PROGRAM PROGRESS PERFORMANCE REPORT

Submitted to: United States Department of Transportation
Office of the Assistant Secretary of Transportation,
Research and Technology (OST-R)

Federal Grant No.: DTRT13-G-UTC36

Project Title: Southern Plains Transportation Center (SPTC)

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Submission Date: October 31, 2017

DUNS & EIN No.: DUNS # 848348348 EIN # 73-6017987

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Grant Period: October 1, 2013 – September 30, 2017

Report Period End Date: September 30, 2017

Report Term: April 1, 2017 – September 30, 2017

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1 ACCOMPLISHMENTS

1.1 Goals The two complementary goals of the Southern Plains Transportation Center (SPTC) are: (i) to develop comprehensive, cost-effective and immediately implementable solutions to critical infrastructure-related issues facing the transportation system in Region 6 and the nation; and (ii) to prepare aspiring transportation personnel and students for leadership roles in professional and research careers that support sustainment and improvement of the nation's transportation systems. We particularly focus on under-represented professionals – Hispanic, Native Americans and African Americans – capable of leading public and private sector efforts aimed at providing U.S. citizens a sustainable and resilient transportation system. Our focus is climate adaptive freight and transportation infrastructure.

1.2 Accomplishments The Southern Plains Transportation Center is making significant progress toward realizing its vision of developing a diverse and inclusive, regionally-based and nationally recognized research, education and outreach center. During the reporting period, our primary accomplishments included: (i) delivering research and education/outreach programs and project outputs, outcomes and impacts; (ii) preparing for the 2017 Oklahoma Transportation Research Day; (iii) delivering the SPTC17.1 Research Program; (iv) conducting many other education and outreach activities at member institutions across the consortium; (v) delivering the 2017 SPTC Workshop Series; (vi) executing summer workshops and internship programs; (vii) engaging student TLC chapters and awarding students for meritorious research; (vii) enhancing collaborations; (viii) and delivering techniques, technologies and products that have impact. An overview of some of these activities is provided in the following sections.

1.2.1 Research and Technology Transfer In the reporting period, the SPTC was engaged in advancing the following activities: preparing for technology transfer events, delivering the new SPTC17.1 research solicitation program and facilitating SPTC Research and Education project progress. An overview of each of these activities follows.

Oklahoma Transportation Research Day: The ODOT-SPTC Oklahoma Transportation Research Day (OTRD) is a major technology transfer event in Oklahoma. It consists of oral presentations, poster presentations, discussions, and identification of potential research topics for ODOT, Oklahoma Turnpike Authority (OTA), FHWA, and other transportation stakeholders. SPTC is working with the Oklahoma Department of Transportation in preparing for the 2017 Oklahoma Transportation Research Day scheduled for October 17th. More information about this event can be found at: http://www.sptc.org/2017-ok-trans-res-day/.

2019 CUTC Summer Meeting: The SPTC prepared and submitted a proposal (which was subsequently awarded) to host the Council of University Transportation Center's 2019 Summer Meeting at The University of Oklahoma (OU). The meeting will be held at The National Weather Center (NWC; located on the OU research campus), which is a confederation of federal, state, and academic organizations that work together in partnership to improve understanding of events occurring in Earth's atmosphere. The University of Oklahoma and the National Oceanic and Atmospheric Administration, partner agencies of the NWC, spent $69 million to construct and occupy this building. The building is 250,000 square feet with five stories plus a rooftop outdoor classroom and enclosed weather observation deck. The NWC houses about 550 people, including research scientists, operational meteorologists and climatologists, engineers, technicians, support staff, and graduate and undergraduate students.

SPTC17.1 Program: The SPTC facilitated the solicitation, proposal review and award processes for the SPTC17.1 funding competition. The SPTC17.1 program focus is on high impact and implementable projects consistent with the priorities of the SPTC that can produce meaningful deliverables within the project period. The SPTC has received 12 proposals. These proposals represented six consortium members. The proposals have been reviewed by domain experts and the SPTC Associate Directors, and 4 proposals have been funded to date. The funded proposals are listed in the following table. Proposals were reviewed for merit, impact and implementation potential. Projects are posted on the SPTC website (http://www.sptc.org/projects/).

SPTC Project	Title	PI, Co-PI (Institution)
17.1-03	Economic Impacts of Multi-Modal Transportation Network Recovery	**Kash Barker (OU)**
17.1-04	Expanding PARIS+ to regional police agencies	**Ron Barnes,** Joseph Havlicek **(OU)**
17.1-07	Surface Resistivity Testing for Quality Control of Concrete Mixtures	**Julie Ann Hartell (OSU)**
17.1-10	Combined effect of sea-level rise and coastal land subsidence – Identification of critical transportation infrastructure at-risk in coastal SPTC region	**Sanjay Tewari**, Wesley Palmer **(LaTech)**

Research Project Progress: The following institutions are currently reporting research progress for the SPTC14 and 15 programs: Arkansas State University (ASU); Langston University (LU); Louisiana State University (LSU); Louisiana Tech University (LTU); Oklahoma State University (OSU); The University of Oklahoma (OU); Prairie View A&M University; University of Tulsa (TU); Texas Tech University (TTU); University of Arkansas (UARK); University of New Mexico (UNM); The University of Texas at Austin (UT-Austin); The University of Texas – Rio Valley Grande (UT-RVG); and The University of Texas at El Paso (UTEP). A short summary of progress by project category during the reporting period is as follows.

Climate and Safety

- "Enhancing Driver Safety during Severe Weather Conditions" (Project team includes Mohammed Atiquzzaman (OU), Ron Barnes (OU), Joseph Havilcek (OU) and Majeed Hayat (UNM).) A safety application is being developed to analyze information from neighboring vehicles and create a threat map to alert drivers of potentially hazardous road conditions. During this reporting period progress has included developing an algorithm for forwarding packets broadcast from a vehicle. Implementation of results will contribute to a reduction in vehicle crashes, fatalities and injuries due to adverse weather conditions. See more about this project in the April 2016 SPTC brief, http://www.sptc.org/briefs/.
- "Identifying Dust Emission 'Hot Spots' in the Southern Plains Region of New Mexico, Oklahoma and Texas: Effect of Blowing Dust on Highway Safety" (Project team includes Junran Li (TU), Thomas Gill (UTEP) and Jeffrey A. Lee (TTU).) This study is identifying and quantitatively assessing the spatial and temporal patterns of wind erosion hot spots that contribute to blowing dust to the highways of New Mexico, Oklahoma and Texas. During the reporting period, progress has included development and review of final report. Implementation of the developed integrated modeling and monitoring system will assist in highway safety management and mitigate the hazardous impacts of dust. See Products section for related products. See more about this project in the September 2015 SPTC brief, http://www.sptc.org/briefs/.
- "Trends in Cold Temperature Extremes and Winter Weather for the SPTC Region" (Project team includes Renee A. McPherson (OU), Esther Mullens (OU), Derek Rosendahl (OU), Mark Shafer (OU) and Michael Richman (OU).) This project is quantifying historical and future trends in winter precipitation (ice, snow and rainfall), cold air outbreaks (frequency, intensity), and freeze-thaw cycles for the southern plains region. During the reporting period, progress has included reviewing the final report. Project outcomes will be of benefit across a broad range of sectors, covering the necessary "first step" in climate risk assessment. See Products section for related products. Find more information about this project in the 2015 Spring SPTC Newsletter (pp.16,17), http://www.sptc.org/publications/ and http://www.sptc.org/newsletters/.

