

Exhibit D

Research Project Submission Template

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

Probabilistic Bridge Condition Projections: Toward Reliability-Based Assessment of Precast Concrete Bridges

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

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

Principal Investigator(s): Eun Jeong Cha

Project Partners: N/A

Research Project Funding: \$120,944 (\$69,967 Federal and \$50,977 Non-Federal)

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

Project Description:

This project advances bridge condition modeling by developing probabilistic methods that explicitly quantify uncertainty in deterioration forecasts, with a focus on comparing precast concrete (PC) and cast-in-place (CIP) bridges. Building on Year 1's machine learning framework, the research will extend condition projections from single-point estimates to calibrated probability distributions and survival-based forecasts using NBI/NBE inspection data. By integrating uncertainty quantification into bridge condition assessment, the project will provide agencies with more reliable tools for planning inspections, prioritizing repairs, and evaluating safety. Comparative analysis will quantify whether PC bridges exhibit reduced variability and higher reliability than CIP bridges, providing evidence of PC's durability advantages. The anticipated outcome is an uncertainty-aware assessment framework that links condition ratings to reliability-based safety evaluation, delivering actionable insights that support TRANS-IPIC's mission to improve durability, extend service life, and strengthen workforce capacity in transportation infrastructure.

US DOT Priorities:

This project will develop probabilistic bridge condition models that quantify uncertainty in deterioration forecasts, enabling more reliable comparisons of precast (PC) and cast-in-place (CIP) bridges. By showing how reduced variability in PC condition translates into improved reliability and extended service life, the research directly supports TRANS-IPIC's theme of Application of New Materials and Technologies and USDOT's statutory priority of improving durability, resilience, and safety in transportation infrastructure.

First, it addresses the statutory goal of extending the life of transportation infrastructure by providing agencies with uncertainty-aware models that better capture deterioration patterns and guide proactive maintenance. Second, it advances the Application of New Materials and Technologies theme by producing quantitative evidence of PC's performance benefits in terms of reduced uncertainty and improved reliability. Third, by delivering probabilistic decision-support tools, the research enhances agencies' ability to allocate resources efficiently and make maintenance decisions with greater confidence, thereby contributing directly to the long-term durability and safety of the nation's bridge infrastructure. In doing so, the project will help transition bridge condition modeling from deterministic forecasts to reliability-based decision tools, providing a transformative step toward extending the durability and service life of precast concrete transportation infrastructure.

Outputs:

The primary result of this research will be a probabilistic bridge condition projection framework that

quantifies uncertainty in deterioration and links it to reliability assessment. Building on Year 1 models, the Year 2 work will extend forecasts from single-point estimates to calibrated probability distributions and survival-based projections. Key deliverables include validated probabilistic models (OLR, GB, and RSF), comparative analysis of uncertainty profiles for PC and CIP bridges, integration of condition ratings into reliability-based frameworks, and technical documentation of methods and findings. These results directly support TRANS-IPIC's priority of improving durability and extending service life. They will provide quantitative evidence that PC bridges exhibit reduced variability and higher reliability, and offer agencies tools to plan inspections, prioritize repairs, and manage assets more effectively.

Outcomes/Impacts:

The expected outcome is an assessment toolset that incorporates uncertainty into bridge condition projections and reliability-based safety evaluations. This resource will enable agencies to make more confident, data-informed maintenance decisions. Technology transfer activities will include technical documentation, workshop demonstrations, and example applications (e.g., PC vs CIP comparisons) illustrating benefits for durability and service life. If successfully adopted, the framework will provide reliability assessments that highlight the durability advantages of PC, directly advancing TRANS-IPIC's mission of extending infrastructure service life.

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