TRAN-SET
QUARTERLY NEWSLETTER
FALL 2019 | ISSUE 8

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ABOUT TRAN-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late-November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes."

LETTER FROM THE DIRECTOR

Wishing You All a Wonderful Autumn!

I am excited to report Tran-SET's continued progress. We are finalizing arrangements for our **2020 Tran-SET Conference** to be held in Albuquerque, New Mexico, on April 2-3, 2020. The conference is co-sponsored by the ASCE Construction Institute and hosted by the University of New Mexico and New Mexico State University. Registration will open **November 18, 2019**, and most importantly, we have extended the deadline to submit abstracts for presentation and publication to **October 1, 2019**. The conference is a great opportunity to learn how Tran-SET-sponsored research is solving regional transportation needs and to network, collaborate, and engage with professionals in a wide-range of transportation fields. For more information, please visit the conference website.

Tran-SET has finalized selection and award of its third-cycle projects. In total, 33 research projects were awarded and started on **August 15, 2019**. If you are interested in learning more about the projects, two-page fact sheets have been developed for each and are available on Tran-SET's website. The call for problem statements for our fourth-cycle of funding has closed; Tran-SET received nearly 100 problem statements!
Finally, we are currently preparing the research reports and corresponding datasets for our second-cycle projects. Expect these to be finalized, publicly posted, and disseminated by the end of October. Stay tuned!

I invite you to read through our Fall 2019 newsletter and learn more about our other research, technology transfer, educational, and workforce development activities.

If you haven't done so already, I highly encourage you to follow us on LinkedIn and Twitter. You can also subscribe to our mailing list by clicking here.

Enjoy!

Marwa Hassan, PhD, PE, F.ASCE
CETF Distinguished Professor
College of Engineering, Louisiana State University

RESEARCH PROGRAM UPDATES

First-Cycle Research Reports and Datasets Now 508 Complaint

Tran-SET has been working diligently to ensure all of its public-facing content is 508 compliant and accessible to those with disabilities. Tran-SET has revised the following to be 508 compliant: 30 first-cycle final reports and datasets (previously finalized December 2018), 225 documents on Tran-SET's website, and more than eight hours of video content (captioned). Tran-SET has also created its own accessibility guide to ensure future final reports and datasets are accessible. First-cycle research reports and corresponding datasets are available through Tran-SET's website or directly at LSU Digital Commons.

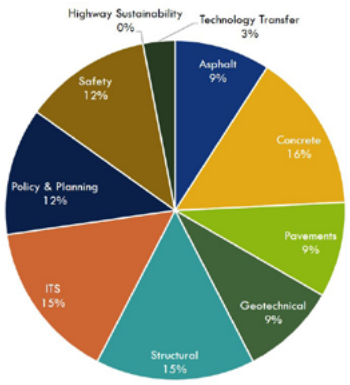
Second-Cycle Research Reports and Datasets Almost Finalized

Tran-SET's second-cycle projects ended their technical phase March 2019, completed their draft research reports, and had these reports reviewed by each project's project review committee (PRC). Currently, Tran-SET has finalized 18 research reports (while the remaining 17 are being revised by their respective research teams). Tran-SET expects to finalize and publicly post all second-cycle reports and datasets by the end of October. These will be posted to Tran-SET's website and archived on LSU Digital Commons. Please stay tuned, as Tran-SET will disseminate these reports when available.

Award of Third-Cycle Projects

Tran-SET has finalized selection and award of its third-cycle projects. In total, 33 research projects were awarded and started on August 15, 2019. The projects totaled $4.5 million (this includes both grant and matching funds), including $470,000 and $243,000 in matching funds from external public agencies and private industries, respectively. Projects are categorized below by Tran-SET research theme and topical area.

If interested in learning more, two-page fact sheets have been developed for each project and are available on Tran-SET's website.



Problem statements categorized by topical area

Received Problem Statements for Fourth-Cycle Projects

The call for problem statements for Tran-SET's fourth-cycle of funding ended August 30, 2019. In total, Tran-SET received 96 problem statements from 15 different institutions. Seventeen problem statements were collaborative in nature, involving multiple partnering institutions.

Interested parties can submit problem statements through Tran-SET's open year-round process; submitted problem statements will be considered for our fifth-cycle of funding.

