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

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

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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 – 9/30/2023

Reporting Period end date: 3/31/2020

Report term or frequency: Semi-Annual

Signature of submitting official:

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I. ACCOMPLISHMENTS

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

Research

The over-arching 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. Additional funding of $250,000 will be made available through an annual competitive RFP process.

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 bi-monthly progress reports for each research project to ensure performance is adequately tracked.

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 women and underrepresented racial and ethnic groups 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 STEM education by sharing research with future members of the workforce at middle and high schools. This will include both exposing young people to opportunities that exist within the field of transportation infrastructure and engaging them transportation-related educational activities.

Formal metrics to measure program effectiveness include numbers of undergraduate and graduate students participating in intra-consortium exchange initiatives or industrial internships; seminars, workshops, and conferences hosted; number of K-12 students who participate in transportation-focused tours or activities at member institutions; total number of classrooms reached by TIDC activities, including specifics on classrooms populated by under-represented groups of students.

Technology Transfer

The TIDC goals and performance metrics reflect the full spectrum of research activities through technology concept inception and assessment to technology adoption. The projects funded by TIDC will support the following technology transfer activities: (1) development of new technologies, techniques, or methodologies; (2) publishing journal, conference and policy papers that become references for practitioners for the modification of codes and standards for technology adoption; (3) deployment of new technologies, techniques, or practices; (4) improvements in the processes, technologies, and techniques in addressing transportation issues; (5) workforce development; (6) adoption of technologies, techniques, or practices; and, (7) development or modification of codes and standards to facilitate wider technology adoption.

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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 four research thrust areas; 1) monitoring and assessment, 2) new materials for longevity and constructability, 3) new systems for longevity and constructability, and 4) connectivity for enhance asset and performance management.

TIDC's technology transfer objectives are:

- Ensure research developments and findings are accessible, disseminated, and transferred to a variety of users.
- Ensure research developments have long-term value and significant impact to the transportation industry through collaboration with government and non-profit organizations.

Formal metrics to measure technology transfer goals include successfully demonstrated proof-of-concept; number of technical reports published; number of relevant papers published through peer-reviewed journals; number of relevant papers published in conferences, symposia, workshops, and meetings; number of technologies deployed in transportation applications through pilot or demonstration studies; number of research deliverables disseminated; number of webinars given; number of instances of technology adoption by Industry or transportation agencies and of commercialization; and, number of instances of research changing Industry or transportation agency practices, decision making, or policies.

As part of TIDC's Technology Transfer Plan (dated November 30, 2018) the following technology transfer goals and performance measures were established:

Table 2: Technology Transfer Goals & Performance Measures

Goal	Performance Metrics
Output: Development of new technologies, techniques, or methodologies	Successfully demonstrate proof-of-concept
Output: Publishing journal, conference and policy papers that become references for practitioners for the modification of codes and standards for technology adoption	Number of technical reports published
	Number of relevant papers published through peer-reviewed journals
	Number of relevant papers published in conferences, symposia, workshops, and meetings
Outcome: Deployment of new technologies, techniques, or practices	Number of technologies deployed in transportation application through pilot or demonstration studies
Outcome: Improvements in the processes, technologies, and techniques in addressing transportation issues	Number of research deliverables disseminated
Impact: Workforce development	Number of webinars given
Impact: Adoption of technologies, techniques, or practices	Number of instances of technology adoption by industry or transportation agencies and of commercialization
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

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Collaboration

Institutional leads will serve on the TIDC Management Team which will help to ensure each institution has ownership 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 has a Technical Champion. The Technical Champion has subject matter expertise and serves as a resource for the principal investigators. The Technical Champion will help integrate the research results into DOT or Industry practice and will help with the implementation or project results during and after the research. 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. As more projects are added and advanced, the number of Technical Champions and their contributions will change. See table 5 on page 10 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 within its designated Fast Act topic. The Advisory Board evaluates and recommends the disbursement of competitive funding through an open RFP process to support additional activities at member universities. The Advisory Board also reviews TIDC's annual performance metrics from each member university to determine the status of performance based base funded projects. The Advisory Board is currently comprised of members from state DOTs in Region 1.

Formal metrics to measure collaboration goals include presentations given at non-member universities, documented conversations regarding collaboration between TIDC and other UTCs, the number of industrial partners and state DOTs participating in TIDC research, dollar amount of state DOT and industry invested into 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 periodic 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 31 projects that were active during the reporting period. One project (2.3) was unable to conduct research (see section VI for more information) and one project (1.1) completed work during the reporting period. See Table 3 for a list of all TIDC funded research projects that were active during the reporting period. (* indicates projects that completed work 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		
1.1 – Field Live Load Testing and Advanced Analysis of Concrete T-Beam Bridges to Extend Service Life *	University of Maine	7/1/2018

