Intelligent Asset Management for Improved Mobility:
Technology Transfer for South Carolina

Technology Transfer Activities

by

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1 Outputs

This project developed a graphical user interface (GUI) for the digital twin load rating of the bridge. Developing and utilizing digital twins for bridge load rating involves several steps. First, vehicle loads are assessed using acoustic emission (AE) data captured by sensors installed on the bridge. This data is then applied to a high-fidelity finite element model (FEM) of the bridge to simulate its structural response. The model is continuously updated and validated using actual strain measurements from the bridge, ensuring its accuracy. Additionally, drone inspections are employed to detect surface cracks and other defects, which are used to update the bridge's condition factor in the load rating formula. Finally, all this information is integrated into a GUI that allows users to calculate the bridge's load rating factor.
The project also included hosting a workshop. Participants comprised the University of South Carolina (USC), Benedict College, IBM, LUNA, and Structural Monitoring Solutions researchers. They collectively discussed the application of digital twin technology in bridge load rating and maintenance.

1.1 Output #1

One report has been submitted to C^2M^2.

The project also resulted in the following:

Journal Article:

1. Ai, L., K C, L., Elbatanouny, E., Henderson, A., & Ziehl, P. (2024). Assisting Load Rating Testing of Precast Reinforced Concrete Bridge Slab through Digital Twins and Field Monitoring Data. Journal of Testing and Evaluation, 52(4).

Technology Demonstration:

1. Ai, L., Comert, G., & Ziehl, P. (2024), “Assisting Load Rating Testing of Precast Reinforced Concrete Bridge Slab through Digital Twins and Field Monitoring Data”, C2M2 8th Annual Fall Conference, South Carolina, USA

1.1 Output #2

New Research Methodologies: Developed a digital twin framework that integrates AE data, FEM simulations, and drone-based defect assessments. The project integrates innovative methods including AE data analysis, high-fidelity FEM, drone defect detection and real-time validation using strain measurement to ensure accurate and dynamic rating load calculations.
Improved Products: Created a user-friendly GUI for practical applications in bridge load rating. The GUI provides an easy-to-use platform for engineers to integrate these advanced technologies into a user-friendly tool.

2 Outcomes

The outcomes of this project include a user-friendly GUI for practical applications in bridge load rating, and a workshop.

2.1 Outcome #1

As part of this project, a workshop was organized to train the current and future transportation workforce in applying digital twin technology for bridge load rating and maintenance. The event included participants from USC, Benedict College, IBM, LUNA, and Structural Monitoring Solutions, fostering collaboration between academia, industry, and research organizations. Attendees were introduced to the integration of AE data, FEM, and drone inspections in a digital twin framework, along with practical demonstrations of the newly developed GUI.

2.2 Outcome #2

The outcomes include a novel GUI that integrates cutting-edge techniques such as AE data analysis, high-fidelity FEM, drone inspection, and real-time strain measurement validation. Combining these methods improves the accuracy and efficiency of bridge load rating calculations.

3 Impacts

The project enhances infrastructure maintenance through digital twin technology, integrating real-time data and automated tools for precise structural evaluations and proactive management.

3.1 Impact #1

The impact will be a significant enhancement in bridge maintenance, achieved through the implementation of a digital twin-based load rating method that integrates lab data with finite element models for precise structural evaluations.

3.2 Impact #2

The impact will be a substantial advancement in concrete structure maintenance, as it introduces an automated, drone-based framework for precise crack detection, measurement, and visualization, leading to more informed repair and maintenance strategies.