RESEARCH IN PROGRESS: HIGHLIGHTS

The following is a selection of recent Tran-SET research projects. Is our research applicable to your technical area? Beneficial or a potential solution to your local transportation system? Can benefit from your efforts? Interesting? Please contact us for ways to coordinate, be involved, and engaged. To learn more about the following projects (and the rest of our 35 active research projects), please visit the Tran-SET website.

Use of Bagasse Ash as a Concrete Additive for Road Pavement Applications

Dr. Gabriel Arce, Dr. Marwa Hassan, Dr. Maria Gutierrez-Wing – LSU

Bagasse ash is the fibrous by-product of sugarcane stalks after they are crushed to extract their juice. It contains more than 50% by weight of silica, up to 10% by weight of lime, about 5% by weight of aluminum oxide, and several other chemical components in smaller amounts. The high content of silica and aluminum oxide suggests that bagasse ash can be a suitable supplemental cementitious material and substitute for cement in the production of concrete. The use of such additives as bagasse ash presents several benefits: (1) lower cost and lower carbon footprint of the concrete, (2) higher long-term compressive strength at the expense of a small reduction of short-term compressive strength, and (3) better durability.

This study develops new uses for sugarcane bagasse ash (SCBA) as an additive for concrete. The study also explores the properties of SCBA produced from three different processing methodologies (i.e., raw SCBA, controlled SCBA, and post-processed SCBA). In particular, the use of SCBA as a partial substitute for cement and fly ash is investigated to develop an efficient production method to maximize the beneficial properties of SCBA, identify optimal amounts of SCBA to obtain desired concrete properties, and verify the economic feasibility of SCBA use as a concrete additive through a preliminary life-cycle cost analysis.

Typical disposal of bagasse ash

Development of Metals Corrosion Maps of Arkansas and Maintenance of Cross-Drains

Dr. Zahid Hossain, Dr. Ashraf Elsayed – ASU

The Arkansas Department of Transportation (ARDOT) spends a significant amount of funding in the installation and maintenance of metal culverts. Additionally, it does not have detailed guidelines nor specifications for the selection of culvert materials based on corrosion susceptibility. Corrosion is one of the main reasons for replacement, removal, and cleaning of these culverts. The main objective of this study is to develop user-friendly corrosion and life-cycle cost maps for various metal pipe materials by analyzing soil properties, water properties, and environmental data collected from public domains and laboratory experiments.

Specifically, this study will utilize: (1) extensive physical and chemical properties of topsoil from the USDA's Soil Survey Geographic Database; (2) surface water quality data from the EPA, USGS, and Arkansas Department of Environmental Quality; and (3) geotechnical, electrochemical, and electromagnetic information gathered from laboratory investigations of varied soil samples. Neural network-based models will be developed from these tests and data to estimate the expected service life of three different metal pipe materials (galvanized steel, aluminized steel type II, and aluminum pipe culverts), depending on the conditions of the area. The findings of this study are expected to help ARDOT engineers in planning and maintaining highway drainage systems and minimize unexpected/unplanned future removal and/or replacement.

Corrosion of corrugated metal culvert

RESEARCH IN PROGRESS: HIGHLIGHTS

Workforce Development Symposiums for UHPC

Dr. Brad Weldon, Dr. Craig Newtson – NMSU

Ultra-high performance concrete (UHPC) is a cementitious material with a dense microstructure that contributes to high compressive strengths and enhanced durability properties. UHPC also possesses significant post-cracking strength and ductility due to the addition of fibers. These characteristics produce a material that provides advantages over conventional concrete; however, high costs attributed to materials and production, lack of industry familiarity and knowledge, and the absence of standardized design procedures have impeded its widespread use. To help disseminate knowledge on UHPC, this study will conduct two workforce development symposiums on the material in Las Cruces, New Mexico.

The symposiums will provide extensive coverage of UHPC topics, including: (1) a review of past and current UHPC projects in the United States; (2) UHPC materials and mixture development, including coverage of testing methods and procedures; (3) potential modifications to testing procedures; (4) engineering design with UHPC; (5) experiences of batch plant and precast plant operators in batching, mixing, and placing UHPC; and (6) a hands-on demonstration of batching, mixing, and placing UHPC produced with local materials. The symposiums are anticipated to provide engineers and construction personnel with a knowledge base that will prepare them for projects that specify the use of UHPC.

