# Exhibit D

**Research project name: Holistic Quality Management of Precast Concrete Construction for Transportation Infrastructure**

**Recipient/Grant (Contract) Number:** University of Illinois Urbana-Champaign / Purdue University / Grant Number 69A3552348333

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

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

**Principal Investigator(s):** Hubo Cai, Dulcy Abraham, Phillip Dunston, Jiansong Zhang

**Project Partners:**

A *Project Advisory Committee (PAC),* composed of representatives from INDOT and neighboring DOTs, contractors (Walsh, Milestone, etc.), and precasters(certified with INDOT, Fort Miller, etc.), will be established to guide and coordinate the project with other industry stakeholders, and to disseminate findings and key lessons into practice. The PAC members will function as the bridge to an expanded ecosystem of precast concrete for transportation infrastructure.

**Research Project Funding:** $101,984.00 ($62,119.00 Federal and $39,865.00 Non-Federal)

**Project Start and End Date:** 09/01/2023 – 08/31/2024

**Project Description:**

Precast concrete (PC) is manufactured in a controlled environment, and is a promising alternative to cast-in-place concrete and provides desired quality, durability, adaptability, efficiency, and (with embedded sensors) real-time performance monitoring capacity to construct transportation assets that address significant infrastructure challenges faced by the nation. High-quality precast concrete systems (PCS) provide several benefits including: shorter lane closures and reduced traffic congestion attributed to accelerated construction with shorter project duration, and increased road user and worker safety when such systems are utilized correctly. However, quality deficiencies during any PCS lifecycle phases (i.e., design, manufacturing, transporting, lifting and installation, and operation and maintenance (O&M)) can easily offset the expected benefits, leading to premature failures and excessive repair costs.

This project aims to design a holistic quality management framework/model for precast construction of transportation infrastructure and test it for the stage of precast at the plant. The framework integrates building information modeling (BIM), laser scanning, ground penetrating radar (GPR), vision sensing, extended reality (XR) along with advanced computational tools to create a digital twin as the ‘seamless’ method of information management and sharing for quality control from the life-cycle perspective. Specific objectives are to: (1) design a system-level framework for lifecycle data/information/knowledge acquisition and data exchange in PCS; (2) design an expandable BIM approach to meet the data and information needs of lifecycle PCS quality management (QM); (3) validate and test at the precast-at-plant stage through case studies; and (4) present and solicit feedback from researchers and practitioners in the field of precast concrete in transportation projects through venues such as the 2024 Purdue Road School.

**US DOT Priorities:**

This project focuses on technology and process innovation to realize the full potential of precast concrete systems (PCS) towards a reliable and sustainable future transportation system that provides accessible and equitable service to individuals and businesses in the United States.

Precast concrete (PC) is manufactured in a controlled environment. Compared to cast-in-place concrete, PC provides desired quality, durability, adaptability, efficiency, and real-time performance monitoring capacity to constructed transportation assets. By ensuring the quality of PC and enabling the adoption of PC in transportation infrastructure construction, this project contributes to *improving the durability and extending the life of transportation infrastructure* (the statutory area of focus for the UTC). It contributes to the achievement of following research objectives: Advanced Materials and Structures; Asset Management and Inspection; Accelerated Project Delivery. The first two belong to research priority Advanced Asset Management, and the third objective belongs to System Performance. Both research priorities contribute to the strategic goal of Economic Strength and Global Competitiveness.

Specifically, this research contributes to TRANS-IPIC’s Strategic Goal 3, Advance the field of building information modeling (BIM) using new technologies, and Research Area B, Construction Methodologies and Management.

**Outputs:**

This project embraces BIM as the central platform to integrate multimodal, holistic sensing data and leverages its capability in interoperability and data and information sharing to create a digital twin of PCS. It enables data collection, measurement and monitoring, and evaluation of the precast process across its life cycle, from design to production, transport, installation/construction, commission, O&M, and decommission/reuse. Aligned with the quality control and measurement process, the design of the digital twin is a ‘seamless’ method of lifecycle data, information, and knowledge management and sharing that can be used for holistic quality control and management of the precast systems. Jointly, these novelties compose the critical step towards ensuring that the following key attributes of successful PCS projects can be achieved: constructability, concrete durability, load transfer at joints, panel support, performance efficiency.

Anticipated results include: (1) BIM templates for MSE walls, deck panels, bridge beams, and concrete pavement; and (2) a structured, validated approach for implementing BIM for lifecycle quality management for precast plant operations for transportation assets.

**Outcomes/Impacts:**

The validated BIM framework and resulting BIM templates can be used directly by the precasters to assist in all in-plant tasks. Since the BIM model will drive all project data, precasters and designers can work closely to reduce the total project life cycle cost (improved productivity), more accurately estimate quantities, check that designs meet constructability and safety requirements, and reduce the probability of errors during production at the plant and during erection at the job site. Designers can check interferences in 3-D, anticipate them before creating drawings, and use 3-D models to create production drawings. BIM can also be used to ensure that tolerance is built into the design and construction details to ensure that discrepancies do not appear during transportation and installation of PC units. The resulting BIM model can serve as the input to simulate the installation of PCS and assess constructability. Therefore, the project improves the quality of PCS by ensuring it is properly designed, casted, and installed and ensures its short-, mid-, and long-term performance to reduce maintenance, enhance durability, and extend service life of transportation infrastructure.

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