Exhibit D

Research Project Submission Template

Recipient/Grant (Contract) Number: University of Illinois Urbana-Champaign / Louisiana State University / Grant No.: 69A 355 234 8333

AI-Based Vision Deblurring for Precast Concrete Bridge Inspection Considering Environmental Disturbances

Center Name: Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

Research Priority: Improving the Durability and Extending the Life of Transportation Infrastructure

Principal Investigator(s): Chao Sun

Project Partners: N/A

Research Project Funding: $105,000 ($70,000 Federal and $35,000 Non-Federal)

Project Start and End Date: 01/16/2026 – 01/15/2027

Project Description:

Unmanned Aerial Vehicles (UAVs) and computer-vision techniques have become increasingly important for automatic low-cost monitoring of hard-to-reach precast concrete bridges. However, a major challenge for UAV-based monitoring is video/image quality degradation due to environmental disturbances (like wind gusts), abrupt UAV motion, and camara instability. This research aims to develop an AI-based vision deblurring framework for low-cost inspection of precast concrete bridges. The research goal is to restore high-quality videos/images affected by defects from UAV-captured blurry inputs. Specific research activities include: (1) construct comprehensive datasets of structural defect images with real UAV-induced blur and simulated camera-shake blur; (2) develop a deep learning-based deblurring framework; (3) integrate the deblurring framework with state-of-the-art defect detection and segmentation networks to detect and quantify various damage (cracks, corrosion, and concrete spalling) on precast concrete bridges. The ultimate goal is to develop preventive technology to ensure safe operation of precast concrete bridges.

US DOT Priorities:

Many precast concrete bridge components (e.g., precast prestressed concrete girders, deck panels, piles, and columns) are working under serious degradation conditions where the damage (cracks, corrosion, and concrete spalling) threatens bridge structural integrity and public security. To ensure safe operation and public security, it is required that bridges in the U.S. be inspected and rated every two years. Currently, this biannual assessment is largely implemented using manual visual inspection methods, which is slow and costly. In addition, it is challenging for workers to detect bridge defects in hard-to-reach regions. As unmanned aerial vehicles (UAVs), AI (artificial intelligence), and computer vision techniques have become increasingly popular for condition monitoring, researchers have started to utilize images and videos to detect structural damage of bridges. UAVs can quickly fly to the desired locations for inspection, thereby enabling low-cost, efficient, and automated condition monitoring of damaged bridges. However, one of the major challenges for UAV-based monitoring is video/image quality degradation due to environmental disturbances (e.g. wind gusts), abrupt UAV motion, and camara instability. To address these issues, this project aims to develop a new AI- and UAV-based vision deblurring framework to enable low-cost automated inspection of precast concrete bridges considering environmental disturbances. The overarching goal of this research is to ensure public safety and extend service life of precast concrete bridges.

This project will be mainly implemented by a research team led by PI Sun at Louisiana State University (LSU). The field-testing part of the project will be conducted via collaboration between the LSU team and Louisiana Transportation Research Center (LTRC), and Louisiana Department of Transportation and Development (LADOTD). LTRC and LADOTD will assist the LSU team in field inspection of realistic

bridges to validate the developed framework. This is a multi-phase project. The first step is to develop a new AI-based framework to restore images/videos contaminated by blurry inputs caused by environmental disturbances. Based on existing computer vision techniques, the research team will investigate effective algorithms with optimal parameters for detecting concrete bridge defects using mixed high-quality and blurred low-quality images/videos recorded by UAVs exposed to disturbances. Performance of the developed algorithm and framework will be evaluated via laboratory and field testing. The second phase of the research will focus on remaining service life prediction of precast concrete bridges with defects. Based on the first-phase results, quantified assessment of the bridge damage will be performed, and another new integrated AI- and physics-based framework will be developed to estimate the remaining service life of the bridges with defects.

This project aligns well with the mission of TRANS-IPIC to develop effective solutions for condition monitoring of precast concrete bridge components and revolutionize the development and performance of future transportation infrastructure. The research outcomes are expected to enhance the durability, security, and resilience of precast concrete bridges and extend their service life. Engagement of LTRC and LADOTD in this project will on one hand facilitate essential data collection for model validation. On the other hand, the research deliverables (developed framework and the associated algorithms) can be easily disseminated to relevant stakeholders and practitioners, thereby promoting the application of the research products in practice and enhancing the performance and safety of the aging transportation infrastructure in the US.

Outputs:

Upon completion of this project, our team will develop an AI-based vision deblur framework and UAV-based computer vision algorithms for detecting defects of precast concrete bridge components with high accuracy. Currently, there is a lack of an automated framework that can deblur images/videos for defect detection using UAV-based monitoring exposed to environmental disturbances. The proposed framework is expected to address the technology gap and provide a transformative condition monitoring and remote sensing approach for concrete bridges and other types of structures. The outcome of this project will improve the durability and safety of precast concrete bridges which is well aligned with the strategic goal of TRANS-IPIC to incorporate “built-in” quality control and repair mechanisms in PC components.

Outcomes/Impacts:

Our research team will provide a practical tool for automated low-cost inspection of precast concrete bridges (also applicable for other types of bridges) to extend their service life and ensure public safety. To promote the application of the research products, we will collaborate with LTRC and LADOTD and share them with our research outcomes. Our team will conduct condition monitoring under different weather conditions (clear, windy, cloudy, and overcast), at different times of day (morning, noon, and afternoon), and on different days. Specifically, the test will consist of inspecting precast concrete bridges with different conditions (intact and damaged). Based on the overall performance and feedback from practice, we will improve the developed framework.

Final Research Report: URL link to the project's final report will be provided upon the completion of the project.