Semi-Annual Progress Report for University Transportation Centers

Submitted to	Office of the Assistant Secretary for Research and Technology
Federal Grant Number	69A3552348330
Project Title	Coastal REsearch And Transportation Education University Transportation Center (CREATE-UTC)
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Submitting Official	Same as above
Submission Date	10/31/2024
DUNS	07-460-2368
EIN	74-6002248
Recipient Organization	Texas State University
Project / Grant Period	Start Date: June 1, 2023 End Date: May 31, 2029
Reporting Period Start Date	April 1, 2024
Reporting Period End Date	September 30, 2024
Report Term or Frequency	Six months
Signature	

1. ACCOMPLISHMENTS

1.1 What are the major goals of the program?

Coastal REsearch And Transportation Education (CREATE) is a Tier 1 UTC led by Texas State University. Our consortium partners include Texas State University (TXST), Oregon State University (OSU), Texas A&M University (TAMU), University of Miami (UM), and University of Puerto Rico at Mayagüez (UPRM). Coastal infrastructure face unique challenges compared to inland infrastructure. From a durability perspective they must be designed, constructed, and maintained to withstand highly varied climatic conditions and multiple hazards including hurricanes, tsunami, and earthquakes. Intense coastal storms can result in damage or failure of multimodal transportation infrastructure due to surge, wave and debris impacts, scour, erosion, and landslides. All these take place with long-term environmental exposure to salt water and wind-borne salt spray that can produce corrosion and asset deterioration. Coastal areas also have very high population density, which result in highly constrained transportation networks that are often multimodal and intersectional between waterways, ports and harbors, rail, transit, ferries, and highways, and embraces urban, suburban, and rural communities. These high-density regions have significant inequity gaps of infrastructure conditions in historically underserved communities. Thus, the objective of the CREATE UTC is to address coastal infrastructure durability challenges to support the US DOT's mission of safe, efficient, sustainable, and equitable movement of people and goods. This objective will be achieved through goals divided into four categories: research, leadership, education and workforce development, and technology transfer and collaboration.

1.1.1 Research

CREATE conducts research in four thrusts, which were formed to address the significant challenges of coastal infrastructure durability and to reduce inequities in the transportation system, including transportation careers. Table 1 shows our quantitative annual goals and our progress since the start of the center. As year 1 projects are nearing completion, research achievements during this period are the initial dissemination of products to advance transformative knowledge, where all contributions were achieved during this reporting period. We anticipate exceeding our annual goals by the next SAR and will begin looking towards our long-term center goals. Due to the current overlap in year 1 projects and newly established year 2 projects, we currently exceed our annual blue economy workforce goals. More details about the 28 CREATE funded projects are included in "Research Accomplishments."

Table 1: CREATE annual research performance metrics

Metric	Annual goals	2023-2024 (SAR 3)
Advance transformative knowledge	-12 peer-reviewed journal articles -15 final reports -20 conference proceedings	-8 journal articles (3 in press, 5 under review, all 8 during this period) -2 final reports (2 published during this period) -1 conference proceedings (1 during this period)
Collaborations	-5 awarded joint projects	-5 joint CREATE projects (3 awarded during this period)
Blue economy workforce	-20 undergraduate researchers -15 graduate research assistants	- 33(*18*) total undergraduate researchers -19(*16*) undergraduate researchers during this period - 37(*20*) total graduate research assistants -33(*15*) graduate research assistants during this reporting period

*Total(*Number from underrepresented in engineering*)

1.1.2 Leadership

CREATE researchers have strong records in leadership within the transportation, construction, materials, and coastal communities. Our leadership goals are to develop future leaders throughout the organization and operation of CREATE. Table 2 includes our leadership performance metrics for the center. Leadership achievements during this period emphasize individual PI leadership achievements and new mentorship relationships through research projects.

Table 2: Leadership performance metrics

Metric	Annual goals	2023-2024 (SAR 3)
Transform. research implementation	-5 implementation presentations w/stakeholders	Nothing to report
Equitable technology transfer	-10 short courses, webinars, or information sharing sessions	- 18 (3 webinars, 7 sharing sessions during this period
Equitable pathways to blue economy careers	-20 new faculty and student mentorships in CREATE	- 70 faculty / student mentorships (33 during this period)

1.1.3 Education and Workforce Development

Transportation agencies and private industry will be increasingly challenged to find highly qualified and technically trained employees due to higher retirement rates, fewer entrants into the transportation field, and increased competition for skilled labor, engineers, and planners. CREATE education and workforce development goals will be addressed using existing programs and new activities. The rigorous, progressive, and inclusive character of the programs at our member universities provide a natural environment to validate existing experiences, understand emerging challenges, and develop new skills for our blue economy workforce. Table 3 includes the center metrics related to education and workforce development. Achievements during this period include developing two new course modules from our research findings and mindful recruiting for full participation from all demographics in CREATE activities. As shown in Table 1, over 55% of CREATE undergraduate researchers and 57% of CREATE graduate researchers are from historically underrepresented groups in engineering.

Table 3: Education and workforce development metrics

Metric	Short-term goals	2023-2024 (SAR 3)
Ugrad Student Development	-5 course modules implemented with assessments to facilitate improvement	-3 new course modules (2 during this reporting period)
Grad Student Development	- 5 external committee members -15 graduate student presentations	- 2 external members - 8 (2 poster, 1 podium during this period)
Non-degree programs	-6 virtual webinars -50 non-affiliated CREATE symposium registrants	- 5 CREATE webinars - 4 other webinar series -Symposium scheduled for next SAR

1.1.4 Technology Transfer and Collaboration

We envision a strength of CREATE being the goal to serve as a hub for technology transfer, commercialization, and collaboration of coastal multimodal transportation infrastructure research. Our leadership team has a strong record of taking research through the implementation phase, including patents and commercialization. Highlights of our technology transfer plan include mandatory individual project advisory boards, entrepreneurial mindset training, and innovative information exchange mechanisms. The technology transfer and collaboration metrics are included in Table 4. We ensured that all projects have an external advisory board (EAB). During this reporting period we strengthened the EAB requirements for new projects by requesting letters

of support for final proposals. We are also emphasizing the need for documenting meetings with EAB members and incorporating their feedback to maximize early adoption and implementation in practice. Two projects without EABs are related to the Summer Transportation Institute projects. CREATE researchers applied for two provisional patents during this reporting period.

