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Office of the Assistant Secretary for Research and
Technology (OST-R)**

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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, and 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. **Planning for the Transportation Infrastructure Precast Workshop:** Following the conclusion of the 2025 TRANS-IPIC UTC Workshop, the TRANS-IPIC Management Team began planning the 3rd Annual TRANS-IPIC UTC Workshop. The Transportation Infrastructure Precast Workshop, TIP2026 for short, is the annual UTC Workshop hosted by the TRANS-IPIC center. In and around Chicago, event space books quickly, and as such, planning for each year's event takes place over the entire year leading up to the event. TIP2026 will be held on Tuesday, 04/14/2026, at the Big Ten Office and Conference Center (Rosemont, IL). This event space offers great proximity to the O'Hare Airport, which aids the ability for out-of-state consortium members, industry members, and DOT participants to attend. For TIP2026, we are proud to announce that ACI and PCI are co-sponsoring this event with TRANS-IPIC. We have secured great speakers from both State DOTs and industry partners.

- Tennessee Department of Transportation will present on 'TDOT's Use of Precast Bridge Elements & Systems in ABC Projects'
- Texas Department of Transportation will present on 'Precast Concrete in Texas Bridges: Design Innovations and Durability Strategies'
- WJE will present on 'Hollow Precast Inverted Tees in Bridge Substructures'
- HNTB will present on 'Practical Lessons learned from application of precast elements over the years'
- Systra will present on 'Precast Segmental in Urban Transit – CTA Red-Purple Modernization Case Study'

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For internal speakers from the research team, there will be (6x)

- Professor Yen-Fang Su will present on 'Integrating 3D Printing and Smart Sensing into Permanent Formwork for Next-Gen Precast Concrete Structures'
- Professor Chaozhe He will present on 'Can road users play a role in structural health inspection? Continuous inspection of precast concrete bridges using connected automated vehicles'
- Professor Bassem Andrawes will present on 'Advancements in the Application of Shape Memory Alloys in Transportation Infrastructure'
- Professor Mirian Velay-Lizancos will present on 'Advanced curing methods and nanomodification for accelerated production of durable precast elements: Opportunities and challenges.'
- Professor Ravi Ranade will present on '3D Printed Advanced Materials to Mitigate Prestressed Concrete Girder End Cracks'
- Professor Jiannan Cai will present on 'Gaze-directed UAV-UGV Coordination Framework for Onsite Quality Inspection of Precast Bridge Construction'

Additionally, there will be a precast manufacturer panel discussion with precast producers Dukane Precast and County Prestress and Precast. This panel discussion is intended to give participants insight into how the precast industry might change in the next 5 to 10 years, opportunities and challenges related to precast in transportation infrastructure, new technologies (such as AI) in precast concrete, career advice for students, what skills are needed for students to prepare for working in this industry, and what areas of research precasters would like to see focused on in the near future.

This year, we are happy to include an award for best student poster at the event, and we will be conducting voting during the poster session for all attendees.

For the TIP2026 Workshop, TRANS-IPIC has upgraded our previous event plan to include published proceedings following the event. Manuscripts submitted by each funded research team will be given an individual DOI, and the entire workshop Proceedings will be published by the publisher, Zenodo, under an event designated for TIP2026.

Transportation Infrastructure Precast Workshop

Organized by TRANS-IPIC & Sponsored by USDOT
April 14: Rosemont, IL





The Transportation Infrastructure Precast Innovation Center (TRANS-IPIC) is happy to announce its 2026 Transportation Infrastructure Precast (TIP2026) Workshop. TRANS-IPIC is a research consortium, funded through the USDOT's University Transportation Centers (UTC) Program, and led by the University of Illinois Urbana-Champaign. Our research focuses on Precast Concrete (PC) and related technologies. Register for the workshop to hear how PC and its related technologies can be utilized to boost durability and safety of various transportation modes in the U.S. through infrastructure repair and reconstruction.

8:00-8:25 a.m.	Breakfast/Networking	1:45-2:15	Advanced Curing Methods and Nanomodification for Accelerated Production of Durable Precast Elements: Opportunities and Challenges PI and Presenter: Mirian Velay-Lizancos, Purdue University
8:25-8:30	Welcome and Summary Remarks Bassem Andrawes, TRANS-IPIC Director		
8:30-9:00	Innovative Design and Monitoring Technologies for Transportation Infrastructure PI and Presenter: Bassem Andrawes, University of Illinois Urbana-Champaign	2:15-2:45	Precast Segmental in Urban Transit – CTA Red-Purple Modernization Case Study Presenter: Ben Soule, Systra International Bridge Technologies
9:00-9:30	TDOT's Use of Precast Bridge Elements & Systems in ABC Projects Presenter: Ted A. Kniazewycz, Tennessee Department of Transportation	2:45-3:00	Afternoon Break
9:30-10:00	Practical Lessons Learned from Application of Precast Elements Over the Years Presenter: Tony Shkurti, HNTB	3:00-3:30	Can Road Users Play a Role in Structural Health Inspection? Continuous Inspection of Precast Concrete Bridges using Connected Automated Vehicles PI and Presenter: Chaozhe He, University at Buffalo
10:00-10:15	Morning Break		
10:15-10:45	Integrating 3D Printing and Smart Sensing into Permanent Formwork for Next-Gen Precast Concrete Structures PI: Yen-Fang Su, Louisiana State University Presenter: Khalilullah Taj	3:30-4:00	Precast Manufacturer Panel Moderator: Joe Lombard, Precast Concrete Institute of Illinois and Wisconsin Panelists: Donald S. Dardis, Dukane Precast Gary Courneya, County Prestress & Precast LLC
10:45-11:15	Hollow Precast Inverted Tees in Bridge Substructures Presenters: Sam Keske and John Kintz, WJE	4:00-4:30	Human-in-the-loop Framework for UAV-UGV Coordinated Onsite Inspection of Precast Bridge Construction PI and Presenter: Jiannan Cai, University of Texas at San Antonio
11:15-11:45	3D Printed Advanced Materials to Mitigate Prestressed Concrete Girder End Cracks PI: Ravi Ranade, University at Buffalo Presenter: Pranay Singh		
11:45-12:30 p.m.	Poster Session & Live Demo		
12:30-1:15	Lunch		
1:15-1:45	Precast Concrete in Texas Bridges: Design Innovations and Durability Strategies Presenter: Anthony Felderhoff, Texas Department of Transportation		










Fig 1. Dedicated webpage and event information are currently available on the TRANS-IPIC website for the 2026 TRANS-IPIC UTC Workshop to be held Tuesday, 04/14/2026, at the Big Ten Office and Conference Center (Rosemont, IL).

- Initial Planning for the Symposium on Shape Memory Alloys (SMAs) in Infrastructure:** The TRANS-IPIC management Team has begun extensive planning for a new symposium event dedicated to Shape Memory Alloys in Infrastructure. This symposium will provide a forum to discuss the state-of-the-art research, emerging applications, and future directions of SMAs in structural, infrastructure, and transportation systems. The event aims to connect researchers, engineers, and industry professionals to exchange knowledge on how SMA's unique thermomechanical properties, including superelasticity and shape memory effect, can be utilized to improve the safety, resilience, durability, and adaptability of civil infrastructure.

This 2026 SMA symposium is a 2-day event to be held at the Big Ten Office and Conference Center in Rosemont, IL. The exact date of the event is expected to be September 17th and 18th, 2026. A symposium

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chair, and three organizing committee members have agreed to aid with planning the event, and (26x) faculty members from seven countries have agreed to serve on the Scientific Committee to review manuscripts. Over twenty topics have been proposed via abstracts for this Symposium, each dealing with Shape Memory Alloys. We are currently in the process of collecting manuscript submissions, following feedback to interested researchers. The proceedings will be published on Zenodo, on an 'event' page within Zenodo dedicated to the SMA Symposium. We are targeting approx. 50 attendees.

Topics expected to be covered on submitted manuscripts and presented in person at the symposium are Material Behavior & Characterization (Thermo-mechanical properties, fatigue, and constitutive modeling of SMAs), Seismic Applications (SMA-based dampers, braces, and self-centering connections for earthquake resilience), Prestressing & Strengthening (SMA bars, tendons, and wires for prestressing, retrofitting, and crack control in concrete structures), Structural Applications (Use of SMA in bridges and other types of structures), Infrastructure Applications (SMA for pipelines, pavements, foundations, transportation networks, and resilient lifeline systems), Smart & Adaptive Systems (Integration of SMA in hybrid designs, adaptive structures, and smart infrastructure), Durability & Lifecycle Performance (Durability, corrosion resistance, and long-term reliability), Numerical Modeling & Simulation (Finite element modeling, design methods, and predictive analysis of SMA-based systems), and Implementation & Industry Adoption (Case studies, challenges in field application, cost considerations, and progress toward design codes).

The Transportation Infrastructure Precast Innovation Center (TRANS-IPIC) will not pay for international travel of attendees or speakers.

3. **2026 American Concrete Institute Spring Convention:** TRANS-IPIC hosted a session at the 2026 American Concrete Institute Spring Convention, called "*Innovative Applications of Shape Memory Alloys in Precast Concrete Bridge Elements*". This session took place on March 30th, and was moderated by TRANS-IPIC Director, Professor Bassem Andrawes, and featured the work of four TRANS-IPIC UTC student researchers.