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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
1.11 – Energy Harvesting and Advanced Technologies for Enhanced Life	University of Rhode Island	7/1/2018
C3.2018 – Condition Assessment of Corroded Prestressed Concrete Bridge Girders	University of Massachusetts Lowell & Western New England University	1/1/2019
C5.2018 – Leveraging High-Resolution LiDAR and Stream Geomorphic Assessment Datasets to Expand Regional Hydraulic Geometry Curves for Vermont: A Blue Print for New England States	University of Vermont	6/1/2019
C11.2019 – Development id system-Level Distributed Sensing Technique for Long-Term Monitoring of Concrete and Composite Bridges	University of Massachusetts Lowell, University of Vermont, University of Maine	Project has been selected but start has been delayed
Thrust Area 2: New Materials for Longevity and Constructability		
2.1 – Asphalt Mixtures with Crumb Rubber Modifier for Longevity and Environment	University of Rhode Island	7/1/2018
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
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		
3.4 – Testing, Monitoring, and Analysis of FRP Girder Bridge with Concrete Deck	University of Maine	3/1/2019

3.5 – Prevention of Stressed-Induced Failures of Prestressed Concrete Crossties of the Railroad Track Structure	Western New England University	9/1/2018
3.6 – Optimal Design of Sustainable Asphalt Mixtures with RAP	University of Rhode Island	7/1/2018
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
3.8 – Bridge Modal Identification via Video Processing and Quantification of Uncertainties	University of Massachusetts Lowell	11/1/2018
3.11 – Assessment of Micropile-Supported Integral Abutment Bridges	University of Maine	9/1/2019
3.12 – Lateral Loading of Unreinforced Rigid Elements and Basal Stability of Column-Supported Systems	University of Maine	6/1/2019
C9.2019 – A New Method for Determining Payment for In-Pace Concrete with Double-Bounded Compressive Strength Pay Factors	University of Vermont	Project has been selected but start has been delayed
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
4.7 – Integrated Green Infrastructure and Sustainable Transportation Planning	University of Rhode Island	7/1/2018

The following accomplishments have been achieved during the reporting period:

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

Project 1.1 (UMaine): The research team completed work on this project and submitted their final report to MaineDOT. A journal article was published highlighting the development of a novel finite-element analysis technique for predicting the load capacity of older, reinforced T-beam bridges that indicates many of these structures are structurally sufficient. The MaineDOT is using the improved load ratings determined from this study for bridge posting and closure decisions.

Project 1.2 (UConn): Baseline tensile stress-strain material behavior for the 115 year old Cos Cob steel railroad bridge in Greenwich, CT has been determined. Testing methods have been established and validated.

Project 1.5 (UMass Lowell): The research team successfully installed sensing textile to the bottom of the Salmon Falls River Bridge and completed testing the Brillouin Frequency signals under different

conditions. The strain noise caused by the different system parameters has been studied and the temperature impact on the system has been analyzed. By comparing the Brillouin Frequency Shift, the team is able to identify the loading condition of the bridge.

Project 1.11 (URI): The research team was able to successfully produce voltage from the copper plated solar energy harvesting apparatus they designed and built based on studies conducted in Europe and Texas. The team was also able to attach a sensor to the circuit board to enable data collection.

Project 3.6 (WNEU): The research team was able to produce high-strength concrete for railroad concrete crossties. Using the developed concrete, the team was able to successfully conduct pull-out tests with three different prestressing wires: 1) smooth, 2) shallow chevron indentation, and 3) deeper chevron indentation. The team was also able to conduct a large scale simulation based on their updated algorithm. This simulation allows the team to model a real size concrete crossties with a larger set of problems to identify how bond-slip characteristics can affect the performance of railroad crossties.

Project 4.4 (UVM): The research team built a 2D HEC-RAS model for the Mad River site in VT and calibrated it for the 2011 Tropical Storm Irene event. The calibration allows for sensitivity analysis which helps in identifying structural, hydrogeological, and landscape features of importance in the stream network.

Additionally, in March 2020, TIDC released the 2020 Request for Proposals for both competitively funded projects and base-funded projects on the TIDC website and through an email blast sent to TIDC researchers and Advisory Board members. Both groups have sent the solicitation to colleagues within their universities and to other universities within Region 1, including the University of New Hampshire. Through the 2020 Request for Proposals, TIDC is seeking proposals from universities in Region 1 for research relevant to one of the four thrusts that will address enhanced durability and life extension of infrastructure and add long-term and real-world value to the transportation industry in New England and beyond. Proposals are due June 15, 2020 and will be sent to the Advisory Board and external, content expert reviewers. Upon completion of the review process, notifications of award will be sent on August 30, 2020.

