



## 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 has made 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 2019 Oklahoma Transportation Research Day; (iii) facilitating the SPTC Research Programs; (iv) conducting many other education and outreach activities at member institutions across the consortium; (v) delivering the 2019 SPTC Workshop Series; (vi) executing summer workshops and internship programs; (vii) engaging student TLC chapters and awarding students for meritorious research; (viii) enhancing collaborations; (ix) delivering techniques, technologies and products that have impact and (ix) working to close out the grant during this no-cost extension year. 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 and facilitating SPTC Research and Education project progress. An overview of each of these activities follows.



**2019 CUTC Summer Meeting:** The Council of University Transportation Center's 2019 Summer Meeting occurred in June at The University of Oklahoma (OU). The meeting was held at The National Weather Center (NWC). There were one hundred fifty-nine (159) participants and over forty (40) presenters, comprised of academic and DOT members, along with students. The feedback survey showed that participants found value in the program and event and that the Summer Meeting was successful in meeting its objectives.

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 2019 Oklahoma Transportation Research Day scheduled for November 5<sup>th</sup>. More information about this event can be found at: <http://www.sptc.org/>.

Research Project Progress: The following institutions are currently in project close-out mode for the SPTC14, SPTC15 and SPTC17 programs. A short summary of progress by project category during the reporting period is as follows.

## Climate and Safety

- “Combined effect of sea-level rise and coastal land subsidence – Identification of critical transportation infrastructure at-risk in coastal SPTC region” (Project team includes Sanjay Tewari and Wesley Palmer (LaTech)). This project investigates the trends for sea-level rise and land subsidence in coastal regions of Louisiana and Texas. During the reporting period, progress has included making the final report ADA compliant. The project will deliver spatial maps created using ArcGIS for transportation infrastructure that is at risk because of combined risk of land subsidence and sea-level rise.

## Bridge Structures

- “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 provides methods to quantify, manage and decrease the vulnerability of transportation infrastructure - specifically bridges and drainages - to wildfires. During the reporting period, progress has included making the final report ADA compliant. An initial cost for the debris deflector was estimated using standard cost estimation procedures. 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.
- “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 making the final report ADA compliant. Based on the findings, recommendations will be made for using A1035 steel in the design of bridge decks.
- “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 making the final report ADA compliant. The project will yield a methodology of monitoring the degradation of Mechanically Stabilized Earth Reinforcements.

## 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 seeks to develop a Travel Time Reliability Monitoring System (TTRMS) consisting 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 has included making the final report ADA compliant. Implementation will improve system responsiveness and reliability.
- Expanding PARIS+ to regional police agencies (Project team includes Ron Barnes and Joseph Havlicek (OU)). During the reporting period, progress includes writing the final report. This project expands the availability of the Police Automated Records Information System+ (PARIS) across the state and to begin marketing the system to police agencies in neighboring states.

## Pavement and Materials

- “Development of Guidelines for High-Volume Recycled 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 has included making the final report ADA compliant. 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 (formerly OU, now South Dakota State University) 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 has included making the final report ADA compliant. 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 for moisture damage.
- “Design Data for Rigid Pavements in New Mexico” (Project team: Rafiqul A. Tarefder and Mahmoud Reda Taha (UNM)). During the reporting period, progress has included posting the final report here: <http://www.sptc.org/projects>. This study developed three most important inputs, among many inputs required by the AASHTOWare pavement M-E software, for the design of rigid pavements in New Mexico considering materials, traffic, and climate.
- “Development of Special Provision for Mix Design of Foamed-WMA Containing RAP” (Project team includes Rouzbeh Ghabchi (formerly OU, now South Dakota State Univ.), Musharraf Zaman (OU) and Manik Barman (formerly OU, now University of Minnesota-Duluth).) 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 making the final report ADA compliant. 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.

**1.2.2 Workforce Development, Education and Outreach:** In the reporting period, the SPTC was engaged in advancing the following activities: 2019 SPTC Summer Symposium; 2019 SPTC Thesis Awards; 2019 Transportation Regional Internship Program (TRIP); 2019 Summer Programs; 2019 SPTC Workshop/Seminar Series, 2019 SPTC Short Course Series and other education/outreach events; and SPTC Briefs. An overview of some of these activities follows.