- "Safety Evaluation of Pavement Surface Characteristics with 1mm 3D laser Imaging" (Project Principal Investigator – Kelvin Wang (OSU).) PaveVision3D technology data is being used to evaluate various benchmarks for surface characterization related to pavement safety. During the reporting period, progress has included continuation of final report preparation. The research outcomes will be particularly relevant when extreme weather conditions cause substantial water on the pavement surface contributing to hydroplaning, which contributes to numerous accidents and fatalities. An SPTC Brief contains highlights of this project, http://www.sptc.org/briefs/.
- "Crash Severity Formulation and Analysis under Extreme Weather Conditions" (Project team includes Guohui Zhang and Rafiqul A Tarefder, (UNM).) A new approach is being developed to identify the underlying patterns behind crash data. A series of significant contributing attributes on crash severities impacted by weather extremes in the southwest region will be identified. During the reporting period, progress has included identifying effective countermeasures and proper policies. Implementation will help transportation agencies to develop cost-effective countermeasures to reduce crash severities under extreme weather conditions and minimize weather-related risks to traffic safety in the southwest region. See Products section for related products. Find more information about this project in the 2016 Spring SPTC Newsletter (pp. 24,25), http://www.sptc.org/publications/.
- "Understanding Impact of Climate Change on Highway Hydraulic Design Procedures" (Project team includes Vivek Tandon and Vinod Kumar, (UTEP).) The study will evaluate current resiliency of highway drainage infrastructure. During the reporting period, progress has included continuing effort on climate change vulnerability and risk assessment. Implementation will include delivery of cost-effective adoption solutions that extend service life despite not having been designed for climate change.
- "Assessing the Risk of Landslide on I-35 Near Davis Oklahoma Utilizing LiDAR 3D Mapping" (Project team includes Yongwei Shan, Joshua Qiang Li and Xiaoming Yang, (OSU).) Landslides are a threat to public traffic when they occur on roads passing through mountainous regions. The main goal of this research is to investigate the use of Light Detection and Ranging (LiDAR) technology for slope monitoring and landslide/rockslide risk assessment on major highways in Oklahoma. During the reporting period, progress has included developing and reviewing the final report. The effort will yield an innovative procedure for DOTs to monitor slopes and assess the risk of landslide on highways in the mountainous regions so that proactive actions can be taken to reduce the disruptions and dangers to the traffic due to landslides.
- "A Sustainable Performance-Based Methodology to Address the Impact of Climate Changes on the "State of Good Repair" of Transportation Infrastructure" (Project PI is Carlos Chang (UTEP).) This research investigates how to incorporate performance measures for climate change and risk assessment methods into Transportation Asset Management (TAM) practices. During the reporting period, progress has included development of the methodology (to include mitigation and adaptation strategies) to quantify climate change impacts for TAM practices. The results of this research will facilitate transportation agencies to incorporate climate change effects and risk assessment in the TAM decision making process specifically when formulating sustainable strategic plans to preserve the transportation infrastructure in a "State of Good Repair."
- "Infrastructure-Relevant Climate Projections for the Southern Great Plains" (Project team includes Katharine Hayhoe, Darryl James and Anne Stoner (TTU).). During the reporting period, progress has included using the new ARRM v2 Kernel Density Estimation-based statistical downscaling model to downscale 25 CMIP5 GCMs for both the upper (RCP8.5) and lower (RCP4.5) scenario for daily minimum and maximum temperature for the continental U.S on a 1/16th degree grid. Currently performing quality control and nearest neighbor checks on station-based observations, of which there are thousands, thereafter they will be ready to be downscaled with the same number of GCMs and RCP scenarios. The project will assess the potential future impacts of climate non-stationarity on the SPTC region and explore the extent to which these projections can be incorporated into the design, building, and maintenance of a transportation infrastructure that is resilient in the face of a changing climate.

Bridge Structures

- "Impact of Extreme Summer Temperatures on Bridge Structures" (Project team includes Micah Hale (UARK) and Royce Floyd (OU).) This multi-institutional project is assessing the effects of recent heat events on prestressed concrete bridges in Region 6. During the reporting period, progress has included continuing to obtain data from

the girder and developing the model. The project's outcomes will support the management and design of current bridges subjected to extreme temperatures, reduce maintenance costs and increase the service life, safety and effectiveness of our transportation infrastructure.

- "Evaluation of Surface Treatments to Mitigate ASR" (Project Principal Investigator – Micah Hale (UARK).) This project is examining the effectiveness of silane (and other sealers) in reducing the internal relative humidity of ASR-infected concrete. During the reporting period, progress has included continued monitoring the barrier wall and exposure blocks. See Products and Impacts sections for related work. An SPTC Brief contains highlights of this project and is available at: http://www.sptc.org/briefs/.
- "Temperature Effects in Bridge Condition Evaluation and Capacity Rating in Oklahoma" (The OU project team includes Naiyu Wang, K.K. Muraleetharan and Luther White.) This research is using Finite Element Analysis to perform heat flow and thermal stress analysis. During the reporting period, progress has included preparing the final report. Implementation of the developed guidelines for considering temperature effect in capacity rating will enhance efficient estimation of temperature-induced stresses in bridges with different construction materials, skewnesses and cross section geometries and lateral constraints, which will be economically beneficial to the improvement of the transportation systems regionally and nationally.
- "Impact of Deicing Salts on Corrosion Rates of MSE Reinforcement" (The TTU project team includes Priyantha Jayawickrama, Sang-Wook Bae, Andrew Jackson, William Lawson and Hoyoung Seo.) This research is evaluating corrosion rates in steel MSE reinforcement and embedded MSE backfill materials under different levels of exposure to deicing chemicals. During the reporting period, progress has included preparation of the final report. The effort will result in a comprehensive test protocol and assessment criteria that can be used to evaluate the complete range of MSE backfill materials, including coarse graded fill, under specified levels of exposure to deicing chemicals.
- "Development of Mixture Designs for Pumpable Concrete for Extreme Weather" (Project Principal Investigator – Tyler Ley (OSU).) This study is investigating the concrete pumping process and evaluating if frost durable concrete can be achieved. During the reporting period, progress has included review of the final report. Implementation will allow immediate changes to be made to the optimized graded concrete specifications for structural concrete. See Products section and link (www.optimizedgraded.com) for related information.
- "Design of Integral Abutment Bridges (IABs) in Extreme Climate" (The OU project team includes K.K. Muraleetharan and Gerald A. Miller.) This project is utilizing data collected from an instrumented IAB in Oklahoma and computer models to develop readily implementable design and construction guidelines for IABs in areas with extreme variations in temperature and moisture. During the reporting period, the final report was being finalized and reviewed. SPTC Brief contains highlights of this project and can found at: http://www.sptc.org/briefs/. This project was also highlighted by the UTC: http://www.rita.dot.gov/utc/publications/spotlight/spotlight_2015_09.
- "Monitoring Extreme Loading and Climate Impact on Infrastructure" (The OSU project team includes Julie Ann Hartell, Tyler Ley, Phil Lewis and Yongwei Shan.) This project is evaluating climate and overload impact on transportation infrastructure, determining extent of damage and monitoring damage progression. During the reporting period, progress has included continued acoustic emissions monitoring and analysis and destructive/non-destructive testing. Implementation of the developed guidelines will facilitate an effective condition assessment system. This project will provide the transportation industry a monitoring tool so that infrastructure problems can be detected and corrected sooner, resulting in improved public safety and reduced maintenance costs.
- "Rapid and cost-effective rehabilitation alternatives for transportation infrastructure affected by extreme conditions" (The UNM project team includes Vanessa Valentin and John Stormont.) This study will provide methods to quantify, manage and decrease the vulnerability of transportation infrastructure - specifically bridges and drainages - to wildfires. During the reporting period, progress has included revising the model based upon interviews and the site visit to the case study watershed conducted to verify geometric inputs of the culverts in the model which were initially defined through aerial photos. The results can be immediately implemented through the decision support tool, which can be used by decision-makers to manage and reduce the risks associated with fires. Additionally, a report on post-wildfire mitigation and rehabilitation best practices will be produced.
- "Risk-based life-cycle management of deteriorating bridges" (The OSU project team includes Mohamed Soliman

and Julie Ann Hartell.) The research will develop a risk-based life-cycle management technique for bridges susceptible to failure due to scour and floods considering the long-term impact of climate change. A decision making tool will be formulated to assist in planning future adaptation and mitigation strategies. During the reporting period, progress has included development of the multi-objective stochastic optimization to find the management plan which provides the optimal tradeoff between conflicting life-cycle criteria. Implementation will yield a tool that will identify available adaptation strategies, as well as their effect on the risk profile, and perform stochastic optimization to obtain the optimum time and adaptation type required to reduce the risk of failure and extend the service life.

