A NATIONAL UNIVERSITY TRANSPORTATION CENTER
AT MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

ADVANCED MATERIALS, TRANSITION-STATE FUELS AND NON-DESTRUCTIVE TESTING TECHNOLOGIES

Seventh Year Annual Report
July 1, 2012 – June 30, 2013

PART A: CORPORATE STYLE ANNUAL REPORT

Submitted by
Kamal H. Khayat, Ph.D., P.E.
Center Director

AUGUST 31, 2012

Seventh Year Annual Report
Part A: Corporate Style Annual Report

Table of Contents

OVERVIEW: CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

Introduction

Throughout seven years of operation as a National University Transportation Center (NUTC), the Center for Transportation Infrastructure and Safety (CTIS) has become a Center of Excellence on the theme areas of advanced materials, transition-state fuel vehicle infrastructure and non-destructive testing technologies.

CTIS has provided the faculty, staff and students at Missouri University of Science and Technology (Missouri S&T) with the means for establishing key relationships with transportation-oriented state and federal agencies and industry partners. With NUTC leverage, the research and development (R&D) projects carried out at Missouri S&T have created the critical mass and the track record necessary to establish a Center of Excellence.

In addition to contributing to successful and relevant R&D projects, with the development of significant educational resources and by facilitating the transfer of advanced technology developed within the Center's theme areas, CTIS has impacted the quality of available education for engineers and transportation professionals, equipping engineers with interdisciplinary skills and experiences. As a result of CTIS activities, new academic programs for educating better-prepared engineers have been created at Missouri S&T and the University has become, and continues to be, the provider of the Local Technical Assistance Program (LTAP) for the state of Missouri.

Since its inception, CTIS has performed work in accordance with its strategic plan to accomplish projected goals in the areas of education, research and technology transfer. CTIS has put forth significant efforts to become highly visible and credible with the aim to recruit and retain quality students, faculty and professionals and to make significant contributions to transportation-related fields.

Future

The future activities of CTIS will continue to draw on the capabilities and campus expertise in the Center's research theme areas. This synergism will be further fostered by the second annual Transportation Infrastructure Conference, which will be held on the Missouri S&T campus on September 13, 2013. The conference will showcase recent transportation-related projects dealing with advanced construction materials and structural systems, non-destructive testing and structural health monitoring of surface transportation infrastructure. This year's conference will feature four leading engineers as keynote speakers who will discuss some of the cutting-edge technology related to the research themes of the CTIS. The CTIS hopes that this technology transfer event will grow in the future to foster further exchange between S&T researchers, industry and government agencies in the area of transportation infrastructure engineering.

Partnerships with industry professionals and organizations will be continuously sought out and developed. Currently, partnerships with University of Nevada-Las Vegas, University of Nebraska-Lincoln, University of Minnesota, University of Arkansas, North Dakota State University and University of Texas-Austin and several state DOTs (MoDOT, MnDOT, NDOT and CalTran). In addition to these partnerships, CTIS researchers are further expanding the reach of their network by undertaking joint projects with counterparts in Belgium, Iceland, France, and Mexico for summer internships.

In particular, CTIS aims to become the point of reference and preferred partner of industry organizations that have not traditionally been involved with transportation-related applications and activities. The intention is to improve the quality and lifespan of existing transportation infrastructure using the broadest-based technology possible and to stimulate the economic viability of U.S. corporations.

Mission and Theme

Mission: The mission of the Center for Transportation Infrastructure and Safety (CTIS) at Missouri S&T is to advance U.S. technology and expertise in the many disciplines comprising transportation through the mechanisms of education, research and technology transfer at university-based centers of excellence.

Theme: To address national needs in the areas of transportation infrastructure and safety, focusing on the following topical areas:

- **Advanced materials** including constructed facilities security, which will involve several tasks:
    - The development, manufacture and application of modern construction materials
    - Installation processes and engineering design
    - Standardization and code approval of products and design protocols
- **Transition-state fuel vehicle infrastructure** leading to a hydrogen economy, which will require two critical tasks:
    - Development of safety codes, standards and regulations
    - Infrastructure development and deployment
- **Non-destructive evaluation (NDE) technologies and methods** including monitoring and evaluation of new and repaired structures and system components.

Advanced materials developed for use in transportation infrastructure offer superior mechanical properties, long-term durability and design flexibility. R&D in advanced materials address the growing needs for strengthening/rehabilitation of aging structures and for the design/construction of new structures to more stringent requirements and for extended service life. These materials apply to all modes of surface transportation.

Alternative fuel vehicles face the same implementation challenges as that of hydrogen vehicles. Research, development, demonstration and deployment activities of alternative fuel (including

hydrogen) vehicles and supporting infrastructure across all modes of transportation address the growing need for a successful transition to a hydrogen economy.

Recent advances in sensor technologies and NDE techniques offer new methods of non-intrusive, in-situ monitoring of the health, geometric, environmental and structural characterization of civil structures and their supporting systems. NDE sensor technologies and methods enable more accurate, sensitive, cost-effective, rapid and straightforward evaluations. Integration of NDE technology to existing and future infrastructure systems will improve network evaluation and enhance the safety of the transportation infrastructure.

The choice of the Center theme comes from an analysis of state and national needs/opportunities, as well as the strengths/potential of Missouri S&T. We are walking the bridge that connects the transportation infrastructure of the second millennium to that of the third millennium. Existing infrastructure was conceived to support vehicular traffic powered by fossil fuel and has dramatic shortcomings in terms of durability and congestion. But the future will be an intelligent infrastructure incorporating advances in information technology and supporting a new generation of alternative fuels up to an ending point, which is conceivably hydrogen, with all the associated challenges in terms of safety, deployment and market acceptance.

Missouri S&T determined that it is of critical importance to its own mission and future, as well as the economic success of the state of Missouri, to focus on advanced materials in order to: a) help with the upgrade and maintenance (including security hardening) of existent infrastructure; and b) contribute to the development of new infrastructure. Similarly, NDE methods and techniques are a core area of expertise at Missouri S&T and their development and deployment continues to help with health monitoring of existing infrastructure and is becoming an integral part of new infrastructure to ensure both acceptance and safety. Finally, the Center takes a systematic approach to tackle the challenge of alternative fuels (including hydrogen) as the only viable methodology for the safe deployment of a new form of transportation.

MANAGEMENT STRUCTURE

This section presents an overview of the Center's management structure and staff, those individuals who actively contribute to the functioning of Center activities.

Center Staff

In addition to the Director, the following individuals actively contribute to the management/operation of the Center: one associate director, four office staff persons and three laboratory staff persons. The Research Scholar position is currently open.

Name	Title	Address/Phone/Fax/E-mail	Responsibilities
Khayat, K.	Director	224 ERL, Rolla MO 65409 573-341-6223/6215 khayatk@mst.edu	Center management
Myers, J. J.	Associate Director	325 Butler-Carlton Hall, Rolla MO 65409 573-341-6618/6215 jmyers@mst.edu	Research activities
Sherman, A.	Program Support Specialist	222 ERL, Rolla MO 65409 573-341-7884/6215 abigayle@mst.edu	Proposal coordination/ newsletter/website
Spitzmiller, G.	Admin. Assistant	221 ERL, Rolla MO 65409 573-341-7170/6215 spitz@mst.edu	Administration and accounting
Geisler, C.	Secretary	223 ERL, Rolla MO 65409 573-341-4497/6215 geislerc@mst.edu	Clerical support
Open Position	Research Scholar	218 ERL, Rolla MO 65409 573-341-6223/6215	Research activities/mentoring
Cox, J.	Sr. Research Specialist	211 ERL, Rolla MO 65409 573-341-6742/6215 coxjn@mst.edu	Laboratory and field testing/coordination
Bullock, J.	Lab/Research Technician	211 ERL, Rolla MO 65409 573-341-7895/6215 bullockjr@mst.edu	Laboratory testing/ equip. maintenance
Hampton, D.	Lab/Research Technician	211 ERL, Rolla MO 65409 573-341-6742/6215 hamptondw@mst.edu	Laboratory testing/ equip. maintenance

OVERVIEW OF EDUCATION, RESEARCH, AND TECHNOLOGY TRANSFER PROGRAMS

This section presents a summary and overview of all projects awarded during Year VII (2012-2013).

Research Projects

R367— Assessment of Active Karst Features in Proximity to Paved Roadways
[Anderson, N., PI – Missouri S&T, new in this reporting period]

In an effort to better understand and define the lateral and vertical extent of active karst features in immediate proximity to paved municipal roadways in Nixa Missouri, MS&T will acquire electrical resistivity tomography (ERT) data. The intent is to use this non-invasive technology to map the lateral and vertical extent of the active karst features so that appropriate mitigation plans can be developed.

R366— Admixture Compatibility of Alternative Supplementary Cementitious Materials for Pavement and Structural Concrete
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The objective of the research plan presented in this proposal are: (1) to gain a better understanding about the interaction among alternative SCMS and chemical admixtures in portland cement mixtures; and (2) to facilitate implementation of alternative SCMs in transportation structures. Such information can assist in the encouraging adoption of alternative SCMs in the United States, both in pavement and infrastructure applications. In order to accomplish these goals, the NUTC supported project seeks to:

(1) Investigate the influence of selected types of alternative SCMs on air-void system in concrete
(2) Investigate the influence of selected alternative SCMs on key fresh and hardened properties of concrete designated for the construction of bridge infrastructure

The completion of this project will benefit the national transportation infrastructure construction and repair business in term of identifying new, alternative supplementary cementitious materials. The benefits can be regarded in two ways: it can be considered as anticipation to a shortage of fly ash in the near future. Thus, similar to fly ash, a benefit of these alternative SCMs is that it can be considered as another alternative way to reduce greenhouse gas emissions and waste generation by reducing portland cement production and the use of waste materials. As an outcome of this project, the benefits and restrictions on the application of the selected SCMs on pavement concrete and structural concrete will be communicated to the Infrastructure construction industry.

R365— Structural Health Monitoring and Remote Sensing of Transportation Infrastructure Using Embedded Frequency Selective Surfaces
[Kinzell, E., PI – Missouri S&T, new in this reporting period]

Frequency Selective Surfaces (FSS) have long been used in the RF/microwave community to control Radar Cross-Section. The scattering parameters of the FSS form a signature which is a function of the frequency, element size and spacing, as well as the local electromagnetic environment, but with proper design is largely independent of angle. These attributes can be related to engineering parameters of a transportation structure such as strain, temperature, moisture, and damage such as cracking or delamination. We will integrate a FSS into a structure (initially on the surface and eventually embedded within layers). This will allow the properties of the structure to be remotely detected. This application of FSS has significant potential for Structural Health Monitoring (SHM). For example the strain on gusset plates as well as other parts of a bridge can be detected from a considerable standoff. Other applications that will be considered are embedding FSS into concrete or composites. Each of these requires effective manufacturing approaches which we will begin to develop. After implementation, an in service component can be quickly and remotely interrogated for damage, initially using standard microwave network-analyzer/antennas. Additional localized inspection can be performed on an as needed basis to determine more detailed information regarding local strain field (or other relevant parameters).

R364— Highway Rockfall Measurements Using LIDAR
[Maerz, N., PI – Missouri S&T, new in this reporting period]

The objective of this study is to clarify the relationship between rainfall and rockfall. Previous research has shown that there is a tentative relationship between rockfall and rainfall (Fig. 1, bottom of this document). But the relationship is not always present. Some rainfalls cause rockfall, some do not. This leads to speculation that is that some level of accumulated water in the ground is also a precursor to rockfall. In this project we will install piezometers and continuously monitoring pressure transducers behind the rock face to determine the effect of water levels and pressures.

This will help with the development of a model for rockfall, incorporating the effect of groundwater pressures behind the rock face. This will help in modeling rock raveling processes as shown in (Fig. 2, bottom of this document). In addition this will allow us to address the question of whether drainage might be useful to reduce rockfall. (It has traditionally been believed that in this type of broken rock faces, drainage was not necessary because it is believed that the cracks in the rock facilitate drainage.)

R363— Roller Compacted Concrete – Ripley County Rt 160
[Khayat, K., PI – Missouri S&T, new in this reporting period]

Roller-compacted concrete (RCC) is a concrete of no-slump consistency in its unhardened state that is typically transported, placed, and compacted using asphalt, earth and rock fill construction equipment. The constituents are the same as for conventional concretes but the mixture proportions differ in that the aggregate grading and content has to be such that the RCC can immediately take load. RCC is can be design to develop compressive and flexural strengths in the range associated with structural concrete. The proposed research study will evaluate the fresh and hardened properties, durability, and in-situ performance of RCC. Optimized RCC formulation will be used for widening Route 142 in Doniphan, Missouri. Field cast concrete will be extensively sampled and tested to compare its performance to conventional concrete used in pavement construction. The structural health monitoring of the performance of the pavement will

also be determined. The results from this study will provide feedback to future field implementation of this technology in transportation-related infrastructure.

R360— Integrated Embedded Frequency Selective Surface Sensors for Structural Health Monitoring
[Donnell, K., PI – Missouri S&T, new in this reporting period]

The objective of this project is to design an embedded sensor element capable of characterizing mechanical properties including shear strain. This element will be designed using a Frequency Selective Surface (FSS) approach, and will be intended for integration into composite materials. The successful outcome of this project will result in a new embedded integrated sensing method with the potential to significantly impact the method by which composite structures are inspected. Further, the outcomes of this project may directly impact the potential for remote (standoff) inspection of such structures.

R359— Analysis of Carbon Emission Regulations in Supply Chains with Volatile Demand-University of Missouri St. Louis
[Campbell, J., PI – University of Missouri – St. Louis, new in this reporting period]

The objective of this research is to evaluate the impact of carbon emission regulations on supply chains with volatile demand. Supply chain operations such as inventory holding, freight transportation, logistics, and warehousing activities are major contributors to emissions for manufacturing, retailing, transportation, health, and service industries. Therefore, it is crucial that supply chain agents plan their operations with environmental considerations. Recently, several forms of carbon emission regulations have been proposed and/or implemented to reduce emissions.

This research will model and solve a supply chain agent's operations planning problem under two well-known carbon regulations: carbon-taxing and carbon-cap-and-trade. The growing literature on "green" supply chains and emissions is nearly exclusively focused on settings with deterministic demand. To better capture practical aspects of supply chains/logistics, our research will formulate an integrated inventory control and transportation model with stochastic demand under the aforementioned carbon regulations. This model will be solved using engineering management/operations research concepts.

This project will provide decision-making algorithms to help supply chain agents better manage inventory and transportation in light of economic and environmental pressures in the presence of demand volatility. The theoretical modeling and sensitivity analysis will be complimented with a pilot case study using a Missouri firm.

R358— Analysis of Carbon Emission Regulations in Supply Chains with Volatile Demand-Missouri S&T
[Konur, D., PI – Missouri S&T, new in this reporting period]

The objective of this research is to evaluate the impact of carbon emission regulations on supply chains with volatile demand. Supply chain operations such as inventory holding, freight transportation, logistics, and warehousing activities are major contributors to emissions for

manufacturing, retailing, transportation, health, and service industries. Therefore, it is crucial that supply chain agents plan their operations with environmental considerations. Recently, several forms of carbon emission regulations have been proposed and/or implemented to reduce emissions.

This research will model and solve a supply chain agent's operations planning problem under two well-known carbon regulations: carbon-taxing and carbon-cap-and-trade. The growing literature on "green" supply chains and emissions is nearly exclusively focused on settings with deterministic demand. To better capture practical aspects of supply chains/logistics, our research will formulate an integrated inventory control and transportation model with stochastic demand under the aforementioned carbon regulations. This model will be solved using engineering management/operations research concepts.

This project will provide decision-making algorithms to help supply chain agents better manage inventory and transportation in light of economic and environmental pressures in the presence of demand volatility. The theoretical modeling and sensitivity analysis will be complimented with a pilot case study using a Missouri firm.

The objective of this research is to evaluate the impact of carbon emission regulations on supply chains with volatile demand. This research will model and solve a supply chain agent's operations planning problem under two well-known carbon regulations: carbon-taxing and carbon-cap-and-trade.

R357— Behavior of Double-Skin Bridge Columns
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

This research program aims to investigate the behavior of thin-wall circular hollow columns. Hollow core columns have lighter weight compared to columns having solid cross sections which recue the seismic demand on the column and make it ideal candidate for accelerating bridge construction. In the past few years, several researchers explored the constructability of hollow core circular columns; however, confining the internal layer of flexural steel is challenging issue. This project will investigate the behavior of thin-wall concrete cylinders having an outer fiber reinforced polymer tube and internally have a steel tube. Concrete cylinders having different void ratios and different types of FRP will be subjected to axial cyclic loads.

R356— Feasibility Analysis of System Dynamics for Inland Maritime Logistics
[Long, S., PI – Missouri S&T, new in this reporting period]

The commercially important U.S. inland waterway system is an open system consisting of 12,000 miles of navigable waterways managed by the U.S. Army Corps of Engineers (USACE)(Stern, 2012). Inland and intracoastal waterways serve thirty-eight states with nearly 200 commercially active lock sites (USACE, 2009). Multimodal Transportation Systems (MTS) play an essential role in corporations competing in US maritime logistics operations. In transportation, the effectiveness and efficiency of the whole system depends upon the interconnectivity of its elements. Because disruptions in the supply chain are costly, this research will look at improving the efficiency of Multimodal inland maritime hubs by looking at disruptions that have a negative impact on the elements that make up the MTS. Although past research classifies disruptions in MTS as: congestion, demand fluctuations, time delays, capacity

limits, scheduling and, connectivity between the different modes, limited research address the relationship between these failures and the system. System Dynamics (SD) is a fairly sophisticated way of thinking about the interconnections of these elements. This research explores the feasibility of a SD approach to MTS modeling, which will let us iterate and mitigate a system to be able to forecast scenarios and meaningful hypothesis of a system's behavior over time. The SD model will aid to identify and understand those major elements and disruptions that impacts the efficiency of the MTS. The model will help determine how the disruptive factors of the supply chain are related to the efficiency of the system. Future work will suggest decision-making strategies that will improve MTS performance over time being able to enhance customer satisfaction.

R354— Functionally Graded Biomimetic Energy Absorption Concept Development for Transportation Systems
[Birman, V., PI – Missouri S&T, new in this reporting period]

We can learn many lessons from a study of biological systems that are applicable to engineering applications. In the proposed research we apply the observations from the study of tendon-to-bone insertion site conducted by PI with his colleagues at the School of Medicine at Washington University to a development of a robust and resilient functionally graded cylindrical sandwich shock absorber. The concept utilizes concentric foam shells of variable mass density constrained within a stiffer outer shell that reduces radial deformations of the assembly under axial shock. As was demonstrated for both biological tissues (e.g., the tendon-to-bone insertion site) and for engineering materials (metals, ceramics, composites), a lower stiffness material possesses a higher resilience and toughness. In the considered concept, we maximize the energy dissipation of the assembly by grading the foam shells utilizing variable mass density (and accordingly, variable stiffness and strength) of foam. The energy absorption is maximized, while maintaining the prescribed deformation as well as the necessary strength of the system.

R353— Reliability-based Optimization Design of Geosynthetic Reinforced Road Embankment
[Luna, R., PI – Missouri S&T, new in this reporting period]

Road embankment is normally a large structure, the construction of which requires for large amounts of soil normally of good quality. In order to limit costs, the utilization of geosynthetic in road embankment allows for construction of steep slopes up to 80 - 85 degrees, which can save vast amounts of fill soil and land take compared to a traditional unreinforced one.

It then requires for a stability analysis regarding the geosynthetic reinforced slope, which is highly depending on the selection and properties of geosynthetic including the tensile strength, transfer efficiency, length and number of geosynthetic layers placed in embankment, etc. To minimize costs, the optimization design is necessary to select an optimal combination of those design parameters. In this study, the reliability-based optimization (RBO) will be implemented on the basis of reliability-based probabilistic slope stability analysis considering the variability of soil properties. RBO intends to minimize the cost involved in geosynthetic reinforced road embankment design while satisfying all technical requirements. The limit equilibrium method will be embedded to compute the factor of safety (FS), meanwhile, the MPP-based first-order reliability method (FORM) will be performed to determine the probability of failure (pf). The cost is assumed as a function of design parameters: the number of geosynthetic layers, embedded

length, and the tensile strength of geosynthetic. Coupling with the reliability assessment and some other technical constraints, the combination of design parameters can be optimized for a minimum cost.

R352—Long-term Behavior of GFRP Reinforced Panels after Eight Years of Field Exposure
[Myers, J., PI – Missouri S&T, new in this reporting period]

Since 1998, Missouri S&T/University of Missouri-Rolla investigators have been involved in more than 25 bridge repairs and/or new bridge construction involving composite materials. To date, many of these projects have shown reliable field performance. However, there have been little follow-up investigations to study their residual capacity and behavior after long-term exposure to conditioning. This study will examine the crack pattern development over time in GFRP reinforced panels fabricated in 2005 and exposed to field conditions. The study will also test and autopsy the GFRP reinforcing bars to examine property degradation. The GFRP reinforced panels will be studied in flexure to examine any degradation in flexural behavior.

R351— Implementation of RFID Sensors for Monitoring of Bridge Deck Corrosion in Missouri
[Myers, J., PI – Missouri S&T, new in this reporting period]

This work involves the implementation of a new RFID sensor that researchers developed at Oklahoma State University. The sensor uses an Atmel low-frequency RFID transponder. Initial versions used the metal on which corrosion was to be detected to connect the RFID chip to the antenna. If the connection eroded, the RFID transponder would stop working, indicating a potential problem. The second generation of the sensor implements the technology where corrosion is determined by the loss of section on the sensor circuit. When the circuit is broken, that information is transferred to the RFID chip and the information is communicated to the reader the next time the tag is read. Laboratory efforts still need to correlate the sensor's sensitivity to the level of corrosion in the structure.

R350— Non-invasive Imaging and Assessment of Active Karst Features in Proximity to Paved Roadways
[Anderson, N., PI – Missouri S&T, new in this reporting period]

In an effort to better understand and define the lateral and vertical extent of karstic voids that have developed immediately adjacent to DOT roadways in Springfield Missouri, MS&T will acquire electrical resistivity tomography data. ERT data will be acquired along traverses laid out in the DOT ROW. We will acquire geophysical data using a Supersting R8 resistivity unit. Resistivity probes will be placed on 2.5-foot centers. The subsurface will be imaged a depth of approximately 50-60 feet bags.

R349— Strength of Unbonded Post-Tensioned Walls
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

Post-tensioned masonry walls (PT-MWs) will be an ideal candidate for accelerating the construction of sound barriers in highways. PT-MWs have been in use for a while; however, there has been no rigorous single-study in the United States about in-plane strength of PT-MWs

built out of concrete masonry units. This project will investigate the in-plane behavior of six full-scale unbonded post-tensioned walls. All the walls will have the same total post-tensioning force and identical dimensions of 104 in. long, 96 in. high, and 8 in. wide. Spacing between tendons ranging from 32 in. to 96 in. will be investigated. The walls will be subjected to in-plane shear loads of increasing amplitude. Both flexural strength and shear strength will be evaluated and compared to the strengths given by MSJC (2011). The stresses in the tendons will be measured using strain gauges and compared to different formulae.

R348— Adapting Risk Management and Computational Intelligence Network Optimization Techniques to Improve Traffic Throughput and Tail Risk Analysis
[Wunsch, D., PI – Missouri S&T, new in this reporting period]

Risk management techniques are used to analyze fluctuations in uncontrollable variables and keep those fluctuations from impeding the core function of a system or business. Examples of this are making sure that volatility in copper and aluminum prices do not force an aircraft manufacturer to abruptly shut down manufacturing and making sure a failed bank or state does not cause an entire financial system to fail. Computer network optimization techniques involve many nodes and routes communicating to maximize throughput of data while making sure not to deadlock high priority or time sensitive data. This project will involve exploring possible remappings of these application spaces from risk and computer networks to traffic. Some of these possible mappings include mapping flash crashes and black swans to traffic jams, bank failure to construction or traffic accidents, data packets to vehicles, network routers to traffic lights and other intersection policies. Due to the large data and large solution/ state/ policy spaces computational intelligence techniques are a natural fit for traffic as they are for risk management and computer network optimization.