Demonstration and participants at the first conducted UHPC Symposium

Integrated Full-Scale Physical Experiments and Numerical Modeling of the Performance and Rehabilitation of Highway Embankments

Dr. Navid Jafari – LSU, Dr. Anand Puppala UTA

The resilience of transportation infrastructure, such as highway embankments, is critical in avoiding commuter delays and costly repairs. The majority of highway embankments across the United States are in marginal condition, as high-plasticity clays used during construction soften over time and lower in strength. Additionally, recurring cycles of wetting and drying (due to infiltration of rainfall) may ultimately lead to slope instability. As a result, failures may occur and require periodic maintenance to ensure proper highway safety, requiring significant upkeep costs.

This study aims to understand how soil strength and hydraulic properties are impacted by recurring wetting-drying cycles induced by climate variability, with the practical implication of forecasting the stability of highway embankment slopes. Laboratory model-scale experiments of Louisiana and Texas soils will be conducted and related to weathering cycles by accounting for rainfall intensity and duration, evapotranspiration, temperature, and relative humidity. Laboratory testing will determine the strength and unsaturated soil properties in order to investigate the subsequent changes in hydro-mechanical properties of clayey soils. Numerical modeling of highway embankments (with laboratory test results) will be used to predict the factor of safety for select embankments in Louisiana and Texas. The outcome of this project may assist DOTs by developing a predictive tool for identifying high-risk zones of instability and compiling the rehabilitation methods for highway embankments.

Embankment failure in Texas (site included in study)

RESEARCH IN PROGRESS: HIGHLIGHTS

Mitigating Pavement Reflective Cracking Using a Ductile Concrete Interlayer

Dr. Mohammad Khattak – ULL

Reflective cracking is considered one of the most common causes of premature deterioration of composite pavements. This cracking is the direct result of horizontal and vertical movements of the cement slabs at the joints. These movements are mainly due to temperature changes, shrinkage, and repeated traffic loads that induce destructive tensile, shear, and bending stresses. Several mitigation measures of reflective cracking have been implemented and studied previously. However, these measures either are not effective in delaying the reflective cracking or extend the service life by only a few years. To address the issue, this study investigates a ductile interlayer made of engineered cementitious composites (ECC). It is proposed that by adding a thin layer of highly ductile ECC material between the existing pavement and overlay, reflective cracking can be mitigated by the ductile interlayer.

Specifically, this study will experimentally evaluate the effectiveness of ECC as an interlayer system. A laboratory test protocol will be designed to simulate repeated traffic loads to measure the fatigue performance of the ECC interlayer system. Strain field and reflective cracking will also be monitored. The results of this study will ultimately develop a mechanism to prevent or mitigate reflective cracking and increase the durability of the transportation system.

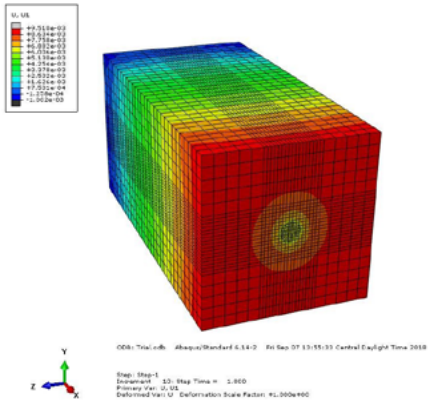
Example of reflective cracking

Integrated Full-Scale Physical Reduction of Structural Damage from the Thermal Expansion of Concrete Using Multifunctional Materials

Dr. Darren Hartl – Texas A&M University

Control of thermal expansion is a critical goal of engineering design in a wide range of applications. Thermal expansion causes thermal stresses in structures and can lead to structural failure if excessive. In structures made of "brittle" materials (e.g., concrete), stresses due to thermal expansion failure can be catastrophic. Shape memory alloys (SMAs), due to their thermomechanical coupling behavior, can be considered as a replacement for components made of steel (e.g., in reinforced or plain-jointed concrete pavements) to control distresses resulting from thermal expansion during season/daily temperature change. The most common SMA candidate for civil engineering applications is the NiTi SMA, which is cost-prohibitive for large-scale use. However, a low-cost and easily processed iron (FE)-based SMA exists as an alternative.

This study proposes to leverage past successes in the analysis and design of FE-SMA components to address the issue of thermal expansion in concrete structures. Through a combined approach of structural optimization, mechanics, and materials design, this research aims at simultaneously achieving advantageous mechanical properties and passive actuation behavior in a single material for concrete infrastructures. This project will define a viable path for technology transfer by establishing substantive partnerships with commercial alloy manufacturers and cultivate the awareness and expertise in the technology through workforce development and outreach activities.



