Awarding Federal Agency: University Transportation Centers Program, Office of The Assistant Secretary for Research and Technology, U.S. Department of Transportation

Federal Grant Number: 69A3551847101

Project Title: Transportation Infrastructure Durability Center (TIDC) at the University of Maine

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Submission Date: 10/28/2022

DUNS: 186875787

EIN: 016000769

Recipient Organization (name and address): The University of Maine, Transportation Infrastructure Durability Center, 35 Flagstaff Road, Orono, Maine 04469

Recipient Identifying number or account number, if any: N/A

Project/grant period: 6/5/2018 – 9/30/2024

Reporting Period end date: 9/30/2022

Report term or frequency: Semi-Annual

Signature of submitting official:

I. ACCOMPLISHMENTS

a. What are the major goals and objectives of the program?

Research

The overarching research objective of the TIDC is to improve the durability and extend the life of transportation infrastructure, including roads, bridges, and rail facilities. This objective will be achieved through (1) fundamental and applied research that will broaden our overall knowledge base while providing practical solutions to the state and federal agencies responsible for constructing and maintaining the nation's transportation facilities; (2) educational offerings in various fields of transportation that include comprehensive course work and student participation in research; (3) workforce development activities and programs to expand the workforce of transportation professionals; and (4) a perpetual program of technology transfer to ensure TIDC research results are disseminated and applied as widely as feasible.

Specific research projects are selected through a combination of peer-review and state DOT/industry input, and are expected to fall within TIDC's four research thrust areas identified in the table below.

Table 1: TIDC Research Thrusts Areas

Thrust Area Title	Description
Thrust Area 1: Transportation Infrastructure Monitoring and Assessment for Life	Managing aging civil infrastructure is a major challenge facing every country in the world. Research conducted under this theme tackles this issue through the development and implementation of novel strategies for the assessment and health monitoring of highway bridges, rail structures, pavements, slopes, embankments, and foundations. The ability to monitor the performance and health of these vital elements will provide the information required to prioritize the repair and replacement of our transportation infrastructure, while advanced assessment will justify extending the service life of these assets.
Thrust Area 2: New Materials for Longevity and Constructability	This thrust investigates new materials and technologies to improve durability and extend the life of transportation infrastructure. The materials and technologies investigated can apply to a range of transportation modes (vehicular, rail, etc.).
Thrust Area 3: New Systems for Longevity and Constructability	This research thrust focuses on evaluation, development, performance, reliability, and application of engineering systems to improve the durability and longevity of new and existing transportation infrastructure. New England's transit networks face challenges related to cold weather, changing climate, age-related deterioration, evolving load demands, construction efficiencies, and congestion, among others. In these times of economic austerity, innovative engineering systems are needed to alleviate existing and future financial strain on the region.
Thrust Area 4: Connectivity for Enhanced Asset and Performance Management	The system operational efficiency of transportation infrastructure can be improved by smart technologies that connect the infrastructure to information/management systems, vehicles, and roadway users. These emerging, connected technologies – coupled with appropriate and evolving management systems – can improve the durability of existing and new infrastructure. This is essential in the coming age of highly automated, connected vehicles and given the need to improve the performance of the existing infrastructure through more cost-effective and targeted assessments of asset vulnerabilities due to extreme weather events. This research theme applies to all forms of infrastructure including highway, railroad, marine ports, and airports.

TIDC will provide base funding to each member university contingent upon performance. An additional annual amount of $250,000 is available through an internal competitive RFP Process. The competitive RFP is released in conjunction with the base-funded RFP solicitation. The competitive project proposals are reviewed and scored by

the TIDC Advisory Board and other technical professionals. Upon completion of the review, the Advisory Board meets and provides their recommendation(s) for the selection of the competitive proposal(s). The TIDC administrative team (Center Director, Senior Program Manager, Grant and Fiscal Manage, Program Coordinator, and Advisory Board Chair) then reviews the recommendation(s) and makes the final selection of the successful proposal(s). A similar process is followed for the base-funded project selection.

Base and competitive funding are contingent upon performance, and all funded activities must meet metrics defined in technology transfer, education and workforce development, and collaboration. Each member university will provide performance metrics information to UMaine through quarterly progress reports for each research project to ensure performance is adequately tracked. In order to ensure successful implementation of research findings, each project's funding is also contingent on the commitment of a Technical Champion in implementing the potential findings of the work. See the Collaboration section on page 4 for more details about the role of the Technical Champion. Funding for research projects is also contingent upon collaboration with transportation organizations, including the region's DOTs and transportation companies.

Formal metrics to measure program effectiveness includes the number of new research initiatives/projects funded, number of continued base-funded research projects funded at member universities, number of research projects completed during the reporting period, number of active industrial and DOT partners involved in TIDC projects, dollar amount invested in TIDC research, and number of times findings have been implemented. Formal metrics under the research section overlap with metrics in other subsections.

Education & Workforce Development

TIDC seeks to attract a more diverse pool of talented students into careers in science and engineering and ensure that these students receive the best education possible. Beyond providing students with a detailed knowledge of existing public transportation infrastructure and system challenges in the realm of durability and life extension, TIDC activities will (1) enhance student communication skills to ensure they can reach a variety of audiences including researchers, the public, and decision-makers; (2) create an inclusive multi-cultural and multi-disciplinary student body by recruiting underrepresented populations into our program; and (3) foster the development of leadership skills through vertically integrated research teams (faculty, post-docs when applicable, graduate students, and undergraduate students) and peer mentoring. Undergraduate and graduate students will be directly supported by TIDC research projects and make meaningful contributions under the mentoring and guidance of faculty that is essential to student success.

TIDC will strengthen diversity and STEAM education by sharing research with future members of the workforce in K-12 education settings. This will include both exposing young people to opportunities that exist within the field of transportation infrastructure and engaging them in transportation-related educational activities. TIDC will partner with industry members and non-profit education organizations like 4-H Cooperative Extensions and Jobs for Maine Grads (JMG), after-school programs, homeschooling cooperatives, and local libraries throughout New England to bridge transportation related activities into schools. TIDC will also create an online resource guide, portfolio, and transportation-related curriculum and activities for educators to utilize in their classrooms. TIDC will work with the College of Education and Engineering Colleges at the partner universities to create opportunities for professional development (continuing education requirements) for educators to create a better understanding of how to incorporate engineering activities into already existing curriculum at school districts.

TIDC will implement a series of webinars, workshops, conference sessions, and symposiums to provide opportunities for current transportation professionals to receive training on new technologies and outputs from TIDC funded research projects to help current professionals implement the findings into practice. Certificates of attendance will be offered to all attendees to be used toward professional development hours for all training opportunities.

Formal metrics to measure program effectiveness includes the number of undergraduate and graduate students participating in industrial internships; number of presentations and poster sessions led by students; number of papers published by students; number of seminars, workshops, and conferences hosted by TIDC researchers; number of

presentations led by TIDC supported students; number of PDH certificate hours issues; number of K-12 students who participate in transportation-focused tours or activities at member institutions; and total number of K-12 classrooms reached by TIDC personnel, students, and/or researchers, including specifics on classrooms populated by under-represented groups of students.

Technology Transfer

As identified in the TIDC Technology Transfer Plan, the Center's mission is to develop innovative, sustainable, next-generation solutions to improve the durability and extend the lifespan of existing and new transportation assets in New England and beyond. TIDC is committed to making dramatic impacts in the cost-effectiveness of transportation infrastructure through transformative research, education, outreach, workforce development, and technology transfer through the four research thrust areas identified in Table 1.

TIDC's technology transfer objectives are:

- Ensure research developments and findings are accessible, disseminated, and transferred to a variety of users.
- Ensure research developments and findings are disbursed consistently and in a scheduled manner to effectively reach a steady audience.
- Ensure research developments have long-term value and significant impact to the transportation industry through collaboration with government and non-profit organizations.

The technology transfer objectives of TIDC support the TIDC mission through their emphasis on research impact and dissemination. The TIDC goals and performance metrics reflect the full spectrum of research activities through technology concept inception and assessment to technology adoption. See Table 2: Technology Transfer Goals & Performance Measurers for the goals and performance metrics that TIDC-funded research projects are striving to meet during the course of their work.

Table 2: Technology Transfer Goals & Performance Measures

Goal	Performance Metrics	Annual Target
Output: Develop new technologies, techniques, or methodologies	Number of successfully demonstrated proof-of-concept activities for newly developed technologies, techniques, or methodologies	2
Output: Publish journal, conference, and/or policy papers that become references for practitioners for the modification of codes and standards for technology adoption	Number of technical reports, theses, dissertations, DOT reports, and other report types submitted and/or published	5
	Number of papers published in peer-reviewed journals	4
	Number of papers, abstracts, or posters published and/or presented in conferences, symposia, workshops, and/or meetings	12
Output: Post updates for technology transfer activities to TIDC virtual platforms	Number of posts to all TIDC platforms	350
Outcome: Deploy new technologies, techniques, or practices	Number of technologies deployed in transportation applications through pilot or demonstration studies	2
Outcome: Improve the processes, technologies, and techniques in addressing transportation issues	Number of licenses granted to industry or patent applications submitted	1
Impact: Workforce development	Number of webinars given to disseminate findings to industry professionals	6
	Number of seminar, workshop, and/or conference sessions delivered by researchers to present findings of research activities to industry professionals	45

Impact: Adoption of technologies, techniques, or practices	Number of instances of technology adoption by industry or transportation agencies and of commercialization	1
	Number of instances that TIDC supported findings were referenced, cited, or mentioned in journal articles, presentations given by others not active in the research project, newspaper or magazine articles, etc.	5
Impact: Development or modification of codes and standards to facilitate wider technology adoption	Number of instances of research changing industry or transportation agency practices, decision making, or policies	1

*To see how TIDC performed against these targets during this reporting period, see section I.b. – Technology Transfer.