Table 4: Technology transfer and collaboration metrics

Metric	Annual goals	2023-2024
Stimulate coordination with stakeholders	-Document individual project EAB feedback and implementation status	-28 projects, 93% with individual EABs
Accelerate technology commercialization	- 10 trained future entrepreneurs	Nothing to report
Open, equitable, efficient information	-5 open access publications from CREATE research	-1 open access publication in press
CREATE collaboration	-3 supported projects with other UTCs	Nothing to report

1.2 What was accomplished under these goals?

The accomplishments that support the four center goals during this reporting period are completing two projects with final reports published on our website. We anticipate 10 of the 12 year one projects to be complete by the next reporting period with final reports published on our website and results disseminated in high impact peer reviewed journals. Of the remaining two, one is a multi-year project (support for the Texas State University National Summer Transportation Institute), and one was delayed. We have also added a requirement for a final, five-minute video highlighting research outputs for each project. These videos are available on our website with the final report and will be shared broadly across our social media platforms to maximize dissemination. We have also started 16 new projects, engaging eight new PIs in our center. We hold monthly meetings with the associate directors to ensure continuity across the center. Specific accomplishments under each goal are further described below.

1.2.1 Research

Research activities are underway for 26 projects, 2 projects are complete with published final reports. All projects are included in the list of new research projects to the USDOT and posted in the Transportation Research Boards's Research in Progress database. Project level objectives are described below within the four thrusts.

Thrust 1: Transformational coastal transportation infrastructure design and construction

COLLABORATION: SEAHIVE® solutions to mitigate bridge scour Phase I (UM)
Antonio Nanni and Landolf Barbarigos, University of Miami
Stacey Kulesza and Salah Faroughi, Texas State University
9/1/2023 – 8/30/2024 (*Complete*)

The objective of this research is to design and optimize SEAHIVE® elements to mitigate bridge scour. In this phase, UM focused on Characterization and production of the SEAHIVE® elements. Six elements were fabricated with wet-cast technology. UM evaluated the structural performance of SEAHIVE® reinforced internally with GFRP bars and externally with GFRP wraps under longitudinal compressive loading. Two peer-reviewed journal papers are under review regarding the findings.

COLLABORATION: SEAHIVE® solutions to mitigate bridge scour Phase I (TXST)
Stacey Kulesza and Salah Faroughi, Texas State University
Antonio Nanni and Landolf Barbarigos, University of Miami
9/1/2023 – 12/31/2024

The objective of this research is to design and optimize SEAHIVE® elements to mitigate bridge scour. TXST is optimizing the SEAHIVE® flow characteristics for scour. TXST has established experimentally and numerically that a vertical SEAHIVE® monopile results in less scour than a circular monopile. Furthermore, when SEAHIVE® are placed horizontally in front of a circular monopile as a flow altering scour mitigation system, the ultimate scour around the monopile is significantly reduced. We have published one conference paper on the experimental setup and are preparing a manuscript on the results of the SEAHIVE® monopile as well as the SEAHIVE® scour mitigation system.

Biowaste materials as supplementary cementitious materials for coastal concrete applications
Xijun Shi, Texas State University
9/1/2023 – 12/31/2024
The objective of this project is to investigate the feasibility of using two bio-waste materials, i.e., sugarcane bagasse ashes and ground waste eggshells, as alternative SCMs in portland cement concrete for coastal applications. Ground eggshells are rich in calcium carbonate, making it a viable alternative to limestone in cement. At 15% replacement, limestone and ground eggshell mortars have comparable performance. However, the strength of mortar with 35% eggshell cement is compromised due to the presence of organic impurities. The application of heat treatment to denature the organic content within eggshell is being explored. Meanwhile, SCBA exhibits pozzolanic behavior and can be used as a supplementary cementitious material. SCBA improves the compressive strength and durability of mortars at 5% to 10% optimal cement replacement. For higher replacements, the alkali substances present in the SCBA need to be eliminated through washing or acid cleaning. “Assessment of Waste Eggshell Powder as a Limestone Alternative in Portland Cement” is in press to disseminate the findings from this project.

Composite mangroves for reducing soil erosion near transportation infrastructure
Anand Puppala and Nripojyoti Biswas, Texas A&M University
9/1/2023 – 2/28/2025
The objective of this research is to investigate the effectiveness of composite artificial mangroves in reducing incoming wave velocities and energies. This research could contribute to mitigating overtopping and wave-induced erosion around coastal transportation infrastructure, such as highway embankments and levees. To simulate wave action and study its effects on these coastal structures, we have constructed a small-scale laboratory flume. The laboratory setup will help estimate the reduction in discharge and near-bed velocity fields. This data will assist in the numerical modeling of coastal structures. This project was highlighted at the USDOT Future of Transportation Summit and Texas A&M Center for Infrastructure Renewal Advisory Panel Meeting during this reporting period.

COLLABORATION: SEAHIVE® solutions to mitigate bridge scour Phase II (UM)
Antonio Nanni and Landolf Barbarigos, University of Miami
Stacey Kulesza, Texas State University
6/1/2024 – 8/30/2025
Phase II will focus on the production of internally-prestressed units using conventional precast beds currently available for producing 30-inch square piles. Using this technique, it will be possible to increase production efficiency and, as importantly, manufacture units of lengths up to 24 ft. Such a length could be necessary for scour applications in marine and riverine environments if the SEAHIVEs are to be driven as monopiles.

