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

Eight Year Annual Report
July 1, 2013 – June 30, 2014

PART A: CORPORATE STYLE ANNUAL REPORT

Submitted by
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Center Director

AUGUST 31, 2013

Eighth Year Annual Report
Part A: Corporate Style Annual Report

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OVERVIEW: CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

Introduction

Throughout eight 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 and structural health monitoring.

The 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 and other partnering universities. 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, the CTIS has impacted the quality of available education for engineers and transportation professionals, equipping engineers with interdisciplinary skills, best practice guidelines and experience. As a result of the CTIS activities, new interdisciplinary academic programs have been created at Missouri S&T. The University has become, and continues to be, the provider of the Local Technical Assistance Program (LTAP) for the state of Missouri, and some of the new courses are now offered to transportation professionals as part of the LTAP.

Since its inception, the CTIS has performed work in accordance with its strategic plan to accomplish projected goals in the areas of education, research and technology transfer. The 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 the faculty associated with the 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 third annual Transportation Infrastructure Conference, which will be held on the Missouri S&T campus on October 3, 2014. 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. In recent years, 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). Efforts will also continue to undertake joint projects with counterparts in foreign countries, including Belgium, Canada, Iceland, France, and Mexico.

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 Coordinator I	222 ERL, Rolla MO 65409 573-341-7884/6215 abigayle@mst.edu	Proposal coordination/ newsletter/website
Spitzmiller, G.	Administrative 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
Sooduck Hwang	Lead Scientist	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 VIII (2013-2014).

Research Projects

R369— Air-Launched GPR Evaluation for Rapid Assessment of MoDOT Bridge Decks
[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 air-launched GPR tool in rapidly 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 compare and contrast the results acquired using air-launched GPR in terms of accuracy and ease in evaluating the with those acquired using ground coupled GPR with existing and emerging noninvasive imaging technologies in terms of accuracy and ease in evaluating the existing condition of bridge decks. 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

No new projects to report.

Research Equipment

RE368— Acquisition of uniaxial shaking table for dynamic testing of structural elements
[Elgawady, M., PI - Missouri S&T, new in this reporting period]

This equipment purchase will enable the development and implementation of several types of innovative and sustainable structural elements for transportation infrastructure. For example, the development of durable accelerated bridge construction (ABC) that can sustain damage due to extreme events and seismic behavior of existing bridge columns are of prime interests. ABC reduces initial construction cost, construction time from months to days, and traffic disruption and lane closures. In addition, ABC improves work zone safety, constructability, and construction quality leading to long lasting bridges. ABC has a high level of sustainability and lower environmental impacts. It has lower life-cycle costs by using materials more efficiently and reducing construction waste. Finally, ABC reduces noise, leakage of wet concrete into waterways leading to harm to migrating fish, and fuel consumption due to congestion and rerouting. In particular the seismic behavior of innovative structural systems will be investigated. This includes hollow-core ultra-high performance segmental bridge columns, double-skin bridge columns, behavior of columns constructed out of self-consolidated concrete. Moreover, bridge girder movement criterion for ABC will be investigated as well.

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 is brief explanation of a research project meant to serve as an example of how work and research at CTIS serves the transportation and infrastructure needs of our state and nation.

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SUCCESS STORIES

This section lists a sampling of "success stories" for Year VIII, 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 NUTC News

- "Field implementation of recycled concrete aggregate – Mississippi River Bridge project." Volume 8, Issue 1.
- "MoDOT funds pavement preservation project." Volume 8, Issue 2.
- "Influence of mixing procedure on the robustness of self-consolidating concrete." Volume 8, Issue 1.
- "Non-destructive evaluation of bridge decks." Volume 8, Issue 1.
- "Automated measurement and control of concrete properties in a ready mix truck." Volume 8, Issue 2.

- “Functionally graded biomimetic energy absorption concept development for transportation systems.” Volume 8, Issue 2.

- “Highway rock fall measurements using LIDAR.” Volume 8, Issue 2.

- “Missouri S&T formula electric racing.” Volume 8, Issue 2.

- “Examining system dynamics to study maritime transportation system.” Volume 8, Issue 3.

