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Structural Identification and Damage Detection in Bridges Using Wave Method and Uniform Shear Beam Models: A Feasibility Study

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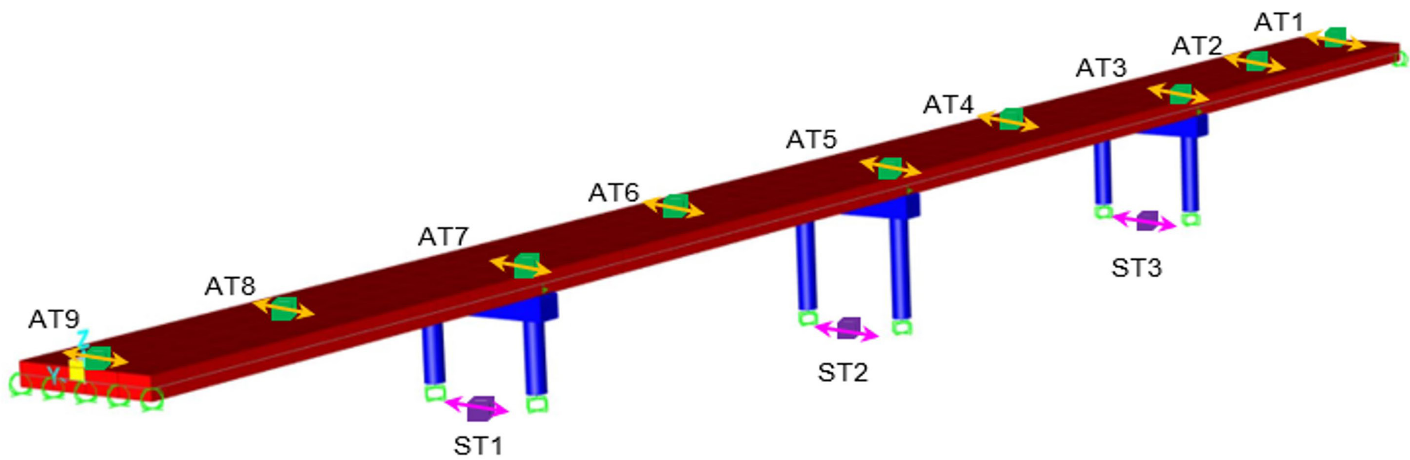

This report presents a wave method to be used for the structural identification and damage detection in bridges. This method was shown to be promising when applied to real structures and large amplitude response in buildings. This study is the first application of the method to a damaged bridge structure. Using the wave method, we identify changes in the shear wave velocities in the bridge. The changes in velocities are directly related to change in the structure's stiffness and thus, can be used as a damage indicator for the bridge structure. The main goal of this study is to assess the feasibility of the wave method for damage detection in bridges. Availability of a robust damage detection methodology can potentially help detect damage in bridges soon after an earthquake. A rapid health monitoring technique, in comparison to traditional on-site inspections, can prevent large monetary losses of an unnecessary closure of a safe bridge.

Study Methods

The bridge identification was performed using wave propagation in a simple uniform shear beam model. The method identifies a wave velocity for the structure by fitting an equivalent uniform shear beam model in impulse response functions of the recorded earthquake response. The structural damage is detected by monitoring changes in the identified wave velocities from one damaging event to another. The process involves utilizing on-site recorded acceleration data, finite element modeling of the bridge, mathematical derivations, and MATLAB programming.

Findings

The results revealed that the average percentage of reduction in the velocities was consistent with the overall observed damage in the bridge. Therefore, the wave method is a feasible approach for detecting damage in the bridge piers. However, the results showed that there was no clear correlation between a specific wave-passage and the observed reduction in the velocities. This indicates that the uniform shear beam model was not able to localize the damage in the bridge. It rather provides a proxy on the extent of overall change in the response due to damage.

Policy/Practice Recommendations

To increase the accuracy of the structural identification and damage localization, a more complex wave propagation model (e.g., a Timoshenko beam model), with ability of capturing the bending motions at the bridge deck and piers, will improve the spatial accuracy of the structural identification and its capacity for damage localization.

The average percentage reduction in the estimated velocities was consistent with the overall observed damage in the case-study bridge.

About the Principal Investigator

Dr. Mehran Rahmani is an assistant professor in the Civil Engineering Construction Engineering Management (CECEM) department at California State University, Long Beach. He earned his PhD in Structural and Earthquake Engineering from the University of Southern California (USC) in 2014. He is a registered Professional Engineer (PE) in the state of California.

To Learn More

For more details about the study, download the full report at **transweb.sjsu.edu/research/1934**

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