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Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

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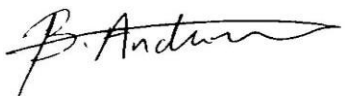
Signature of Submitting Official: 

Bassem Andrawes, TRANS-IPIC UTC Director

1. ACCOMPLISHMENTS

1.1. Major Goals

The Transportation Infrastructure Precast Innovation Center (TRANS-IPIC) is a Tier 1 University Transportation Center (UTC) that focuses on improving the durability and extending the life of transportation infrastructure by advancing the technologies used in precast concrete (PC) construction and maintenance. The consortium is composed of the following five universities:

- University of Illinois at Urbana-Champaign (UIUC) – Lead Institution
- Purdue University (PU)
- University at Buffalo (UB)
- Louisiana State University (LSU)
- University of Texas, San Antonio (UTSA)

TRANS-IPIC's mission is to leverage research innovation and strong industry support to guide and provide leadership in the transportation domain's highly overlooked area of precast concrete technology. TRANS-IPIC's innovative research on PC-related technologies aims to develop short-term solutions for current infrastructure problems and revolutionize the development and performance of future infrastructure of various transportation modes, providing gains in durability, safety, and economy. The primary goals of TRANS-IPIC are:

1) Develop durable, cost-effective advanced materials (concrete and reinforcement) for precast components.
2) Develop a new design framework for infrastructure PC elements based on innovative computational mechanics, topology optimization, efficient manufacturing, and accelerated construction processes.
3) Advance the field of building information modeling (BIM), automated manufacturing, repair, and inspection of precast infrastructure using new technologies like drones, satellite imaging, and 3D printing of forms and concrete.
4) Incorporate novel "built-in" quality control, self-assessment, and repair mechanisms in PC components.
5) Establish comprehensive economic plans for operating, managing, and processing off-site PC manufacturing, shipping, and installation.

1.2. Activities During This Period

During this period, the following activities have been completed:

1. **Hosted the First Annual TRANS-IPIC Transportation Infrastructure Precast Day (TIP Day):** Among the important activities that took place during this period was TRANS-IPIC hosting the first annual Transportation Infrastructure Precast Day (TIP Day) for the TRANS-IPIC UTC. This event occurred on 11/01/2024. Six industry experts were invited to attend on site at the UIUC campus and presented on the latest technologies and real-world projects for PC in transportation to Civil and Environmental Engineering (CEE) students. Students were encouraged to attend and learn about the innovations in transportation infrastructure, and to meet/network with industry professionals. In addition to the presentation from industry experts and discussion about precast concrete in transportation infrastructure, time was included for students to interface directly with industry professionals. Each of the six industry presentations had between 45 and 57 students in attendance (in each session). The industry experts attending and presenting at TIP Day were from Utility Concrete Products (Increasing Efficiency & Sustainability Through Precast Segmental Bridge Construction), Illinois Department of Transportation (Research to Reality), HNTB (Franklin Ave Bridge: Use of Precast Element and UHPC), PCI of Illinois & Wisconsin (How Precast Builds – Transportation Engineering), AtkinsRéalis (Design, Construction and Validation of a Rehabilitation Technique for PC Slab Bridges), and The Sherwin Williams Company (Today's

coating technologies – impacting the future of concrete structures).

Fig 1. Image of students and speaker at the First Annual TRANS-IPIC Transportation Infrastructure Precast Day (TIP Day).

2. **Hosted TRANS-IPIC Workshop at TRB 2025:** TRANS-IPIC hosted a Workshop at the Transportation Research Board (TRB) annual meeting, on Sunday, January 5, 2025, from 1:30 PM-4:30 PM. The TRANS-IPIC Workshop, event (#1045), is titled 'The Role of Precast Concrete in the Sustainability of Transportation Infrastructure: Approaches and Challenges', was sponsored by the Standing Committee on Concrete Bridge, Standing Committee on Advanced Concrete Materials and Characterization, and the International Coordinating Council. TRANS-IPIC Director, Bassem Andrawes (University of Illinois Urbana-Champaign), Tommy Nantung (Indiana Department of Transportation), Tyson Rupnow (Louisiana Transportation Research Center), Larry Sutter (Sutter Engineering), Mirian Velay-Lizancos (Purdue University) presented and lead session discussions.

Fig 2. Image of TRANS-IPIC Director, Bassem Andrawes, presenting at the TRANS-IPIC hosted Workshop at TRB 2025.

3. **Planning the 2nd Annual 2025 TRANS-IPIC UTC Workshop:** TRANS-IPIC has partnered with the Precast/Prestressed Concrete Institute of Illinois & Wisconsin (PCI-IW) to organize the 2025 in-person UTC Workshop. During the period of this report, there was extensive planning of this event. This two-day Workshop will be held on Tuesday, 04/22/2025, and Wednesday, 04/23/2025 at the Big Ten Office and Conference Center (Rosemont, IL). Over the two days of this event, in addition to research teams from the (5x) Universities in our consortium (University of Illinois Urbana-Champaign), Purdue University, Louisiana State University, University at Buffalo, and University of Texas at San Antonio), TRANS-IPIC worked with seven external companies from which representatives will attend and present on the latest projects relating to precast concrete in transportation infrastructure (HDR, AP Formliners, Sumiden Wire, Walsh Group, Holcim, Chryso –