- “Modelling the geomorphology of an active landslide.” Volume 8, Issue 3.

- “Application of active microwave thermography to structural health monitoring.” Volume 8, Issue 3.

- “Innovative concrete bridge to open in 2014 near Jefferson City, MO.” Volume 8, Issue 3.

- “Non-destructive evaluation of bridge decks.” Volume 8, Issue 4.

- “Advanced moisture modeling of polymer composites.” Volume 8, Issue 4.

- “Advanced Construction Materials Laboratory (ACML) Inauguration.” Volume 8, Issue 4.

- “Analysis of carbon emission regulations in supply chains with volatile demand.” Volume 8, Issue 4.

- “Nano-engineered polyurethane resin-modified concrete.” Volume 8, Issue 4.

- “Dilation behavior and strain rate effects of rubberized concrete confined with fiber reinforced polymers.” Volume 8, Issue 4.

- “Optimization of rheological properties of self-consolidating concrete by means of numerical simulations, to avoid formwork filling problems in presence of reinforcement bars.” Volume 8, Issue 4.

- “Shear wave velocity measurement of fresh concrete with bender element.” Volume 8, Issue 4.

Featured Articles in The Bridge Newsletter

- “ElGawady elected to The Masonry Society.” Winter 2013 Issue.
- “RE-CAST: Leading the effort to improve sustainability in our nation’s transportation infrastructure.” Winter 2013 Issue.
- “Innovative Concrete Bridge.” Winter 2013 Issue.
- “ACML Lab Inauguration.” Spring 2014 Issue.
- “Scrap Tires used to boost masonry blocks.” Spring 2014 Issue.
- “Advanced materials is among first “signature’ areas named.” Spring 2014 Issue.
- “Chen named Abbett Chair.” Spring 2014 Issue.
- “2013 CTIS Student of the Year: Mahdi Arezoumandi.” Spring 2014 Issue.

Awards

- A team of students from Missouri University of Science and Technology scored the highest among U.S. teams in an international hydrogen design competition held in summer 2013.
- 15 S&T faculty receive tenure, promotions in Fall 2013.
- Twenty-two Missouri University of Science and Technology faculty members received the Faculty Achievement, Research, Service or Teaching Award for 2013.
- Missouri University of Science and Technology’s Advanced Aero Vehicle Group earned fourth place in the advanced class at the annual Aero Design West Competition, held Friday, March 28, through Sunday, March 30, 2014 at the Fort Worth Thunderbirds Flying Field in Fort Worth, Texas.
- Missouri University of Science and Technology’s Chem-E-Car Design Team earned first place at the American Institute of Chemical Engineers’ 2014 Mid-America Regional Conference, held April 11-12 at the University of Iowa.
- Missouri University of Science and Technology’s Steel Bridge Design Team earned first place at the American Society of Civil Engineers’ Mid-Continent Student Conference, held Thursday, April 24, through Saturday, April 26, at Oklahoma State University in Stillwater, Oklahoma.
- Missouri University of Science and Technology’s Human Powered Vehicle Team earned third place at the American Society of Mechanical Engineers 2014 Human Powered Vehicle Challenge West Coast Competition, held April 25-27 in San Jose, Calif.

- The Mars Rover Design Team at Missouri University of Science and Technology took second place in an international competition that challenges college students to design and build the next generation of Mars rovers. The competition took place May 29-31 at the Mars Desert Research Station in Hanksville, Utah.

- Dr. John Myers named Fellow of The Masonry Society.

Missouri S&T in the News

External Media Sources

- “Spotlight on regional concrete construction growth at 'concrete in the middle east' conference in lebanon.” Go Dubai. July 2013.

- “Highway 50 bridge to test technology.” Columbia Daily Tribune. September 23, 2013.

- “Missouri bridge to test concrete technology.” KRCG News connectmidmissouri.com. September 23, 2013.

- “Project Profile: Missouri S&T Experimental Bridge.” Country Materials Corporation. April 14, 2013

- “S&T names first ‘signature’ area.” The Rolla Daily News. January 20, 2014.

- “University Study Shows Verifi Benefits for Concrete Quality.” Verifi.com. February 18, 2014.

