Semi-Annual Progress Report for University Transportation Centers

Submitted to	U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology (OST-R)
Federal Grant	University Transportation Centers (UTC)
Project Title	Tier 1 University Transportation Center for Durable and Resilient Transportation Infrastructure (DuRe-Transp)
Consortium Members	The University of Texas at Arlington (Lead Institution) Arlington, TX Howard University Washington, DC University of Puerto Rico at Mayagüez Mayagüez, Puerto Rico Missouri University of Science and Technology Rolla, MO Oregon State University Corvallis, OR Purdue University West Lafayette, IN
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Submitting Official	Same as above
Submission Date	04/29/2024
DUNS Number	64234610
Recipient Organization	The University of Texas at Arlington 701 S Nedderman Dr Arlington, TX 76019
Recipient Identifying Number	69A3552348339
Grant Period	06/01/2023 – 05/31/2029
Reporting Period End Date	03/31/2024
Report Term	Semi-Annual
Signature	

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ACCOMPLISHMENTS

1.A - What are the major goals and objectives of the program?

The Tier-1 UTC, Center for Durable and Resilient Transportation Infrastructure (DuRe-Transp), focuses on the statutory research priority area "Improving the durability and extending the life of transportation infrastructure". The consortium driving the Center's mission is comprised of a transdisciplinary team of prominent researchers from six universities in the U.S.: The University of Texas at Arlington (UTA-Lead), Howard University (HU), Missouri University of Science and Technology (S&T), Oregon State University (OSU), Purdue University (PU), and the University of Puerto Rico - Mayagüez (UPRM). By leveraging such collaboration, DuRe-Transp addresses critical scientific and technological advancements in the strategic topics of Durability, Construction and Finance**.**

Research Goals

DuRe-Transp Center's overall goal is premised on Innovation, Durability, Life-cycle performance, Climate change mitigation initiatives and Performance-based standards for revitalization of the nation's infrastructure. DuRe-Transp addresses critical challenges in 7 Research Themes (RT):

- **Durability**
  1. RT-I: Inspection, Maintenance and Preservation (IMP)
  2. RT II: Sustainability and Longevity (SL)
  3. RT III: Health Monitoring (HM)
- **Construction**
  4. RT IV: Sustainable Materials and Structures for Climate Change Mitigation (CCM)
  5. RT V: Advanced Materials and Technologies for Construction and Retrofitting (CR)
  6. RT VI: Construction Methods and Management (CMM)
- **Finance**
  7. RT VII: Innovative Revenue and Finance (RF)

DuRe-Transp's Research Themes identify and prioritize scientific and technological advancements that support U.S. DOT's goals for inspecting, repairing, and rebuilding the transportation infrastructure, improving roadway safety for all users, and charting innovative cost-effective pathways for transition to net-zero emissions and climate change mitigation. Under the 7 Research Themes, the Center will lead cross-disciplinary research projects to develop and deploy the next generation of durable and sustainable concrete-based materials, with emphasis on mitigation of degradation mechanisms liable for diminishing the service life of transportation infrastructure. The performance of these materials will be rigorously tested in both laboratory and field conditions, evaluating the materials' exposure to various environments (e.g., marine and frost). This research will support the development of standard guidelines for the formulation and deployment of the next generation of durable materials. The Center will also dedicate resources for comprehensive research on advanced structural retrofitting and repair solutions for existing infrastructure. Focus will be given on the development of carbon-neutral materials and renewable energy-related technologies for mitigating the greenhouse gas (GHG) emissions in transportation infrastructure and alleviating the urban heat island. The Center will develop and implement in-place and remote-sensing technologies for structural health monitoring (SHM) including unmanned aerial vehicles (UAVs). The SHM tools will provide the ability to detect damage – at its onset or at very-early stages – in the infrastructure elements. Such tools will be supplemented

with advanced data-driven models to perform life-cycle analysis, asset management, and performance characterization. The models will employ state-of-the-art artificial intelligence and machine learning techniques, and deep learning methods for data inference, prediction, and optimization. The Center will also deploy novel technologies and data-fusion frameworks to advance revenue and finance in transportation sector, with an emphasis on the design and implementation of data-driven blockchain-based smart contracts and commercial vehicle user fee models. Such finance systems will provide actionable managerial data that will ultimately increase return on investment while also reducing project risks.

Education and Workforce Development

The educational, training and professional development activities of the project are closely integrated with the research objectives with the aim to contribute to the successful training of students at all levels of education, graduate, undergraduate and pre-college/K-12, focused on women and underrepresented groups. The DuRe-Transp Center will also contribute to enhancing the potential of postdoctoral fellows and early career researchers to flourish as scholars and become the nation's front-line engineers, allowing them to acquire new scientific knowledge, technological know-how and professional skills in engineering practices that can extend the durability and service life of our TI. This goal will be facilitated by specific education and workforce development activities:

- New Certificate program with cross-disciplinary courses in the strategic focus area "Improving the durability and extending the life of transportation infrastructure". The courses will be delivered blended/hybrid (face-to-face and on-line), and in live webcasts and self-paced on-line. To complete the certificate, students will select 4 courses from the following list: Inspection and Preservation of Concrete Structures; Durability and Long-term Performance of Sustainable Infrastructure; Structural Health Monitoring (SHM) of Existing Superstructures and Substructures; Carbon Neutral Construction Materials and Structures; Advanced Materials for Construction and Retrofit; Additive Manufacturing in Transportation Infrastructure; Assets Management and Risk Assessment of Concrete Infrastructure; Digital Financing for Transportation Infrastructure.
- Special education modules, aligned with the Center's research activities, to reinforce existing academic programs and support the development of new skill sets in upper-level undergraduate and graduate courses.
- New learning opportunities, i.e., development of new materials, technologies and tools, that can be used for senior undergraduate design and capstone projects.
- Educational seminars/webinars with invited plenary lectures from scientists and engineers from the academia and industry.
- DuRe-Transp Outstanding Student of the Year. DuRe-Transp will select an outstanding student of the year, annually, starting the AY 24-25 based on accomplishments in one or more Research Themes of DuRe-Transp, academic performance, professionalism, and leadership.
- Research Scholarships to Community College Students. DuRe-Transp will provide scholarships to students from community colleges through existing partnerships, such as the Tarrant County College to The University of Texas at Arlington (TCC-to-UTA) admission program, and TCC-UTA-Dallas College partnerships supported by the North Central Texas Council of Governments (NCTCOG). The scholarship awardees will

participate in undergraduate research activities and attend courses at the consortium's universities, e.g., UTA's Department of Civil Engineering.

- Pre-college/K-12 summer camps to deliver age-appropriate presentations and research showcases to pre-college/K-12 students with focus on students from underserved communities.
- Webinars and Educational Modules to K-12 teachers about innovative construction technologies, novel infrastructure materials and smart structure through existing education programs in the consortium's universities, i.e., STEM Education program of the Kummer Center at S&T.

Technology Transfer Activities

A primary objective of the DuRe-Transp Center is the transition of research into practice by developing hands-on technologies for engineers and transportation practitioners. Specific plans for technology transfer and collaboration activities to accelerate the development and deployment of research findings will be designed.

- Technical webinars to highlight new technological advances from the Center's research projects. The webinars will provide Professional Development Hours to professional, engineers and practitioners.
- Training sessions to students from Technical Trade Schools, i.e., Edge Tech Academy in Arlington, TX and the Rolla Technical Institute in Rolla, MO, in new areas such as bridge inspection, Structural Health Monitoring (SHM) and 3D printing of concrete.
- Online training webinars in collaboration with Local Technical Assistance Programs (LTAP). DuRe-Transp will collaborate with LTAPs in Texas (TxLTAP), Missouri (MoLTAP) and Puerto Rico (PRLTAP) to integrate new research findings and robust technologies developed by the Center's projects into practice. Topics of the quality training webinars will cover, but not limited to, the use of non-metallic reinforcement, inspection, maintenance and preservation of concrete pavements and bridges, structural health monitoring, and repair and rehabilitation of concrete infrastructure using novel materials, such as Ultra High Performance Concrete (UHPC).
- Annual half-day seminar to highlight research outcomes/products, starting the AY 24-25. Target audiences are consortium members, transportation professionals from state and local governments, and transportation agencies/enterprises.
- DuRe-Transp faculty will disseminate knowledge and develop guidelines and standards through numerous technical committees in Transportation Research Board (TRB), American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), and International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM).
- The Center's faculty members will also organize sessions at the technical conventions, e.g., TRB Annual Meeting and ACI Fall and Spring Conventions to disseminate the research findings from the Center's projects.
- The Center's research teams will publish the research findings in joint publications in peer-reviewed journals actively involving postdoctoral fellows and Ph.D. students.
- The Center's website will be created and utilized to publicize on-going research, educational activities, technology transfer events, and project reports.

1.B - What was accomplished under these goals?

Research Objectives Accomplished

- 12 Interdisciplinary research projects of the DuRe-Transp Center (09/01/2023 – present) were developed involving multiple partners. The research projects are aligned with the U.S. DOT mission to repair, rebuild, and modernize the nation's TI, with a particular focus on climate change mitigation, resilience, and safety for all users (U.S. DOT Strategic Plan FY 2022-2026). The research projects are categorized within the Center's 7 research themes as follows:

Durability

- *RT-I: Inspection, Maintenance and Preservation*
  1. Best Practices for Application of Sealers/Coatings for Extending Service Life of Bridges
     Lead Institution: The University of Texas at Arlington
     RIP Database: https://rip.trb.org/view/2344520
- *RT II: Sustainability and Longevity*
  2. Extending the Lifespan of Concrete Superstructures via Alkali-Silica Reaction Mitigation
     Lead Institution: The University of Texas at Arlington
     RIP Database: https://rip.trb.org/view/2343323
- *RT III: Health Monitoring*
  3. Comprehensive Diagnostic System for Corrosion Assessment of Concrete Infrastructure
     Lead Institution: Missouri University of Science and Technology
     RIP Database: https://rip.trb.org/view/2344530
  4. AI/video-driven SHM and Lifespan Estimation of In-service Bridges
     Lead Institution: Howard University
     RIP Database: https://rip.trb.org/view/2344522