- "Experimental Investigation of Tangential Heave Stress Acting on Deep Foundations in Cold Regions" (The TTU project team includes Hoyoung Seo, William Lawson and Priyantha Jayawickrama.) This study will quantify the effect of ground conditions such as frost depth, water content, and ground temperature on tangential heave stress which is a key design parameter for deep foundations in cold regions. During the reporting period, three frost-heave tests without pile have been performed in the 8-in-wide square apparatus, and variations of temperature and moisture contents in the soil have been measured. Implementation will yield a testing system and procedure may serve as a standard test method to more reliably determine peak and residual values of tangential heave stress.
- "Structural performance of concrete bridge decks reinforced with high-strength reinforcing bars" (The UARK project team includes Micah Hale, Gary Prinz and Canh Dang.) The main objective of this project is to investigate the behavior of bridge decks reinforced with A1035 steel at the service and strength limit states. The experimental program is aimed at generating necessary information to understand the mechanical properties of A1035 steel, and how these properties affect the design of bridge decks at the two limit states. During the reporting period, progress has included project start up. Based on the findings, recommendations will be made for using A1035 steel in the design of bridge decks.
- "Rehabilitation of Deteriorated Timber Piles using FRP Composites" (The LaTech project team includes David Hall and Shaurav Alam.) This project will evaluate the capacity of fiber reinforced polymers (FRP) strengthened deteriorated timber piles under axial loads, and a combination of axial loads plus bending with different lengths of deterioration zone. During the reporting period, progress has included preparing and review of final report. Implementation will facilitate investigation of the feasibility of restoring and enhancing the capacity of the original timber piles.
- "Degradation of Mechanically Stabilized Earth Reinforcements Exposed to Different Environmental Conditions" (The project PI is Arturo Bronson (UTEP).) This study examines the effect of moisture in the fines in which chlorides tend to segregate and corrode the mechanically stabilized earth (MSE) reinforcements composed of galvanized steel. During the reporting period, progress has included establishing experimental tank for corrosion measurements. The project will yield a methodology of monitoring the degradation of Mechanically Stabilized Earth Reinforcements.
- "Towards an Open-source Web GIS-based Bridge Management System Using Advanced Geo-Spatial Data Visualization and Integration Technologies" (The TTU project team includes Hongchao Liu and Dayong Wu.) This project will (1) provide a comprehensive review of current BMS development activities; (2) identify available bridge-related data sources at the state DOT, which enable the further data integration needed for a variety of analytical purposes; (3) build a more realistic model to represent the deterioration of bridge components by using a semi-Markov transition process. During the reporting period, progress has included comprehensive literature review. Implementation will yield a web GIS-based bridge management system, which allows advanced geospatial visualization and potential data integration on a centralized cloud platform.
- "Development of Novel Analysis Model for Foundations Subjected to Combined Torsional and Lateral Loads Due to High Wind" (The project PI is Hoyoung Seo (TTU).) In this study, a mechanically-rigorous-yet-easy-to-use analysis model will be developed for load-displacement response of circular foundations (circular footings or drilled shafts) in a layered soil under combined loading of torsion and lateral load. During the reporting period, progress has included obtaining governing differential equations for a circular foundation in a homogeneous soil under simultaneous loading of torsion and lateral load at the top of the foundation. Results will provide invaluable insights on combined effects of lateral load and torsion on the foundation behavior, potentially leading to a safer and optimized foundation design.

Traffic and Multimodal Considerations

- "Incorporation of Speed/Travel-time Data Sets in Traffic Performance Analysis" (Project team includes Hazem Refai (OU) and Samir Ahmed (OSU).) This project will develop a Travel Time Reliability Monitoring System (TTRMS) composed of Bluetooth identification devices strategically placed on interstate highways coupled with analytical models and software algorithms designed to evaluate the quality of real-time collected data. During the reporting period, progress included examing the tablets, data, and database schema prior to the development of user interface. Implementation will improve system responsiveness and reliability.
- "The Effects of Weather Events on Truck Traffic Using Fixed and Mobile Traffic Sensors" (Project team includes Sarah Hernandez and Song Feng (UARK).) This study will develop a predictive model that relates variations in truck traffic patterns to weather conditions, with a focus on extreme weather events. It will explore spatial regression models which correct for spatial autocorrelation that exists in explanatory variables due to spatial differences in transportation network density and land uses. During the reporting period, progress included Truck pre-processing GPS data so that it can be used to estimate vehicle miles travelled (VMT) at each of the study sites. Ultimately, this research will help leverage existing freight data sources to support freight transportation planning and decision making.
- "The Dependence of Infrastructure Restoration on Transportation Networks" (Project PI is Sarah Nurre (UARK)). This research effort will explicitly model the transportation network for the development of infrastructure restoration plans. During the reporting period, progress included continuing development of the optimization model and linking the feasible completion and timing of an interdependent network on the restoration activities of the transportation network. Delivery will include an integrated network design and scheduling problem to determine restoration plans for transportation and other networks by deciding (i) what damaged components or temporary components should be installed and made operational immediately after event, (ii) who performs the tasks necessary to make these selected components operational, and (iii) at what time the tasks are conducted.
- "Modeling Resilience and Impact in Multi-Modal Transportation Networks" (Project PI is Kash Barker (OU)). During the reporting period, progress included formulation of a multi-commodity network flow model to describe a multi-modal transportation network for Oklahoma and surrounding states. This work will assist transportation planners in understanding the contribution of individual components in the multi-modal network to economic productivity given a protracted disruption. It could also assist logistics planners in measuring the efficacy of rerouting strategies given a disruption, and policy makers will be benefit from the methods to analyze how network development decisions in terms of the accessibility of potential nodes/links within the network and the availability of incremental capacities would improve the network survivability at the time of a disruption.

Pavement and Materials

- "Resistance of Asphalt Mixes with Recycled Materials to Withstand Extreme Temperatures" (The project team includes Amit Bhasin (UT-Austin) and Zahid Hossain (ASU).) This research is investigating the use of low-temperature tests on asphalt binders, as well as mortars with and without RAP, to determine the resistance of asphalt materials to low temperature cracking. During the reporting period, progress has included reviewing the final report. This effort will result in a user-friendly test method and analysis program that can be used by material and pavement engineers to evaluate cracking resistance of asphalt materials for any pavement cooling scenario.
- "Numerical Modeling of Asphalt Crack Resistance" (The project team includes Enad Mahmoud (UT-Pan American) and Soheil Nazarian (UTEP).) This study is developing a Discrete Element Method (DEM)-based model of the resistance to cracking exhibited by asphalt mixtures using the Overlay Tester, which will be beneficial to asphalt design programs within state DOTs. During the reporting period, progress has included progress has included reviewing the final report.
- "Asphalt Binder Rheological Characterization for Extreme Climate Events" (The TTU project team includes Sanjaya Senadheera and Rajesh Khare.) This research is analyzing climate data to predict future weather patterns, relating climate to pavement condition, and using techniques of molecular modeling to elucidate the relationship between asphalt chemical composition and rheological properties. During the reporting period, progress has included progress has included drafting of the final report. Research findings will contribute to the building of highways that better adapt to new climate realities. See Products section for related products.
- "Evaluating Rutting and Stripping Potentials of Asphalt Mixes using Hamburg Wheel Tracking Device" (Project Principal Investigator – Rafiqul A. Tarefder (UNM).) The issues of repairing transportation infrastructure by

preventing damage resulting from extreme weather conditions are addressed. During the reporting period, progress has included evaluating rutting performance of mixtures 39, 40, and 41. The outcome of this study will be a specification that addresses rutting due to extreme temperatures that will be useful in areas with extreme hot climate. The February 2016 SPTC Brief contains highlights of this project, http://www.sptc.org/briefs/.

- "Impact of Severe Drought on the Compacted Expansive Clays (Subgrade) in Northern Louisiana" (Project Principal Investigator – Jay Wang (LTU).) This study is evaluating the fundamental volume change behaviors of compacted expansive clays in Louisiana, with a focus on severe drought conditions. During the reporting period, progress has included posting the final report, http://www.sptc.org/projects/. The research will advance in-depth understanding of the volume change properties of expansive clays. See Products section to see related work. See Products section for related products.
- "Characterization of Asphalt Binders Exposed to Extreme Temperatures through Simple and Effective Test Methods" (Project team includes Nazimuddin Wasiuddin (LTU), Zahid Hossain (ASU), Rouzbeh Ghabchi (OU) and Louay N. Mohammad (LSU).) The research is developing a simple and dynamic shear rheometer-based test method that can be used as an alternative to PG Plus tests (elastic recovery and force ductility) to accurately determine high temperature performance of asphalt materials. During the reporting period, progress has included analyzing MSCR-test results and working on the creation of the MSCR database. Implementable specifications for commonly used extreme temperature asphaltic materials will be developed to reduce cost and testing time. The June 2016 SPTC Brief contains highlights of this project, http://www.sptc.org/briefs/.
- "Validating Field Employed X-Ray Fluorescence (XRF) on Stabilized Subgrade Projects to Assess Impact of Extreme Precipitation Events, Improve Construction Quality Control and Facilitate Geotechnical Forensic Investigations" (The OU project team includes Amy Cerato and Gerald A. Miller.) This research is validating the portable field employed XRF (PFXRF) test by assessing its detection accuracy on selected roadway stabilization projects. During the reporting period, progress has included development and review of the final report. Recommendations will be developed for transportation officials to employ PFXRF and to implement a laboratory XRF testing protocol that will enhance jobsite quality control, assess impact of extreme precipitation events and expedite geotechnical forensic investigations. See Products section for related products.
- "Special Provisions for Intelligent Compaction (IC) of Stabilized Soil Subgrades" (The OU project team includes Sesh Commuri, Musharraf Zaman and Manik Barman.) This study is developing and validating Oklahoma Department of Transportation "Special Provisions" for the use of IC rollers during compaction of stabilized subgrades. During the reporting period, progress has included review of the final report.
- "Development of statewide WIM data quality control and axle load spectra and traffic volume adjustment factors for Oklahoma" (Project team includes Joshua Qiang Li (OSU) and Musharraf Zaman (OU).) This project will develop quality control (QC) metrics and associated software interfaces for checking the quality of statewide WIM data. It will also develop site-specific, region-specific, and statewide traffic inputs that are required for the Mechanistic-Empirical (ME) based pavement design in Oklahoma. During the reporting period, progress included conducting the TMAS and consistency data checks on the traffic data acquired from ODOT and utilizing the Prep-ME software to examine the traffic data quality by year for each traffic station. The WIM data sets have been imported to the customized Prep-ME software. Implementation will facilitate design and analysis of pavement structures.
- "Development of Guidelines for High-Volume Recylced Materials for Sustainable Concrete Pavement" (Project team includes Jeffrey Volz (OU) and Julie Hartell (OSU).) This study will evaluate concrete in conventional pavement construction, incorporating at least 50% recycled materials (both recycled concrete aggregate and supplementary cementitious materials) without compromising performance or service life. During the reporting period, progress included development of guidelines for material selection and mixture optimization. Outcomes include guidelines for material selection and mixture optimization.
- "Development of a SFE Database for Screening of Mixes for Moisture Damage in Oklahoma" (Project team includes Rouzbeh Ghabchi (OU) and Rifat Bulut (OSU).) Surface Free Energy (SFE) characteristics of asphalt mixes will be evaluated for bond strength and debonding of aggregate and asphalt binder in presence of water, which cannot be achieved using either a TSR or a HWT test. During the reporting period, progress included SFE testing of binders. This study will deliver a SFE database and training for pavement designers for the implementation of this innovative and cost-effective mechanistic approach for screening of asphalt mixes.