*2019 SPTC Summer Symposium:* The Symposium was held on August 8, 2019 at the National Cowboy and Western Heritage Museum with the goal of providing an opportunity for graduate student presentations and spurring discussion on transportation related research in Region 6. One hundred and five (105) attendees participated in the Symposium and included representatives from consortium members in the region. The symposium was divided into sessions focused on Transportation Technology and Automated Vehicles, Bridge Construction and Repair, Durable Materials and Balanced Mix Design, Highway Mobility and Safety, Rail and Multimodal Transportation. The sessions included podium and poster presentations by graduate students, undergraduate students, and faculty members. In addition to providing students an opportunity to present their work, the symposium provided a networking opportunity for students, faculty members, and DOT personnel in the region. Six (6) pdhs were offered to eligible attendees. The diversity of attendees allowed for excellent discussion of important research topics while keeping the focus on the Southern Plains Region <http://www.sptc.org/2019-summer-symposium>.



SPTC 2019 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 two theses published or accepted during 2018: **Melissa Escalante** and **Rodrigo A. Collao Benitez**. Melissa’s work is entitled, “Assessing Delamination of Concrete Bridge Decks with Aging in Arid Regions Using Nondestructive Methods”. Rodrigo’s work is entitled, “Developing Affordable Smart Solutions for Police Reporting”. The awardees presented their work in an SPTC webinar on July 16<sup>th</sup>. More information can be found at <http://www.sptc.org/awards/>.

SPTC Seminar Series 2019: On April 8<sup>th</sup>, Dr. Vijaya Gopu, Ph.D., P.E., Professor in Civil



Engineering at the University of Louisiana, Associate Director for External programs at Louisiana Transportation Research Center (LTRC), delivered a workshop entitled, “Challenges and Opportunities in Deploying Connected and Autonomous Vehicles” at the Oklahoma Department of Transportation. 1-Hour PDH was provided to eligible attendees. The workshop provided information regarding autonomous and connected vehicle technologies are advancing at a rapid pace and hold the promise of delivering substantial benefits to the society by reducing fatalities, crashes, congestion, fuel consumption, and pollution while significantly enhancing mobility. Major companies are investing heavily in the development of autonomous vehicles so that they can reap the benefits of what may soon be recognized as the most disruptive technology of the first half of this century. The emergence of these new technologies will have a profound effect on jobs and businesses based on public transportation, auto-body and auto repair, and auto insurance since these might slowly become obsolete. This presentation provides an overview of the current status and the needs in the areas of technology, infrastructure, and regulations to implement automated driving. The challenges and risks associated with autonomous vehicles, the specific needs in the Gulf South Region, and a look into the future were discussed.

On June 28<sup>th</sup>, Dr. Amit Prashant, Dean, Research and Development Professor, Civil Engineering, Indian Institute of Technology Gandhinagar (shown far left in photo) delivered a workshop entitled, “Double Wedge Model and Design Charts for Displacement-Based Design of Cantilever Retaining Walls” at the Oklahoma Department of Transportation. 1-Hour PDH was provided to eligible attendees. The workshop provided information regarding case studies, which have reported failure of cantilever retaining walls under earthquake loading due to lack of sufficient understanding on the seismic design of these structures. A displacement-based design methodology for cantilever retaining walls has been developed assuming double wedge formation in the backfill and with due consideration to sliding and rotational failure modes. Experimental investigations show the formation of double wedge with v-shaped rupture planes in the backfill evolving from the heel of wall, wherein practically, the rupture



planes may or may not intersect the backface of wall. The double wedge model computes seismic sliding displacements of these walls due to the applied earthquake motion and the tangential downward movement of soil wedge along the rupture planes. To compute residual and peak rotational displacements at the top of wall in a simplified manner, residual and peak displacement factor have been proposed to be multiplied with sliding displacements computed from the model. These factors are determined after analyzing 144 cases of rigorous FE non-linear dynamic analysis. Similar exercise has been performed on wall with shear key by analyzing 64 different cases. To account for uncertainties associated with the effect of earthquake characteristics on deformation response of wall, suitable load factors have been proposed in the realm of displacement-based seismic design using LRFD framework. These load factors depend on the PGA of earthquake under consideration. As a much simpler alternative, design charts and corresponding equations based on double wedge model have been proposed to estimate the required heel-length of wall for the expected seismic ground motion. (<http://www.sptc.org/seminars/>).

