Pilot Investigation of Dynamic Characteristics of a Repaired Timber Beam

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Abstract This paper presents a pilot study on the health status assessment of damaged timber structures before and after repair. The modified damage index (MDI) method, proposed by the authors in previous research, was adopted for locating damage in a timber beam using modal parameters obtained from experimental modal analysis. The presented research work extends the existing functionality of the method in identifying damage location to evaluate the "improved" state of the damaged structure after damage is repaired. The results of the experimental investigation showed that the proposed method is effective and reliable in locating severe damage. In addition, it is also capable of evaluating condition of the damaged timber beam structure qualitatively before and after repairing. The test results further confirmed that damage reduces the structural natural frequencies and subsequent repairing can restore lost natural frequencies..

Keywords timber, repaired, natural frequency, damping ratio, mode shape, modified damage index method

1. INTRODUCTION

In Australia, there are about 29,000 timber bridges still remaining in service, but many are old and structurally deficient. Replacing or repairing an in-service timber bridge using Australian hardwood is becoming increasingly difficult due to lack of availability and generally poorer quality timber than was available 50-100 years ago. Therefore, many methods have been developed to repair existing timber bridges that are in a degraded state, such as adding steel sections to the overstressed part of a structural member or replacing the decking system with alternative structural systems – both timber and non timber. The issue that has not been widely investigated until the last 10 years is to undertake an accurate assessment of the extent of degradation in order to assess the remaining structural capacity of the structure. This paper presents a preliminary effort to dynamically evaluate the state of damage typically found in structural timber before and after it has been repaired. It is considered as an important initiative to advance the knowledge of non-destructive testing (NDT) for timber structures.

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2. MODIFIED DAMAGE INDEX (MDI) METHOD

The damage index method developed by Kim and Stubbs (1995) was adopted and modified by the authors (referred to as modified damage index (MDI)) to locate and quantify damage in timber beams before and after repair. The MDI is based on the relative differences in modal strain energy between an undamaged structure and that of the damaged/repaired structure.

3. TEST BEAM

To experimentally verify the proposed method, a timber beam with the dimensions of 90 × 45 mm (depth × width) and a span length of 4.5 m was used. To simulate degradation in timber girders, the beam was inflicted with single rectangular notch-type damage at the soffit of the beam located at mid span (2.25 m). The inflicted damage corresponds to 87.5% loss of '*I*' (moment of inertia). To simulate a repaired timber structure, the cut section was first glued back using a standard timber adhesive material and then steel elements (Tylok Connector nail plates) were attached across the damage to provide continuity of the timber fibres, which were previously cut when the damage was inflicted.

4. EXPERIMENTAL MODAL TESTING AND ANALYSIS

At each stage of the experimental testing (undamaged, damaged and repaired stage), experimental modal testing and analysis was performed to obtain the dynamic properties of the tested timber beam. In experimental modal testing an impact hammer was used to excite the beam. Nine accelerometers were attached to the structure to measure the dynamic responses of the beam. The accelerometers were located at 1/8 intervals of the span length starting from one end of the beam. In experimental modal analysis, a frequency domain direct measurement curve-fitting technique was used to obtain the modal parameters from the measured data, i.e. natural frequencies, mode shapes and damping ratios.

5. EXPERIMENTAL RESULTS

From the experimental results, it was found that the proposed method estimated very accurately the loss of '*I*' for the investigated damage case. The method also provided some estimation of the percentage of '*I*' gained after the damage was repair. Further, the method worked reasonably well in evaluating the damaged and repaired beam even though they came with some false positives. Furthermore, the test results confirmed that damage and subsequent repair can change structural natural frequency, i.e. initially reduce and subsequently restore the natural frequencies of a structure. No specific trend in the changes of damping ratios was observed.

6. CONCLUSIONS

The presented research work investigated the feasibility of using the modified damage index (MDI) method for assessment of the degree of health condition of damaged timber structures before and after repair. The proposed method was experimental validated on a timber beam, which was first inflicted with notch-type damage and subsequently repaired using gluing and plate connector techniques. The results of the experimental tests showed that the proposed method is effective and reliable in locating severe damage and it is also capable of indicating qualitatively where a damaged timber structure has been repaired. With the insight gained from this study, it is recommended that more research efforts be directed into utilising the MDI method for assessing the structural capacity of repaired timber members once some repairs have been undertaken.

REFERENCES

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