# Exhibit D

**Research Project Requirement Template**

**Research project name: Shape Memory Alloy Transverse Reinforcement for Precast Bridge Girders End Regions**

**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:** Illinois Department of Transportation

**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:**

Despite the success of using concrete prestressing technology in the longitudinal direction, it has not been implemented in the transverse direction due to many practical challenges. The reason is that no practical method exists for prestressing internal shear reinforcement such as hoops, stirrups, or spirals because these reinforcements are fully embedded in the concrete; hence, gripping the reinforcement ends for prestressing is not feasible. This research will investigate a new technology for applying prestressing in the transverse direction using a class of smart metallic materials known as shape memory alloys (SMAs). Excessively deformed bars and wires made of SMAs can remember their original shape when subjected to a temperature of approximately 200⁰C. This project will use this novel material to solve the longstanding problem of splitting and bursting cracking at the end regions of precast concrete (PC) bridge girders. Applying prestressing in the transverse direction (i.e., vertically) within that local region will help mitigate concrete cracking during prestressing and reduce steel congestion in this region. The research plan for this project includes two primary tasks:

*Task (1): Design of Specimens using Finite Element Method*: This task will focus on evaluating the behavior of the specimens through a detailed finite element (FE) analysis. A realistic longitudinal prestress force that satisfies all AASHTO limit states will be adopted. The specimen's behavior with conventional (non-prestressed) transverse reinforcement will also be investigated using the amount of transverse steel specified by AASHTO. The case that produces the highest bursting effect will be used for the experimental stage of the project. *Task (2): Fabrication, Instrumentation, and Testing of Specimens:*  Three specimens (one used as a control specimen with conventional steel and two specimens with SMA) will be fabricated and tested. Before casting, prestressing strands will be tensioned, and SMA transverse reinforcement will be placed at the specimen's ends. Next, the strands will be detensioned, and the progression of bursting stresses/cracks will be monitored.

**US DOT Priorities:**

This research supports the US DOT priority to improve the durability and extend the life of transportation infrastructure. It will address innovatively one of the longstanding types of bridge damage that leads to the rapid deterioration of PC bridges in the US, namely, end region damage in PC prestressed girders. The project supports the RD&T strategic goal of performing transformative research that will investigate an emerging type of metallic smart material with unique thermomechanical behavior to advance the durability, safety, and resilience of the transportation infrastructure in the US.

**Outputs:**

This project will introduce a new class of smart reinforcement with unique properties that have never been used in the US. During this project phase (12 months), this research is expected to produce the following results: 1) New guidelines for designing the new transverse reinforcement at the end regions of prestressed PC bridge girders. 2) Assessment of the ability of the new reinforcement to mitigate the damage and reduce steel congestion at end regions. 3) Develop an efficient and practical method for installing and activating (prestressing) SMA transverse reinforcement internally in PC girders without using mechanical tensioning. The research team plans to partner with a PC producer to test the new end region SMA reinforcement at a precast concrete facility.

**Outcomes/Impacts:**

The results of this project will provide the transportation infrastructure industry with the first experimental data on the feasibility of the novel concept of using internal prestressed transverse reinforcement at PC girders end regions that are typically heavily congested with transverse reinforcement. The new technique will eliminate cracks in these critical regions, improving infrastructure's durability, safety, and reliability. The results of the comparison between the proposed technology and the current practice will directly translate to potential savings in the amount of reinforcing steel, labor, time, and cost associated with the formwork and construction of PC bridge girders. The involvement of PC producers in the project will ensure that the work is relatable to the current state of practice. It will also help with the future implementation of the proposed technology for end regions of prestressed PC elements and other similar applications in transportation infrastructure systems constructed with precast concrete.

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