Education & Workforce Development

The TIDC Program Coordinator has completed the creation of the curriculum to be turned into an approved 4-H STEM toolkit. While existing 4-H STEM Toolkits provide an experiential science learning opportunity for youth by providing materials needed to successfully complete science-based activities, TIDC's transportation related toolkit will be used to encourage youth to learn more about the transportation industry. The curriculum was scheduled to be piloted beginning in February and March of 2020 in four classrooms at an elementary school in Orono, ME. After the completion of the pilot, TIDC Administration at UMaine was to meet with the elementary school teachers to receive feedback and make recommended adjustments to the curriculum before releasing the curriculum to the rest of the school and additional elementary schools in the State of Maine. The goal was to have a completed curriculum to be implemented throughout all of the classroom in this elementary school and to add 3 more elementary schools to that list for the fall of 2020. Unfortunately, due to the closing of schools for the remainder of the 2019-2020 school year in response to the COVID-19 pandemic, the curriculum implementation has been tentatively rescheduled for fall 2020 with further school involvements planned for spring 2021. It is TIDC's

goal to receive final approval in the fall of 2021 for an official 4-H toolkit that can be distributed to schools in the state of Maine and other 4-H participating states in Region 1.

Additionally, in an effort to meet the goals of TIDC and the US DOT to encourage more individuals to join transportation related fields, member universities will be offering internship opportunities to high school students. WNEU is the first university to have a high school intern join their team. The senior from Minnechaug Regional High School joined the team to study the relations between environmental changes and transportation infrastructure with the aim of presenting her findings to local middle and high school students. Unfortunately, due to the COVID-19 pandemic, she was unable to complete her internship.

Student researchers at member universities have been disseminating research findings through poster presentations, seminars, and conferences. For example, and student from UConn led a presentation at the Structures and Applied Mechanics Seminar Series at UConn in February 2020 and led a presentation at the 32nd Rhode Island Transportation Forum in October 2019. Additionally, a former UVM graduate student (May 2019 degree date) presented findings at the TRB Annual Meeting in Washington D.C. this January. TIDC was also pleased to award Andrew Schanck the TIDC Student of the Year Award for his research efforts that were detailed at the TIDC Annual Conference. Additionally, TIDC faculty are incorporating their research findings into their course curriculum each semester. For example, a lecture was given in UMaine's Numerical Methods course about the mathematical optimization aspects of Andrew Schanck's research. TIDC faculty taught 20 undergraduate courses and 22 graduate courses during the reporting period.

Technology Transfer

TIDC research results have been disseminated through a variety of ways including the TIDC website and social media platforms.

TIDC researchers have participated in 16 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
STEM Complex Celebration	Symposium – Presentation	Burlington, VT	10/4/2019
UMaine Mechanical Engineering Seminar Series	Seminar – Presentation	Orono, ME	10/18/2019
32nd Rhode Island Transportation Forum	Conference – Presentations	Kingston, RI	10/25/2019
8th International Conference on Through-Life Engineering Services	Conference – Presentation	Cleveland, OH	10/28/2019-10/29/2019
2019 Maine Transportation Conference	Conference – Presentation	Augusta, ME	12/5/2019
2019 Accelerated Bridge Construction Conference	Conference – Presentation	Miami, FL	12/12/2019-12/13/2019
International Seminar in Civil Engineering	Seminar – Presentation	Chungli, Taiwan	12/19/2019
Chung Yuang University School of Engineering Seminar	Seminar – Presentation	Chungli, Taiwan	12/20/2019

The 2020 TRB Annual Meeting	Conference – Live Presentations and Poster Presentation	Washington, DC	1/12/2020-1/16/2020
ASCE Construction Institute Summit	Conference – Presentation	Los Angeles, CA	2/20/2020-2/22/2020
Geo-Congress 2020, Annual Conference of ASCE	Conference – Presentation	Minneapolis, MN	2/25/2020-2/28/2020
Structures and Applied Mechanics Seminar Series	Seminar – Presentation	Storrs, CT	2/28/2020
ASCE Construction Research Congress	Conference – Poster Presentation	Tempe, AZ	3/9/2020
UConn School of Engineering Annual Poster Competition	Poster Presentation	Storrs, CT	3/11/2020
Hipermat 5, 2020	Conference – Presentation	Kassel, Germany	3/11/2020
ACI Spring Convention	Conference – Presentation	Web-Teleconference	3/30/2020

Additionally, TIDC has published or submitted 8 journal papers/articles, 9 conference papers, 2 conference abstracts, and 3 other publications and has held 9 other 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.

During this reporting period, the TIDC Management Team met each month, with the exception of December, for a total of five meetings. Four of the five meetings were held via Zoom and one meeting in November acted as the Semi-Annual in-person meeting for the Management Team in conjunction with the Semi-Annual Advisory Board meeting. During the Advisory Board meeting, Advisory Board members met the new TIDC Senior Program Manager and discussed project selection for the 2019 Competitive Solicitation and the research needs of their states. The in-person Management Team meeting provided an opportunity for the Institutional Leads to meet the new TIDC Senior Program Manager and discuss collaborative research projects.

Equally as important to the collaboration with the TIDC Advisory Board and the inter-institutional collaboration is the collaboration that happens with the Technical Champions (TC), industry partners, and State DOT collaborators. 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 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. For example, the research team for Project 2.5 (UConn) met with their TCs at ConnDOT in October 2019 to discuss the direction of their project and its priorities to enhance the impact of their research towards product development, implementation, and application. Two new research aims were identified as a result of this meeting.