Saint Gobain, and NawKaw), as well as representatives from the Illinois Tollway accompanied by WSP), and the Indiana Department of Transportation. Representatives from the Illinois Department of Transportation will also be in attendance. There will be (18x) presentations, nine providing the latest updates on ongoing TRANS-IPIC-funded research projects and an additional nine presentations from external companies and Indiana DOT. Across all (18x) presentations, we are expecting a combined total of twenty-five presenters. There will be time allotted for (14x) posters, presented by research teams from other currently funded research projects that will not be presenting. Lastly, we are proud to be able to offer our Workshop attendees the ability to participate in an educational precast plant tour at Dukane Precast, for which transportation is provided free to all attendees. To aid the ability of University of Illinois students to attend the Workshop, a shuttle will be provided from the University of Illinois Urbana-Champaign campus to the Workshop and back. Based on attendance records we expect (approx.) 80 attendees on Day 1, and 65 attendees on Day 2.

4. **Highschool Outreach at University at Buffalo:** As part of Science Exploration Day, the University at Buffalo's researchers from the project "Evaluating Prestressed Concrete Beams with Cracks using Machine Learning", led by Pinar Okumus, presented their work to 33 local high school students. The presentation included a demonstration of the web-based machine learning tool developed as part of this project, as well as a demonstration of equipment used to test bridges.

Fig 3. High school students attending Science Exploration Day at the University at Buffalo and learning about projects and tools developed as part of TRANS-IPIC projects.

5. **Planning future collaboration with Capital Precast:** Researchers from the University of Texas at San Antonio have ongoing meetings with and tours of Capital Precast, one of the leading precast concrete manufacturers in Texas. These activities are part of ongoing research activities in TRANS-IPIC collaborations that provide valuable insights into the manufacturing processes, plant operations, and innovations in precast utility products. The research team working with Capital Precast is engaged together on potential future collaborations.

Fig 4. Researchers at the University of Texas at San Antonio meeting industry collaborator Capital Precast.

6. **Hosting Research Highlights Webinars:** After receiving Final Reports for Year 1 Projects and

selecting Year 2 projects for funding. Research Highlights Webinars restarted in 2025, on February 19th, 2025, and March 28th, 2025.These Research Highlights Webinars are presented by faculty (accompanied by their students) to present their research findings and discuss how to achieve the goals of the center. Each webinar includes two to three presentations related to the UTC projects. Each webinar offers 1.0 Professional Development Hour (PDH) to attendees.

7. **Quarterly Progress Reports:** Utilizing an online system developed for the TRANS-IPIC researchers to share their projects' quarterly progress reports (QPRs), TRANS-IPIC has collected Quarterly Progress Reports. These reports are reviewed by the center's leadership team to ensure that the funded projects are on the right track. After reviewing the reports, the TRANS-IPIC management team provides the project Principal Investigators (PIs) with feedback about their progress. A copy of the QPRs is posted on the TRANS-IPIC's website (https://trans-ipic.illinois.edu/research).

8. **Proposals Selected for Year 2 Funding**: In the Fall of 2024, TRANS-IPIC conducted the second Call for Proposals to select Year 2 projects for funding. From the five universities in the TRANS-IPIC consortium, (27x) proposals were submitted to the open call. TRANS-IPIC utilized a total of 13x external reviewers, selected from members of the TRANS-IPIC External Advisory Board and Industry Partnership Committee. These external reviewers, from both DOTs and various industry partners, assessed and rated proposals. Proposal Reviewers were from the following organizations: American Concrete Institute - ACI, American Segmental Bridge Institute – ASBI, Illinois Department of Transportation, Indiana Department of Transportation, Texas Department of Transportation, Illinois State Toll Highway Authority, Louisiana Transportation Research Center – LTRC, Wiss/Janney/Elstner Associates – WJE, Parsons Corporations, and EXP.

   As this Call for Proposal process included both Research Projects previously funded by TRANS-IPIC in Year 1, seeking additional funding to continue their research in Year 2, proposals were separated into those seeking extensions and new research ideas seeking funding. This allowed the review process to be tailored to assess whether 'new' research ideas were rated based on innovation, durability, potential for implementation, research quality, and workforce development. Additionally, projects seeking additional funding to continue research were assessed based on the findings and results accomplished during Year 1, the research plan and quality for Year 2, and future plans for workforce development. (19x) total proposals were selected for funding. (14x) proposal Research Projects, 1 year in length, were selected for funding. Of these Research Projects, (10x) Research Projects are a continuation of previously funded Year 1 projects. Additionally, (5x) Exploratory Projects were selected for funding, which are intended to be shorter in length than Research Projects. Finally, (1x) Industry Partnership project was selected for funding, which focuses on the Practical Implementation of Thermal Prestressing using Smart Materials.

9. **Final Project Reports and Year 1 Reports:** TRANS-IPIC collected from all Year 1 funded research teams either a Final Report (for projects not receiving additional funding to continue research this same research in Year 2), or a Year 1 Report (for projects that have been selected to receiving additional funding on the same research topic). All Final Reports and Year 1 Reports were received by Nov. 30th, 2024. Each report was then reviewed by the center's leadership team to ensure all projects met their research goals and could be closed out. Additionally, Year 1 Reports were reviewed to confirm all continuation projects were at an acceptable point to continue funding. A copy of all Final Reports is posted on the TRANS-IPIC's website (https://trans-ipic.illinois.edu/research).