Cracking-resistant Concrete for Durable Coastal Structures
Xijun Shi, Anthony Torres, and Carlos Moro, Texas State University
9/1/2024 – 12/31/2025
The objective of this research project is to investigate the potential of synergetic utilization of internal curing (IC) agents and recycled steel fibers to develop crack resistant and durable concrete for coastal structures, with a specific focus on a continuously reinforced concrete pavement (CRCP). This is a collaborative project with the Texas Department of Transportation.

Self-Sealing Concrete to Enhance Durability and Longevity of Coastal Concrete Infrastructure under Corrosive Environment
Jung Yeon, Texas State University
09/01/2024 - 2/28/2026
The objective of this research is to develop an innovative way to use a functional infrastructure material known as "self-sealing concrete" to mitigate rebar corrosion in coastal concrete infrastructure. The developed material can be used on a variety of coastal infrastructure components, including seawalls, piers, concrete bridge decks, and structural and non-structural elements that require active protection against steel corrosion. Superabsorbent polymers, or SAPs, serve as a key component in performing this vital function. When present in concrete, SAPs' exceptional capacity to absorb and hold huge volumes of water will significantly increase the water tightness of concrete by absorbing water, forming an expansive hydrogel, and sealing capillaries and cracks in the matrix. Because SAPs are economical, non-toxic, and easy to handle, it is anticipated that SAPs will offer a practical solution to the corrosion problem in coastal concrete infrastructure.

Vehicles over dunes: Biocementation-based coastal infrastructure for flood protection and beach access
Jens Figlus and Anand Puppala, Texas A&M University
09/01/2024–08/31/2025
The objective of this research is to evaluate biocementation (microbially- and enzymatically-induced carbonate precipitation) as a method of stabilizing beach dunes in order to support vehicular traffic and mitigate wave-induced erosion.

Soil Innovations for Enhanced Coastal Infrastructure Durability: Durable Soil Stabilization
Pavan Akula, Oregon State University
09/01/2024–08/31/2025
The objective of this research is to optimize the current approach for chemical stabilization of soils in coastal environments, which are salt-rich, have dynamic pH, moisture fluctuations, and temperature changes. This study will seek to improve the chemical composition of the stabilizer to encourage the development of strong strength-enhancing compounds (such as low calcium C-S-H) in coastal environments and enhance the density of compacted stabilized soil to reduce the infiltration of moisture and dissolved salts.

Thrust 2: Coastal transportation infrastructure evaluation, prediction, and degradation prevention

COLLABORATION: Quantifying vessel propeller wash impacts on sedimentation in shallow bay ports and waterways
Jens Figlus, Texas A&M University
Stacey Kulesza, Texas State University
9/1/2023 – 05/30/2025
The project aims at collecting and analyzing field data on hydrodynamics and suspended sediment concentrations associated with large vessels (deep-draft, tankers, container ships, tug-barge combos, etc.) traversing a ship channel in a shallow bay system (Houston ship channel in

Galveston Bay). Data from close to 50 vessel passages have been collected over two separate field campaigns using a vessel-mounted 5-beam ADCP system and marine electrical resistivity. Analyzed ADCP data clearly show the captured prop wash plume features needed to quantify sediment suspension and evolution during vessel passages. Currently, acoustic backscatter signals are being calibrated with in situ sediment measurements to finalize the quantifications. A novel approach to processing the marine electrical resistivity data is underway to support the final sediment quantifications with real-time images of the suspended sediment.

Automated data knowledge graphs for life-cycle management of coastal bridge networks
Minghui Chen, University of Miami
9/1/2023 – 8/30/2024 (*Complete*)
To construct a digital twin, a prerequisite and a main challenge is to establish a knowledge graph. The objective of this project was to generate a city-scale knowledge graph to represent the relationships between the needed variables related to data-driven life-cycle risk analysis of a coastal bridge network. In contrast to existing knowledge graphs developed for digital twins, the knowledge graph in this project considered statistical correlations within a system and across different systems. The established automated knowledge graphs can be turned into Bayesian networks for probabilistic modeling and Bayesian analysis. The Miami-Dade County bridge network was used as an illustrative example to generate a knowledge graph that integrates multiple layers of data from the bridge network, traffic monitoring facilities, and flood water watch stations. The final report is published on our website and a peer-reviewed journal article is currently under review.

Development and deployment of titanium alloy bars for strengthening and cathodic protection of corrosion damaged transportation infrastructure
Burkan Isgor and Christopher Higgins, Oregon State University
9/1/2023 – 12/31/2024
The research demonstrated and reported on the practical feasibility of using discrete near-surface mounted titanium alloy bars (TiABs) for both structural strengthening and ICCP. Results offer the potential for a novel multi-functional material application to common infrastructure preservation challenges that can restore structural strength and preserve the remaining reinforcing steel in corrosive conditions. The need for a mixed-metal oxide coating was identified as needed to ensure long service life of the titanium anodes. Partners were contacted to explore potential development of a coating type and application process. We are currently preparing the final report for the USDOT and have a peer-reviewed journal article under review. This project was our center highlight at the US DOT Future of Transportation Summit.

Development of deep learning based automated data collection technology for coastal highway pavements
Feng Wang, Texas State University
9/1/2023 – 2/2/2025
The three objectives of this research are: 1) To establish a library of pavement surface images from coastal areas, representing various combinations of pavement distress types and severity levels under different coastal environmental conditions. 2) To develop AI/ML models and tools for coastal pavement condition assessment based on pavement surface images. The AI/ML models will have sufficiently high accuracy for detecting distresses under coastal environments. 3) To test and validate the developed AI/ML models on actual pavement case studies representing coastal environmental conditions. The research team has made progress in the following aspects: 1) pavement surface image data were collected; 2) annotation of image data; 3) literature reviews are conducted; 4) development of machine learning models. Two peer-reviewed journal articles

have been accepted and two have been accepted for the TRB 2025 Annual meeting. This is a collaborative research project with the Texas Department of Transportation.