A crucial outlet by which TIDC research is disseminated is through the use of social media platforms, YouTube, and the TIDC website. This serves to accomplish TIDC's technology transfer objectives by reporting TIDC technological findings and advances primarily to those who would not normally have exposure to TIDC operations. Our primary goal is to reach and inform as many people as possible from various demographics. Since the last report, TIDC social platforms have continued to promote findings and opportunities for collaboration directly to the public, and have promoted market-ready technology transfer opportunities.

Collaboration

Institutional leads serve on the TIDC Management Team which ensures each institution has ownership in and is committed to the success of the program. Additionally, in an effort to ensure all TIDC research projects are relevant to Department of Transportation and/or Industry needs, each TIDC research project is required to have a Technical Champion. The Technical Champion has subject matter expertise and is actively involved in the research activities, from the creation of the project proposal to assisting with the implementation of successful research findings as a result of the work. The Technical Champion acts as a resource, connecting the researchers to the industry and meeting with the researchers to continue to help the teams keep their research relevant. Technical Champions on each project are providing in-kind support and are not monetarily compensated for the time they spend working with the principal investigators and research team. As more projects are added and advanced, the number of Technical Champions and their contributions will change. See Table 5 on page 11 for a complete list of Technical Champions.

To ensure the successful selection and implementation of relevant research projects, TIDC has assembled an Advisory Board. The role of the Advisory Board is to ensure TIDC continues to meet the needs and challenges of Region 1, as described within its designated Fast Act topic, in collaboration with New England Transportation Agencies. The Advisory Board evaluates and recommends the selection of competitively funded research projects through an open RFP process that encourages collaboration and implementation of next-generation solutions. The Advisory Board also reviews TIDC's annual performance metrics from each member university to assess the status of base funded projects. Additionally, the goal is to have all Advisory Board members work toward facilitating the engagement of researchers and students with Design and Maintenance Department members to encourage real-world solutions. The Advisory Board is currently comprised of members from each state DOT/AOT in Region 1. The Advisory Board meets two to three times annually to ensure effective partnership in achieving TIDC's research objectives and goals and add value to New England's Transportation Infrastructure.

Formal metrics to measure collaboration goals include presentations given at non-member universities, documented conversations regarding collaboration between TIDC and other UTCs, documented conversations/meetings between researchers, DOTs, industry partners, and technical champions, the number of industrial partners and state DOTs participating in TIDC research, dollar amount of state DOT and industry investments in TIDC research projects,

number of technical champions actively involved in TIDC research projects, and number of outside attendees to the TIDC Annual Conference.

b. What was accomplished under these goals?

Research

In order to ensure TIDC is conducting relevant and transferable research projects, individual projects are required to submit quarterly reports to ensure the approved goals and objectives of each research project are being met and are working toward TIDC's mission and research goals. During this reporting period, TIDC has 54 projects that were active, 8 projects that concluded their work, 6 new projects and 1 Phase II were funded as a result of the 2022 RFP Solicitation during the reporting period. See Table 3 for a list of the 5 TIDC funded research projects that were active and/or selected/extended during the reporting period. (* indicates a newly selected/awarded project during the reporting period.)

Table 3: TIDC Projects Active During the Reporting Period

Project Number & Title Institution	Institution(s)	Start Date
Thrust Area 1: Transportation Infrastructure Monitoring and Assessment of Enhanced Life		
1.2 – Condition/Health Monitoring of Railroad Bridges for Structural Safety, Integrity, and Durability	University of Connecticut	10/1/2018
1.4 – Electromagnetic Detection and Identification of Concrete Cracking in Highway Bridges	University of Massachusetts Lowell	1/1/2019
1.5 – Distributed Fiber Optic Sensing System for Bridge Monitoring	University of Massachusetts Lowell	1/1/2019
1.6 – Progressive Fault Identification and Prognosis of Railway Tracks Based on Intelligent Inference	University of Connecticut	10/1/2018
1.8 – Enhancing Intelligent Compaction with Passive Wireless Sensors	University of Vermont	7/1/2018
1.12 – Improved UAV-Based Structural Inspection Techniques & Technologies for Northeast Bridges	University of Maine	10/1/2020
1.13 – Structural Integrity, Safety, and Durability of Critical Members and Connections of Old Railroad bridges Under Dynamic Service Loads and Conditions.	University of Connecticut	10/1/2021
1.14 – Exploring the Safety Impact of Rumble Strips on Prevention of Lane Departure Crashes in Maine	University of Maine	10/1/2021
1.15 – Non-Contact Intelligent Inspection of Infrastructure	University of Connecticut	10/1/2021
1.16 – Wireless Joint Monitoring (j-JMS) for Safety of Highway Bridges	University of Connecticut	10/1/2021
1.17 – Determining Layer Thickness and Understanding Moisture Related Damage of State-Owned Roads Using GPR and Capturing Such in a GIS-Based Inventory	University of Rhode Island	9/1/2021
C3.2018 – Condition Assessment of Corroded Prestressed Concrete Bridge Girders	University of Massachusetts Lowell & Western New England University	1/1/2019
C11.2019 – Development of System-Level Distributed Sensing Technique for Long-Term Monitoring of Concrete and Composite Bridges	University of Massachusetts Lowell, University of Vermont, University of Maine	1/1/2020
C19.2020 – Damage Modeling, Monitoring, and Assessment of Bridge Scour and Water Borne Debris Effect for Enhanced Structural Life	University of Connecticut	10/1/2020

C20.2020 – Advanced Sensing Technologies for Practical UAV-Based Condition Assessment	University of Maine	10/1/2020
Thrust Area 2: New Materials for Longevity and Constructability		
2.2 – Concrete Systems for a 100-Year Design Life	University of Maine	3/1/2020
2.4 – Thermoplastic Composites by 3D Printing and Automated Manufacturing	University of Maine	1/1/2019
2.5 – Development and testing of High/Ultra-High Early Strength Concrete for Durable Bridge Components and Connections	University of Connecticut	10/1/2018
2.7 – High Performance Concrete with Post-Tensioning Shrinking Fibers	University of Vermont	1/1/2019
2.9 – Carbonating Subgrade Materials for In Situ Soil Stabilization	University of Maine	9/1/2018
2.10 – Durability Evaluation of Carbon Fiber Composite Strands in Highway Bridges	University of Maine	6/1/2019
2.11 – Culvert Rehabilitation Using 3D Printed Diffusers	University of Maine	7/1/2020
2.12 – Evaluation of Processed Glass Aggregate for Utilization in Transportation Projects as a Sand Borrow	University of Vermont	10/1/2020
2.13 – Performance Structural Concrete Optimized for Cost, Durability, and Manufacturability	University of Vermont	10/1/2020
2.14 – Implementation of UHPC Technology into the New England Construction Industry	University of Connecticut	10/1/2021
2.15 – Incorporation of Pollinator Planning to Enhance Ecosystem Functions and Durability of Transportation Right-of-Way Infrastructure	University of Rhode Island	10/1/2021
2.16 – Enhancing the Durability of Bridge Decks by Incorporating Microencapsulated Phase Change Materials (PCMs) in Concrete	University of Rhode Island	1/1/2022
2.17 – Design and Development of High-Performance Composites for Improved Durability of Bridges in Rhode Island	University of Rhode Island	1/1/2022
2.18 – Recycling Large-Scale 3D-Printed Polymer Composite Precast Concrete Forms	University of Maine	1/1/2022
C7.2018 – Alternative Cementitious Materials (ACMs) For Durable and Sustainable Transportation Infrastructures	University of Maine	6/1/2019
Thrust Area 3: New Systems for Longevity and Constructability		
3.5 – Prevention of Stressed-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure	Western New England University	9/1/2018
3.7 – Development of General Guidelines on the Effects of Bridge Span Range and Skew Angle Range on Integral Abutment Bridges (IAB's)	University of Massachusetts Lowell	7/1/2018
3.10 – Assessment and Optimization of Double CT Bridge Girder Sections with Longitudinal Precast Decks	University of Maine	7/1/2020
3.11 – Phase 1: Assessment of Micropile-Supported Integral Abutment Bridges Phase 2: Development of a Simplified Methodology to Evaluate the Factor of Safety and Link the Magnitude of Lateral Spreading for CSEs Supported on Rigid Inclusions	University of Maine	9/1/2019
3.12 – Phase 1: Lateral Loading of Unreinforced Rigid Elements and Basal Stability of Column-Supported Systems Phase 2:	University of Maine	6/1/2019