Modeled concrete block with embedded SMA rod

TECHNOLOGY TRANSFER ACTIVITIES

Tran-SET has two objectives that guide its technology transfer (T2) activities—to ensure that scientific and technological developments are accessible, disseminated, and transferred to a wide range of users including state agencies, universities, and industries; and that these developments have long-term research value and significant impact to the transportation industry.

The following are a sampling of T2 activities sponsored by or involving Tran-SET. You can stay up-to-date with our activities by following us on LinkedIn and Twitter, visiting our website, and subscribing to our mailing list!

Workshop on Using Augmented Reality to Inspect Structures

Dr. Fernando Moreu (Tran-SET principal investigator) conducted a workshop on "Augmented Reality for Structural Inspection" on September 5, 2019, in Nanjing, China. The workshop was part of a one-day course associated with the Experimental Vibration Analysis for Civil Engineering Structures (EVACES) 2019 Conference. More than 100 students attended. EVACES 2019 is a premier venue where recent progress in the field is presented and discussed by worldwide experts. The work presented by Dr. Moreu partly involved research from Tran-SET project Augmented Reality Enhancing the Inspections of Transportation Infrastructure: Research, Education, and Industry Implementation. More information on EVACES 2019 can be found on its website.

Developed Sinkhole Extractor Tool and Recorded Tutorial

As part of Tran-SET project Karst Sinkhole Detecting and Mapping Using Airborne LiDAR, Dr. Su Zhang (Tran-SET principal investigator) and his research team developed a robust toolset that utilizes airborne LiDAR data to detect and map sinkholes. It is designed to conduct a preliminary reconnaissance for possible sinkholes and uses digital elevation model (DEM) tiles to look for and extract potential sinkholes. The toolset is publicly available and can be downloaded from GitHub. Additionally, the research team prepared a recorded tutorial that details the tool requirements, initial setup, optional DEM creator, sinkhole extractor, and acknowledgments.

Warning of potential sinkhole

TECHNOLOGY TRANSFER ACTIVITIES

2020 Tran-SET Conference: Abstract Submissions Extended!

The 2020 Tran-SET Conferenc e will be held in Albuquerque, New Mexico, on **April 2–3, 2020**. The conference is co-sponsored by the ASCE Construction Institute and hosted by the University of New Mexico and New Mexico State University. This year's theme is "enhancing durability and service life of infrastructure: materials, methods, and technology." The conference is a great opportunity to learn how Tran-SET-sponsored research is solving regional transportation challenges. It's also a great chance to network, collaborate, and engage with professionals in a wide-range of transportation fields.

Please note that the due date to submit abstracts for presentation and publication has been extended to **October 1, 2019** (previously August 31, 2019). Please also note changes to important dates (below), and that registration will open **November 18, 2019.**

Accepted papers will be published by ASCE and will provide bibliographic information for each preceeding paper to abstracting and indexing (A&I) services (e.g., Elsevier Engineering Index (EI), National Academies, ExLibris Primo, etc.). To learn more, please visit the conference website or contact transet2020@nmsu.edu with any questions.

Important Conference dates

May 14, 2019 | Call for Papers Begins

Oct 1, 2019 | Papers Abstracts Due

Nov 18, 2019 | Draft Papers Due & Registration Opens

Jan 17, 2020 | Final Papers Due

Feb 1, 2020 | Posters Abstracts Due

Apr 2, 2020 | Conference Begins

Full-Scale Engineered Cementitious Composites (ECC) Overlay

In Tran-SET project Application of Engineered Cementitious Composites (ECC) for Jointless Ultrathin White-Topping (UTW) Overlay, Dr. Gabriel Arce (Tran-SET principal investigator) and his research team are investigating the feasibility of ECC as an overlay application in order to mitigate joint-related distresses typically observed in UTW and increase construction speed. This study involved conducting a full-scale experiment of an UTW-ECC overlay system that was recently constructed at the Louisiana Transportation Research Center (LTRC) Pavement Research Facility. A 120-ft-long section of ECC and a 60-ft-long section of regular concrete was laid in three main sections. Section 1 is a jointless 2.5-inch-thick ECC overlay, section 2 is a jointless 4-inch-thick ECC overlay, and section 3 is a jointed 4-inch-thick regular concrete overlay. During construction, it was confirmed that due to the better workability of ECC and the lack of joints, construction is much easier and faster for overlays with ECC than with regular concrete. Falling weight deflectometer (FWD) testing was conducted before and after construction of the overlay, which revealed a significant increase in pavement stiffness after construction. This was expected due to the stiffening effect of the overlays. For future work (planned for November and December of this year), an Accelerated Transportation Loading System, or ATLas 30, capable of compressing many years of road wear into a few months will be used, and the stiffness deterioration of ECC overlays will be compared against that of regular concrete.