SPTC Webinar Series 2019: On July 16<sup>th</sup>, SPTC Thesis Award Winners, Melissa Escalante and Rodrigo A. Collao Benitez, led a webinar. Melissa presented her work entitled: "Assessing Delamination of Concrete Bridge Decks with Aging in Arid Regions Using Nondestructive Methods." Rodrigo presented his work entitled: "Developing Affordable Smart Solutions for Police Reporting." The full webinar is available here <http://www.sptc.org/webinars>.

SPTC 2019 Short Course Series On April 4<sup>th</sup>, Gerald A. Miller, Ph.D., P.E., Professor and Associate Director of the OU School of Civil Engineering and Environmental Science and Associate Director of SPTC delivered a short course entitled, "Course Series Practical Unsaturated Soil Mechanics: Part I" to engineers from the Oklahoma Department of Transportation and consulting firms. 8-Hour PDHs were provided to attendees. The short course provided information regarding: In Oklahoma and many other States, it is common to place foundations, building slabs and pavements on or in unsaturated soils.



In addition, all compacted soils begin their service life in an unsaturated state. Yet, practice has not evolved to fully embrace the importance of unsaturated soil behavior in geotechnical engineering. This one-day short course is the first in the series that will focus on application of unsaturated soil mechanics principles in engineering practice. The morning session will introduce basic unsaturated soil mechanics principles related to stress-strain, volume change and shear strength behavior. Behavior of unsaturated soils is closely tied to the variations in soil moisture and suction states in the soil. Due to seasonal weather variations, these states can change in the near surface soils affecting soil behavior and performance of geotechnical works. Thus, significant emphasis will be given to the determination of suction components including total, osmotic and matric suction and their variation with moisture content as described by the Soil Water Characteristic Curve. The afternoon session will focus on laboratory and field testing of unsaturated soil profiles with consideration of unsaturated soil mechanics and changes in moisture that may occur after the subsurface exploration is complete. Geotechnical engineering examples, including bearing capacity of foundations and volume change in compacted and natural soils will be presented emphasizing the importance of considering unsaturated soil mechanics in the



subsurface exploration and design phases of a project. The emphasis of this course is on “practical” methods that can be incorporated into practice without major investment in sophisticated laboratory testing equipment. For many geotechnical problems, the basic equipment found in most geotechnical labs can be used to gain a deeper understanding of unsaturated soil behavior by simple modifications to testing procedures and augmenting the interpretation of results with some basic measurements of moisture content and suction.



On July 12<sup>th</sup>, Dr. Dominique Pittenger, Technical Director of SPTC and Research Assistant Professor in the Gallogly College of Engineering at The University of Oklahoma delivered a short course entitled, “Transportation Asset Management” to engineers from the Oklahoma Department of Transportation and consulting firms. 8-Hour PDHs were provided to attendees. The short course provided information regarding transportation agencies that must meet MAP-21/FAST Act requirements by integrating various transportation asset management (TAM) practices into investment strategies to the benefit of agency. The legislation requires States to develop and implement risk-based TAM plans for the National Highway System (NHS) to improve or preserve the condition of the assets and the performance of the system. TAM facilitates decision analysis and justification that can offer insight as to relative differences between investment alternatives in the areas of uncertainty, objectives and trade-offs to assist agencies in making strategic long-term investment decisions under short-term budget constraints. This one-day short course will focus on TAM elements and application of its principles in engineering practice related to FHWA TAM concepts and methodologies for a “strategic and systematic process of operating, maintaining, and improving physical assets” (e.g., pavement and bridge condition performance management requirements), “with a focus on engineering and economic analysis based upon quality information (e.g., data), to identify a structured sequence of maintenance, preservation, repair, rehabilitation, and replacement actions that will achieve and sustain a desired state of good repair (SOGR) over the lifecycle of the assets at minimum practicable cost”. The emphasis of this course was on the engineering and economic analysis concepts and processes used to support routine system investment, performance and management activities.

*Transportation Regional Internship Program (TRIP):* An important element of SPTC’s workforce development effort is TRIP. Seventy-four (74) students participated in the 2019 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 Department of Transportation). 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 (<http://www.sptc.org/2019-internships>).

*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, twenty-one briefs have been posted that highlight specific SPTC projects (<http://www.sptc.org/briefs/>). Regular discussions are 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): planning for the 2019 Summer CUTC Meeting, meeting frequently to discuss Center operations and future direction, TLC activities and other activities.