Presentations:

- "Novel Repair Technique for Transversely Cracked Bridge Decks Using a Coupled Prestressing Plates System with Shape Memory Bars", presented By: Ernesto Pérez Claros and Osama Ibrahim
- "A New Design of Precast Concrete Bridge Piers with SMA Spirals", presented By: Ishat Mushfiq
- "Addressing the Issue of End Splitting Cracks in Precast Girders using SMA Stirrups", Presented By: Siyoung Park

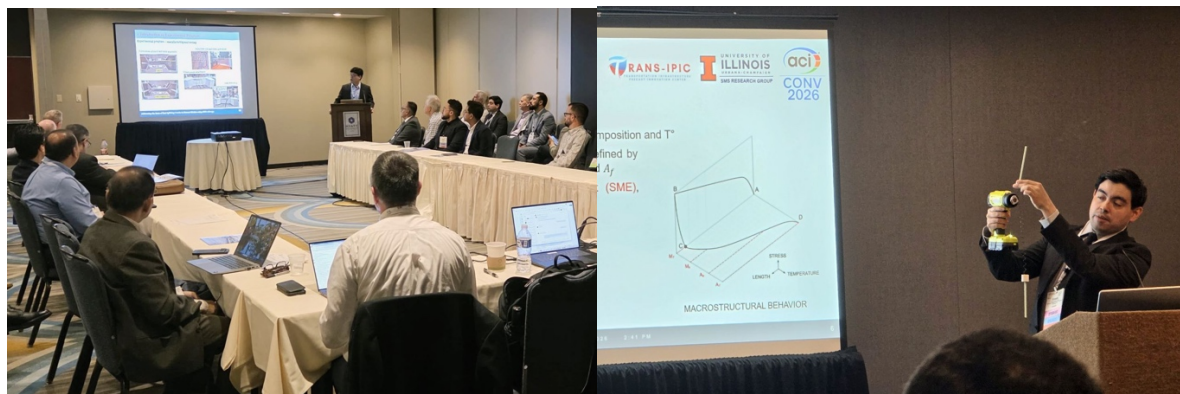




Fig 2. TRANS-IPIC team members hosting a session at the 2026 American Concrete Institute Spring Convention, called "Innovative Applications of Shape Memory Alloys in Precast Concrete Bridge Elements". Moderator, TRANS-IPIC Director, Professor Bassem Andrawes. Presenters, Ernesto Pérez Claros, Osama Ibrahim, Ishat Mushfiq, and Siyoung Park.

- 4. 2026 Transportation Research Board (TRB) Annual Meeting:** TRANS-IPIC was excited at the start of the year, taking part in the 2026 Transportation Research Board (TRB) Annual Meeting and exhibiting our technologies. Our booth attracted many transportation experts and triggered great discussions. Alongside the booth, eight innovative TRANS-IPIC-affiliated projects were presented, including:

TRANS-IPIC Projects highlighted at TRB:

- "Experimental And Numerical Evaluation of an Adaptive Prestressing System for Crack Mitigation in Bridge Decks" Osama Ibrahim, Bassem Andrawes, University of Illinois Urbana-Champaign
- "Multi-Bridge Monitoring using MT-InSAR and Machine Learning" Arslan Khan, Bassem Andrawes, University of Illinois, Urbana-Champaign
- "Full-Scale Testing of an Innovative External Prestressing Bridge Repair Technology using Shape Memory Bars" Dachina Gunasekaran, Bassem Andrawes, University of Illinois, Urbana-Champaign
- "Stiffness of Cracked Prestressed Concrete Beams" Mohamed Hassan Lasheen, Pinar Okumus, Negar Elhami Khorasani, University at Buffalo
- "Multi-objective Metaheuristic Optimization of Reinforced Concrete Beam for Improved Flexural Performance" Yizhou Lin, Huaixiao Yan, Junyi Duan, Yongfei (Rocky) Li, Xiaoli Xiong, Shanyue Guan, Chengcheng Tao, Purdue University
- "Systematic Investigation of Testing Configurations Toward Standardization of Piezoresistivity-Based Self-Sensing Method for Smart Concrete Structures" Khalilullah TAJ, Dhanushka P., Yen-Fang Su, Louisiana State University
- "Enhancing Anchorage Zone Durability in Pretensioned Girders Using Additively Manufactured SHCC Shells: Material Design and Proof-of-Concept Study" Pranay Singh, Ravi Ranade, Pinar Okumus, Chi Zhou, University at Buffalo
- "IFC-based Installation Simulation of Precast Bridge Panels in Pre-planning" Meta Soy, Zirui Hong, Fan (Aria) Yang, Jiansong Zhang, Hubo Cai, Purdue University

TRANS-IPIC UTC TRB Papers and Presentations	
Experimental And Numerical Evaluation of an Adaptive Prestressing System for Crack Mitigation in Bridge Decks.	Ibrahim, O., Andrawes, B., University of Illinois Urbana-Champaign
Multi-Bridge Monitoring using MT-InSAR and Machine Learning	Khan, A., Andrawes, B., University of Illinois Urbana-Champaign
Full-Scale Testing of an Innovative External Prestressing Bridge Repair Technology using Shape Memory Bars	Gunasekaran, D., Andrawes, B., University of Illinois Urbana-Champaign
Stiffness of Cracked Prestressed Concrete Beams	Lasheen, M., Okumus, P., Elhami Khorasani, N., University at Buffalo
Multi-objective Metaheuristic Optimization of Reinforced Concrete Beam for Improved Flexural Performance	Lin, Y., Yan, H., Duan, J., Li, Y., Xiong, X., Guan, S., Tao, C., Purdue University
Systematic Investigation of Testing Configurations Toward Standardization of Piezoresistivity-Based Self-Sensing Method for Smart Concrete Structures	Taj, K., Palipana, D., Su, Y., Louisiana State University
Enhancing Anchorage Zone Durability in Pretensioned Girders Using Additively Manufactured SHCC Shells: Material Design and Proof-of-Concept Study	Singh, P., Ranade, R., Okumus, P., Zhou, C., University at Buffalo
IFC-based Installation Simulation of Precast Bridge Panels in Pre-planning	Soy, M., Hong, Z., Yang, F., Zhang, J., Cai, H., Purdue University

Fig 3. TRANS-IPIC team members at the 2026 Transportation Research Board (TRB) Annual Meeting, presentation and posters highlighting (8x) funded projects.

- Featured Article:** Work by TRANS-IPIC Center Director, Professor Bassem Andrawes, and his research team at the University of Illinois Urbana-Champaign using smart memory alloys in railroad tracks has been featured in a new article by Interesting Engineering. The article, titled “*US engineers’ new shape memory*”

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alloy system could make rail tracks safer, longer-lasting", details that SMA-based rail ties, tested with industry partner Rocla Concrete Tie, can exceed U.S. rail safety standards in simulated traffic tests.

LINK = <https://interestingengineering.com/innovation/shape-memory-alloy-rail-tracks-safer>

- 6. Hosting Research Highlights Webinars:** Research Highlights Webinars to promote and disseminate the research conducted by TRANS-IPIC UTC researchers have been held in 2025 and continuing into 2026 on October 24th, January 23rd, and March 25th. These Research Highlights Webinars are presented directly by faculty members, PIs or Co-PIs for each project, and accompanied by their students, to highlight the interesting research findings and discuss how to achieve the goals of the center. Each webinar includes between two (sometimes three) presentations related to the UTC projects. Each webinar offers 1.0 Professional Development Hour (PDH) to attendees, and all are uploaded to TRANS-IPIC's YouTube channel for later viewing (and PDH). An ongoing and up to date playlist of all TRANS-IPIC Research Highlights Webinars can be found at the YouTube channel, <https://www.youtube.com/@TRANS-IPIC>.
- 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 through. 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. Request for Proposals for Year 3 Projects:** Following the yearly Call for Proposals process to select Year 3 projects for funding. TRANS-IPIC received a total of 32 research project proposals submitted to this open call. (8x) Proposals were from the University of Illinois Urbana-Champaign. (6x) Proposals from Louisiana State University, (4x) Proposals from Purdue University, (6x) Proposals from the University at Buffalo, and (8x) proposals from the University of Texas San Antonio. TRANS-IPIC utilized a total of (24x) external reviewer, selected from members of the TRANS-IPIC External Advisory Board and Industry Partnership Committee, and additional members of companies represented by committees. These external reviewers, from both DOTs and various industry partners, assessed and rated proposals based on criteria provided the TRANS-IPIC Management Team. Proposal Reviewers were from the following organizations: Illinois Department of Transportation, Indiana Department of Transportation, Louisiana Department of Transportation, Texas Department of Transportation, American Segmental Bridge Institute – ASBI, Precast/Prestressed Concrete Institute (PCI), Precast/Prestressed Concrete Institute of Illinois/Wisconsin (PCI-IW), Utility Concrete Products (UCP), HNTB, HDR, Wiss/Janney/Elstner Associates – WJE, Research Civil Engineer with the US Army Corps of Engineers, Parsons Corporations, EXP, AtkinsRealis, and Coastline Composites.

To be compliant with the 2025 Executive Orders and Secretarial Memoranda, projects were pre-reviewed to confirm none relation to climate change, environment, greenhouse gas emissions, sustainability, or DEI. Based on external review process, (15x) projects were selected to receive funding. Please see the project listing below for reference. The breakdown of research projects by consortium university as a follows: (3x) Louisiana State University, (2x) Purdue University, (3x) University at Buffalo, (5x) University of Illinois Urbana-Champaign, and (2x) University of Texas at San Antonio.