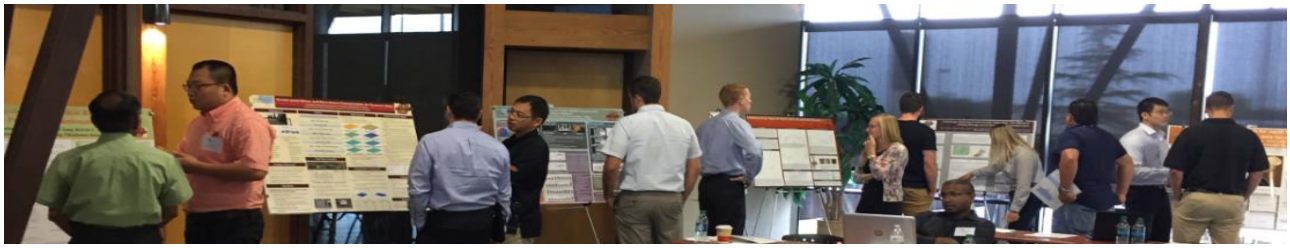
- "Design Data for Rigid Pavements in New Mexico" (Project team: Rafiqul A. Tarefder and Mahmoud Reda Taha (UNM).) During the reporting period, progress included analyzing the proposed model with reference to the ME design model. This study will develop three most important inputs among many inputs required by the AASHTOWare pavement M-E design software in the design of rigid pavement for New Mexico materials, traffic, and climate.
- "A Novel Approach for the Characterization of the Rutting Performance of Pavement Foundations" (Project team includes Reza Ashtiani and Bill Tseng (UTEP).) The study will provide a Variable Dynamic Confining Pressure (VDCP) stress path protocol for permanent deformation characterization of geomaterials in the laboratory. During the reporting period, progress included identifying the parameters pertaining to the dissipated pseudo strain energy such as growth and change in the inclination of the hysteresis loops during the stress path tests. Implementation will potentially mitigate the unforeseen maintenance and repair costs associated with underestimation of the parameters of the rutting models for the design of pavement structures.
- "Development of Numerical Simulation Tool for Continuously Reinforced Concrete Pavements" (Project team includes Cesar Carrasco and Soheil Nazarian (UTEP).) During the reporting period, progress included carrying out a series of parametric studies to evaluate the interplay between the different geometric and material parameters that define the pavement structure to verify the implementation of finite element model. This research project will expand the capacity of the existing source code of NYSLAB by upgrading its FEM models to predict the stresses and strains in continuously reinforced concrete pavement.
- "Quantifying Thermomechanical Fatigue of Hot Mix Asphalt: A Feasibility Study" (Project team includes Calvin M. Stewart and Imad N. Abdallah (UTEP).) A systematic experimental-theoretical-numerical paradigm will be developed to evaluate the fracture and fatigue resistance of HMA materials, especially when subjected to thermomechanical conditions. During the reporting period, progress included establishing the empirical evidence necessary to develop a multiscale model for the deformation and microstructural evolution of HMAs subjected to Thermomechanical fatigue. A provisional standard test method for the fracture and fatigue resistance of HMA subjected to TMF and a computational model capable of predicting the mechanical state of HMAs subjected to climate extremes will be developed.
- "Mitigating Dry Shrinkage Pavement Cracking by Geocell" (Project team includes Xiaoming Yang, Rifat Bulut and Joshua Qiang Li (OSU).) This project investigates an innovative and potentially cost-effective approach to mitigate the dry shrinkage cracking problem in pavements. It uses a three-dimensional geosynthetic product (commonly known as geocell). During the reporting period, progress included collecting data from the numerical model and extracting information from the data. Preliminary design and construction guidelines will be developed for geocell use to treat expansive subgrade soils for pavement construction and maintenance.
- "Development of a mechanistic-based design method for geosynthetics-reinforced pavement on expansive soils" (Project PI is Jay Wang (LaTech).) This project extends the current SPTC project by characterizing local expansive soils, developing methods to predict soil heaves and calculate induced stresses in pavements and shallow foundations. During the reporting period, progress included developing the algorithm and spreadsheet. An easily implementable model will be developed on the basis of the theory of Timoshenko beam on elastic foundation, in which the mechanism of soil strength and stiffness enhancements from geosynthetics is mathematically considered.
- "ODOT Guidelines for the Use of FRS in Highway Construction" (Project PI is Kianoosh Hatami (OU).) Transportation agencies in the U.S. are continually faced with a persistent problem of landslides and slope failures along highways. During the reporting period, progress included developing the best practice guidelines and construction specifications for DOT implementation. This study will develop guidelines for FRS technology for the mitigation of landslides and slope failures.
- "Development of a RTFO-Aging Test Protocol for WMA Binders and Its PG Grading" (Project PI is Nazimuddin Wasiuddin (LaTech).) The objective of this study is to investigate the aging during foam-based warm mix asphalt production in the field and during laboratory short-term oven aging and develop a revised rolling thin film oven (RTFO) protocol to simulate these aging. During the reporting period, progress included collecting plant-mixing data. A method will be developed that will determine if asphalt binder grade bumping is necessary. The method will require a revised RTFO procedure.
- "Development of Special Provision for Mix Design of Foamed-WMA Containing RAP" (Project team includes

Rouzbeh Ghabchi, Musharraf Zaman and Manik Barman (OU and University of Minnesota).) Although the use of Warm Mix Asphalt (WMA) is increasing rapidly in Oklahoma and neighboring states in Region 6, lack of specifications for mix designs is inhibiting the asphalt producers and users (DOTs and others) alike. During the reporting period, progress included constructing the test section with in-kind donation from industry. The primary goal of this project is to develop a draft special provision that can be adopted readily by the Oklahoma Department of Transportation (ODOT), Oklahoma Turnpike Authority (OTA), the asphalt industry and others for WMA mix designs, and to realize the benefits of WMA without compromising quality of constructed pavements.

- "Rapid and Continuous Assessment of Soil Conditions along Highway Alignments" (Project PI is Clinton Wood (UARK).) The purpose of this study is to improve upon this method of characterization, to include geophysical methods, particularly capacitively coupled resistivity (CCR), which can be used to provide a rapid and continuous evaluation of the subsurface soil conditions. During the reporting period, progress included collecting data to determine the ability of CCR to refine boring data after post drilling calibration and provide a continuous estimate of soil information. Ultimately, the project will develop a new testing methodology, which can be used to evaluate subsurface soil conditions for new highway alignments in order to reduce the cost of the investigation and provide more comprehensive results for design.
- "Field Implementation of Fatigue Enhanced Polymer Concrete Incorporating Nanomaterials" (Project PI is Mahmoud Reda Taha (UNM).) This project will identify the optimal nanomaterials combination for producing PC with nanomaterials for efficient field implementation. During the reporting period, progress included microstructural investigation. Optimal nanomaterial combinations and PC mixture proportions to meet field requirements will be identified. Performance of a small set of selected PC mixes incorporating nanomaterials will be monitored after field implementation.
- "Cotton-Derived Composite Materials for Climate Resilient Transportation Infrastructure" (Project team includes Noureddine Abidi, Priyantha W. Jayawickrama (TTU).) This study examines cellulose and its derivatives, which have been extensively used for diverse applications. Amongst them, acidic hydrolysis of native cellulose leading to low-molecular-weight (MW) cellulosic products, referred to as nanocrystalline cellulose (NCC), has become an effective way to develop nano-based materials. During the reporting period, progress included conducting tests to characterize cotton-based concrete for strength and durability (compressive and modulus of elasticity tests). These cotton fiber-concrete and NCC microbeads-concrete composites have potential to effectively serve as an alternative to conventional construction materials while significantly enhancing the sustainability of infrastructure construction, maintenance, and rehabilitation.

