

Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

# University Transportation Center (UTC)

*Optimizing the Planning of Precast Concrete Bridge Construction Methods to Maximize Durability, Safety, and Sustainability*

*UI-23-RP-05*

### Quarterly Progress Report

For the performance period ending *[3/31/2024]*

## Submitted by:

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## Collaborators / Partners:

None.

## Submitted to:

TRANS-IPIC UTC

University of Illinois Urbana-Champaign Urbana, IL

# TRANS-IPIC Quarterly Progress Report:

## Project Description:

### Research Plan - Statement of Problem

The poor conditions of aging bridges in the US prompted the federal government to enact a $1 trillion infrastructure bill in 2021 that includes $110 billion in additional funding for repairing and rebuilding US bridges and roadways (White House, 2022). State DOTs need to optimize the use of these investments to accomplish multiple objectives including maximizing durability, safety, sustainability, and mobility while minimizing life- cycle cost. This presents DOTs with a number of challenges including how to (1) select an optimal bridge construction method from a set of feasible alternatives including conventional cast-in-place, precast bridge elements or systems, precast lateral slide, and precast self-propelled modular transporter, for each planned project based on its specific conditions and requirements; (2) accurately predict the cost of these alternative bridge construction methods during the early project phase with limited design data; (3) optimize the planning of off-site PC manufacturing, transportation, and onsite installation; and (4) quantify and optimize the impact of important construction decisions on multiple objectives including durability, safety, sustainability, mobility, and life-cycle cost

### Research Plan - Summary of Project Activities (Tasks)

Task 1: Develop novel predictive Machine Learning (ML) models that can be used by DOT planners during the early design phase to quantify the impact of conventional and PC accelerated bridge construction methods on construction cost during the early design phase.

Task 2: Create a novel multi-objective optimization model to support DOTs in identifying optimal bridge construction planning decisions such as optimal size, number, transportation, and onsite installation of all bridge PC modules to maximize durability, safety, sustainability, and mobility while minimizing bridge life-cycle cost.

## Project Progress:

### Progress for each research task

Task 1 progress [50% completed]. Last quarter, the research team started the first research task that focused on developing novel predictive Machine Learning (ML) models. These models were designed to assist DOT planners in quantifying the impact of both conventional and PC accelerated bridge construction methods on construction cost during the early design phase. The team successfully developed six different ML models and conducted preliminary comparative analyses to identify the most appropriate model for accurately estimating construction costs associated with each construction method in the early design phase. The developed ML models including (1) Ordinary Least Squares (OLS), (2) Lasso Regression, (3) Ridge Regression, (4) Random Forest (RF), Gradient Boosting (GR), and (6) Xtreme Gradient Boosting (XGBoost).

Task 2 progress [0% completed] (Not started).

### Percent of research project completed

25% of total project completed through the end of this quarter.

### Expected progress for next quarter

In the next quarter, the research team will continue working on the first research task and will continue collecting available historical cost data and characteristics of previously constructed bridge projects utilizing different construction methods to improve the accuracy of the developed ML models. Additionally, the team will start working on the second research task that focuses on developing multi-objective optimization Decision Support Tool (DST) for optimizing the construction decisions of PC bridges*.*

### Educational outreach and workforce development

The research team actively participated in all TRANS-IPIC Monthly Webinars. Furthermore, the research team is planning to present their preliminary research findings at the TRANS-IPIC workshop on April 22, 2024.

### Technology Transfer

None.

## Research Contribution:

### Number of papers

None.

### Number presentations (when, where)

The research team is planning to present their preliminary research findings at the TRANS-IPIC workshop on April 22, 2024.

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