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Structural Safety Assessment of a Suspension Bridge using Analysis Model Updating

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Abstract

A reduction in concrete compressive strength is detected in the main tower of a suspension bridge. Since this strength is below the design strength, structural safety assessment is required. Ambient vibration tests (AVTs) were performed to identify current dynamic of the bridge with 56 dense installation point of accelerometers. Manual tuning method is applied to update analysis model based on measured dynamic properties. As a result, errors between the analysis and measurement of the natural frequencies are reduced from 9% to 4%. Automated model updating method with sensitivity-based optimization is additionally applied to update analysis model. Finally, update model has errors of natural frequencies below 2%. Utilizing the updated model, structural safety assessment is performed considering live load, wind load and seismic load.

Keywords: ambient vibration tests; manual tuning; automated model updating; assessment.

1 Introduction

Generally, bridge behaviour is not exactly represented by analysis model utilized in design stage. Actual bridge has different stiffness with design stiffness due to incompleteness of design analysis model. Furthermore, uncertainties arising from the manufacturing and construction stage, material properties, damage and deterioration over time can be reason. In order to assess safety of bridge, it is necessary to develop analysis model reflecting the current state of bridge [1,7].

A reduction in concrete compressive strength is detected in the main tower of a self-anchored suspension bridge during operation. Since this strength is below the design strength, structural safety assessment is required. Therefore, in this research, analysis model representing suspension bridge is updated to reflect measured dynamic properties obtained by ambient vibration tests. Manual tuning method which adjust the parameter artificially and automated model update algorithm based on sensitivity-based optimization method are utilized for this model updating framework. Then, safety assessment is performed utilizing updated analysis model.

2 Ambient vibration tests

Figure 1 shows the structural dimensions of an investigated suspension bridge. The dynamic properties of a suspension bridge are obtained by ambient vibration tests with 56 dense installation point of accelerometers including two main tower. After tests over three days, three vertical modes, one lateral mode, and one torsional mode are identified. Measured and analysed frequencies obtained from design analysis model are presented in Table 1. Table shows that design analysis model has lower frequency than AVT results. This means stiffness of design analysis model is modelled smaller than actual. Or mass of

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