   Table 1 Lists Year 2 projects funded by the TRANS-IPIC UTC. These are posted on TRANS-IPIC's website (https://trans-ipic.illinois.edu) and the Transportation Research Board's (TRB) Research

in Progress (RIP) database, and reported to UTC Grant Manager.

Table 1. List of Projects Year 2 TRANS-IPIC funded projects

Project Title	Institution & PI Name	Federal ($)	Match ($)
Developing a cost-effective, reliable and sustainable PC supply system under price volatility and uncertain materials supply - Phase II (LS-23-RP-04)	Louisiana State University Bhaba Sarker	$65,000.00	$32,502.00
3D Printed Smart Permanent Concrete Formwork for Precast Structural Component	Louisiana State University Yen-Fang Su	$65,000.00	$32,513.00
Data-driven smart composite reinforcement for precast concrete - Phase II (PU-23-RP-05)	Purdue University Chengcheng Tao	$65,000.00	$32,510.00
IFC-based BIM for Robotic Installation of Precast Bridge Components	Purdue University Jiansong Zhang	$30,000.00	$15,000.00
Unveiling synergistic effects of Nano-modification and CO2 curing on the durability and carbon footprint of precast elements - Phase II (PU-23-RP-02)	Purdue University Mirian Velay-Lizancos	$64,091.00	$35,267.00
Bio-Inspired Solutions for Jersey and Road Noise Barriers: Exploring 3D Printing as Alternative Precast Technology - Phase II (PU-23-RP-03)	University at Buffalo Chaozhe He	$75,546.00	$37,851.00
Precast concrete with self-powering defrosting capability	University at Buffalo Deborah Chung	$30,000.00	$15,000.00
Continuous & Low-cost Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs)	University at Buffalo Chaozhe He	$65,000.00	$32,500.00
Evaluating Prestressed Concrete Beams with Cracks using Machine Learning - Phase II (UB-23-RP-01)	University at Buffalo Pinar Okumus	$100,000.00	$50,000.00
3D Printed Advanced Materials to Mitigate Prestressed Concrete Girder End Cracks - Phase II (UB-23-RP-02)	University at Buffalo Ravi Ranade	$100,000.00	$50,000.00

Combining Specific Heat of Concrete and Actuator Placement Optimization for Self-Powered Ice-Melting Precast Concrete Bridge Panels	University of Illinois Urbana-Champaign Ann Sychterz	$30,659.46	$21,444.00
Shape Memory Alloy Transverse Reinforcement for Solving End Region Problems in Precast Bridge Girders - Phase II (UI-23-RP-01)	University of Illinois Urbana-Champaign Bassem Andrawes	$100,000.00	$50,000.00
Innovative Precast Concrete Truss Using Adaptive Shape Memory Prestressing System - Phase II (UI-23-RP-02)	University of Illinois Urbana-Champaign Bassem Andrawes	$100,000.00	$50,000.00
Advancing Durability in Transportation Infrastructure through Practical Implementation of Thermal Prestressing	University of Illinois Urbana-Champaign Bassem Andrawes	$60,000.00	$30,888.00
Environmentally-Informed, Data-Driven Precast Concrete Bridge Condition Modeling for Future-Proof Transportation Infrastructure	University of Illinois Urbana-Champaign Eun Jeong Cha	$64,991.00	$38,860.00
Optimizing the Planning of Precast Concrete Bridge Construction Methods to Maximize Durability, Safety, and Sustainability - Phase II (UI-23-RP-05)	University of Illinois Urbana-Champaign Khaled El-Rayes	$65,000.00	$50,246.00
Physics-Informed Viscoelastic/Viscoplastic Model of Prestressed Concrete Creep	University of Illinois Urbana-Champaign Ramez Hajj	$65,000.00	$42,776.00
IoT-Driven Digital Twin Framework for the Design and Fabrication of Precast Elements	University of Texas at San Antonio Ibukun Awolusi	$30,000.00	$15,000.00
AI-based Lift Path Planning for Robotic Installation of Precast Bridge Components	University of Texas at San Antonio Jiannan Cai	$30,000.00	$15,000.00
Thermally Conductive Pre-cast Concrete Pavement for Urban Heat Island Mitigation - Phase II (UT-23-RP-01)	University of Texas at San Antonio Samer Dessouky	$86,641.00	$43,322.00

Table 2. TRANS-IPIC Project granted an extension to continue spending Year 1 funding in Year 2

Exploring Fungal-Mediated Carbonate Precipitation for Healing Concrete Cracks	Louisiana State University Hai Lin	$64,999.00	$32,503.00

10. TRANS-IPIC would like to highlight a few of the Year 2 projects that illustrate the groundbreaking research into precast concrete in transportation infrastructure:

Project Highlight 1: 3D Printed Smart Permanent Concrete Formwork for Precast Structural Component led by Dr. Yen-Fang Su at LSU, addresses critical challenges in aging transportation infrastructure by integrating self-sensing cementitious composites (SSCCs) into 3D-printed precast concrete elements. The innovative approach combines robotic-based additive manufacturing with embedded sensing capabilities to enable real-time structural health monitoring without relying on external sensors. This not only improves durability and reduces lifecycle maintenance costs but also facilitates the creation of geometrically optimized components. The work presents a transformative pathway toward more resilient, long-lasting, and intelligent transportation infrastructure. It can potentially enable future automated construction of precast elements with built-in monitoring functionality.