R347— Numerical Simulation of CFRP-Repaired Reinforced Concrete Columns
[Sneed, L., PI – Missouri S&T, new in this reporting period]

Damage to bridge structures during an earthquake can have devastating social and economic consequences, particularly for bridges located along key routes critical for emergency response and other essential functions. According to ATC 18, damage to important bridges should be repairable within three days. Thus rapid and effective repair methods for varying levels of damage are needed to enable quick opening of these bridges and to minimize impact on the community. The subject of this study is the rapid repair of severely-damaged concrete bridge columns under combined loading effects. The term "rapid" in the context of this study refers to a 3-day time period as defined in the literature. Research in this field is currently limited to the repair of columns with slight to moderate damage levels; thus this research will fill in a critical gap in the literature with respect to the severe damage level. In this study, one-half scale concrete bridge columns that have been tested to failure as part of a separate ongoing study are repaired using externally-bonded carbon fiber reinforced polymer (CFRP) wrap. The repaired columns are then tested under the same loading regime as the original columns, combined action of bending, shear, torsion, and axial effects, and the behavior is compared directly with the original response. Since the current literature contains little information with respect to repair of columns subjected to torsion, the inclusion of torsion in the combined loading is a significant contribution to the state of knowledge, and represents a more comprehensive and realistic loading condition than without. Results of this study will also serve as the basis for and add credibility to future

proposals on repair of damaged reinforced columns, with high potential for collaboration with leading researchers in this field.

R346— Quantitative Modeling of Failure Propagation in Intelligent Transportation Systems
[Sedigh Sarvestani, S., PI – Missouri S&T, new in this reporting period]

Unmanned vehicles are projected to reach consumer use within this decade - related legislation has already passed in California. The most significant technical challenge associated with these vehicles is their integration in transportation environments with manned vehicles. Abnormal or incorrect manipulation of the manned vehicles by their human drivers creates a highly nondeterministic environment that is difficult to consider in the control algorithms for unmanned vehicles. Our ultimate goal is to develop a Markovian model that can capture the stochastic elements of this environment, in particular failure propagation from the manned to unmanned vehicles and vice versa. The analytic model will be validated through simulation with a purpose built tool that we plan to develop in the course of the proposed work. In the nine months of the project, we expect to create a qualitative model for the environment, to begin work on the quantitative model (using Petri nets and the qualitative model as a basis), and to develop the simulation environment required.

R345— Nano-Engineered Polyurethane Resin - Modified Concrete
[Chandrashekhara, K., PI – Missouri S&T, new in this reporting period]

Latex modified concrete (LMC), also known as polymer portland cement concrete refers to hydraulic cement mixed with organic polymers that are either dispersed or redispersed in water. The dispersion of polymers in water is sometimes referred to as emulsions. When polymer emulsions are mixed with portland cement concrete, the polymer particles come together to form a polymer film coating on aggregate particles and cement grains, and seals any voids or microcracks. The resulting mixture of polymer emulsion and portland cement concrete will have higher strength, high resistance to chloride penetration and is more inert to chemical attack than plain cement. One of the weak links in a cement-aggregate composite material is the bond between the matrix and the aggregates. To improve the performance of the alternative cement binder (ACB), the research team will develop a NEPU resin to act as an intermediary between the aggregates and the ACB matrix. The NEPU will be used to precoat the aggregates prior to their placement within the ACB matrix. Embedded within the NEPU will be grains of the ACB. Then, when combined with the ACB and water, the unhydrated ACB particles embedded within the NEPU-coated aggregates will react with the surrounding matrix during hydration, providing an enhanced interfacial zone and corresponding improvement in the material properties of the hardened material. In the proposed work, the used of bio-based NEPU emulsion for LMC application will also be investigated. The characterization of NEPU including cure kinetics, rheology, UV resistance, and flame resistance will be conducted. The proposed NEPU-modified concrete will be subjected to physical and mechanical testing. The optimal composition of NEPU system will be investigated for determining the percentage by weight of nano-clay and soy-content.

R344— Optimization of Rheological Properties of Self-Consolidating Concrete by Means of Numerical Simulations, to Avoid Formwork Filling Problems in Presence of Reinforcement Bars
[Feys, D., PI – Missouri S&T, new in this reporting period]

The main objective of this project is to perform numerical single-fluid simulations to identify critical rheological parameters of Self-Consolidating Concrete for which formwork filling problems occur. As a function of the variables studied, namely the formwork width, the rebar diameter, the concrete cover (distance between rebar and formwork), the distance between rebars (group effect) and the discharge rate, this project allows to establish a set of guidelines for the rheological properties of concrete to avoid the presence of dead zones or zones with very high shear rates. In this way, the occurrence of construction defects can be reduced.

R343— Mechanical Characteristics of Low-cost Hybrid Fiber Reinforced Polymer
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

With the rapid development of polyethylene terephthalate (PET) and Polyethylene naphthalate (PEN) and their wide use in industry, there is a substantial volume of plastics added to waste streams every year. Both PET and PEN are not biodegradable and hence causing serious environmental issues. On the other hand, both PET and PEN have very high ductility and low modulus. Conventional FRP such as glass FRP, carbon FRP, and aramid FRP possess high modulus but low ductility. Developing hybrid PET-FRP and/or PEN-FRP presents significant improvement for structural applications such as retrofitting concrete columns using wrapped FRP. The goal of the proposed research is to determine the mechanical characteristics of hybrid PET-FRP and/or PEN-FRP.

R342— Dilation Characteristics of Rubberized Concrete
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

Recently, the PI research group developed a structural system for accelerating bridge construction. The system consists of precast post-tensioned concrete filled fiber reinforced polymer tubes (PPT-CFFT). However, the system has limited viscous damping.

Recent research showed that viscous damping of concrete can be increased by adding shredded rubber. To incorporate the rubberized concrete into PPT-CFFT, the factors that affect the behavior of confined rubberized concrete need to be quantified. One of the main parameters to quantify the confinement is dilation angle. This research will use triaxial tests to determine the dilation angle of rubberized concrete having different rubber content and different confining pressure.

Rubberized concrete is a conventional concrete including scrap tire rubber as a partial substitution for mineral aggregates. Recent research showed that adding rubber to concrete significantly improves it viscous damping; hence, reduce its vibration and corresponding forces under earthquake ground motion. In order to use rubberized concrete, the dilation angle of rubberized concrete having different rubber content need to be determined. The objective of this proposal is to use triaxial tests to determine the dilation angle of concrete having rubber content ranging from 0 to 20% as a replacement of fine gravel.

R341— Novel Integrated Nondestructive Testing Methodology for Detection and Evaluation of Corrosion in Cement-Based Materials
[Donnell, K., PI – Missouri S&T, new in this reporting period]

The integration of thermography/infrared (IR) and ultrasonic test (UT) methods has been successfully demonstrated by others. By vibrating a material via UT, heat is generated at the location of flaws.

Subsequently, this heat is imaged using an IR camera. The work proposed here suggests a similar yet unique approach through the integration of microwave methods with IR/thermography, an established NDT technique. The combination of microwave and IR NDT may offer a substantial improvement to traditional thermographic techniques. First, microwaves can be used to selectively and locally heat an area of interest, as opposed to heating the entire sample (and risking heat damage). Furthermore, thermography has an issue with speed, as heat transfer can be quite slow. Using microwaves to selectively heat a localized area will improve the speed of the method by 50%, as microwave heating is instantaneous.

Preliminary results have shown the combination of microwave and IR methods as a promising technique for detection of surface cracks and corrosion in metals. This project will build upon these preliminary results to development a new technique to detect and evaluate the presence of corrosion in cement-based materials, which is of critical importance to the nation's transportation infrastructure.

This project focuses on the development of an integrated nondestructive testing and evaluation (NDT&E) methodology that combines the benefits of multiple NDT&E techniques into one new technique. In this way, unique features of multiple NDT methods can be brought together to achieve new results that one method alone cannot achieve. Further, this new method may have the potential to address issues in NDT&E that are currently without a practical solution.

R340— Data Acquisition, Detection and Estimation for Structural Health Monitoring
[Cheng, M., PI – Missouri S&T, new in this reporting period]

Although using sensor networks for SHM (structural health monitoring) is not a new concept, very few projects have investigated the problems of detection (of defects) and estimation (of damage location) using network-acquired data. In statistics detection and estimation theory were established by assuming the measurement data come with reliable statistics, for instance, the probability of a particular observation. However, such statistics often requires large amount of observations. In wireless sensor networks, data acquisition is a costly operation since wireless sensor networks are both bandwidth and power limited. The amount of measurement data that can be reported to the base station is therefore very limited. Data acquisition from sensor networks has been treated as a trivial subject and often is performed by using fixed-interval sensing and reporting. In this project, we will provide a thorough treatment of sampling, detection and estimation for using sensor network data. Specifically, (a) We will investigate the fundamental sampling issue, particularly, for each type of physical measurement, what is the best sampling rate and whether adaptive sampling is more suitable than uniform sampling. Based on the sampling discipline, the sensing and communication protocols are developed; (2) for structural defect detection, we propose to use the likelihood ratio test method with Bayes

criterion and compare it with the basic LRT method; through the detector, we narrow the scope of the defect to be within the spatial interval of some sampling points; (3) once it is concluded that a defect exists, the maximum likelihood estimator is used to further estimate the location of the defect. The algorithms will be validated thorough test bed experiments or simulations.

R339— Using Shear Wave Velocity to Monitor the Curing Process of High Performance Flowable Concrete
[Bate, B., PI – Missouri S&T, new in this reporting period]

Shear wave velocity measurement of geomaterials using bender element has been used widely in geotechnical engineering during the last decades. The shear wave velocity, or the stiffness of a freshly casted concrete will also change significantly from close to zero to 1300- 2000 mjs. However, monitoring of the lateral pressure, instead of S-wave velocity, was currently adopted as the standard method. The first objective of this proposal is to use bender element as a new monitoring tool to monitor the curing process of a concrete. The second objective of this proposal is to use S-wave velocity as a tool to predict the strength of the early (1 or 3 days) strength of a freshly-casted concrete using correlation between these two quantities.

The first objective of this proposal is to use bender element as a new monitoring tool to monitor the curing process of a concrete. The second objective of this proposal is to use S-wave velocity as a tool to predict the strength of the early (1 or 3 days) strength of a freshly-casted concrete.

R338— Site Assessment using Echo Sounding, Side Scan Sonar and Sub-bottom Profiling
[Anderson, N., PI – Missouri S&T, new in this reporting period]

The objective is to demonstrate the utility of using echo sounding, side scan sonar and sub-bottom profiling techniques to characterize foundation materials in fluvial and lacustrine environments and to assess the potential for stream scour in fluvial environments. Echo sounders provide highly accurate estimates of water depths; side scan sonar provides 3-D acoustic images of the river/lake bottoms; sub-bottom profilers provide extremely high-resolution 2-D images of the sediment/rock to depths on the order of 60 meters.

R337— Life Cycle Maintenance Cost Analysis of RC Columns Rehabilitation Techniques under Various Durability Exposures
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

The Federal Highway Administration (FHWA) requires that state highway agencies preserve and maintain existing roads so that the highway systems work better and last longer. This is a major part of the Asset Management goals undertaken by the federal government. The goal of this research is to assist Missouri Department of Transportation (MoDOT) in identifying opportunities to use performance-based maintenance contracting (PBMC) in their road maintenance activities. This research will focus on benefits of using this innovating contracting method and will determine the MoDOT road maintenance activities that can be performed under performance based contract.

The study objectives are:
• Life-cycle maintenance cost analysis within the context of PBMC.
• Use accelerated aging tests to determine the effect of saltwater environment on the residual

strength of CFFT and HDS-FRP/S
• Investigate the effects of combination of temperature cycles, high moisture, and UV radiation on the residual strength of CFFT and HDS-FRP/S
• Investigate the effects of chloride solution on the residual strength of HDS-FRP/S

R336— Extending the Usage of High Volume Fly Ash in Concrete
[Volz, J., PI – Missouri S&T, new in this reporting period]

Concrete mixtures that contain a high volume of fly ash (greater than 30%) have become more desirable for the increase in sustainability and economy of these mixtures. Extensive work has been completed by PI Volz for the Missouri DOT under several previous projects to show that there are many applications where high volume fly ash can be used to provide satisfactory performance. However, several additional additives had to be included in the concrete mixture to improve the reactivity and subsequent strength gain of the mixture. While these additives did improve the performance of the mixtures, there was still a measurable difference between the high volume fly ash mixtures and concretes that use traditional volumes of fly ash. Furthermore, during the durability testing of these mixtures, there was poor performance of these mixtures in the ASTM C 672 salt scaling test. These differences in performance in these materials provide significant barriers between low and high dosages of fly ash that will not allow their usage in bridge decks, pavements, sidewalks, or any element with a time sensitive strength gain.

Recent work has been completed by Silva, Cheung, and Roberts of W.R. Grace to introduce a new and promising method of pre-treating fly ash by soaking it in water or other solutions before using it in concrete. This treatment allows the fly ash mixtures investigated to show improved early and later age reaction rates and subsequent strength gain. This methodology needs to be investigated with a larger number of fly ash sources and also the mechanisms need to be better understood. If the benefits of this method could be achieved in a practical manner, then this would greatly improve the ability to use high volume fly ash concrete and would address several of these critical issues with delayed strength and setting.

Even if these issues are addressed then there will still be problems with the subsequent scaling of these mixtures. While there are a number of different ways to address this problem, it would be better if there was a greater understanding of the mechanisms of salt scaling with high volume fly ash and why it is more severe than low volumes. In order to investigate this, the research team will use X-ray computed tomography techniques to image samples during freezing and thawing cycles. This technique can make 3D maps of materials with a scale of 1 micron and has been a significant focus of research of PI Ley at OSU. This technique will allow direct observations to be made of the crack initiation sites and their subsequent growth under freezing cycles. Once the scaling mechanism is better understood, then this will give much greater insight to guide future solutions.

R335— Automated Measurement of Concrete Slump Using the Verifi System
[Khayat, K., PI – Missouri S&T, new in this reporting period]

This study will evaluate the performance of an automated system of measuring the fresh properties of concrete in truck mixer. The automated system called “Verifi” enables the evaluation of slump and temperature variations as well as monitoring of the amount

of water and/or dispersant added to the mixture. This collaboration is essential for future quality management of infrastructure materials.

The expected results from this project will be initial guidelines dealing with feasibility of using this system in ready mix industry. These guidelines will provide both MoDOT and system designers with a resource to implementing, testing, and making improvements in QC/QA systems.

R334— Bridge Hydro-mining Thickness Measurements
[Maerz, N., PI – Missouri S&T, new in this reporting period]

We propose to measure the thickness of the removed concrete material as a result of hydro-demolition (and manual removal) using before and after LIDAR measurements and adapting/developing change detection algorithms. The objective of this project is to measure the thickness of concrete material removed by hydro mining and manual scaling (MODOT project) on 2 lanes each of 3 MODOT bridges up to 1000' long, using before and after LIDAR (Light Detection and Ranging) scans and developing change detection algorithms.

R333— Influence of Mixing Procedure on Robustness of Self-Consolidating Concrete
[Feys, D., PI – Missouri S&T, new in this reporting period]

Self-Consolidating Concrete is, in the fresh state, more sensitive to small variations in the constituent elements and the mixing procedure compared to Conventional Vibrated Concrete. Several studies have been performed recently to identify robustness of SCC and to develop solutions to increase the robustness of SCC. Ghent University obtained a major research project from the Research Foundation in Flanders (FWO) to investigate fundamentally robustness of SCC and to identify potential solutions in the form of alternative materials to enhance robustness.

In the proposed research project, Missouri S&T intends to extend the research at Ghent University by investigating the influence of the mixing procedure on the robustness of SCC. The project is split into four tasks. In a first task, the sequence of adding the constituent elements and mixing will be investigated by measuring the rheological properties of the produced mortars. In a second task, the consequences of the main influences of the mixing procedure will be compared to the influence of small variations of the most important constituent elements. In the third task, the results obtained on mortars are validated on concrete scale, while in the fourth task, the robustness of thixotropy and loss of workability will be investigated on concrete scale.

The research team hopes in this way to acquire more knowledge on the influence of the mixing procedure on the robustness of SCC, enabling the establishment of a set of guidelines. As a result, the practical application and perception of SCC in the construction and transportation industry can be enhanced.

R332— Recycled Concrete Aggregate Field Implementation – MRB Project
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The proposed project involves the field evaluation of special concrete made using RCA in pavement construction that will be part of the Mississippi River Bridge (MRB) construction project and will involve the construction of a ramp approach from the Cass Ave. stub out to the

EB Parkway Bridge over I-70. A pavement section measuring 16’ in width (inside lane and shoulder) from the Cass Ave. stub out to the EB Parkway Bridge over I-70 will be used as the control pavement. The attached 22.5’ wide outside lane of the same section would be used as the section for the experimental concrete made with RCA. It is estimated that 425 and 600 cubic yards will be used for the reference and experiment concrete mixtures, respectively. It may be advantageous to consider a second experimental section for the placement of another mixture made with RCA.

The study will evaluate the fresh and hardened properties, durability, and in-situ performance of concrete containing recycled concrete aggregate (RCA) that will be used in experimental pavement construction carried out in 2013 by MoDOT. The result from this study will be provide feedback to refine the research program underway at Missouri S&T with MoDOT and future field implementation of this technology in transportation-related infrastructure.

R331— LIDAR Scanner for Highway Rock Fall and Slope Movement Monitoring
[Maerz, N., PI – Missouri S&T, new in this reporting period]

This project enables the purchase of a LIDAR scanner to continue our work on measuring rock fall on highway rock cuts and soft slope movements on highways.

R330— Unbonded Portland Cement Concrete/Pavement Monitoring with Integrated Grating (Local) and Scattering (Global) Optical Fiber Sensors
[Chen, G., PI – Missouri S&T, new in this reporting period]

In this study, an integrated grating and Brillouin scattering optical fiber sensing system is proposed and applied to the strain monitoring of concrete pavements. The new sensing system combines multiple fiber Bragg grating (FBG) sensors and a Brillouin optical time domain Analysis (BOTDA) sensor into one single optical fiber, thus referred to as an FBG-BOTDA sensing system. The FBG sensors will be applied for local strain measurements while the BOTDA sensor will provide strain distributions over a large area. The integration of grating and Brillouin scattering sensors also allow for temperature compensation of individual sensors. The more recently introduced PPP-BOTDA/TW-COTDR hybrid technology further allows the measurement of strains and temperatures along the length of a single-mode optical fiber without deploying any grating. This project will take advantage of the pool-funded field study on the performance of concrete overlays on existing pavement in the state of Minnesota with contributions of both MnDOT and UMN.

R329— Non-invasive Imaging and Assessment of Pavements
[Anderson, N., PI – Missouri S&T, new in this reporting period]

The objective is to thoroughly assess the cost-effectiveness and utility of non-invasive technologies identified as applicable to paved roadways. The intent is to develop a guidance document focused on the utility and cost-effectiveness of project-applicable and network-applicable non-invasive imaging technologies. The optimal utilization of appropriate non-invasive imaging technologies will result in more accurate pavement assessments at significantly reduced costs.

Specific objectives include:

- Assessment of the utility and cost-effectiveness of tested network-applicable non-invasive imaging tools based, in large part, on the analyses of data acquired along two designated roadways;
- Assessment of the utility and cost-effectiveness of tested project-applicable non-invasive imaging tools based, in large part, on the analyses of data acquired along eight designated roadways; and
- Development of a comprehensive guidance document including a matrix on what cost-effective site assessment technologies are applicable, how to employ them, and what site condition data can be obtained.

R328— Self-Consolidating Concrete for Connecting Precast Concrete Deck Panels and I-Girders
[Khayat, K., PI – Missouri S&T, new in this reporting period]

Existing precast concrete deck systems are either partial depth or full-depth with open channels/pockets that require cast-in-place concrete and deck overlay. There operations negatively affect the quality and speed of construction, which are the main goals of using precast deck systems. The Kearney East Bypass in Kearney, NE is the first bridge project that uses the latest developments in full-depth precast concrete deck systems for precast/prestressed concrete girder bridges. These developments include using full-depth full-width deck panels with covered individual pockets at 4 ft spacing eliminating the need for deck overlay or exposed cast-in-place concrete. Self-consolidating concrete (SCC) is vital to the success of the new deck system to fill the deck pockets and the large gap between the deck soffit and precast concrete girders without the need for expensive commercial grouts. A research project titled “Implementation of Precast Deck Panel NUDECK” is currently being conducted at the University of Nebraska – Lincoln (UNL) and sponsored by Nebraska Department of Roads (NDOR) to address design and detailing of the new deck system to be implemented in the Kearney Easy Bypass by the end of 2013. However, the constructability of the developed deck system needs to be investigated to improve its competitiveness against cast-in-place concrete decks.

The objective of this project is to experimentally investigate the effectiveness of using SCC to fill the gap between the precast concrete girder and precast deck soffit as well as the shear pockets in the deck panels. This includes developing a specific SCC mixture(s) for this special application and evaluating its flowability and pumpability in small–scale and full-scale laboratory settings. Sequence of pumping SCC as well as its quality control and quality assurance procedures will be investigated and presented to bridge owners/contractors. This investigation is crucial for the success of such a great system and for avoiding any problems that might occur due to the unfamiliarity of the involved parties with these new developments.

R327— Development and Testing of Synthetic Riprap Constructed from Coal Combustion Products (CCPs)
[Volz, J., PI – Missouri S&T, new in this reporting period]

Since the 1930’s, fly ash – a pozzolanic material – has been used as a partial replacement of portland cement in concrete to improve the material’s strength and durability, while also limiting the amount of early heat generation. From an environmental perspective, replacing cement with fly ash reduces concrete’s overall carbon footprint and diverts an industrial by-product from the

solid waste stream. Unfortunately, only about 40% of fly ash is reclaimed for beneficial reuse, with the remaining 60% disposed of in landfills.

In some instances, the reason for only a 40% use rate is the lack of a viable market, but in other instances, it is because the fly ash does not meet the required specification for use in concrete or as soil stabilization. For instance, current specifications limit the carbon content of fly ashes used as partial replacement of cement in concrete to less than 6%. However, Ameren Corporation's (Ameren) Sioux Power Plant and other plants containing cyclone-fired boilers produce ash with very high levels of unburned carbon, often in the 20 to 50% range. Furthermore, activated carbon injection for mercury control will usually increase the carbon content of fly ashes from conventional boilers, reducing potential sales of ashes from these plants as well. In general, higher carbon contents reduce the reactivity of the ash and the efficacy of air-entraining admixtures.

There are several ranges of potential products depending on the specific applications, such as armoring shorelines, streambeds, bridge abutments, and pilings against scour and ice damage. Scour is particularly critical for bridge abutments and pilings, as it is the number one cause of bridge failures. The proposed project will include evaluation of CCPs from several Ameren power plants, product development, mix design development, and small-scale specimen construction and testing. This research project will serve as a proof-of-concept for synthetic riprap constructed from 90% CCPs.

R326— Cyclic Behavior of Self-Consolidated Concrete
[Elgawady, M., PI – Missouri S&T, new in this reporting period]

Self-consolidating concrete (SCC) is an innovative type of concrete technology with significantly enhanced fresh properties that eliminates the need for mechanical vibrations. SCC is characterized by its ability to flow through structural elements under its own weight, filling every corner of the formwork, even in the presence of congested steel reinforcement. Currently, NDOT uses SCC mainly for casting drilled shafts. Several federal agencies are currently promoting the expansion of SCC use for all the advantages it provides. This project has two folds. The first fold is sponsored by NDOT where the effects of concrete pumping, tremie use, form shape, local aggregate properties, casting height and/or reinforcement congestion would be investigated. The first fold will conclude with proposing different mixes to be used by NDOT for SCC applications. The second fold will be sponsored by Missouri University of Science and Technology NUTC. The second fold will investigate the cyclic behavior of SCC and will be compared to cyclic behavior of conventional concrete.

R323— Adding Faculty in the Areas of Transportation – Engineering Management
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The UTC provides funds to help departments build up their faculty in the transportation field over the next years. Broad areas will be considered as listed in the UTC mission or other areas that relate to State Departments of Transportation and MoDOT in particular as stated in their goals, interests, and objectives.