Risk-based assessment of ports and interconnected networks subjected to coastal hazards
Maria Koliou, Texas A&M University
9/1/2024 – 8/31/2025
The objective of this research is to probabilistically evaluate the resilience of port infrastructure accounting for system interdependencies. Creating a resilient transportation system has been identified as a priority by public and private organizations to address the risks of climate change and extreme weather events. Ports play an important role in the economy of coastal communities across the Gulf Coast and they are significantly impacted by weather-related events. This project will focus on addressing issues related to the resilience and recovery of port infrastructure in the Gulf coastal regions subjected to weather-related hazards and propose/optimize mitigation strategies.

Strengthening and corrosion protection of coastal transportation infrastructure with titanium alloy bars
Burkan Isgor and Christopher Higgins, Oregon State University
9/30/2024 – 9/1/2025
This research builds on Phase I that demonstrated the practical feasibility of using discrete near-surface mounted titanium alloy bars (TiABs) for both structural strengthening and ICCP. Results offer the potential for a novel multi-functional material application to common infrastructure preservation challenges that can restore structural strength and preserve the remaining reinforcing steel in corrosive conditions. In this phase, a mixed-metal oxide coating is being applied to TiABs in partnership with De Nora NA. The coating has been shown to be achievable and electrochemical tests of the coating will be assessed to determine if it can provide long service life of the titanium anodes. Bond and mechanical tests will also be conducted with this project to determine if MMO coated bars perform as structurally intended.

Thrust 3: Equitable response to unprecedented coastal hazards

Transportation asset risk and resilience analysis to reduce societal risks to vulnerable populations
Ali Mostafavi, Texas A&M University
09/01/2023–02/28/2025
This project aims to create quantitative tools to identify and prioritize critical transportation assets, thus mitigating risks during coastal extreme weather events. A model has been developed to simulate various flood scenarios, allowing for a comprehensive assessment of these impacts. We have successfully implemented a user cost model to estimate the financial burden on users under different scenarios. Additionally, the model to evaluate physical damage costs has been fully developed and assessed.

Vehicular safety during wave-overtopping of coastal highways
Daniel Cox, Oregon State University
09/01/2023–12/31/2024
Vehicular Safety During Wave-Overtopping of Coastal Highways was postponed due to lack of graduate student. Instead, "Hydrodynamic Properties of a Large-Scale Bridge Model Under Free and Forced Vibration " was conducted. This project examined test data collected for a 1:12 scale model of a prestressed girder bridge subjected to snap tests and solitary waves. Snap tests were conducted at different still water depths and using different structural stiffnesses. The test data were used to develop a complete single-degree-of-freedom dynamic model based on the free

vibration response of the specimen. Dynamic properties were estimated based on a number of different methods. Key parameters such as added mass and hydrodynamic damping were captured. Methods for estimating these parameters were developed. We are currently preparing the final report for the USDOT and a peer-reviewed manuscript. Vehicular safety during wave-overtopping will be re-considered as a future project.

Analyzing Pre- and Post-Coastal Hazard Pavement Conditions to Optimize Response Strategies for Coastal Infrastructure Resilience
Xiaohua Luo, Feng Wang, and Feng Hong, Texas State University
09/01/2024–2/28/2026
The objective of this research is to investigate the effects of coastal hazards on pavement conditions in Texas' coastal region, particularly in Houston, and to optimize infrastructure response through network analysis. The study aims to analyze historical pavement data before and after Hurricane Harvey, focusing on various pavement types and employing statistical models to assess data variability and performance. The research seeks to compare pre- and post-Harvey pavement conditions to evaluate the impact of the hurricane on pavement distress and severity. Another objective is to assess the effectiveness of maintenance strategies implemented after coastal hazards, enhancing decision-making for future maintenance planning. Finally, the research aims to develop tailored strategies for improving infrastructure resilience by reviewing existing methods and conducting scenario analyses specific to Texas' coastal context. Ultimately, the findings are intended to inform equitable maintenance decisions and contribute to strategies that enhance the resilience of coastal pavement infrastructure. Currently, we are working on finding the areas highly impacted by hurricane Harvey in Houston. We will analyze the pavement condition data of these areas to understand the pavement condition. This is a collaborative research project with the Texas Department of Transportation that builds on “Development of deep learning based automated data collection technology for coastal highway pavements.”

Identification of Unprecedented Coastal Flooding Hotspots for Highway Network Durability and Social Justice
Eunsang Cho and Subasish Das, Texas State University
9/1/2024 – 12/31/2025
The objectives of this project are to develop a super-resolution, physically-informed AI algorithm to improve flood hazard mapping on a road network scale, implement a data fusion approach to uncover social vulnerability in transportation systems, and transfer research outputs to operations for public benefits. The outcome of the project will be an interactive web-based highway network-level durability and flood risk assessment map. This tool will provide broader impacts on regional and local societies by empowering decision-makers with the information needed to formulate equitable responses to potential flooding scenarios and enabling them to identify the critical links, spots, or zones in coastal areas, especially in underserved communities. While this research will focus on Galveston, TX, as a testbed, the research framework is expected to apply to other coastal regions in the U.S. and worldwide.

Agent-based modeling for assessment of coastal transportation network resiliency and environmental justice
Amirali Najafi, Texas A&M University in collaboration with Joseph Louis, OSU
9/1/2024 – 8/31/2025
This research focuses on the vulnerability of socially vulnerable communities to climate change impacts, particularly in coastal areas. It explores how infrastructure resilience planning can inadvertently worsen disparities in community vulnerability. The objective is to develop an agent-based model (ABM) framework that integrates infrastructure resilience, community vulnerability, agency decision-making, and climatic hazards, with a focus on transportation networks. The ABM

aims to advance our understanding of complex social-environmental-infrastructure interactions and inform engineering and decision-making policies. The broader impact involves promoting climate change equity in Houston through civil infrastructure solutions.

Improving post-disaster access to critical facilities for underserved coastal communities
Joseph Louis and Haizhong Wang, Oregon State University in collaboration with Amirali Najafi, TAMU
9/1/2024 – 6/14/2026
The overall goal of this project is to methodically plan for recovery operations after unprecedented hazard scenarios by linking them to what we know about hazards and infrastructure, by devising methods to calculate recovery times that are dependent on hazard characteristics, equipment availability, and community demographics. Thus far, we have had a project kickoff meeting and students and project personnel have been assigned tasks relating to literature review and dataset preparation about different aspects of the project including hazard characteristics, post-disaster connectivity, and recovery operations.

