Large-scale strain sensing approach for detecting fatigue cracks in steel bridges

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ABSTRACT

Fatigue cracking in steel highway bridges presents major safety and maintenance concerns for bridge owners: if bridges are not regularly inspected and maintained, fatigue cracks can lead to structural failure. In this study we present a novel strain sensing technology for fatigue crack monitoring based on the soft elastomeric capacitors (SECs). SECs are large-scale flexible strain gauges, capable of monitoring deformations over a much larger area than traditional metal foil strain gauges. Our previous research investigated SEC’s performance for in-plane fatigue crack detection on small-scale specimens (Kong et al. 2016, Kong et al. 2017).

To translate the SEC fatigue sensing technology from small-scale specimens to large-scale realistic structural components, a challenge lies in detecting fatigue cracks over large fatigue-susceptible regions without prior knowledge of locations of crack initiation and propagation. To tackle this problem we deployed dense SEC arrays on a bridge girder-to-cross-frame connection subjected to out-of-plane distortion induced fatigue cracks, as shown in Figure 1a. Dense SEC arrays were deployed on the connection to cover a large fatigue-susceptible region (Figure 1b). Then, a novel data visualization method (Figure 1c) was established to convert fatigue damage features, termed the crack growth index (CGI), into a 2-dimensional CGI map. Fatigue damage sensing can be achieved by monitoring intensity changes across CGI maps.

The effectiveness of the proposed approach has been validated through experimental tests. Preliminary results demonstrated an explicit intensity change on the CGI map from 0 to 71000 cycles (Figure 1e), while the fatigue crack propagated from 14 to 42 mm as shown in Figure 1d. The results of this study indicate that the SEC technology has great potential for detecting and monitoring fatigue crack growth in practical applications.

REFERENCES
