



Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

University Transportation Center (UTC)

Automated Construction of Concrete Bridge Components With Shape Memory Bars
Project No.: UI-25-RP-01

Quarterly Progress Report
For the performance period ending June 30th, 2026

Submitted by:

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Collaborators / Partners:

LX Construction

Submitted to:

TRANS-IPIC UTC
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Urbana, IL

TRANS-IPIC Quarterly Progress Report:

Project Description:

1. Research Plan - Statement of Problem

This project aims to address the challenge of incorporating prestressing in the automated construction of bridge components without using hydraulic jacking or concrete forms. The approach will utilize existing large 3D concrete printers currently employed in the construction of 3D-Printed Concrete (3DPC) buildings, ensuring that the transportation industry can easily adopt the methods demonstrated. As prestressed concrete elements are commonly used in bridges, this project will introduce an innovative technique for internally prestressing large 3DPC components with complex shapes using rebars made from a novel class of metallic material known as shape memory alloy (SMA). This new reinforcement can be activated (prestressed) through heating. The research will explore induction heating as a potential industrial method for prestressing the SMA bars without the need for direct contact. Overall, this research aims to provide the transportation industry with an efficient and practical method for prestressing structural 3DPC components used in transportation infrastructure.

2. Research Plan - Summary of Project Activities (Tasks)

Task 1. Design of Specimens Using Finite Element Method:

A finite element model (FEM) of bridge girders will be employed to design optimized geometries through an iterative process. The quantity and placement of the SMAs will be varied to determine the optimal use of the material.

Task 2. 3D Printing and Testing of Beam Specimens:

Beam specimens will be manufactured with LX Construction. During the printing process, the SMA and steel reinforcement will be integrated between the layers, eliminating the need for rebar ties or concrete rebar chairs.

Task 3. 3D Printing and Testing of Large-Scale Truss Beam:

This task will focus on 3D printing a relatively large concrete truss with embedded SMA bars. The design of the truss will build upon the results of the previous tasks.

Task 4. 3D Printing and Testing of Topology Optimized Beam:

The specimen for this task will feature a more complex geometry with curved contours compared to the truss beam printed in task 3. The design will be created using topology optimization techniques.

Task 5. Induction Heating for SMA Activation:

Induction heating will be employed to heat the 3DPC specimens in this project. This task will focus on optimizing the design of the coil and the power and frequency of the induction system required to activate SMA bars inside the concrete efficiently.

Project Progress:

3. Progress for each research task

Task 1. Design of Specimens Using Finite Element Method [100% completed]

This task was completed in the previous quarter.

Task 2. 3D Printing and Testing of Beam Specimens: [50% completed]

This quarter's progress focused on specimen fabrication. The reinforcement was prepared at the university laboratory before printing. The SMA bars were prestrained, and thermocouples were attached (**Figure 1**). The ends of the SMA bars were bent into hooks, which will be used in the printed concrete for anchorage. The steel bars were also cut and bent as required. These were transported by truck to the site of LX Construction's 3D concrete printer. The printing procedure of the beam specimens was straightforward, as they consisted of stacked straight lines. A computer-controlled nozzle extruded concrete into four 1" thick layers. The printer's nozzle and one of the finished beam specimens are shown in **Figure 2**.

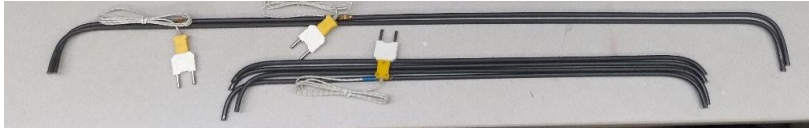


Figure 1. Prestrained SMA bars



Figure 2. Process of printing the fourth layer of the beams

Task 3. 3D Printing and Testing of Large-Scale Truss Beam: [40% completed]

The truss specimen had a more complex geometry and, therefore, a more complicated reinforcement layout relative to the beams. The ends required perpendicular sets of reinforcement to resist shear cracks. Adding the bars in that region one by one would have delayed the printing. Speed was critical because intentionally having the printer idle would lead to clogging in the machine. Thus, the steel bars were tied together into rebar cages prior to printing to expedite the rebar laying process. The remaining bars could be laid down without rebar ties or chairs, as seen in **Figure 3**. Another difference between the truss and the beam specimens is the need for infilling of concrete. The truss consisted of a complex printing path, where each turn produced gaps between the lines. These gaps were infilled with concrete once all the layers were printed, by using the printed portion as formwork.



Figure 3. Insertion of reinforcement

Task 4. 3D Printing and Testing of Topology Optimized Beam [40% completed]

The printing process of the topology-optimized beam was similar to that of the truss beam. There were no shear cages to tie beforehand, but other regions needed rebar ties. The #5 bars that serve as lift points were angled into a thin region in order to fit within the overall geometry. For additional strength, segments of #2 bars were tied to the lifting bars, which helped the lifting points engage a wider area of the top chord while also doubling as longitudinal reinforcement. These bars were then laid in between the printed layers, as was done with the remaining reinforcement (**Figure 4**). Another similarity shared with the truss is the need for infilling with concrete. The turns of the print path created irregularly shaped gaps. These areas were filled following the previously described method of using the printed portion as formwork.