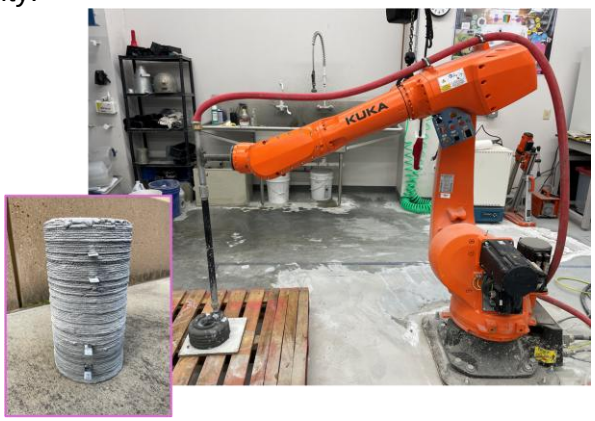


Fig 5. Image of robotic-based additive manufacturing.

Project Highlight 2: Research into Innovative External Prestressing Techniques using Shape Memory Alloy-Coupled Prestressing Plates (SMA-CPP) has conducted the first full-scale test in the U.S. on a new class of smart material known as shape memory alloy (SMA) to repair damaged prestressed bridge girders. SMAs can apply prestressing through heating, eliminating the need for mechanical tensioning. The groundbreaking technique offers transportation agencies a powerful, yet simple method to extend the service life of bridges. This research is being conducted by the TRANS-IPIC center director, Bassem Andrawes.

Fig 6. Image of ongoing Shape Memory Alloy-Coupled Prestressing Plates (SMA-CPP) large-scale test at UIUC.

Project Highlight 3: Continuous & Low-cost Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs) aims to transform transportation infrastructure, such as bridges and highway sections, into proactive monitors of their own health. By leveraging the penetration of connectivity and the advances in vehicle autonomy, infrastructure can request passing vehicles to continuously and instantaneously collect critical information that exposes signs of structural issues. Ultimately, this capability extends the lifespan of infrastructure, ensuring safer and more efficient transportation infrastructure. As a foundational step, this project is developing an implementable framework that enables precast concrete bridges to proactively request connected automated vehicles to inspect for early signs of deterioration in vulnerable areas, such as joint cracking, grout spalling, and reflective cracking. By acquiring these targeted inspection results, the bridges can assess the severity and progression of these signs and continuously monitor their health status. By the end of the project, we aim to demonstrate this innovative framework at a pilot bridge in New York State, showcasing the potential for smarter, more resilient infrastructure.

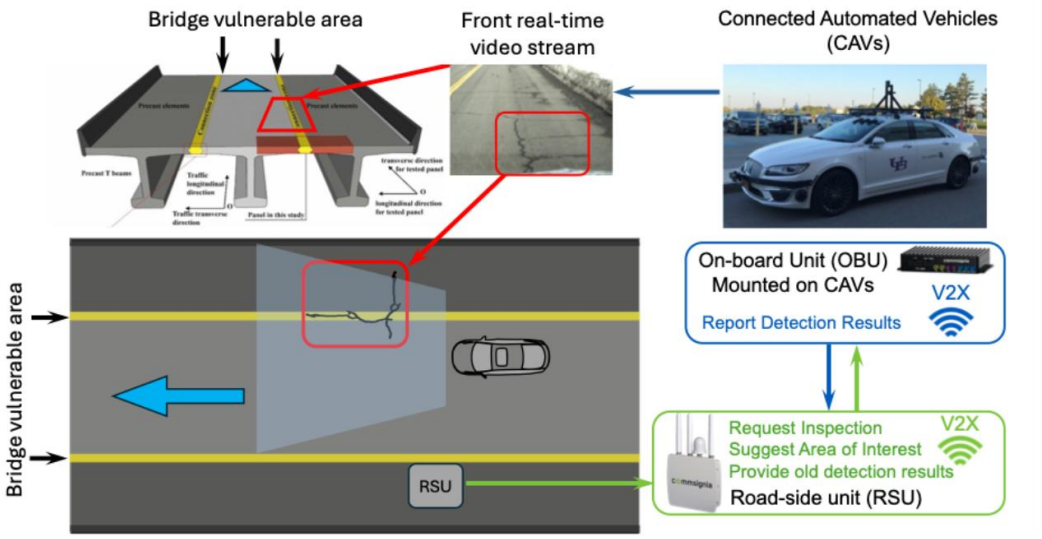


Fig 7. Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs).