Flexural Strength and Durability of Micropile Threaded Connections		
3.13 – Investigating the Effectiveness of Enzymatic Stabilizers for Reclaimed Stabilized Base Products	University of Vermont	10/1/2020
3.14 – FRP-Concrete Hybrid Composite Girder Systems: Web Shear Strength and Design Guide Development	University of Maine	10/1/2020
3.15 – Nonstructural Approaches to Reduce Sediment and Pollutant Runoff from Transportation Infrastructure in Urbanized Areas	University of Rhode Island	9/1/2021
3.16 – CT Bridge Girder Sections with Precast Decks and FRP girder-deck Shear Connectors	University of Maine	1/1/2022
3.17 – Assessment of CT Girder Load Distribution and Web Buckling Through Field Load Testing and Finite Element Analysis*	University of Maine	6/1/2022
3.18 – Steel-free Concrete Bridge Decks*	University of Maine	6/1/2022
3.19 – Detection and Monitoring of Material Aging and Structural Deterioration using Electromagnetic and Mechanical Sensors with Virtual Reality and Machine Learning Modeling*	University of Massachusetts Lowell	6/1/2022
3.20 – Analysis of MaineDOT Road and Bridge Infrastructure Construction Costs	University of Maine	2/7/2022
3.21 – GBeam Bridge Girder Pultrusion: Section Design and Optimization*	University of Maine	6/1/2022
C9.2019 – A New Method for Determining Payment for In-Pace Concrete with Double-Bounded Compressive Strength Pay Factors	University of Vermont	10/1/2020
C17.2020 – Durability of Modified Helical Piles under Lateral and Torsional Loads: Embracing Efficient Foundation Alternative to Support Lightweight Transportation Structures	University of Maine & University of Rhode Island	10/1/2020
Thrust Area 4: Connectivity for Enhanced Asset and Performance Management		
4.1 – Highly Automated Vehicles and Bridge Infrastructure	University of Maine	9/1/2018
4.2 – Future-Proof Transportation Infrastructure through Proactive, Intelligent, and Public-involved Planning and Management	University of Connecticut	10/1/2018
4.3 – Towards Quantitative Cybersecurity Risk Assessment in Transportation Infrastructure	University of Connecticut	10/1/2018
4.4 – Bridge-stream Network Assessments to Identify Sensitive Structural, Hydraulic, and Landscape Parameters for Planning Flood Mitigation	University of Vermont	7/1/2018
4.9 – Analysis of Covid-19 and Travel In Maine (ACTIME) – Validation Study	University of Maine	8/1/2020
4.10 – Road Salt Impact Assessment	University of Maine	8/15/2020
4.11 – Safety Assessment of New England Roadways during the COVID-19 Pandemic	University of Maine	9/15/2020
4.12 – Proactive and Intelligent Risk Management in Complex Civil Infrastructure Project Systems	University of Connecticut	10/1/2021

Projects 1.6, 1.8, 3.10, 3.14, 4.2, 4.3, 4.10, and C9.2019 completed work and submitted final reports during the reporting period.

The following are a few examples of the accomplishments achieved under individual research projects:

- The UMaine Project 2.9 team developed and tested an innovative ground improvement method (i.e., soil carbonation) to sequester gaseous CO2 via shallow subgrade soils stabilization. Testing showed that, when deployed under certain circumstances, the method can stabilize soil efficiently and consumes carbon dioxide during the process, significantly reducing the carbon footprint relative to conventional stabilization methods for soil.
- The UMaine Project 2.10 team installed a new data acquisition computer with a solid-state drive to provide improved response and increased storage capacity within a smaller housing. This will alleviate issues with overheating and network communications, enabling continuous operation and eliminating system downtime. Additionally, the team updated the data acquisition code to improve the system restart after a power outage and to incorporate the temperature at the wireless nodes to be included in the data that is being recorded. This will minimize the need for physical site visits for maintenance and the additional node for temperature will improve the accuracy of the data.
- The UMaine Project 3.17 team conducted live-load testing, in collaboration with MaineDOT, on the Grist Mill Bridge in Hampden Maine, the first of its kind composite tub girder bridge, in July 2022. The data was analyzed and compared between the live-load test data collected in Dec. 2020. A finite element model was used to compare with the test data and to confirm the validity of the finite element model method for analysis. Additional Rosette strain gauges were included in the July 2022 test to provide shear strain data to give more information on shear distribution and girder web behavior, which is important for developing the live-load distribution factor. The data comparison between the Dec. 2020 and July 2022 tests showed where the bridge behavior changed and stayed the same after an initial 1.5-year service period.

More TIDC research accomplishments can be found in sections III and IV of this report and on the TIDC website on each research project's individual page.

Education & Workforce Development

The TIDC Education & Outreach Manager is actively working with K-12 educators to bring transportation activities into classrooms as COVID-19 restrictions being mostly lifted for the 2022-2023 school year. The Education & Outreach Manager has identified educators in area middle and high schools in Maine, as well as groups, such as Jobs for Maine Grads, that would like to implement the activities created in 2020-2022 and help make adjustments to the curriculum for the target age groups.

To meet our goal of increasing the number of professionals entering the transportation field, UVM's team provided an opportunity for three of their students to take a training at VTrans for the ACI Concrete Field Testing Technician – Grade I on April 18, 2022. All three students passed the exam that same month. WNEU's continued experiential learning opportunities for undergraduate students to expose students to transportation related research efforts for independent study course credit supported six students during the reporting period. TIDC is pleased to report that one of the six students entered the transportation field upon graduation, going to work for BluRoc, LLC. Additionally, In August 2022, one of UConn's students graduated with a Ph.D. and received a tenured track faculty position at Marshall University and one of UML's students obtained his Master's and went to work for a construction firm in Boston.

In an effort to encourage more individuals to enter the transportation field, TIDC continues to collaborate with the Maine Engineering Promotional Council (MEPC) during the planning process of the Engineering Expo, with the Education & Outreach Manager acting as a Director on the Board. The Expo is planned for March at the University of Maine. The MEPC Board is comprised of academic and industry members who are all committed to raising awareness of engineering through the Banquet and Expo events. The Education & Outreach Manager continued to work with industry partners through the Maine State Transportation Innovation Council to create Career Profiles to be used to encourage more K-12 students to enter transportation related fields. The Career Profiles will highlight current professionals in the field, their path to their current position, and any tips they might have for future professionals

entering the field. The Career Profiles will be hosted on the TIDC website and will be shared with K-12 educators throughout New England.

UMaine Upward Bound students participating in a cementitious materials activity.

UMaine researchers collaborated with UMaine's Upward bound program to provide high school students with a hands-on learning experience in materials and structures. During two sessions held July 11 and 18, 20 high school "Upward Bound" students participated in an outreach program intended to introduce students to some basic materials concepts through some brief classroom discussions about Portland cement concrete. Then students went to the lab to prepare their own batches, with different groups producing different types of mixes. Students were tasked with evaluating properties of freshly mixed material, while casting test cylinders. One week later, students returned to learn about concepts of stress and strength and how those properties are used in engineering design. Students then measured compressive strength of their concrete (often with a satisfying bang at failure) and discussed how the fresh properties they evaluated the week before affected the strength of the material. The Upward Bound program is intended "To provide fundamental support to participants in their preparation for college entrance. The program provides opportunities for participants to succeed in their precollege performance and ultimately in their higher education pursuits. Upward Bound serves: high school students from low-income families; and high school students from families in which neither parent holds a bachelor's degree. The goal of Upward Bound is to increase the rate at which participants complete secondary education and enroll in and graduate from institutions of postsecondary education."

Other K-12 education outreach efforts included activities conducted at WNEU, where Dr. Changhoon Lee presented research findings to 28 10th and 11th graders that visited the WNEU Transportation Lab on 9/24/2022. He introduced students to TIDC and WNEU's research efforts within the consortium regarding engineering cementitious materials with basalt fibers. The students learned about the effect of fibers in concrete in terms of impact resistance.

Student researchers at member universities have been disseminating research findings through poster presentations, seminars, and conferences. TIDC faculty taught 35 transportation-related undergraduate courses, reaching about 1,553 students, and 18 transportation-related graduate courses, reaching about 189 students, during the reporting period.

TIDC's commitment to workforce development was evidenced by researchers providing training opportunities for practitioners and issuing certificates of attendance for professionals to use toward their required professional development hours. During the reporting period, TIDC held its Annual Conference and we issued 50 certificates of attendance, bringing TIDC's total PDH hours issued to 589.75 through its inception.

Technology Transfer

TIDC research results have been disseminated through a variety of ways including the TIDC website and social media platforms. TIDC has employed a new approach and a newly developed plan for social media operations during the last semi-annual period. With a focus on schedule consistency and higher volume of output, TIDC platforms have seen steady increase in a number of analytical categories with the goal of more consistently reaching the general public. TIDC virtual platforms, links to which can be found in section II. e - website(s), have accumulated the following total results over the last semi-annual period:

- TIDC Website - 8,717 views, 3,333 unique visitors
- TIDC YouTube Channel - 1,736 views, 93.8 hours of watch time, 21 new subscribers
- TIDC LinkedIn - 2,777 impressions, 102 reactions, 40 new followers
- TIDC Facebook - 98 unique impressions, 3 reactions, 3 new followers
- TIDC Twitter - 337 impressions, 33 reactions, 3 new followers

- TIDC Instagram - 126 unique impressions, 38 reactions

TIDC researchers gave 33 presentations at 18 conferences, workshops, and/or seminars during the reporting period. The following table indicates the conferences and workshops attended by TIDC researchers and the activity they conducted to disseminate information during this reporting period.