*SPTC Leadership Prepares for and Participates in the CUTC Summer Meeting:* SPTC Leadership worked to prepare for the 2019 June Summer CUTC Meeting held in Norman, Oklahoma. Many of the Associate Directors and Advisory Board members participated in the development and delivery of the program. More information about these groups can be found at <http://www.sptc.org/leadership> and <http://www.sptc.org/advisory-board>. Meeting information can be found here <http://www.sptc.org/cutc>.



*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. Some of the activities for this period included TLC participation at the 2019 Summer CUTC Meeting in June. Students were actively engaged in the program and were given the opportunity to present their work in a poster session and network with attendees. For example, Recently, LA Tech TLC/ASCE had the opportunity to send two students to the

meeting (pictured left). The students presented their research on asphalt binders to professionals and other students within the transportation field. It was a great way for our students to communicate with today's transportation leaders.

UTEP TLC Members attended the T&DI International Airfield and Highway Pavements Conference, July 21-24 in Chicago, IL. According to Mojtaba Asadi, “the T&DI pavements conference was a unique experience where I met great names in the field of pavement research, Imad Al-Qadi, Erol Tutumluer, Shiraz Tayabji, to name some, in a friendly environment. For a PhD student, this can be inspiring to have a conversation and learn from the pioneers of the field. In addition, I met the UTEP alumni who are now involved in pavement research in both academia and industry. To me, this was so resourceful to hear from experiences of my peers, and to picture my future career opportunities. The backbone of the conference, i.e., its technical sessions, were full of interesting topics and latest findings of research not only from across the US but also from around the world. The poster

session was a great time to explain our study of modeling pavement drainage systems using unsaturated flow principles.”



**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 SPTC research programs are becoming available and being posted on the Center website (<http://www.sptc.org/projects/>) 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/newsletters/>). 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** The grant expired September 2019. Remaining activities for this year include grant close out and the 2019 Oklahoma Transportation Research Day. The SPTC will continue to report activities scheduled for next year on its website. The SPTC will continue to execute leadership meetings and TLC activities. It will also continue the TRIP Internship Program, Summer Symposium, Research Conference, Student of the Year and other activities that are beneficial to stakeholders.

## 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 SPTC research programs for this reporting period are listed in this section. To date, researchers have disseminated SPTC research through one hundred and one (101) journal publications or conference papers and one hundred thirty-eight (138) presentations.

### Publications/Conference Papers

Khandel, O., Soliman, M. and Floyd, R. "Application of Fiber Optic Sensors for Damage Detection and Performance Monitoring of Prestressed Concrete Bridge Girders," 9th International Conference on Structural Health Monitoring of Intelligent Infrastructure, St. Louis, MO, August 4-7, 2019.

Murray, C. D., Cranor, B. N., Floyd, R. W., Pei, J. S., "Experimental Testing of Older AASHTO Type-II Bridge Girders with Corrosion Damage at the Ends," PCI Journal, Vol. 64, No. 1, 2019, pp. 49-64.

Murray, C. D., Diaz Arancibia, M., Okumus, P., and Floyd, R. W., "Destructive Testing and Computer Modeling of a Scale Prestressed Concrete I-girder Bridge," Engineering Structures, Vol. 183, 2019, pp. 195-205. DOI: 10.1016/j.engstruct.2019.01.018.

Adnan Khan and Jay X. Wang, 2019, Development of an Analytic Method for Analyzing Expansive Soil-Induced Stresses in Highway Pavement. Accepted by ASCE International Journal of Geomechanics, April 18, 2019.

Debojit Sarker, Jay X. Wang, and Md Adnan Khan, 2019, Development of the Virtual Load Method by Applying the Inverse Theory for the Analysis of Geosynthetic-Reinforced Pavement on Expansive Soils, ASCE Geo-congress 2019, GSP 310, pp. 326-329, Philadelphia, March 24-27, 2019. The paper was presented as well at the conference.

Stewart, C.M., Garcia, E., 2019, "Fatigue Crack Growth of a Hot Mix Asphalt using Digital Image Correlation," International Journal of Fatigue, 120.  
<https://doi.org/10.1016/j.ijfatigue.2018.11.024>

Stewart, C. M., Oputa, C.W., and Garcia, E., 2018, "Effect of Specimen Thickness on Fracture Resistance of Hot Mix Asphalt in Disk-Shaped Compact Tension (DCT) Configuration," Construction and Building Materials, 160, pp. 487-496.  
<https://doi.org/10.1016/j.conbuildmat.2017.11.041>

Contreras-Nieto, C., Shan, Y., Lewis, P., & Hartell, J. A. (2019). Bridge maintenance prioritization using analytic hierarchy process and fusion tables. Automation in Construction, 101, 99-110.

