Structural Crack Identification in Railway Prestressed Concrete Sleepers Using Dynamic Mode Shapes

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Extended Abstract

Structural Crack Identification in Railway Prestressed Concrete Sleepers Using Dynamic Mode Shapes †

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Railway prestressed concrete sleepers are a structural and safety-critical component in railway tracks. They are commonly embedded in ballast or gravel to enhance lateral track stability. This practice has prohibited the ability to visually observe or inspect the structural condition of the railway sleepers. It is important to note that damage of a sleeper may not seem to immediately lead to train derailments in a plain ballasted track. However, such the damage can lead to broken switch, bowed crossing, broken welds and wing-rail in switches and crossings or on the transom or railway bridge, potentially resulting in a train derailment from either excessive resultant track geometry defects or progressive component defects. Without proper maintenance or replacement in a timely manner, such the small damage can extend to a larger damage and lead to costly unplanned maintenance costs from aggravated impact loading, unbalanced load transfer, and other consequences caused by broken sleepers [1–10].

This study is the word first to demonstrate a novel identification technique that is able to locate crack damage in full-scale railway prestressed concrete sleepers. By using dynamic mode shapes of the sleepers, the curvature squares can be used to identify structural cracks in the sleepers. This novel approach adopts structural deflection shapes extracted from experimental modal analysis using an impact excitation [11–15]. In this study, the full-scale railway concrete sleepers are loaded to experience the first crack and exposed to 1.5 times above the first-crack loads using quasi-static loading regimes in accordance with the British Standard as shown in Figure 1.

We are the first to report that the curvature square approach can be used to identify the structural damage in the full-scale railway prestressed concrete sleepers. It is found that accurate locations of structural cracks mostly in the mid span of the sleepers (e.g., centre binding cracks in the field) can be reasonably detected in comparison with the actual crack measurements from the experimental data. Our future work will establish a standardized damage index distributions and subsequent thresholding with different levels of confidence of damage localization to enhance the accuracy of crack localization. The insight into this approach can enhance the development of on-board and on-track technology to identify structural cracks for railway concrete sleepers embedded in ballasted railway tracks using operational modal analysis.

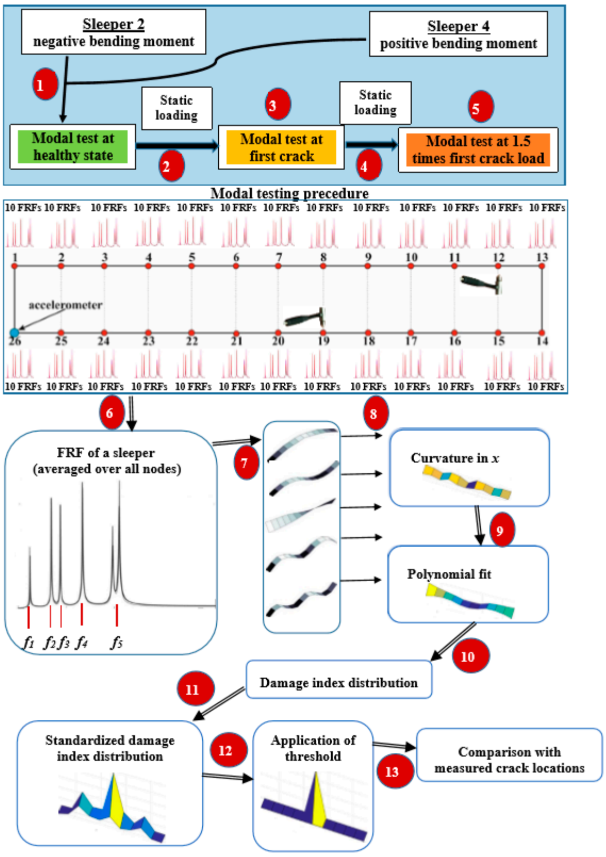

Figure 1. Experimental testing and damage localization flowchart.

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