Table 4: Conferences, Workshops, and Seminars

Name of Conference/Workshop	Activity	Location	Dates
Structures Congress 2022	Conference Presentation	Atlanta, GA	04.2022
ASCE Online Live Online Training Course	Webinar	Virtual	04.04.2022
2022 Chicago Geotechnical Lecture Series	Conference Presentation	Chicago, IL	05.05.2022
Manufacturing Renew3D	Conference Presentation	Orono, ME	05.23-24.2022
2022 International Crosstie and Fastening System Symposium	Symposium Presentation	Urbana, IL	05.24-25.2022
MassDOT Transportation Innovation Conference	Conference Presentation	Worcester, MA	05.25.2022
ITCD-ASCE Conference	Conference Presentation	Seattle, WA	05.29.2022 – 06.03.2022
2022 European Bridge Conference	Conference Presentation	Edinburgh, Scotland	06.2022
2022 ASCE Engineering Mechanics Institute Conference	Conference Presentation	Baltimore, MD	06.01-03.2022
TIDC FRP Composite Girders Webinar Series Part I	Webinar	Virtual	06.06.2022
TIDC FRP Composite Girders Webinar Series Part II	Webinar	Virtual	06.27.2022
The 11th International Conference on Bridge Maintenance, Safety and Management	Conference Presentation	Barcelona, Spain	07.2022
Maine Summer Transportation Institute	Workshop Presentation	Orono, ME	07.13-20.2022
AASHTO Research Advisory Committee (RAC) Summer Meeting	Seminar Presentation	Newton, MA	07.28.2022
16th International Symposium on Functionally Graded Materials	Conference Presentation	Hartford, CT	08.07-10.2022
2022 Transportation Infrastructure Durability Conference	Conference Presentation	Orono, ME	08.09-12.2022
2022 VTrans Innovation and Research Symposium	Conference Presentation	Barre, VT	09.14.2022
Joint Tran-SET Webinar Series & Transportation Professionals and Researchers	Webinar	Virtual	09.23.2022

Additionally, TIDC has published or submitted 12 journal papers/articles, 4 conference papers, and 5 other publications and presentations during the reporting period. For a complete list of the submitted papers, please see Section III, Outputs.

Collaboration

Critical to TIDC's success is the development of partnerships and collaborations with state DOT's, the transportation industry, transportation professionals, and various stakeholders that assist in addressing the center goals.

TIDC researchers are actively working with industry partners during their research efforts to ensure their findings will be able to transition into practice more efficiently. For example, during the 2022 International Crosstie and Fastening System Symposium the research team for Project 3.5 (WNEU) had discussions with Vossloh-Rocla Concrete Tie, Inc. (P. Logan Lemmertz; project engineer) and discussed a possibility of adopting the developed fiber-ECM concrete for their concrete crosstie production. Likewise, the UVM Project 2.12 team met with their Technical Advisory Committee (TAC) twice during the reporting period to discuss research findings, answer the TAC's questions, and made adjustments to the scope of the work, implementing the TAC's feedback.

Also, during this reporting period, the TIDC Management Team met each month, with the exception of July (due to the Annual Conference Planning), for a total of five meetings. Four meetings were held via Zoom and one was held in person during the Annual Conference.

All TIDC funded projects have met the goal of having a Technical Champion (as described in Section I a, Collaboration) assigned to each. Some research projects have additional Technical Champions (TC) and Advisors involved in their projects. Each PI is responsible for submitting their quarterly reports to their TC and working with them to ensure their research with have the greatest impact on the transportation industry. In addition to sending their reports to the TC, PIs from multiple projects are meeting with their TC to discuss and adapt their research. The following table identifies the 60 active Technical Champions and Advisors involved in TIDC research projects during this reporting period. (* Indicates newly added Technical Champions and Advisors during this reporting period.)

Table 5: Active Technical Champions & Advisors

Name and Title of Technical Champion or Advisor	Organization
Ulrich Amoussou-Gueno, Transportation Engineer II	Maine Department of Transportation
Dr. Ian Anderson, Manager	HMA Materials
August Arles, Geotechnical Engineer	Vermont Agency of Transportation
Warren Best, Assistant Deputy Director, Structures	Metro-North Railroad Company
Tanner Blackburn, Chief Geotechnical Engineer	Hayward Baker
Robert Blunt, Project Manager	VHB
Richard Bradbury, Director of Materials Testing	Maine Department of Transportation
Andy Cardinali, Principal Engineer of Bridge Design	Connecticut Department of Transportation
David Cist, Chief Technology Officer	Geophysical Survey Systems, Inc. (GSSI)
Bao Chuong, Supervising Engineer of Bridge Design	Connecticut Department of Transportation
Taylor Clark, Assistant Engineer	Maine Department of Transportation
Cassidy Cote, Hydraulics and Structures Engineer	Vermont Agency of Transportation
Jeff DeGraff, P.E., Hydraulics Project Engineer	Vermont Agency of Transportation
Paul DelSignore, Deputy Chief Engineer, Structures	Amtrak
Haresh Dholakia, Transportation Engineering Supervisor	Connecticut Department of Transportation
Anthony Diba, Engineer	AIT Bridges
Manesh Dodia, Transportation Engineer	Connecticut Department of Transportation
Todd Dragland, Vice President	Hayward Baker
Lamont Dutra	Maine Department of Transportation
Dennis Emidy, State Safety Engineer	Maine Department of Transportation
Callie Ewald, P.E., Geotechnical Engineering Manager	Vermont Agency of Transportation
Jeff Folsom, Assistant Bridge Program Manager	Maine Department of Transportation
Benjamin Foster, P.E., Deputy Chief Engineer	Maine Department of Transportation
Edward Hanscom, Head of Transportation Systems Analysis	Maine Department of Transportation
Peggy Hagerty Duffy	ADSC-IAFD; Hagerty Engineering
Robert Haradon, Senior Technician	Maine Department of Transportation
Joshua Hasbrouck, Civil Engineer, Bridge Program	Maine Department of Transportation

Peter Healey, Pavement Engineer	Rhode Island Department of Transportation
Dr. Mark Jen, P.E., S.E., Technical Manager	Michael Baker Engineering, Inc.
Gregory Krikoris, Area Bridge Engineer	Massachusetts Department of Transportation
John Kocur, Director of Engineering	Sperry Rail Service
Laura Krusinski, Senior Geotechnical Engineer	Maine Department of Transportation
James Lacroix, P.E., State Bridge Design Engineer	Vermont Agency of Transportation
Alexander Mann, Hydrologist	Maine Department of Transportation
Tanya Miller, Research Engineer	Vermont Agency of Transportation
Andrew Mrockowski, Transportation Engineer	Connecticut Department of Transportation
Richard Myers, Senior Structural Engineer	Maine Department of Transportation
Deirdre Nash, Assistant Research Engineer	New Hampshire Department of Transportation
Dr. Emily Parkany, P.E., Research Manager	Vermont Agency of Transportation
Dale Peabody, Director, Transportation Research	Maine Department of Transportation
Mario Pineda, Territory Manager	Polytec, Inc.
William Pratt, Principal Engineer	Connecticut Department of Transportation
John Preiss, Bridge Engineer	Rhode Island Department of Transportation
Michael Redmond, Business Systems Manager, Concrete Quality Control Specialist, Bridge Program	Maine Department of Transportation
Karen Riemer, Asset Management Group	Connecticut Department of Transportation
Ann Scholz, Research Engineer	New Hampshire Department of Transportation
Gary Seider, Engineering Manager	Hubbell
Rita L. Seraderian, P.E., FPCI, LEED AP, Executive Director	Precast/Prestressed Concrete Institute Northeast
Robert Skehan, Director, Office of Safety	Maine Department of Transportation
Joseph Stilwell, Fabrication Engineer	Maine Department of Transportation
Craig Stratton, Director of Sensing Sales	Luna Incorporated
James Surwilo, Environmental Analyst	VTDEC, Solid Waste Management Program
Ken Sweeney, President	AIT Bridges
Josh Tyler, Director of Operations	Chittenden Solid Waste District (CSWD)
Nicholas Van Den Berg, Materials & Certification Manager	Vermont Agency of Transportation
Susan Votta	Rhode Island Department of Transportation
Nick Wark, P.E., Hydraulics Engineer, Project Delivery Bureau, Structures	Vermont Agency of Transportation
James Wild, Concrete Materials Manager	Vermont Agency of Transportation
Christos Xenophontos, Assistant Director	Rhode Island Department of Transportation
Hailing Yu, Civil Engineer	U.S. DOT Volpe Center

The following table identifies the 40 active collaborators and stakeholders and their contributions during the reporting period. (* indicates new project collaborators during this period)

Table 6: Research Project Collaborators

Organization	Location	Contribution
AIT Bridges, a division of Advanced Infrastructure Technologies	Brewer, ME	In-kind, collaborative research, personnel, facilities
American Concrete	Auburn, ME	Financial support, facilities, collaborative research
Chittenden Solid Waste District (CSWD)	Williston, VT	Financial support, facilities, personnel