- “Researchers study ‘smart’ rocks use for detecting bridge damage.” Phys.org. July 2, 2014.

- “”Smart” rocks detect bridge damage.” Homeland Security News Wire. July 3, 2014.

Internal Media Sources

- “S&T to lead partnership with industry in modular reactor consortium.” Missouri S&T Public Relations. July 29, 2013.

- “S&T researchers create model for managing urban restoration after a natural disaster.” Missouri S&T Public Relations. September 5, 2013.

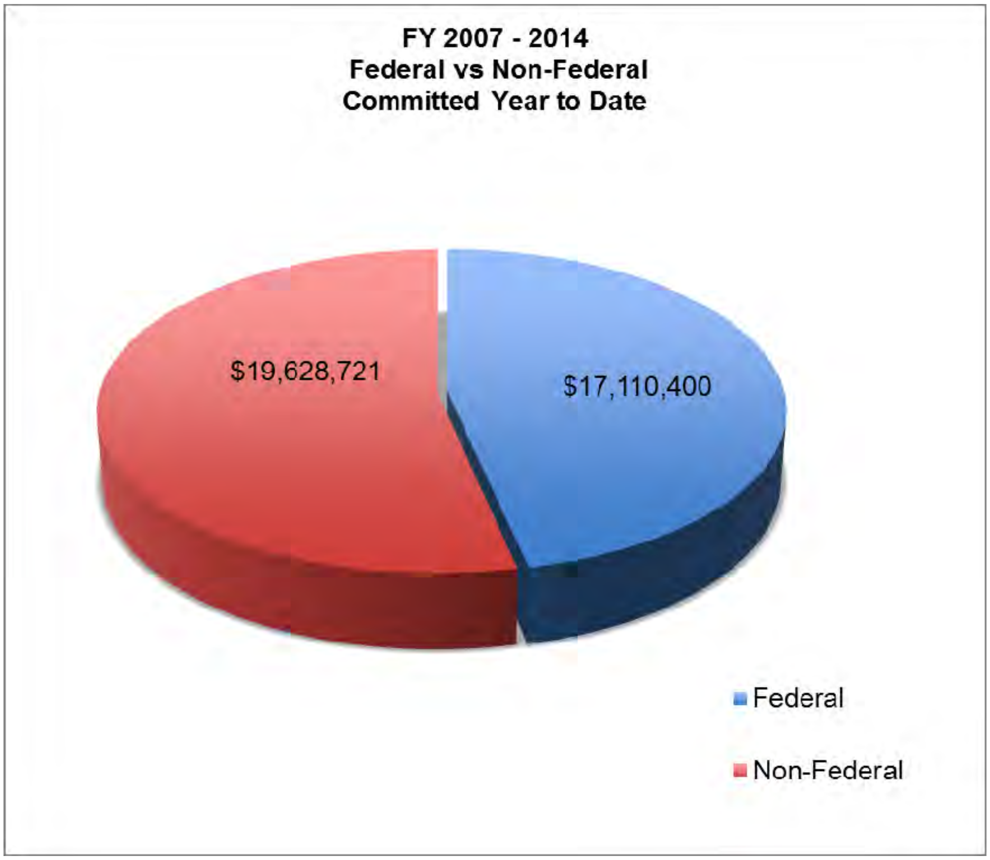
- “Innovative concrete bridge to open this fall near Jefferson City, Mo..” Missouri S&T Public Relations. September 19, 2013.