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The following table identifies the 34 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 6: Active Technical Champions & Advisors	
Name and Title of Technical Champion or Advisor	**Organization**
Andrew Bardow, Director, Bridges and Structures	Massachusetts Department of Transportation
Mary Baker, Transportation Principal Engineer*	Connecticut Department of Transportation
Raymond Basar, *	Connecticut Department of Transportation
Warren Best, Assistant Deputy Director, Structures*	Metro-North Railroad Company
Steven Cascione, Programming Services Officer	Rhode Island Department of Transportation
Henry Chango, Contract Administrator	D'Ambra Construction Company, Inc.
Bao Chuong, *	Connecticut Department of Transportation
Brian Clang, Bridge Inspection Engineer	Massachusetts Department of Transportation
Cassidy Cote, Hydraulics and Structures Engineer	Vermont Agency of Transportation
Haresh Dholakia, Transportation Engineering Supervisor*	Connecticut Department of Transportation
Manesh Dodia, Transportation Engineer*	Connecticut Department of Transportation
Callie Ewald, P.E., Geotechnical Engineering Manager	Vermont Agency of Transportation
Karen Gross, Geotechnical Engineer	Maine Department of Transportation
Joshua Hasbrouck, Civil Engineer, Bridge Program	Maine Department of Transportation
Dr. Wilfred Hernandez, P.E., Safety Specialist/EDC Coordinator	Federal Highway Administration – Rhode Island Division
Garrett Kilfoyle, Assistant Engineer, Bridge Maintenance	Maine Department of Transportation
Brandon Kipp, Project Manager, Pavement Management Section	Vermont Agency of Transportation
John Kocur, Director of Engineering	Sperry Rail Service
Laura Krusinski,	
James Lacroix, P.E., State Bridge Design Engineer	Vermont Agency of Transportation
John Moran, Deputy Chief of Performance and Asser Management, Director of Asset Management	Massachusetts Department of Transportation
Sam Maxim, Bridge Maintenance Engineer	Maine Department of Transportation
Andrew Mrockowski, Transportation Engineer	Connecticut Department of Transportation
Dale Peabody, Director, Transportation Research	Maine Department of Transportation
Paul C. Petsching, P.E., Senior Civil Engineer	Rhode Island Department of Transportation
Michael Redman, Business Systems Manager, Concrete Quality Control Specialist, Bridge Program*	Maine Department of Transportation
Karen Riemer, Asset Management Group*	Connecticut Department of Transportation
Aaron Schwartz, Hot Mix Asphalt Engineer	Vermont Agency of Transportation
Rite L. Seraderian, P.E., FPCI, LEED AP, Executive Director	Precast/Prestressed Concrete Institute Northeast

Nick Ward, P.E., Hydraulics Engineer, Project Delivery Bureau, Structures	Vermont Agency of Transportation
James Wild, Concrete Materials Manager	Vermont Agency of Transportation
Dr. Kathleen Wilson, P.E., Chief Civil Engineer	Rhode Island Department of Transportation
Mark Woolander, Pavement Engineer	Vermont Agency of Tranportation
Hailing Yu, Civil Engineer	U.S. DOT Volpe Center

The following table identifies the 47 active collaborations and stakeholders and their contributions during the reporting period. (* indicates new project collaborators during this period)

Table 5: Research Project Collaborators		
Organization	**Location**	**Contribution**
AAIS Corporation	West Haven, CT	Facilities, personnel
ADAPT Corporation	Redwood City, CA	In-kind
AIT Bridges, a division of Advanced Infrastructure Technologies	Orono, ME	In-kind, collaborative research, personnel, facilities
American Concrete	Auburn, ME	Financial, facilities, collaborative research
Amtrak	Philadelphia, PA	Collaborative research, personnel
Argonne National Laboratory	Lemont, IL	Collaborative research, personnel
ATANE Consulting	Wethersfield, CT	Collaborative research, personnel
City of Lowell	Lowell, MA	Collaborative research, facilities, personnel
Connecticut Department of Transportation	Newington, CT	Collaborative research, personnel
Connecticut Manufacturing Simulation Center	Storrs, CT	In-kind, facilities
Connecticut Transportation Institute	Storrs-Mansfield, CT	Collaborative research
Deep Foundations Institute	Hawthorne, NJ	Financial
Federal Highway Administration – Rhode Island Division	Providence, RI	Collaboration with outreach efforts
Geophysical Survey Systems, Inc. (GSSI)*	Lowell, MA	Collaborative research, personnel
GPC Applied Technologies Inc.		In-kind
Intergraph Corporation	Madison, AL	In-kind
Jacobs Engineering*	Herndon, VA	In-kind
Kleinfelder Inc.	Augusta, ME	Personnel
Lafarge Holcim*		In-kind
Lehigh Cement*		In-kind
Maine Department of Transportation	Augusta, ME	In-kind, collaborative research, financial, personnel, equipment
Massachusetts Department of Transportation	Boston, MA	Collaborative research, personnel
McInnis Cement	Montreal, Quebec, Canada	Collaborative research
Metro-North Railroad Company	Bridgeport, CT	Collaborative research, facilities, personnel
National Center for Supercomputing Applications*	Urbana, IL	In-kind