R322— Sustainable Crack-Free, Environmental-Friendly Concrete "Crack Free Eco-Crete"
[Khayat, K., PI – Missouri S&T, new in this reporting period]

Since concrete is the most used construction material in the world, it accounts for a considerable part of CO_2 emissions. This means that besides to its appreciable roles, it may be considered as a significant source of emission of greenhouse gases. The solution of this problem is to reduce the environmental impact of concrete and cement through the idea of Eco-Concrete. Besides to its environmental benefits, Eco-Crete is also important from the economical perspective. Because, incorporating high volumes of industrial by-products as replacements for Portland cement makes the Eco-Crete more energy efficient and cheap to produce.

The main objective of the proposed project is to produce a new-class of environmental friendly concrete material of normal compressive strength that is highly flowable: either self-consolidating concrete (SCC or, super workable concrete (SWC) consistency. The project aims at maximizing SCM and filler contents to reduce the carbon footprint of the material. The project will seek to evaluate the feasibility of using expansive agents to prevent shrinkage cracking and to induce chemical prestressing in the fiber reinforcement.

R321— Ultra High Strength Concrete Wearing Surface for Asphalt and Concrete Road as well as Bridge Deck
[Khayat, K., PI – Missouri S&T, new in this reporting period]

Pavements usually consist in base and sub-base layers which last 20-40 years or more, covered with a wearing coarse having a much shorter service life. The maintenance works for these surface layers induce high external costs. In order to solve the problem, intensive effort is devoted to introducing new generations of materials to enhance the performance of such surface layers. With regard to their amazing mechanical and durability performances, UHPC materials have changed to issues of great importance in this research area.

Due to time, cost, and environmental considerations, developing new concrete materials for pavement applications to achieve the minimum possible thickness is of a great significance. But, besides the mentioned benefits of producing pavement materials of minimum possible thicknesses, these materials are prone to shrinkage and cracking. As solution for this problem, the idea of fiber-reinforced mortar for the wearing surface is proposed. Pavements manufactured from ultra-high performance concrete (UHPC) can provide significant durability improvement due to the high strength and extremely low permeability of the UHPC material. It is worth mentioning that to enhance both the mechanical and durability properties of these pavement materials, it is suggested to incorporate the steel and/or synthetic fibers in the mixtures as a technical and environment friendly solution. Besides it should be noted that the use of fibers can lead to a reduction in pavement depth, thus, reducing the overall costs, as well as speeding the on-site process and reducing trip hazards

R320— Fast Construction and Repair of Bridge Elements Using Low Carbon Foot Print SCC and UHPC Prefabricated Panels Reinforced with FRP
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The service life of concrete infrastructure elements depends on the quality of the cover-crete; outer 50 mm of the concrete. The use of high-performance concrete can indeed prolong service life of the material. However, this material is still prone to cracking. Recently, ultra high-performance concrete (UHPC) has been introduced which has much higher mechanical properties and toughness than HPC. UHPC is typically a micro-mortar reinforced with micro fibers (typically steel fibers) resulting in extremely impermeable and crack-resistant material. Such material can be used to produce precast panels that can be assembled on-site for the construction of bridge vertical elements, such as the construction of girder and bridge pier elements.

This project aims at developing UHPC that can be used as a formwork system for cast in-place bridge construction. The proposed units are targeted for bridge construction and use low carbon foot print self-consolidating concrete (SCC) and UHPC prefabricated panels reinforced with fiber-reinforced plastic (FRP) bars. The use of the proposed approach can result in several advantages for the United States transportation infrastructure system, including: (1) design of fast construction and rehabilitation system for transportation infrastructure that can exhibit extended service life; (2) use of environmentally friendly SCC to cast the structural element can provide a rapid construction procedure; (3) notable savings in labor and time by designing a permanent formwork system.

R319— The NASP Bond Test as a Predictor of Strand Bond, Transfer Length, and Development Length
[Volz, J., PI – Missouri S&T, new in this reporting period]

The research team hypothesized that the North American Strand Producers (NASP) test could be used to evaluate bond of prestressing strand in concrete. Specifically, that the test would predict transfer and development lengths of strand in different types of concrete, such as self-consolidating concrete and high-volume fly ash concrete. The researchers found a reasonable correlation between the NASP test and measured transfer and development lengths, but because of the cost of full-scale specimen tests, the number of tests is limited.

To provide additional data, the research team will model the bond of prestressing strand in concrete using finite element analyses. The purpose of the analyses is to perform parametric studies on the different variables to determine if a stronger correlation exists between the NASP test and transfer and development lengths of prestressing strand. Dr. K. Chandrashekhara – Curators' Professor of Mechanical and Aerospace Engineering – has significant expertise in analytical modeling of complex material behavior. He will be added to the project to provide this expertise and strengthen this additional phase of the project.

R318— Adding Faculty in the Areas of Transportation – Civil Engineering
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The UTC provides funds to help departments build up their faculty in the transportation field over the next years. Broad areas will be considered as listed in the UTC mission or other areas that relate to State Departments of Transportation and MoDOT in particular as stated in their goals, interests, and objectives.

R317— Lightweight Concrete Modification Factor for Shear Friction
[Sneed, L., PI – Missouri S&T, new in this reporting period]

This project is aimed at studying the influence of aggregate type on direct shear transfer across an interface of concretes cast at different times. The shear friction design concept is applicable in conditions where direct shear must be transferred across a structural concrete plane or interface, such as an existing crack or an interface between dissimilar materials or concretes cast at different times. Shear friction provisions are commonly used in the design of precast-prestressed concrete elements and connections in building and/or bridge structures including corbels, dapped double tees, beam bearings, and diaphragms. These types of connections are critical because there is little or no redundancy.

Data used to develop shear friction provisions in both the ACI 318 Code and the PCI Design Handbook are predominantly from experiments with specimens constructed of normal weight concrete (NWC). Only a limited number of studies have been performed on lightweight concrete (LWC), and particularly for conditions with concrete surfaces cast at different times. This condition may exist, however, due to precast plant practices and the increasing use of self-consolidating concrete (SCC), and where projecting elements might be cast after the underlying concrete has partially hardened. Alternatively, projecting elements might be cast in advance and inserted into the fresh concrete when the main member is cast, resulting in a similar condition. It should also be noted that the influence of SCC on the interface shear has not been thoroughly studied. In summary, lack of LWC test data and clear and consistent design provisions underscore the need for a systematic approach to isolate and examine the influence of factor λ on the interface friction so that it can be applied clearly and confidently in shear friction design.

R316— NCHRP 24-38 Payload Project – Development of Bridge Girder Movement Criteria for Accelerated Bridge Construction
[Chen, G., PI – Missouri S&T, new in this reporting period]

It was observed after the 2010 Chile Earthquake that the bridges with full-depth end diaphragms always performed well. Partial-depth end diaphragms sometimes caused transverse shear block or lateral fracture failures of reinforced concrete (RC) girders. The bridges with no end diaphragms and no concrete teeth on cap beams suffered more damage. However, a number of bridges with no end diaphragms but with concrete teeth on a cap beam survived the earthquake with no significant damage except for local spelling at the concrete teeth due to the earthquake-induced pounding effect.

The above observations from the real-world bridge constructions indicated that bridge superstructures with no end diaphragms but with concrete teeth between girders are a potential alternative to the well-understood superstructures with end diaphragms. The key to make this no-diaphragm concept work is to understand how multiple girders work together during a transverse earthquake excitation or how much relative deformation they can tolerate without breaking the girders and bridge deck. The proposed payload project represents the first feasibility study towards this direction. It can greatly benefit the U.S. and beyond in terms of understanding of the seismic behavior of accelerated bridge construction connections between precast girders and thus cost effectiveness of rapid bridge constructions.

The main objective of the payload project is to develop bridge girder movement criteria in a multi-girder superstructure of bridges for accelerated bridge construction in seismic region. Specifically, a representative real-world, multi-girder highway bridge in Missouri will be analyzed and critical tolerances of the relative movement between steel or RC girders will be quantified, corresponding to the strength limits of girders and the bridge deck due to lateral loads. Two three-girder superstructures with steel I-girders and RC girders supported on a cap beam with pedestals (teeth) in between the girders will be built and tested under a slowly-increasing, pseudo static load in order to validate the numerically determined critical tolerant movement between steel girders.

R315— High-Strength Self-Consolidating Concrete (HS-SCC) and High-Volume Fly Ash Concrete (HVFAC) for Infrastructure Elements: Implementation
[Myers, J., PI – Missouri S&T, new in this reporting period]

Because of its unique nature, high-strength self-consolidating concrete (HS-SCC) has the potential to significantly reduce costs associated with transportation-related infrastructure, benefiting both MoDOT and the residents of Missouri. HS-SCC is a highly flowable, non-segregating concrete that can be placed without any mechanical consolidation, and thus has the following advantages over conventional concrete:

- decreased labor and equipment costs during concrete placement,
- decreased potential for and costs to repair honeycombing and voids,
- increased production rates of precast and cast-in-place elements, and
- improved finish and appearance of cast and free concrete surfaces.

In addition to HS-SCC, innovative materials, such as High Volume Flay Ash Concrete (HVFAC), also provide a significant potential to produce more cost effective mix designs for cast-in-place concrete. Since the 1930's, fly ash – a pozzolanic material – has been used as a partial replacement of portland cement in concrete to improve the material's strength and durability, while also limiting the amount of early heat generation. From an environmental perspective, replacing cement with fly ash reduces concrete's overall carbon footprint and diverts an industrial by-product from the solid waste stream (currently, about 40 percent of fly ash is reclaimed for beneficial reuse and 60 percent is disposed of in landfills). In this implementation study, a level of 50% fly ash to cement proportions will be utilized.

This project aims to implement research undertaken at Missouri S&T and elsewhere on HS-SCC and HVFAC into an implementation project. It also aims to study the shear behavior in full-scale NU girders that are fabricated with HS-SCC.

R313— Experimental Investigation of the FRCM/Concrete Interfacial Debonding
[Sneed, L., PI – Missouri S&T, new in this reporting period]

This project will study the bond behavior of fiber reinforced cementitious matrix (FRCM) composites externally bonded to reinforced concrete (RC) members. Fiber-reinforced composite systems are widely used for strengthening, repairing, and rehabilitation of reinforced concrete structural members. A promising newly-developed type of composite, comprised of fibers and an inorganic cement-based matrix, provides several environmental, structural, and sustainability-related advantages over fiber reinforced polymer (FRP) composites traditionally used in

structural applications, which potentially expands the strengthening applications beyond those currently utilized. Such advantages include: 1) high resistance to fire and high temperatures; 2) resistance to UV radiation; 3) ease of handling during the application because the inorganic binder is water-based; 4) easy cleanup and reuse of tools; 5) low odor and toxin emissions during application and curing; 6) permeability compatibility with the concrete substrate; and 7) unvarying workability time (between 40°F and 105°F). Stress-transfer mechanisms and interfacial fracture propagation of fiber-reinforced composites externally-bonded to a concrete substrate are complex phenomena that are highly dependent on the bond characteristics of the composite matrix material to the fibers. These phenomena have not yet been clearly defined and understood for FRCM composites. Experimental work will be carried out in this study to isolate the shear debonding phenomenon using single lap shear tests.

R312— Recycled Concrete Aggregate (RCA) for Infrastructure Elements
[Volz, J., PI – Missouri S&T, new in this reporting period]

Sustainability is at the forefront of our society, and concrete is the most consumed man-made material on our planet. Unfortunately, the production of concrete consumes an enormous amount of virgin materials. One area that offers significant potential for increasing the sustainability of concrete is the use of recycled concrete as aggregate for new construction. Recycled concrete is less expensive than virgin aggregate sources, and its use would remove a sizeable amount of material from landfills, turning a waste product into a viable construction material.

Concrete recycling protects natural resources and eliminates the need for disposal by using readily available concrete as an aggregate source for new concrete, including in-place recycling. However, the successful application of RCA requires a thorough understanding of its effect on the fresh and hardened properties of the resulting concrete. For instance, recycled aggregate usually has higher absorption and lower specific gravity than virgin sources. Both of these issues require adjustments during the mix design process. Concrete made with RCA can also experience increased creep, shrinkage, and permeability – as well as decreased stiffness and compressive strength – compared to concrete produced from virgin aggregate. Nonetheless, proper application of RCA can decrease the cost of transportation-related infrastructure and remove a significant amount of material from landfills, increasing the sustainability of concrete.

The objective of the proposed research is to determine the implications of using recycled concrete aggregate (RCA) in the production of new concrete. Specifically, the study will evaluate the fresh and hardened properties, durability, and structural behavior of concrete containing RCA. The expected result from this study will be guidelines for evaluating, selecting, and specifying RCA concrete. These guidelines will provide both MoDOT and design engineers with a resource to design, test, and implement RCA in transportation-related infrastructure.

R311— Nondestructive Evaluation of MoDOT Bridge Decks – Pilot Study
[Sneed, L., PI – Missouri S&T, new in this reporting period]

Data required assessing the structural condition of bridge decks can be collected using various methods such as visual examination, surface sounding, removal and evaluation of samples, and noninvasive imaging. Nondestructive testing (NDT) techniques, in particular, enable rapid and comprehensive data collection. The optimal utilization of appropriate NDT technologies can result in more accurate bridge deck assessments and significantly reduced costs. The overarching

goal of this pilot study is demonstrate proof of concept that advanced nondestructive testing/evaluation (NDT/NDE) techniques can be rapidly, effectively, and economically implemented as part of MoDOT bridge deck surveys to improve the overall quality and cost of bridge deck evaluation. The accuracy and appropriateness of selected existing and emerging technologies will be evaluated using field data acquired from the entire suite of bridge decks investigated in this study. Technologies investigated will include two types of ground penetrating radar (GPR) and a portable seismic property analyzer (PSPA). Results of this pilot study will be used to evaluate the feasibility of a large scale, long-term program (multi-year, routine basis) that incorporates NDE techniques into MoDOT bridge deck surveys for the purpose of reducing cost on assessment and maintenance of bridge decks. The results will enable better, more cost-effective decisions of when to repair, strengthen, or replace the deteriorated bridge deck. The proposed research will also serve to educate and train multi-disciplinary students and future engineers in these technologies.

The objective of this study identified by the Matching Research Agency (MoDOT) is to demonstrate the utility of the GPR tool in evaluating the condition of MoDOT bridge decks and confirm that it can be implemented as part of a long-term program that enables faster, better, and more cost-effective bridge deck assessments. ***Additional research objectives*** that will be investigated by the researchers as part of this study are to explore, compare, and contrast existing and emerging noninvasive imaging technologies in terms of accuracy and information provided in evaluating the existing condition of bridge decks. At least two additional technologies (namely a GPR of different type and a portable seismic property analyzer) will be included as part of the deck investigations for this research. A comprehensive comparison will be accomplished including evaluation of data acquired from the entire suite of bridge decks investigated in this study.

Education and Technology Transfer Projects

ETT362— Second Annual Transportation Infrastructure Engineering Conference
[Khayat, K., PI - Missouri S&T, new in this reporting period]

Funding will be used to organize and host annual technology transfer conference. This conference will showcase recent findings in the areas of advanced construction materials, non-destructive testing and structural health monitoring of transportation infrastructure. This event will provide a forum for researchers and practicing engineers to review studies on hear about our cutting edge research and field implementation projects in transportation infrastructure engineering that have been sponsored by the Center for Transportation Infrastructure and Safety.

ETT355— Missouri S&T Formula Electric Racing
[Hutcheson, R., PI - Missouri S&T, new in this reporting period]

The Formula Electric racing team will promote Missouri S&T’s engineering excellence by successfully competing against other top engineering universities in the US and around the world. Students on the team will have the opportunity to reinforce their classroom education through practical application of modern, and future, automotive technologies.

ETT325— Women In Science & Engineering and Minority Engineering Scholarships/ Programs
[Elmore, C., PI - Missouri S&T, new in this reporting period]

This support will make scholarships available to minority and women students interested in engineering and science and will increase significantly the number of minority and female students that Missouri S&T can recruit to its science and engineering programs. Recipients of scholarships will also be exposed to career opportunities in transportation.

Women in Science and Engineering (WISE) scholarships are awarded to support female Missouri S&T students studying science and engineering. Missouri S&T's WISE program provides a campus focal point for increasing the number of women in science, engineering, math, and technology fields through outreach, recruitment, and retention efforts from middle school age through undergraduate levels. WISE provides support programs such as mentoring, advising, professional/technical workshops, and social activities, with the goal of providing a rich academic and social experience for young women at Missouri S&T.

Since the inception of this scholarship program in 2004-2005, women's enrollment has increased in the following transportation- related fields of study: architectural engineering-80%, chemical and biological engineering-57%, civil engineering-56%, computer science-37%, engineering management and systems engineering-35%, information science & technology-69%, materials science and engineering-27%, and mechanical engineering-58%. Also, the female students who have enrolled in undeclared engineering as freshman has increased by 65%, so those students have the potential to major in a transportation-related field.

ETT324— 2013 Missouri Local Technical Assistance Program (LTAP) at Missouri S&T
[Pickerill, H., PI - Missouri S&T, new in this reporting period]

The objective of this project is to manage the Missouri LTAP program for the Missouri Department of Transportation (MoDOT). The LTAP program was established by the Federal Highway Administration (FHWA) in 1982 and operates in each state to provide community leadership through advocacy and implementation of education and training.

The Missouri LTAP program will provide a resource center and technology transfer activities for local officials, counties, parishes, townships, cities and towns throughout the state of Missouri in the form of: workforce development services; resources to enhance safety and security; solutions to environmental concerns, congestion, capacity and other issues; technical publications; and training materials and videos.

ETT314— Seventh International Conference on Case Histories in Geotechnical Engineering
[Prakash, S., PI - Missouri S&T, new in this reporting period]

This funding was used to enhance objectives of conference and to present successful case histories of varied project, orally, in posters and in proceedings. This will become a storehouse of knowledge for future reference. Conference agenda includes international experts delivering state-of-the-art presentations and technical papers along with exhibitors/vendors from the

geotechnical engineering community. This gathering allows for networking and forum discussion of research with teachers, practicing engineers, scientists and students.

Research Equipment

RE361— Acquisition of Specialized Testing Equipment for Advanced Cement-based Materials – Addendum

[Khayat, K., PI - Missouri S&T, new in this reporting period]

The purpose of this addendum is to cover the installation cost associated with several of the specialized pieces of equipment purchased in project 00038844. See work orders below from Missouri S&T Physical Facilities itemizing the scope of work and associated costs. This equipment purchase will enable the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, with emphasis on concrete. The developments of “green” technologies that can lead to cost savings are of prime interest. This will include projects dealing with the performance of self-consolidating concrete (SCC) in cast-in-place bridge superstructure and substructure elements, use of high volume fly ash concrete (HVFAC) in infrastructure applications, the performance of roller compacted concrete (RCC) for rigid concrete pavement for highways, rural roads, and airfield pavements, as well as the feasibility of using high contents of reclaimed asphalt pavement and reclaimed asphalt roofing shingles in flexible pavement mixtures. The common denominator of these technologies is savings of construction duration and cost, and reduction in the carbon footprint of construction materials and activities.

DOT PRODUCTS

Because the Center's theme areas focus around safety in transportation infrastructure as well as new technologies in fuel and infrastructure monitoring, many of the awarded research projects are tied to the U.S. and state Departments of Transportation, particularly Missouri Department of Transportation (MoDOT).

Below are brief explanations of a few research projects meant to serve as examples of how work and research at CTIS serves the transportation and infrastructure needs of our state and nation.

R311— Nondestructive Evaluation of MoDOT Bridge Decks – Pilot Study
[Sneed, L., PI – Missouri S&T, new in this reporting period]

The objective of this study identified by the Matching Research Agency (MoDOT) is to demonstrate the utility of the GPR tool in evaluating the condition of MoDOT bridge decks and confirm that it can be implemented as part of a long-term program that enables faster, better, and more cost-effective bridge deck assessments. ***Additional research objectives*** that will be investigated by the researchers as part of this study are to explore, compare, and contrast existing and emerging noninvasive imaging technologies in terms of accuracy and information provided in evaluating the existing condition of bridge decks. At least two additional technologies (namely a GPR of different type and a portable seismic property analyzer) will be included as part of the deck investigations for this research. A comprehensive comparison will be accomplished including evaluation of data acquired from the entire suite of bridge decks investigated in this study.

R316— NCHRP 24-38 Payload Project – Development of Bridge Girder Movement Criteria for Accelerated Bridge Construction
[Chen, G., PI – Missouri S&T, new in this reporting period]

It was observed after the 2010 Chile Earthquake that the bridges with full-depth end diaphragms always performed well. Partial-depth end diaphragms sometimes caused transverse shear block or lateral fracture failures of reinforced concrete (RC) girders. The bridges with no end diaphragms and no concrete teeth on cap beams suffered more damage. However, a number of bridges with no end diaphragms but with concrete teeth on a cap beam survived the earthquake with no significant damage except for local spalling at the concrete teeth due to the earthquake-induced pounding effect.

The above observations from the real-world bridge constructions indicated that bridge superstructures with no end diaphragms but with concrete teeth between girders are a potential alternative to the well-understood superstructures with end diaphragms. The key to make this no-diaphragm concept work is to understand how multiple girders work together during a transverse earthquake excitation or how much relative deformation they can tolerate without breaking the girders and bridge deck. The proposed payload project represents the first feasibility study towards this direction. It can greatly benefit the U.S. and beyond in terms of understanding of the seismic behavior of accelerated bridge construction connections between precast girders and thus cost effectiveness of rapid bridge constructions.

The main objective of the payload project is to develop bridge girder movement criteria in a multi-girder superstructure of bridges for accelerated bridge construction in seismic region. Specifically, a representative real-world, multi-girder highway bridge in Missouri will be analyzed and critical tolerances of the relative movement between steel or RC girders will be quantified, corresponding to the strength limits of girders and the bridge deck due to lateral loads. Two three-girder superstructures with steel I-girders and RC girders supported on a cap beam with pedestals (teeth) in between the girders will be built and tested under a slowly-increasing, pseudostatic load in order to validate the numerically determined critical tolerant movement between steel girders.

R332— Recycled Concrete Aggregate Field Implementation – MRB Project
[Khayat, K., PI – Missouri S&T, new in this reporting period]

The proposed project involves the field evaluation of special concrete made using RCA in pavement construction that will be part of the Mississippi River Bridge (MRB) construction project and will involve the construction of a ramp approach from the Cass Ave. stub out to the EB Parkway Bridge over I-70. A pavement section measuring 16’ in width (inside lane and shoulder) from the Cass Ave. stub out to the EB Parkway Bridge over I-70 will be used as the control pavement. The attached 22.5’ wide outside lane of the same section would be used as the section for the experimental concrete made with RCA. It is estimated that 425 and 600 cubic yards will be used for the reference and experiment concrete mixtures, respectively. It may be advantageous to consider a second experimental section for the placement of another mixture made with RCA.

The study will evaluate the fresh and hardened properties, durability, and in-situ performance of concrete containing recycled concrete aggregate (RCA) that will be used in experimental pavement construction carried out in 2013 by MoDOT. The result from this study will be provide feedback to refine the research program underway at Missouri S&T with MoDOT and future field implementation of this technology in transportation-related infrastructure.

R351— Implementation of RFID Sensors for Monitoring of Bridge Deck Corrosion in Missouri
[Myers, J., PI – Missouri S&T, new in this reporting period]

This work involves the implementation of a new RFID sensor that researchers developed at Oklahoma State University. The sensor uses an Atmel low-frequency RFID transponder. Initial versions used the metal on which corrosion was to be detected to connect the RFID chip to the antenna. If the connection eroded, the RFID transponder would stop working, indicating a potential problem. The second generation of the sensor implements the technology where corrosion is determined by the loss of section on the sensor circuit. When the circuit is broken, that information is transferred to the RFID chip and the information is communicated to the reader the next time the tag is read. Laboratory efforts still need to correlate the sensor's sensitivity to the level of corrosion in the structure.