Construction

- *RT IV: Sustainable Materials and Structures for Climate Change Mitigation*
  5. Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector
     Lead Institution: The University of Texas at Arlington
     RIP Database: https://rip.trb.org/view/2344523
  6. Reducing Embodied Carbon by Optimizing Cementitious Systems for Alternative Cement Use via Thermodynamic Modeling- Carbonation and Corrosion in Low Clinker Cement Concretes
     Lead Institution: Oregon State University
     RIP Database: https://rip.trb.org/view/2344524

- *RT V: Advanced Materials and Technologies for Construction and Retrofitting*
  7. Design and Performance of Shotcrete Using Ultra-High Performance Concrete
     Lead Institution: Missouri University of Science and Technology
     RIP Database: https://rip.trb.org/view/2344521
  8. Performance of Eco-Fiber-Reinforced Concrete for Bridge Construction and Rehabilitation
     Lead Institution: Missouri University of Science and Technology
     RIP Database: https://rip.trb.org/view/2344525
- *RT VI: Construction Methods and Management*
  9. Quantitative Risk Assessment of Concrete Infrastructure Assets
     Lead Institution: The University of Texas at Arlington
     RIP Database: https://rip.trb.org/view/2344526

Finance

- *RT VII: Innovative Revenue and Finance*
  10. Role of Blockchain Enabled Smart Contracts in Facilitating Transportation Sector Projects
      Lead Institution: Missouri University of Science and Technology
      RIP Database: https://rip.trb.org/view/2344527
  11. Commercial Vehicle Life Cycle Use Fees Based on Pavement Impact
      Lead Institution: The University of Texas at Arlington
      RIP Database: https://rip.trb.org/view/2344528
  12. Machine Learning Maintenance Cost Forecasts for Better Infrastructure LCCA
      Lead Institution: Missouri University of Science and Technology
      RIP Database: https://rip.trb.org/view/2344529

Education and Workforce Development (EWD) Objectives Accomplished

- The curricula of courses in DuRe-Transp's partnering institutions were updated:
  1) UTA's courses "CE 5302: Advanced Concrete Materials" and "CE 4300: Advanced Topics in Civil Engineering" were updated with a special course enhancement module entitled "Sustainable Net-Zero Concrete". The lectures of the course enhancement module include research activities and findings from DuRe-Transp's project "Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector".
  2) Howard University's course "Introduction to Structural Protection Systems" was updated with a special course enhancement module entitled "Computer vision techniques for structural analysis". The module's lectures include research findings from DuRe-Transp's project "AI/video-driven SHM and Lifespan Estimation of In-service Bridges".
  3) S&T's course "Smart Contracts for Efficient Transportation Management" was updated with lectures featuring the research activities of the project "Blockchain-based Smart Contracts for Allocating Resources and Automating Contract Payments".

4) The lecture notes of PU's undergraduate course "Civil Engineering Materials" were updated with findings from DuRe-Transp's research activities about the use of new supplementary cementitious materials for the transportation infrastructure.
5) UPRM's graduate course "Advanced Concrete Technology" was updated with findings from DuRe-Transp's research activities about durable and sustainable cement-based materials and concrete.

- A new three-credit-hour undergraduate course entitled "3D Printing for Infrastructure Applications" (CE 49700) was offered for the first time at Purdue University during Spring 2024 Semester. The lecture and lab activities of the course include presentations of the research activities and findings from DuRe-Transp projects. Several guest speakers from the 3D printing industry were invited for guest lectures in this course, including engineers from COBOD International, ICON, RCAM and 1Print companies.
- Partnering institutions organized special guest seminars:
  1) UTA: Invited lecture from Professor Ravidra Gettu, IIT Madras, entitled "Sustainability Assessment of Concrete: Implications for Projects, Decisions and Policy" was held on Friday, February 23rd, 2024. The seminar was offered to undergraduate and graduate students from UTA's Departments of Civil Engineering and Materials Science and Engineering.
  2) S&T: Invited lecture from Professor Ruben Paul Borg, University of Malta and Fulbright Scholar at S&T, entitled "Resilience of Concrete Coastal Infrastructure" was held on Monday, April 29th, 2024. The seminar was offered to undergraduate and graduate students from S&T' Departments of Civil, Architectural and Environmental Engineering, and Materials Science and Engineering.
- DuRe-Transp's research team at UTA provided training sessions to the UTA-ASCE Student Chapter members for the development of an Engineered Concrete Mix Design for the ASCE Concrete Canoe Competition 2024. The Competition will be held on June 20 – 22, 2024 at Brigham Young University.
- S&T team provided a technical review seminar, in collaboration with the research team of University of São Paulo, within the framework of DuRe-Transp's projects "Design and Performance of Shotcrete Using Ultra-High Performance Concrete" and "Performance of Eco-Fiber-Reinforced Concrete for Bridge Construction and Rehabilitation". The seminar was held in S&T campus on Wednesday, March 20th, 2024.
- Scholarship funding from the DuRe-Transp budget was provided to the Center's Students:
  - UTA: One student from Tarrant County College (TCC), was awarded a scholarship to participate in the research activities of the Center's projects "Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector" and "Extending the Lifespan of Concrete Superstructures via Alkali-Silica Reaction Mitigation" and take undergraduate level courses in UTA's Department of Civil Engineering, through the TCC-to-UTA admission program.
  - HU: 8 students from Howard University, including 2 students from the Department of Civil and Environmental Engineering and 6 students from the Department of Computer Science, were awarded scholarships to participate in the DuRe-Transp's project "AI/Video-Driven SHM and Lifespan Estimation of In-Service Bridges."