Title	Institution	Federal (\$)	Non-Federal (\$)
Improving Temporary Traffic Control Systems in Highway Construction Zones with Precast Concrete Installation Strategies using Traffic Flow Simulation of Lane Closures	Louisiana State University	70,000	35,000
3D Printed Smart Permanent Concrete Formwork for Precast Structural Component - Phase II	Louisiana State University	70,000	35,001
AI-Based Vision Deblurring for Precast Concrete Bridge Inspection Considering Environmental Disturbances	Louisiana State University	70,000	35,000
Integrating Sensing Technologies, AI, and BIM to Automate the Lifecycle Quality Control of Precast MSE Wall Systems	Purdue University	69,214	34,622
New simplified and Adaptive Method for Quality Control of Precast elements through Advanced NDT Evaluation	Purdue University	70,000	38,500
Continuous & Low-cost Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs) - Phase II	University at Buffalo	70,000	35,000
Digital Twins for Evaluation of Precast Concrete Bridge Girders	University at Buffalo	70,000	35,000
Advanced concretes for girders with unbonded posttensioning strands	University at Buffalo	70,000	35,001
Automated Construction of Concrete Bridge Components With Shape Memory Bars	University of Illinois Urbana-Champaign	70,000	35,000
Condition Assessment of Transportation Infrastructure using Space-Borne Sensors and AI	University of Illinois Urbana-Champaign	70,000	35,000
Probabilistic Bridge Condition Projections: Toward Reliability-Based Assessment of Precast Concrete Bridges	University of Illinois Urbana-Champaign	69,967	50,977
Optimizing Maintenance Decisions for Precast Concrete Bridges	University of Illinois Urbana-Champaign	70,000	50,852
Computer Vision-Based Sorptivity Test for Automated Durability Assessment and Service Life Prediction of Precast Concrete	University of Illinois Urbana-Champaign	69,957	51,954
AI-based Lift Path Planning for Robotic Installation of Precast Bridge Components	University of Texas San Antonio	70,000	35,000
Instrumented Precast Concrete Curbs for Urban Infrastructure Readiness to Autonomous Vehicle Deployment	University of Texas San Antonio	70,000	38,500

Fig 4. The list above is the (15x) Research Projects selected for funding in Year 3, by an external review process.

9. Final Project Reports and Year 2 Reports: TRANS-IPIC collected Final Reports for Year 2 Research Projects that were either continued from Year 1 (these projects are two years in length), or, alternatively, projects are 1 year in length and had started in Year 2. Final Reports were then reviewed by the center's leadership team to ensure all projects met their research goals and could be closed out. (2x) research projects that were initially funded in Year 2 and will continue this same research in Year 3 after their year-end reports (for the continuation projects) were reviewed and confirmed that each is at an acceptable point to continue funding. A copy of all Final Reports will be posted on the TRANS-IPIC's website (<https://trans-ipic.illinois.edu/research>) once completed and reviewed by the TRANS-IPIC Management Team.

Dissemination

1) Conferences and Meetings: The outcomes from the TRANS-IPIC UTC projects were highlighted at

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multiple events that are heavily attended by transportation professionals. As mentioned earlier, targeting attendance of transportation professionals is an ongoing center goal for the yearly TRANS-IPIC Workshop (held each April). TRANS-IPIC researchers also heavily focus on having papers published at the TRB annual meeting. For the 105th TRB Annual Meeting on January 11–15, 2026, TRANS-IPIC had (8x) papers accepted for presentation. This list is below for reference:

(8x) selected of TRB Accepted papers acknowledging TRANS-IPIC:

- Experimental And Numerical Evaluation of an Adaptive Prestressing System for Crack Mitigation in Bridge Decks. Ibrahim, O., Andrawes, B., University of Illinois, Urbana-Champaign.
- Multi-Bridge Monitoring using MT-InSAR and Machine Learning, Khan, A., Andrawes, B., University of Illinois, Urbana-Champaign
- Full-Scale Testing of an Innovative External Prestressing Bridge Repair Technology using Shape Memory Bars, Gunasekaran, D., Andrawes, B., University of Illinois, Urbana-Champaign.
- Stiffness of Cracked Prestressed Concrete Beams. Lasheen, M., Okumus, P., Elhami Khorasani, N., University at Buffalo.
- Multi-objective Metaheuristic Optimization of Reinforced Concrete Beam for Improved Flexural Performance. Lin, Y., Yan, H., Duan, J., Li, Y., Xiong, X., Guan, S., Tao, C., Purdue University.
- Systematic Investigation of Testing Configurations Toward Standardization of Piezoresistivity-Based Self-Sensing Method for Smart Concrete Structures. Taj, K., Palipana, D., Su, Y., Louisiana State University.
- Enhancing Anchorage Zone Durability in Pretensioned Girders Using Additively Manufactured SHCC Shells: Material Design and Proof-of-Concept Study. Singh, P., Ranade, R., Okumus, P., Zhou, C., University at Buffalo.
- IFC-based Installation Simulation of Precast Bridge Panels in Pre-planning. Soy, M., Hong, Z., Yang, F., Zhang, J., Cai, H., Purdue University.

Additionally, a selection of more regional events, workshops, and conferences with TRANS-IPIC presentations are listed below, highlighting information dissemination and technology transfer.

Selection of Additional TRANS-IPIC Presentations:

- K. TajG, L. ReidUG, Y.-F. Su*, "Environmental influence on the smart self-sensing 3D-printed concrete column", SPIE Smart Structures + Nondestructive Evolution, Vancouver, B.C., Canada, March 16-19, 2026
- Mazumder, A. and Sarker, B. R. (2025c), "Optimizing Pallet Utilization to Reduce Curing Costs in Precast Concrete Manufacturing," Poster ID: 7037, 2025 INFORMS Annual Meeting, Georgia World Congress Center and Omni Atlanta Hotel at Centennial Park, Atlanta, Georgia, October 26- 29, 2025.
- Mazumder, A. and Sarker, B. R. (2026), "A Cooperative Vendor-Manufacturer Inventory Policy for Perishable Precast Materials under Stochastic Demand and Lead Time Variability," Presentation ID: 17637, IISE Annual Conference & Expo 2026, Lowes Arlington Hotel, Arlington, Texas, Scheduled on May 16- 19, 2026
- Mazumder, A. and Sarker, B. R. (2025a), "Optimizing Raw Material Ordering Policies for Efficient Precast Concrete Production under Fluctuating Demand and Price," Presentation ID: 6670, IISE Annual Conference & Expo 2025, Renaissance Atlanta Waverly Hotel & Convention Center (Room: Tyndall), Atlanta, Georgia, May 31- June 3, 2025.
- Mazumder, A. and Sarker, B. R. (2025b), "Optimal Component Allocation on Pallet to Minimize Curing Costs in Precast Manufacturing," Presentation ID: 8864, IISE Annual Conference & Expo 2025, Renaissance Atlanta Waverly Hotel & Convention Center (Room: Andover), Atlanta, Georgia, May 31- June 3, 2025.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "An Enhanced and Implementable Machine Learning-Based Evaluation Tool for Prestressed Concrete Bridges." presentation, PCI Northeast Technical Bridge Committee Meeting, April 24, Sturbridge, MA and online.

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- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2026). "Stiffness of Cracked Prestressed Concrete Beams." TRB Annual Meeting, poster presentation, January 11-15, Washington, DC.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2025). "An Implementable Machine Learning-Based Evaluation Tool for Prestressed Concrete Bridges.", ACI Fall Convention, poster presentation, October 26-29, Baltimore, MD.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2025). "Machine Learning for Associating Field-Measured Crack Information with Beam Condition.", ACI Fall Convention, presentation, October 26-29, Baltimore, MD.
- Okumus, P., Elhami Khorasani, N., Hassan Lasheen, M. (2025) "Evaluating Concrete Bridges for Shear using Machine Learning.", presentation, TRANS-IPIC Research Highlights Webinar, July 25.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "An Enhanced and Implementable Machine Learning-Based Evaluation Tool for Prestressed Concrete Bridges." presentation, PCI Northeast Technical Bridge Committee Meeting, April 24, Sturbridge, MA and online.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "An Enhanced and Implementable Machine Learning-Based Evaluation Tool for Prestressed Concrete Bridges." presentation, TRANS-IPIC Workshop, April 22-23, Rosemont, IL.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "Evaluation of Structural Cracking in Reinforced and Prestressed Concrete Bridges: A Review and a Machine Learning-based Framework.", presentation, Transportation Research Board (TRB) Annual Meeting, January 5-9, Washington, DC.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "Evaluating Prestressed Concrete Beams with Shear Cracks Using Machine Learning.", poster presentation, Department of Civil, Structural and Environmental Engineering Graduate Student Poster Competition, University at Buffalo, January 31, Buffalo, NY.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "Evaluating Prestressed Concrete Beams with Shear Cracks Using Machine Learning.", poster presentation, Transportation Research Board (TRB) Annual Meeting, Institute of Bridge Engineering Reception, January 5-9, Washington, DC.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2024) "Evaluating prestressed concrete beams with cracks using machine learning.", presentation, TRANS-IPIC Research Highlights Webinar, August 22.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2024). "Machine Learning for Evaluating In-Service Concrete Bridges.", presentation, Northeastern Peer Exchange for Resilient and Sustainable Bridges, August 7, Buffalo, NY.
- Okumus, P., Elhami Khorasani, N. (2024), "Bridge engineering research at University at Buffalo.", presentation, New York City DOT and University at Buffalo Meeting, New York City, NY, June 12.
- Okumus, P., Elhami Khorasani, N., Hassan Lasheen, M. (2024) "Evaluating prestressed concrete beams with cracks using machine learning.", presentation, External Advisory Board Meeting of Institute of Bridge Engineering, University at Buffalo, the State University of New York, virtual, April 30.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2024). "Evaluating Prestressed Concrete Beams with Cracks using Machine Learning." Presentation, TRANS-IPIC Workshop, April 22, Rosemont, IL.
- Hassan Lasheen, M., Okumus, P., Elhami Khorasani, N. (2024). "Predicting shear strength of prestressed concrete beams using machine learning", poster presentation, TRB Annual Meeting, Institute of Bridge Engineering Reception, University at Buffalo, January 8.
- PI Chaozhe He and PhD Student Haosong Xiao gave presentations at the 5th Modeling, Estimation

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and Control Conference (MECC 2025) on October 8th 2025, reporting results from research funded in this project.