R363— Roller Compacted Concrete – Ripley County Rt. 160
[Khayat, K., PI – Missouri S&T, new in this reporting period]

Roller-compacted concrete (RCC) is a concrete of no-slump consistency in its unhardened state that is typically transported, placed, and compacted using asphalt, earth and rock fill construction equipment. The constituents are the same as for conventional concretes but the mixture proportions differ in that the aggregate grading and content has to be such that the RCC can immediately take load. RCC is can be design to develop compressive and flexural strengths in the range associated with structural concrete. The proposed research study will evaluate the fresh and hardened properties, durability, and in-situ performance of RCC. Optimized RCC formulation will be used for widening Route 142 in Doniphan, Missouri. Field-cast concrete will be extensively sampled and tested to compare its performance to conventional concrete used in pavement construction. The structural health monitoring of the performance of the pavement will also be determined. The results from this study will provide feedback to future field implementation of this technology in transportation-related infrastructure.

SUCCESS STORIES

This section lists a sampling of "success stories" for Year VII, including notable Center events; NUTC News articles of interest; faculty and student awards; and media articles about the Center, faculty or campus. Articles, awards and events with corresponding clips are available in the Appendix.

Featured Articles in the NUTC News / The Bridge Newsletters

- "Bridge Design, Test, and Construction on Arnault Branch, Washington County, Missouri." Volume 7, Issue 3.
- "LED Roadway Luminaires Evaluation." Volume 7, Issue 3.
- "Transportation Infrastructure Conference." The Bridge, Winter 2012.
- "Ancient Structural Element Leads to New Ideas in Bridge Building." The Bridge, Winter 2012.
- "ElGawady Joins the Department." The Bridge, Winter 2012.
- "Khayat Delivers IBRACON Keynote." The Bridge, Winter 2012.
- "Advanced Materials Research Reaches New Heights." The Bridge, Spring 2013.
- "Dimitri Feys: materials engineering." The Bridge, Spring 2013.
- "And the Winners are...." The Bridge, Spring 2013.

Awards

- Nathan Muncy, a civil, architectural and environmental engineering M.S. student, was named Missouri S&T's 2011 UTC Outstanding Student of the Year.
- Dr. Jeffrey Volz, assistant professor of civil, architectural and environmental engineering, received the Faculty Excellence Awards at a ceremony held on Tuesday, Feb. 12, 2013.
- Dr. David Richardson, associate professor and Dr. Jeffery Volz, assistant professor of civil, architectural and environmental engineering, received Outstanding Teaching Awards for 2011-2012.
- Dr. John Myers, associate professor of civil, architectural and environmental engineering, was awarded the 2012 Research Award.

- S&T Steel Bridge Team was first in construction speed, first in construction economy and second in structural efficiency, which gave the team a second place finish overall in the steel bridge competition at the American Society of Civil Engineers' Mid-Continent Student Conference held April 4-6, 2013 at Southern Illinois University-Edwardsville in Edwardsville, Ill..

- Dr. Suzanna Long, assistant professor of engineering management and systems engineering, recipient of the President's Award for Early Career Excellence for her research in the field of transportation infrastructures and organizations.

- Missouri University of Science and Technology wins a 2013 Climate Leadership Award

- Two computer science students at Missouri University of Science and Technology received National Science Foundation funding to support their research to create a future "smart" electric power grid.

- S&T graduate student receives Nevada award for bridge research

Missouri S&T in the News

External Media Sources

- "Ancient design concept leads to new ideas for building durable bridges." Homeland Security News Wire. 6 June 2012.

- "Missouri S&T nationally ranked for value." Rolla Daily News. September 14, 2012.

- "Missouri S&T students create device to test lifespan of LED traffic lights." ky3.com. November 01, 2012.

- "2013 Nevada Medal for Bridge Engineering Winner Announced." unr.edu May 23, 2013.

- "S&T grad student win international competition." Rolla Daily News. July 26, 2012.

- "Top-Ranked Universities that Grant the Most STEM Degrees." U.S. News and World Report. June 18, 2013.

Internal Media Sources

- "30 faculty members hired this year at S&T." Missouri S&T Public Relations. September 12, 2012.

- "Missouri S&T among nation's best values, U.S. News says." Missouri S&T Public Relations. September 12, 2012.

- “Missouri S&T offers sustainability minor.” Missouri S&T Public Relations. November 30, 2011.

- “Fall enrollment at S&T highest in 30 years.” Missouri S&T Public Relations. September 18, 2012.

- “Time to change an LED light? S&T researchers design system to tell.” Missouri S&T Public Relations. September 21, 2012.

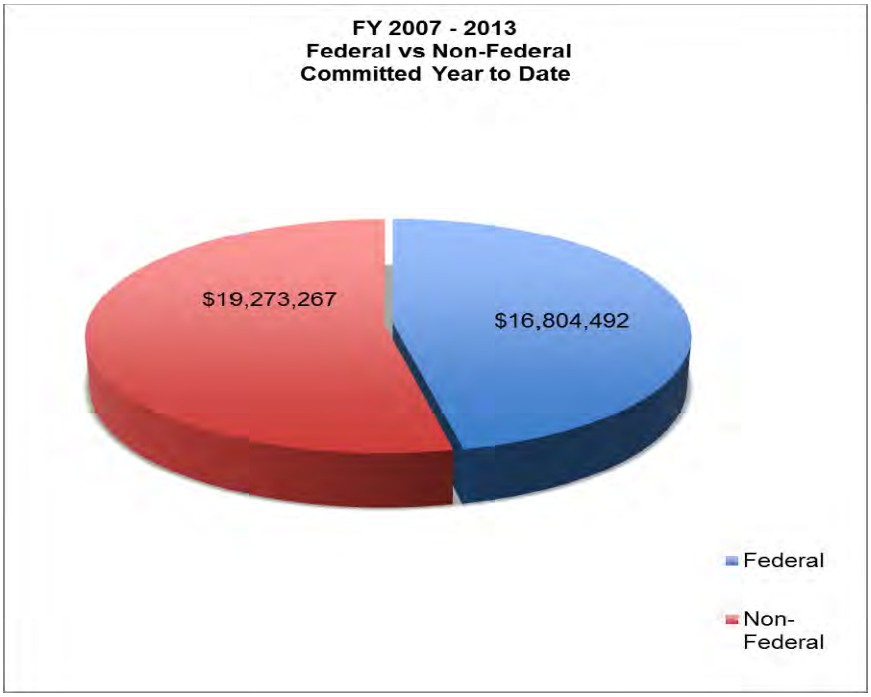
- “S&T Concrete Canoe Team set to sail.” Missouri S&T Public Relations. March 28, 2013.

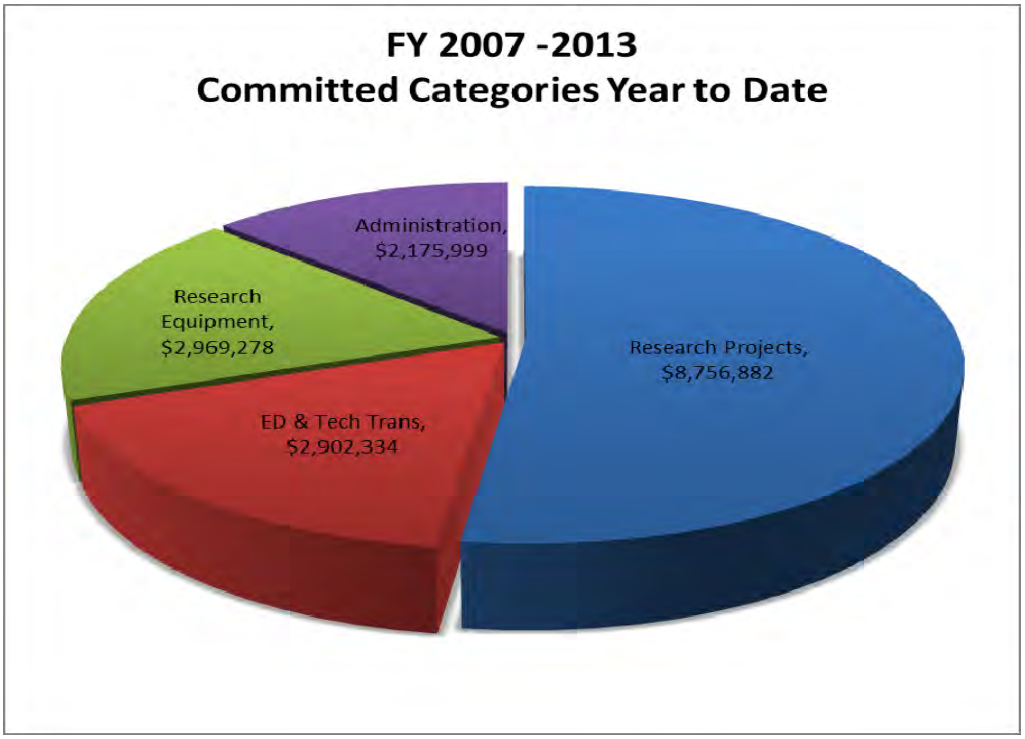
- “S&T professor’s ‘multicopter’ improves structure monitoring.” Missouri S&T Public Relations. May 3, 2013.

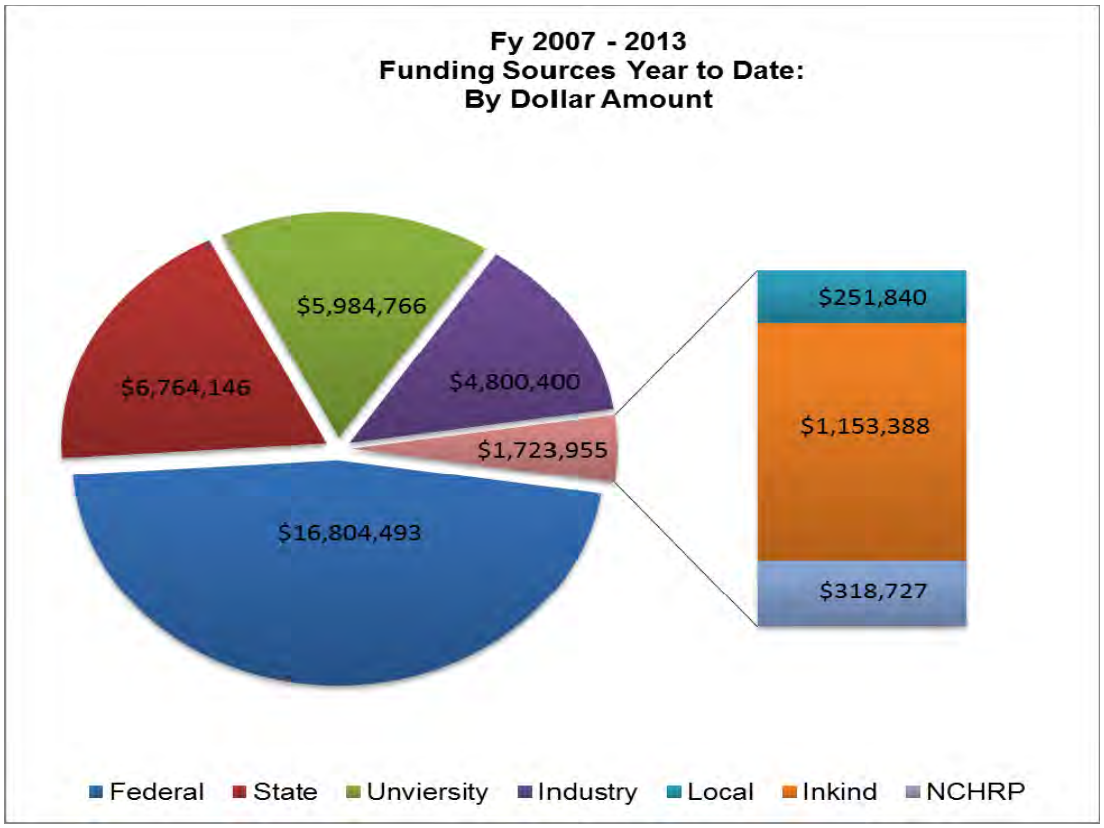
- “S&T students build and compete with racecar.” Missouri S&T Public Relations. May 22, 2013.

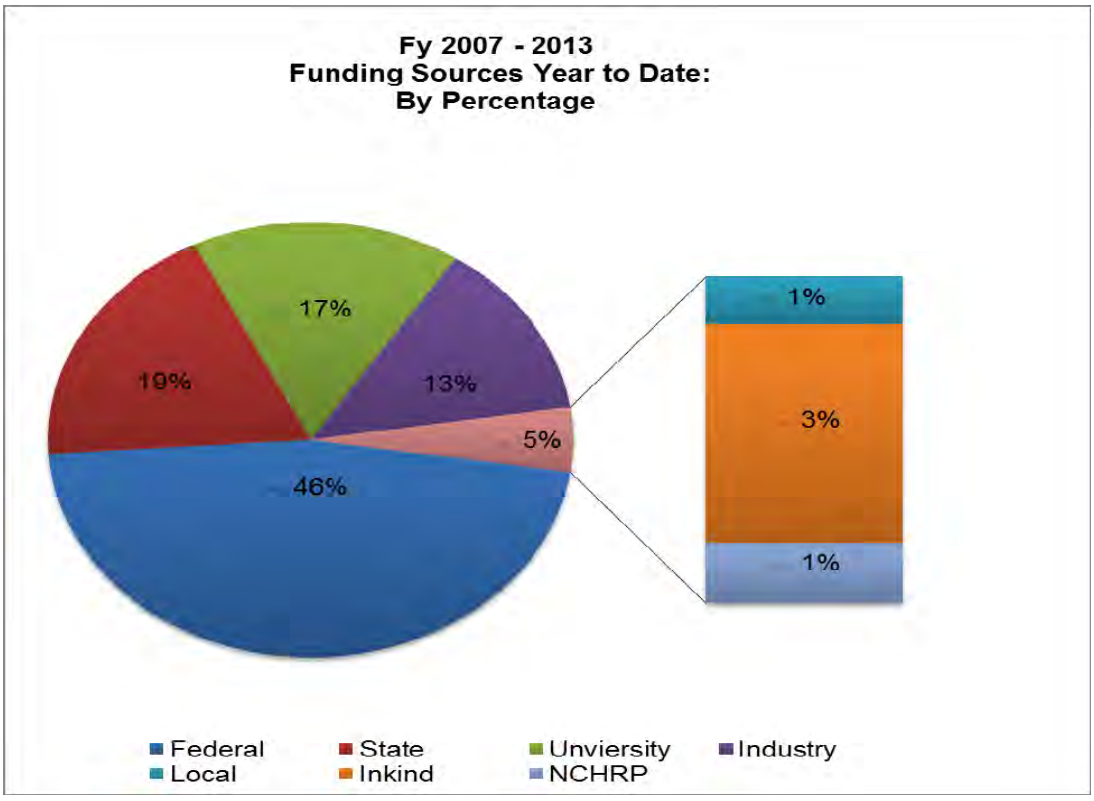
FUNDING SOURCES AND EXPENDITURES

This section provides information on Funding Sources and Expenditures for Years I-VII of the NUTC grant. The following funding charts and tables show committed revenues; expenditure categories; match funding sources; pending project allocations; and funding sources and expenditures for both awarded and pending projects.






Fy 2007 - 2013
Funding Sources Year to Date:
By Dollar Amount
$5,984,766
$6,764,146
$4,800,400
$1,723,955
$16,804,493
$251,840
$1,153,388
$318,727
Federal
State
Unviersity
Industry
Local
Inkind
NCHRP


Fy 2007 - 2013
Funding Sources Year to Date:
By Percentage
17%
19%
13%
5%
46%
1%
3%
1%
Federal
State
Unviersity
Industry
Local
Inkind
NCHRP

Funding Sources and Expenditures				
Amounts and Sources of Funding: July 1, 2006–June 30, 2013				
Seq.	**Non-Federal ***		**UTC**	**Total**
No.	**Source**	**Amount**		
R195	NCHRP-NYSDOT-MS&T CE	$ 157,873	$ 78,936	$ 236,809
ETT196	Industry	$ 394,450	$ 187,500	$ 581,950
R197	NCHRP-MS&T CE	$ 120,000	$ 60,000	$ 180,000
R198	MoDOT-UMC CE	$ 283,162	$ 100,087	$ 383,249
ETT199	MoDOT	$ 200,054	$ 99,537	$ 299,591
R200	General Motors	$ 26,902	$ 13,776	$ 40,678
R201	EPRI	$ 68,980	$ 42,985	$ 111,965
R202	MS&T GS&E	$ 58,087	$ 115,000	$ 173,087
R203	MS&T Depts.	$ 500,000	$ 250,000	$ 750,000
R204	GTI	$ 600,000	$ 250,000	$ 850,000
ETT205	MS&T DCE	$ 19,366	$ 10,000	$ 29,366
RE206	LGA	$ 133,880	$ 66,939	$ 200,819
R207	CDOT	$ 21,960	$ 9,286	$ 31,246
R208	Roesch, Inc	$ 10,000	$ 5,000	$ 15,000
R209	Coreslab Structures	$ 7,746	$ 3,873	$ 11,619
R210	Transystems, Inc.	$ 21,200	$ 10,599	$ 31,799
R211	USB	$ 50,000	$ 24,944	$ 74,944
ETT212	Industry	$ 23,400	$ 7,525	$ 30,925
R213	Ameren	$ 25,000	$ 12,500	$ 37,500
R214	EPRI	$ 68,658	$ 29,330	$ 97,988
ETT215	MS&T VPR	$ 19,115	$ 19,115	$ 38,230
ETT216	Industry	$ 376,790	$ 187,500	$ 564,290
ETT217	Retired	$ -	$ -	$ -
R218	MoDOT	$ 44,813	$ 23,877	$ 68,690
R219	MoDOT	$ 59,279	$ 34,161	$ 93,440
ETT220	MoDOT	$ 211,831	$ 211,885	$ 423,716
R221	SCI Engineering	$ 17,759	$ 11,715	$ 29,474
R222	HNTB Corp.	$ 10,387	$ 5,116	$ 15,503
R223	Lake Sherwood Estates	$ 3,239	$ 2,250	$ 5,489
ETT224	MS&T-VPR	$ 26,102	$ 26,102	$ 52,204
R225	MS&T Departments	$ 1,371,541	$ 900,000	$ 2,271,541
ETT226	Industry	$ 77,125	$ 20,769	$ 97,894

R227	Egyptian Concrete	$ 28,172	$ 14,087	$ 42,259
R228	Ameren	$ 25,000	$ 12,500	$ 37,500
ETT229	MoDOT	$ 35,358	$ 17,679	$ 53,037
R230	NYSERDA	$ 50,000	$ 50,000	$ 100,000
R231	MS&T Departments	$ 500,000	$ 250,000	$ 750,000
R232	ASNT	$ 15,000	$ 7,475	$ 22,475
R233	MoDOT MS&T-CE	$ 121,555	$ 75,972	$ 197,527
R234	MoDOT MS&T-CE	$ 192,069	$ 121,633	$ 313,702
R235	MoDOT MS&T-CE	$ 77,139	$ 48,870	$ 126,009
R236	MoDOT Missouri S&T-CE	$ 361,578	$ 152,981	$ 514,559
R237	MoDOT Missouri S&T-CE	$ 60,216	$ 48,077	$ 108,293
R238	MoDOT UMC-CE	$ 80,033	$ 37,750	$ 117,783
R239	MoDOT UMC-CE	$ 101,265	$ 50,178	$ 151,443
R240	MoDOT UMC-CE	$ 92,883	$ 53,928	$ 146,811
R241	MoDOT UMKC-CE	$ 131,450	$ 35,612	$ 167,062
R242	MoDOT / UMC CE	$ 159,594	$ 35,965	$ 195,559
R243	MoDOT / Missouri S$T CE	$ 143,790	$ 97,406	$ 241,196
R244	MoDOT / Missouri S$T CE	$ 61,132	$ 55,927	$ 117,059
R245	MoDOT / UMC CE	$ 87,409	$ 50,863	$ 138,272
R246	MoDOT / Missouri S&T CE	$ 127,384	$ 91,620	$ 219,004
R247	MoDOT / UMC CE	$ 929,381	$ 43,218	$ 972,599
ETT248	MoDOT	$ 343,240	$ 218,261	$ 561,501
ETT249	MoDOT	$ 30,506	$ 11,438	$ 41,944
R250	City of Rolla	$ 216,840	$ 165,000	$ 381,840
ETT251	Industry	$ 375,750	$ 187,500	$ 563,250
RE252	Spirit Aerosystems	$ 25,000	$ 12,500	$ 37,500
R253	NCHRP/MAPA/MS&T CE	$ 134,228	$ 95,449	$ 229,677
R254	Industry	$ 1,208,409	$ 604,205	$ 1,812,614
R255	USB	$ 49,225	$ 25,000	$ 74,225
R256	KH	$ 2,469	$ 3,500	$ 5,969
R257	CRSI	$ 30,000	$ 15,000	$ 45,000
ETT258	Industry	$ 376,250	$ 187,500	$ 563,750
ETT259	MoDOT	$ 218,289	$ 218,289	$ 436,578
R260	MoDOT	$ 99,978	$ 49,966	$ 149,944
R261	UAF-CE	$ 39,342	$ 20,006	$ 59,347
R262	GEI	$ 3,500	$ 2,400	$ 5,900
R263	USB	$ 50,000	$ 25,000	$ 75,000
R264	MS&T-MRC	$ 15,000	$ 7,500	$ 22,500

R265	MoDOT	$ 120,000	$ 60,000	$ 180,000
R266	EPRI	$ 14,999	$ 7,500	$ 22,499
ETT267	MoDOT	$ 218,120	$ 218,290	$ 436,410
R268	MoDOT	$ 99,986	$ 50,000	$ 149,986
R269	MoDOT	$ 74,008	$ 37,195	$ 111,203
R270	MoDOT	$ 60,000	$ 30,000	$ 90,000
R271	MoDOT UMC-CE	$ 78,066	$ 20,000	$ 98,066
R272	MoDOT	$ 48,173	$ 23,057	$ 71,230
R273	MoDOT	$ 80,000	$ 40,000	$ 120,000
R274	UM-RB	$ 25,800	$ 12,899	$ 38,699
R275	MoDOT/WCM	$ 140,001	$ 112,500	$ 252,501
R276	PCI	$ 20,000	$ 10,000	$ 30,000
R277	PCI	$ 20,000	$ 10,000	$ 30,000
R278	GEI	$ 10,115	$ 5,000	$ 15,115
ETT279	Industry	$ 207,335	$ 93,085	$ 300,420
ETT280	Industry	$ 239,000	$ 99,501	$ 338,501
R281	MoDOT	$ 59,425	$ 39,500	$ 98,925
R282	MoDOT	$ 46,995	$ 31,238	$ 78,233
R283	GEI	$ 3,333	$ 1,667	$ 5,000
R284	Ameren	$ 20,000	$ 10,000	$ 30,000
R285	EPRI	$ 125,001	$ 79,206	$ 204,207
R286	MS&T-MRC	$ 15,000	$ 7,500	$ 22,500
R287	AHDT	$ 5,000	$ 2,171	$ 7,171
R288	MS&T-CE	$ 8,353	$ 8,353	$ 16,706
R289	MS&T-CE	$ 8,353	$ 8,353	$ 16,706
ETT290	MS&T/Industry	$ 199,000	$ 99,500	$ 298,500
ETT291	MoDOT	$ 218,288	$ 218,288	$ 436,576
R292	MS&T-GS&E	$ 8,353	$ 8,353	$ 16,706
R293	MoDOT	$ 120,000	$ 60,000	$ 180,000
ETT294	MS&T/Industry	$ 147,154	$ 97,600	$ 244,754
R295	MoDOT	$ 140,409	$ 140,000	$ 280,409
R296	Bell Helicopter	$ 50,000	$ 50,000	$ 100,000
R297	MS&T-Geo	$ 27,708	$ 13,921	$ 41,629
R298	CalTrans	$ 65,854	$ 65,853	$ 131,707
RE299	MS&T-CIES	$ 139,230	$ 2,285,634	$ 2,424,864
R300	MoDOT/MS&T-CE/UMC	$ 873,769	$ 500,000	$ 1,373,769
R301	MS&T-CE	$ 13,281	$ 13,281	$ 26,562
R302	MS&T-CE	$ 13,281	$ 13,281	$ 26,562