- S&T: 4 students from the Departments of Civil, Architectural and Environmental Engineering, Mechanical Engineering and Biological Engineering were financially supported to participate in DuRe-Transp's research activities.

- One graduate student from DuRe-Transp team at UTA was awarded a prestigious scholarship from the Fort Worth Branch of the American Society of Civil Engineers, due in part to his participation in DuRe-Transp project "Extending the Lifespan of Concrete Superstructures via Alkali-Silica Reaction Mitigation".
- One undergraduate student from DuRe-Transp team at PU was the recipient of the Office of Undergraduate Research (OUR) scholarship at PU. The student was also selected by the Summer Undergraduate Research Fellowship (SURF) Program at PU to participate in the research projects of DuRe-Transp.
- One undergraduate student from DuRe-Transp team at UPRM was sponsored by LTAP Center EPC^2 to participate in research activities about the development concrete mixtures using lightweight aggregates for internal curing of concrete mixtures within the framework of research projects of DuRe-Transp.

Technology Transfer Objectives Accomplished

- Development of a monthly Webinar Series with topics focused on the Center's Research Area "Improving the Durability and Extending the Life of Transportation Infrastructure". The webinars, organized by DuRe-Transp' Associate Director for Technology Transfer *Weiss*, included presentations from invited speakers from the academia.

  Webinar #1

  Tuesday, December 12, 2023 – 2:00 pm – 3:00 pm CST

  1) Self Monitoring Concrete, An Alternative for Resilient Infrastructures
     Andrzej Cwirzen
     Professor and Head of Subject
     Department of Civil, Environmental and Natural Resources Engineering
     Luleå University of Technology

  2) Leveraging Computer Vision for Transportation Infrastructure Health Monitoring
     Claudia Marin
     Professor, Department of Civil and Environmental Engineering
     Associate Director for Diversity and Outreach, DuRe-Transp
     Howard University

  Webinar #2

  Tuesday, January 16, 2024 – 2:00 pm – 3:00 pm CST

  1) Utilization of Thermodynamic and Reactive Transport Modeling to Optimize Performance Engineered Mixtures for Reduced Carbon Footprint and Service Life
     Burkan Isgor
     Professor, Department of Civil and Construction Engineering
     Oregon State University

2) Enhancing UHPC Performance through Rheology Control and Use of Nanotechnology
   Kamal Khayat
   Vice Chancellor for Research and Innovation
   Vernon and Maralee Jones Endowed Professor of Civil Engineering
   Associate Director for Education and Workforce Development, DuRe-Transp
   Missouri University of Science and Technology

Webinar #3

Tuesday, February 20, 2024 – 2:00 pm – 3:00 pm CST

1) Maybe for Golf Clubs, but Isn't Titanium too Expensive for Infrastructure?
   Chris Higgins
   Cecil and Sally Drinkward Professor of Structure Engineering
   School of Civil and Construction Engineering
   Oregon State University
2) Sustainable Transition of the Concrete Industry: Achieving Carbon Negative Concrete
   Maria Konsta-Gdoutos
   Professor of Civil Engineering
   Director, DuRe-Transp
   Associate Director, Center for Advanced Construction Materials (CACM)
   The University of Texas at Arlington

Webinar #4

Tuesday, March 19, 2024 – 2:00 pm – 3:00 pm CST

1) Penetrating Sealer Effects on the Durability Performance of Concrete Joints
   Peter Taylor
   Director, National Concrete Pavement Technology Center
   Research Professor, Department of Civil, Construction and Environmental Engineering
   Iowa State University
2) Sustainable Concrete
   Matthew Adams
   Associate Professor, Department of Civil and Environmental Engineering
   New Jersey Institute of Technology

- Associate Director *Weiss* was the Chair of the Advanced Materials for Sustainable Infrastructure Development Gordon Research Conference "Accelerating Sustainable Concrete Construction", February 25 – March 01, 2024, Ventura, CA.
- Director *Konsta-Gdoutos* was the Discussion Leader of the Research Topic "Enhancing Early Age Properties" in the Advanced Materials for Sustainable Infrastructure Development Gordon Research Conference "Accelerating Sustainable Concrete Construction", February 25 – March 01, 2024, Ventura, CA. This Research Topic included 4 presentations from faculty and researchers, followed by a 30-minute discussion.

- A meeting between research teams from Missouri University of Science and Technology and Howard University was organized by the Associate Director for Education and Workforce Development *Khayat* and the Associate Director for Diversity and Outreach *Marin*. The objective of the meeting was to explore new joint collaborations for the development of test methods for 3D printing concrete within the framework of DuRe-Transp's existing and new projects.
- Field demonstrations developed by the DuRe-Transp team at Purdue University in November 2023 within the framework of the Center's research activities. The demonstrations included placement of slabs with non-traditional and traditional pozzolans.