Contreras-Nieto, C., Shan, Y., & Lewis, P. (2018). Characterization of Steel Bridge Superstructure Deterioration through Data Mining Techniques. Journal of Performance of Constructed Facilities, 32(5), 04018062.



## Presentations

Stoner, A.M.K., J.S. Daniel, J. Jacobs, K. Hayhoe, and I. Scott-Fleming, 2018. Decreases in asphalt pavement performance and lifetime in the U.S. due to climate change. Fall Meeting of the American Geophysical Union. Washington, DC. (poster)

Stoner, A.M.K., J.S. Daniel, J. Jacobs, K. Hayhoe, and I. Scott-Fleming, 2019. Decreases in asphalt pavement performance and lifetime in the U.S. due to climate change. Transportation Research Board Annual Meeting. Washington, DC. (poster)

Stoner, A.M.K., 2019. Preparing our infrastructure for a changing climate. Webinar for the American Society of Civil Engineers Knowledge & Learning series.

Stoner, A.M.K., 2018. Engineering Solutions for a Changing Climate. Presented at the American Council of Engineering Companies – Washington-Oregon Joint Fall Conference.

J. Q. Li, Y. Fei, and K. Wang, “Prep-ME: Data Preparation and Analysis for the AASHTO Pavement ME Design”, 2019 SPTC Summer Symposium.

K. Hatami, G. S. Garland, T. Simpson, K. Falcon, S. Schnabel, and L. Pena, “Performance Monitoring of GRS Bridges in Oklahoma”, 2019 SPTC Summer Symposium.

K. Hatami, K. Matsuura, and A. Weishaar “Use of Sensor-Enabled Geosynthetics (SEG) for Performance Monitoring of GRS Bridge Abutments and MSE Walls”, 2019 SPTC Summer Symposium.

**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>. SPTC Researcher Esther Mullins created the following website to disseminate her project findings regarding regional climate projections for the transportation sector: <https://climateprojections.wixsite.com/transportation>. It provides multiple climate datasets to identify historical trends and future climate scenarios for the five-state region of Oklahoma, Texas, Arkansas, Louisiana, and New Mexico.

**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.

SPTC Research Rafiqul Tarefder investigated testing and data interpretation of the tested mixtures, deeming it necessary to extend the results of the study to better understand the rutting and stripping susceptibility of AC mixtures due to material variability and testing conditions. The project investigated the effects of aggregate, binder PG grade, gradation, warm mix asphalt agents and polymer modified binders in Hamburg Wheel Tracking Device. This project delivers beneficial analyses for future asphalt concrete mix designs.



SPTC Researchers Rouzbeh Ghabchi and Rifat Bulut delivered the final report entitled, “Development of a SFE Database for Screening of Mixes for Moisture Damage in Oklahoma”. Surface Free Energy (SFE) characteristics of asphalt mixes were evaluated for bond strength and debonding of aggregate and asphalt binder in presence of water, which cannot be achieved using either a Tensile Strength Ratio (TSR) or a Hamburg Wheel Track (HWT) test. This study delivered an SFE database and training for pavement designers for the implementation of this innovative and cost-effective mechanistic approach for screening of asphalt mixes.

SPTC Researchers Hazem Refai and Samir Ahmed delivered “Incorporation of Speed/Travel-time Data Sets in Traffic Performance Analysis”. This project develops 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. Implementation will improve system responsiveness and reliability.

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

**2.5 Other Products** During the reporting period, methodologies and evaluation frameworks were developed. SPTC Researchers Vanessa Valentin and John Stormont provided methods to quantify, manage and decrease the vulnerability of transportation infrastructure - specifically bridges and drainages - to wildfires. 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 was produced.