Project Highlight 4: The research project, Innovative Precast Concrete Truss Using Adaptive Shape Memory Prestressing System, is investigating optimizing the material used in transportation infrastructure by studying the application of an innovative Adaptive Prestressing System (APS) in a geometrically optimized (truss) Precast Concrete (PC) system. The new APS includes a shape memory alloy fuse that applies localized prestressing in any direction without mechanical tensioning or special hardware, ideal for prestressing short diagonal or vertical members of a PC truss. The research includes experimental testing and numerical simulation of geometrically complex PC truss structures with APS placed in tension members that are difficult to prestress using conventional methods. Furthermore, to enhance the durability, the concrete “self-healing” capability of the innovative APS is performed where an activated SMA fuse can close cracks formed under service conditions. The performance of the new APS-reinforced PC truss is compared with traditional PC bridge girders to prove the feasibility of the new concept.

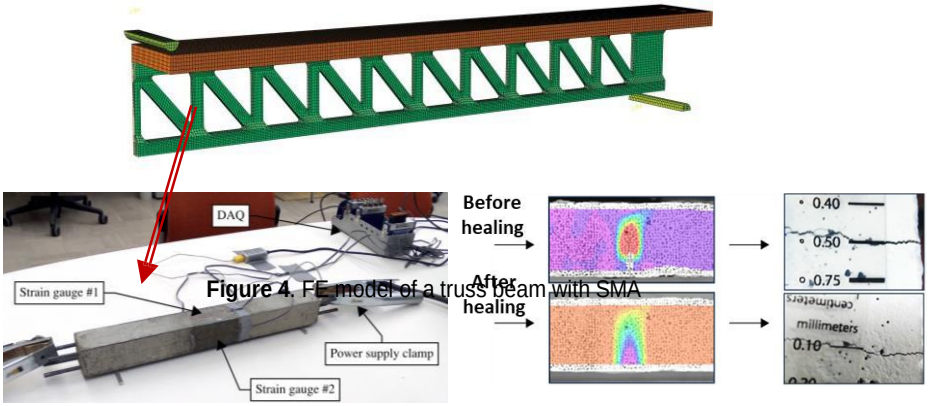


Figure 4. FE model of a truss beam with SMA

Figure 8. Tensile member reinforced with SMA, and Effect of SMA in healing tensile cracks in truss members

Project Highlight 5: Data-driven smart composite reinforcement for precast concrete - Phase II aims to develop an innovative framework to characterize and optimize the mechanical, environmental, and economic performance of precast concrete (PC). This research is needed because PC is made of different constituent materials with very different properties that complement each other. It is critical to design high-performance, sustainable, and cost-effective reinforced precast concrete to extend the life of PC transportation infrastructure. Physical testing with trial-and-error approaches on reinforced PC components requires substantial time, labor, and material resources to achieve the optimal design for superior material properties, and ecological and economic sustainability. The research's framework can provide performance-based optimal solutions based on user requirements by exploring massive design spaces. A physics-informed database of reinforced PC will be established from physical testing and multivariant numerical modeling. Multi-objective metaheuristic optimization algorithms will be implemented to achieve optimal trade-off solutions based on the user's requirements such as strength, environmental impact, and cost of the materials.

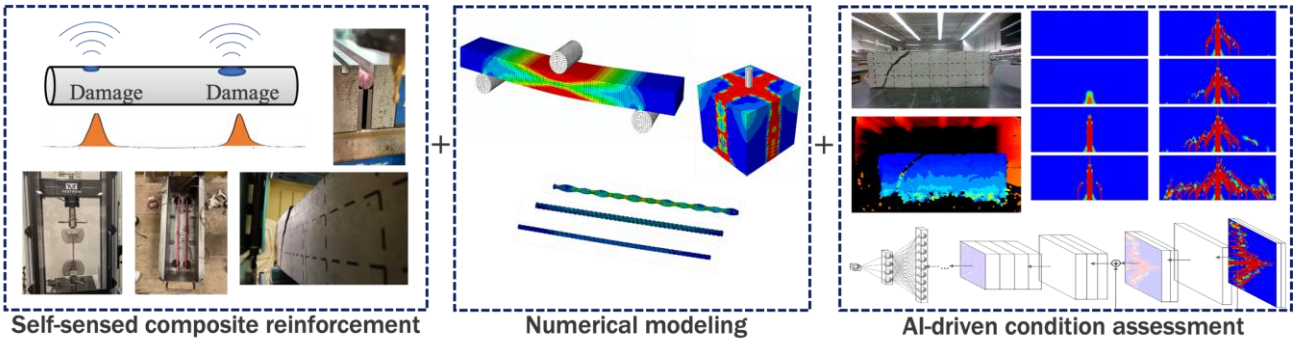


Fig 9. Progression of physical testing, numerical modeling, and AI-driven assessments.

1.3 Dissemination

1) **Conferences and Meetings:** The outcomes from the TRANS-IPIC UTC projects were highlighted at multiple events that are heavily attended by transportation professionals including TRANS-IPIC's first annual Transportation Infrastructure Precast Day (TIP Day), the TRANS-IPIC hosted Workshop and Faculty meeting at TRB in January 2025, TRANS-IPIC researchers also presented on their ongoing research at TRB in January, Science Exploration Day in Buffalo for High School students that included demonstrations of (1) a web-based tool developed as part of TRANS-IPIC (2) a laboratory tool that showcased the equipment used to test bridges and (3) demonstrating 3D-printing of SHCC, 2025 Graduate Student Appreciation Week (GSAW) Symposium and Award Ceremony held at UTSA, presentations to precast companies (Precast Concrete Products, Waskey, Gainey's and Rinker) through the Louisiana Transportation Research Center (LTRC), and BEFIB 2024 XI International symposium on fiber reinforced concrete.

