# Exhibit D

**Research project name: Innovative Precast Concrete Truss Using Adaptive Shape Memory Prestressing System**

**Recipient/Grant (Contract) Number:** University of Illinois at Urbana-Champaign / 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:** Bassem Andrawes

**Project Partners:** N/A

**Research Project Funding:** $150,000 ($100,000 Federal and $50,000 Non-Federal)

**Project Start and End Date:** 9/1/2023 – 8/31/2024

**Project Description:**

The ever-growing demand for making our transportation infrastructure more durable and sustainable requires serious efforts to reduce carbon emissions associated with the concrete and steel used in transportation infrastructure. Almost half of the CO2 emission in the construction industry is related to steel and cement production. Cement alone is the source of about 8% of the world's CO2 emissions, and concrete is the second most used substance by mass after water. One way to achieve sustainability is by optimizing the materials used in transportation infrastructure. Taking precast concrete (PC) prestressed bridge components as an example, the geometric configurations of PC bridge girders have not significantly changed over the last several decades. Part of this could be attributed to the constraints imposed by the prestressing system and how the prestressing force is applied, which has not changed much over the years. This research will help address this issue by studying the application of an innovative Adaptive Prestressing System (APS) in a geometrically optimized (truss) PC system. The new APS can apply localized prestressing in any direction without mechanical tensioning or special hardware, which is ideal for prestressing short diagonal or vertical members of a PC truss. Additive manufacturing (3D printing) technology advancements make casting concrete trusses more feasible. Reusable, durable 3-D printed molds can be used in precast plants to construct trusses with various complex geometries. This research will investigate the APS technology to overcome the issue of cracking in lightweight PC trusses. APS utilizes shape memory alloys (SMAs); a class of smart metallic material that can remember their original shape by heating after being excessively deformed. APS is based on utilizing the permanent force associated with the shape recovery of the deformed SMAs to prestress members subjected to tension in a truss that are hard to prestress using conventional methods. The research will include experimental testing and numerical simulation of reduced-scale PC truss structures with APS placed in tension members that are hard to prestress using conventional methods. In this project, the performance of the new APS reinforced PC truss will be compared with traditional PC bridge girders as an example application to prove the feasibility of the concrete truss concept.

**US DOT Priorities:**

This research supports the US DOT priority to improve the durability and extend the life of transportation infrastructure. It will introduce a novel, sustainable, durable (i.e., crack-free) lightweight structural truss system for critical transportation infrastructure. It supports the RD&T strategic goals of performing transformative research that promotes sustainability by introducing a novel method for constructing PC transportation infrastructure with less construction material, lowering the carbon emissions of producing these materials.

**Outputs:**

This project will introduce to the transportation infrastructure sector the new technology of using APS to construct lightweight, sustainable, and durable (crack-free) PC truss systems for bridges. During this phase of the project (12 months), this research is expected to produce the following results: 1) Develop an optimum design (diameter and length) for the APS in PC truss that would help eliminate the cracking of concrete under realistic design loads as per AASHTO. 2) Propose an effective method for fabricating and installing the APS internally in PC truss members using conventional tools currently used at precast concrete producers. 3) Evaluate the ability to mitigate cracking of the newly designed system compared to conventional PC girders. The research team plans to partner with a PC producer to test the new end APS technology at a precast concrete facility.

**Outcomes/Impacts:**

This research will provide the transportation industry with the first experimental data on the feasibility of using the novel Adaptive Prestressing System to develop geometrically complex PC components (using 3D printed molds) for transportation systems. The results of the comparison between the proposed technology (APS reinforced truss) and the current practice (conventional PC girders) will directly translate to potential savings in the amount of concrete and steel used in building more sustainable bridges. It will also offer the option for future implementation of the proposed APS technology in similar applications in transportation infrastructure systems constructed with precast concrete. The involvement of PC producers in the project will ensure that the work is relatable to the current state of practice and will facilitate future implementation of the proposed technology to build a more sustainable and durable transportation infrastructure.

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