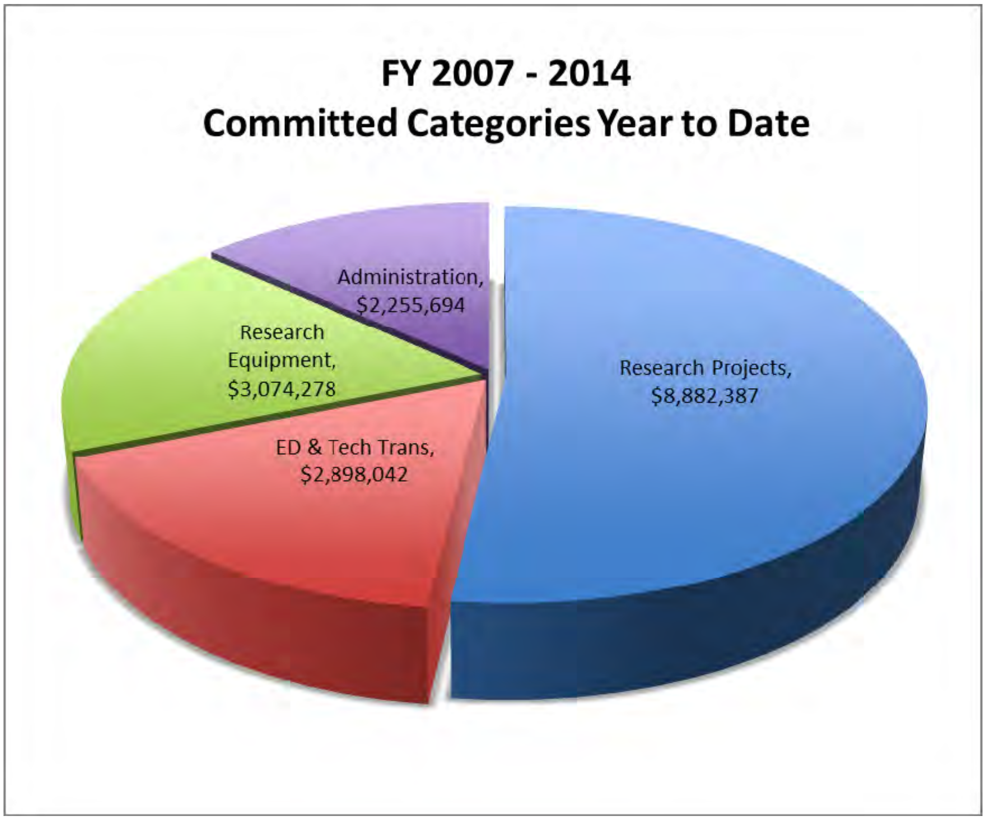
- “ElGawady elected to The Masonry Society.” Missouri S&T Public Relations. October 9, 2013.