- PhD Student Haosong Xiao entered poster competition at UB Mechanical and Aerospace Engineering (MAE) and at School of Engineering and Applied Sciences (SEAS), won 2nd place.
- The World's First Infrastructure-Guided, Connectivity-Enhanced Approach for Road Crack Detection and Estimation, H. Xiao, Y. Ramesh, R. Shukla, S. Sarkar, C. R. He.
- Prestation at PCINE (Precast Concrete Institute North East) Technical Bridge Committee Meeting, Online, April 24, 2025. Authors: Singh, P., Zhou, C., Okumus, P., and Ranade, R. Title: Additively manufactured fiber reinforced shells for concrete bridge durability.
- Presentation at ASU-Swinburne Workshop on Advances in Concrete 3D printing. Authors: Singh, P., Zhou, C., Okumus, P., and Ranade, R. Title: 3D-Printed Concrete Covers for Girder Ends: Advancing Bridge Durability, One Layer at a Time.
- Radwan, I. M., and Dessouky, S. (Sept 18th, 2025). Cool Concrete Sidewalk Pavement: Mitigating Urban Heat Island Effect with Integrating Phase Change Materials, poster presentation at The Texas Civil Engineering Conference (CECON2025), San Marcos, TX.
- 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).
- The UTSA Mini E-Week Lab Exhibit event on Friday, March 6 2026 provided tour to local school districts to our lab where we presented our research work including Trans-IPIC.
- Mohsen Navazani, Ao Du, Shuai Li, and Jiannan Cai. "Reinforcement Learning-Based Motion Planning for Mobile Crane Operation in Precast Concrete Bridge Installation". Date: March 20, 2026. Conference: CI & CRC Joint Conference 2026. Location: San Antonio, TX. The corresponding paper is accepted for proceedings and is in press.

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 to the broad research team, consortium members, External Advisory Board, Industry Partnership Committee, industry members, and State DOTs. All recordings of our Research Highlights Webinars are shared with the community through the center's website and YouTube (see the figure below for reference). These Research Highlights Webinar recordings help connect the center with the community and keep the community aware of the ongoing work by the center. TRANS-IPIC is in the planning process of working through to have external industry experts to be included in our monthly webinars, in addition to regular research highlights webinars focusing on center funded research.

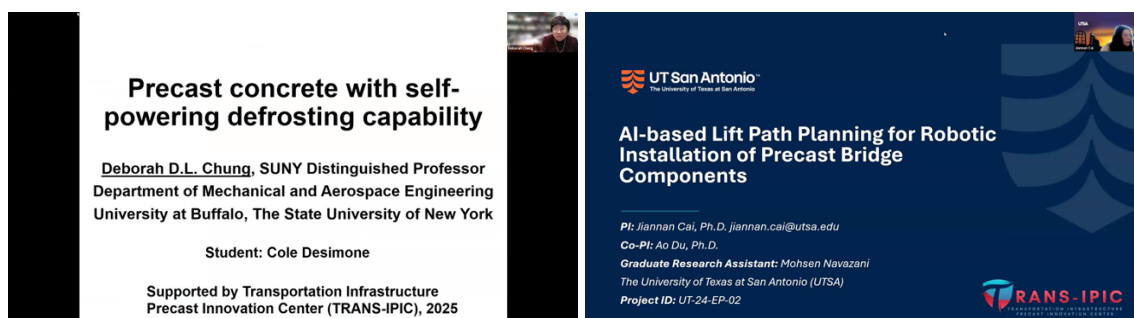




Figure 5. Snapshots from the recorded are available on the TRANS-IPIC UTC Research Highlights Webinars for the end of 2025, and beginning of 2026, leading up to the yearly TRANS-IPIC UTC Workshop (TIP2026).

a. Plans for the Next Reporting Period

The next reporting period will focus on:

- 1) TRANS-IPIC is currently working to complete the center-level budget for Year 4 to provide to the USDOT for review. Ongoing discussions are in place with Louisiana State University, Purdue University, University at Buffalo, University of Texas at San Antonio, and, of course, with the sponsored program administration from the University of Illinois Urbana-Champaign.
- 2) The TRANS-IPIC Management Team will begin planning for our 4th annual UTC Workshop (TIP2027), immediately following the 3rd annual event. TRANS-IPIC will continue the planning and execution of the 4th annual UTC Workshop, potentially in April 2027 (as previous years have been held in April), or to locate a new timeframe to aid in hosting this event. As with previous events, in addition to the members of the TRANS-IPIC research consortium, we expect transportation professionals, industry members, precast producers, and State DOT members from across the U.S. to attend and collaborate. This event is to include published proceedings with an individual DOI for each paper.
- 3) The TRANS-IPIC Management Team is continuing to plan the 2026 International Symposium on Shape Memory Alloys in Infrastructure. TRANS-IPIC will continue the plan to execute this event dedicated to Shape Memory Alloys in Infrastructure, in order to provide a forum to discuss the state-of-the-art research, emerging applications, and future directions of SMAs in structural, infrastructure, and transportation systems, connecting researchers, engineers, and industry professionals to exchange knowledge on how SMA's unique thermomechanical properties, including superelasticity and shape memory effect, can be utilized to improve the safety, resilience, durability, and adaptability of civil infrastructure. Including published proceedings with an individual DOI for each paper.
- 4) In the Summer of 2026, TRANS-IPIC will again work with the Grainger College of Engineering and WYSE to host high school students at the University of Illinois Urbana-Champaign campus in July of 2026, as

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part of the City Designers and Builders Camp, for the Civil and Environmental Engineering Department.

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

- (1) Texas Department of Transportation
- (2) Tennessee Department of Transportation
- (3) HNTB
- (4) WJE
- (5) Dukane Precast
- (6) County Prestress and Precast LLC
- (7) Systra International Bridge Systems
- (8) Rinker, Gainey's, Premier Concrete Products, & WASKEY for collaboration and validation
- (9) Louisiana Transportation Research Center (LTRC)
- (10) Terran Robotics
- (11) Sperra (former RCAM Technology)
- (12) Circle Up Indy, Ltd
- (13) AccelNet (Arizona State University, West Pomeranian University of Technology, Poland) MS&T, UT Arlington, University of Puerto Rico)
- (14) Heidelberg Materials
- (15) North Dakota State University
- (16) Atlas Excavating
- (17) Milestone Contractors
- (18) Force Construction
- (19) Kelley Construction
- (20) Walsh Group
- (21) Aldridge Electric
- (22) Superior Construction
- (23) FH Paschen
- (24) Microtek laboratories Company
- (25) City of San Antonio
- (26) Tindall Corporation

b. Other Collaborators

Several individuals from organizations and universities expressed a strong interest in the mission of the UTC. They offered to collaborate with TRANS-IPIC in various forms, including reviewing research proposals, delivering training sessions, and on-campus seminars to the UTC students. Many of these individuals participated in both Year 1, Year 2, and Year 3 proposal review processes, which resulted in funding 19 projects in Year 1, 20 funded projects in Year 2, and 15 projects in Year 3.

3. OUTPUTS

a. Publications and Conference papers:

A selection of TRANS-IPIC papers published and those under review.