1.2.2 Workforce Development, Education and Outreach: In the reporting period, the SPTC was engaged in advancing the following activities: 2017 SPTC Summer Symposium; 2017 SPTC Dissertation and Thesis Awards; Transportation Regional Internship Program (TRIP); Summer Programs; SPTC Workshop/Seminar Series, Early Career Development Program and other education/outreach events; and SPTC Briefs. An overview of some of these activities follows.

2017 SPTC Summer Symposium: The Symposium was held on August 15, 2017 at the Association of Oklahoma General Contractors Conference Center with the goal of providing an opportunity for graduate student presentations and spurring discussion on transportation related research in Region 6. Seventy-four (74) attendees participated in the Symposium and included representatives from OSU, OU, UARK, LaTech, ODOT and SPTC. The symposium was divided into sessions focused on Transportation Planning and Technology, Asphalt/Concrete Materials and Pavements, and Bridges and Infrastructure. The sessions included eighteen podium presentations by graduate students, undergraduate students, and faculty members on topics such as travel demand modeling, connected vehicle technology, data for Pavement ME Design, x-ray imaging of concrete material and decision-making framework for prioritizing bridge maintenance. Sixteen research posters were also presented on a diversity of related topics. In addition to providing students an opportunity to present their work, the symposium provided a wonderful networking opportunity for students, faculty members, and DOT personnel in the region. The diversity of attendees allowed for excellent discussion of important research topics while keeping the focus on the Southern Plains Region.



SPTC 2017 Dissertation and Thesis Awards: This award program has been established to recognize scholarly research conducted by graduate students in engineering or a closely related field on transportation topics important to the region, including but not limited to the SPTC focus on Climate Adaptive Transportation and Freight Infrastructure. Part of the regional mission of the SPTC is to support graduate study and research to develop the next generation of transportation leaders. Awards were given to the following students for the top dissertation and the top two theses published or accepted during 2016. The awardees presented their work in an SPTC webinar on April 26, 2017. More information can be found at http://www.sptc.org/awards/.

Adnan Khan (LaTech) received the SPTC Dissertation Award for his dissertation entitled "Influence of Moisture Distribution in Soil on Pavement and Geothermal Energy." Khan completed his Ph.D. in Materials and Infrastructure Systems at Louisiana Tech University in December of 2016.

Victor Garcia (UTEP) won the 1st Place Thesis Award for his work entitled **"**A Cracking Methodology to Assess Fracture and Fatigue Properties of Asphalt Concrete Mixtures with Overlay Tester". He earned his Master's Degree in Civil Engineering with focus in the area of Geotechnical/Pavement Engineering.

Darion Mayhorn (OU) won the 2nd Place Thesis Award for his work entitled **"**Investigation of the Effects of End Region Deterioration in Precast, Prestressed Concrete Bridge Girders". He earned his Master's Degree in Civil Engineering with a focus in Structures at the University of Oklahoma.

SPTC Seminar Series 2017: On April 18th, Dr. Esther Mullins (The University of Oklahoma) conducted an SPTC Seminar entitled "*Climate and Transportation - What's the Big Deal?"* at the University of Oklahoma. PDHs were provided. Extreme weather, such as heat waves, cold waves, heavy precipitation, and winter storms, is well known to impact transportation safety and state of good repair. Climate variability is associated with changes in the frequencies and/or intensities of adverse events. In some cases, these changes may be such that using only historical climate information in planning and design may no longer be sufficiently accounting for the potential range of extreme conditions that the transportation system is likely to encounter. In this seminar, some detailed climatological information for the South Central U.S was presented, focusing on central Oklahoma. A large suite of historical and future datasets were evaluated, based on observations and high-resolution climate model projections. Exert input was solicited to determine the relevant climate variables and thresholds. Our results support the potential for some substantial shifts in climate "normal", and implications to the transportation sector were discussed. In addition, initiatives and resources that are currently in place were identified to support the use of climate future information in infrastructure planning, and the challenges that remain to be overcome. More information can be found at http://www.sptc.org/seminars/.

On June 30th, Dr. Rouzbeh Ghabchi (South Dakota State University) delivered two (2) workshops at the Oklahoma Department of Transportation. PDHs were provided. The first workshop was entitled "*Effect of WMA and Anti-Stripping Additives on PPA-Modified Binders*". Enhancing the high-temperature PG grade of asphalt binders by using

Polyphosphoric Acid (PPA) is becoming more common due to its lower cost, compared to polymer modification. Despite its benefits, long-term performance and moisture-induced damage are major concerns associated with adding PPA to asphalt binders. The purpose of this workshop was to present the outcomes of the research to evaluate the effect of PPA on rheology and moisture-induced damage potential of asphalt binders. The presentation was followed by questions and discussion. More information can be found at http://www.sptc.org/seminars/.

The second workshop was also delivered by Dr. Ghabchi and was entitled "*Applicability of MSCR Grading of Polymer- and RAP-Modified Binders*". PDHs were provided. Multiple Stress Creep Recovery (MSCR) is a relatively new test method and has been proposed to replace the Superpave® performance grade (PG) and PG plus tests. The aim of the workshop was to introduce the MSCR test method and specifications and to compare the results of the Superpave® and MSCR tests conducted on Oklahoma binders. The workshop was followed by questions and discussion.

2017 Early Career Development Program (2017-ECDP): The SPTC announced its Early Career Development Program (ECDP) Awards in June. The SPTC competitively awards up to two ECDP projects to teams from the Oklahoma State University (OSU) in Stillwater and the University of Oklahoma (OU) in Norman to solicit and develop new research opportunities to advance the transportation systems in the state and the nation. Topics strongly related to the objectives and goals of the SPTC and of ODOT are especially encouraged. The goal of this program is to provide seed funding to promote collaboration between tenure-track faculty members at OSU and OU. This funding should allow these groups to share their expertise in hopes of obtaining additional funding, publishing joint papers, and cross training students. Five ECDP project submissions were received and reviewed and two awards were made. The selected 2017 ECDP projects are entitled "Application of fiber optic sensors for monitoring prestressed concrete bridges" and "Measuring Benefits of Horizontal Directional Drilling compared to Open-Cut using a Real-Time Wireless Smart Sensor".

SPTC and Langston University Transportation Academy (LUTA): LUTA was conducted this summer. The Academy was led by Director of LUTA 2017, Dr. D. Chongo Mundende and the LU-PI, Dr. Marshan Marick. High school students participated in the Academy. The objectives of the Academy were to: (1) create awareness and stimulate interest in secondary school students to take maximum advantage of the career opportunities in the transportation industry; (2) attract a broad and diverse selection of bright minds, and acquaint and stimulate them with the various aspects of the transportation industry; and (3) increase the number of students who choose careers in the transportation industry. Participants learned about land, air, water, and space transportation, and how these modes of transportation interface with each other, through classroom presentations, hands-on activities, and field trips. They also enhanced their communications, math, science, computer, and team building skills. Professionals from federal and state agencies as well as from the private industry provided students with information on careers in transportation, safety, and environmental awareness and protection. More information about this program can be found in an SPTC Brief found at http://www.sptc.org/briefs/.

Transportation Regional Internship Program (TRIP): An important element of SPTC's workforce development effort is TRIP. Thirty nine (39) students participated in the 2017 TRIP to gain valuable professional experience through working for a transportation company (e.g. Wallace Engineering, EST) or a government organization/agency such as a department of transportation (e.g. Arkansas State Highway and Transportation Department). Since State of Good Repair and climate-adaptive freight and transportation infrastructure are SPTC's focus, a diverse set of topics were covered by this regional internship program, including design, construction, testing (laboratory/field), management, compliance, safety and training. To highlight, the following students are two of the 2017 SPTC TRIP interns.

Christopher Benton, Major: Civil Engineering
Christopher is currently a Civil Engineering Student Intern for the Arkansas Department of Transportation, working his third summer in the Resident Engineer Office in El Dorado. He is working alongside field engineers and inspectors assisting with an overlay project — staking the project for stationing and sign installation, taking pay tickets, and producing reports for payment documentation. He has also inspected activities such as embankment construction, culvert extensions, and the installation/ maintenance of erosion control devices.

Mickayla Eisenbrandt, Major: Civil Engineering
As a student intern at EST, Mickayla worked with the Roadway Design Team in Norman, under Cassidy Doescher, P.E. Working for the roadway department, she assisted in the creation and submittal of plans. She drafted sheets including: title, typical, plan and profile, cross sections, traffic control and erosion control. In addition, she learned to operate MicroStation, InRoads, and Estimator. Mickayla remarked that the most helpful part of working at EST is that she had the ability to learn about roadway design from beginning to final submission, including attending a few utility meetings and public meeting. "I believe the experience I have gained at EST has given me additional knowledge that I could not have received though college alone and reassurance that I have an exciting career ahead."

LaCarie Jordan, Major: Civil Engineering
La Carie worked for the Arkansas Department of Transportation this summer in the Resident Engineer Office in West Memphis. She worked with field engineers and inspectors assisting with the oversight of highway and bridge construction projects. Typical assignments included inspection and documentation of subgrade, asphalt and pipe culvert operations.