Present and future hazard scenario database for coastal infrastructural resilience and maintenance planning
Jame Kaihatu, Texas A&M University, in collaboration with Alberto Figueroa-Medina, UPRM
9/1/2024-8/31/2025
The objective of this research is to develop a hazard database for three locations along the Texas coast which can be used to help allocate repair and maintenance resources for coastal infrastructure. This project will use a database of historical and synthetic storms to force a suite of hydrodynamic and wave models for a community of interest. Projections of wave, surge, and flooding will be particularly focused on areas near critical infrastructure components (e.g., roads critical for evacuation and recovery; bridge piers, etc.). The overall product will be a set of maps delineating flooding risk and vulnerability. For selected infrastructure components of particular concern, a phase-resolved wave model, driven by flooding and wave events from hurricanes, can be used to simulate the time-dependent forces from hurricane-driven waves and help pinpoint potentially damaging conditions within hurricane events. Finally, the results will be used to evaluate the impact of flooding on evacuation and traffic flow as a collaboration with “Use of Enhanced Visualization Technology...”, see below.

Use of Enhanced Visualization Technology to Assess the Equity States of Coastal Transportation Infrastructure
Alberto Figueroa-Medina, University of Puerto Rico Mayaguez in collaboration with James Kaihatu, TAMU
9/1/2024-8/30/2025
The overall project concept is to devise a mechanism that incorporates the needs and preferences of coastal communities in the development of a decision-making support tool that assesses risks for transportation corridors based on equity and performance and that improves infrastructure and services in support of the blue economy. This project looks to enhance the transportation infrastructure of coastal communities through a methodology that assesses equity in terms of accessibility based on three states of equity: perceived, actual, and designed, using mixed reality visualizations as educational tool. Additionally, UPRM will collaborate as part of Task 5 of “Present and Future Hazard Scenario Database…” (above) in evaluating the impacts of infrastructure damages on traffic flow conditions and performance, evacuation routing, and other transportation issues.

Equity and Resilience Based Decision Support System for Critical Transportation Corridors
Ismael Pagan Trinidad, University of Puerto Rico, Mayaguez
9/1/2024-8/30/2025
The objective of this research is to determine the level of vulnerability of transportation corridors in coastal communities by applying USDOT's Vulnerability Assessment Scoring Tool (VAST). Incorporate equity in vulnerability assessment to improve decision making and guide the allocation of funds and projects. By considering both infrastructure vulnerabilities and the needs of marginalized and vulnerable populations, this approach ensures that resources are targeted to areas where they will have the most significant impact, improving both resilience and equity in coastal communities. To implement equity within the VAST framework, we propose developing an additional Equity Category. This category will include indicators reflecting the social and economic conditions of coastal communities.

Thrust 4: Pathways to blue economy transportation careers

Capacity building and workforce development for coastal transportation infrastructure exposed to multi-hazards, Phase I
Alberto Figueroa Medina, Carla Lopez del Puerto, and Ismael Pagan Trinidad, University of Puerto Rico Mayaguez
9/1/2023-12/31/2024
The objectives include the evaluation of the diverse experiences of transportation officials in coastal contexts, to recognize strategies for adaptation and change of transportation infrastructure, to identify communication and information limitations in coastal communities, and to study the challenges for attracting a diverse workforce that can reflect the variety of perspectives of coastal communities and support equitable planning and decision making in transportation infrastructure. We conducted a literature review during the reporting period and developed a preliminary theoretical framework for measuring equity for the development of infrastructure durability. The next steps include developing survey instruments that will assist us to acquire the perceptions and opinions of the community, decision-makers, and transportation professionals related to the equity component and the vulnerability issues of the transportation infrastructure in coastal areas.

National Summer Transportation Institute at Texas State University
Xiaohua Luo, Feng Wang, and Yihong Yuan, Texas State University
9/1/2023-8/31/2026
Texas State University organizes a National Summer Transportation Institute program to introduce the broad field of transportation to a diverse group of motivated high school students. These students are introduced to concepts associated with the application of high technology to transportation engineering and transportation infrastructure. The two-week residential program includes well-designed daytime and evening activities for the students to have a real experience of college life. The curriculum focuses on a different mode (highway, air, rail, water, or transit) of transportation with an associated theme each day. Contents and activities related to planning, design, construction, operations, and management of transportation systems and infrastructure are considered. Throughout the program, related transportation careers are highlighted. The CREATE Center, TXST, and the NSTI collaborate with the Federal Highway Administration, the Texas Department of Transportation, and Austin Capital Metro to provide guest lectures, field trips, laboratory tours, and/or investigations.

National Summer Transportation Institute at University of Miami
Ali Ghahremaninezhad, University of Miami
6/1/2024-5/31/2025
The objective of this project is to encourage K-12 students toward the STEM disciplines by educating them on transportation engineering career opportunities. Participants showed increased interest and awareness about the STEM and the transportation industry following the 2024 summer camp.

Capacity Building and Workforce Development for Coastal Transportation Infrastructure Subjected to Multi-hazards (Phase 2)
Carla Lopez del Puerto, University of Puerto Rico Mayaguez
9/1/2024-8/30/2025
The ongoing project focuses on the characterization of a coastal community in the municipality of Isabela, PR, in terms of vulnerability, demographics, access to and equity in transportation, and the aspects of blue economy present (or with potential development) in the community. These are to be assessed, aided by GIS tools, and possible areas of best practice of transportation infrastructure are to be suggested. This project involves the community in a collaborative exchange of ideas to deliver a more cohesive result.

