# Exhibit D

**Research project name: 3D Printed Advanced Materials to Mitigate Prestressed Concrete Girder End Cracks**

**Recipient/Grant (Contract) Number:** University of Illinois Urbana-Champaign / University at Buffalo / 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):** Ravi Ranade, Chi Zhou, and Pinar Okumus

**Project Partners:** N/A

**Research Project Funding:** Federal (UTC): $120,000 ($80,000 Federal and $40,000 Non-Federal)

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

**Project Description:**

Despite the recent popularity of 3D printing, its applications in transportation infrastructure are largely unexplored. This research aims to investigate a specific application of 3D printing for tackling the problem of end cracking in precast-prestressed concrete bridge girders caused by prestress release, which could be detrimental to bridge durability. 3D-printed shells, serving as permanent formworks and made of strain-hardening cementitious composites (SHCC), are proposed for providing a damage-tolerant protective layer around the girders at their ends. The project will involve the development of a new 3D-printable SHCC, design of an SHCC shell for lab-scale beams, testing of beam specimens, and numerical simulations for aiding an integrated material-printer-structure design approach. If this proof-of-concept project is successful, future research will seek to scale up the novel idea to large-scale girders, which could significantly enhance the durability and service life of the precast-prestressed concrete bridge girders.

**US DOT Priorities:**

Cracking in precast-prestressed concrete bridge girders is one of the most critical durability issues faced by various state DOTs. Cracks allow ingress of water, chlorides, and other deleterious agents inside structural elements causing premature deterioration and requiring frequent maintenance, which is economically and environmentally unsustainable. If left unrepaired, such cracking could lead to significant corrosion of rebars and prestressing strands endangering the safety of the bridge. This project addresses the fundamental problem of cracking in bridge girders through a transformative approach that links innovative materials and construction processes. Thus, this project directly addresses the US DOT’s research priority of improving durability and extending the life of transportation infrastructure and advanced asset management though advanced materials and structures. The project’s objectives are aligned with the strategic goals of economic strength and global competitiveness, climate and sustainability, and transformation.

**Outputs:**

The major outputs expected from this project are as follows:

* A new method for reducing cracking in precast-prestressed concrete bridge girders.
* A 3D-printable advanced concrete material (strain-hardening cementitious composite).
* Numerical model of a bridge girder for investigating the effect of the protective shell in reducing cracking.
* Experimental data on material and structural performance of specimens.

**Outcomes/Impacts:**

As mentioned above, successful completion of this project will demonstrate a new method to reduce cracking in bridge girders, which will lead to significant reduction in maintenance costs and improvements in durability and safety of concrete bridges. Although this research focuses on precast-prestressed concrete bridge girders, the innovative crack control method developed in this project could also be adopted for solving other durability problems in concrete bridges. Similarly, the 3D-printable advanced concrete material developed in this project could be employed in a variety of transportation infrastructure applications for improving the construction efficiency and quality, which reduces construction cost.

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