- Mazumder, A. and Sarker, B.R. (2025a), "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 Asia Pacific Journal of Operational Research. 1st submission: September 8, 2025 (APJOR-S-25-00647).
- Mazumder, A. and Sarker, B. R. (2025b), "Optimal vendor-manufacturer cooperative policy for perishable precast materials under stochastic demand and lead-time uncertainty," Paper-4 (LS-23-RP-04), Submitted to International Journal of Production Economics (under review), August 19, 2025 (PROECO-D-25-02726)
- Mazumder, A. and Sarker, B. R. (2025c), "Optimal Vehicle and Resource Allocation for Precast Concrete Transportation under Demand and Travel Time Uncertainty," Working Paper-3 (LS-24-RP-01), Intended for ASCE: Journal of Transportation Engineering.
- Mazumder, A. and Sarker, B. R. (2026b), "Optimal Pallet and Components Assignment Configuration to Minimize Curing Cost in Precast Manufacturing," Paper-2 (Pallet Opt.) submitted to Annals of Operation Research. 1st submission: January 27, 2026 (with editor). (ANOR-D-26-00288)
- Mazumder, A., Bappy, M. M. and Sarker, B. R. (2026c), "Monotonicity-Constrained Physics-Informed Neural Networks for Concrete Compressive Strength Prediction," Paper-5 (PINN) submitted to Innovative Infrastructure Solutions. 1st submission: January 28, 2026 (with editor). (IIS-D-26-00174)
- K. TajG, Y.-F. Su*, "Durability Evaluation of Economical Self-Sensible Cementitious Composites," Case Study in Construction Materials, 2025 (Under review)
- K. TajG, D. Palipana, Y.-F. Su*, "Systematic Investigation of Testing Configurations Toward Standardization of Piezoresistivity-Based Self-Sensing Method for Smart Concrete Structure", Transportation Research Record, 2026 (Under review)
- Mazumder, A. and Sarker, B. R. (2026b), "Optimal Pallet and Components Assignment Configuration to Minimize Curing Cost in Precast Manufacturing," Paper-2 (Pallet Opt.) submitted to Annals of Operation Research. 1st submission: January 27, 2026 (with editor). (ANOR-D-26-00288)
- Mazumder, A., Bappy, M. M. and Sarker, B. R. (2026c), "Monotonicity-Constrained Physics-Informed Neural Networks for Concrete Compressive Strength Prediction," Paper-5 (PINN) submitted to Innovative Infrastructure Solutions. 1st submission: January 28, 2026 (with editor). (IIS-D-26-00174)
- Y. Wang, A.E. Douba, J. Olek, P. D. Zavattieri, J.P. Youngblood, Better, Cheaper, Greener: A high-performance Cementitious Composite for Sustainable Concrete 3D Printing, to be submitted to Nature Communications.
- Wang, S., Lin, Y., Duan, J., Yan, H., Wang, X., Xiong, X., Huang, Y., Guan, S., & Tao, C.* (submitted in June, 2025). Intelligent Prediction Framework for Mechanical Response of FRP-Concrete Beam Reinforcement using KAN-based Convolutional Neural Network, Computer-Aided Civil and Infrastructure Engineering.
- Duan, J., Yan, H., Lin, Y., Guan, S., Tao, C. * (submitted in September, 2025). Advanced Structural Health Monitoring and Situational Awareness of Reinforced Concrete Beam using Smart, Self-sensing Composite Reinforcement through Digital Twin Model. Journal of Civil Structural Health Monitoring.
- Wang, S., Wang, X., Duan, J., Yan, H., Huang, Y., & Tao, C.*. (submitted in August, 2025). UNet-based Buckling Deformation Reconstruction from Strain Distributions and Knowledge Distillation. Engineering Applications of Artificial Intelligence.
- Duan, J., Wang, X., Yan, H., Wang, S., Huang, Y., & Tao, C.* (submitted in August, 2025). A Damage-informed Digital Twin Framework for Self-sensing Cured-in-place Underground Pipelines. Engineering Structures.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N., Chandola, V. "Predicting Shear Strength of Prestressed Concrete Beams using Machine Learning." Submitted to the ACI Structural Journal.
- Hassan Lasheen, M., Okumus, P., Elhami-Khorasani, N. (2025). "Evaluation of Structural Cracking in Reinforced and Prestressed Concrete Bridges: A review and a machine learning-based framework." Transportation Research Board (TRB) Annual Meeting, January 5-9, Washington, DC.

- H. Xiao and C. R. He, "Safe and Efficient Data-driven Connected Cruise Control," presented at the 5th Modeling, Estimation and Control Conference (MECC 2025), Pittsburgh, PA, 2025
- H. Xiao, Y. Ramesh, R. Shukla, S. Sarkar, C. R. He. Infrastructure-Guided Connectivity-Enhanced Road Crack Detection and Estimation. The Fourth IEEE International Conference on Mobility: Operations, Services, and Technologies (MOST), Detroit, MI, May 2026 (to appear).
- 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).
- Helaly, H., K. El-Rayes, and E.J. Ignacio. (under review). "Multi-Objective Optimization for the Planning of Prefabricated Bridge Construction Projects" Submitted to the Journal of Construction Engineering and Management, ASCE in August 2025.
- Andrawes, B., Colombani, I., Khan, A. (August 2025). "Using Spaceborne Sensors to Evaluate the Performance of Civil Infrastructure Systems" published in the ASCE Journal of Performance of Constructed Facilities.
- Pérez-Claros, E., Andrawes, B. (July 2025) "Experimental Testing of Concrete Crossties Prestressed with Shape Memory Alloys" Published in the ASCE Journal of Transportation Engineering.
- K. TajG, Y.-F. Su*, V. Gopu, T. Rupnow, "Impedance-Based Characterization and Equivalent Circuit Modeling of Recycled Carbon Fiber-Enabled Self-Sensing Cementitious Composites" Construction and Building Materials, 2026 (Revision under review)
- K. TajG, L. ReidUG, Y.-F. Su*, "Environmental influence on the smart self-sensing 3D-printed concrete column", Proceedings of SPIE. 2026 (Accepted)
- B. Andrawes, I.A. Colombani, A.Q. Khan, Using Spaceborne Sensors to Evaluate the Performance of Civil Infrastructure Systems, Journal of Performance of Constructed Facilities 39 (2025) 06025004. <https://doi.org/10.1061/JPCFEV.CFENG-5114>.
- 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>.

Sung M. and Andrawes B. (2024) "Innovative precast prestressed concrete truss system using shape memory alloys and conventional steel" Journal of Intelligent Material Systems and Structures 35 (10), 875-891

Andrawes B., Colombani IA, and Khan AQ (2025) "Using spaceborne sensors to evaluate the performance of civil infrastructure systems" ASCE Journal of Performance of Constructed Facilities 39 (6)

Gunasekaran D., Khan A., and Andrawes B. (2025) "Innovative Repair of Transversely Cracked PPC Bridge Deck Girder using Precast Prestressing Plates with Shape Memory Alloys" International Journal of Bridge Engineering, Management and Research 2 (3)

Khan AQ and Andrawes B. (2025) "Multi-bridge deformation monitoring and abnormal behaviour detection using MT-InSAR and machine learning" Structure and Infrastructure Engineering, 1-16

Mushfiq KI. and Andrawes B. (2025) "Seismic performance of precast shape memory alloy confined bridge piers" Bridge Structures 21 (1), 47-59

Pérez-Claros E. and Andrawes B. (2025) "Experimental Testing of Concrete Crossties Prestressed with Shape Memory Alloys" ASCE Journal of Transportation Engineering, Part A: Systems 151 (10)

Yaghmour E. and Andrawes B. (2025) " Experimental and Numerical Analysis of a Precast Segmental Bridge with Corroded External Post-Tensioned Tendons: A Case Study of the Kishwaukee River Bridge" ASCE Journal of Bridge Engineering 30 (10)

Yaghmour E. and Andrawes B. (2025) "Concrete sleepers in modern railways: A review of

Innovative material technologies” Engineering Failure Analysis, 110305

- Park S. and Andrawes B. (2025) “Evaluating the stress transfer and detailing of shape memory alloy transverse reinforced at the end region of prestressed concrete beams” *Journal of Intelligent Material Systems and Structures*
- Andrawes B., Sung M., Park S. (2026) “NiTiNb shape memory bars for concrete prestressing Applications” *ASCE Journal of Materials in Civil Engineering* 38 (3)
- Gunasekaran D., Andrawes B. (2026) “Large-scale testing of precast bridge deck girder repaired with shape memory alloy coupled prestressing plates” *Engineering Structures* 353
- Park S. and Andrawes B. (2026) “Application of NiTiNb shape memory alloys in the end region of prestressed concrete bridge girders” *Advances in Structural Engineering* 29 (1), 102-118
- Sung M. and Andrawes B. “A hybrid prestressing system for concrete crossties using shape memory alloy and steel reinforcement” *AREMA 2023 Annual Conference*, Indianapolis, IN, October 1–4
- Perez-Claros E. and Andrawes B. (2024) “Active Confinement of Precast Concrete Columns Using FeMnSi Shape Memory Alloy Hoops” *World Conference on Earthquake Engineering proceedings*
- Chen A. and Andrawes B. “Crack Healing of Concrete Structures Using Hooked Shape Memory Bars” *Structures Congress 2025*, 348-361
- Gunasekaran D. and Andrawes B. “Novel Repair of Transversely Cracked Prestressed Girders Using Shape Memory Alloys” *Bridge Engineering Institute Conference 2025 (BEI-2025)* Paris, France, July 21-24, 2025
- Perez-Claros E. and Andrawes B. “A New Technology for Prestressing Concrete Crossties with Shape Memory Bars” *AREMA 2025 Annual Conference*, Indianapolis, IN, September 14–17, 2025
- Andrawes B. “Regional-scale monitoring of bridge performance using MT-InSAR and ML” *International Association for Bridge Maintenance and Safety IABMAS*, Orlando, FL, July 7-10, 2026
- Gunasekaran D. and Andrawes B. “Bridge Preserving Using SMA: Full-Scale Testing & Load Rating Analysis” *International Association for Bridge Maintenance and Safety IABMAS*, Orlando, FL, July 7-10, 2026

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 reactivation 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/ynpgxwugd04b34mefveeg7we6fzn9fr>.

Live Demo Crack Closure: Various studies on prestressed concrete railroad cross-ties have demonstrated their susceptibility to certain cracking patterns. To mitigate this problem and improve their durability, researchers have explored different self-healing strategies. Although shape memory alloys (SMAs) show promise for self-healing in concrete, most of the available information focuses on small-scale, non-prestressed specimens, which limits their understanding in realistic infrastructure components. TRANS-IPIC studied the feasibility of SMAs to heal full-scale prestressed concrete cross-ties and evaluated their performance when combined with conventional prestressing. After multiple phases of testing, the findings indicate that SMAs can provide significant self-healing to control cracks and improve the durability of prestressed concrete cross-ties.