New Hampshire Department of Transportation	Concord, NH	Collaborative research, personnel
Oak Ridge National Laboratory	Oak Ridge, TN	In-kind, collaborative research, personnel, facilities
Omnisens	Morges, Switzerland	Collaborative research, personnel, equipment
Pike Industries, Inc	VT, NH	Equipment
Precast/Prestressed Concrete Institute Northeast (PCINE)	CT, MA, ME, NH, NY, RI, VT	Collaborative research, personnel
Rhode Island Department of Transportation	Providence, RI	Collaborative research, personnel
Saint-Gobain*	Northborough, MA	In-kind
Sperry Rail Service	Shelton, CT	Collaborative research, in-kind, facilities, personnel
Steelike Concrete	Springfield, VA	In-kind
Superior Concrete*	Auburn, ME	Financial, facilities, collaborative research
Texas Advanced Computing Center*	Austin, TX	Facilities
The Nature Conservancy of Vermont	Montpelier, VT	Collaborative research, personnel
Tilcon Connecticut		In-kind
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
Urban Mining Northeast	New Rochelle, NY	In-kind
Vermont Agency of Natural Resources	Montpelier, VT	Collaborative research, personnel
Vermont Agency of Transportation	Montpelier, VT	In-kind, collaborative research, personnel, financial
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 individual Semi-Annual Progress Reports are available at https://www.tidc-utc.org/research/tidc-funded-projects-and-reports/. Information was shared at conference presentations, including the 1st TIDC Annual Conference (see table 4 on page 8 for a complete list of Conferences and Workshops). Further results were disseminated through journal articles, professional magazines, and meetings with New England State DOTs. Additionally, research findings are being disseminated in undergraduate and graduate courses at each university.

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

Research

TIDC will continue to start new, relevant, and innovative research projects. During the next reporting period, the review of the 2020 Request for Proposals will be completed and the awards will be announced on August 30, 2020. The performance of current research projects will continue to be evaluated against the mission, goals, and objectives of TIDC. Some of the goals for TIDC funded projects are as follows:

Project 1.2 (UConn) plans to have a complete FE model of the Cos Cob Bridge and plans to begin field testing during the 2020 summer months.

Project 3.4 (UMaine): Installation of the first Composite Tub (CT) Girder bridge system is planned for summer 2020 in Hampden, Maine. The research team will observe and monitor the mobilization of the CT Girders for construction and will be on-site to observe their installation. The team is working with Dr. Yu at UMass Lowell to install sensors before the installation on the bridge to ensure continuous monitoring of the CT Girders from the date of installation.

Education & Workforce Development

TIDC personnel at UMaine have created a partnership with a local elementary school to begin the process of implementing transportation related activities into their curriculum. The pilot of the activities is expected to begin in fall 2020 with activities in four classrooms. After this pilot, the program is expected to be delivered to the entire school in by January 2021.

TIDC personnel at UMaine are also working to create better partnerships with MaineDOT, industry leaders in Maine, and Maine Community Colleges to create more opportunities for workforce development in the state and beyond. A forum for collaboration is planned for fall of 2020. The goal of this forum is to allow TIDC personnel and researchers to better understand the needs of DOTs and industry in regards to workforce development. Focus will be placed on infrastructure durability needs to match with the goals and objectives of TIDC.

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.

Technology Transfer

To accomplish TIDC's technology transfer objectives identified in Section I. a., Technology Transfer (pg. 2), the following venues and mechanisms will be employed: (1) a TIDC website and social media accounts that promote findings and opportunities for collaboration directly to the public; (2) widely disseminated, online TIDC bi-annual newsletters to begin in 2020; (3) the expansion of the TIDC Annual Conference through early advertising and outreach activities in New England; (4) continued participation in regional transportation conferences (i.e. the Maine Transportation Conference hosted by the Maine DOT, the Rhode Island Transportation Conference hosted by URI, and others as appropriate); and (5) promotion of all market-ready technology transfer opportunities through industry/trade publications, the TIDC website and social media accounts.

TIDC will continue to update the Center website and social media accounts to inform the public of TIDC activities, workshops, and research. Publications and papers will be submitted for conferences

and publication in journals. TIDC principal investigators will attend conferences and workshops to disseminate research findings.

Collaboration

Principal Investigators and TIDC Management team members will continue to collaborate with state DOT 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. Additionally, the TIDC Management Team and the TIDC Advisory Board will be meeting in November 2019 to discuss the TIDC program and the expansion efforts for greater success. Also, to help with the goal of expanding the next TIDC Annual Conference for more collaboration opportunities, the dates and location for the 2020 conference have been selected (June 3-4, 2020 at UMass Lowell).