R303	MS&T-CompSci/RB	$ 26,562	$ 26,562	$ 53,124
R304	MS&T-CE	$ 12,889	$ 13,281	$ 26,170
R305	MS&T-CE	$ 13,281	$ 13,281	$ 26,562
R306	MS&T-CE	$ 13,281	$ 13,281	$ 26,562
R307	ISU	$ 49,966	$ 24,983	$ 74,949
R308	MS&T-CE	$ 13,281	$ 13,281	$ 26,562
R309	MS&T-CE	$ 13,282	$ 13,281	$ 26,563
R310	MS&T-CE	$ 13,281	$ 13,281	$ 26,562
R311	MoDOT	$ 48,089	$ 48,089	$ 96,178
R312	MoDOT	$ 130,000	$ 130,000	$ 260,000
R313	MS&T-OSP	$ 1,975	$ 1,975	$ 3,950
ETT314	MS&T-CE	$ 12,154	$ 10,000	$ 22,154
R315	MoDOT/MS&T-CE	$ 129,809	$ 129,809	$ 259,618
R316	NCHRP	$ 29,260	$ 52,511	$ 81,771
R317	PCI	$ -	$ 10,000	$ 10,000
R318	MS&T-CE	$ 100,954	$ 100,954	$ 201,908
R319	PCI	$ -	$ 10,000	$ 10,000
R320	ICA	$ 140,000	$ 140,000	$ 280,000
R321	ICA	$ 120,000	$ 120,000	$ 240,000
R322	ICA	$ 110,000	$ 110,000	$ 220,000
R232	MS&T-EngMgt	$ 177,193	$ 177,193	$ 354,386
ETT324	MoDOT	$ 218,288	$ 218,288	$ 436,576
ETT325	Industry	$ 197,518	$ 195,200	$ 392,718
R326	NDOT - UNLV	$ 107,937	$ 107,937	$ 215,874
R327	Ameren	$ 20,000	$ 20,000	$ 40,000
R328	NDOR - UNL	$ 149,778	$ 149,778	$ 299,556
R329	MS&T - Geo	$ 23,178	$ 23,178	$ 46,356
R330	NDDOT - NDSU	$ 429,260	$ 429,260	$ 858,520
R331	MS&T - Geo	$ 33,485	$ 28,547	$ 62,032
R332	MoDOT	$ 265,000	$ 265,000	$ 530,000
R333	MS&T - CE - GU	$ 123,476	$ 123,415	$ 246,891
R334	MoDOT	$ 5,000	$ 2,500	$ 7,500
R335	MS&T - Geo	$ 77,580	$ 77,580	$ 155,160
R336	ODOT - OSU	$ 187,618	$ 187,618	$ 375,236
R337	NDOT - UNLV	$ 117,263	$ 117,263	$ 234,526
R338	MS&T - Geo	$ 17,000	$ 11,099	$ 28,099
R339	MS&T - CE	$ 16,057	$ 16,052	$ 32,109
R340	MS&T - CompSci	$ 16,052	$ 16,052	$ 32,104

R341	MS&T - ECE	$ 16,052	$ 16,052	$ 32,104
R342	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R343	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R344	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R345	MS&T - MAE	$ 16,054	$ 16,052	$ 32,106
R346	MS&T - ECE	$ 16,054	$ 16,052	$ 32,106
R347	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R348	MS&T - ECE	$ 11,099	$ 11,099	$ 22,198
R349	MS&T - CE	$ 12,539	$ 12,539	$ 25,078
R350	MS&T - Geo	$ 9,450	$ 9,450	$ 18,900
R351	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R352	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R353	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R354	MS&T - CE	$ 23,203	$ 23,203	$ 46,406
ETT355	AMAE - MSC	$ 22,453	$ 22,417	$ 44,870
R356	UAF-CE	$ 56,205	$ 56,203	$ 112,408
R357	FYFE	$ 28,590	$ 28,590	$ 57,180
R358	UM - RB	$ 10,197	$ 10,197	$ 20,394
R359	UM - RB	$ 9,483	$ 9,483	$ 18,966
R360	MS&T - ECE	$ 35,924	$ 35,925	$ 71,849
R361	MS&T- CIES	$ -	$ 102,156	$ 102,156
ETT362	MS&T - CIES	$ -	$ 19,565	$ 19,565
R363	MoDOT	$ 220,713	$ 220,713	$ 441,426
R364	MS&T - Geo	$ 11,237	$ 11,237	$ 22,474
R365	MS&T-EngMgt	$ 22,858	$ 22,858	$ 45,716
R366	TxDOT - UT Austin	$ 105,523	$ 105,523	$ 211,046
R367	MS&T-Geo	$ 3,000	$ 3,000	$ 6,000
Facilities & Admin. Indirect Costs			$ 2,175,999	$ 2,175,999
TOTAL		**$ 19,273,267**	**$ 16,804,493**	**$ 36,077,760**

Legend:

AHDT=Arkansas State Highway and Transportation Department

AMAE - MSC = American Mechanical and Aerospace Engineers - MSC Software and Dassault Systems

CDOT=California Department of Transportation

CRSI= Concrete Reinforcing Steel Institute

EPRI=Electrical Power Research Institute

FMSME=Fuller, Mossberger, Scott & May Engineering

FYFE = FYFE Company

GEI=GeoEngineers Inc.
GTI=Gas Technology Institute

Industry = Women's leadership institute - Women in Eng. Development Fund - AT&T Minority Scholarships - Ford Scholarships - Boeing Scholarships - Halliburton Scholarships - Pre-College Programs

IRC - Icelandic Road Association

ISU=Iowa State University

KH=Knight Hawk

LGA=Leica Geosystems Advantage

MODOT = Missouri Department of Transportation

MODOT/WCM = Missouri Department of Transportation & Washington County Missouri

MS&T DCE = Missouri University of Science & Technology-Distance & Cont. Education

MS&T GS&E = Missouri University of Science & Technology-Geological Science & Engr

MS&T-CE= Missouri University of Science and Technology-Civil Engineering

MS&T-CompSci = Missouri University of Science and Technology-Computer Science

MS&T-ECE = Missouri University of Science and Technology-Electrical & Computer Engr

MS&T-EngMgt = Missouri University of Science and Technology-Engineering Management

MS&T -CE - UG = Missouri S&T - Civil Engineering - Ghent University

MS&T ME = Missouri University of Science & Technology-Mining Engineering

MS&T MRC = Missouri University of Science & Technology-Materials Research Center

MS&T MAE = Missouri University of Science & Technology - Mechanical & Aerospace Engr

MS&T-VPR= Missouri University of Science and Technology-Vice Provost of Research

NCHRP = National Cooperative Highway Research Program

NDDOT- NDSU = North Dakota Department of Transportation - North Dakota State University

NDOT- UNLV = Nevada Department of Transportation - University of Nevada, Las Vegas

NDOR- UNL = Nebraska Department of Roads - University of Nebraska-Lincoln

NYSDOT=N**e**w York State Depart. of Transportation

NYSERDA= New York State Energy Research and Development Authority

ODOT - OSU = Oklahoma Department of Transportation - Oklahoma State University

PCI=Precast Concrete Institute

UAF-CE =University of Arkansas, Fayette-Civil Engineering

UM-RB =University of Missouri-Research Board

UMC-CE =University of Missouri-Columbia Civil Engineering

UMKC-CE=University of Missouri Kansas City-Civil Engineering

UNR=University of Nevada-Reno

TxDOT - UT Austin = Texas Department of Transportation - University of Texas at Austin-CE

USB=United Soybean Board

APPENDIX: SUCCESS STORIES CLIPS

Featured Articles in the NUTC News / The Bridge Newsletters (see next page)

FEATURED PROJECT:

Bridge Design, Test, and Construction on Arnault Branch, Washington County, Missouri

– Genda Chen, Professor, Department of Civil, Architectural and Environmental Engineering, Missouri S&T

Figure 1. Complete three-span bridge over Arnault Branch, Washington County, MO

Existing Structure

The old overpass located on Pat Daly Road over Arnault Branch, Washington County, MO, consisted of an unreinforced concrete slab-on-ground structure with two corrugated steel pipes running parallel through the concrete underneath the roadway as water passages. The slab-on-ground was structurally and functionally inadequate, and posed a real safety issue when water passed over the structure during flood seasons.

New Bridge with Innovative Uses of Materials

In collaboration with Great River Associates (GRA), Springfield, MO, Missouri University of Science and Technology (Missouri S&T) proposed to replace the slab-on-ground overpass with a rapidly constructed and durable, three-span bridge with precast concrete slabs and girders reinforced with glass fiber reinforced polymers (GFRP) and cast-in-place cladding steel reinforced concrete substructure, striving for high corrosion resistance and durability of the bridge structure. As illustrated in Fig. 2(a), the proposed bridge was constructed by crews from Washington County, MO, with a total engineering and construction cost of approximately $340,000. The post-tensioning of carbon fiber reinforced polymer (CFRP) bars was completed by Missouri S&T led by Mr. Jason Cox as shown in Fig. 2(b). On August 20, 2012, the completed bridge as shown in Fig. 1 was visually inspected by a team (see Fig. 3) of Dr. Genda Chen (Principal Investigator of the project from Missouri S&T), Mr. Steve Brown and Mr. Darrel

- Continued Next Page -

Whitman (engineering and construction management from GRA), Mr. Marvin Wright and Mr. Todd Moyers (Washington County Commissioners), and Mr. Dennis Krenning (bridge engineering and inspection from Missouri Department of Transportation).

(a) Lift and placement of precast panel

(b) Post tensioning of CFRP bars

Figure 2. Bridge construction and post-tensioning of carbon fiber reinforced polymer (CFRP) bars

Figure 3. Visual inspection of the completed bridge on August 20, 2012
(from left to right: Todd Moyers, Genda Chen, Dennis Krenning, Darrel Whitman, Steve Brown, and Marvin Wright)

Bridge Structure and Design

To ensure that the validated technologies in this project can be applied into both new construction and the deck replacement of existing bridges, one conventional concrete-girder span, one conventional steel-girder span, and one innovative concrete box-girder span were considered for the bridge structure. Their performance can be compared over the time. The conventional girder structures provide good benchmarks for the box-girder design of the bridge superstructure. Each span of the bridge was 21 ft wide and 27 ft long, totaling 81 ft in length of the entire bridge.

- Continued Next Page -

Specifically, the **Innovative Strategies for Bridge Design and Accelerated Construction** included:

Span 1 – Precast GFRP-reinforced concrete panels on steel girders

The bridge deck was composed of three precast panels that were supported on five steel girders and post tensioned longitudinally at the bridge site. The idea of using GFRP as flexural and shear reinforcement would be implemented with relevant implications from both the structural and constructability standpoints. This type of construction will allow a fair comparison with conventional steel girder bridges that have been widely used in the Central and Eastern United States. The field validated technology will have a long-lasting value for the future deck replacement projects of existing bridges.

Span 2 – Precast GFRP-reinforced concrete box girders

This span had four precast box girders, each reinforced with GFRP bars and simply supported on piers at both ends. The box girders were transversely post-tensioned at the bridge site to close the longitudinal joints between them. This span represents a new application of GFRP bars in the design of precast box girders. In this way, no additional bridge deck needs to be cast at the bridge site and no separate bridge panels need to be cast at precast yards. The end product enables the accelerated construction of short-span bridge.

Span 3 – Precast GFRP-reinforced concrete panels on concrete girders

The purpose of this span was to allow for comparison among various design requirements associated with different types of girders and with different specifications. In addition, this span also gave insight on how GFRP-reinforced concrete panels work with conventional concrete girders for future deck replacement projects of existing concrete bridges from both constructability and long-term performance of the rehabilitated structures.

Substructure

The substructure was constructed using high grade MMFX steel. The current focus for MMFX's core technology is uncoated steel that has a microstructure fundamentally different from conventional steel. Steel made using MMFX nanotechnology does not form microgalvanic cells (the driving force behind corrosion). The use of MMFX steel in the substructure will allow for a nearly complete non-corrosive system for the bridge structure.

The bridge deck was finished with approximately 3 in. asphalt overlay as seen in Figure 2. The bridge was also instrumented with embedded sensors to monitor the strain at critical locations during load testing. Drs. Genda Chen (PI) and Sahra Sedighsarvestani (Co-PI) will continue to monitor the performance of the bridge in the following years.

- Continued Next Page -

Design Validation with Laboratory Testing of Full-Size Bridge Components

As shown in Fig. 4(a), a full-size, 27-ft long and 5-ft wide box girder with GFRP reinforcement was tested on February 23, 2012, in the Highbay Structures Laboratory at Missouri S&T to ensure that the innovative box girder behave as designed prior to field constructions. Similarly, a 9-ft long and 21 ft wide concrete panel reinforced with GFRP bars was tested in the laboratory as shown in Fig. 4(b). The load capacities of both the tested bridge panel and the tested box girder exceeded their respective design values. Test results successfully validated the original design.

(a) Testing of a full-size concrete box girder

(b) Working team for laboratory tests

Figure 4. Laboratory validation of a full-size GFRP reinforced concrete box girder

Acknowledgements

Financial support for this project was provided in part by the USDOT Innovative Bridge Research and Construction (IBRC) Program, by Washington County, MO, and by the Center for Transportation Infrastructure and Safety at Missouri S&T. Thanks are due to Hughes Brother, NE, for providing their engineering assistances related to the design and construction of GFRP/CFRP components.

Minority Intro to Technology & Engineering (MITE)

June 5-10, 2012 and
June 19-24, 2012

MITE was an on-campus week long summer program for traditionally under-represented minority students. Campers will participate in one- to two-hour sessions covering the work performed in the different fields of engineering. They include both experimental and applied work. In addition, orientation sessions were held to discuss admission requirements and procedures; how to apply for scholarships and other forms of financial aid; student government and social organizations, and other campus resources.

Bridge Span Contest

FEATURED PROJECT:
LED Roadway Luminaires Evaluation

- Suzanna Long, Assistant Professor of Engineering Management & Systems Engineering, Missouri S&T

Nationally, there is considerable interest in moving to the use of light-emitting diode (LED) roadway luminaires. This sustainable solution, much like the LED traffic signal indication solution implemented over the past 10 plus years, provides the following benefits:

- Longer life roadway luminaires
- Low energy cost
- Reduced maintenance and operation costs
- Less impact to the environment

This evaluation was funded by the Missouri Department of Transportation (under TRyy1101) and the Mid-America Transportation Center and aimed to provide transportation agencies the data required to make an informed decision on whether or not they should pursue the transition from their current standard (high pressure sodium (HPS)) to LED roadway luminaires.

LED roadway luminaires research and development has lagged behind the proven LED signal indicator technology for various reasons; however, over the past several years the LED roadway luminaire industry has invested significant research and development efforts in producing a quality product that is very comparable to HPS roadway luminaires.

Figure 1 below shows the cost comparison between the three different HPS luminaires currently used by MoDOT and their equivalent counterpart LED luminaires. For the most part, they are very close in annual cost when evaluated over the expected 12-year LED luminaire life (based on a 50,000 hour LED luminaire life expectancy with an annual usage rate of 4000 hours).

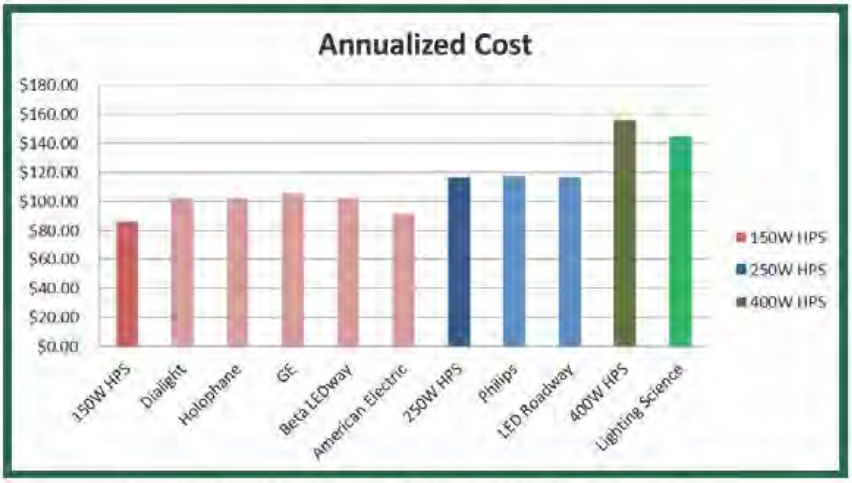


Figure 1. Annualized Cost of HPS Equivalent LED Luminaires

- Continued Next Page -

Two potential variables not calculated in the annual cost were discount pricing for large annual acquisition (i.e. 2000 luminaires per year for 10-year replacement program) and the potential reduction in price experienced as the economy of manufacturing (or economy of scale) is achieved. For example, based on increased demand, LED traffic signal indicators experienced a 40% to 50% reduction in initial cost.

Although only select LED luminaires are a break even solution when compared to HPS (see Figure 1), LED technology is changing rapidly and additional products are expected to offer cost effective solutions in the near future.

The following are other factors that should also be considered in determining future direction for roadway lighting:

- **Maintenance Cost** - labor and equipment costs are major components under the HPS luminaire scenario. There are four HPS installation/maintenance responses required compared to one for the LED luminaire scenario over the 12-year life expectancy for LED luminaires. Based on a comprehensive literature research of national evaluations, a three-year life expectancy for HPS was predominately used.

- **Safety** – workers and roadway users will experience less exposure to maintenance activities along major corridors with LED luminaires.

- **Demand** - the national interest by the Department of Energy (DOE), other local and state agencies and the lighting industry demonstrates a strong trend towards LED roadway luminaires and away from HPS roadway luminaires.

- **Previous technology transition** - in the 1980's, a similar transition from mercury vapor roadway luminaires to HPS roadway luminaires was made. This transition was completed over a ten year period and was implemented due to power cost savings (luminaire's cost and lifecycle were about the same) and concerns with the disposal of mercury, a hazardous material.

Two prevailing issues surfaced in our evaluation – cost effectiveness and performance. Based on previous trends in LED technologies, the LED roadway luminaires should experience a reduction in cost based on the economy of increased manufacturing. This fact will make LED roadway luminaires a more cost effective solution.

Performance was a major issue in early development of LED roadway luminaires. Most manufacturers invested in product development to ensure that LED roadway luminaires performed at similar or higher performance levels as the HPS roadway luminaires. These initial investments were focused at 30 foot mounting height luminaires and have in the recent past moved towards mounting heights of 40 feet or higher. Based on factors mentioned above and information contained in this report, the study concluded that the transition from HPS to LED roadway luminaires should be delayed until both cost and performance stabilizes.

NOTE: This project was selected as the AASHTO Midwest Region High Value Research Project of the Year and was named one of the "Sweet 16" National High Value Research Projects by AASHTO.

Upcoming Outreach Programs:

Fall ¡Si, Se Puede!

November 9-12, 2012

Society of Professional Hispanic Professionals annually coordinates ¡Si Se Puede! This helps students to explore the career options Missouri S&T has to offer and gives them an inside look at real college life. It is an on-campus visit program for Hispanic and Latino students to explore a future career in math and science.

Society of Hispanic Professional Engineers National Conference

November 14-18th, 2012

With over 10,000 students attending the event each year it is an excellent opportunity to recruit minority students at both the undergraduate and graduate levels. The goal is designed to increase the awareness, participation, and excitement surrounding graduate school and the pursuit of higher education.

Fall Conference Series

Transportation Infrastructure Conference

S&T held its first Transportation Infrastructure Conference in September. The conference was hosted by the Center for Transportation Infrastructure and Safety (CTIS) and the Center for Infrastructure Engineering Studies (CIES).

Four prominent civil engineers from the U.S., Canada and Europe served as keynote speakers. They discussed cutting-edge technologies related to the research themes of the centers, as well as the value of research to the transportation industry. This year's inaugural conference showcased recent findings of projects supported by the CTIS in the areas of advanced construction materials, non-destructive testing and structural health monitoring of transportation infrastructure. The event hosted 90 participants and included a tour of S&T's outstanding research facilities.

"We hope that this technology transfer event will grow in the future to foster further exchange between S&T researchers, industry and government agencies with the ultimate goal of building S&T's recognition at the national level in the area of transportation infrastructure engineering," says conference chairman **Kamal H. Khayat**, the Vernon and Maralee Jones Endowed Professor of Civil Engineering and the Director of the Center for Infrastructure Engineering Studies at Missouri S&T. "This conference series will be held every Fall and will rotate locations on each of our sister campuses."

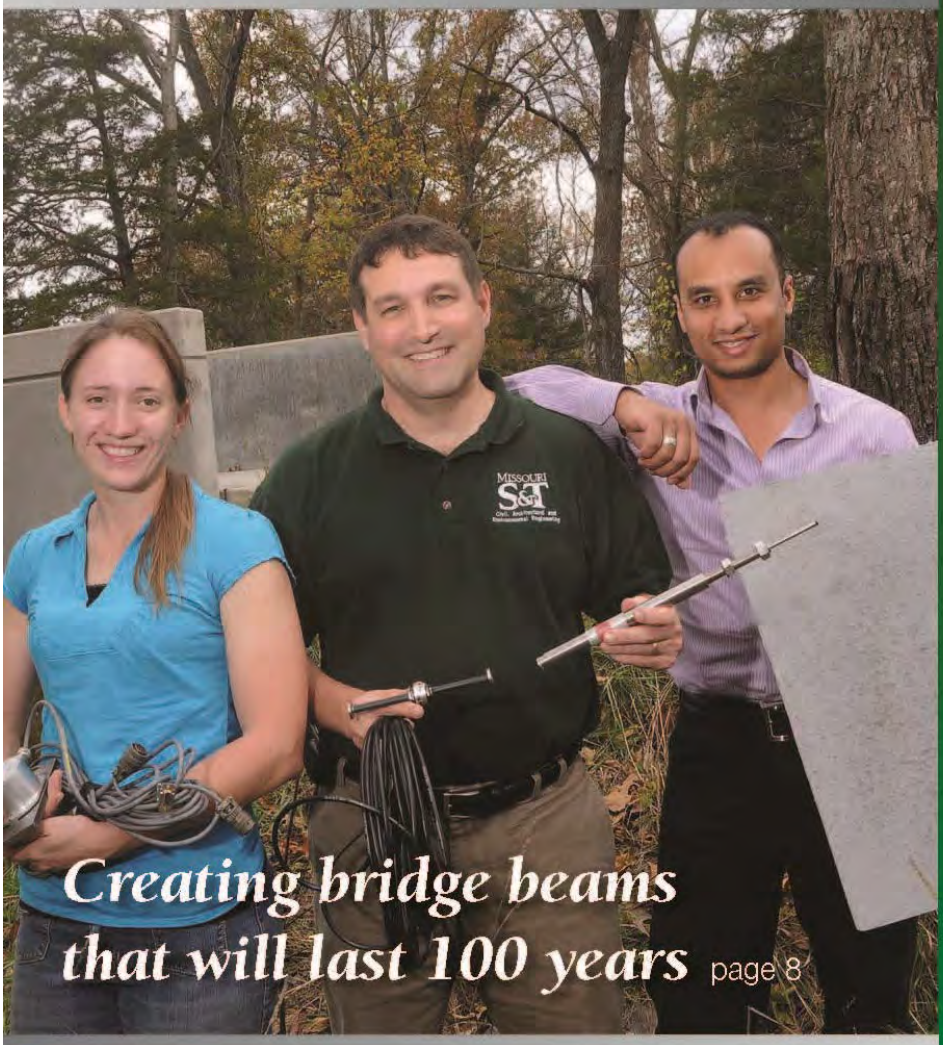
If you'd like to be a part of the next conference, please contact Khayat at 573-341-6223 or email khayatk@mst.edu.

The BRIDGE

Civil, Architectural and Environmental Engineering

Winter 2012 | Vol. 29

MISSOURI S&T



Creating bridge beams that will last 100 years page 8

Great school, great price
page 5

Recruiting technical minds
page 18

Combatting obesity, diabetes
page 20

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

ANCIENT STRUCTURAL ELEMENT LEADS TO NEW IDEAS IN BRIDGE BUILDING

Douglas County Bridge in Missouri
Photo submitted

BY MINDY LIMBACK

Researchers are ***bridging a gap*** between an ancient structural element and modern technology.