The experimental program focused on widening the existing upper central cracks in the specimens and then reactivating the SME of the SMA reinforcement arrangements to measure their crack-closing capacity. In the final stage of testing, the specimens were reloaded to compare their pre- and post-activation performance.

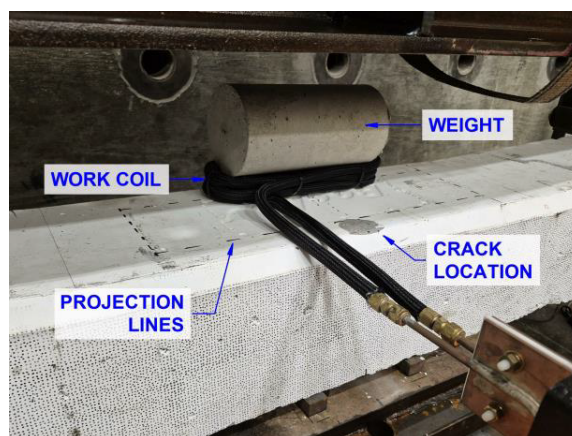


Figure 6. Work coil aligned with the existing crack over the projection of the SMA arrangement during the reactivation test.

This study represents the first step in evaluating the self-healing characteristics of localized SMA reinforcement in full-scale prestressed concrete cross-ties. Three specimens with pre-existing cracks were tested, each incorporating a specific SMA arrangement embedded in their top middle region. First, the cracks were widened through repeated flexural demands, based on the four-point bending configuration recommended by AREMA (2020), until the crack widths were visually detectable. The SMAs were then reactivated using induction heating, and, lastly, the specimens were subjected to additional flexural

demands to assess their post-reactivation stiffness.

The study concludes with the following findings:

(1) An additional activation of the SME in the NiTiNb and FeMnSi SMAs was achieved with the implemented induction heating strategy, which resulted in crack closures due to the recovery of deformations in the vicinity of the existing cracks.

(2) Significant crack closures were observed after the second activation of the SME. Specifically, reactivating the full length of the fuses in the specimens produced the best crack closures.

(3) The hybrid SMA-based prestressing approach shows potential not only to improve the design of prestressed concrete crossties but also to incorporate self-healing capabilities that can be activated following events that could induce cracking in these members. Thus, further exploration of this technology could contribute to the durability and resilience of the railway industry by mitigating damage that might otherwise compromise the service life of prestressed concrete crossties

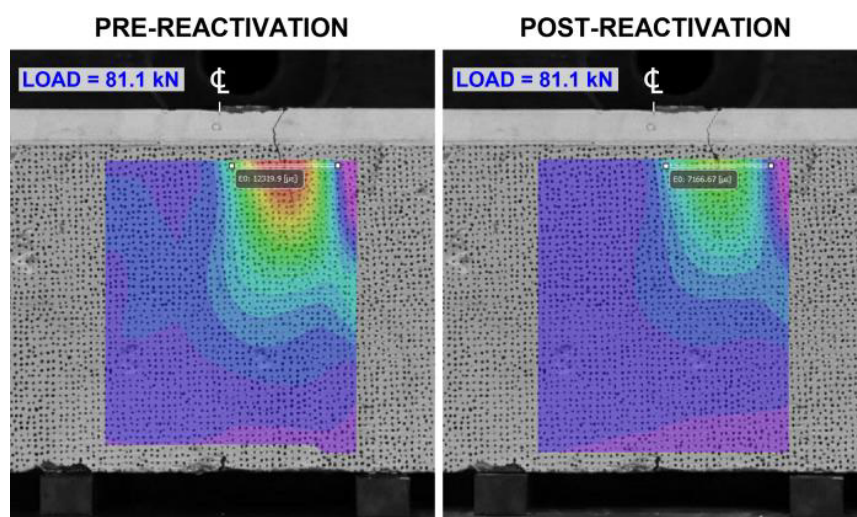


Figure 7. Strain comparison near the crack in the APS-S specimen during the final pre- and post-reactivation.

4. OUTCOMES

Several of the ongoing and completed TRANS-IPIC projects have resulted in technologies that are ready for implementation or are progressing to this goal. 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. below).



Figure 8. Innovative technique for externally prestressing bridge girders proposed by TRANS IPIC researchers using smart materials.

- **Shear strength and normalized shear predictions for PC beams:** Bridge owners face difficult decisions on whether a bridge should be posted, repaired or replaced when prestressed concrete (PC) members have shear related cracks due to overloading. The decisions are currently made based on engineering judgment, costly load testing or time consuming and complex modeling. Guidance is needed to interpret cracks and their impact on shear capacity to avoid overly conservative load ratings and to keep bridges operational, without compromising safety and economy. This project developed a reliable and efficient tool through machine learning (ML) to relate cracking to load history of bridge members. Shear strength was also predicted through ML as a reference point for load history. A MATLAB user interface tool that facilitates the use of the ML algorithm in shear capacity predictions has been developed. Additionally, a web application tool created using Python was also developed to provide free access to the tool without the need for a license and enables users to predict shear strength and normalized shear for PC beams. The link to the developed web application is the following: <https://hassan-lasheen.onrender.com/>.

University at Buffalo The State University of New York

Diagram: A bridge with a truck crossing it, showing the beam width b_w and the beam bottom flange width b_b .

Input Parameters:

- b_w = in
- d_p = in
- a = in
- f'_c = ksi
- A_{ps} = in²
- f_{se} = ksi
- A_{st} = in²

Legend:

- b_w : Beam web width
- b_b : Beam bottom flange width
- d_p : Distance from extreme compression fiber to centroid of strands
- a : Shear span
- f'_c : Concrete compressive strength
- A_{ps} : Prestressing steel area
- f_{se} : Effective prestress
- A_{st} : Longitudinal tensile reinforcement area
- f_y : Yield strength of longitudinal reinforcement
- A_{st} : Shear strength area
- f_y : Yield strength of shear reinforcement
- s : Shear reinforcement spacing
- A_{ps} : Draped prestressing steel area
- α : Angle of draping
- W_p : Crack width
- V_u : Shear strength
- V : Shear load history

Figure 9: Web application tool created using Python, an open-source programming software, enables users to predict shear strength and normalized shear for PC beams.

- **Multi-objective optimization model to support State DOTs:** The team researching 'Optimizing the Planning of Precast Concrete Bridge Construction Methods to Maximize Durability, Safety, and Sustainability (Phase II)' has developed a multi-objective optimization model to support State DOTs in generating and evaluating optimal trade-offs among four key objectives: maximizing safety, mobility, and sustainability while minimizing the total cost of precast bridge construction projects during the preconstruction phase. The development process involved three main stages: (1) model formulation, which identified all relevant decision variables, objective functions, and constraints; (2) model implementation, which employed the Nondominated

Sorting Genetic Algorithm II (NSGA-II) supported by four additional modules; and (3) model evaluation, which analyzed a case study to demonstrate the model capabilities in optimizing the planning of precast bridge construction projects. This manuscript has been submitted to the ASCE Journal of Construction Engineering and Management on August 1, 2025. This project's final report and publication of this model will help distribute to State DOTs for use.

- Condition Assessment of Transportation Infrastructure using Satellite Imaging: This research focuses on developing a new framework for utilizing space data routinely acquired using satellites to make an accurate assessment of the structural condition of bridge infrastructure in the U.S. The proposed framework was developed using high-resolution Multi-Temporal Interferometric Synthetic Aperture Radar (MT-InSAR) satellite images, advanced structural analysis, environmental data, and data-driven AI models. MT-InSAR analysis is capable of capturing small movements of bridges at a scale of a few millimeters, a feature that was utilized in this research. The project represents an important step towards developing a framework for a National infrastructure assessment system based on monitoring bridge movements in near real-time. This project helps in: (1) advancing the knowledge and overcome challenges related to time series analysis of satellite images for bridge monitoring, and (2) developing a structure-based data-driven ML system that can be used for providing near real-time “quantitative” continuous assessment of bridge networks.