1.2.2 Leadership
Individual project PIs are engaged in national and international leadership. Current notable leadership roles are:

- Alberto Figueroa-Medina, Codirector of the Puerto Rico Local Technical Assistance Program (LTAP), Member Oversight Panel for NCHRP 07-29 (Green Book); Member National Institute for Congestion Reduction Executive Committee
- Anand Puppala, ASCE Geo-Institute Board Member
- Antonio Nanni, American Concrete Institute Executive Committee, Founding Chair of ACI Technical Committee 243 - Seawater Concrete
- Christopher Higgins, Academic Director of the Western Bridge Preservation Partnership, Member World Steel Bridge Symposium Organizing Committee
- James Kaihatu, Member Coastal Advisory Board of Structural Extreme Events Reconnaissance Network, Member ASCE 7 Flood Loads Committee
- Xijun Shi, Secretary of ACI Committee 555; Chair of ACI Sub-Committee 555-A

We established the CREATE Student Leadership Council (SLC) during the previous reporting period. Students were charged with hosting an on-campus event during this reporting period to welcome the incoming CREATE students. Ayush Kumar of Texas A&M developed the student poster template for our virtual symposium, to be held October 24, 2024. The SLC will attend the first in person CREATE symposium at TXST in March 2025 and are coordinating the onsite student poster session. Additionally, there is a half-day leadership training course planned for the SLC and other interested students at the symposium.

1.2.3 Education and Workforce Development
All project PIs teach transportation related courses at the graduate and undergraduate level. During this reporting period CREATE faculty taught 34 undergraduate and 18 graduate courses in Departments of Civil Engineering, Civil Engineering and Surveying, Civil and Architectural Engineering, Ocean Engineering, Ocean Sciences, and Concrete Industry Management. Faculty have started to develop teaching modules based on research output and will begin assessments in the next reporting cycle.

The Civil Engineering Program at TXST includes a two-semester senior design capstone series where students work in teams of four in collaboration with a sponsor (typically an engineering firm), to address a design challenge. CREATE is sponsoring two teams during this reporting period on a bridge scour project. As shown in Figure 1a, Kulesza delivered a module on bridge scour, including the innovative SEAHIVE solutions which are part of the CREATE research portfolio. Partnering with TxDOT, the teams were assigned a scour critical bridge. TxDOT provided a site visit where they discussed scour assessment (Figure 1b). The teams will be responsible for conducting the hydraulic analysis to assess scour vulnerability and propose remediation measures, including exploring the use of SEAHIVEs. We plan to expand this model to other university senior design teams following assessment during the next reporting period.

(a) (b)

Figure 1: CREATE Senior Design Sponsorship, (a) class module on bridge scour and SEAHIVE solutions; (b) Scour team site visit to scour critical bridge

Since the start of CREATE, 33 undergraduate students have been hired to work on CREATE research projects, of which 18 are from underrepresented demographics including Hispanic, African American, military veterans, and women students. A total of 35 graduate research assistantships have been created to work on research projects, of which 20 are from underrepresented demographics in engineering.

Table 5 includes details of the CREATE webinar series for our first year. All webinars have attracted attendees from outside our UTC consortium including participants from state DOTs outside the consortium states (e.g. Wisconsin, Michigan), engineers from the private sector (e.g., HDR, SMH Consultants), public agencies (e.g., FEMA), and other universities (e.g., Rutgers, NC A&T). During the next reporting period we will host a virtual symposium to include a panel discussion from our advisory board, project overviews for the 28 projects listed herein, a ‘faculty mixer’ to ignite cross consortium collaborations, and a virtual student poster session.

Table 5: Year 1 CREATE supported webinars

Date	Title	Speaker	Attendees	Thrust
11/8/23	Unpacking and responding to USDOT Mission and Strategic Goals for Equity	Kristina Henry-Collins, PhD	36	Thrust 4
3/8/24	Optimizing the Location and Configuration of Disaster Resilience Hubs Under Transportation and Electric Power Network Failures	Daniel Rodríguez-Román, PhD	26	Thrust 3
4/22/24	Shoreline & Foundation Protection with SEAHIVE Technology	Steven Nolan, PE; Amin Mirdarsoltany, PhD Student	31	Trust 1, Thrust 2
6/3/24	Integrated Approach for Geotechnical and Hydrodynamic Analyses in Coastal Residential Built Infrastructure: A Holistic Perspective	Nripojyoti Biwas, PhD	39	Trust 1 Thrust 2
8/29/2024	Automated assessment of transportation infrastructure condition using sensor technology and imaging processing	Robin Huang, PhD	22	Thrust 2
10/24/2024	CREATE Virtual Symposium	Stacey Kulesza, PhD; Steven Nolan, PE; Jack Cadigan, PhD; Eileen Velez Vega, PE	-	All

1.2.4 Technology Transfer and Collaboration

CREATE exchanges information with the public through six primary mechanisms: CREATE website, databases, communication materials, sponsored exhibits, social media, and science on tap. We have published our website, create.engineering.txst.edu, which we will continue to build as we generate content and update on an on-going basis. The 28 research projects described herein are posted on our website as well as in TRB's Research in Progress database. We have created accounts for Twitter, LinkedIn, Facebook, and a YouTube Channel. The YouTube Channel archives all CREATE Webinars and will archive final project summary videos.

Our collaboration goals include collaborating within the center, with other UTCs, and with external agencies. We emphasize collaboration within CREATE and currently have five collaborative projects. We continue to meet with our advisory board every six months. Our current board is very engaged, but relatively small at four active members. We plan to add to our board during the next reporting period.

1.3 How have the results been disseminated?

Results have been disseminated through final reports, seminars (Table 5), presentations and publications listed in Section 3.0 Outputs.

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

There is no change to the center plans. Expected highlights of the next reporting period include:

- Final reports and technology brief videos for five additional year 1 projects
- Brief updates on current project activities
- Output updates from completed projects via dissemination in journal articles, conference presentations, and webinars
- Summary of CREATE Virtual Symposium, October 24, 2024
- Highlights of the first CREATE symposium, scheduled for March 6, 2025

2. Participants & Collaborating Organizations

2.1 What organizations have been involved as partners?

Table 6 lists CREATE partners and the type of support by each.