SPTC Dissemination: The SPTC develops SPTC Briefs, which are two-page summaries of SPTC projects to be published, distributed and posted to the website to enhance impact. To date, nineteen briefs have been posted that highlight specific SPTC projects (http://www.sptc.org/briefs/). The SPTC has engaged a PR firm in an effort to disseminate SPTC findings to users and the general public. Regular discussions were held about SPTC research and dissemination opportunities.

1.2.3 Leadership: In the reporting period, the SPTC leadership was engaged in advancing the following activities (in addition to participating in regularly scheduled meetings): executing the 2017 Annual Advisory Board Retreat and participating in Transportation Leadership Councils (TLC). An overview follows.

SPTC Delivers the Annual Advisory Board Retreat: On April 6th, SPTC held its Advisory Board Retreat in Dallas, Texas to discuss the SPTC strategic plan, performance deliverables, challenges, opportunities and future direction. The SPTC Advisory Board plays a key role in maintaining communications with the greater transportation community and advises the Center Director and Leadership Core as to the critical transportation needs both regionally and nationally. The following table shows attendees that participated in this productive, one-day retreat.

Attendee (Board Retreat)	Role	Institution
Dawn Sullivan	SPTC Board Chair	Oklahoma Department of Transportation
Harold "Skip" Paul	SPTC Board Member	Louisiana Transportation Research Center
David Hadwiger	SPTC Board Member	New Mexico Department of Transportation
C. Michael Lee	SPTC Board Member	Texas Department of Transportation
Michael Kelly	SPTC Board Member	Arkansas State Highway and Transportation Dept.
Basharat Siddiqi	SPTC Board Member	Federal Highway Administration
Angel Correa	SPTC Board Member	Federal Highway Administration
Sheldon Drobot	SPTC Board Member	Environmental Solutions Space/Intelligence Systems
Soheil Nazarien	SPTC Associate Director	The University of Texas at El Paso
Kevin Hall	SPTC Associate Director	The University of Arkansas
Musharraf Zaman	SPTC Director	The University of Oklahoma
Cerry Leffler	SPTC Program Coordinator	The University of Oklahoma
Dominique Pittenger	SPTC Technical Director Coordinator	The University of Oklahoma

Transportation Leadership Council (TLC) Chapters: TLC chapters have been active at each member institution (for more information, see http://www.sptc.org/tlc/). These are student-led groups that provide opportunities for developing leadership. The chapters have autonomy to perform leadership development activities locally; however, a central mission is to develop regional collaborative activities with other chapters. The following activities have occurred during this reporting period:

- OU TLC hosted a seminar delivered by Cort S. Westphal, P.E. with Garver Engineering on April 5th entitled, "Consulting in Transportation". The TLC hosted a general interest meeting on September 21, 2017. Michael Molina from the Oklahoma Transportation Library participated in the presentation and provided information about the library holdings and services. Adan Ortiz was named interim president until officer elections are held in Spring 2018.
- The UTEP TLC held short chapter meetings every Friday for TLC officers only. Elections were held July 7, 2017 TLC members voted for new officers (fall 2017- spring 2018): President- Luisa Morales, Vice-president – Jose Luis Arciniega, Secretary- Miguel Perez, Treasurer- Alejandro Gomez, Historian- Mohammad Rashidi, Web Master- David Teutli, Community Representative- Luiza Barros, Student Advisor- Victor Garcia, Advisor- Carlos Chang, Chairman- Jose Luis Garibay. The TLC's first general meeting was held on September 22nd and was oriented in presenting the new TLC officers, upcoming activities, scholarship opportunities, renewing student's membership, and brought a guest speaker. The guest speaker was Janet Hernandez.

  During the Mining Engineer Camp/ ExciTES held on June 13, June 26, July 18 and July 25, the TLC provided tours for the Center of Transportation Infrastructure Systems (CTIS) facilities. During the Nexus Shadowing Program in August, the TLC officers shadowed two High School students to learn about transportation engineering research. The CTIS and TLC hosted the Franklin Mountains Retreat for members to collaborate with one another as a team in group activities, and hiking on Wednesday, July 14, 2017 at Franklin Mountains. The TLC provided a webinar to members about new tools designed by the Long Term Pavement Performance (LTPP) Program through the TRB Webinar: New Pavement Engineering Technologies on August 21st. The TLC sponsored the Texas Society of Professional Engineers Presents FUTURE ENGINEERS 5K RUN/WALK AND 1 MILE FUN WALK/RUN by including its logo on the T-shirt provided to those who participated on the race on September 23rd. The TLC and other organizations participated in the community service event of cleaning up a two-mile stretch of highway for the Adopt-A-Highway program on September 30th.
- UARK TLC (aka TL-21, a part of the new Institute of Transportation (ITE) student chapter) has had meetings with 10-12 regular attendees and an officer corps of five students. Nathan Becknell (Traffic Engineer from the City of Rogers and President of the Missouri Valley Section of ITE (MOVITE)) came to speak at a meeting. Nine students attended the ITE Student Leadership Summit in Purdue University in September (pictured).
- LaTech TLC: Gloria Mwebaza will serve as the TLC officer for 2017. The TLC is operating as part of ASCE at Louisiana Tech. More information can be found at http://coes.latech.edu/civil-engineering/asce.php.

1.3 Dissemination of Results SPTC uses both electronic and printed materials as well as social media and a public relations firm for the dissemination of results. For example, the results of the 14.1 and 14.2 programs are becoming available and being posted on the Center website (http://www.sptc.org/reports/) and are included in our published Briefs (http://www.sptc.org/briefs/). The Briefs are being distributed widely to all UTCs through OST-R, state DOTs, and other stakeholders. A summary of each funded project and SPTC activities are posted on the website (http://www.sptc.org/projects/). Also, conferences, seminars, workshops, summits and professional meetings are used to disseminate SPTC results. SPTC Newsletters are prepared and distributed, which highlight project results (http://www.sptc.org/publications/). Basecamp and emails are also used regularly as vehicles for communication and dissemination of results. SPTC is regularly using WebEx technology to facilitate webinars delivered by SPTC researchers and serve to disseminate project results.

1.4 Activities for the Next Reporting Period As noted throughout this progress report, the

SPTC14, SPTC15 and SPTC17 competitions have resulted in several research, education and outreach projects. Talented teams across Region 6 are working on these projects, which represent a major component of SPTC's work plan for the next period. Other activities for the next reporting period include: 2017 Oklahoma Transportation Research Day, TLC activities, SPTC Leadership and Advisory Board Retreats, Seminars, Webinars and Workshops. A number of experiential learning and outreach activities are also planned.

2 PRODUCTS

2.1 Publications, Conference Papers and Presentations The SPTC consortium members have been actively sharing their achievements during the reporting period through associated activities supported by matching and leveraging funds. Publications/ Conference Papers and Presentations produced and delivered by SPTC researchers stemming from the 14 and 15 programs for this reporting period are listed in this section. To date, researchers have disseminated SPTC research through forty-five (45) journal publications or conference papers and ninety-one (91) presentations.

Publications/Conference Papers

- Rahman, M.A., Arshadi, A., Ghabchi, R., Ali, S.A., and Zaman, M., "Evaluation of Rutting and Cracking Resistance of Foamed Warm Mix Asphalt Containing RAP". Geo-China International Conference, 2018. (accepted for presentation and publication)
- Asadi, M. and Ashtiani, R., "Stability Analysis of Anisotropic Pavement Foundations", Accepted for Publication in the Elsevier Journal of Transportation Geotechnics, 2017.
- Arteaga, U., Ashtiani, R., "Analysis of Cyclic Behavior of Geomaterials Using Dissipated Energy Concept". Proceedings of the ASCE's International Conference on Highway Pavements and Airfield Technology, August 2017, pp. 322-333.
- Ashtiani, R., Asadi, M., "Application of Statistical Pattern Classification Methods for Characterization of Pavement Foundations.", Proceedings of The 10th international Conference on the Bearing Capacity of Roads, Railways and Airfields, Athens, Greece, June 2017.
- Ashtiani, R., Asadi, M., "Stability Control of the Unbound Aggregate Base in Multi-Layer Pavement Structures," Proceedings of the ASCE's International Conference on Highway Pavements and Airfield Technology, August 2017, pp. 35-44.
- Whitman, M.G., K. Barker, J. Johansson, and M. Darayi. 2017. "Component Importance Measures for Multi-Commodity Networks: Application in Swedish Railway," Minor revisions in Computers and Industrial Engineering.
- Whitman, M.G., H. Baroud, and K. Barker. 2017. "Multi-Criteria Risk Analysis of Commodity-Specific Dock Investments at an Inland Waterway Port. Submitted to Journal of Infrastructure Systems."

