Damage Location Identification of Railway Bridge under moving Train

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Summary

In order to detect the structural damage of railway bridge, based on acceleration response caused by moving vehicles, a novelty damage location method with the combination pattern recognition and Hilbert-Huang Transform in time-frequency domain is put forward. The structural damage vulnerability is analyzed to find out the vulnerable zones at first, and then several subdomains are obtained from the structural time-histories induced by moving vehicles. As for each subdomain, damage location identification is divided into 2 steps with different damage location models. Hilbert-Huang transform is adopted to construct damage indexes, and Support Vector Machine is taken as the classification algorithm. One certain railway continuous girder bridge is taken to verify the proposal method, and the results show that the proposed method can obtain the preferable results for damage location identification with better anti-noise capability.

Key words: bridge engineering; damage location identification; sub-domain; HHT; support vector machine

The train load is the most frequent load for railway bridge and easy to cause the damage in bridge structure. Therefore, the damage identifications of railway bridges under train load are studied by many domestic and foreign scholars. The optimization model without prior knowledge of the moving loads is established in light of minimizing the elastic restoring force error, and the simple supported bridge structural damage location and extent are identified by Zhu X. Q et al and Lu Z. R et al. Both structural element stiffness and bearing stiffness are regard as the optimization variables for damage identification in time domain by Majumder Luna et al, and moving wheel with sprung mass is adopted to simulate the moving vehicle in his study, then of the dynamic interactions between vehicle and the bridge, bridge deck unevenness, spatial incomplete measurement and measurement noise are taken into account as well. Based on the sensitivity analysis of bridge damage factor about the bridge dynamic responses induced by moving vehicle, the least square method and the regularization technique are adopted to identify bridge damage by Pu Jianqing et al. Damage sample sets composed of structural dynamic response time-history and pattern recognition method are adopted to study the damage identification of simply supported girder bridge under moving load by Shan Deshan et al.

Through the analysis of above mentioned literatures can be seen that the damage state is assumed unchanged during the damage location identification. It means that the damage is independent of the magnitude and position of moving vehicle/load. As for real railway bridge, because of its larger proportion of live load, the structural cracks may be opened under the action of live load, and the structural crack will be closed once the train is not moving on the bridge. Hence the damage state of railway bridge is associated with the moving train load. Therefore, based on the correlation between damage state of railway bridge structures and moving train load, and Hilbert-Huang transform is adopted to construct damage indexes, then the damage location identification model is established based on the support vector machine classification algorithm in this paper. And the damage location identification of bridge structure under moving train is studied finally.

With the analysis and discussion in this paper, the following conclusions can be drawn:

(1) The damage state of railway bridge structure is changed along with the moving train load, so damage location identification method should consider the variety;

(2) The vulnerable section should be identified in the time sub-domain when the damage is prone to appear, so that the result closer to the reality can be obtained;

(3) According to the characteristics of damage location identification, the structural damage location identification can be regarded as the pattern recognition problem;

(4) Using HHT to construct the time-frequency damage index, optimizing the sample library from different viewpoints, selecting the appropriate support vector machine algorithm and kernel function, and the damage location identification model can be established in light of the statistical learning theory;

(5) The damage location of bridge structure can be correctly identified by the proposal method in this paper. The recognition result under low noise level is more favorable.

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