Figure 4. Partial printing and reinforcing of the last layer

Task 5. Induction Heating for SMA Activation: [0% completed]

Nothing to report yet.

4. Percent of research project completed

Total project completed through the end of this quarter = [50% completed to date]

5. Expected progress for next quarter

The next quarter will focus on activating and testing the specimens. The specimens will be transported by truck to the Newmark Structural Engineering Laboratory after they have fully cured. Once there, they will be instrumented with strain gauges for use during both the prestressing and loading stages. The SMA bars within the specimens will be activated by heating them up to their transformation temperature and triggering the shape memory effect. This, in turn, will prestress the concrete at that location. The heating procedure will be conducted using an electromagnetic induction heater in the lab. After the bars are activated, the specimens will be tested in three-point bending.

6. Educational outreach and workforce development

Nothing to report yet.

7. Technology Transfer

Nothing to report yet.

Research Contribution:

8. Papers that include TRANS-IPIC UTC in the acknowledgments section:

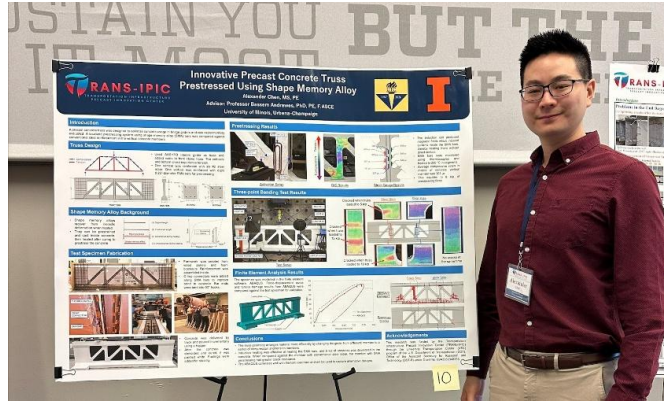
Chen, A.; Andrawes, B. Prestressing and Self-Healing of Fiber-Reinforced and Ultra-High-Performance Concrete Using Shape Memory Alloys. *Buildings* 2026, 16, 1289.

<https://doi.org/10.3390/buildings16071289>

9. Presentations and Posters of TRANS-IPIC funded research:

A presentation on "Innovative Precast Concrete Truss Using Shape Memory Prestressing System" was given as part of the TRANS-IPIC monthly research highlights webinar on June 22nd.

A poster on the experimental results of a precast concrete truss bridge girder prestressed with SMAs was presented at the 3rd annual TRANS-IPIC workshop held in Chicago, Illinois on April 14th.



10. Please list any other events or activities that highlights the work of TRANS-IPIC occurring at your university (please include any pictures or figures you may have). Similarly, please list any references to TRANS-IPIC in the news or interviews from your research.

TRANS-IPIC hosted members of PCI and County Prestress & Precast on May 15th. The visit consisted of a tour of the Newmark Structural Engineering Laboratory to see the completed and current research. The visit concluded with a discussion on potential collaborations between the industry and research to solve transportation infrastructure challenges.



Appendix 1: Research Activities, leadership, and awards (cumulative, since the start of the project)

- A. Number of presentations at academic and industry conferences and workshops of UTC findings
 - No. = 2
- B. Number of peer-reviewed publications submitted based on outcomes of UTC funded projects
 - No. = 0
- C. Number of peer-reviewed journal articles published by faculty.
 - No. = 1
- D. Number of peer-reviewed conference papers published by faculty.
 - No. = 1
- E. Number of TRANS-IPIC sponsored thesis or dissertations at the MS and PhD levels.
 - No. MS thesis =
 - No. PhD dissertations = 1
 - No. citations of each of the above =
- F. Number of research tools (lab equipment, models, software, test processes, etc.) developed as part of TRANS-IPIC sponsored research
 - Research Tool #1 (Name, description, and link to tool) = None
- G. Number of transportation-related professional and service organization committees that TRANS-IPIC faculty researchers participate in or lead.
 - Professional societies
 - No. participated in = 7
 - No. lead =
 - Advisory committees (No. participated in & No. led)
 - No. participated in =
 - No. lead =
 - Conference Organizing Committees (No. participated in & No. led)
 - No. participated in = 1
 - No. lead =
 - Editorial board of journals (No. participated in & No. led)
 - No. participated in = 1
 - No. lead =
 - TRB committees (No. participated in & No. led)
 - No. participated in = 1
 - No. lead =
- H. Number of relevant awards received during the grant year
 - No. awards received =
- I. Number of transportation related classes developed or modified as a result of TRANS-IPIC funding.
 - No. Undergraduate =
 - No. Graduate = 2
- J. Number of internships and full-time positions secured in the industry and government during the grant year.
 - No. of internships =
 - No. of full-time positions = 1

References:

Chen, A.; Andrawes, B. Prestressing and Self-Healing of Fiber-Reinforced and Ultra-High-Performance Concrete Using Shape Memory Alloys. Buildings 2026, 16, 1289.
<https://doi.org/10.3390/buildings16071289>