1.C - What opportunities for training and professional development has the program provided?

- DuRe-Transp provides financial support to the Center's faculty and students to attend symposia and conferences:
    - Students:
        1) DuRe-Transp's MS and Ph.D. students at UTA and PU participated in the 2024 Spring Convention of the American Concrete Institute in New Orleans, LA.
    - Faculty:
        1) UTA: Faculty participated in the Advanced Materials for Sustainable Infrastructure Development Gordon Research Conference "Accelerating Sustainable Concrete Construction" and the Advanced Materials for Sustainable Infrastructure Development Gordon Research Seminar "Exploring Emerging Technologies for Reducing Carbon Emissions", February 25 – March 01, 2024, Ventura, CA.
        2) UPRM: Faculty participated in EDC 7 Summit "Enhancing Performance with Internally Cured Concrete (EPIC2)" and "Environmental Product Declaration for Sustainable Project Delivery: Climate Challenge" in San Juan, PR.
- DuRe-Transp supports faculty and students who are actively involved in the Technical Committees and Tasks Groups of the American Concrete Institute (ACI) and International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM). DuRe-Transp's Director *Konsta-Gdoutos* is the Chair of ACI TC 241 "Nanotechnology of Concrete" and TG-2 "Nanoscale Fiber Reinforced Concrete". DuRe-Transp Program Coordinator, *Danoglidis*, and the Center's Ph.D. Students are involved in the development of a new Technical Note "Why Carbon Nanofibers in Concrete?" within the activities of ACI TG-2 "Nanoscale Fiber Reinforced Concrete".

1.D - How have the results been disseminated?

- Research findings of DuRe-Transp's research projects were disseminated through scientific papers and technical presentations in conferences, e.g., ACI Fall 2023 Convention, ACI Spring 2024 Convention, 2024 ASCE International Conference on Transportation & Development.

- *Konsta-Gdoutos* and *Danoglidis* were invited to present their work in the 2024 Marseille Winter School, organized by the National Centre for Scientific Research (CNRS) in France and the Engineering School of Aix-Marseille University, January 22 – 25, 2024.
- DuRe-Transp's Students *Singh* and *Marquez* presented research findings from the Center's projects "Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector" and "Extending the Lifespan of Concrete Superstructures via Alkali-Silica Reaction Mitigation" in the 2024 Marseille Winter School in Engineering School of Aix-Marseille University, January 22 – 25, 2024.
- *Olek* delivered an invited plenary talk at the "Emerging Cementitious Materials for Construction Industry" conference, February 1 – 2, 2024, in New York University Abu Dhabi (NYUAD), Abu Dhabi, United Arab Emirates (UAE).

1.E - What Do You Plan to Do During The Next Reporting Period To Accomplish The Goals And Objectives?

- The webinars #5-10 of the monthly Webinar Series will be held in the next reporting period of May – October 2024.
- The 8th International Symposium on Nanotechnology in Construction Materials (NICOM8) is organized by UTA in Catania, Italy, July 8-11, 2024. The theme of the conference is "The Path to Decarbonization Through Nanotechnology – Achieving Carbon Net-negative Production". *Konsta-Gdoutos* is the Chair of The Scientific Committee of NICOM8. *Olek* serves as a member of the Scientific Committee. *Konsta-Gdoutos*, *Olek* and *Shah* will present plenary lectures.
- A request for proposals for new projects starting 2025 will be issued. DuRe-Transp Director *Konsta-Gdoutos,* Associate Director *Khayat*, Director of Scientific Committee *Shah* and the Theme Leaders of the 7 Research Themes will evaluate the research proposals based on specific intellectual merit and broader impact criteria. The selected project will be sent to the Grant Manager for review.
- Two technical sessions entitled "Decoupling of Concrete Production from Embodied Carbon Emissions through Nanotechnology" will be organized by *Konsta-Gdoutos* in the ACI Fall Convention 2024 in Philadelphia, PA.
- A workshop on 3D printing concrete technology will be organized by *Khayat*, in collaboration with Purdue University, in August 2024. The workshop will include 12-hour modules offering a comprehensive understanding about 3D printing concrete technology, including rheology-based methods.
- UTA and S&T will contact Edge Tech Academy and Rolla Technical Institute, respectively, to initiate discussions for organizing training sessions to the Technical Trade School students. These sessions will provide insights into the durability, longevity, sustainability, and resilience of cement concrete infrastructure through STEM research.

- DuRe-Transp team at PU will organize research symposium sessions at the Engineering Mechanics Institute Conference and Probabilistic Mechanics & Reliability Conference (EMI/PMC 2024), May 28-31, 2024, as follows:
    1. Architected Materials
    2. Advances in computer vision, deep learning and artificial intelligence for structural health monitoring and inspections
    3. Infrastructure assessment automation with robotics, deep learning and digital twins
- The DuRe-Transp team at UPRM will lead the activities of the 2024 Summer Transportation Institute for high school seniors and juniors. UPRM's faculty will prepare a module on Concrete Sustainability, develop laboratory activities on concrete basics, and provide support for a final project poster presentation on the topic of Recycled Concrete.
- A new course entitled "CCE 321- Ecampus – Civil and Construction Engineering Materials" will be offered by *Weiss* in OSU's Department of Civil Engineering during Winter 2024 Semester.