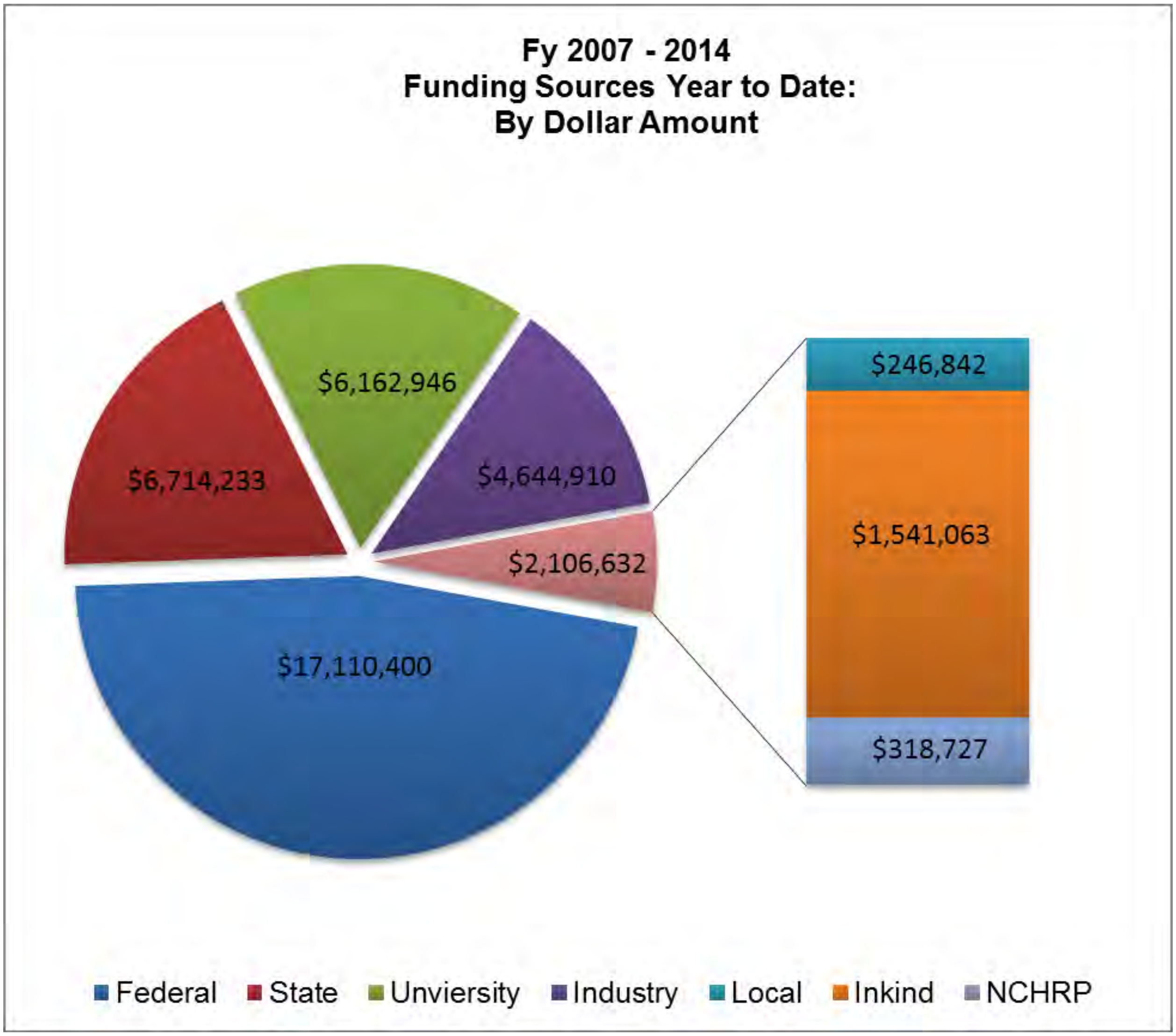
- "S&T selected to lead effort to improve sustainability in nation's transportation." Missouri S&T Public Relations. October 25, 2013.
- "First two of four 'signature' areas named." Missouri S&T Public Relations. January 17, 2014.
- "Scrap tires used to boost masonry blocks." Missouri S&T Public Relations. February 6, 2014.
- "Genda Chen named Abbett Chair." Missouri S&T Public Relations. March 19, 2014.
- "S&T's 2014 summer camps have it all." Missouri S&T Public Relations. April 10, 2014.
- "New electric-powered bus to shuttle S&T students." Missouri S&T Public Relations. April 11, 2014.
- "Researchers study 'smart' rocks use for detecting bridge damage." Missouri S&T Public Relations. July 1, 2014.
- "Students, faculty from around the world attend workshop." Missouri S&T Public Relations. July 21, 2014.