Figure 10. TRANS-IPIC UTC members presenting their work at various transportation-related conferences and meetings.

2) **Research Highlights Webinars:** In order to disseminate knowledge acquired on each TRANS-IPIC funded research project, TRANS-IPIC hosts Research Highlights Webinars, where all funded projects present, Additionally, to allow all Year 1 funded projects the opportunity to present to the broad research team and consortium members, External Advisory Board, and Industry Partnership Committee, TRANS-IPIC previously accelerated the webinar schedule so that every team presented prior to the external review portion of the Call for Proposal process which occurred in the Fall of 2024. Projects selected to receive additional funding to continue ongoing research began presenting in February and March of 2025, and following the TRANS-IPIC in-person Workshop in April 2025, extension projects will resume in May 2025. New projects selected to receive funding in Year 2 will begin presenting in future Research Highlights Webinars when these projects have received sufficient time to develop results and disseminate them with the consortium. All recordings of our Research Highlights Webinars are shared with the community through the center's website and YouTube (see **Fig. 11**). These Research Highlights Webinar recordings help connect the center with the community and keep the community aware of the ongoing work by the center. Lastly, TRANS-IPIC is currently in discussions with external industry experts to be included in our monthly webinars, in addition to research highlights.

Figure 11. Snapshots from the recorded TRANS-IPIC UTC February and March webinars. Recordings are available on the center's website

a. Plans for the Next Reporting Period

The next reporting period will focus on:

1) TRANS-IPIC previously conducted the Yearly Call for Proposal process in the Fall of each year. In 2025, TRANS-IPIC is looking to transition the next (Year 3) Call of Proposals process to begin

in the Summer to improve the timing for external universities (based on feedback from our consortium members).

2) We will plan and host the 2nd annual Transportation Infrastructure Precast Day (TIP Day) in October/November 2025, again hosting external industry experts on the UIUC campus to educate students on the latest technologies in PC application in transportation infrastructure. This event will also offer an opportunity for students to interface directly with industry professionals.

3) In the Summer and Fall of 2025, TRANS-IPIC will begin the initial planning and coordinating efforts, in order to host the third Annual TRANS-IPIC workshop. This event is currently planned to be held in April 2026. As with previous events, we will invite researchers and transportation professionals from all over the U.S. to attend the workshop.

4) TRANS-IPIC Director, Bassem Andrawes to attend the 2025 CUTC Summer Meeting from June 24-26, Rogers, Arkansas.

5) TRANS-IPIC will host high school students at the University of Illinois Urbana-Champaign campus in July of 2025, as part of the City Designers and Builders Camp, for the Civil and Environmental Engineering Department. TRANS-IPIC's session is titled "*Building with Memory*".

6) Continue disseminating the knowledge created by TRANS-IPIC research projects through conference proceedings and journal papers.

7) Leverage strong ties with the industry and partnership committees to promote collaborative projects between TRANS-IPIC and the transportation industry.

2. PARTICIPANTS AND COLLABORATING ORGANIZATIONS

a. Partners

A list of the partners who indicated strong interest in contributing to TRANS-IPIC's activities can be found at (https://trans-ipic.illinois.edu/team/industry-partners). The organizations that are involved in the currently funded projects:

(1) Rinker, Gainey's, Premier Concrete Products, & WASKEY for collaboration and validation
(2) Louisiana Transportation Research Center (LTRC)
(3) Terran Robotics
(4) Sperra (former RCAM Technology)
(5) Circle Up Indy,Ltd
(6) AccelNet (Arizona State University, West Pomeranian University of Technology, Poland) MS&T, UT Arlington, University of Puerto Rico)
(7) Heidelberg Materials
(8) North Dakota State University
(9) Atlas Excavating
(10) Milestone Contractors
(11) Force Construction
(12) Kelley Construction
(13) Walsh Group
(14) Aldridge Electric
(15) Superior Construction
(16) FH Paschen

(17) Microtek laboratories Company
(18) City of San Antonio
(19) Tindall Corporation

b. Other Collaborators

Several individuals from organizations and universities expressed strong interest in the mission of the UTC. They offered to collaborate with TRANS-IPIC in various forms, including reviewing research proposals and delivering training sessions and on-campus seminars to the UTC students. Many of these individuals participated in both Year 1 and Year 2 proposal review process which resulted in funding 19 projects in year 1, and 20 projects in year 2.

3. OUTPUTS

a. Publications and Conference papers:

- Sung M. and Andrawes B. "Innovative Precast Concrete Truss System Using Shape Memory Alloys for Infrastructure Applications" Intelligent Material Systems and Structures. (https://doi.org/10.1177/1045389X241239701) (Federal Funds Acknowledgment: Yes)

- Lin, H. (2025). "Harnessing Fungal Mycelia for Sustainable Soil Improvement: Opportunities and Challenges." Biogeotechnics, Under preparation.

