# EXHIBIT D

**Research Project Requirement**

# Research project name: Developing A Cost-Effective, Reliable, and Sustainable Precast Supply System under Price Volatility and Uncertainty of Material Supply

**Recipient/Grant (Contract) Number:** University of IllinoisUrbana-Champaign / Louisiana State University: Grant No.: 69A 355 234 8333 (LSU Subaward #: LS-23-RP-04)

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

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

**Principal Investigator(s):** Bhaba Sarker (PI)

**Project Partners:** None

**Research Project Funding:** $97,508 (Federal: $65,000; LSU Cost-sharing: $32,508, Non-Federal)

**Project Start and End Date:** 01/01/2024 – 12/31/2024

**Project Description:**

The supply channel of the precast process begins with the procurement of the raw materials that are processed through the PC (precast concrete) manufacturing operations and subsequently transporting the final products to the point of delivery for assembly or installation on site. The whole system forms a sequential and/or parallel or mesh network of activities to each of which there are three main qualifiers: cost, time, and reliability which dictate the production cost, product durability and reliability which contribute to the final reliability and sustainability of the PC supply system. In this research, a methodology for a cost-effective, reliable, and sustainable precast supply system is to be developed when price volatility and uncertainty of materials exist. As the price of materials and the cost of PC production fluctuate with an uncertainty of materials, an expected cost of supply system can be estimated and an optimal cost-effective supply/process plan with multiple alternatives can be prescribed with an enhanced or desired reliability and sustainability of the system.

**US DOT Priorities:**

As stated earlier, developing an optimal cost-effective, reliable, and sustainable supply logistics system for precast operations in transportation infrastructure is fully aligned with the *Trans-IPIC/USDOT* general objective because this proposal will seek an optimal decision-making process that will cost-effectively prescribe some solutions applicable to the general operations of the transportation infrastructure construction process. The scope of this research is further aligned with 2024-2025 USDOT's general objectives in the sense that PC raw materials or finished products may not be available timely due to a shortage of materials in the disrupted or unavailable supply chain, resulting in price volatilities and consequent cost-ineffectiveness. So, the development of an efficient methodology and solution to enhance the durability, reliability, and sustainability of a PC supply system falls clearly within the umbrella of *Trans-IPIC*/USDOT. Since this proposal will prescribe a cost-effective methodology that will create a significant amount of savings in infrastructure construction, it will serve the purpose and priority of the DOT research, especially because it will improve the durability and extend the life of transportation infrastructure.

**Outputs: Methodology and Results**

The costs, reliability (of system, component, and transportation), and sustainability are the three main ingredients that need to be addressed in this research. The one-year research output will include:

1. A multi-dimensional *cause-effect matrix* to be developed to extract different controlling variables and system parameters or factors that affect the stated performance outcome of the PC supply system:
* A *supply network* representation with variables and corresponding factors will provide the precedence and parallel relationships of general understandings of the system.
* Interrelationships and dependencies of variables, factors, and their related variants will be constructed for information of DOT and the construction community.
1. *CRS Problem:* A *cost-reliability-sustainability (CRS)* model will be formulated to determine the optimal process path that will minimize the expected PC supply system’s cost and simultaneously improve the system's reliability and sustainability of the system.
* To accomplish this activity, dependent and independent jobs will be programmed in series and/or parallel configurations, respectively, such that different products can be completed in the shortest time and/or with maximum reliability.
* The CRS problem will provide a cost-effective optimal process/activity sequence to enhance higher reliability and sustainability; it will provide multiple alternative solutions to the management to choose the most suitable one for implementation purposes.
1. *UPV (Uncertainty & Price Volatility):* Process variability and expected cost with individual material’s prices and supply uncertainty will be considered for refurbishing the warehouse in time.
* Supplying the PC components to the site(s) and sustaining the supply of the material ingredients are another part of the problem wherein repair/replacement is to be incorporated.
* The UPV problem will evaluate the cost, reliability, and sustainability when the prices are fluctuating, and uncertainty exists in the procurement of materials as they are directly dependent on the cost significantly.

**Outcomes/Impacts:**

All PC products may not last the same life (due to different usage and application environments) even though they might be installed at the same time. So, the repair or replacement of the affected components may enhance the life of the infrastructure sub-system; this replacement will sustain the structure for longer life. This problem becomes compounded when the price volatility and uncertainty of materials supply exist, impacting the huge cost involved in timely supply and/or repair/replacement of the PC components. Thus, the demand for a cost-effective, reliable, and sustainable PC supply system is essential when the supply uncertainty and the volatile prices are additional impeding factors—it has a high potential for transferring the technology to practice. Embedding the reliability in PC manufacturing processes and supply chain and maintaining the sustainability of the PC products (or structures/installation) under volatile price and uncertainty of materials, the proposed research will uniquely provide an *innovative methodology and solution techniques* that may be applied to the construction industry that will *enhance both quality and durability* of the transportation infrastructure system.

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

The final research results will be available in the form of research reports to be submitted to *Trans-IPIC/USDOT.* This will include: 1. A written short report describing the problem, solution methodology and simulated/ experimental results, (2) A written survey paper on the existing systems and procedures, (2) Modeling and solution methodology, (3) computer output if applicable, and (4) Recommendation as to its applicability to enhance the durability, reliability and life of PC product or operations.

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