City of Lowell	Lowell, MA	Collaborative research, facilities, personnel
Connecticut Department of Transportation	Newington, CT	Collaborative research, personnel, facilities, in-kind support
Deep Foundations Institute	Hawthorne, NJ	Financial
ENSOFT Inc.	Austin, TX	In-kind, Personnel
Geophysical Survey Systems, Inc. (GSSI)	Lowell, MA	Collaborative research, personnel, in-kind, facilities
Genesee & Wyoming, Inc.*	Darien, CT	In-kind, collaborative research
GMS		In.kind
Helix Mooring Systems, Inc.	Cumberland, ME	Financial, in-kind,
Hexagon PPM	Madison, AL	In-kind, personnel
Hubbell Power Systems, Inc.	Centralia, MO	Financial, in-kind, facilities, personnel
International Association of Foundation Drilling (ADSC-IAFD)	Pennsylvania	Financial
Jacobs Engineering	Herndon, VA	Personnel
Luna Innovation	Roanoke, VA	In-kind, collaborative research, personnel
Maine Department of Transportation	Augusta, ME	In-kind, collaborative research, financial, personnel, equipment
Massachusetts Department of Transportation	Boston, MA	Collaborative research, personnel, facilities, in-kind
Metro-North Railroad Company	Bridgeport, CT	Collaborative research, facilities, personnel, in-kind
New Hampshire Department of Transportation	Concord, NH	Personnel
Nucor	Pennsylvania	In-kind
Oak Ridge National Laboratory	Oak Ridge, TN	Financial support, collaborative research
Polytec, Inc.	Hudson, MA	In-kind, collaborative research, personnel, equipment, facilities
Precast/Prestressed Concrete Institute Northeast (PCI-NE)	CT, MA, ME, NH, NY, RI, VT	Collaborative research, personnel
Rhode Island Department of Transportation	Providence, RI	In-kind, facilities, personnel
Saint-Gobain	Northborough, MA	In-kind, facilities, collaborative research, personnel, equipment
Sperry Rail Service	Shelton, CT	In-kind, facilities, personnel
Texas Advanced Computing Center	Austin, TX	Facilities
U.S. DOT Volpe Center	Cambridge, MA	Personnel
Unistress Corporation	Pittsfield, MA	In-kind, collaborative research
University of Connecticut	Storrs, CT	In-kind, collaborative research, personnel, facilities, financial
University of Maine	Orono, ME	In-kind, collaborative research, personnel, facilities, financial
University of Massachusetts Lowell	Lowell, MA	In-kind, collaborative research, personnel, facilities, financial
University of Rhode Island	Kingston, RI	In-kind, collaborative research, personnel, facilities, financial

University of Vermont	Burlington, VT	In-kind, collaborative research, personnel, facilities, financial
Vermont Agency of Transportation	Montpelier, VT	In-kind, collaborative research, personnel, financial
Vermont Department of Environmental Conservation	Montpelier, VT	Personnel, in-kind
Vermont Technical College	Randolph Center, VT	Facilities, collaborative research, personnel
VHB	Augusta, ME	Collaborative research, in-kind, personnel
Western New England University	Springfield, MA	In-kind, collaborative research, personnel, facilities, financial

c. How have the results been disseminated?

Research results have been disseminated in a variety of ways throughout this reporting period. Research results are provided on each project's page on the TIDC Website through quarterly progress reports, available at https://www.tidc-utc.org/research/tidc-funded-projects-and-reports/. Further results were disseminated through journal articles, professional magazines, and meetings with New England State DOTs (for a full list see Section II and Appendix I). Additionally, research findings are being disseminated in undergraduate and graduate courses at each university. Lastly, presentations from webinars, the 2020, 2021, and 2022 Annual Conferences, and the 2021 New England Railroad Symposium are available on the TIDC YouTube page and the TIDC website.

d. What do you plan to do during the next reporting period to accomplish the goals?

Research

TIDC has identified several new high impact research topics which will be proposed for approval with remaining TIDC research funds. To allocate the remaining funds, TIDC plans to approve at least four new research projects within the consortium. These topics include manufacturing enhancements for commercial viability of our GBeam Girders, new FRP material Shear Connectors for 100+ year lifespan bridges, and analyzing the aggregate mineral composition as the potential source of recent poorly performing MDOT highway pavements. The planned GBeam-related research will directly facilitate the design and fabrication of girders for a new, 270' long, continuous, multi-span bridge over the Stillwater River in Orono, Maine. This high profile, high-volume bridge is planned for completion within the next three years and will incorporate findings from TIDC research. We will also be closely monitoring both the effective start-up of sixteen newly begun projects in the last quarter of 2022, as well as assisting researchers with reaching successful conclusions and to ensure high impact/State DOT engagement.

Education & Workforce Development

TIDC personnel at UMaine plan to work with local school districts to implement transportation related activities created as part of the curriculum developed by the Education & Outreach Manager. As part of the effort to continue collaborating with Jobs for Maine Grads (JMG) and Career & Technical Centers (CTEs), the Education & Outreach Manager is working with industry partners to create Career Profiles that will be housed on the TIDC website for JMG, CTEs, public and private middle and high schools, homeschool groups, and after school programs at organizations like the Boys & Girls Club to use throughout New England. This new resource will be launched in November 2022.

TIDC plans to attend the MEPC's Engineering Expo in March. The Education & Outreach Manager will continue to serve on the MEPC's Board and will continue to help increase the MEPC's reach throughout the year by finalizing the Council's bylaws and objectives to include more frequent events and outreach effort throughout the year, not just though the Annual Expo.

TIDC personnel at UMaine are continuing to work to create better partnerships with MaineDOT departments (including the HR, training, operations, and maintenance departments), industry leaders in Maine and New England region, and New England Community Colleges to create more opportunities for workforce development in the state and beyond.

TIDC personnel and researchers are working to create more professional development opportunities through webinar, workshop, and symposium offerings. The Annual TIDC New England Railroad Symposium is currently being planned and will be hosted on February 16, 2023, bringing railroad industry professionals and TIDC researchers together to address real-world infrastructure problems facing the rail industry. This is a virtual event and we anticipate an audience of 200+ professionals throughout the country.

TIDC faculty and principal investigators will continue to work with students on their research projects and add new students to replace those who have graduated. Additionally, research findings will continue to be disseminated in university classrooms and curriculum will be updated as new findings are presented. Professional development hours will continue to be made available to professionals who attend the TIDC Webinars, Symposia, and individualized trainings.

Technology Transfer

To accomplish TIDC's technology transfer objectives identified in Section I. a., Technology Transfer, the following venues and mechanisms will be and/or continue to be employed: (1) a TIDC website and social media accounts that promote findings and opportunities for collaboration directly to the public; (2) the expansion of the 2023 TIDC Annual Conference at the University of Maine, August 8-10, through early advertising and outreach activities in New England; (3) continued participation in regional transportation conferences; (4) The 2nd Annual New England Railroad Symposium will be held virtually on February 16; (5) The 2022 TIDC Student Poster contest taking place during the months of October and November, with results being announced on November 30th; (6) planning the June GBeam Girder Design, Manufacture, and Install Workshop for State DOT and Industry design firms, slated for June 2023; (7) involvement and planning in the 2023 Maine Summer Transportation Institute at the University of Maine, July 11-15 and July 18-22; and (8) promotion of all market-ready technology transfer opportunities through industry/trade publications, the TIDC website, and social media accounts.

TIDC will continue to output consistent technology transfer centered posts to virtual platforms. During the next reporting period, TIDC will organically increase total social media impressions by 50%, follower count by 50%, and reactions by 125%. TIDC will increase YouTube viewership, watch time, and subscribers all by 50%. Additionally, TIDC will increase website views by 100% for the next year and unique viewership by 50%. To that end, TIDC is launching its new website during the next reporting period to more effectively engage the public in our research findings and successes.

TIDC will also use the webinars, workshops, and symposiums mentioned in the above section as a form of Technology Transfer. Not only will these provide opportunities for professionals to receive profession development hours (PDH), but it will allow TIDC research findings to be presented to the public.

Collaboration

Principal Investigators and TIDC Management team members will continue to collaborate with state DOT/AOT representatives. All TIDC projects will continue to be supported by at least one Technical Champion (as described in Section I c – collaboration). Projects are encouraged to seek support from additional technical advisors in DOTs, government agencies, and industry leaders. These additional partnerships will increase the applicability of TIDC's research findings and create more opportunities for the adoption of findings in the region and beyond. Monthly management team meetings will continue and the Program Manager will visit each member university on a quarterly basis. Also, to help with the goal of expanding the next TIDC Annual Conference for more collaboration opportunities, the dates and location for the 2023 conference have been selected and planning has begun.

II. PARTICIPANTS & COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

In total, 64 principal investigators, faculty, administrators, and management team members and 92 students participated in TIDC research projects during the reporting period. As the projects progress, more student researchers will be added. All TIDC participants who were active during the reporting period are listed in the table below. (* Indicates students who graduated and received their degree during the reporting period.)