2) PARTICIPANTS & COLLABORATING ORGANIZATIONS

2.A - What organizations have been involves as partners?

- All the participating institutions of DuRe-Transp are actively involved by providing support to the Center.
    1) The University of Texas at Arlington, Arlington, TX – LEAD, financial and in-kind support, supply facilities and equipment, and research collaborations
    2) Howard University, Washington, DC, in-kind support, supply facilities and equipment, and research collaborations
    3) University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico, in-kind support, supply facilities and equipment, and research collaborations
    4) Missouri University of Science and Technology, Rolla, MO, financial and in-kind support, supply facilities and equipment, and research collaborations
    5) Oregon State University, Corvallis, OR, in-kind support, supply facilities and equipment, and research collaborations
    6) Purdue University, West Lafayette, IN, in-kind support, supply facilities and equipment, and research collaborations
- Several state governments and industrial partners are in the process of partnering with DuRe-Transp to provide financial and in-kind support and facilities to the Center:
    1) Texas Department of Transportation, Austin, TX, in-kind support
    2) Missouri Department of Transportation, Jefferson City, MO, in-kind support
    3) District of Columbia Department of Transportation, in-kind support
    4) Oregon Department of Transportation, Salem, OR, in-kind support
    5) Indiana Department of Transportation, Indianapolis, IN, in-kind support
    6) Federal Highway Administration (FHWA), financial and/or in-kind support
    7) Ecocem Materials Ltd, in-kind support

8) Army Engineer Research and Development Center (ERDC), in-kind support
9) Federal Highway Administration (FHWA), in-kind support
10) Shelby Materials, in-kind support
11) E5 Specifications Product, in-kind support
12) Puerto Rico Highway Authority, in-kind support
13) Empresas Ortiz Brunet (Aggregate Producer), Guaynabo, PR, in-kind support
14) Ferrovial Construccion, LLC, San Juan, PR, in-kind support
15) Macro Mix Concrete, Hormigueros, PR, in-kind support

2.B - Have other collaborators or contacts been involved?

- DuRe-Transp has contacted several potential collaborators to establish the External Advisory Committee (EAC), indicatively:
  1) Kevin Pete, Director of Research and Technology, Texas Department of Transportation
  2) Alireza Hatefi, Director, Public Works Department, City of Dallas, Dallas, TX
  3) Kenneth Drake, Professor of Chemistry, Department of Physical Science, Tarrant County College, Hurst, TX
  4) Jen Harper, Research Director, Missouri Department of Transportation, Jefferson City, MO

3) OUTPUTS

3.1 - Publications, conference papers, and presentations

Publications:

1) Jaberizadeh, M.M., Danoglidis, P.A., Shah, S.P. and Konsta-Gdoutos, M.S., 2023. Eco-efficient cementitious composites using waste cellulose fibers: Effects on autogenous shrinkage, strength and energy absorption capacity. *Construction and Building Materials*, **408**, p.133504.
2) Aghaee, K. and Khayat, K.H., 2024. Use of hybrid fibers and shrinkage mitigating materials in SCC for repair applications. *Construction and Building Materials*, **413**, p.134903.
3) Wei, J., Farzadnia, N. and Khayat, K.H., 2024. Synergistic effect of macro synthetic fiber and shrinkage-reducing admixture on engineering properties of fiber-reinforced super-workable concrete. *Construction and Building Materials*, **414**, p.134566.
4) Teng, L., Addai-Nimoh, A. and Khayat, K.H., 2024. Contribution of Shrinkage Reducing Admixture and Lightweight Sand on Moist Curing Requirement for Fiber-Reinforced Ultra-High-Performance Concrete. *Materials Journal*.
5) Li, H., Addai-Nimoh, A., Kreiger, E. and Khayat, K.H., 2024. Methodology to design eco-friendly fiber-reinforced concrete for 3D printing. *Cement and Concrete Composites*, **147**, p.105415.

6) Han, S.H., Khayat, K.H., Park, S. and Yoon, J., 2024. Machine learning-based approach for optimizing mixture proportion of recycled plastic aggregate concrete considering compressive strength, dry density, and production cost. *Journal of Building Engineering*, **83**, p.108393.

7) Teng, L., Jin, M., Du, J. and Khayat, K.H., 2024. Synergetic effect of viscosity modifying admixtures and polycarboxylate ether superplasticizer on key characteristics of thixotropic UHPC for bonded bridge deck overlay rehabilitation. *Case Studies in Construction Materials*, **20**, p.e02739.

8) Huang, Y-T., Jahanshahi, M.R., Shen, F. Autonomous comprehensive road condition assessment using crowdsourcing data and RGB-D sensors: enhancing pavement condition evaluation. IEEE Transactions on Intelligent Transportation Systems, in review, submission date: November 2023.