Table 6: CREATE partner organizations

Organization	Location	Support
Circle Concrete Tech	Austin, Tx	In kind support
De Nora Tech	Concord, OH	In-kind support, Collaborative research
Florida Department of Transportation	Tallahassee, FL	Collaborative Research
Perryman Company	Houston, PA	Collaborative research
Municipality of Isabela	Isabela, PR	In-kind support
NestFresh Eggs	Denver, CO	In-kind support
Rio Grande Valley Sugar Growers, Inc	Santa Rosa, TX	In-kind support
Texas Department of Transportation	Austin, TX	Financial support
University of Maryland	College Park, MD	Collaborative research

2.2 Have other collaborators or contacts been involved?

CREATE has an external advisory board that provides feedback and recommendations on CREATE operations. Additionally, CREATE faculty collaborate with colleagues at other institutions and other departments within our own institutions on CREATE research.

3. Outputs

3.1 Publications, conference papers, and presentations

Peer reviewed journal articles

Cheng, M., Shah, S (**undergraduate student**), Nanni, A., and Gao, O. Automated knowledge graphs for complex systems (AutoGraCS): Applications to management of bridge networks. *Resilient Cities and Structures*. (Under review)

Chong, B. (**PhD student**), Gujar, P., Shi, X., Suraneni, P. (2024). Assessment of Waste Eggshell Powder as a Limestone Alternative in Portland Cement, *Materials and Structures*, 57(219), https://doi.org/10.1617/s11527-024-02478-9

Gombac, A. (**MS Student**), Almikati, A. Kulesza, S. Efficacy of marine electrical resistivity surveys to determine maximum scour depth and scour infill. *Transportation Research Record*. (Under Review).

Luo, X., Tao, J., Wang, F, Faieq, A. (**MS student**), Gong, H., Hong, F. (2024) Enhancing Reliability in Automated Pavement Condition Data with a Data Quality Check Approach for Highway Agencies. *Transportation Research Record*, https://doi.org/10.1177/03611981241246247

Mirdarsoltany, M. (**PhD student**), Hussain, Z., Khodadadi, N. and Nanni, A. Strength Performance of Hexagonal, Hollow and Perforated Concrete Units. *Journal of Construction Building Materials*. (Under review)

Mojabi, S., Mirdarsoltany, M. (**PhD student**), Subacci, C., and Nanni, A. Evaluating Structural Performance of FRP-Wrapped Concrete Element: Sustainable Solution for Coastal Protection. *Journal of Sustainability*. (Under review)

Slawinski, A. (**MS student**), Higgins, C., and Isgor, B. Impressed Current Cathodic Protection with Near-Surface Mounted Ti Retrofit Bars. *ACI Materials Journal*. (Under review)

Yuan, Y., Chow, T.E., Wang, P. (**PhD student**), and Wang, F (*in press*). "A Review of Third-Party Traffic Data for Public and Private Use: Opportunities and Challenges", *Advances in Transportation Studies: An International Journal.*

Meeting/Conference presentations/posters made by key researchers and students
Chong, B. (**PhD Student**), Majumder, A. (**MS Student**), Shi, X. (2024). Biowaste as Sustainable Supplementary Cementitious Materials in Portland Cement Concrete, the 14th Advances in Cement-Based Materials, American Ceramic Society. June 19–21st, 2024, Poster Presentation.

Figueroa-Medina, A. and López, C. (2024). Capacity Building for Transportation Infrastructure Subjected to Multi-Hazards: Mitigating the Risks of Coastal Communities, Presentation at Institute of Civil Engineers Mega Viernes Congress, April 5, 2024.

Figueroa-Medina, A. (2024). Research and Education Strategies to Improve the Durability of the Transportation Infrastructure in Coastal Areas. Presentation at the Summer Transportation Institute, University of Puerto Rico at Mayagüez. June 21, 2024

Figueroa-Medina, A. (2024). Equity and Resilience-Based Analysis of Transportation Corridors in Coastal Areas. Presentation at the 12th IRF Caribbean Regional Congress. Session 7: Designing Inclusive Transportation Systems. Puerto Rico Conventions Center, San Juan, Puerto Rico. August 1, 2024.

Figlus, J., Turnbaugh, J. (**PhD Student**), and Kamalanathan, M. Bio-cementation of coastal sediment features and rock revetments to reduce erosion and flood risk. International Conference on Coastal Engineering (ICCE), Rome, Italy. September 10, 2024.

Higgins, C. (2024). Development of Titanium Alloy Bars that Strengthen and Preserve Infrastructure. Future of Transportation Summit, Aug. 13-15, 2024, Washington DC.

Isgor, B. (2024). Dual Purpose Titanium Alloy Anodes for Near-surface Mounted Retrofit and Impressed Current Cathodic Protection. CONSEC 2024, Sept. 25-27, 2024, India

Joubert, J. (**PhD Student**) and Figlus, J. (2024). Contributions of primary and secondary vessel wake to suspended sediment concentration in shallow bay systems. American Short and Beach Preservation Association (ASBPA) National Conference, Galveston, Texas.

Kumar, A. (**PhD Student**) (2024). Composite Mangroves for Reducing Soil Erosion Near Transportation Infrastructure, USDOT Future of Transportation Summit and CIR Advisory Panel Meeting. Poster Presentations.

Shi, X. (2024). Field Testing of Recycled Steel Fiber-reinforced Concrete, CECON2024. Podium Presentation.

Shi, X. (2024). Utilization of Recycled Materials in Concrete to Promote Sustainability, 09/12/2024, Central Texas Chapter ACI September 2024 Meeting, Podium Presentation.

Conference proceedings
Castillo, R. (**MS Student**), Kulesza, S., Rhode-Barbarigos, L. (2025). Experimental investigation for a novel bio-inspired scour countermeasure. Accepted September 2024 *for Geotechnical Frontiers 2025*.