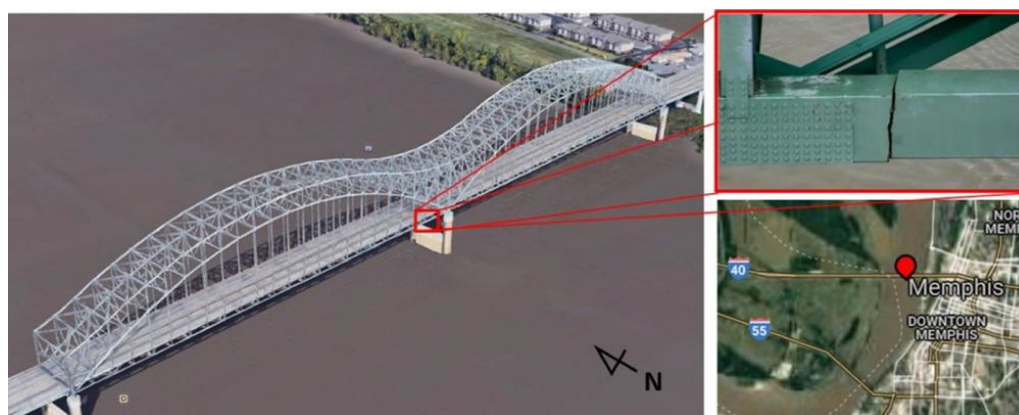


Figure 10. Image of Hernando De Soto Bridge in Memphis, TN, showing a fracture

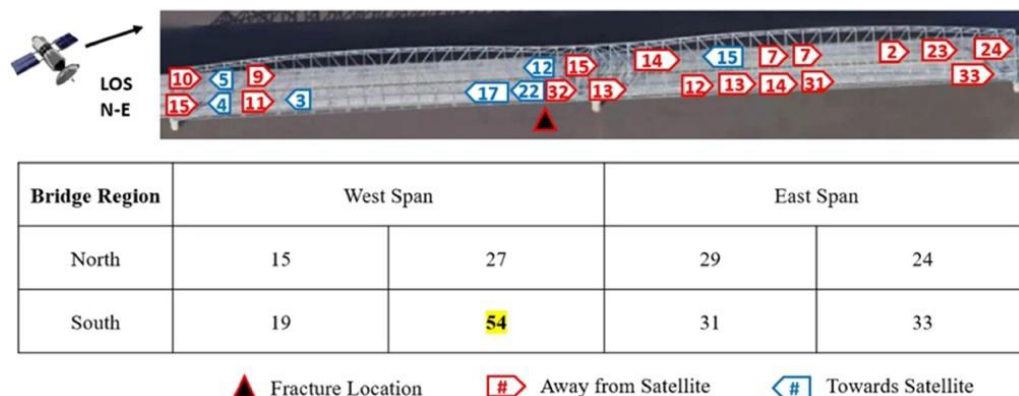


Figure 11. Final averaged cumulative bridge displacement values throughout the entire monitoring period detected by TRANS-IPIC reserachers (in millimeters). (Base image © Google Earth, Landsat/Copernicus.)

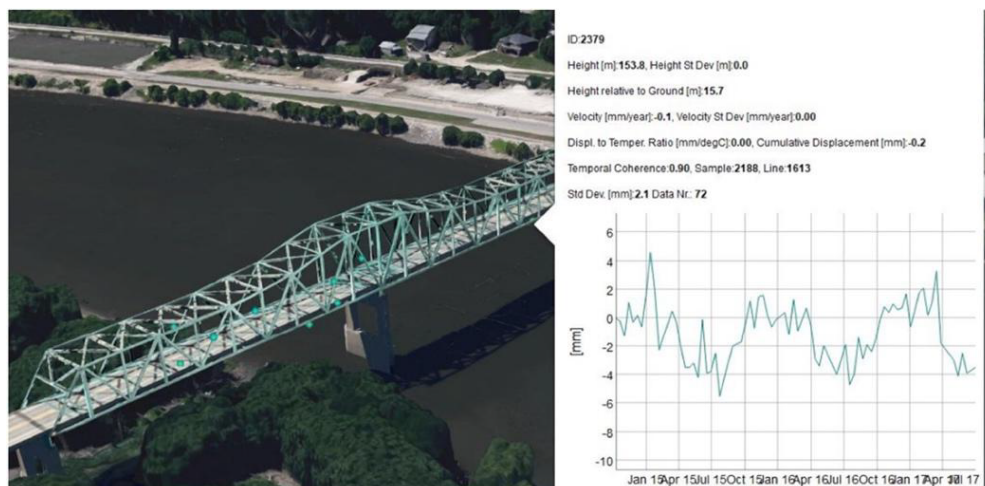


Figure 12. Thermal deformation trend of the scatterer at midspan of IL-251 Bridge. (Base image © Google Earth, Image © 2025 Airbus, Image © 2025 CNES/Airbus.)

- Innovative Precast Concrete Truss Using Adaptive Shape Memory Prestressing System: This research focused on the fabrication and testing of a large-scale truss bridge girders. The study experimentally validated prestressing with SMAs at a large scale. During the development of prestressing forces, no splitting cracks occurred in the member. This is a notable difference between the test results of the isolated member and a full system. The truss had additional material and rigidity at the ends of the prestressed member, thus preventing the splitting cracks. This showed that splitting cracks would not be an issue in practice. The flexural test validated the effects of prestressing in a truss system and opened up new possibilities in the construction of complex concrete geometries for bridge construction.

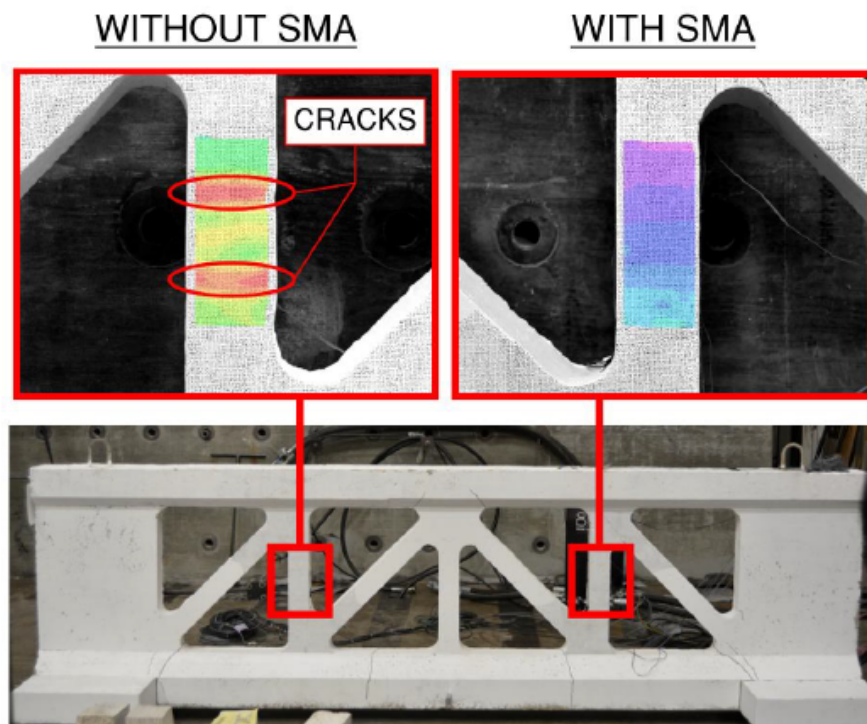


Figure 13. DIC corresponding to a load of 40 kip

5. IMPACTS

a. Effectiveness of the Transportation System and Scientific Knowledge

TRANS-IPIC finished and closed (16) funded research projects from Year 2 of the center, working to address critical problems our transportation infrastructure faces. During this same period, an external review process was completed to select (15) Year 3 research projects for funding at (5x) universities. The projects, starting during the phase outlined in this report, will research innovative ideas and technologies that will help the transportation community improve the durability and sustainability of transportation systems.

Title	PI Last Name
Optimizing Precast Concrete Supply Logistics System under Variable Demand and Probabilistic Delivery Time to Enhance Reliability, Sustainability and Cost-Effectiveness	Dr. Sarker
IFC-based BIM for Robotic Installation of Precast Bridge Components	Dr. Zhang
Multi-objective Optimization of Reinforced Precast Concrete for Improved Performance	Dr. Tao
Unveiling synergistic effects of Nano-modification and CO ₂ curing on the durability and carbon footprint of precast elements: Phase II	Dr. Velay-Lizancos
Bio-Inspired Solutions for Roadside Barriers: Exploring 3D Printing as Alternative Precast Technology	Dr. Zavattieri
Precast concrete with self-powering defrosting capability	Dr. Chung
Continuous & Low-cost Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs)	Dr. He
3D Printed Advanced Materials to Mitigate Prestressed Concrete Girder End Cracks - Year 2	Dr. Ranade
Combining Specific Heat of Concrete and Actuator Placement Optimization for Self-Powered Ice-Melting Precast Concrete Bridge Panels	Dr. Sychterz
Shape Memory Alloy Transverse Reinforcement for Precast Bridge Girders End Regions	Dr. Andrawes
Innovative Precast Concrete Truss Using Adaptive Shape Memory Prestressing System	Dr. Andrawes
Climate-Informed, Data-Driven Precast Concrete Bridge Condition Modeling for Future-Proof Transportation Infrastructure	Dr. Cha
Optimizing the Planning of Precast Concrete Bridge Construction Methods to Maximize Durability, Safety, and Sustainability	Dr. El-Rayes
IoT-Driven Digital Twin Framework for the Design and Fabrication of Precast Elements	Dr. Awolusi
AI-based Lift Path Planning for Robotic Installation of Precast Bridge Components	Dr. Cai
Thermally Conductive Precast Concrete Pavement for Urban Heat Island Mitigation - Implementation	Dr. Dessouky

Figure 14: TRANS-IPIC funding projects that were completed and closed during the reporting period ending March 31st, 2026.