II. PARTICIPANTS & COLLABORATING ORGANIZATIONS

a. What individuals have worked on the project?

In total, 43 principal investigators, faculty, administrators, and management team members and 80 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, Dr. Warda Ashraf, Kathryn Ballingall, Dr. Keith Berube, James R. Bryce, Amanda Collamore, Dr. Bill Davids, Dr. Aaron Gallant, Dr. Douglas Gardner, Dr. Andrew Goupee, Dr. Yousoo Han, Dr. Hosain Haddad Kolour, Dr. Eric Landis, Dr. Roberto Lopez-Anido, Vu Phan, and Dr. Jonathan Rubin.	Nicholas Alvarez, Danilo Botero-Lopez, Sunil Bhandari, Peta Fifield, Sheldon Green, SK Belal Hossen, Mohammad Rakibul I. Khan*, Braedon Kohler, Sebastian Montoya, Anthony Salafia, Andrew Schanck, Parry Seddiqi, Kelsey Weir, and Ryan Worster.
University of Connecticut	Dr. Ramesh Malla, Dr. Jiong Tang, Dr. Kay Wille, Dr. Jin Zhu, and Dr. Song Han	Cydney Alexis, Areej Althubaity, Ethan Beattie, Chris Boisvert-Cotulio, Alexander Biron, Mark Castaldi, Sudipta Chowdhury, Celso de Oliveira, Suvash Dhakal, Alex Distelman, Douglas Hendrix, Xinyan Huang, David Jacobs,

		Bradley Kelle, Salvatore Luzzi, Meghan Palumbo, Kelly Quinn, Bijaya Rai, Zheng Ren, Jeet Rosa, Deepa Shukla, Sachin Tripathi, Jason Trieu, Jiachen Wang, Weiqi Wang*, Yixin Yao, Yang Zhang
University of Massachusetts Lowell	Dr. Tzuyang Yu, Dr. Xingwei Wang, Dr. Susan Faraji, and Dr. Zhu Mao	Hamed Abshairi, Ahmed Alzeyadi, Roman Bates, Andres Miguel Biondi Vaccariello, Celso doCabo, Harsh Gandhi, Xu Guo, Jade Man, Hao Peng, Aral Sarrafi, Matt Southwick, Qixiang Tang, Mark Todisco, Nick Valente, Sanjana Vinayaka, Rui Wu, Xiaoyu Zhang, and Jingcheng Zhou*
University of Rhode Island	Dr. K. Wayne Lee, Dr. Michael Greenfield, Dr. Sze Yang, Dr. George Veyera, Dr. Natacha Thomas, Dr. Christopher Hunter, and Dr. Farhad Atash	Mohammad Alotaibi, Appy Appolonia, Austin DeCotis, Masoud Farahmarzi, Mason Hyde, Ali Sahraei Joubani, and Mathew Schryver*
University of Vermont	Dr. Mandar Dewoolkar, Dr. Ehsan Ghazanfari, Dr. Ting Tan, Dr. Dryver Huston, Dr. Donna Rizzo, Dr. Arne Bomblies, Dr. Hamid Ossareh, and Dr. Kristen Underwood	Maziar Foroutan, Ahmad Ghazanfari, Diarmuid Gregory, Zhuang Liu, Sienna Roberge, and Rachel Seigel
Western New England University	Dr. Moochul Shin and Dr. ChangHoon Lee	Matthew Colonna, Cameron Cox, Abdoulaye Diallo, Alexis Herrera Andrew Masullo, Nicholas Pantorno, and Caleb Tourtelotte,

b. What organizations have been involved as partners?

During the process of selecting research projects, TIDC has received commitments of support and matching funds from 47 collaborators during this reporting period. The type of support provided by the collaborators varies from in-kind, financial, equipment, to supplies. In addition, many collaborators provide direct personnel links in research through Technical Champions (see below for further information). See table 5 on page 10 and table 6 on page 11 for an overview of the collaborators on TIDC research projects and what they have contributed.

c. Have other collaborators or contacts been involved?

The University of Vermont's Physics department has provided equipment for testing.

III. OUTPUTS

a. Publications, conference papers, and presentations:

The following table includes a list of the accepted and submitted papers and reports and presentations given during the reporting period:

REV:4/30/2020

Table 8: Publications, Conference Papers, and Presentations				
Type	**Title**	**Citation**	**Date**	**Status**
Conference Paper	Synthetic Aperture Radar Imaging of Concrete Cracking	Synthetic Aperture Radar Imaging of Concrete Cracking. SPIE Smart Structures/NDE Conference.	10/17/2019	Accepted
Conference Paper	Determining response of a Railroad Bridge using Limited Number of Sensors	Dhakal, S., Tripathi, S., and Malla, R.B. "Determining response of a Railroad Bridge using Limited Number of Sensors," 37th Annual International Bridge Conference, Pittsburgh, PA, June 8-11, 2020	10/21/2019	Under Review
Conference Paper	Specification-based Detection of Rank-related Attacks in RPL-Based Resource-constrained Real-Time Wireless Networks	Areej Althubaity, Tao Gong, Kim-Kwang Raymond, Mark Nixon, Reda Ammar, Song Han, "Specification-based Distributed Detection of Rank-related Attacks in RPL-based Resource-Constrained Real-Time Wireless Networks", accepted and to appear in the 3rd IEEE International Conference on Industrial Cyber-Physical Systems (ICPS 2020).	10/23/2019 3/31/2020	Under Review Accepted
Conference Paper	Geo-statistical evaluation of the intelligent compaction performance in a reclaimed base project	Foroutan, M., Ghazanfari, E., Geo-statistical evaluation of the intelligent compaction performance in a reclaimed base project, 4th International Conference on Transportation Geotechnics, August 30-September 2, 2020; Chicago, Illinois	11/30/2019	Under Review
Webinar	Emergence of Resilience from Network Dynamics in Civil Infrastructure Project Systems	Zhu, J. (2019). Emergence of Resilience from Network Dynamics in Civil Infrastructure Project Systems. *University of South California iLab Research Webinar*. December, 2019.	12/2/2019	Presented
Presentation	Development and Implementation of a Hybrid FRP-Concrete Girder Bridge	"Development and Implementation of a Hybrid FRP-Concrete Girder Bridge." Presented at the *2019 Maine Transportation Conference*, Augusta, ME, December 2019.	12/5/2019	Presented

Presentation	Future-Proofing Transportation Infrastructure	Zhu, J. (2019). Future-Proofing Transportation Infrastructure. *NSF Research Coordination Network on Sustainable Human-Building Ecosystem working group meeting*. Cleveland, OH. December 2019.	12/9/2019	Presented
Presentation	Design, fabrication and testing of hybrid composite-concrete bridge girder system	Davids WG, Diba A and Dagher HJ (2019). Design, fabrication and testing of hybrid composite-concrete bridge girder system. *2019 Accelerated Bridge Construction Conference*, Miami, FL, December 2019.	12/12/2019-12/13/2019	Presented
Presentation	Hydraulic Interdependence Between Bridges along a River Corridor	Trueheart, M. E., Dewoolkar, M. M., Rizzo, D. M., Huston, D. R., and Bomblies, A. (2020), "Hydraulic interdependence between bridges along a river corridor," *Transportation Research Board Annual Meeting*, January 12-16, 2020, Washington, D.C.	1/12/2020-1/16/2020	Presented
Peer-Reviewed Conference Paper	Elemental Testing of Carbonated Silty Sand Treated with Lime	Hossen, S.B., Gallant, A.P., and Ashraf, W. (2020). Elemental Testing of Carbonated Silty Sand Treated with Lime. *Geo-Congress 2020*, ASCE, Minneapolis, MN, pp. 562-571.	2/21/2020	Published
Conference Paper	A Conceptual Framework for Understanding the Relationships between Transportation Infrastructure and Human Resilience	Zhu. J., Zhang, L., Ren, Z. (2020). How Transportation Infrastructures Enable Human Resilience: Towards a Conceptual Framework. ASCE Construction Research Congress, March 8-10, 2020, Tempe, AZ.	3/8/2020	Accepted

Additionally, all TIDC projects were presented in April 2020 for the first round of quarterly presentations. In addition to researchers and TIDC Advisory Board members, PIs invited guests from outside collaborators.

b. Journal publications:

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

Table 9: Journal Articles and Publications

Title	Citation	Date	Status
Enhancing the Interlayer tensile strength of 3D printed	Bhandari, S., Lopez-Anido, R.A. & Gardiner, D,J., 2019. Enhancing the Interlayer tensile	11/1/2019	Accepted