Presentations

1. Rahman, M.A., Arshadi, A., Ghabchi, R., Ali, S.A., and Zaman, M., "Rutting and Cracking Resistance of Foamed Warm Mix Asphalt Containing RAP". SPTC Summer Symposium, Oklahoma, USA, 2017.
2. "Analysis of Cyclic Behavior of Geomaterials Using Dissipated Energy Concept", Presentation at the ASCE's International Conference on Highway Pavements and Airfield Technology, Philadelphia, PA, August 30th, 2017.
3. "Stability Control of the Unbound Aggregate Base in Multi-Layer Pavement Structures", Presentation at the ASCE's International Conference on Highway Pavements and Airfield Technology, Philadelphia, PA, August 28th, 2017.

2.2 Website or Other Internet Sites The SPTC website, http://www.sptc.org, disseminates the results of the research and program activities, such as seminar, workshop and research related events. It also hosts the *SPTC Newsletters* and *SPTC Briefs*. UTEP developed a website for its Transportation Leadership Council (TLC) Student Chapter http://ctis.utep.edu/utc/tlc/. SPTC Researcher Sanjay Tewari developed the following website to disseminate education/outreach activities for K-12 STEM efforts http://www2.latech.edu/~dehall/SPTC/main.html.

2.3 Technologies and Techniques SPTC projects have resulted in delivering technologies and techniques to entities in government or industry. During the reporting period, SPTC researchers have delivered several techniques. "Special Provisions" for the use of intelligent compaction rollers for compaction of stabilized subgrades have been developed and validated. (An overview of the project is found in the SPTC Fall 2014 Newsletter (pp. 13-14), http://www.sptc.org/newsletters/.) Additionally, SPTC researchers have delivered a technique to assist state agencies in improving stabilized subgrade behavior by providing a fast, easy-to-implement method of testing stabilizer content and distribution during construction, prior to pavement construction. The method provides a tool for forensic investigations, where the presence or lack of additive in a stabilized layer is in question. This project also validated the use of x-ray fluorescence technology in subgrade applications. SPTC researchers developed a technique for predicting the axial load versus axial deformation relationship of concentrically loaded repaired timber bridge piles, as well as developed several methods for repairing these piles. SPTC researchers also employed technologies and techniques to assess road surface characteristics for safety. State-of-the-art data collection devices were used for data collection, including the 3D laser imaging technology (named as PaveVision3D Ultra) for 1mm 3D pavement surface data, the Inertial Measurement Unit (IMU), Grip Tester for continuous surface friction, dynamic friction tester (DFT) for dynamic friction coefficients, AMES high speed profiler for pavement roughness and macro-texture, and the portable LS-40 3D Surface Analyzer for ultra-high resolution pavement texture. The estimation of pavement cross slope, hydroplaning speed, macrotexture, and friction performance can be performed via the 3D pavement image at high resolution. This study with field pavement applications has shown that the 1mm 3D Ultra technology is promising in real-time pavement surface characterization and evaluation for both pavement and safety management at network and project level surveys (http://www.sptc.org/briefs/2016/1/21/sptc-brief-evaluation-of-pavement-surface-characteristics-with-imaging-for-enhancing-safety). Moreorver, researchers developed the technique for applying LIDAR technology to landslide monitoring and risk assessment for highways.

2.4 Inventions, Patent Applications and/or Licenses Nothing to report this period.

2.5 Other Products During the reporting period, a state-of-the-art characterization of Moreland clay was delivered. It includes the identification of its swell-shrink properties, soil index property measurement, plotting of the soil water characteristics curve (SWCC) to understand the water retention capacity of the clay, development of an empirical equation for its unsaturated shear strength, establishment of its three-dimensional constitutive surface, and the soil heave predictions. More information can be found at SPTC14.1-76, http://www.sptc.org/projects/. Additionally, a numerical model of the Overlay Tester (OT) and Semi-Bending Circular (SCB) test were delivered. The developed models combined DEM with imaging techniques to study asphalt mix crack resistance. SPTC researchers also provided an analysis and experimental testing of steel bridge details susceptible to fatigue and end regions of precast prestressed concrete girder ends subjected to reinforcement corrosion (SPTC14.1-58, http://www.sptc.org/projects/). SPTC researchers created an integrated modeling and monitoring system to assist the management of the hazardous impacts of dust on highway safety (http://www.sptc.org/briefs/2015/11/11/sptc-brief-evaluating-dust-and-highway-safety-in-the-southern-plains). SPTC researchers delivered a project that will assist agencies in determining the impact that pumping has on the air void system of a concrete mixture. It provides the effects that different air contents, pumping time, and pressure have on the air volume and stability of the air void system. SPTC researchers also delivered a model and observation-derived spatial 36-year dataset for freezing precipitation that can be used for winter hazard and vulnerability assessment (an overview of the project is found in the SPTC Spring 2015 Newsletter (pp. 16-17), http://www.sptc.org/newsletters/).

3 PARTICIPANTS AND COLLABORATING ORGANIZATIONS

The SPTC consortium is tied together by its collaborative culture, *sharing to gain*, and its core values of communication and collaboration. Each consortium member (http://www.sptc.org/consortium) is committed to sharing its human expertise and facilities to serve Region 6 through research, education, outreach and workforce development effort. This willingness to share extends not just to the members of the consortium, but to all stakeholders including state and local transportation agencies, the private sector, international collaborators and any educational institution

in the region that is willing to work with the SPTC. Examples of collaborations for the reporting period are outlined as follows.

3.1 Individuals

The individuals that operate/support the SPTC can be found in the recent progress report (PPPR #7), http://www.sptc.org/progress-reports/. These individuals collaborated on activities within their respective institutions and among the consortium institutions, as listed in the following table.

SPTC Advisory Board	Leadership Retreat, 2017 SPTC Summer Symposium, Quarterly Conference Call, Exploring industry collaborations, ECDP Proposal Review
The University of Oklahoma	Leadership Retreat, 2017 SPTC Summer Symposium, 2017 SPTC Seminar Series, Overseeing overall operation of Center, Representing Center and/or the UTC Program at external meetings, Working closely with the Advisory Board and the Leadership Core to set goals and priorities, Working closely with stakeholders, Enhancing collaborations with both consortium members and non-consortium institutions including international institutions, Working closely with TTAP and LTAP, Associate Director's monthly meeting, TLC Activities, Developed proposal for 2019 CUTC Summer Meeting, SPTC 17.1 Program, SPTC Research Programs, 2017 TRIP, 2017 OTRD, 2017 SPTC Newsletter
Langston University	2017 Transportation Academy (LUTA), Monthly Conference Call , SPTC Reporting
Louisiana Tech University	Managing SPTC Requirements, SPTC17.1 Proposal Review. Monthly AD Conference Call, TLC Activities, Local Internship Program
Oklahoma State University	Monthly AD Conference Call, Managing SPTC Requirements, Coordinate SPTC Events on the OSU campus, TRIP Internships, 2017 OTRD, 2017 Summer Symposium
Texas Tech University	Monthly AD Conference Call Participation, Managing SPTC Requirements, SPTC17.1 Proposal Reviewer, TRIP Internships, TLC Activities
University of New Mexico	Monthly AD Conference Call, Managing SPTC Requirements, SPTC17.1 Proposal Review
University of Texas at El Paso	Monthly AD Conference Call, Managing SPTC Requirements, SPTC17.1 Proposal Review, TRIP Internships, TLC Activities, 2018 Leadership Retreat and Forum
University of Arkansas	Monthly AD Conference Call, Managing SPTC Requirements, TLC Activities, TRIP Internships

3.2 Other Organizations

Departments of Transportation: State DOTs are an important stakeholder. With one representative from each DOT in Region 6, the SPTC Advisory Board provides a unique opportunity to identify and address some complex and challenging problems in Region 6 and the nation. These members participated in the Advisory Board Retreat in Dallas and in regular quarterly meetings during the reporting period. The Oklahoma Department of Transportation is providing cash match to the SPTC. New Mexico DOT, Texas DOT and Louisiana Transportation Center (LTRC) are providing substantial cash match to support a number of SPTC projects. These projects constitute an integral component of the SPTC work plan. As described in the first section of this report, AHDT sponsored the TRIP interns and ODOT participated in the SPTC Summer Symposium during this reporting period.

Private Sector: The private sector is another key stakeholder of the SPTC. Two at-large members from the private sector serve on the SPTC Advisory Board. These members participated in the Advisory Board Retreat and in regular quarterly meetings during the reporting period. A number of companies, within Region 6 and outside, are contributing substantial cash match and in-kind match for several of the projects funded from the 14.1 and 15.1 competitions. During the reporting period, eight (8) private sector companies also participated in the 2017 Summer TRIP program.

3.3 Other Collaborations
Nothing to report this period.

4 IMPACT

4.1 Impact on the Principal Discipline

Findings, results and techniques that were developed by SPTC researchers during this reporting period that have made an impact or are likely to make an impact on the base of knowledge, theory, and research in transportation are described in this section.