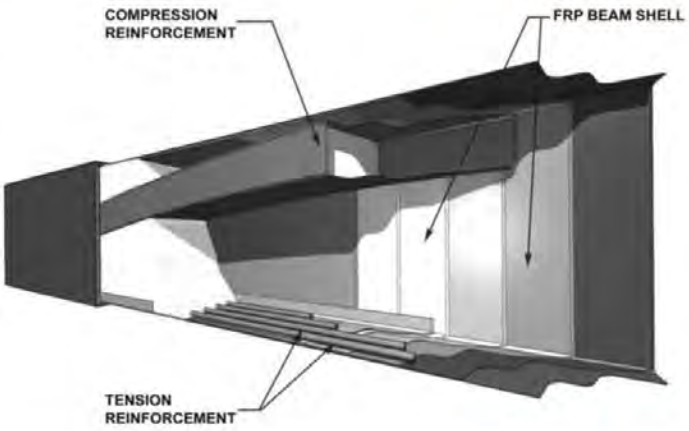
Structures professor John Myers pictured with graduate students Renee Earley and Mohamed Aboel Seoud.

Led by **John Myers**, S&T researchers are working with designers at HC Bridge Co. to combine an ancient concrete arch form — dating back to the Roman empire — with a composite shell to create bridge beams that are designed to last 100 years. Tucked inside durable, fiberglass composite shells, the lightweight beams are supported by a concrete arch and anchored by seven wire tendons, which serve as the system's tension tie.

"The composite shell protects the system from the elements, extending its service life and reducing the maintenance expenses that might normally be needed in a traditional bridge girder," says Myers, associate professor of civil, architectural and environmental engineering at Missouri S&T. "It also serves as a formwork for the construction of the concrete arch system."

The system uses a high-performance concrete, known as self-consolidating concrete, which can flow easily into tight and constricted spaces without needing vibration to remove trapped air or allowing the coarse aggregate to separate from the cement paste.

Illustration submitted



Tucked inside durable, fiberglass composite shells, the lightweight beams are supported by a concrete arch and anchored by seven wire tendons, which serve as the system's tension tie.

Using advanced concrete materials and composites for bridges and other infrastructure applications has been a key focus for Myers, who was recently appointed to serve a three-year term on the Federal Highway Administration's Long-Term Bridge Performance Program Expert Task Group Advisory Committee.

At the end of the project, the three new bridges will be located in Douglas, Dade and Reynolds counties. The bridges will be funded in part by the Missouri Department

(continued on the next page)

The Douglas County bridge, which opened to traffic in December 2011, carries Highway 76 over Beaver Creek just outside Jackson Mill.

The ***closed loop structural tied arch system*** housed in a composite shell will extend the expected service life to 100 years.

of Transportation's Safe and Sound bridge program, which is currently replacing or rehabilitating more than 800 of the state's poorest bridges.

Habor Technologies in Maine was commissioned to manufacture the composite shell and housing for the beams. Myers says the technology is flexible enough to allow for the arch's self-consolidating concrete to be poured either at a precast facility or at the job site directly.

"Quality control is often better at a precast facility since the concrete is batched in a very close proximity to the beam," Myers says. "It's also often more cost-effective to pour at that type of facility because these bridges are in a rural part of the state."

The first two bridge beams were cast at a ready-mix plant in Mountain Grove, Mo., and a precast plant in Virginia, respectively. The final bridge involved placing concrete at the job site after the beams are erected into place. "In all cases, lower capacity cranes can set them in place because it's a lighter weight, more efficient structural system," Myers adds.

Myers and S&T graduate students **Renee Earley** and **Mohamed Aboel Seoud** are working on the project with Glenn Washer, associate professor of civil and environmental engineering at the University of Missouri-Columbia.

Project Summary:

FIRST BRIDGE
Bridge B0439 in Douglas County is located on Missouri Highway 76 over Beaver Creek.
(completed Dec. 2011)

SECOND BRIDGE
Bridge B0410 in Dade County is located on Missouri Highway 97 over Sons Creek. This bridge is instrumented with structural health monitoring sensors.
(completed Sept. 2012)

THIRD BRIDGE
Bridge B0478 in Reynolds County is located on Missouri Highway 49 over Ottery Creek Overflow.
(completed Aug. 2012)

Initial load testing of MoDot HCB Bridge B0439 in Douglas County, Missouri.

Laufer Chair leads Missouri S&T energy center

Joseph Smith

Wayne Laufer

Joseph Smith, the Laufer Chair of Energy at Missouri S&T, became director of S&T's Energy Research and Development Center (ERDC) on Sept. 1.

Smith is the first person to hold The Wayne and Gayle Laufer Endowed Chair in Energy. The position was established through a 2009 gift of $3.4 million from **Wayne Laufer**, CE'67, and his wife, Gayle.

Laufer, who spent his career in the energy industry, is the retired co-founder and CEO of Bois d'Arc Energy Inc., an NYSE Houston-based company that specialized in offshore oil and natural gas exploration and production. Laufer retired from Bois d'Arc executive management in November 2007 but remained active on the board of directors until the company was sold to Stone Energy Corp. for $1.6 billion in August 2008.

As director of the ERDC, Smith will be responsible for coordinating and leading various energy-related research activities. Approximately 35 S&T faculty members are involved in energy-related research. Their expertise includes coal, nuclear energy, and petroleum and natural gas; energy transportation, transmission and distribution; electric power generation and delivery efficiency; alternative and renewable energy sources; energy conservation and efficiency; and the environmental aspects of generation, transport and consumption of energy resources.

"Energy security is our generation's grand challenge," Smith says. "Wars have been fought over energy and our nation's future will be defined by how we address our growing energy needs. Finding and using economically and environmentally sustainable energy is essential to supporting the economy and minimizing our impact on the environment. I am excited for the focus this position provides to address our grand challenge."

ElGawady joins the department

We are happy to announce that **Mohamed ElGawady** has joined the department of civil, architectural and environmental engineering at Missouri S&T as an associate professor this fall.

ElGawady earned his Ph.D. in structural engineering from the Swiss Federal Institute of Technology at Lausanne (EPFL) in 2004. Previously, he earned a bachelor of science with honors in civil engineering, as well as a master of science in structural engineering, from Cairo University in Egypt. He has held positions at University of South Australia, Tokyo Institute of Technology, Washington State University and University of Auckland. He also worked in industry as a structural engineer for three years.

ElGawady's research encompasses seismic behavior of masonry and concrete structures. He is involved in developing modern building codes for earthquake-resistant masonry structures. He has authored and co-authored 60 refereed journal and conference papers, as well as technical reports.

His current research interests include: seismic behavior of unreinforced masonry (URM) structures, the application of Fiber Reinforced Polymers (FRP) in strengthening and repair of masonry/reinforced concrete structures, seismic behavior of reinforced concrete bridges, damage-free bridge columns,

Mohamed ElGawady

segmental construction, rocking mechanics and the use of sustainable materials in seismic prone regions.

Keynote speaker Kamal Khayat

Khayat delivers IBRACON keynote

In October, Kamal Khayat presented the keynote address at the 54th IBRACON Brazilian Concrete Conference held in Maceió, Alagoas-Brazil. This is one of Brazil's largest technical forums to discuss emerging concrete technologies and construction techniques. During the conference, participants celebrated 40 years of IBRACON's service to the concrete industry.

Khayat addressed an audience of over 800 during the plenary session with his talk titled, "Evaluation of Thixotropy of Self-Consolidating Concrete and the Influence of Thixotropy on Material Performance." He also gave presentations at the first Latin American Symposium on Self-Compacting Concrete and the 2nd Symposium on Subway, Railway and Highway Infrastructure.

"It was a great honor to take part in this major event. It was an excellent opportunity for me to foster international collaborations for Missouri S&T with various research institutes from Brazil," says Khayat.

To learn more about IBRACON, Brazilian Concrete Institute, visit their website at http://www.ibracon.org.br/.

Burken **brings together** academic leaders

Joel Burken, professor and associate chair of civil, architectural and environmental engineering at Missouri S&T, is leading a new effort to bring academic leaders in environmental engineering together on an annual basis to improve education in universities nationwide.

He served as chair for the Environmental Engineering Department and Program Chairs Conference that was held in July at The Ohio State University. The conference is sponsored by the Association of Environmental Engineering and Science Professors (AAESP) and the American Academy of Environmental Engineers (AAEE).

Burken is president of AAESP, an association of roughly 900 professors in the U.S. and abroad. The conference theme — "Preparing the Future Stewards of Our Planet" — underscored the mission of both organizations to recruit and educate more prospective college students into the environmental engineering field. The meeting was supported with a grant from the National Science Foundation (NSF) to Missouri S&T.

"Environmental engineering is rapidly expanding in scale and in professional scope as we face many new challenges in protecting human health and the environment around us," says Burken. "This conference and continuing efforts will focus on establishing a continuing communications platform among the leaders in academia to address the needs of educating and training those entering the environmental engineering profession."

"The number of undergraduate programs has expanded greatly, going from fewer than 10 in 1995 to over 50 in 2007," Burken says. "We have roughly 50 leaders registered for the conference, representing most of the programs in the country."

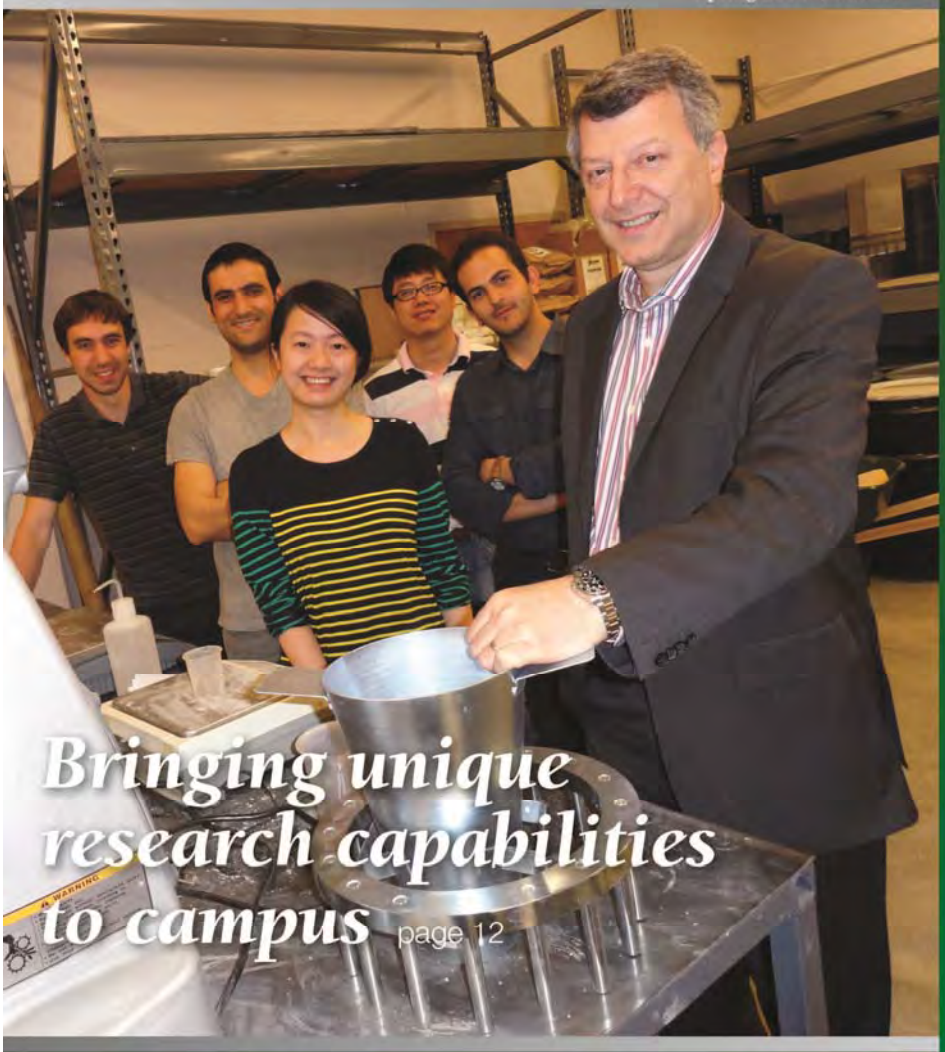
Burken and his co-organizers plan to hold the conference annually, with next year's meeting scheduled to be held in Golden, Colo.

The BRIDGE

Civil, Architectural and Environmental Engineering

Spring 2013 | Vol. 30

MISSOURI S&T



Bringing unique research capabilities to campus

page 12

From trash into treasure...
page 4

Improving wellness...
page 16

Raising the roof...
page 20

MISSOURI UNIVERSITY OF SCIENCE AND TECHNOLOGY

Advanced materials research REACHES NEW HEIGHTS

The year 2012 marked a year of significant change in the Center for Infrastructure Engineering Studies (CIES) at S&T. Under the new leadership of **Kamal Khayat**, the center has been re-vitalized with the acquisition of new equipment and the rennovating of existing facilities to bring unique research capabilities to campus. The center is evolving at full speed with the vision of becoming a focal point for infrastructure material research in the national arena.

Pictured from left to right: Mahdi Valipour, Weina Meng, Iman Mehdipour, Joel Mauger, Kamal Khayat and Qi Cao.

Over the past year, the CIES staff have undertaken a labor-intensive effort to transform the previously under-utilized laboratory space in the basement of the Engineering Research Laboratory into a new Advanced Construction Materials Laboratory. The area has been cleaned out, repainted and re-organized in order to utilize this space to its fullest potential. A new gutter system was installed for a concrete mixing area, and a clean room was created to house several pieces of dust-sensitive specialized equipment.

This new laboratory will enable the development, manufacturing and implementation of innovative and sustainable materials for civil infrastructure, with an emphasis on cement-based materials. Examples of the type of studies this facility will allow include: projects on the design and performance of a number of innovative materials, including self-consolidating concrete (SCC) for bridge elements, high volume fly ash concrete (HVFAC) for infrastructure construction, and roller compacted concrete (RCC) for rigid concrete pavement for highways, rural roads and airfield pavements.

In May 2012, Khayat secured a $2.28 million grant from the U.S. Department of Transportation to purchase the equipment that is being housed in this space. This equipment grant has allowed the acquisition of 35 highly specialized pieces of material testing equipment.

The largest and most unique piece of equipment, which will be delivered to S&T in June 2013, is a unique dual-mixer concrete batching plant consisting of two planetary motion high shear mixers with 750-L and 250-L output capacities. This custom designed system will allow for the production of "à la carte" cement-based materials and consistency in producing concrete for casting large specimens for structural testing, a capability that is currently unavailable on the S&T campus.

In addition to the concrete batch plant, the following specialized pieces of equipment have been aquired:

- **Concrete mixers**
  - Eirich intensive mixer with 100-L output
  - 3 drum mixers with variable speed and capacity
  - Omni high-sheer mixer with 10-L capacity
  - Hobart mortar mixers with 5- and 20-L capacity
- **State-of-the-art rheology infrastructure equipment**
  - Contec 5 and ICAR viscometers for concrete and Contec 6 for paste and grout
  - Modular compact rheometer 302 and FANN 35 for paste
  - Gyratory compactor for stiff concrete
- **Material characterization equipment**
  - Mercury intrusion porosimeter
  - Isothermal calorimeters
  - Maturity monitoring device
  - Cement characterization devices

(continued on page 21)

Investing in the future

Advanced Construction Materials Laboratory Expansion Project

Missouri S&T has always been a forward-looking institution, dedicated not only to preserving the past, but also to embracing the future. Now we are looking ahead to the next phase of our advanced construction materials laboratory — an expansion onto the department's structural engineering research laboratory that will create a new home for the advancement of construction materials development by significantly adding to the facilities involved in the testing, monitoring and evaluation of new and repaired structures.

Kamal Khayat, the Vernon & Maralee Jones Chair of Civil Engineering and director of the Center for Infrastructure Studies (CIES), recently secured a $2.28 million grant from the U.S. Department of Transportation to purchase equipment that would be housed in the expansion. Currently there is no space available on campus to house most of this new equipment. Khayat, along with department chair **Bill Schonberg** and director of the structural engineering high-bay laboratory **John Myers**, is leading this laboratory expansion effort in Butler-Carlton Civil Engineering Hall with the addition of a 16,000 GSF Advanced Construction Materials Laboratory. This expansion is about much more than extending the high-bay structures lab — it is about enhancing student experiences and addressing the ever-changing infrastructure needs of the state, the nation and the world. Estimated cost of the proposed Advanced Construction Materials Laboratory is $7 million and will require private support to make it a reality.

The Design

This much-needed expansion will not only house the recently acquired state-of-the-art equipment, but will also provide an interactive area that will promote educational and experiential learning for undergraduate and graduate students. There will be a conference room overlooking the lab that will showcase our activities to campus visitors, public agencies and industry partners.

These expanded facilities will also consolidate teaching and research functions that are currently spread over multiple buildings. Specifically, the new space will foster collaboration among faculty members on projects of mutual interest.

New Technologies

Our new Advanced Construction Materials Laboratory will grant students and researchers the ability to develop innovative and sustainable cement-based materials. The development of these "green" technologies would ultimately lead to cost savings, extension of service life and reduction of the carbon footprint of construction activities.

(continued on page 21)

Investing in the future *(continued from pg. 13)*

The Architects
S&T contracted with the St. Louis-based firm of Hastings+Chivetta Architects, Inc. in 2012, to develop a concept for this laboratory expansion. Programming and design activities occurred over several months including three on-campus visits by the design team to conduct stake-holder workshops and survey existing conditions.

Project Support
The new state-of-the-art facility will be one-of-a-kind in the country. It will give S&T investigators the opportunity to connect their research with other leading universities. It will also help build S&T's reputation as one of the nation's leading research universities.

To help build a future for advanced construction materials R&D at S&T, alumni support is essential. If you are interested in hearing more about or in participating in this exciting opportunity, please contact Bill Schonberg at 573-341-4787 or Kamal Khayat at 573-341-6223.

Materials Research
(continued from pg. 12)

- **Durability testing equipment**
  - Air-void system
  - Chloride-ion permeability, electrical conductivity and resistivity for corrosion of rebars

  Environmental chambers
  - Frost durability
  - De-icing salt scaling
  - Alkali–silica reactivity
  - Creep/shrinkage
  - Control temperature and humidity
- **Non-destructive testing equipment**
  - Portable ultrasonic NDT digital tester
  - Impact echo
  - Remote sensing vibrometer
  - Accoustic emission system

Our faculty has *got talent*

Photos by Terry Barner

Engineers Without Borders hosted the Missouri S&T Faculty Talent Show on Friday, March 8. It was a definitely a show that kept viewers entertained and amazed. Our talented professors sang and danced to all kinds of music — from Hip Hop, Reggae and Folk to Gangnam Style. There were also a few "S&T Emmy's" presented such as "Best Professor in a Comedic Role" and "Best Hairstyle in a Classroom Series."

New professor

Photo by B.A. Rupert

The department of civil, architectural and environmental engineering at Missouri S&T is pleased to welcome **Dimitri Feys** as an assistant professor in materials engineering this spring.

Feys earned his civil engineering degree, which is a combined bachelor's and master's degree, from Ghent University in Belgium in 2004. He then pursued his Ph.D. research at the same institute, concentrating on the rheological properties and pumping of self-consolidating concrete (SCC). After completing his Ph.D. in 2009, he started as a post-doctoral fellow at the Université de Sherbrooke, in Canada, under the supervision of professor **Kamal Khayat**.

Feys actively serves on various national and international scientific committees. He was a member of the organizing committee of the fifth and sixth International RILEM Symposium of Self-Consolidating Concrete in Ghent, Belgium, and Montreal, Canada.

Feys' current research focuses on the mix design and behavior of highly workable concrete in the fresh state, including rheology. His other research interests include: the rheology of complex materials and suspensions, suspension flow and sedimentation, fluid mechanics and flow modeling. He is also working on advanced concrete mix design procedures that incorporate concrete placement considerations and the properties of hardened concrete, including special concrete made with recycled materials and advanced sustainability.

Bootheel focus of scholarship established by CE alumnus

The Bootheel Alumni Endowed Scholarship was established by **Joseph F.** and **Mary Reichert** in December 2012 through the Miner Alumni Association. Joe, CE'59, a long-time supporter of MSM-UMR-S&T, passed away in February 2013. The Reichert family has requested that memorials be sent to Missouri S&T to support the new scholarship.

The purpose of the new endowed fund is to assist S&T in recruiting undergraduate students by offering scholarships to graduates of high schools in six counties that comprise Missouri's Bootheel: Pemiscot, Dunklin, Stoddard, New Madrid, Mississippi and Scott. Recipients will be selected by Missouri S&T's Office of Student Financial Assistance. Only students who are graduates of high schools in these six counties and who are enrolled as undergraduate students at S&T may qualify for this scholarship.

Joe was a member of the Academy of Civil Engineers. He was a long-time volunteer for the Miner Alumni Association, and in 2004, he received the Mackaman Volunteer Service Award. Joe and Mary were inducted into the Order of the Golden Shillelagh at S&T in 2009.

Joe was a Professional Engineer for Kansas City, Superintendent of Streets, Project Manager and a Professional Registered Land Surveyor. He was a lifetime member of the American Society of Civil Engineers, Missouri Society of Professional Engineers, American Public Works Association; and a member of the National Society of Professional Engineers.

To support the endowment fund, please send contributions to: The Miner Alumni Association, 1200 N. Pine Street, Rolla, MO 65409-0650. Please direct questions about the fund to Paula McBurnett, senior development officer, 1-800-392-4112 or paulam@mst.edu.

MoDOT funds pavement preservation project

A student uses ground-penetrating radar to map the pavement subsurface.

The Missouri Department of Transportation (MoDOT) has funded a project with the university to enhance its pavement management system. The project will focus on developing a pavement maintenance process that will allow for the selection of appropriate maintenance treatments based on optimization of performance and cost for each project. The total project funding is $1.5 million, including matching funds from NUTC and the University of Missouri at Columbia.

Five faculty members and research staff from S&T are involved in the project. They include: project PI **David Richardson** and co-PI's **Michael Lusher**, **Ronaldo Luna**, **Lesley Sneed** and **Neil Anderson**. Those from the Columbia campus include: co-PI's Brent Rosenblad and Andrew Boeckmann. Eight graduate and undergraduate students are also participating.

The two-year project will be comprised of six Tasks. Task 1 involves historical data mining and production of data; Task 2 is concerned with the development of pavement performance models and pavement treatment models; Task 3 is an assessment of available non-destructive pavement evaluation techniques; Task 4 involves field use of several promising non-destructive evaluation techniques; Task 5 involves the evaluation of maintenance materials plus the development of pavement treatment triggers and a selection process of candidate treatments; and Task 6 will be the creation of a re-calibration process for models and triggers.

Stirrat awarded professional degree

Missouri S&T awarded six honorary professional degrees during winter commencement ceremonies held in December. **Bryan A. Stirrat**, president of Tetra Tech BAS, was a recipient of one of those degrees.

Stirrat earned a bachelor of science degree in civil engineering from Missouri S&T in 1967. He also earned master of science degrees in petroleum engineering and environmental engineering from the University of Southern California. Stirrat founded Bryan A. Stirrat and Associates, a consulting firm specializing in solid waste engineering and environmental remediation, and BAS Construction Co. He co-founded Geologic Associates, a geotechnical engineering company. BAS acquired KFM Engineering and WEC Engineering and then was acquired by Tetra Tech. Tetra Tech BAS is a wholly owned subsidiary of Tetra Tech. A member of the S&T Academy of Civil Engineers, Stirrat and his wife, Jeanne, live in Diamond Bar, Calif.

Annual Asphalt Conference

The department of civil, architectural, and environmental engineering conducted the 55th Annual Asphalt Conference on Dec. 4-5, 2012. Eighteen presentations were made, including those by departmental alumni **Mike Lusher** ('96, '04), **Brent Whitwell** ('05, '06), **Steve Jackson** ('07), **Jason Blomberg** ('97), and **Joe Schroer** ('81). The conference was directed by **Dave Richardson** ('71). Attendance totaled 235.

And the winners are...

Three civil, architectural and environmental engineering faculty members received campus awards this past February for their outstanding performance. Each honoree received a stipend funded by industry and alumni contributions. Below are the winners pictured with Chancellor Cheryl B. Schrader.