Title	Institution	Federal (\$)	Non-Federal (\$)
Improving Temporary Traffic Control Systems in Highway Construction Zones with Precast Concrete Installation Strategies using Traffic Flow Simulation of Lane Closures	Louisiana State University	70,000	35,000
3D Printed Smart Permanent Concrete Formwork for Precast Structural Component - Phase II	Louisiana State University	70,000	35,001
AI-Based Vision Deblurring for Precast Concrete Bridge Inspection Considering Environmental Disturbances	Louisiana State University	70,000	35,000
Integrating Sensing Technologies, AI, and BIM to Automate the Lifecycle Quality Control of Precast MSE Wall Systems	Purdue University	69,214	34,622
New simplified and Adaptive Method for Quality Control of Precast elements through Advanced NDT Evaluation	Purdue University	70,000	38,500
Continuous & Low-cost Inspection of Precast Concrete Bridges using Connected Automated Vehicles (CAVs) - Phase II	University at Buffalo	70,000	35,000
Digital Twins for Evaluation of Precast Concrete Bridge Girders	University at Buffalo	70,000	35,000
Advanced concretes for girders with unbonded posttensioning strands	University at Buffalo	70,000	35,001
Automated Construction of Concrete Bridge Components With Shape Memory Bars	University of Illinois Urbana-Champaign	70,000	35,000
Condition Assessment of Transportation Infrastructure using Space-Borne Sensors and AI	University of Illinois Urbana-Champaign	70,000	35,000
Probabilistic Bridge Condition Projections: Toward Reliability-Based Assessment of Precast Concrete Bridges	University of Illinois Urbana-Champaign	69,967	50,977
Optimizing Maintenance Decisions for Precast Concrete Bridges	University of Illinois Urbana-Champaign	70,000	50,852
Computer Vision-Based Sorptivity Test for Automated Durability Assessment and Service Life Prediction of Precast Concrete	University of Illinois Urbana-Champaign	69,957	51,954
AI-based Lift Path Planning for Robotic Installation of Precast Bridge Components	University of Texas San Antonio	70,000	35,000
Instrumented Precast Concrete Curbs for Urban Infrastructure Readiness to Autonomous Vehicle Deployment	University of Texas San Antonio	70,000	38,500

Figure 15: TRANS-IPIC funding projects selected for funding in year 3 and kicked off during the reporting period ending March 31st, 2026.

TRANS-IPIC researchers also show that damage to concrete railway ties can be mitigated using shape memory alloys (SMAs). Ties warped by simulated rail traffic were shown to return to their original state with the help of SMAs activated by induction heating. A University of Illinois Urbana-Champaign news release related to the SMAs usefulness in healing railway tie warpage, here: <https://cee.illinois.edu/news/Alloys-that-remember-their-shape-can-prevent-railroad-damage>.

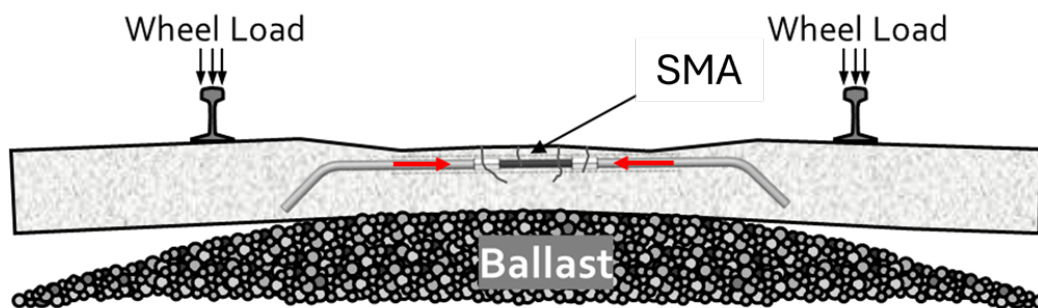


Figure 16: A concrete tie deforming under the weight of rail traffic. The arrow indicates where SMAs were inserted to demonstrate adaptive reinforcement.

Self-healing concrete / Using SMA bars to prestress and heal a tensile specimen representing truss members subjected to tension: SMAs were prestrained and placed inside a specimen representing a small-scale tensile member from a concrete truss. The SMAs were activated prior to loading to prestress the member, and strain gauges were used to measure the prestressing force. The specimen was then loaded under uniaxial tension until cracking developed. The SMA bars were then activated once more to trigger crack closure and assess the effect of SMAs for healing tensile cracks.

Activation of the SMA bars successfully prestressed the concrete tensile test specimen. This validated the use of SMAs to improve the durability of concrete tensile members by delaying crack onset. The activation of the SMA bars after loading closed cracks as wide as 0.02 inches validates the use of SMA bars for improving the durability of trusses reinforced with SMA bars.

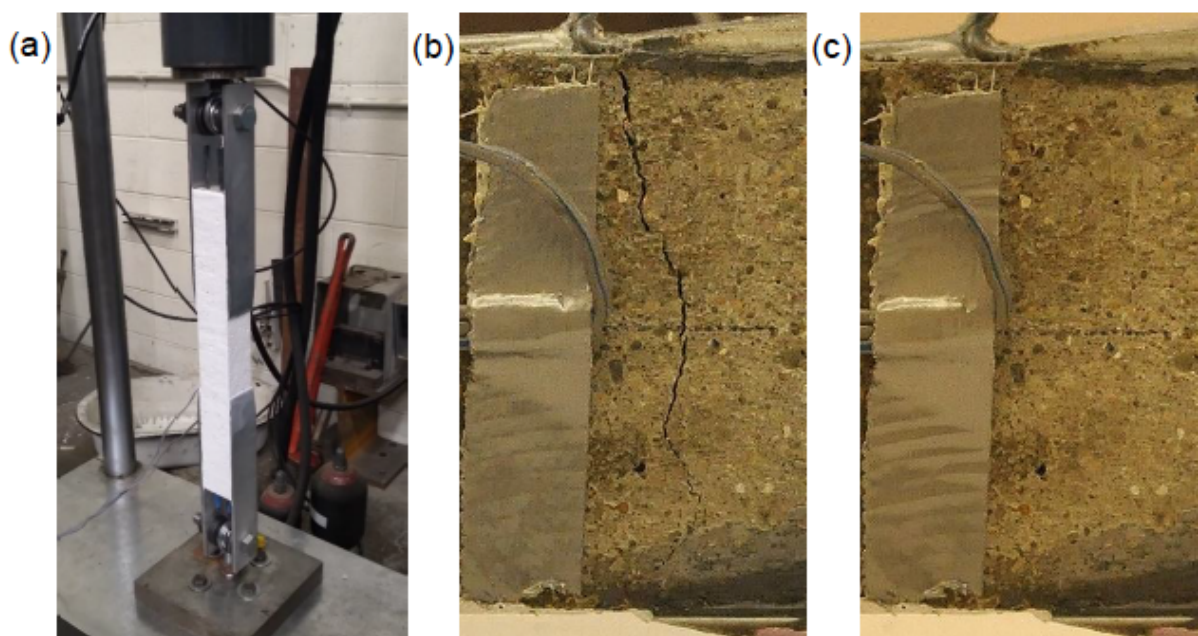
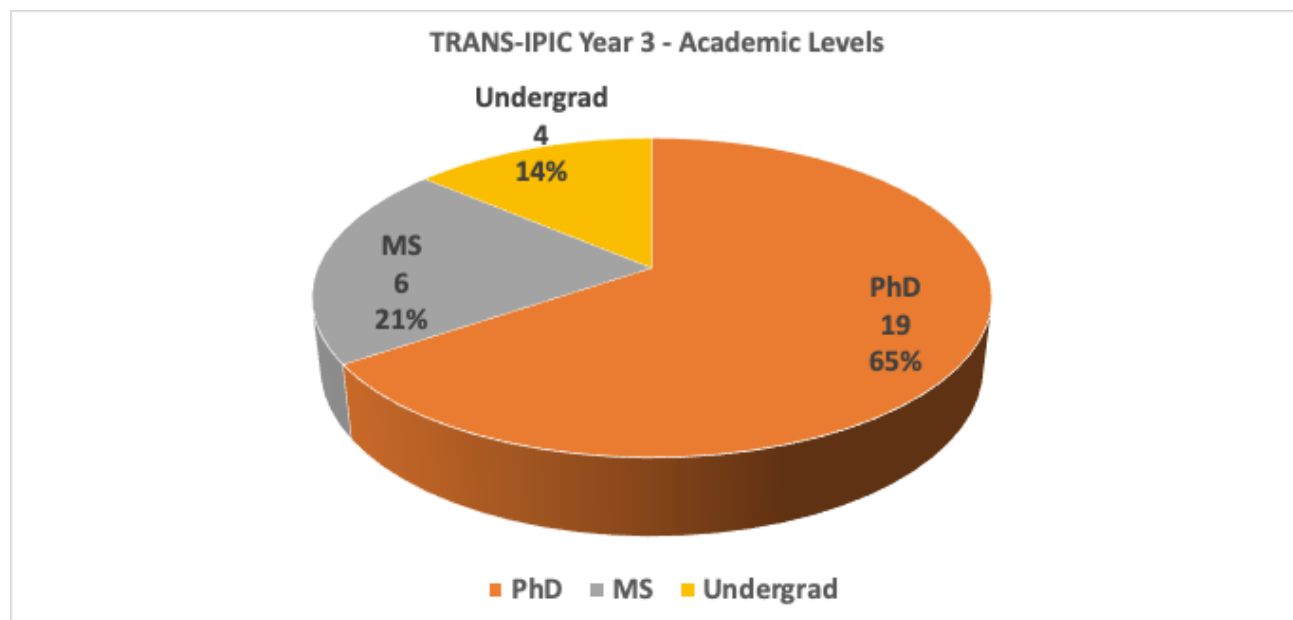


Figure 17: (a) Test setup, (b) crack before healing, and (c) crack after healing

b. Transportation Workforce Development

TRANS-IPIC funded projects provide significant opportunities for students and young people in the transportation and related fields. Across all currently funded TRANS-IPIC projects during the start of Year

3, a total of 29 students are supported by TRANS-IPIC-funded projects (4, 6, and 19 undergraduate, MS, and Ph.D. students, respectively) (see **Fig. 18**).



(a) Academic level

Figure 18. Breakdown of TRANS-IPIC current students based on (a) academic level

6. CHANGES/PROBLEMS

Nothing to Report.

7. SPECIAL REPORTING REQUIREMENTS

Nothing to Report.