- Park, J.S., and Lin, H. (2025). "Role of Trichoderma Virens Mycelium in Enhancing Erosion Resistance of Low Plasticity Silt." Biogeotechnics, In Press.

- Mazumder, A. and Sarker, B.R., "Determining optimal variable order quantities of raw materials for precast concrete production considering demand variability and uncertain material prices," Paper-1 (LS-23-RP-04), Submitted to European Journal of Operational Research. 1st submission: March 27, 2025 (EJOR-S-25-01345), BS@lsu/3209T@PFTH, Corr: BRS

- Mazumder, A. and Sarker, B. R. (2025b), "An Optimal Delivery System of Multiple Precast Components for Multiple Construction Sites of Transportation Infrastructure," Working Paper 2 (LS-24-RP-01), QPR Y2-1 (January 1 - March 31, 2025). Intended for ASCE: Journal of Transportation Engineering

- Y. Wang, A.E. Douba, J. Olek, P. D. Zavattieri,J.P. Youngblood, Better, Cheaper, Greener: A highperformance Cementitious Composite for Sustainable Concrete 3D Printing, to be submitted to Nature Communications.

- Y. Wang, L. Shyamsunder J. Olek, P. D. Zavattieri, J.P. Youngblood, Impact resistant sinusoidallyarchitected Bouligand 3DPC materials inspired by the mantis shrimp, to be submitted to Advanced Materials.

- Duan, J., Yan, H., Tao, C.*, Wang, X., Guan, S., & Zhang, Y. (2025), Integration of Finite Element Analysis and Machine Learning for Assessing Spatial-Temporal Conditions of Reinforced Concrete. Buildings, 15(3), 435.

- Peer-reviewed conference paper: Singh, P., Gadde, V.S., Zhou, C., Okumus, P., and Ranade, R. (2024) "Development of 3D printable strain hardening cementitious composites for bridge-related applications." Editors: Viktor Mechtcherine, Cesare Signorini, and Dominik Junger. In proceedings of 11th International Symposium on Fiber Reinforced Concrete (BEFIB-2024), 15-18 September 2024, Dresden, Germany, pp. 451-458. DOI: 10.1007/978-3-031-70145-0_55

- Helaly, H., K. El-Rayes, E.J. Ignacio, and H. J. Joan. (January 2025). "Comparison of Machine Learning Algorithms for Estimating Cost of Conventional and Accelerated Bridge Construction Methods During Early Design Phase." Journal of Construction Engineering and Management, ASCE. https://doi.org/https://ascelibrary.org/doi/10.1061/JCEMD4.COENG-15934.

- Helaly, H., K. El-Rayes, and E.J. Ignacio. (February 2025). "Predictive Models to Estimate Construction and Life Cycle Cost of Conventional and Prefabricated Bridges During Early Design Phases." Canadian Journal of Civil Engineering. https://doi.org/10.1139/cjce-2023-0493.

- Helaly, H., K. El-Rayes, and E.J. Ignacio. (July 2025). "Machine Learning Models for Estimating Construction Costs of Conventional and Accelerated Bridge Construction Methods." ASCE Construction Research Congress (CRC) 2025, Modular and Office Construction Summit (MOC).

- Radwan, I., Dessouky, S., Sharif, H., Accepted manuscript for presentation at the TRB Annual Meeting, Jan 2025.

- Radwan, I., Dessouky, S., Sharif, H. Submitted manuscript to Int. J. of Pavement Engineering, Dec 2024 (under review).

b. Technologies and Techniques:

With SMA technology, TRANS-IPIC is working closely with the industry (Rocla Concrete Ties, Inc.) to develop “smart ties” that can be prestressed at critical regions, which will help solve the problem of center binding cracks that are still haunting PC ties on tracks cutting down their service life span. If cracked under service conditions, the smart tie “heals” itself through the re-activation of the embedded SMA reinforcement using electromagnetic induction. The link provided below showcases a brief video overview of this innovative technology.

https://uofi.box.com/s/ynpgxwugd04b34mefveeg7we6fzjn9fr

4. OUTCOMES

Several of the ongoing and completed TRANS-IPIC projects have resulted in technologies that are ready for implementation. Below are a few examples of these technologies.

- SMA-CPP Strengthening Technique: A novel technique for applying external prestressing without mechanical jacking or stressing (see **Fig. 12**) (paper under review in Engineering Structures journal).

Figure 12. Innovative technique for externally prestressing bridge girders proposed by TRANS-IPIC researchers using smart materials.