short carbon fiber reinforced PETG and PLA composites via annealing	strength of 3D printed short carbon fiber reinforced PETG and PLA composites via annealing. *Additive Manufacturing*, 30, p.100922		
Elasto-Plastic Finite element Modeling of Short Carbon Fiber Reinforced 3D Printed Acrylonitrile Butadiene Styrene Composites	Bhandari, S., Lopez-Anido, R.A. & Gardiner, D,J., 2019. Elasto-Plastic Finite element Modeling of Short Carbon Fiber Reinforced 3D Printed Acrylonitrile Butadiene Styrene Composites. *JOM*, 72(1), 475-484	11/1/2019	Accepted
Live Load Response of Eyebars on a Very Old Steel Truss Railroad Bridg	Jacobs, D.W., Dhakal, S., and Malla, R. B., "Live Load Response of Eyebars on a Very Old Steel Truss Railroad Bridge." ASCE Journal/ Practice *Periodical on Structural Design and Construction*.	12/20/2019	Submitted and in Revision
Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials	C.H. Lee, S.J. Lee, M. Shin, and S. Bhattacharya, "Interrelation of Morphological Indices and 2-D Generalized Regularity for Coarse Aggregate in Cement-Based Materials," *Construction and Building Materials*, 2019	12/31/2019	2nd Review
Field Observations and Analysis of the Subgrade Response beneath GRCS Embankments at the Council Bluffs Interchange System	Gallant, Aaron, Ehab Shatnawim and Danilo Botero-Lopez. 2019. "Field Observations and Analysis of the Subgrade Response beneath GRCS Embankments at the Council Bluffs Interchange System." *Journal of Geotechnical and Geoenvironmental Engineering* (in press).	1/2020	Accepted
Capacity assessment of older concrete t-beam bridges by nonlinear proxy finite-element analysis	Schanck, A. & Davids, W. (2020) Capacity assessment of older concrete t-beam bridges by nonlinear proxy finite-element analysis. *Structures*, 23 (2020) 267-278	2/1/2020	Published
Subsurface characterization of moisture content and the water-to-cement ratio of concrete specimens using synthetic aperture radar imaging	A.Alzeyadi, T. Yu, (2020). Subsurface characterization of moisture content and the water-to-cement ratio of concrete specimens using synthetic aperture radar imaging, *Journal of Applied Remote Sensing*.	3/37/2020	Published

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 and Presentations

Type	Title	Citation/Description	Date	Status
Magazine Article	Better bridges and roads: UMaine-led research coalition tackles the future of transportation	"Better bridges and roads: UMaine-led research coalition tackles the future of	10/28/2019	Published

		transportation". *Mainebiz*, October 28, 2019.		
Report	Investigation of Behavior of Skewed and Unskewed Reinforced Concrete T-Beam Bridges and Load Rating Improvement through Proxy Finite Element Analysis	Schanck, A. (2019) Investigation of Behavior of Skewed and Unskewed Reinforced Concrete T-Beam Bridges and Load Rating Improvement through Proxy Finite Element Analysis. Orono, ME: University of Maine Report No. 20-20-1613.	12/20/2019	Final Report Submitted to MaineDOT
Report	Field Live Live-Load Testing and Advanced Analysis of Concrete T-Beam Bridges to Extend Service Life	Schanck, A., Davids, W. Field Live Live-Load Testing and Advanced Analysis of Concrete T-Beam Bridges to Extend Service Life. University of Maine: Orono, ME.	1/31/2020	Final Report Submitted to MaineDOT

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
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:

Project 1.1 (UMaine): The findings of this research project has resulted in an increased understanding of the behavior of reinforced concrete T-beam bridge behavior through diagnostic live-load testing. In particular, it examined the differences between the behavior of skewed and unskewed structures and resulted in improved rating factors for a collection of five such structures. In addition, a method by which older, reinforced concrete bridge structures can be load-rated with a higher degree of accuracy than is available through conventional beam-line analysis. This method uses a novel finite element modeling technique to account for the considerable post-elastic capacity and ductility of these structures, resulting in increased rating factor over both conventional analysis and diagnostic live-load testing in most cases. The MaineDOT is considering use of the results of the nonlinear analysis results for bridge posting decisions.

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

Nothing to report.

IV. OUTCOMES

Project 1.1 (UMaine): As a result of this research, the load ratings of five reinforced concrete T-beam bridges were improved through an increased understanding of their behavior. This has effectively removed most of these bridges from the list of structures in need of posting or other remedial action by the Maine Department of Transportation.

V. IMPACTS

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

Project 1.1 (UMaine): The removal of several bridges from the list of structures in need of remedial action (for instance load posting, repair, or replacement) has allowed the MaineDOT to allocate scarce resources elsewhere and has mitigated potential costs to the general public due to construction and repair delays.

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 has published a number of journal papers which have made an impact on the body of engineering and scientific knowledge. For example, Project 1.1 (UMaine) had impact on effectiveness by reducing bridges that need posting or repair and saving Maine money. This was possible, however, because the basic research conducted as part of this project that was disseminated in our journal paper.

d. What is the impact on transportation workforce development?

Nothing to report.

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:

Due to the COVID-19 pandemic, TIDC member Universities were required to close their labs. This has caused delays in research for many of the TIDC funded projects. Researchers are working with their University Administrators to identify an appropriate timeline to begin safely working in their respective labs. Work being conducted on the projects is focused on tasks that can be completed remotely. Testing of specimens and field work will continue once it is deemed safe to do so. Also, Project 2.3 (UVM) was unable to run during the reporting period due to testing equipment failure. The project is currently under review to decide what steps to take going forward. No charges have been made against this project to date. Lastly, Project C7.2018 had a change of PI due to Dr. Ashraf accepting a position at a university outside of the region. Dr. Eric Landis is now acting as the project's PI and Dr. Ashraf will collaborate and provide suggestions and guidance as needed.

c. Changes that have a significant impact on expenditures:

We are currently evaluating the impact of pandemic safeguards on laboratory operations.

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.