Finite Element Modeling and Verification of a Retrofitted Member of a Long-span Truss Bridge by Employing Stochastic System Identification

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Abstract

This paper presents a method for finite element modeling and its application for a retrofitted member of a long-span truss bridge. A critical fatigue crack occurred and propagated at the bottom of a diagonal member of the bridge due to wind-induced vibrations. In such the case, finite element analysis with a precise structural model is effective for simulating dynamic structural behavior such as changes of stress condition to consider countermeasures. In this study, a model of the retrofitted truss member is refined by model updating method based on the actual dynamic characteristics of the member such as the natural frequencies, mode shapes and modal damping ratios estimated by stochastic system identifications. Model updating consists of FE analysis with a commercial FE analysis tool and optimization analysis with a numerical computing tool. Model parameters such as sectional specifications of the original member, boundary condition and material properties are automatically modified under optimization analysis by minimizing an objective function. The objective function is formulated as a combination of fitness on dynamic characteristics obtained by measurements and analysis. Established FE model was validated by comparing strains collected by measurement and analysis.

Keywords: finite element analysis; model updating; structural identification; truss bridge; fatigue damage; wind-induced vibration; bridge monitoring

1 Introduction

Finite element (FE) analysis is effective and helpful to simulate behaviors for assessing a capacity of a structure, and the reliability of its solution depends on the accuracy of modeling. However, problems in accuracy of analysis often occur since an actual structure has uncertainty due to its complex conditions. Modeling error often prevents applications of FE analysis from detailed studies such as the capacity assessment of a bridge in operation, monitoring the state under constructions, the analytical investigation for damage and deterioration [1]. The model updating is an effective technique to manage such a problem [2].

In this study, the model updating method is employed to refine the accuracy of a FE model by updating its model parameters with referring to the dynamic characteristics of the target structure. The actual structure has various structural uncertainties such as material properties,

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