral dissertation include the following: (1) Developing a damage identification method based on the modal strain energy method for the plate structure with different boundary conditions. (2) Establishing new formulas utilizing the 9-node iso-parametric element enhances accuracy in estimating the modal strain energy value, while eliminating the impact of boundary conditions on the element strain energy value. (3) Enhancing the local damage identification procedure by utilizing only modal data on the local damaged area to reduce the input data while maintaining

the accuracy of diagnostic results. (4) Calculating a correlation coefficient between the mode shapes in the undamaged and damaged states of the plate to identify modes that provide the most accurate damage location results. (5) Developing a two-step procedure for identifying the location and extent of the damage. (6) Enhancing the procedure for estimating the extent of damage in the second step by employing an iterative genetic algorithm. (7) Verifying the proposed damage location identification procedure on reinforced concrete slabs subjected to to loads.

These improvements are verified using numerical simulation models of aluminum and concrete slabs, which include complex damage scenarios such as multiple, minor and near-margin damages. The results of the damage diagnostics demonstrate that the strain energy calculation method based on the 9-node element outperforms the 4-node element-based method in terms of damage location identification. Notably, this strain energy approximation can be applied to plates with any boundary conditions. Additionally, selecting mode shapes with higher modal assurance criteria values as input for the diagnostic algorithm yields superior results in locating the damage compared to using some first mode shapes.

The verification problems also demonstrate that the damage location procedure, which combines both the global and local strain energy methods, yields superior results in locating the damage compared to the application of only the global method. In the global step, a damage threshold of 20% of the maximum damage index value is utilized to identify preliminary damaged zones. Subsequently, the local step employs a damage threshold of 30% to achieve more accurate identification of the damaged elements identified in the global step. In cases where the first step determines an excess of damaged elements, the iterative genetic algorithm aids in gradually removing misdiagnosed elements throughout the iterative phases.

The damage location diagnostic procedure is verified on a reinforced concrete slab operating beyond the elastic period. The results demonstrate that the proposed procedure accurately identifies the location of cracks in the slab as they begin to appear under load. Therefore, this diagnostic procedure facilitates early detection of damage in practical applications. The findings of this thesis contribute to diagnosing the occurrence, location, and severity of damage in plate structures. Furthermore, these results serve as a scientific basis for further studies on the implementation of structural health monitoring systems in practice.

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