Improvements in Quality Control of Subgrade: SPTC researcher Sesh Commuri's project team has delivered "Special Provisions" for the use of intelligent compaction rollers for compaction of stabilized subgrades. Improper compaction during construction is one of the leading causes for the early deterioration of asphalt pavements. Intelligent Compaction offers transportation agencies a means of constructing high quality and longer lasting roads. This contribution will be especially critical given the increase in vehicular and truck traffic as well as extensive variations arising from seasonal and extreme weather conditions.

SPTC Researcher Amy Cerato and her team have delivered a technique to assist state agencies in improving stabilized subgrade behavior by providing a fast, easy-to-implement method of testing stabilizer content and distribution during construction, prior to pavement construction. Agencies can reliably determine the actual amount and distribution of stabilizer in the subgrade soil, which can significantly impact the long-term behavior of the roadway.

SPTC Researcher Jay Wang and his team's project can assist transportation agencies in reducing pavement cracking resulting from issues with expansive soils. The product can assist in identifying swell-shrink properties, soil index property measurement, plotting of the soil water characteristics curve (SWCC) to understand the water retention capacity of the clay, development of an empirical equation for its unsaturated shear strength, establishment of its three-dimensional constitutive surface, and soil heave predictions.

Improvements in Asphalt Testing: SPTC researcher Enad Mahmoud and his team have developed a numerical model of the Overlay Tester (OT) and Semi-Bending Circular (SCB) test that can assist agencies in evaluating asphalt mix crack resistance. Most of the state DOTs, especially in the southern region, have used stiffer hot mix asphalt (HMA) to mitigate rutting. The shift toward stiffer mixes has resulted in asphalt pavements that are more prone to reflective and fatigue cracking. Cracking in HMA usually results in much faster deterioration rates of the pavement. Therefore, it is imperative that DOTs have the tools necessary to determine cracking propensity. This study developed models that combined DEM with imaging techniques to provide such a tool.

Improvements in Bridge Evaluation and Maintenance Techniques: SPTC researcher David Hall's project team has delivered a technique that will assist transportation agencies in mitigating the effects of biological degradation in timber-pile bridges that initiates in the wet-dry zones. Replacing these deteriorated piles is a costly process and in-situ repair of the piles with fiber reinforced polymers (FRP) is an economic alternative that does not require shoring the superstructure and does not interfere with the daily operation of the bridge. The project delivered an evaluation of the capacity of FRP strengthened deteriorated timber piles under concentric and eccentric loads with different deterioration configurations as well as delivering other cost-effective methods for repairing these piles.

SPTC researcher Royce Floyd and his team's project have assisted transportation agencies with addressing the growing burden of bridges that are currently classified as either structurally deficient (due to deterioration) or functionally obsolete by providing an understanding of the corrosion effects in concrete bridges and longevity of existing steel bridges subjected to corrosion induced deterioration and metallic fatigue.

4.2 Impact on Other Disciplines

Improvements in Blowing-Dust Risk Assessment: SPTC researcher, Jimmy Li and his project team created an integrated modeling and monitoring system to assist the management of the hazardous impacts of dust on highway safety that will be useful to various types of agencies. It provides agencies with methods to identify the characteristics of

the dust emission hotspots in relation to the distribution of highway, geomorphology, and land use, and a method for classifying the hotspots for the potential of blowing dust production based upon field observations and dust emission modeling.

Improvements in Vulnerability Assessment Data: SPTC researcher Renee McPherson and her team also delivered a model and observation-derived spatial 36-year dataset for freezing precipitation which can be used for winter hazard and vulnerability assessment. The project provides extensive climate analysis examining historical trends and future climate scenarios for the South Central United States, focusing on transportation-relevant conditions that reflect extreme and impactful events which stress transportation infrastructure and affect safety.

4.3 Impact on Workforce Development

During this reporting period, SPTC activities have been executed that have an impact on workforce development through providing opportunities for research and teaching in transportation and related disciplines and improving the performance and skills of members of underrepresented groups that will improve their access to or retention in transportation research, teaching, or other related professions. Activities also included developing and disseminating new educational materials and awards, as well as providing exposure to transportation, science and technology for practitioners, teachers and young people and other members of the public. A summary of these activities follows.

Improving Performance and Skills of the Future Workforce in 2017 TRIP: SPTC is committed to strengthening the UTC program's legacy of invaluable contributions to transportation education and workforce development by executing a comprehensive strategy keyed to the complimentary life-long learning themes of higher education, professional development, encouraging new ideas and new entrants to the profession, as well as K-12 outreach. This cradle-to-grave approach is particularly relevant in Region 6. The region's underrepresented groups – Hispanic, African-American, Native American and women – are best served by early intervention, targeted higher education, and continuing education. An important element of SPTC's workforce development effort is the Transportation Regional Internship Program (TRIP). The following quotes are from TRIP participants. See more about the TRIP participant profiles in the SPTC Newsletter (pp.19-21) found here http://www.sptc.org/newsletters/.

(1) "This summer I was an intern with KSA in the Aviation Services group in their Sugar Land, Texas office. This internship was a valuable addition to my academic studies. I enjoyed using several skills from college coursework including surveying, excel, and Civil 3D. I was able to take initiative beyond the basic requirements of the job. I learned so much, and I also realized how much I have yet to learn. I was able to learn about all the different processes that go into a project (such as all the components to marketing, design, biding, construction, and close out)."

(2) "I was given the opportunity to work on different projects and I got to work on both of my interests [Roadway and Geotechnical]. I thank Olsson for giving me the opportunity to join the summer intern team and for giving me the opportunity to work for them through my last semester of my school. I am also going to continue working for them after graduation, which I am excited about."

(3) "The experience I had at Olsson enriched my college and educational experience while reaffirming the fact that I wanted to pursue a career in civil engineering."

(4) "My role was to prepare construction specs for the construction documents, drafting dimensions for the site plan, and finding all spot elevations needed for the grading plans. Along with these projects, I got the chance to visit a steel fabrication facility near the Port of Catoosa and perform an inspection of the facility for a SPCC plan that needed to be updated. This summer opened my eyes to many different aspects of the civil engineering profession and also helped me figure out what would be the best direction for me to go in for the future. I learned a lot about good drafting practices and what is needed for most construction projects in the construction documents. Zoning and ADA requirements were also something that the other engineers in the office talked to me about and taught me how to find the appropriate manuals for the appropriate project. I thought that my internship experience was very beneficial to my education because it taught me the way engineers apply the knowledge they gain in school to their work and how the project process works."

(5) "Prior to this summer, I had not been exposed to connection design outside of a classroom setting. This was a new, challenging experience for me in determining how forces in a connection flow from the location the load is being applied, back to the structural member. I have gained useful knowledge in the field of structural engineering, particularly with the design of metal structures. I am more confident in my ability to break down a structure, large or small, into components to determine how loads applied get transferred through members and connections to the structural foundation."
(6) "This summer has afforded me the opportunity to work on many exciting and challenging projects. Through this internship I have developed skills that are invaluable to my future … in the job market."

Continuing Education Seminars, Workshops and Conferences: There have been at least ten (10) major events, as noted in the Accomplishments section of this report (1.2.2 Workforce Development, Education and Outreach), which provided important educational experience to hundreds of participants and students across Region 6, including current workforce seeking to advance their knowledge and others considering transportation as potential career opportunities. For example, LUTA participants (high school students) indicated that the academy impacted them in terms of the careers they will choose in the future.

Developed and Disseminated New Educational Materials and Awarded Scholarships: New materials and scholarship award, as stated in the Accomplishments section of this report, provided important educational experience and motivation to college students, including current workforce, seeking to advance their knowledge and others considering transportation as potential career opportunities.

4.4 Impact on Physical, Institutional and Information Resources

Improved Safety Information Resources for Agencies: SPTC researcher Kelvin Wang and his team's project delivered technologies and techniques to assist agencies in assessing road surface characteristics for safety. The goal is to reduce traffic fatalities due to deterioration of pavement surface friction. Collecting pavement safety data is critical to the process. This project allows estimation of pavement cross slope, hydroplaning speed, macrotexture, and friction performance that can be done in real-time for both pavement and safety management at network and project level surveys.

SPTC researcher Yongwei Shan and his team developed a technique for applying LIDAR technology to landslide monitoring and risk assessment for highways. This will allow agencies to mitigate the danger to travelers by monitoring the fill/cut slopes change over the time along the roads that pass through mountainous areas, which can be an effective approach to assessing the risk of landslide properly and proactively deploy prevention, mitigation measures, or emergency response to reduce the impact of landslides.

4.5 Impact on Technology Transfer

SPTC projects have resulted in the transfer of results to entities in government or industry and adoption of new practices. SPTC projects have resulted in delivering technologies and techniques that have the potential to greatly impact government or industry, as described in Section 2 of this report. Additionally, the Continuing Education Seminars, Workshops, Conferences and Symposium (as detailed in Section 1 of this report) have greatly impacted technology transfer.

4.6 Impact Beyond Science and Technology Nothing to report during this period.

5 CHANGES/PROBLEMS Nothing to report during this period.