5. IMPACTS

a. Effectiveness of the Transportation System and Scientific Knowledge

The Twenty (20) funded TRANS-IPIC projects in Year 2, and previously funded Year 1 projects, are aiming to address critical problems our transportation infrastructure faces. As the center progresses through Year 2, these projects (as well as the projects expected to be funded this fall from the third RFP cycle) will research innovative ideas and technologies that will help the transportation community improve the durability and sustainability of transportation systems. For example, to expedite the repair process and improve the durability of deteriorating/damaged bridges, TRANS-IPIC researchers conducted the first full-scale test in the U.S. on bridge girder repairs using shape memory alloys (SMAs), an emerging class of smart materials that can remember their shape by heating. The test was completed successfully and the results are very promising. This technology is now ready for implementation. TRANS-IPIC researchers are also investigating integrating self-sensing cementitious composites (SSCCs) into 3D-printed precast concrete elements, which combines robotic-based additive manufacturing with embedded sensing capabilities to enable real-time structural health monitoring without relying on external sensors, to improve durability and reduce lifecycle maintenance costs. Another project aims to transform transportation infrastructure, such as bridges and highway sections, into proactive monitors of their health by leveraging the penetration of connectivity and the advances in vehicle autonomy so the infrastructure can request passing vehicles to continuously and instantaneously collect critical information that exposes signs of structural issues. One of the funded projects focuses on introducing self-healing smart reinforcement in bridge girders and decks to improve their durability and extend their service life. The new reinforcement can be activated during the service life of a bridge to close concrete cracks, protecting steel reinforcement from corrosion. Another project investigates revolutionizing the geometrical configuration of bridge girders to optimize performance and durability while reducing material consumption. Another project will develop an innovative framework to characterize and optimize the mechanical, environmental, and economic performance of reinforced precast concrete that will aid in the design of high-performance, sustainable, and cost-effective reinforced precast concrete in order to extend the life of PC transportation infrastructure by providing performance-based optimal solutions based on user's requirements by exploring massive design spaces. A team of researchers is funded through TRANS-IPIC to develop test and implement UAV-UGV coordinated inspection system (developed in the TRAN-IPIC Year 1 project) in a pilot precast bridge construction site, identify the practical needs and constraints, and then refine the technology to meet industry expectations for future implementation.

b. Transportation Workforce Development

The 20 currently funded and active TRANS-IPIC projects provide significant opportunities for

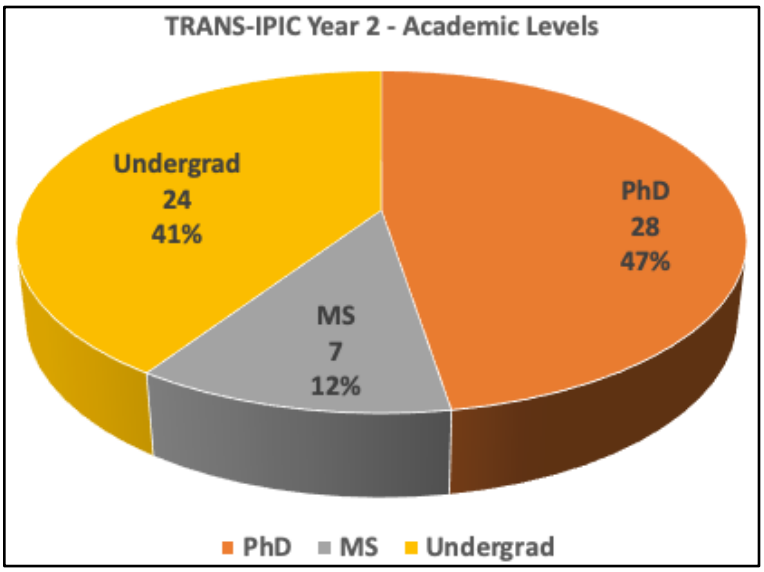
students and young people in the transportation and related fields. Across all currently funded TRANS-IPIC projects a total of 59 students are supported by TRANS-IPIC-funded projects (28, 7, and 24 undergraduate, MS, and Ph.D. students, respectively) (see **Fig. 13**). Among these students, 44% are from under-represented groups.

6. CHANGES/PROBLEMS

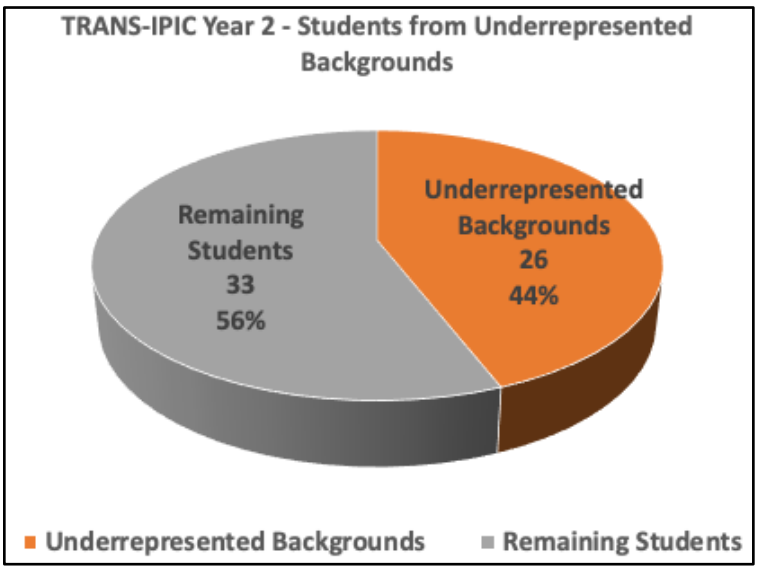
Nothing to Report.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to Report.



(a) Academic level



(b) Students from Underrepresented Backgrounds

Figure 13. Breakdown of TRANS-IPIC current students based on (a) academic level and (b) underrepresented and minority groups