Photos by B.A. Rupert

FACULTY EXCELLENCE AWARD

Jeffery Volz, assistant professor of architectural engineering, was chosen as one of five faculty members on campus to receive a 2012 Faculty Excellence Award. This award recognizes excellence in all areas of teaching, service and research.

RESEARCH AWARD

John Myers, associate professor of structural engineering, was chosen to receive a Research Award for 2012. This award is given annually and recognizes excellence in research activities.

SERVICE AWARD

Joel Burken, department associate chair and professor of environmental engineering, received a Service Award for 2012. This award is given annually to recognize professors who go "above and beyond" in service to the campus.

Faculty receive Outstanding Teaching Awards

Three faculty members in CArE received Outstanding Teaching Awards for 2011-2012. Receiving awards were: **Glenn Morrison**, associate professor of environmental engineering, **David Richardson**, CE'71, associate professor of materials engineering and **Jeffery Volz**, assistant professor of architectural engineering.

Winners were recognized at a ceremony held in November. Outstanding Teaching Awards are given each year to faculty members by the Outstanding Teaching Award Committee, which bases its selections on student evaluations. Richardson has received 11 Outstanding Teaching Awards total. This places him second behind retired faculty member, **William Andrews**, who has won a total of 13 awards.

Prakash presented Bharat Jyoti Award

Shamsher Prakash, professor emeritus, was presented the Bharat Jyoti Award by the India International Friendship Society at an award ceremony held in New Delhi, India on Jan.12, by the Governor of Sikkim.

He was cited for his exemplary services to the people of both India and the United States, as well as developing scientific programs in Yoga, and Peace of mind, and adopting school children in India for full support in their education based on "Performance and Need." He had earlier been bestowed the distinguished membership of the ASCE in October 2010.

Awards

2011 CTIS Student of the Year

Nathan P. Muncy

Hometown and State: Kansas City, MO

Nathan Muncy, 2011 CTIS Student of the Year

Student Bio: Mr. Muncy obtained a B.S. degree in Civil Engineering with Cum Laude honors from the Missouri University of Science and Technology (Missouri S&T) in December 2010 and is expenced to complete his M.S. in Civil Engineering in December 2012.

During his undergraduate career, Mr. Muncy was a member of the Missouri S&T chapters of the American Society of Civil Engineers (ASCE) and the American Concrete Institute (ACI). He was also highly involved in the Missouri S&T Steel Bridge Team as a leader and coordinator of bridge fabrication.

Nathan was also a member of the Concrete Canoe Mix Design Team where he served two years as the lead mix designer. As an undergraduate student, Nathan completed a National Science Foundation (NSF) supported OURE studying the long-term in-situ bond behavior of externally bonded carbon fiber reinforced polymer (CFRP) laminates subject to eight years of field conditioning. This work has added important field data to a very limited database on in-situ FRP strengthened bridges.

As a graduate student, Nathan studied the field performance of three bridge approach slab designs including a new most cost effective innovative prestressed-precast approach slab design. The research evaluated the field performance of bridge approach slabs including the deflection and rotation based on static and dynamic load testing. This work has been sponsored by the Missouri Department of Transportation (MoDOT) and the NUTC at Missouri S&T. He has also continued to document the field behavior of FRP strengthened bridges throughout Missouri creating a database of CFRP bond behavior under varied environmental and mechanical conditioning. During his graduate and undergraduate scholarly activities, Nathan was advised by Dr. John J. Myers.

Nathan was recognized at the TRB Conference in January 2012 along with the other UTC Outstanding Students' of the Year from UTC member institutions.

Selection Criteria: Mr. Muncy was selected as the Outstanding Missouri S&T UTC Student of the Year for his outstanding academic performance, the technical merit and national importance of his research, as well as his service to the Missouri S&T campus and surrounding community.

MISSOURI S&T News & Events

NEWS RESEARCH EVENTS PEOPLE CONTACT US

S&T faculty to receive excellence awards

October 29, 2010 by Linda Fulps

Five Missouri University of Science and Technology faculty members will receive Faculty Excellence Awards at a ceremony scheduled for Feb. 8, 2011.

The awards are given annually to recognize teaching, research and service excellence. Each award winner will receive a $5,000 stipend funded by industry and alumni contributions.
The 2010 award winners are:

- Dr. Joel Burken, professor of civil, architectural and environmental engineering
- Dr. Scott Grasman, associate professor of engineering management and systems engineering
- Dr. John Myers, associate professor of civil, architectural and environmental engineering
- Dr. Matthew O'Keefe, professor of materials science and engineering
- Dr. Hai Xiao, associate professor of electrical and computer engineering.

Share this:

Filed Under: People Tagged With: 'faculty excellence' burken grasman myers o'keefe xiao

34 S&T faculty members honored for outstanding teaching

November 20, 2012 by Mary Helen Stoltz

Thirty-four Missouri University of Science and Technology faculty members will receive the Outstanding Teaching Award for 2011-2012. The winners will be recognized at a ceremony scheduled from 3-4 p.m. Wednesday, Nov. 28, in St. Pat's Ballroom B of the Havener Center. The Outstanding Teaching Award is given each year to faculty members by the Outstanding Teaching Award Committee, which bases its selections on student evaluations.

The following individuals were selected for awards:
Dr. Akim Adekpedjou, assistant professor, of mathematics and statistics
Dr. Kwame Awuah-Offei, assistant professor of mining and nuclear engineering
Dr. Bonnie Bachman, professor of business and information technology
Dr. Jason Baird, associate professor of mining and nuclear engineering
Dr. Petra DeWitt, assistant teaching professor of history and political science
Dr. Kristen Marie Donnell Hilgedick, assistant professor of electrical and computer engineering
Dr. Stephen Gao, professor of geological sciences and engineering
Dr. Lance Haynes, chair and professor of arts, languages and philosophy
Dr. Gregory Hilmas, Curators' Professor of materials science and engineering
Dr. Irina Ivliyeva, associate professor of arts, languages and philosophy
Dr. Ronald Kohser, professor of materials science and engineering
Dr. Vy Le, professor of mathematics and statistics
Dr. John C. McManus, professor of history and political science
Dr. Audra Merfeld-Langston, assistant professor of arts, languages and philosophy
Dr. Glenn Morrison, associate professor of civil, architectural and environmental engineering
Dr. Gary Mueller, associate professor of mining and nuclear engineering
Dr. Jana Neiss, assistant teaching professor, teacher education program
Dr. Kathryn Northcut, associate professor of English and technical communication
Dr. Hank Pernicka, associate professor of mechanical and aerospace engineering
Dr. Ruwen Qin, assistant professor of engineering management and systems engineering

Dr. Ruwen Qin, assistant professor of engineering management and systems engineering
Dr. Kenneth Ragsdell, professor emeritus of engineering management and systems engineering
Dr. David Richardson, associate professor of civil, architectural and environmental engineering
Dr. J. David Rogers, Karl F. Hasselmann Missouri Chair in Geological Engineering and associate professor of geological sciences and engineering
Dr. V.A. Samaranayake, professor of mathematics and statistics
Dr. Jeffrey Schramm, associate professor of history and political science
Dr. John Seiffertt IV, assistant teaching professor of electrical and computer engineering
Dr. Jeffrey Smith, associate professor of materials science and engineering
Dr. R. Joe Stanley, associate professor of electrical and computer engineering
Dr. Greg Story, associate professor of physics
Dr. Theresa Swift, assistant teaching professor of electrical and computer engineering
Dr. Jeffery Volz, assistant professor of civil, architectural and environmental engineering
Dr. David Westenberg, associate professor of biological sciences
Merilee Krueger Wilsdorf, assistant teaching professor of psychological science
Terry Wilson, associate teaching professor of biological sciences.

24 faculty members to receive awards at S&T

January 18, 2013 by Linda Fulps

Twenty-four Missouri University of Science and Technology faculty members will receive the Faculty Achievement, Research, Service or Teaching Award for 2012. Each award winner receives a $1,000 stipend funded by industry and alumni contributions. An awards ceremony will be held on Tuesday, Feb. 12.

Receiving the 2012 Achievement Award are:

- Mathew R. Goldberg, assistant teaching professor of English and technical communication
- Merilee A. Krueger, associate teaching professor of psychological science
- Clayton Price, associate teaching professor of computer science
- Emmalou T. Satterfield, assistant teaching professor of chemistry
- Dr. Honglan Shi, assistant research professor of chemistry
- Kelly J. Tate, assistant teaching professor of English and technical communication.

Receiving the 2012 Research Award are:

- Dr. Roman Dwilewicz, professor of mathematics and statistics
- Dr. Serhat Hosder, assistant professor of mechanical and aerospace engineering
- Dr. Hyoung Koo (Hank) Lee, assistant professor of mining and nuclear engineering
- Dr. Julia Medvedeva, associate professor of physics
- Dr. John Myers, associate professor of civil, architectural and environmental engineering
- Dr. Joshua L. Rovey, assistant professor of mechanical and aerospace engineering
- Dr. Rosa Zheng, associate professor of electrical and computer engineering.

Receiving the 2012 Service Award are:

- Dr. Joel G. Burken, professor of civil, architectural and environmental engineering
- Dr. Kate Drowne, associate professor of English and technical communication

Receiving the 2012 Research Award are:

- Dr. Roman Dwilewicz, professor of mathematics and statistics
- Dr. Serhat Hosder, assistant professor of mechanical and aerospace engineering
- Dr. Hyoung Koo (Hank) Lee, assistant professor of mining and nuclear engineering
- Dr. Julia Medvedeva, associate professor of physics
- Dr. John Myers, associate professor of civil, architectural and environmental engineering
- Dr. Joshua L. Rovey, assistant professor of mechanical and aerospace engineering
- Dr. Rosa Zheng, associate professor of electrical and computer engineering.

Receiving the 2012 Service Award are:

- Dr. Joel G. Burken, professor of civil, architectural and environmental engineering
- Dr. Kate Drowne, associate professor of English and technical communication
- Dr. K.M. Isaac, professor of mechanical and aerospace engineering
- Dr. V.A. Samaranayake, professor of mathematics and statistics.

Receiving the 2012 Teaching Award are:

- Dr. Xiaoping Du, associate professor of mechanical and aerospace engineering
- Dr. Shannon Fogg, associate professor of history and political science
- Dr. Amber M. Henslee, assistant professor of psychological sciences
- Dr. Jennifer Leopold, associate professor of computer science
- Dr. Dev Niyogi, associate professor of biological sciences
- Dr. Daniel Reardon, assistant professor of English and technical communication
- Dr. J. Greg Story, associate professor of physics.

Filed Under: People, Top Headlines Tagged With: 'faculty awards 2012' 'faculty achievement award 2012' 'faculty research award 2012' 'faculty service award 2012' 'faculty teaching award 2012' 'missouri sandt'' 'missouri s&t' 'missouri s&t'

S&T students take second place at steel bridge competition

April 9, 2013 by Peter Ehrhard

Students from Missouri University of Science and Technology won second place at the American Society of Civil Engineers' Mid-Continent Student Conference.

The conference was held Thursday, April 4, through Saturday, April 6, at Southern Illinois University-Edwardsville in Edwardsville, Ill. Missouri S&T's Steel Bridge Team competed with other regional collegiate teams to construct its bridge as fast as possible. Their build time was 11 minutes, 6 seconds, with 2 minutes, 30 seconds of penalties.

The group was judged on bridge weight, construction speed and rigidity. Penalties are assessed for infractions ranging from dropping bolts, holding two pieces of the bridge at once and stepping over designated lines.

The S&T Steel Bridge Team was first in construction speed, first in construction economy and second in structural efficiency, which gave the team a second place finish overall. The team will next head for the national competition, which will be held the last week of May in Seattle at the University of Washington.

This year, the team's bridge weighs 155 pounds and has 44 pieces. The back span is 12 feet long and the cantilever is 3.5 feet long. The group spent all of the fall semester designing the bridge. This spring, leading up to the competition, they have been fabricating the bridge in the Student Design and Experiential Learning Center on the S&T campus, spending approximately 750 hours total in the shop.

Dr. Timothy Philpot, associate professor of civil, architectural and environmental engineering at S&T, is the Steel Bridge Team faculty advisor. Sarah Padgett, a junior in civil engineering from Topeka, Kan., is the 2013 team leader.

The following students are part of the 2013 Steel Bridge Team:
Sermad Amir, a junior in civil engineering from Ballwin, Mo.
Takota Anderson, a senior in mechanical engineering from Stark City, Mo.
Zachary Bardot, a senior in architectural engineering from Luebbering, Mo.
Natalie Bouxsein, a senior in civil engineering from Sugar Hill, Ga.
Joel Cates, a sophomore in mechanical engineering from Pawnee, Ill.
Michael Ishmael, a junior in mechanical engineering from Grain Valley, Mo.
Jermy Jamison, a junior in mechanical engineering from Lone Jack, Mo.
Micah Johnson, a senior in mechanical engineering from Warrenton, Mo.
Samuel Johnson, a senior in engineering management from Maryland Heights, Mo.
Nicholas Kaesik, a senior in civil engineering from Freeburg, Mo.
Matthew Klegseth, a freshman in civil engineering from Kansas City, Mo.
Lynsey Lahey, a senior in civil engineering from Kirkwood, Mo.
Sheryl Mattox, a senior in architectural engineering from Archie, Mo.
Cameron McCormick, a senior in civil engineering from Lee's Summit, Mo.
Francis McCoy, a sophomore in civil engineering from Kansas City, Mo.
David Muller, a senior in architectural engineering from Ballwin, Mo.
Holly Olson, a junior in mechanical engineering from Nanjemoy, Md.
Sarah Padgett, a junior in civil engineering from Topeka, Kan.
Kyle Roberts, a senior in civil engineering from New London, Mo.
Samuel Rothove, a senior in metallurgical engineering from Westphalia, Mo.
Austin Shull, a junior in architectural engineering from La Monte, Mo.
Samantha Smith, a senior in civil engineering from Washington, Ill.
Zachary Smith, a junior in civil engineering from St. Peters, Mo.
Sonya Snyder, a sophomore in metallurgical engineering from Las Vegas, Nev.
Charles Stankovic, a sophomore in civil engineering from Saline, Mich.
Nicholas Traub, a sophomore in civil engineering from Green Bay, Wis.
Darrell Wallace, a senior in civil engineering from Lee's Summit, Mo.

S&T student, faculty members receive UM System President's Awards

May 9, 2013 by Mary Helen Stoltz

Two faculty members and a student from Missouri University of Science and Technology have been chosen to receive President's Awards, the highest honor bestowed by the University of Missouri System, for excellence among the university's four mission areas of teaching, research, service and economic development.

Christa Weisbrook, director of academic programs in the UM System office of academic affairs, presented the President's Award to Suzanna Long.

"These recipients represent our finest faculty and students, and the University of Missouri System is what it is because of their hard work and dedication," says UM System President Tim Wolfe. "Every day, each one of them makes a difference in the lives of Missouri's citizens and truly advances our state — and nation." The award recipients were

nation." The award recipients were announced in April. The awards will be presented at a dinner on June 13 with the University of Missouri Board of Curators. Winners from Missouri S&T include:

Dr. Suzanna Long, assistant professor of engineering management and systems engineering, recipient of the President's Award for Early Career Excellence for her research in the field of transportation infrastructures and organizations. The award recognizes faculty who exhibit exceptional promise in scholarship, research or creativity as substantiated by significant accomplishments within their first seven years with the university. Since joining the Missouri S&T faculty in 2008, Long has received 21 grants totaling more than $7 million.

Dr. Wayne Huebner, chair and professor of materials science and engineering, recipient of the President's Award for Mentoring for his service and support of the faculty in his own department and across the S&T campus, as well as faculty within the UM System. The award recognizes faculty who have provided exemplary mentoring for other faculty.

Casey Burton, a senior in chemistry from Kaiser, Mo., recipient of the Student Entrepreneur of the Year Award for developing The Journal of Undergraduate and High School Research, a research journal aimed at high school and undergraduate students. The award honors students at one of the four University of Missouri System campuses who have shown entrepreneurial talent. Burton also produces a Minecraft gaming magazine called MCQuarterly and founded a company called Sapentia Development, which employs 30 people.

Innovative sustainability leads to Climate Leadership Award

June 5, 2013 by Andrew Careaga

An innovative approach to "recycling" homes built for past Solar Decathlons and turning them into sustainable student and faculty housing, combined with a geothermal project that will cut campus energy use in half, helped Missouri University of Science and Technology win a 2013 Climate Leadership Award.

Missouri S&T received the award from Second Nature, a non-profit organization that promotes sustainability in higher education. Second Nature announced the recognition today (June 5, 2013).

"We are honored to receive this national recognition for what we believe are very pragmatic yet bold approaches to sustainability," says Missouri S&T Chancellor Cheryl B. Schrader. "Our Solar Village is the only neighborhood of its kind on any university campus, and it demonstrates the feasibility of green, low-impact living while highlighting the creativity of the students who designed and built those homes.

"Our geothermal energy system is one of the most comprehensive to be undertaken on a university campus," Schrader adds. "I believe it too will become a model for other institutions to emulate."

The Climate Leadership Awards are presented annually to colleges and universities whose leaders have signed the American College & University Presidents' Climate Commitment. To be eligible for the award, institutions must demonstrate innovative and advanced

The Climate Leadership Award is made from wood reclaimed from a New York City water tower.

"Our geothermal energy system is one of the most comprehensive to be undertaken on a university campus," Schrader adds. "I believe it too will become a model for other institutions to emulate."

The Climate Leadership Awards are presented annually to colleges and universities whose leaders have signed the American College & University Presidents' Climate Commitment. To be eligible for the award, institutions must demonstrate innovative and advanced leadership in education for sustainability and climate mitigation and adaption, says David Hales, president of Second Nature.

Missouri S&T was one of 20 finalists for the 2013 Climate Leadership Awards. S&T was selected for its pragmatic approaches to sustainable energy use. Specifically, the campus was cited for two initiatives:

- The S&T Solar Village, a living laboratory of four solar-powered homes built to compete in the U.S. Department of Energy's Solar Decathlon in past years. Currently occupied by faculty and students, the homes operate on their own solar energy grid, feature sustainable building practices and feed into a prototype community solar storage bank.
- A comprehensive geothermal energy project, which will supply energy and chilled water to much of the campus when completed in 2014. The system, which will replace Missouri S&T's 60-year-old power plant, is expected to save more than $1 million in energy and operational costs annually. It will include approximately 700 wells with pipes creating closed geothermal loops to serve four campus geothermal plants that will provide energy to the campus.

In April, Missouri S&T also won a video contest sponsored by Second Nature in conjunction with the Climate Leadership Awards. The month-long contest featured videos about the sustainability initiatives of all CLA finalists. Missouri S&T's video focused on the Solar Village and the geothermal energy project.

Final winners of the Climate Leadership Awards were chosen by members of the Second Nature Board of Directors unaffiliated with ACUPCC signatory schools.

Share this:

S&T graduate student receives Nevada award for bridge research

June 7, 2013 by Mary Helen Stoltz

Mahdi Arezoumandi, a doctoral student in civil engineering at Missouri University of Science and Technology, has received international recognition for his research to improve bridge safety by using a stronger, more environmentally friendly concrete in modern bridge construction.

Arezoumandi received the 2013 Nevada Medal for the Distinguished Graduate Student Paper in Bridge Engineering from the University of Nevada, Reno. The award carries a $1,500 prize and includes publication in several professional journals.

Fly ash, a by-product of coal-fired power plants, has been used in concrete for decades, but conventional mixes call for 25 percent of the product. Arezoumandi studied the use of higher volumes of fly ash – between 50 and 70 percent – and found that the resulting concrete showed comparable or higher shear strengths.

Increasing the volume of fly ash in concrete will also allow for the reduction of Portland cement, the active ingredient in concrete, which generates a significant amount of carbon dioxide, Arezoumandi says.

"Not only does the fly ash improve the concrete, but its increased use will also remove a significant amount of material from the solid waste stream." he says.

The Nevada Medal, which has been given since 2001, recognizes outstanding graduate student contributions to state-of-the-art bridge engineering. The award is funded through an endowment established by Simon Wong Engineering of San Diego. Wong earned bachelor of science and master of science degrees in civil engineering at the University of Nevada, Reno.

Paper submissions were evaluated by a group of experts in bridge engineering research and design.

Arezoumandi studies under the direction of Dr. Jeffery S. Volz, assistant professor of civil, architectural and environmental engineering at Missouri S&T.

Missouri S&T in the News
External Media Sources

Homeland Security News Wire

Infrastructure

Ancient design concept leads to new ideas for building durable bridges

Published 6 June 2012

Engineers combine an ancient concrete arch form, dating back to the Roman empire, with a composite shell to create bridge beams which are designed to last 100 years

Ancient Roman bridge at Alcantara, Spain // Source: theodora.com

Researchers at Missouri University of Science and Technology are bridging a gap between an ancient structural element and modern technology.

Led by Dr. John J. Myers, S&T researchers are working with designers at HC Bridge Co. to combine an ancient concrete arch form, dating back to the Roman empire, with a composite shell to create bridge beams which are designed to last 100 years. Tucked inside durable, fiberglass composite shells, the lightweight beams are supported by a concrete arch and anchored by seven wire tendons, which serve as the system's tension tie.

"The composite shell protects the system from the elements, extending its service life and reducing the maintenance expenses that might normally be needed in a traditional bridge girder," says Myers, associate professor of civil, architectural and environmental engineering at Missouri S&T. "It also serves as a formwork for the construction of the concrete arch system."

A Missouri University of Science and technology release reports that the system uses a high-performance concrete, known as self-consolidating concrete, which can flow easily into tight and constricted spaces without needing vibration to remove trapped air or allowing the coarse aggregate to separate from the cement paste.

Using advanced concrete materials and composites for bridges and other infrastructure applications has been a key focus for Myers, who was recently appointed to serve a three-year term on the Federal Highway Administration's Long-Term Bridge Performance Program Expert Task Group Advisory Committee.

At the end of the project, the three new bridges will be located in Douglas, Dade, and Reynolds counties. The bridges will be funded in part by the Missouri Department of Transportation's Safe and Sound bridge program, which is currently replacing or rehabilitating more than 800 of the state's poorest bridges.

Harbor Technologies in Maine was commissioned to manufacture the composite shell and housing for the beams. Myers says the technology is flexible enough to allow for the arch's self-consolidating concrete to be poured either at a precast facility or at the job site directly.

"Quality control is often better at a precast facility since the concrete is batched in a very close proximity to the beam," Myers says. "It's also often more cost-effective to pour at that type of facility because these bridges are in a rural part of the state."

The first two bridge beams were cast at a ready-mix plant in Mountain Grove, Missouri, and a precast plant in Virginia, respectively. The final bridge will involve placing concrete at the job site after the beams are erected into place.

"In all cases, lower capacity cranes can set them in place because it's a lighter weight, more efficient structural system," Myers adds.

Myers and two S&T graduate students are working on the project with Dr. Glenn Washer, associate professor of civil and environmental engineering at the University of Missouri-Columbia.

Print Page

By Staff reports

September 14, 2012 12:30PM

Missouri S&T nationally ranked for value

• Missouri University of Science and Technology was recently ranked seventh in the nation among public universities in the U.S. News and World Report's "Great Schools, Great Prices" listing.

Missouri University of Science and Technology was recently ranked seventh in the nation among public universities in the U.S. News and World Report's "Great Schools, Great Prices" listing.

The listing was published in the news magazine's 2012 "America's Best Colleges" guidebook, which was released Wednesday, Sept. 12.

Missouri S&T ranked 46th overall in the "Great Schools, Great Prices" listing.

The news magazine determined the rankings based on a university's academic quality and "the 2011-12 net cost of attendance for a student who receives the average level of need-based financial aid."

In the category of nationally ranked universities, the magazine listed Missouri S&T at No. 60 among public universities and 125th overall.

Missouri S&T is also ranked 45th nationally among doctoral-granting public universities for undergraduate engineering education and 75th overall.

This ranking comes after Missouri S&T was recently included twice in Newsweek's ranking of the nation's 25 "Most Affordable Schools." The university ranked 24th in the nation in terms of affordability for out-of-state students and eighth in affordability for in-state students.

PHOTO / LYNN BRENNAN

Missouri S&T is ranked seventh in the nation among public universities in the U.S. News and World Report's "Great Schools, Great Prices" listing.