Construction of the ECC overlay

TECHNOLOGY TRANSFER ACTIVITIES

Sidewalk Repair Using Novel Concrete Material

As part of Tran-SET project Use of Bagasse Ash as a Concrete Additive for Road Pavement Applications, a small-scale field test was conducted to evaluate the performance of a sugarcane bagasse ash (SCBA) admixed concrete material on the repair of infrastructure. The location selected for the field test was a distress wheelchair ramp on the campus of LSU. This location was selected for: (a) its relevance to the LSU Community, (b) its limited scope made it feasible for the research group to produce sufficient post-processed SCBA with laboratory-scale equipment, and (c) the support from LSU Landscape Services Department, which facilitated the repair. The material utilized for the field test was a repair mortar utilizing the optimal SCBA material produced in the above Tran-SET research project. The repair mortar was produced at the Louisiana Transportation Research Center (LTRC) and transported to the repair site.

Research team installing concrete repair

Smart Sensors in Sandia Peak Tramway

Developed in part by Tran-SET project Development, Training, Education, and Implementation of Low-Cost Sensing Technology for Bridge Structural Health Monitoring, Dr. Fernando Moreu (Tran-SET principal investigator) and his research team from the Smart Management of Infrastructure Laboratory (SMILab), have installed two wireless smart sensors on the Sandia Peak Tramway near Albuquerque, New Mexico. One sensor was attached to the tram car, and the other was secured to the tower. The sensors will collect accelerations and displacements of the tram car and tower under differing performance conditions. Multiple prototypes of the tramway sensors were tested by the research team. One important feature in selecting the sensors was the smart energy harvesting system. Sensors used in this study charge their battery through the solar panels, which enable the recording of vibration data in the node and eliminate the need for an external power source. Each solar-powered sensor has the capacity to record data for several weeks. In addition, sensors are waterproof and can resist harsh weather conditions, such as heavy wind and rain. The research team tested the power levels of the sensor in the Center for Advanced Research Computing's (CARC) lobby windows. The students completed all aspects of the sensor build, from connecting wires and programming micro-controllers to installing the sensors in the field. The results of this collaboration will assist researchers in improving structural health monitoring algorithms, their structural engineering skills, and further improve these low-cost sensors.

Please click here to read the full article for more details. For more information about the SMILab, please visit its website.

TECHNOLOGY TRANSFER ACTIVITIES

Joint Tran-SET Webinar Series: Recording Now Available

The most recent webinar in the Joint Tran-SET Webinar Series was held on **September 26, 2019**, and focused on "Innovative Technology, Techniques, and Processes in Transportation Infrastructure Inspection." It was jointly hosted by the Mid-America Transportation Center. A recording of the webinar is available and can be viewed on Tran-SET's website or directly on Tran-SET's YouTube page.

Tran-SET would like to sincerely thank the webinar presenters (please see below):

EDUCATIONAL AND WORKFORCE DEVELOPMENT

Tran-SET has a firm initiative to advance the transportation workforce and develop its next generation of leaders by attracting and supporting diverse, promising individuals to the transportation field through internships/research assistantships; providing experiences through education and cutting-edge research to more properly prepare these individuals as they enter the workforce; and incorporating and disseminating knowledge generated from sponsored-research into educational and training products/activities.

Please see below a showcase of select educational and workforce development activities sponsored by or involving Tran-SET.

WTS Louisiana Luncheon

WTS Advancing Women in Transportation Louisiana Chapter

Tran-SET hosted WTS Louisiana on LSU's campus for their August luncheon. Christopher Melson (Tran-SET program manager) gave a brief overview of Tran-SET and led a tour of several LSU laboratories—the Building Simulation and Information Modeling (BIM) studio, the Advanced Materials and Methods Laboratory, and the CAT® equipment simulators. Approximately 35 professionals attended.

WTS is an international organization dedicated to building the future of transportation through the global advancement of women. For more information about the WTS Louisiana chapter, please visit its website.