Table 7: Active Principal Investigators, faculty, administrators, students, and Management Team Members

Institution	Principal Investigators, Faculty, Administrators, and Management Team Members	Students
University of Maine	Dr. Habib Dagher, James Anderson, Kathryn Ballingall, Dr. Keith Berube, James R. Bryce, Amanda Collamore, Dr. Sunil Bhandari, Dr. Bill Davids, Dr. Wilhelm Friess, Dr. Aaron Gallant, Dr. Per Garder, Dr. Douglas Gardner, Dr. Andrew Goupee, Dr. Yousoo Han, Dr. Hosain Haddad Kolour, Dr. Eric Landis, Dr. Roberto Lopez-Anido, Genna O'Berin, Vu Phan, Dr. Jonathan Rubin, Brianne Sales, Aaron Schanck, Dr. Andrew Schanck and Dr. Ali Shirazi.	Arnav Acharya, Zahra Ameli, Yugandhar Aremanda*, Jake Bear, Danilo Botero-Lopez, Sebastian Carvajal, Jacob Clark, Jhan Kevin Gil-Marin, SK Belal Hossen, Ennis Marshall, Sebastian Montoya, Temitope Omokinde, Maedeh Orouji, Jon Pinkham, Felipe Saavedra, Alanie Sawtelle*, Katie Schweizer, Amirhossein Shahlaeegilan, and Lily Welch.
University of Connecticut	Dr. Lesley Frame, Dr. Alexandra Hain, Dr. Song Han, Dr. Shinae Jang, Dr. Ramesh Malla, Dr. Nalini Ravishanker, Dr. Jiong Tang, Dr. Kay Wille, Dr. Wei Zhang, and Dr. Jin Zhu	Sreeram Anantharaman, Yiannis Bagtzoglou*, Emmett Christenson, Indrani Chattopadhyay, Sudipta Chowdhury*, Nathan Comment, Celso de Oliveira, Santosh Dhakal, Pierredens Fils, Giovanna Fusco, William Hughes, Harley Jeanty, Cameron Larkin, Steven Matile, Dominic Parciasepe, Max Raha, Bijaya Rai, Daisy Ren, Nicholas Scaglione, Rinchen Sherpa, Sachin Tripathi, Jiachen Wang, Ting Wang, Zelin Yun, and Yang Zhang.
University of Massachusetts Lowell	Dr. Farhad Pourkamali Anaraki, Dr. Susan Faraji, Dr. Xingwei Wang, Dr. Jianqiang Wei, and Dr. Tzuyang Yu,	Farel Adelson, Ritham Batchu, Andres M. Biondi Vaccariello, Lidan Cao, Harsh Gandhi, Koosha Raisi, Yaneliz Garcis Ruiz*, Nimun nak Khun, and Rui Wu
University of Rhode Island	Dr. Christopher Baxter, Dr. Aaron Bradshaw, Dr. Rebecca Brown, Dr. Sumanta Das, Dr. Mayrai Gindy, Dr. Joseph Goodwill, Dr. Michael Greenfield, Dr. Abdeltawab Hendawi, Dr. Vinka Oyanedel-Craver, and Dr. Nicole Martino	Gabriella Biancone, Eva Davet, Sami Doner, Pamela Franco, Anir Gubbala, Hewenxuan Li, Zoe Lin, Gideon Lyngdoh, Katie Marcil, Rebecca Meyers, Helio Nhumaio, Bolaji Oladipo, Andrew Pariseault, Rakesh Paswam, and Andrew Sheerin
University of Vermont	Mandar Dewoolkar, Dr. Jeff Frolik, Dr. Ehsan Ghazanfari, Dr. Eric Hernandez, Dr. Dryver Huston, Dr. John Lens, Dr. David Novak, Dr. Hamid Ossareh, Dr. Donna Rowangould, Dr. Gregory Rowangould, Dr. Matthew Scarborough, Dr. James Sullivan, and Dr. Tian Xia	Joshua Allen, Anna Casavant, Lane Feldeisen, Sarah Foy, Ahmad Ghazanfari, Matt Kaplita, Bijay K-C, Ben Kopacki, Richard Laverty, Brandon Nimberger, Fiona Nutbeam, Lauren Snow, Neha Subedi, Ryan van der Heijden, and Bismark Yeboah

Western New England University	Dr. Moochul Shin and Dr. ChangHoon Lee	Simon Banas, Evan Blake, Christa-Elizabeth Cicerone, Pierre Carriere, Daniel Doyle, Adam Garstka, Brian Leclair, Charles Maloy, Archer Parker, and Christopher Spinazola
Total	64	93

b. What organizations have been involved as partners?

TIDC has received continued commitments of collaboration, support, and matching funds from 45 collaborators during this reporting period. The type of support provided by the collaborators varies from in-kind, financial, equipment, personnel, to supplies. In addition, many collaborators provide direct personnel links in research through Technical Champions. See Table 5 on page 11 and Table 6 on page 13 for an overview of the collaborators on TIDC research projects and what they have contributed.

c. Have other collaborators or contacts been involved?

In addition to the collaborators and Technical Champions listed above, TIDC researchers have partnered with 53 individual collaborators in their research this period.

III. OUTPUTS

a. Publications, conference papers, and presentations:

Table 8 includes a list of some of the 41 accepted, submitted, and published papers, reports, and presentations given during the reporting period. For the full list, see Appendix I on page 22.

Table 8: Publications, Conference Papers, and Presentations

Type	Title	Citation	Date	Status
Peer Reviewed Journal Paper	Development and experimental assessment of friction-type shear connectors for FRP bridge girders with concrete decks.	Davids WG, Guzzi D, and Schanck AP(2022). Development and experimental assessment of friction-type shear connectors for FRP bridge girders with concrete decks. Materials 15(9), 3014; https://doi.org/10.3390/ma15093014.	04.18.2022	Published
Peer-reviewed Journal Paper	A Graph-based Algorithm for Slicing Unstructured Mesh Files	Bhandari, S., A Graph-based Algorithm for Slicing Unstructured Mesh Files, Additive Manufacturing Letters, Vol. 3, Dec. 2022, 100056 (Open Access) https://doi.org/10.1016/j.addlet.2022.100056	05.21.2022	Published online.
Conference	Overview of Thermoplastic Composites in Bridge Applications	Lopez-Anido, R., Davids, W., Bhandari, S., Sheltra, C.A., Erb, D.F., and Abdel-Magid, B., "Overview of Thermoplastic Composites in Bridge Applications," Structural Faults + Repair-2022 and European Bridge Conference-2022, 13 pp., June 20-23, 2022 Edinburgh, Scotland. https://www.structuralfaultsandrepair.com/	06.20-23.2022	Presented
Conference	Technical Survey and Literature Review on Bridge Joint Monitoring Practices	Ren, D., Fils, P. Jang, S., Malla, R. M. (2022). "Technical survey and literature review on bridge joint monitoring practices." American Society of Engineering Education Northeast Conference 2022	04.23.2022	Presented
Peer Reviewed Journal Paper	Investigation of Critical Factors for Future-proofed Transportation Infrastructure Planning Using Topic Modeling and Association Rule Mining	Chowdhury, S., and Zhu J. (2023). Investigation of Critical Factors for Future-proofed Transportation Infrastructure Planning Using Topic Modeling and Association Rule	08.01.2022	Published September 30, 2022

		Mining. ASCE Journal of Computing in Civil Engineering, 37(1).		
Conference	Wireless Joint Monitoring System for New England's Highway Bridges	Jang, S., Fils, P., Ren, D., Wang, J., Han, S., Malla, R.B. (2022). "Wireless Joint Monitoring System for New England's Highway Bridges," 16th International Symposium of Functionally Graded Materials & Researchers and Professionals.	08.08-10.2022	Presented

b. Journal publications:

The following table includes a list of TIDC journal publications and their status during the reporting period:

Table 9: Journal Articles and Publications

Title	Citation	Date	Status
Exploring the Impact of Seasonal Weather Factors on Frequency of Rural Lane Departure Crashes in Maine	Sawtelle, A., Shirazi, M., Garder, P.E., &Rubin, J. 92022). Exploring the Impact of Seasonal Weather Factors on Frequency of Rural Lane Departure Crashes in Maine. Journal of Transportation Safety & Security, 1-22.	09.01.2022	Published
Coupled Thermo-mechanical Numerical Model to Minimize Risk in Large-format Additive Manufacturing of Thermoplastic Composite Designs	Bhandari, S., and Lopez-Anido, R.A., "Coupled Thermo-mechanical Numerical Model to Minimize Risk in Large-format Additive Manufacturing of Thermoplastic Composite Designs," Progress in Additive Manufacturing, Sep, 2022.	09.15.2022	Published
Driver, Roadway and Weather Factors on Severity of Lane Departure Crashes in Maine	Sawtelle, A, Shirazi M, Garder, P, and Rubin, J (2022) Driver, Roadway and Weather Factors on Severity of Lane Departure Crashes in Maine	09.2022	Accepted
Enhanced Lateral and Torsional Resistance of Helical Piles Augmented with a Collar Vane	Gallant, A., Bradshaw, A., Berube, K., Carvajal-Munoz, J.S.		In Progress

c. Books or other non-periodical, one-time publications:

Nothing to Report

d. Other publications, conference papers, and presentations:

The following table includes a list of the articles and presentations that falls within the other publications, conference papers, and presentations section during the reporting period:

Table 10: Other Publications, Presentations, and Meetings

Type	Title	Citation/Description	Date	Status
Report	Road Salt in Maine: An Assessment of Practices, Impacts, and Safety.	Rubin, J., Jain, S., Shirazi, M., Sawtelle, A., Parauli, D., McKee, P., & Bailey, M. (2022). Road Salt in Maine: An Assessment of Practices, Impacts, and Safety.	05.01.2022	Submitted/Posted
Thesis	Statistical Analysis of Frequency and Severity of Lane Departure Crashes in Maine.	Sawtelle, A., (2022). Statistical Analysis of Frequency and Severity of Lane Departure Crashes in Maine.	05.01.2022	Submitted/Posted
Report	Future-Proof Transportation Infrastructure through Proactive, Intelligent, and Public-involved Planning and Management	Chowdhury, S., and Zhu J. (2022). Future-Proof Transportation Infrastructure through Proactive, Intelligent, and Public-involved Planning and Management. TIDC. Orono, ME.	07.01.2022	Submitted

