A multi-modal NDE approach for in-situ deterioration evaluation of aging bridge decks

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Bridge components are exposed to a wide range of deterioration mechanisms including freezing-thawing cycles and reinforcement corrosion. Among these components, bridge decks deteriorate rapidly due to direct exposure to traffic loads and deicing chemical agents. Prolonged exposure to these factors initiates damage in bridge decks, which grows over their service life and can lead to catastrophic failure if not detected and repaired in a timely manner. In this study, we present a comprehensive assessment of aging bridge decks using a multi-modal nondestructive evaluation (NDE) approach. Ground-penetrating radar (GPR), ultrasonic array imaging (UAI), and impact-echo (IE) methods are employed to collect multi-modal NDE data. Subsequently, we introduce a data fusion technique based on unsupervised machine learning to integrate the acquired multi-modal NDE data and generate a visual representation of various internal damages within a concrete bridge deck. We applied this multi-modal NDE approach to real bridge decks and evaluated its performance using destructive testing methods, such as concrete coring. The experimental results demonstrate the effectiveness of the proposed multi-modal NDE approach in detecting internal damages, including delamination, cracking, and concrete degradation, within bridge decks. The obtained findings can serve as valuable insights for bridge maintenance authorities, aiding them in informed decision-making regarding the selection of appropriate repair and retrofitting methods.