## 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.

### 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	2019 SPTC Summer Symposium, Quarterly Conference Call, Exploring industry collaborations, Thesis Award Review Committee
The University of Oklahoma	2019 SPTC Summer Symposium, 2019 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, Associate Director’s monthly meeting, TLC Activities, Executed 2019 CUTC Summer Meeting, Administer SPTC Research Programs, 2019 TRIP, Plan 2019 OTRD
Langston University	Monthly Conference Call, SPTC Reporting
Louisiana Tech University	Managing SPTC Requirements, Administer SPTC research projects, 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, 2019 Summer Symposium, Administer SPTC research projects
Texas Tech University	Monthly AD Conference Call Participation, Managing SPTC Requirements, TRIP Internships, TLC Activities, Administer SPTC research projects
University of New Mexico	Monthly AD Conference Call, Managing SPTC Requirements, Administer SPTC research projects
University of Texas at El Paso	Monthly AD Conference Call, Managing SPTC Requirements, TRIP Internships, TLC Activities, Administer SPTC research projects
University of Arkansas	Monthly AD Conference Call, Managing SPTC Requirements, TLC Activities, TRIP Internships, Administer SPTC research projects

**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 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. ArkDOT 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. Many private industry personnel attended and collaborated in the programs for the seminars and 2019 Summer Symposium presented in the first section of this report. Three at-large members

from the private sector serve on the SPTC Advisory Board. These members participated in regular quarterly meetings during the reporting period. A number of companies, within Region 6 and outside, have contributed 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, eleven (11) private sector companies also participated in the 2019 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.

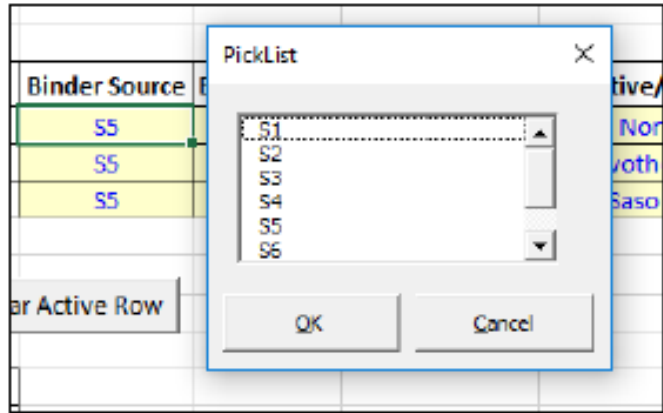
Improvements in Asphalt Testing: SPTC Researcher Rafiqul Tarefder investigated Hamburg Wheel Tracking Device (HWTDT) Testing Criteria to mitigate asphalt pavement distresses for the New Mexico Department of Transportation. Rutting (permanent deformation) is a major concern in asphalt pavements due to the unrecoverable cumulative deformation that occurs in the wheel path under high temperatures as a result of repeated traffic loading. The depression is mostly due to compaction while the lateral movement happens as a result of the shear failure.



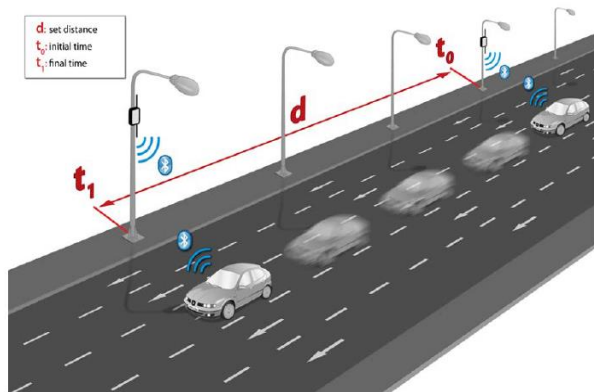
Moisture damage also causes distress in asphalt pavements. It is the progressive deterioration of asphalt mixes caused by loss of adhesion between asphalt binder and aggregate surface and/or loss of cohesion within the binder primarily due to the action of water.

This research project evaluated testing criteria to minimize the impact of rutting and stripping on asphalt concrete pavements. The work builds on the collaboration between researchers at the University of New Mexico (UNM) and the New Mexico Department of Transportation (NMDOT), which involved testing and interpretation of laboratory data to assess the effectiveness of the HWTDT testing criteria. The project developed detailed specifications needed to ensure proper testing for implementation of HWTDT in New Mexico.

