news

Missouri S&T

Center for Transportation Infrastructure and Safety

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From the Desk of the Director

As we transition from Summer to Fall in Missouri, the beautiful Fall foliage is a nice reminder to stop and reflect on the accomplishments achieved over the past few months, before we transition into Winter.

One of the highlights of recent accomplishments of the CTIS was hosting the *First Annual Missouri S&T Transportation Infrastructure Conference,* which was held on the S&T campus on **Thursday, September 27**.

As the inaugural year of this event, with 90 registered participants, the conference was a great success.

The conference featured four leading engineers from the US, Canada and Europe as keynote speakers. They discussed cutting-edge technologies related to the research themes of the CIES/CTIS, as well as the value of research to the advancement of the transportation industry. The conference showcased recent projects supported by the CTIS in the areas of advanced construction materials, non-destructive testing and structural health monitoring of transportation infrastructure.

Fall Foliage and Composite Pedestrian Bridge on S&T campus

The event also included tours of some of the outstanding research facilities at S&T.

"It is anticipated 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."
-Dr. Kamal Khayat

The Missouri S&T Transportation Infrastructure Conference will be an annual event. The conference will have revolving locations at our sister campuses.

The next few months will be devoted to aquiring several large pieces of specialized testing equipment for the CTIS laboratories and to finalize the re-organization of the CTIS laboratory.

In this issue:

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

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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.

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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.

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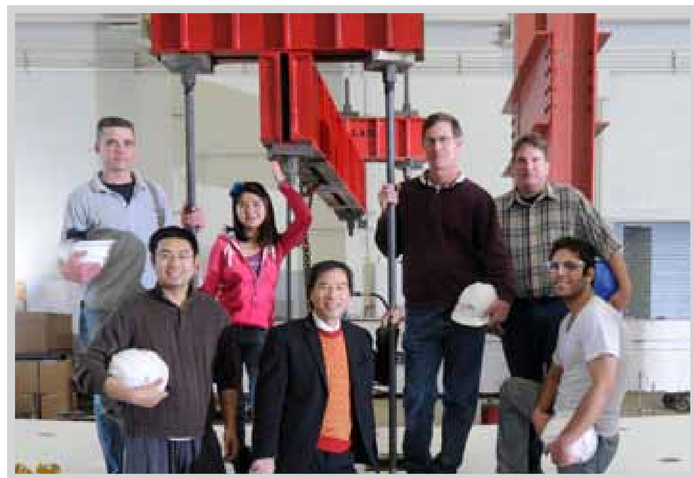
Design Validation with Laboratory Testing of Full-Size Bridge Components

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).

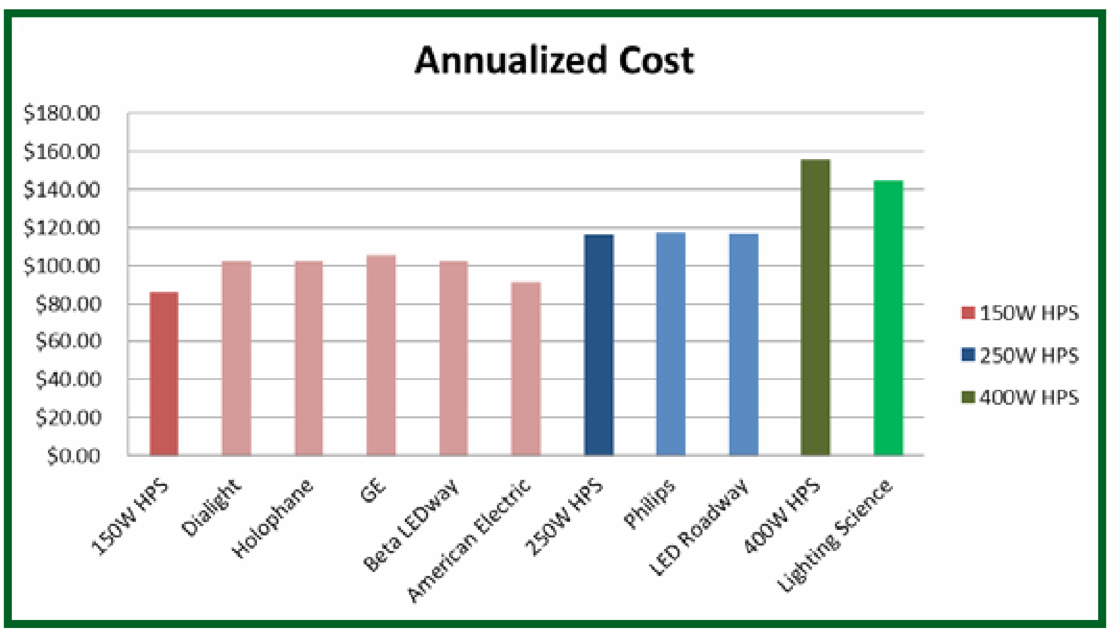


Figure 1. Annualized Cost of HPS Equivalent LED Luminaires

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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 ¡Sí, Se Puede!

November 9-12, 2012

Society of Professional Hispanic Professionals annually coordinates ¡Sí 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.

Local Transportation News:

New training opportunity for local government agencies and engineering consultants

The Missouri Local Technical Assistance Program (Missouri LTAP) is pleased to announce a new training opportunity for local government agencies and engineering consultants. The class, New Sign Retroreflectivity Guidelines Overview & Inspector's Workshop, provides much needed clarification on the final FHWA ruling on sign retroreflectivity requirements and demonstrates the approved inspection methods. The financial burden that the original requirements would have put on the road authorities was overwhelming. After much time, feedback and a secondary review, the FHWA revised the MUTCD requirements and took out many of the financial requirements to comply with the 2009 MUTCD. However, it did keep several key points and deadlines that have already passed. A complete review of the final decision can be found in the Federal Register/Vol. 77 NO. 93 dated Monday, May 14, 2012. The final rule effective date was June 13, 2012.

Heath Pickerill, Missouri LTAP Director, says "The final MUTCD ruling on sign retroreflectivity requirements has been issued. We developed this training in an effort to clear up the confusion and train local agencies on the available inspection methods." The new class is conducted in two parts. The first four-hour session covers all of the changes under the final MUTCD ruling and how they impact agencies. The second two-hour session is a "hands-on" workshop in inspecting signs. First, the importance of retroreflectivity is explained in simple terms. Next, all eight of the requirements are broken down to outline how an agency can comply with the requirements. Then a demonstration of the inspection methods is given to clearly explain sign maintenance and inspection criteria. The workshop enables an agency to pick the best method or combine methods to work for their local area, so they can implement this new rule and comply with the MUTCD. Certificates of completion for inspecting signs to meet retroreflectivity standards will be awarded upon completion of both sessions. It is important to note that FHWA requires training to be qualified to inspect signs for meeting retroreflectivity standards.

Missouri LTAP recently held three retroreflectivity guidelines training and inspector's workshops. The first was at the Platte County Resource Center on September 20. The second was at the Maryland Heights Government Center on September 26, and the third was in Cape Girardeau on October 29. All three classes were very well attended. There were well over 100 employees representing several different city public works and county road departments. Missouri LTAP has one more class scheduled this fall in New London at the Ralls County Extension Center on December 6.

Missouri LTAP is located at Missouri University of Science and Technology and operates on funding provided by the Missouri Department of Transportation and the Federal Highway Administration. Missouri S&T's National University Transportation Center also supports the efforts of the Missouri LTAP by providing 1:1 matching funds to aid in LTAP's services and deliverables. For more information on Missouri LTAP or to view a schedule of other upcoming classes, please visit our website at www.moltap.org.