WTS members in the advanced materials laboratory

WTS members visiting the BIM studio

EDUCATIONAL AND WORKFORCE DEVELOPMENT

Field Demonstration on Flowable Fill Concrete

As a part of Tran-SET project Use of Rice Husk Ash (RHA) in Flowable Fill Concrete Mix Material, Dr. Zahid Hossain (Tran-SET associate director) arranged a technology transfer event in the form of a field demonstration on flowable fill concrete (FFC) mixes. Dr. Hossain and his research team are investigating the benefits of using rice husk, a byproduct of the milling process, as a main component of FFC. This study could increase sustainability for farms and decrease costs for construction companies. This was their second field demonstration and was carried out with support from Arkansas State University Facility Management.

Field demonstration of FFC mixes

Engineering & Technology Week

Dr. Mohamad Jamal Khattak (Tran-SET principal investigator) and his students participated in Engineering & Technology Week at the University of Louisiana at Lafayette. Engineering & Technology Week comprises a week of student activities, including seminars, presentations, competitions, industrial and research exhibitions, and high school visits. Between 1,000 to 1,500 participants attended from industry, universities, and high schools. Dr. Khattak's research group participated as an exhibitor showing soil geopolymer materials and their use as a new road material system.

Researcher presenting geopolymer materials to students

EDUCATIONAL AND WORKFORCE DEVELOPMENT

Presentation at 2019 SEAoT State Conference

Dr. Adolfo Montoya (Tran-SET principal investigator) presented the findings of Tran-SET project Structural Vulnerability of Coastal Bridges Under Extreme Hurricane Conditions at the 2019 annual state conference organized by the Structural Engineering Association of Texas. The SEAoT State Conference continues to be one of the leading events in Texas for practicing and professional engineers and gathers structural engineers from industry, public agencies, and academia. The presentation educated structural engineers on the interaction between bridges and waves during an extreme weather event, brought awareness of the need for improved methods of designing resilient coastal bridges, and questions posed by the audience presented valuable feedback to the research team. More information about the 2019 SEAoT State Conference can be found on its website.

Hosted Seminar by Chicago Testing Laboratory (CTL)

A seminar entitled "Pushing the Limits of Recycled Pavements: Total Recycle Mixtures" by Chicago Testing Laboratory (CTL) was presented on August 23, 2019, at LSU. CTL is a member of Tran-SET's Center Advisory Board (CAB) and was a financial sponsor of the 2019 Tran-SET Conference. Ahmad El Khatib (research and development director of CTL) presented on "total recycle" mixture projects developed by CTL staff. These roadway mixtures are designed with only recycled aggregate, recycled asphalt binder, and minimal new asphalt binder. El Khatib discussed the motivation for these mixtures, production, construction, field performance, and future works. For more information about CTL and its current projects, please visit its website.

Mr. Khatib presenting

EDUCATIONAL AND WORKFORCE DEVELOPMENT

Presentation at 2019 Traffic Engineers Meeting

Christopher Melson (Tran-SET program manager) presented at the 2019 Traffic Engineers Meeting hosted by the Louisiana Department of Transportation and Development (LaDOTD) on August 15, 2019, in Baton Rouge, Louisiana. He provided an overview of the Simulation and Capacity Analysis Users Group of Louisiana (SimCap Lousiana). Melson is the co-founder and interim chair of SimCap Louisiana, a volunteer network of professionals aiming to support, promote, and improve best practices in the application of traffic simulation and capacity analysis. Please visit the SimCap Louisiana website if you are interested in learning more about the organization.

The Traffic Engineers Meeting is an annual event by LaDOTD to communicate important updates, guidance, deployments, and other information to traffic and transportation safety practitioners throughout the state. For additional information on the meeting and to access the agenda and presentation materials, please visit LaDOTD's website.

Presentation at A&WMA Annual Conference and Exhibition

Dr. Raghava Kommalapati (Tran-SET associate director) presented results of Tran-SET project Lifecycle Environmental Impact of High-Speed Rail System in the I-45 Corridor at the 112th Annual Conference and Exhibition (ACE) of the Air & Waste Management Association (A&WMA) on June 26, 2019, in Quebec, Canada. The theme of ACE 2019 was "Winds of Change" and included more than 30 panel sessions, 50 presentation sessions, and 50 technical posters. ACE 2019 covered a wide-range of topics and solutions about current environmental, energy, and health issues. Additional information about the conference, including a detailed technical program, can be found on A&WMA's website.

Student poster session at ACE 2019