SPTC Researchers Rouzbeh Ghabchi and Rifat Bulut delivered the final report entitled, “Development of an SFE Database for Screening of Mixes for Moisture Damage in Oklahoma”. Moisture-induced damage is one of the major distresses responsible for deterioration of asphalt pavement at early age. There is a need to identify mechanistic methods for evaluating moisture-induced damage. In this study, surface free energy (SFE) techniques were used to mechanistically quantify



bonding characteristics of aggregate-asphalt binder systems and consequently moisture-induced damage potential of asphalt mixes. For this purpose, unmodified and polymer-modified asphalt binders from four different sources were collected and mixed with different additives, such as warm mix asphalt (WMA) additive, anti-stripping agent (ASA), polyphosphoric acid (PPA) and reclaimed asphalt pavement (RAP). The SFE components of the binder blends were determined using two different methods, namely, dynamic Wilhelmy plate (DWP) and sessile drop (SD) test. Also, the SFE components of aggregates from five different sources were determined using universal sorption device (USD) and sessile drop (SD) test. Fourier transform infrared, X-ray fluorescence and total acid number tests were conducted on the blended binders to understand the effects of chemical compositions on the SFE components. Asphalt mixes consisting of different additives were produced in the laboratory for moisture-induced damage evaluation using HWT, IDT and Louisiana semi-circular bend (LA-SCB) tests. Correlations between the moisture-induced damage performance parameters from laboratory performance tests and the SFE technique were investigated. The SFE technique was found to be able to differentiate asphalt mixes with different additives based on their moisture-induced damage potentials. It was also found that the LA-SCB test with MIST conditioning can be used as an alternative method to conventional moisture-induced damage test. As a part of this project, a SFE database of asphalt binders and aggregates was developed. The database is expected to be helpful to screen materials during mix design.



Improvements in Decision Making:

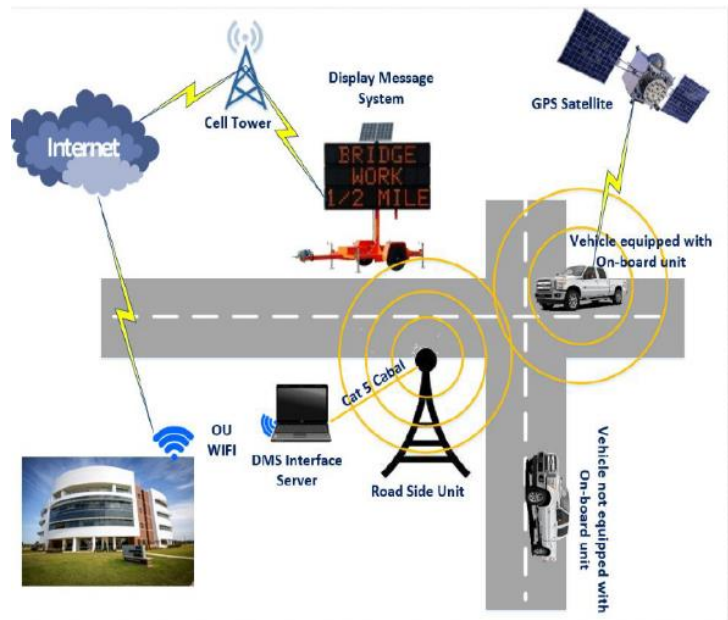
SPTC researchers Hazem Refai and Samir Ahmed delivered a final report for “Incorporation of Speed/Travel-time Data Sets in Traffic Performance Analysis”. This project developed a Travel Time Reliability Monitoring System (TTRMS) composed of Bluetooth identification devices strategically placed on interstate highways coupled with analytical models and software algorithms designed to evaluate the quality of real-time

collected data. The figure depicts the overall Bluetooth Traffic Monitoring System that consists of Bluetooth stations for detecting Bluetooth devices associated with vehicles



using Ubertooth-one — an open source 2.4 GHz wireless development platform used for Bluetooth sniffing. Each Bluetooth station is connected to a Linux box (i.e., Beaglebone) that reads data collected by Ubertooth-one before transmitting the data to a back-end server, where it is stored and processed in real-time. The Bluetooth system proved instant and accurate TT measurements 99.9% of the time. The proposed solution can promptly respond to changes in traffic patterns, proving that accurate TT (or “speed data”) can be obtained in real-time. The project recorded two significant successful technology transfers: 1) an inexpensive (i.e., \$500 versus \$5,000 for commercial systems) portable Bluetooth monitoring system that when integrated with a current network will immediately impact traffic management programs, and 2) a novel design for developing a TTR and monitoring system composed of multi-sensing technology that leverages empirically developed models for providing accurate information about traffic flow and congestion. An accurate Travel Time (TT) information is essential for traffic prediction and analysis. This project facilitates a Department of Transportation in obtaining correct TT measurements that can be used to reduce congestion, improve safety and enhance traffic flow.