Presentations:

1) Konsta-Gdoutos, M.S. Sustainable Transition of the Concrete Industry: Achieving Carbon Negative Concrete. DuRe-Transp Seminar Series. February 20, 2024. Online via Zoom

2) Danoglidis, P.A., Konsta-Gdoutos, M.S. Carbon Negative Eco-efficient Concrete Using Nearly Zero Embodied Energy Agricultural Byproducts and Nanomaterials. Advanced Materials for Sustainable Infrastructure Development. Gordon Research Conference - Accelerating Sustainable Concrete Construction. February 25 – March 1, Ventura Beach Marriott, Ventura, CA.

3) Danoglidis, P.A., Konsta-Gdoutos, M.S. A convergent approach for monitoring fluid to solid transition in 3D printing using adaptive rheology and electrochemical impedance spectroscopy. ACI Spring Convention 2024. March 24 – 28, Hyatt Regency New Orleans, New Orleans, LA.

4) Jaberizadeh, M., Danoglidis, P.A., Konsta-Gdoutos, M.S. Sustainable and Eco-efficient Cementitious Composites Using Waste Cellulose Fibers. ACI Spring Convention 2024. March 24 – 28, Hyatt Regency New Orleans, New Orleans, LA.

5) Singh, R., Danoglidis, P.A., Konsta-Gdoutos, M.S. Strengthening the ITZ Interaction of Metakaolin-OPC Concrete Using Monodispersed Carbon-based Nanomaterials. ACI Spring Convention 2024. March 24 – 28, Hyatt Regency New Orleans, New Orleans, LA.

6) Marin-Artieda, C. Leveraging Computer Vision for Transportation Infrastructure Health Monitoring: Extending Beyond Critical Bridges to General Infrastructure. DuRe-Transp Seminar Series. December 12, 2023. Online via Zoom.

7) Wang, Y., Douba, A., Olek, J., Youngblood, J., Zavattieri, P. Sustainable cementitious composite containing cellulose nano fibers and limestone filler for concrete 3D-Printing. ACI Spring Convention 2024. March 24 – 28, Hyatt Regency New Orleans, New Orleans, LA.

8) Wang, Y., Zavattieri, P., Olek, J., Youngblood, J. Bio-Inspired Solutions for Roadside Barriers: Exploring 3D Printing as Alternative Precast Technology. Presentation to UTC TRANS-IPIC. March 4, 2024. Online.

9) Zavattieri, P., Youngblood, J. Nature-Inspired 3D Printing for Sustainable Infrastructure: From Design Concepts to Large-Scale Application. 3D Printing Natural Materials to Unlock Complex Nature-Inspired Infrastructure Collaborative Workshop: 7-8 Feb 2024, EWN, US Army Corp of Engineers (RDEC).

10) Zhaksybay, B., Castillo, A., Tokpatayeva, R., Olek, J. Performance of Nontraditional SCMs (NNPs) in Concrete Field Mixtures. Poster Presentation. ACI Spring Convention 2024. March 24 – 28, Hyatt Regency New Orleans, New Orleans, LA.

11) Zhussupbekova, A., Castillo, A., Olek, K. Potential Incompatibilities between Admixtures and Nontraditional and Natural Pozzolans (NNPs) in Cementitious Systems. Poster presentation, Spring Undergraduate Research Conference, April 9, 2024. Purdue University.

3.B - Policy papers

Nothing to report.

3.C - Website(s) or other Internet site(s)

- A website was created for the DuRe-Transp Center https://duretransp.uta.edu/. The website will be used for listing all activities related to the grant. In this reporting period, the following information/tabs have been added and updated: The Center, Research Team, Projects, Reports, Directory, News.

3.D - New methodologies, technologies or techniques

- The research team from HU worked jointly with the District Department of Transportation (DDOT) for the development of new technologies/tools for monitoring and evaluating the structural condition of in-service bridges in Washington, DC including the Frederick Douglass Memorial Bridge and Anacostia Riverwalk Trail Bridge.

3.E - Inventions, patents, and/or licenses

Nothing to report.

3.F - Other products, such as data or databases, physical collections, audio or video products application software, analytical models, educational aids, courses or curricula, instruments, equipment, or research material.

- 2D Pixel Tracking Software. The research team of the HU developed a specialized 2D pixel tracking code in the preliminary stages of software development. This program is designed to capture displacement responses at points of interest within video data of specific infrastructures.
- The DuRe-Transp research team at S&T developed an AI platform to predict and optimize the durability of concrete based on the information of mixture design and environment. This application is instrumental in developing the new concrete formula to achieve specific durability criteria.
- The DuRe-Transp research team at S&T conducted structural equation modeling as a statistical analysis of the responses using an open-sourced statistics program: JASP 0.18.1.