Final Project Report	Security Issues in Industrial Wireless Networks: A Comprehensive Review	Song Han, "Towards Quantitative Cybersecurity Risk Assessment in Transportation Infrastructure", Final Report, Computer Science and Engineering Department, University of Connecticut.	07.31.2022	Finalized and Submitted
Report	Road Salt Impact Assessment: Safety Study of Lane Departure Crashes in Maine	Rubin, j., Shirazi, M., & Sawtelle, A. Road Salt Impact Assessment: Safety Study of Lane Departure Crashes in Maine	08.01.2022	Submitted
Presentation	Maine Summer Transportation Institute	N/A	07.13-20.2022	Presented

e. Website(s) or other Internet site(s):

The following websites and social media sites are used to disseminate information about TIDC findings.
TIDC website: www.tidc-utc.org
YouTube: https://www.youtube.com/channel/UCimTO-44wrniqXx4_AXnLGA
Instagram: https://www.instagram.com/tidcatumaine/
Twitter: https://twitter.com/TIDCatUMaine
Facebook: https://www.facebook.com/TIDCatUMaine/
LinkedIn: https://www.linkedin.com/company/transportation-infrastructure-durability-center/
UMass Lowell's TIDC research page: https://www.uml.edu/Research/tidc/

f. Technologies or techniques:

A number of technologies and/or technical innovations were developed during the reporting period:

- UML Project 1.4 research team developed a new image processing algorithm with GPR B-Scan images collect in the field. Additionally, the team produced new GPR B-Scan datasets and included them in the EM database for nondestructive inspection and structural health monitoring of a highway bridge in MA.
- UMaine Project 1.12: developed an AI-based method for quantifying surface cracks on structures from UAV images.
- UConn Project 1.16: developed a prototype wireless displacement, temperature, humidity sensor with a renewable solar-based power station. This technology will enable cost-effective, long-term monitoring of bridge expansion joints.
- UMaine Project 2.4: 3D-printed a formwork for a railroad ballast and delivered it to American concrete in Veazie, Maine for casting in May. Six re-uses of this 3D formwork were successfully demonstrated with six completed concrete structures produced and now ready for installation.
- UMaine Project 2.11: designed and 3D-printed a second culvert outlet diffuser for a 42" CMP liner and inlet upgrade project in Rocky Hill Brook at NH 85/Newfields Rd. in Exeter, NH.
- UMaine Project 3.14: The Design Specification for CT girder bridges was completed, reviewed, and prepared for submission.
- UMaine Project 4.9: finalized a validation report and submitted it to MaineDOT for review and comments. Additionally, the team created a streamlined process for using streetlight outputs using R. This will improve the efficiency and wider use of this data set for a variety of MaineDOT projects.
- The UML research team working on C11.2019 designed and manufactured another system-level distributed sensing textile for long-term bridge health monitoring of a highway bridge in MA.
- UMaine C17.2020: Installed a single-piece collar vane in the summer 2022. This overcomes some installation constraints and increases torsional performance since the load transfer mechanism is uniform since the collar vane is now a single section, whereas all its four blades are connected to the top flange.

g. Inventions, patent applications, and/or licenses:

Nothing to report.

IV. OUTCOMES

The TIDC has a number of outcomes to report as a result of the outputs from TIDC-funded research:

- UML Project 1.4 research team deployed their new EM Sensor on a cracked concrete bridge abutment in June and September of 2022.
- The UMaine Project 1.12 team applied their AI-based method for quantifying surface cracks on structures to images of bridges provided by MaineDOT, implementing a fast region-based neural network method to classify the images.
- The UConn Project 1.16 team deployed their developed prototype two times during the reporting period.
- The Project 2.4 researchers at UMaine demonstrated that complex shapes were able to be effectively and efficiently 3D-printed and the resulting shapes were able to successfully withstand the stresses of casting concrete and striping of the forms from the cast, reusing the forms in several iterations.
- The UMaine Project 2.11 team signed a memorandum of understanding with NHDOT for the purpose of manufacturing a culvert outlet diffuser for use in Exeter, state project #43254, at a proposed rehabilitation of a culvert carrying Rocky Hill Brook under NH Route 85. The installation is planned for summer 2023.
- The UMaine 3.17 & 3.18 Project teams installed a second Bridge utilizing new GBeam FRP Girders on State Rt 69 in Hampden, Maine with AIT Bridges. The team's load and creep test analyses revealed that a that design modifications and girder fabrication modifications were required for this second site application.

V. IMPACTS

a. What is the impact on the effectiveness of the transportation system?

As a result of the successful implementation of the four FRP Composite GBeam bridges (two in Maine, one in Rhode Island, and one in Florida), the MaineDOT has adopted the technology and plans to utilized the GBeams in future installations (i.e. the upcoming Stillwater Bridge replacement in Orono, ME). These bridges are resulting in lightweight construction that will reduce life cycle costs due to lower maintenance requirements and their corrosion resistance in these harsh salt laden environments. Further, our ongoing research continues to advance the technology with more efficient design and fabrication techniques.

b. What is the impact on the adoption of new practices, or instances where research outcomes have led to the initiation of a start-up company?

Nothing to report.

c. What is the impact on the body of scientific knowledge?

TIDC researchers have contributed to the body of scientific knowledge by publishing journal articles and presenting findings at conferences, webinars, seminars, and symposiums to transportation professionals.

d. What is the impact on transportation workforce development?

TIDC research findings have impacted workforce development through trainings and updates offered to transportation professionals at the city and state department/agency of transportations and industry organizations. Additionally, TIDC issued certificates of attendance to 50 out of the 160 (90 in person and 70 virtual) 2022 TIDC 4th Annual Transportation Infrastructure Durability Conference attendees.

VI. CHANGES/PROBLEMS

a. Changes in approach and reasons for change:

Nothing to report.

b. Actual or anticipated problems or delays and actions or plans to resolve them:

The research team on project 3.5 was notified that, due to world-wide supply chain disruptions, the delivery of their reflectometer to conduct work on one of their tasks is delayed. The vendor is estimating a delivery at the end of 2022. Additionally, the Project 4.12 research team had delayed progress during the reporting period due to lack of student researchers at UConn. The team has indicated they will need to submit an internal no-cost extension request. Likewise, the researchers on project C20.2020 have indicated they were delayed by a couple of months and will need an internal extension.

c. Changes that have a significant impact on expenditures:

Nothing to report.

d. Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards:

Nothing to report.

e. Change of primary performance site location from that originally proposed:

Nothing to report.

VII. SPECIAL REPORTING REQUIREMENTS

All TIDC projects are in compliance with Research Project Requirements (located in the Grant Deliverables and Reporting Requirements for 2016 and 2018 UTC Grants (Nov 2016, revised June 2018)) in regards to new research projects.

Appendix I

Table 1: Full List of Publications, Conference Papers, and Presentations				
Type	**Title**	**Citation**	**Date**	**Status**
Peer Reviewed Journal	Development and experimental assessment of friction-type shear connectors for FRP bridge girders with concrete decks.	Davids WG, Guzzi D1 and Schanck AP1 (2022). Development and experimental assessment of friction-type shear connectors for FRP bridge girders with concrete decks. Materials 15(9), 3014; https://doi.org/10.3390/ma15093014.	04.18.2022	Published
Peer-reviewed Journal	A Graph-based Algorithm for Slicing Unstructured Mesh Files	Bhandari, S., A Graph-based Algorithm for Slicing Unstructured Mesh Files, Additive Manufacturing Letters, Vol. 3, Dec. 2022, 100056 (Open Access) https://doi.org/10.1016/j.addlet.2022.100056	05.21.2022	Published online.
Conference Paper	Overview of Thermoplastic Composites in Bridge Applications	Lopez-Anido, R., Davids, W., Bhandari, S., Sheltra, C.A., Erb, D.F., and Abdel-Magid, B., "Overview of Thermoplastic Composites in Bridge Applications," Structural Faults + Repair-2022 and European Bridge Conference-2022, 13 pp., June 20-23, 2022 Edinburgh, Scotland. https://www.structuralfaultsandrepair.com/	06.20-23.2022	Presented
Conference Paper	Technical Survey and Literature Review on Bridge Joint Monitoring Practices	Ren, D., Fils, P. Jang, S., Malla, R. M. (2022). "Technical survey and literature review on bridge joint monitoring practices." American Society of Engineering Education Northeast Conference 2022	04.23.2022	Presented 04.23.2022
Peer Reviewed Journal	Modeling the Impact of the COIVD-19 Pandemic on Speeding at Rural Facilities in Maine using Short-Term Speed and Traffic Count Data	Shahlaeegilan, A., Shirazi, M., Marshall, E., Ivan, J.N. (2021)	06.01.2022	In 2nd Review 03.31.2022; Accepted 06.30.2022
Peer Reviewed Journal	Leveraging Probe Data to Model Speeding on Urban Limited Access Highway Segments During the COVID-19 Pandemic	Marshall, E.,Shirazi, M., Shahlaeegilan, A., Ivan, J.N. (2022)	06.01.2022	Submitted
Peer Reviewed	Development, assessment and implementation of a novel FRP composite girder bridge.	Davids WG, Diba A1, Dagher HD, Schanck AP1 and Guzzi D1 (2022). Development, assessment and implementation of a novel FRP composite girder bridge. Construction and Building Materials, 340(July), 127818.	07.18.2022	Published
Conference Paper	Displacements and Loading of an Old Truss Railrod Bridge Under Service TRains Using a Laser Doppler Vibrometer	de Oliveira, C., Dhakal, S., and Malla, R.B., "Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains Using a Laser Doppler Vibrometer", Transportation Research Board (TRB) 2023 Annual Meeting, Washington, D.C., January 08-12, 2023	08.01.2022 (Date submitted)	Under Review
Conference Paper	Wireless Joint Monitoring System for New England's Highway Bridges	Jang, S., Fils, P., Ren, D., Wang, J., Han, S., Malla, R.B. (2022). " Wireless Joint Monitoring System for New England's Highway Bridges," 16th International Symposium of Functionally Graded Materials & Researchers and Professionals.	08.10.2022	In press