SPTC researchers Mohammed Atiquzzaman, Ronald Barnes, Joejob Havlicek investigated connection among vehicles being established to exchange data regarding inclement weather driving conditions (i.e. vehicle-to-vehicle communication (V2V)), which is based on Dedicated Short Range Communications (DSRC) protocol. Cars have been outfitted with DSRC-capable equipment to facilitate the wireless communication between the vehicles. DSRC is similar to Wi-Fi but has faster network acquisition, low latency, and high reliability to enable development of vehicle



safety applications. Specifically, it supports communications between vehicles and communications between vehicles and roadside infrastructure. Using the technology for this project enables a vehicle to connect to all vehicles within its range to form a Vehicular Ad Hoc Network (VANET) with the cars as nodes of the network. Benefits of implementation include reduction of vehicle crashes, fatalities and injuries due to adverse weather conditions, by alerting drivers in real-time of potentially hazardous road conditions in the region, based on information from neighboring vehicles. The concept was demonstrated in this project through a working prototype of a vehicular network using the connected vehicles technology to increase driver safety.

**4.2 Impact on Other Disciplines** Nothing to report during this period.

### **4.3 Impact on Workforce Development**

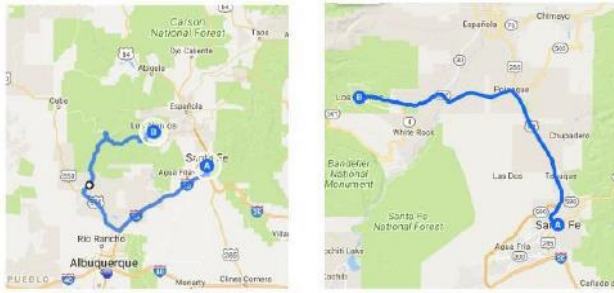
During this reporting period, SPTC activities have been executed that have an impact on workforce development through providing opportunities for research and teaching in transportation and related disciplines and improving the performance and skills of members of underrepresented groups that will improve 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 2019 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). More information can be found here: (<http://www.sptc.org/2019-internships>).

*Continuing Education Seminars, Workshops and Conferences:* There have been at least ten (10) major events, as noted in the Accomplishments section of this report (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.

*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**



(a) Alternative route 1 (125 miles, 2.5 hours) (b) Shortest route (34 miles, 42 minutes)

Figure 20. Example of Disruption due to Inundation in the Case Study and Example Alternative Routes (Source: Google Maps)

Improvements in Evaluation and Assessment Methodologies:

SPTC researchers Vanessa Valentin and John Stormont delivered the final report entitled, “Rapid and cost-effective rehabilitation alternatives for transportation infrastructure affected by extreme conditions”. This study investigated the impacts of post-wildfire floods on transportation infrastructure. Drainages and bridges were specifically

targeted as they are especially vulnerable to fire-related damage, whether directly from fire heat or from subsequent flash flooding that results from fire-induced changes to the watershed. The specific objectives of this study were to: (1) identify post-wildfire flash flood impacts as well as risk mitigation and rehabilitation alternatives for transportation infrastructure, (2) evaluate the sensitivity of a hydrology model to site-specific input data and identify transportation infrastructure components at risk of inundation, and (3) develop a decision-support approach for prioritizing and selecting mitigation and rehabilitation options. In response to these objectives, we developed a modeling framework which integrates pre- and post-wildfire rainfall-runoff modeling and floodplain mapping under different climate and burn severity scenarios. Results from a case study analyzed using the model showed that preventing partial or complete blockage of the culverts will preclude roadway inundation under different climate and burn severity scenarios. Thus, the resulting modeling framework can be used as a screening tool for identifying potential problem areas and deciding where to focus further analyses on failure mechanisms, damage assessment, risk mitigation alternatives, and resource allocation. Finally, the proposed decision-making approach explored a wildfire vulnerability assessment process for transportation infrastructure and provides suggestions, resources, and examples for prioritizing infrastructure components and selecting mitigation and rehabilitation measures while considering asset criticality and other characteristics. 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.

**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.