When considering public universities only, Missouri S&T topped the list for out-of-state students and was ranked third among public universities in terms of affordability for in-state students.

The affordability ranking is part of Newsweek's "College Rankings 2012" listings. The collection of rankings was released online Aug. 6, 2012.

Missouri S&T also has received previous national recognition for providing a high return on investment (ROI). In 2010, Bloomberg BusinessWeek ranked Missouri S&T 13th in the nation for a 30-year return on investment equal to $1,181,000, or an annualized net ROI of 12.4 percent.

http://www.therolladailynews.com/article/20120914/NEWS/120919099

Print Page

Missouri S&T nationally ranked for value

Missouri University of Science and Technology was recently ranked seventh in the nation among public universities in the U.S. News and World Report's "Great Schools, Great Prices" listing.

Zoom Lynn Brennan

Missouri S&T is ranked seventh in the nation among public universities in the U.S. News and World Report's “Great Schools, Great Prices” listing.

By Staff reports
Posted Sep. 14, 2012 @ 12:30 pm

Rolla — Missouri University of Science and Technology was recently ranked seventh in the nation among public universities in the U.S. News and World Report's "Great Schools, Great Prices" listing.

The listing was published in the news magazine's 2012 "America's Best Colleges" guidebook, which was released Wednesday, Sept. 12.

Missouri S&T ranked 46th overall in the "Great Schools, Great Prices" listing.

The news magazine determined the rankings based on a university's academic quality and "the 2011-12 net cost of attendance for a student who receives the average level of need-based

FIND MORE STORIES ABOUT

- Modot

Missouri S&T students create device to test lifespan of LED traffic lights

The LED lights could save taxpayers even more money than once thought, thanks to research by Missouri S&T students.

November 01, 2012 | by Dustin Hodges, KY3 News | dhodges@ky3.com

ROLLA, Mo. -- The LED lights that many states and cities use for new traffic signals could save taxpayers even more money than once thought. State transportation officials are working with a group of Missouri S&T students to develop a device that can measure the brightness of LED lights.

Missouri Department of Transportation officials wanted to know when in their life cycle the LED lights in traffic signals start to dim and need to be replaced. The group designed a device that measures the brightness of the lights, then used it at stop lights all across Missouri.

The research has already shown that the lights can last about two years longer than previously thought. That means they won't need to be changed as often -- saving taxpayers even more money.

"Based on the initial phase, we've extended our change-out program two years. Now that we've done that, they're in looking at it again to see if we can extend it again even further," MoDOT traffic engineer Joe Rickman said. "We hope to extend the change-out cycle a year or two more. That'll save tax dollars and save us time and effort and allow us to use our resources to do other things."

"The work we do here can impact the general population, it can help traffic agencies make decisions and it can really help prevent traffic accidents on the road due to decaying LED lights," said team member Sean Schmidt.

Finding the life cycles for LED lights is a major task for transportation departments nationwide, so having a device like this available could make things a lot easier for transportation departments all over.

The group from Missouri S&T is working on getting a patent for its work. They say, if they are able to get one and manufacture and market their design, they'll see to it that MoDOT gets one for each of its districts.

Missouri S&T students create device to test lifespan of LED traffic lights

The LED lights could save taxpayers even more money than once thought, thanks to research by Missouri S&T students.

November 01, 2012 | by Dustin Hodges, KY3 News | dhodges@ky3.com

ROLLA, Mo. -- The LED lights that many states and cities use for new traffic signals could save taxpayers even more money than once thought. State transportation officials are working with a group of Missouri S&T students to develop a device that can measure the brightness of LED lights.

Missouri Department of Transportation officials wanted to know when in their life cycle the LED lights in traffic signals start to dim and need to be replaced. The group designed a device that measures the brightness of the lights, then used it at stop lights all across Missouri.

The research has already shown that the lights can last about two years longer than previously thought. That means they won't need to be changed as often -- saving taxpayers even more money.

"Based on the initial phase, we've extended our change-out program two years. Now that we've done that, they're in looking at it again to see if we can extend it again even further," MoDOT traffic engineer Joe Rickman said. "We hope to extend the change-out cycle a year or two more. That'll save tax dollars and save us time and effort and allow us to use our resources to do other things."

"The work we do here can impact the general population, it can help traffic agencies make decisions and it can really help prevent traffic accidents on the road due to decaying LED lights," said team member Sean Schmidt.

Finding the life cycles for LED lights is a major task for transportation departments nationwide, so having a device like this available could make things a lot easier for transportation departments all over.

The group from Missouri S&T is working on getting a patent for its work. They say, if they are able to get one and manufacture and market their design, they'll see to it that MoDOT gets one for each of its districts.

2013 Nevada Medal for Bridge Engineering Winner Announced

Doctoral student at the Missouri University of Science and Technology wins award for graduate research established by University alum

May 23, 2013
By Staff Report

The recipient of the 2013 Nevada Medal for the Distinguished Graduate Student Paper in Bridge Engineering is Mahdi Arezoumandi, a doctoral student at the Missouri University of Science and Technology.

Nevada Medal Winner Mahdi Arezoumandi

Arezoumandi's paper, "Shear Strength of Sustainable Reinforced Concrete Bridge Beams," compared the strength of large-scale concrete beams where up to 70 percent of the cement had been replaced with fly ash. The research found that the mixture with 70 percent ash had higher shear strength than mixtures with a lower amount of ash.

"It is a great honor and privilege for me to receive the Nevada Medal for Distinguished Graduate Student Paper in Bridge Engineering," said Arezoumandi. "It is a very prestigious and recognized award, and I feel immense pride in this accomplishment. I would also like to extend my sincere appreciation to Mr. Simon Wong for his generosity in sponsoring this award."

The award, which has been given since 2001, is intended to recognize outstanding graduate student contributions to state-of-the-art bridge engineering. The Nevada Medal is funded through an endowment established by Simon Wong Engineering of San Diego, California. Wong completed a B.S. (1979) and M.S. (1984) in civil engineering at the University of Nevada, Reno.

Award recipients receive a plaque, an engraved 14 karat gold pin and a $1,500 check.

The award is coordinated by Professor M. "Saiid" Saiidi of the Civil and Environmental Engineering Department. Paper submissions were evaluated by a group of experts in bridge engineering research and design.

Arezoumandi's research has been directed by Dr. Jeffery S. Volz. After completing his doctoral studies, Arezoumandi said he intends to pursue an academic career to educate and inspire future engineers.

Paper Abstract

An experimental investigation was conducted to study the shear strength of full-scale beams constructed with two high-volume fly ash concrete mixes -- with one mix replacing 50 percent of the cement with fly ash and the other replacing 70 percent -- and conventional concrete (CC) mix. This experimental program consisted of 18 beams without stirrups with three different longitudinal reinforcement ratios. The experimental shear strengths of the beams were compared with the shear provisions of both U.S. and international design codes. Furthermore, the shear strengths of the beams were evaluated based on fracture mechanics approaches, modified compression field theory, and a shear database of CC specimens. Results of this study show that the mix with 70% fly ash had higher shear strength compared with the mix with 50% fly ash and the CC mix.

Morse Code: Inside the College Rankings

by Bob Morse

Related Articles

U.S. News Releases 2013 Best High Schools for STEM Rankings

Colleges Fight to Retain Interest of STEM Majors

The (Not So) Simple Roadmap to Solving STEM Problems

Top-Ranked Universities That Grant the Most STEM Degrees

By ROBERT MORSE, DIANE TOLIS

June 18, 2013 | RSS Feed | Print

Ninety-eight percent of Caltech's bachelor's degrees were granted in STEM fields, making it one of the top STEM universities in the country.

What are the leading STEM universities in the U.S.?

As part of the U.S. News STEM Solutions conference, we are publishing an exclusive new list of the National Universities from our 2013 Best Colleges rankings that grant the largest proportion of bachelor's degrees in the fields of science, technology, engineering and math.

California Institute of Technology and Colorado School of Mines tied for first place with 98 percent of their degrees granted in STEM fields. Missouri University of Science & Technology came in third with 91

California Institute of Technology and Colorado School of Mines tied for first place with 98 percent of their degrees granted in STEM fields. Missouri University of Science & Technology came in third with 91 percent; Worcester Polytechnic Institute in Massachusetts finished fourth with 88 percent; and Massachusetts Institute of Technology was in fifth with 86 percent.

To determine which college majors to evaluate, U.S. News used the U.S. Department of Homeland Security's list of science, technology, engineering and math designated-degree programs.

Then, looking at the school year that ended on June 30, 2012, we added up how many bachelor's degrees granted at each school were in these STEM fields using the latest degree-completion data from the National Center for Education Statistics.

Next, we computed the percentage of each school's total 2012 bachelor's degrees that were granted in STEM fields and then sorted the schools in descending order based on the largest proportion of STEM degrees granted. A school had to have a third or more of its degrees granted in STEM fields to be listed as a top-ranked STEM university.

How should these results be interpreted? Many of the highest-ranked research universities in the U.S. are also on this new STEM list since they grant large proportions of STEM degrees. This means that these schools emphasize STEM fields in their curriculum and degree offerings.

In fact, 23 of the 39 schools on the STEM list were ranked among the top 50 Best National Universities in 2013 and five were ranked in the top 10.

The STEM list also reveals that there are only 15 top-ranked universities with 50 percent or more of their bachelor's degrees awarded in STEM fields, and only 39 that had a third or more of their degrees in these fields. This shows that STEM education at many of the top-ranked U.S. universities is not the main academic priority.

Only schools that were numerically ranked in the top half of the National Universities category in the 2013 Best Colleges rankings were eligible to be included in this STEM analysis.

As a result, the following schools that have all or nearly all of their bachelor's degrees granted in STEM fields are not included on the list: Franklin W. Olin College of Engineering, Webb Institute, Harvey Mudd College, Rose-Hulman Institute of Technology, Kettering University, Harrisburg University of Science and Technology and South Dakota School of Mines and Technology.

The table below shows the top-ranked universities that granted the largest proportions of bachelor's degrees in STEM fields.

School name (state)	Percentage of 2012 bachelor's degrees granted in STEM fields	National Universities rank
California Institute of Technology	98%	10
Colorado School of Mines	98%	77
Missouri University of Science & Technology	91%	125
Worcester Polytechnic Institute (MA)	88%	65
Massachusetts Institute of Technology	86%	6
Rensselaer Polytechnic Institute (NY)	84%	41
Stevens Institute of Technology (NJ)	82%	75
Michigan Technological University	77%	120
Clarkson University (NY)	76%	115
Georgia Institute of Technology	76%	36
SUNY College of Environmental Science and Forestry (NY)	72%	77
Illinois Institute of Technology	68%	113
Carnegie Mellon University	62%	23

Internal Media Sources

30 faculty members hired this year at S&T

September 12, 2012 by Linda Fulps

Thirty new faculty members began teaching and research at Missouri University of Science and Technology since January 2012. The new faculty are:

- Lana Alagha, assistant professor, mining and nuclear engineering
- Mohsen Asle Zaeem, assistant professor, materials science and engineering
- Michael Beaty, lecturer, civil, architectural and environmental engineering
- Kirk Christensen, assistant teaching professor, mechanical and aerospace engineering
- Kathryn Dolan, assistant professor, English and technical communication
- Kristen Donnell Hilgedick, assistant professor, electrical and computer engineering
- Mohamed ElGawady, associate professor, civil, architectural and environmental engineering
- David Enke, professor and chair, engineering management and systems engineering
- Jie Gao, assistant professor, mechanical and aerospace engineering
- Steve Hall, lecturer, mining and nuclear engineering
- Hetal Hariyani, lecturer, English and technical communication
- Edward Harvey III, lecturer, business and information technology
- Marouane Kessentini, assistant professor, computer science
- Edward Kinzel, assistant professor, mechanical and aerospace engineering
- Brandi Klein, assistant professor, psychological science
- Dincer Konur, assistant professor, engineering management and systems engineering
- Xinhua Liang, assistant professor, chemical and biochemical engineering
- Michael Moats, associate professor, materials science and engineering
- Angel Morales, assistant teaching professor, computer science
- Fui Nah, professor, business and information technology
- Joontaek Park, assistant professor, chemical and biochemical engineering
- Jennifer Pattershall-Geide, assistant professor, psychological science
- Michelle Phillips, assistant teaching professor, economics and finance
- Keng Siau, professor and chair, business and information technology
- Brian Smith, assistant professor, engineering management and systems engineering
- Frankay Stevens, lecturer, arts, languages and philosophy
- Andrew Tohline, lecturer, arts, languages and philosophy
- Mikheil Tsiklauri, assistant research professor, electrical and computer engineering
- Mingzhen Wei, assistant professor, geological sciences and engineering
- Nathan Weidner, assistant professor, psychological science.

Missouri S&T among nation's best values, U.S. News says

September 12, 2012 by Andrew Careaga

Yet another national publication has identified Missouri University of Science and Technology as one of the best deals in the nation for a college education.

This latest recognition comes from *U.S. News & World Report*, which ranks Missouri S&T seventh in the nation among public universities in its "Great Schools, Great Prices" listing (called "Best Value Colleges" in the online edition). The listing was published in the magazine's 2012 "America's Best Colleges" guidebook. The guidebook rankings were released on Wednesday, Sept. 12.

Missouri S&T is ranked 46th overall in the "Great Schools, Great Prices" listing.

U.S. News determined the rankings based on a university's academic quality and "the 2011-12 net cost of attendance for a student who receives the average level of need-based financial aid."

According to the guidebook, "The higher the quality of the program and the lower the cost, the better the deal. Only schools ranked in or near the top half of their categories are included, because *U.S. News* works on the premise that the most significant values are among colleges that are above average academically."

In the category of nationally ranked universities, *U.S. News* lists Missouri S&T at No. 60 among public universities (125th overall). S&T is also ranked 45th nationally among doctoral-granting public universities for undergraduate engineering education (75th overall).

This ranking follows similar recognition of S&T's affordability from *Newsweek* magazine, which rated Missouri S&T as the most affordable public university in the nation.

Missouri S&T is included twice in *Newsweek*'s ranking of the nation's 25 "Most Affordable Schools." S&T ranks 24th in the nation in terms of affordability for out-of-state students and eighth in affordability for in-state students. When considering public universities only, Missouri S&T tops the list for out-of-state students. S&T is ranked third among public universities in terms of affordability for in-state students.

The affordability ranking is part of *Newsweek*'s "College Rankings 2012" listings. The collection of rankings was released online Aug. 6, 2012.

S&T and the other schools on the list are those considered by *Newsweek* to provide the most return on investment "when measured through a lens of the potential earnings with a degree from each institution as well as the average debt level of graduates." They are places "where students are most able to shoulder the cost of their degree – and where the education has a proven record of being a valuable investment relative to other schools."

Missouri S&T has received previous national recognition for providing a high return on investment, or ROI. In 2010, *Bloomberg BusinessWeek* ranked Missouri S&T 13th in the nation for a 30-year return on investment equal to $1,181,000, or an annualized net ROI of 12.4 percent.

Share this:

Fall enrollment at S&T highest in 30 years

September 18, 2012 by Linda Fulps

The fall 2012 enrollment at Missouri University of Science and Technology, officially recorded at the end of the semester's fourth week, is the highest since 1982. This year's enrollment is 7,647 students, up 125 students from the official fall 2011 figure, says Laura Stoll, vice provost and dean of enrollment management.

S&T continues to attract record numbers of women, Hispanics and other minority students. This fall 1,732 female students are enrolled, an increase of 2.8 percent. The American Society for Engineering Education (ASEE) rates S&T among the top 20 universities for awarding engineering degrees to women.

"This growth in the number of women and minorities who choose to attend Missouri S&T shows the value our students place in getting their degree from a university that offers a world-class return on investment," says Missouri S&T Chancellor Cheryl B. Schrader. "Employers continue to tell us that they desire a diverse workforce, and S&T is striving to help them achieve their goals."

Stoll says the majority of S&T students are enrolled in a STEM (science, technology, engineering and mathematics) major. "This gives our graduates multiple career opportunities," she says. "Our median starting salary for undergraduates is second among all public universities in the country at nearly $60,000. Record numbers of employers continue to recruit S&T graduates.

"Given our academic quality, we see excellent job offers in our business, arts and humanities, social science and teacher certification programs," says Stoll.

Missouri S&T continues to be recognized as one of the best deals in the nation for a college education. This latest recognition comes from *U.S. News & World Report*, which ranks Missouri S&T seventh in the nation among public universities in its "Great Schools, Great Prices" listing published in the magazine's 2012 "America's Best Colleges" guidebook. That ranking followed similar recognition of S&T's affordability from *Newsweek* magazine, which rated Missouri S&T as the best "return on investment" among all public universities in the nation.

Fall classes at Missouri S&T began on Aug. 20.

Time to change an LED light? S&T researchers design system to tell

September 21, 2012 by Mindy Limback

In many of the nation's traffic lights, light-emitting diodes or LEDs with their brighter light and longer life have replaced standard bulbs. But knowing when to replace the signal heads has remained a guessing game, says Dr. Suzanna Long, assistant professor of engineering management and systems engineering at Missouri University of Science and Technology. That's because LED traffic lights don't burn out – they just lose brightness over time.

So Long and other researchers at Missouri S&T, in partnership with the Missouri Department of Transportation, have developed an instrument to measure LED intensity. The laser-guided device allows measurements to be taken from the roadside at night, instead of requiring technicians to physically check traffic lights by using a bucket truck.

Long's team created the measurement tool while working to provide MoDOT with a data-driven replacement schedule for LEDs, which have been widely adopted for use in sustainable traffic signal management.

"The majority of agencies replace LED signals on a spot basis when they receive a complaint," she says. "The maintenance costs associated with sending a crew out to replace a single LED are very high. Our methodology provides a more cost-effective mechanism for determining replacement and allows agencies to meet goals of being good stewards of public money."

Long says in addition to addressing individual complaints about brightness, transportation officials have used a generic replacement schedule based on the manufacturers' warranties, usually six years. But since life expectancy of LEDs varies by intersection and the basic science of LED components, that's not the most cost-effective schedule.

Results of this study, named one of the 2012 "Sweet 16" High Value Research Projects by the American Association of State Highway and Transportation Officials, appears in the *Engineering Management Journal*'s special issue on transportation management this month.

The team plans to extend the previous data and collect data from the same LED traffic indicators in the coming years to improve the reliability and accuracy of their results.

Working with Long on the project at Missouri S&T are Dr. Mariesa Crow, the Fred W. Finley Distinguished Professor of Electrical Engineering; Dr. Abhijit Gosavi and Dr. Ruwen Qin, assistant professors engineering management and systems engineering; and Dr. C.H. Wu, professor of electrical and computer engineering.

S&T Concrete Canoe Team set to sail

March 28, 2013 by Peter Ehrhard

A team of students from Missouri University of Science and Technology is taking a 225-pound canoe made of concrete to Edwardsville, Ill., to see if it will float.

The S&T Concrete Canoe Team and its 20-foot-long, 30.5-inch-wide canoe, christened "Gone Fishin'," will compete against universities from around the region at the American Society of Civil Engineers' Mid-Continent Student Conference, held April 4-6, at Southern Illinois University-Edwardsville. The conference will test the group and its creation to the limit.

For the competition, students must design a lightweight canoe that minimizes drag in the water, is strong enough to hold several paddlers and can remain buoyant when completely filled with water. In Edwardsville, the teams will compete in several areas. Each team is judged on engineering reports and presentations, displays that illustrate the students manufacturing process and head-to-head races in slalom and endurance events.

This year the team has constructed its canoe using a male mold, a first for the group. Students cut pine boards into quarter-inch strips and the interior is the smoothest that returning design team members have ever seen, with the group achieving a difficult uniformed edge. The canoe itself is designed to look like a fishing lure, which fits the team's fishing theme, and the display will be designed like a tackle box.

"I am extremely proud of the effort the team put into conquering the male mold this year," says team leader Sonya Snyder, a sophomore in metallurgical engineering from Las Vegas, Nev. "It took many tries and countless hours, but we made it to competition. 'Gone Fishin" is not just a canoe, it is a learning experience."

Dr. John Myers, associate professor of civil, architectural and environmental engineering at S&T, is the Concrete Canoe Team faculty advisor.

For more information about the competition visit the 2013 ASCE Mid-Continent Student Conference website at http://www.ce.siue.edu/asce/MCSC/default.html or contact Brent Vaughn at bvaughn@siue.edu.

S&T professor's 'multicopter' improves structure monitoring

May 3, 2013 by Peter Ehrhard

Chris Seto controls the multicopter while Dr. Zhaozheng Yin (far left) and Yunxiang Mao observe.

The current method of inspecting bridges for structural damage is labor-intensive and, in some instances, dangerous to all involved. Dr. Zhaozheng Yin, assistant professor of computer science at Missouri University of Science and Technology, and his engineering team have been developing a safer, more efficient solution with his latest research project, the "multicopter."

"This system was developed initially to monitor bridge structure health," Yin says. "Our goal is to be able to collect data autonomously using non-invasive sensor technology; to be able to detect and find patterns that could possibly tell us that information about the structure's integrity."

The "multicopter" gets its name from its appearance. The radio-controlled mini-helicopter has multiple propellers to lift it into the sky and is loaded with an assortment of cameras, sensors and other technology that help it to maneuver and hover. Yin's group has created several versions of the machine, including a hexocopter (six propellers) and a quadcopter (four propellers).

While the flying machine may not be groundbreaking, it is incredibly practical.

"Imagine you need to perform a check-up on a bridge that is over an extremely fast-flowing river, or even spans a section of the ocean," says Yin. "The standard procedures are extremely labor-intensive and time-consuming. With a multicopter, you have a feasible solution to a dangerous problem."

Yin's research is funded by Lockheed Martin and sponsored by the Mid-America Transportation Center, a consortium of Midwestern universities based in Lincoln, Neb; Missouri S&T is a member of the group. The finishing touches of this project are set to be completed by December 2013.

Yin says that the project has been fun and challenging. One problem Yin and his research team faced early on had to do with outfitting the multicopter with the necessary equipment while keeping it light enough to maneuver proficiently. He hopes to be able to continue his work after the prototype has been completed in the winter.

Chris Seto, a sophomore in computer engineering from Chesterfield, Mo., works with Yin and says "The multicopter makes an excellent platform for airborne sensors because it is extremely easy to interface with the flight control avionics, which allows the aircraft to be flown automatically and also allows the onboard sensors to collect the data required during these tests."

"These aircraft can be very precisely flown, so even in sensitive environments, such as those with many obstacles, the aircraft can still be successfully maneuvered," Seto adds.

"In the future, besides its initial intentions for bridge structure monitoring, this technology could be incorporated into military or corporate use," Yin says. "Similar to drone uses, auto-detection and tracking is going to be important. Or even something like farming. If you have 60 acres of corn, you can monitor which areas need attention or irrigation, or find where the cows are on a very large farm."

Together with his students, Seto, and Yunxiang Mao, a computer science Ph.D. candidate, Yin will continue to improve and refine the project.

S&T students build and compete with racecar

May 22, 2013 by Peter Ehrhard

Last year's car in action. Photo by Bob Phelan.

A team of students from Missouri University of Science and Technology is racing against 120 international collegiate teams in Formula One-style racecars at the upcoming Formula SAE competition in Canada.

The competition, sponsored by the Society of Automotive Engineers, will be held Thursday, May 23, through Sunday, May 26, in Barrie, Ontario. Missouri S&T's Formula SAE team will compete and race against teams from Brazil, Canada, England, Germany, Italy, Japan and Australia, in addition to teams from schools from across the United States.

In this competition, a panel of judges will evaluate the engineering, design and cost of the vehicle. The competition then moves to the race track. During the racing portion, the team will be judged on fuel economy, endurance, maneuvering an obstacle course and lateral force.

The team builds a new car for each year's competition. This year, the team is hoping for more horsepower compared to previous vehicles. The car has Hoosier Racing tires and uses active aerodynamics, which allows for manual changes to the exterior of the car mid-race, making the car more aerodynamic. Earlier this spring, the team tested its vehicle's aerodynamics in a wind tunnel.

"Once people join the team, they are usually hooked and stay for the rest of their university career," says team leader Lance Kellner, a junior in mechanical engineering from Cainsville, Mo. "We attract all majors; everybody likes racecars."