Peer Reviewed Journal	Investigation of Critical Factors for Future-proofed Transportation Infrastructure Planning Using Topic Modeling and Association Rule Mining	Chowdhury, S., and Zhu J. (2023). Investigation of Critical Factors for Future-proofed Transportation Infrastructure Planning Using Topic Modeling and Association Rule Mining. ASCE Journal of Computing in Civil Engineering, 37(1).	08.01.2022	Published September 30, 2022
Peer Reviewed Journal	Probabilistic Risk Assessment Framework for Predicting Large Woody Debris Accumulations and Scour near Bridges	W. Hughes, L. Santos, Q. Lu, R. Malla, N. Ravishanker, W. Zhang (202x.). "Probabilistic Risk Assessment Framework for Predicting Large Woody Debris Accumulations and Scour near Bridges." Under Review, Journal of Structure and Infrastructure Engineering.	08.07.2022 (submitted)	Under Review
Conference Presentation	Artificial Crack Depth Determination of Concrete Specimens Using Ground Penetrating Radar and Synthetic Aperture Radar		06.03.2022	Presented
Conference	Gas Mobility and Its Role in Emerging Ground Improvement Methods	Gallant, A., (2022). Gas Mobility and Its Role in Emerging Ground Improvement Methods. 2022 Chicago Geotechnical Lecture Series, May 5, 2022, Chicago, IL.	05.05.2022	Presented
Symposium	Development of High Performance Concrete Using Non-steel Fiber for Prestressed Concrete Crossties	Shin, M. Lee, C. and Parker, A. (2022) "Development of High Performance Concrete Using Non-steel Fiber for Prestressed Concrete Crossties", 2022 International Crosstie and Fastening System Symposium, 5/24-25/2022, Urbana, IL	05.24-25.2022	Presented
Conference Presentation	Prediction of Large Woody Debris Accumulations and Scour for Bridges in Flooding Events	Hughes, W. and Zhang, W. (2022) "Prediction of Large Woody Debris Accumulations and Scour for Bridges in Flooding Events" Oral Presentation, Engineering Mechanics Institute, Baltimore, MD	06.01.2022	Presented
Conference Presentation	Shrinking Fibers for Enhanced Durability of Concrete	Huston D., Gregory D., Allen J., Worley II R., Liu Z. (2022) "Shrinking Fibers for Enhanced Durability of Concrete" Engineering Mechanics Institute Conference, Johns Hopkins University, Baltimore, MD	06.02.22	Presented
International Conference	Fusing Infrared and Visible Images of Different Resolutions via Convolutional Neural Network	Z. Ameli and E.N. Landis, "Fusing Infrared and Visible Images of Different Resolutions via Convolutional Neural Network", presented by Zahra Ameli at EMI 2022, Baltimore, MD, June, 1, 2022.	06.01-03.2022	Presented
Conference	Speeding During Covid-19 Pandemic in Maine		05.29.2022-06.03.2022	Presented
Conference	Large Scale AM of Bio-Based Thermoplastic Formwork for Pre-Cast Concrete Panels		05.23-24.2022	Presented
Conference	Large-Scale Extrusion-Based 3D Printing for Highway Culvert Rehabilitation		05.24.2022	Presented
Conference Presentation	Sensing Textiles For Bridge Health Monitoring		05.25.2022	Presented

Webinar	Why FRP Composite Girders?	Davids. (2022). Why FRP composite girders? Overview of FRP Composite Girder Technology. TIDC, Orono, ME (Online).	06.06.2022	Presented
Webinar	Additional Development of the GBeam	Davids. (2022). Additional development of the GBeam. FRP Composite Girder Technology. TIDC, Orono, ME (Online).	06.27.2022	Presented
Conference	Wireless Joint Monitoring System for New England's Highway Bridges	Jang, S., Fils, P., Ren, D., Wang, J., Han, S., Malla, R.B. (2022). "Wireless Joint Monitoring System for New England's Highway Bridges," 16th International Symposium of Functionally Graded Materials & Researchers and Professionals.	08.08.2022 - 08.10.2022	Presented
Conference Presentation	A Risk-based Debris Prediction Framework for Riverine Bridges During Storms	W. Hughes, W. Zhang, "A Risk-based Debris Prediction Framework for Riverine Bridges During Storms." Oral and poster Presentation, 16th International Symposium on Functionally Graded Materials, Hartford, CT, August 2022	08.07-10.2022	Presented
Symposium	Development of High Performance Concrete Using Non-steel Fiber for Prestressed Concrete Crossties		08.7-10.2022	Presented
Conference Poster Presentation	Development of Protocols for Determining Deleterious material Content in Processed Glass Aggregate	Nutbeam, F., Scarborough, M., and Dewoolkar, M. (2022), "Development of Protocols for Determining Deleterious material Content in Processed Glass Aggregate" Poster presented at 2022 Transportation Infrastructure Durability Confernce.	08.09-11.2022	Presented
Symposium	The Impact of the Abutment Wall Height, the Bridge Span Length Range, and the Roadway Profile Grade on the Moment Profile and Lateral Displacement Profile of HP or W Piles Under Thermal Expansion in Intergral Abutment Bridges (IABs)		09.14.2022	Presented
Symposium	Development of Protocols for Determining Deleterious material Content in Crushed Recycled Glass	Nutbeam, F., Scarborough, M., and Dewoolkar, M. (2022), "Development of Protocols for Determining Deleterious material Content in Processed Glass Aggregate" Oral and Poster presentation at the 2022 VTrans Research Symposium.	09.14.2022	Presented
Symposium	Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Cementitious Material	Casavan A., Worley II R. Huston D., (2022) "Analyzing the Effect of Ground Glass Pozzolan as a Supplementary Cementitious Material" presented at VTrans Annual Research Symposium, September	09.14.2022	Presented
Conference	Successful Scaling of an Innovative Subgrade Stabilization Method in the Lab; What's Next/		08.11.202	Presented
Seminar	Large-Scale Extrusion-Based 3D Printing for Highway Culvert Rehabilitation		07.28.2022	Presented

Webinar	Wireless Joint Monitoring System for Highway Bridge Resilience	Jang, S. "Wireless Joint Monitoring System for Highway Bridge Resilience," part of Joint-SET Webinar Series, 9.23.2022	09.23.2022	Presented
Conference Poster Presentation	Probabilistic Risk Assessment of Bridge Vulnerability to Debris Accumulation and Scour	W. Hughes, W. Zhang, R. Malla, N. Ravishanker, "Probabilistic Risk Assessment of Bridge Vulnerabilty to Debris Accumulation and Scour." Transportation Infrastructure Durability Center (TIDC) Conference, August 022, Orono, ME	08.09-11.2022	Presented
Conference Poster Presentation	Data Driven Approach to Enhance Steet Sweeping in Urban Areas		08.09-11.2022	Presented
Conference Poster Presentation	Displacements and Loading Frequencies of an Old Truss Railroad Bridge Under Service Trains using a Laser Doppler Vibrometer	de Olivera, C., Dhakal, S., Raha, M., and Malla, R. B., "Field Testing and Finite Element Analysis of Two Old Truss Rilroad Bridges," 2022 TIDC Annual Conference, poster sessions, Orono, ME, August 9-12, 2022.	08.09-12.2022	Presented
Poster Presentation	Real Time Traffic Monitoring of Pedestrian Bridge Using Distributed Fiber Optic Sensing Textile		08.9-11.2022	Presented
Conference Presentation	Bridge Safety, Management, Life-Cycle, Resilience and Sustainability.	Davids WG and Schanck AP (2022). Field load testing and analysis of a new FRP composite tub girder bridge with a concrete deck. Bridge Safety, Management, Life-Cycle, Resilience and Sustainability. Casas, Frangopol and Turmo (Eds), pp. 1301-1310. Presented at The 11th International Conference on Bridge Maintenance, Safety and Management Barcelona, Spain, July 2022.	07.2022	Presented
Conference Presentation	Overview of thermoplastic composites in bridge applications.	Lopez-Anido R, Davids WG, Bhandari S, Sheltra C, Erb C and Abdel-Magid B (2022). Overview of thermoplastic composites in bridge applications. 2022 European Bridge Conference, Edinburgh, Scotland, June 2022.	06.2022	Presented
Conference Presentation	Field live load testing of a new FRP composite girder bridge.	Davids WG and Schanck AP (2022). Field live load testing of a new FRP composite girder bridge. Structures Congress 2022, Atlanta GA, April 2022.	06.06.2022	Presented
Webinar	An Introduction to Designing with Fiber-Reinforced Polymer (FRP) Composites for Civil and Environmental Engineers.	An Introduction to Designing with Fiber-Reinforced Polymer (FRP) Composites for Civil and Environmental Engineers. ASCE Live Online Training Course, April 4, 2022 (2.0 PDHs, one of three presenters).	04.04.2022	Presented