4) OUTCOMES

- The research activities of the Center's partners have been reported in the national media, increasing the public awareness of novel technological developments:

  1) AZO Build: New Partnership to Manufacture Concrete that Captures Carbon Emissions https://www.azobuild.com/news.aspx?newsID=23287
  2) UTA News: UTA to develop concrete that costs less, lasts longer and is better for environment https://www.uta.edu/news/news-releases/2023/04/27/dot-coe-utc-grant
  3) OSU News: Looking down the road to better transportation infrastructure https://engineering.oregonstate.edu/all-stories/looking-down-road-better-transportation-infrastructure
  4) S&T News: S&T researchers on cutting edge of 3D concrete printing developments https://news.mst.edu/2023/02/st-researchers-on-cutting-edge-of-3d-concrete-printing-developments/
  5) Purdue News: Purdue panels to address US semiconductor needs, 'Next Big Things in Tech' at Fast Company Innovation Festival https://www.purdue.edu/newsroom/releases/2023/Q3/purdue-panels-to-address-us-semiconductor-needs-next-big-things-in-tech-at-fast-company-innovation-festival.html
  6) Purdue News: Purdue's 'talking concrete' embedded into new I-465 and I-69 interchange in Indianapolis https://www.purdue.edu/newsroom/releases/2023/Q3/purdues-talking-concrete-embedded-into-new-i-465-and-i-69-interchange-in-indianapolis.html

- The educational activities of PU team have been featured on the cover page of CE Impact magazine, increasing public awareness of educational and technological developments. https://engineering.purdue.edu/CE/Media/Impact/2024-Spring

5) IMPACTS

5.A - What is the impact on the effectiveness of the transportation system?

- The findings of DuRe-Transp's projects, such as the projects "Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector" and "Performance of Fiber-reinforced Concrete for Bridge Construction and Rehabilitation", are used as case studies to show the implementation potential of advanced materials and technologies developed by the Center for the construction of durable and sustainable concrete pavements and bridge decks using sustainable, eco-efficient concrete materials.

- The Center's research team will deliver new sensor, monitoring and diagnostic systems that support Structural Health Monitoring of transportation infrastructure, i.e., "Comprehensive Diagnostic System for Corrosion Assessment of Concrete Infrastructure" and "AI/video-driven SHM and Lifespan Estimation of In-service Bridges". These systems can allow better prediction of service life and enable better management of the infrastructure.

5.B - 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?

- The technical specifications of new concrete mixes and products, i.e., net-zero and carbon negative concrete mixes (Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector), ultrathin/film nanoengineered concrete coatings (Best Practices for Application of Sealers/Coatings for Extending Service Life of Bridges), and ASR-resistive nanoconcrete mixes (Extending the Lifespan of Concrete Superstructures via Alkali-Silica Reaction Mitigation), will facilitate the design of new mixing protocols, materials and technologies to the contractors in the cement and concrete industry.
- New specifications for off-spec alternative cements will be developed, such as the performance based specification of new supplementary cementitious materials (SCMs) and Portland limestone cements (PLC) in the project "Reducing Embodied Carbon by Optimizing Cementitious Systems for Alternative Cement Use via Thermodynamic Modeling- Carbonation and Corrosion in Low Clinker Cement Concretes". The specifications will be shared with the standardization bodies, i.e., "American Society for Testing and Materials" and "American Association of State Highway and Transportation Officials" for the development of new test and evaluation protocols and guidelines that can be used in construction.

5.C - What is the impact on the body of scientific knowledge?

The interdisciplinary research activities and methodologies followed for the successful execution of the Center's projects exhibit a strong potential for the study and assessment of yet unexplored properties of advanced concrete materials. The research tasks of the project "Carbon Neutral Concrete Pavements for Decarbonizing Transportation Sector" include the evaluation of the chemical, mechanical and electrical properties of concrete interfaces at the atomic- and nano-scale. This scientific direction will significantly contribute to the development of a nano-to-macro scale research pipeline for tailoring and tuning the properties of complex cementitious and concrete materials targeting new functionalities, i.e., CO_2 capture and mineralization ability, thermal to electrical energy conversion efficiency, electrical energy storage capacity. The concept of developing new functional concrete materials, such as thermoelectric concrete, by performing atomic- and nano-scale experimental realization and characterization fosters research activities from all STEM disciplines including Civil and Environmental Engineering, Materials Science and Engineering, Chemistry, Computational Mechanics and Modelling, Prototyping (Technology) and Data/Mathematical Science.

5.D - What is the impact on the body of scientific knowledge?

DuRe-Transp continues to recruit several postdoctoral fellows, graduate and undergraduate students for the 1st year of the grant. The cross-disciplinary research activities of the DuRe-Transp projects are specifically designed to enrich the academic portfolio of the postdocs and students with scientific and technological know-how in major transportation related topics as they move towards an independent research career and reach scientific maturity. The collaboration activities between universities for the projects also contribute to advancing the professional skills of the early career researchers including, but not limited to, research method planning and development, research-specific critical thinking and decision making, and professional network build-up.

6) CHANGES/PROBLEMS

6.A - Changes in approach and reasons for change

Nothing to report

6.B - Actual or anticipated problems or delays and actions or plans to resolve them

Nothing to report

6.C - Changes that have a significant impact on expenditures

Nothing to report

6.D - Significant changes in use or care of human subjects, vertebrate animals, and/or biohazards

Nothing to report

6.E - Change of primary performance site location from that originally proposed

Nothing to report

7) SPECIAL REPORTING REQUIREMENTS

Nothing to report