3.2 Website(s) or other Internet site(s)
https://create.engineering.txst.edu/ - CREATE UTC website. The website currently includes our leadership directory, the advisory board, a description of research thrusts, current projects, final project reports, and webinar information. We continue to add content as the center grows, in the next reporting period we will add the final project videos for a brief overview of the posted reports.

3.3 Technologies or techniques
The high-strength titanium allow bars with MMO coatings for multi-functional applications will likely lead to a new material for commercialization. These coated bars are intended for corrosion prevention and strengthening. The city-scale knowledge graph research generated a user interface where users can modify the graph (add/remove nodes or edges), in put data, and query the nodes. Self-sealing concrete researchers designed a flow tester to evaluate the effect of SAPs on concrete crack-sealing. Cracking-resistant concrete researchers are designing and fabricating a fiber dosing system to automatically deliver, separate, and dose recycled steel fibers at the jobsite or a batch plant.

3.4 Inventions, patent applications, and/or licenses
"Detecting distresses in pavement using images from lightweight sensors", F. Wang, H. Gong, and X. Luo (TXST). April 28, 2024; U.S. Provisional Patent Application for Texas State Docket No. 2023-009

“Use of recycled superabsorbent polymers (SAPs) to create multifunctional concrete”, J. Yeon (TXST). September 23, 2024; U.S. Provisional Patent Application for Texas State Docket No. I2024-007

COLLABORATION: SEAHIVE® solutions to mitigate bridge scour, Antonio Nanni and Landolf Barbarigos, University of Miami, working on invention declaration for scouring protection.

4. Outcomes
Nothing to report.

5. Impacts
5.1 What is the impact on the effectiveness of the transportation system?
CREATE works closely with stakeholders to positively impact the transportation system. For example, SEAHIVE solutions are in close collaboration with the Florida Department of Transportation and the Texas Department of Transportation has expressed interest in the outcomes. We are seeking pilot bridges as test beds to evaluate the effectiveness full scale and understand potential barriers, just as maintenance requirements. In the vessel propeller wash impacts project, there is the potential for the Port of Houston to use the project outcomes to determine the contributions of large vessels to channel shoaling.

5.2 What is the impact of technology transfer on industry and government entities, on the adoption of new practices, or on research outcomes which have led to initiating a start-up company?
Nothing to report.

5.3 What is the impact on the body of scientific knowledge?
CREATE focuses on improving durability and extending the life of coastal transportation infrastructure. Although there have been recent investments in coastal resilience (e.g., DHS

Coastal Resilience Center, NOAA Climate Ready Coasts), there remains a need for targeted research in coastal transportation infrastructure durability. All research projects contribute to the body of scientific knowledge. For example, Development and deployment of titanium alloy bars for strengthening and cathodic protection of corrosion damaged transportation infrastructure demonstrated for the first time that MMO can be achieved for Grade 5 Titanium alloy bars.

5.4 What is the impact on transportation workforce development?

An existing Interactive Learning Hub (IL-HUB), developed for hosting a broad scope interactive learning platform for improving the education of resiliency for coastal infrastructure (https://crc-uprm-dhs-lms.uprm.edu/), will be the host of a Transportation Interactive Learning HUB (TIL-HUB) for workforce development. The TIL-HUB will capitalize the foundations already developed to focus on the capacity building and education outcomes from this project. The TIL-HUB will contain a repository of training and learning modules that will be of interest to a broad range of transportation stakeholders and will function as a vehicle to store, preserve, and disseminate the materials developed by CREATE. Reports, case studies, presentations, webinars, and other materials will be classified based on their level of complexity and will indicate the target population (e.g., academics and researchers, professionals, community members). The interactive component will allow participants to answer questions throughout the presentations to be able to continue watching the webinar, increasing participant engagement. The TIL-HUB will contribute to institutionalizing the long-term permanence of operational activities and leadership on capacity building at CREATE and will contribute to position our Center as a leader in multi-hazard education, capacity building, and workforce development for the durability of coastal transportation infrastructure. The CREATE project will leverage efforts with the CRC IL-HUB to broaden and strengthen the audience that will be impacted by CREATE and UPRM-CRC (https://www.uprm.edu/inci/crc/).

Three CREATE universities held Summer Transportation Institute (STI) camps:

UPRM: CREATE participated in an educational collaboration focused on equity issues in terms of accessibility and vulnerability. As part of the collaboration, two research assistants participated with educational activities with the students, Dr. Figueroa gave a presentation about CREATE and the vulnerabilities of the coastal transportation infrastructure, field trips were made to the coastal community of Maní, in Mayagüez, where participants analyzed the road infrastructure and its impact on accessibility for local residents. A survey was conducted among camp members to evaluate their perception of equity in access to various facilities in the community. The camp group consisted of 14 children, of which 7 were girls and 7 were boys. During the activities, the students actively participated in data collection and discussion of challenges related to accessibility and vulnerability in coastal communities.

UM: University of Miami hosted the STI program to encourage the younger underrepresented generations into the STEM disciplines and coastal transportation infrastructure. Activities included lectures, laboratory hands-on activities, and fun competitions related to coastal transportation infrastructure. Participants engaged in science rich activities, and develop critical thinking, teamwork, and career development skills. Number of attendees: 40, more than 50% female, more than 60% from minority background.

TXST: The 2024 STI program provided 24 high school students with authentic undergraduate engineering experiences. Students stayed in dorms on campus, had engineering lectures, and engaging laboratory sessions. All sessions emphasized transportation and gave students the opportunity to experience “typical” engineering lectures and topics. Most of the students (75%) were from underrepresented backgrounds in engineering.

6. Changes/Problems

6.1 Changes in approach and reasons for change

Nothing to report.

6.2 Actual or anticipated problems or delays and actions or plans to resolve them
Nothing to report.

6.3 Changes that have a significant impact on expenditures
Nothing to report.

6.4 Significant changes in use or care of human subjects, vertebrate animals, and/or *biohazards*
Nothing to report.

6.5 Change of primary performance site location from that originally proposed
Nothing to report.

7. Special Reporting Requirements
Nothing to report.