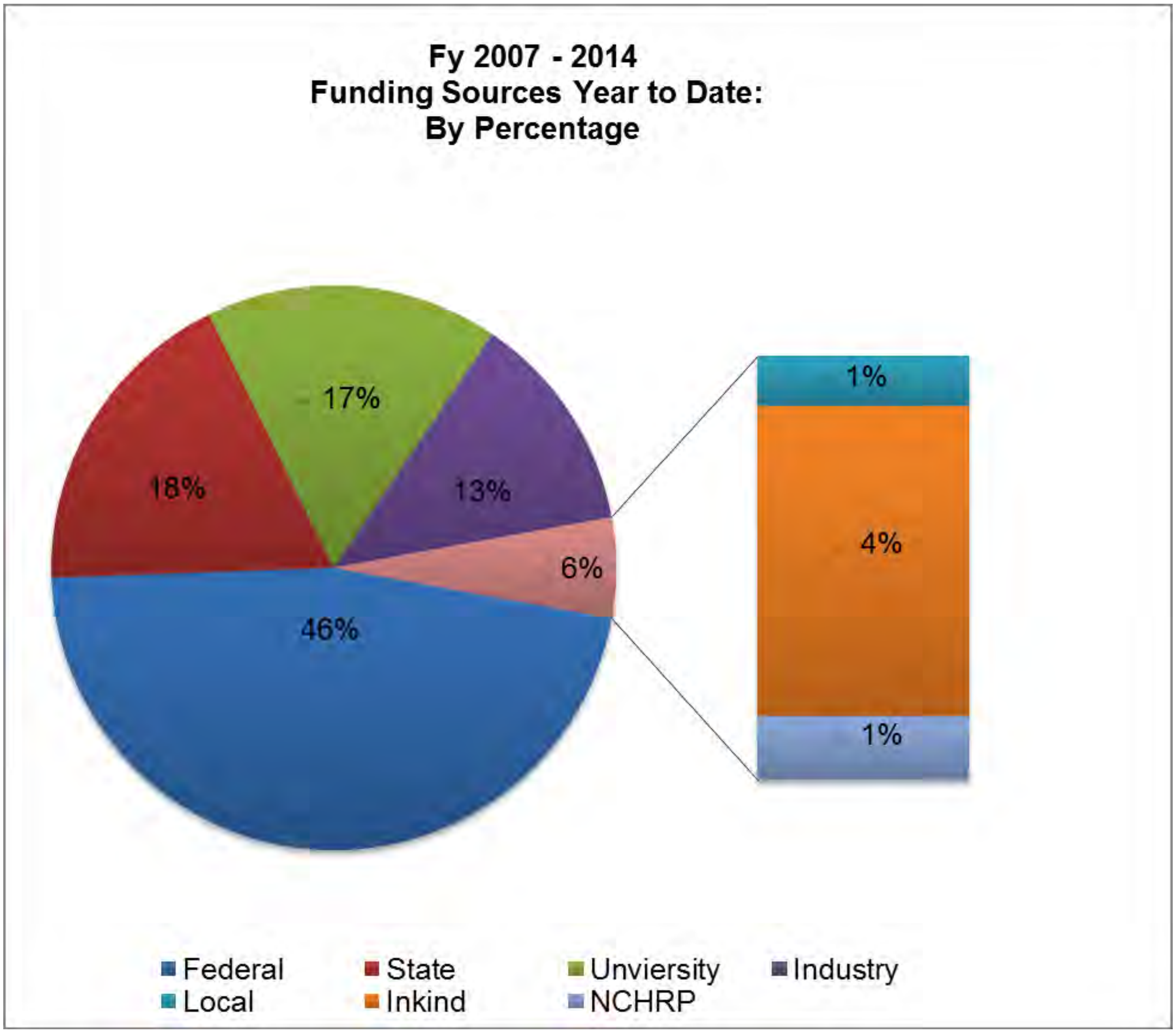
FUNDING SOURCES AND EXPENDITURES

This section provides information on Funding Sources and Expenditures for Years I-VIII 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 - 2014
Committed Categories Year to Date
Administration, $2,255,694
Research Equipment, $3,074,278
ED & Tech Trans, $2,898,042
Research Projects, $8,882,387


Fy 2007 - 2014
Funding Sources Year to Date:
By Dollar Amount
$6,162,946
$6,714,233
$4,644,910
$2,106,632
$17,110,400
$246,842
$1,541,063
$318,727
Federal
State
Unviersity
Industry
Local
Inkind
NCHRP



Fy 2007 - 2014
Funding Sources Year to Date:
By Percentage
17%
18%
13%
6%
46%
1%
4%
1%
Federal
State
Unviersity
Industry
Local
Inkind
NCHRP

Funding Sources and Expenditures

Amounts and Sources of Funding: July 1, 2006–June 30, 2014

Seq. No.	Non-Federal * Source	Amount	UTC	Total
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	$ 1,260,796	$ 900,000	$ 2,160,796

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	$ 211,841	$ 165,000	$ 376,841
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	$	20,005	$	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	$	186,170	$	93,085	$	279,255
ETT280	Industry	$	199,002	$	99,501	$	298,503
R281	MoDOT	$	39,500	$	39,500	$	79,000
R282	MoDOT	$	48,887	$	31,238	$	80,125
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	$	149,059	$	97,600	$	246,659
R295	MoDOT	$	140,410	$	140,000	$	280,410
R296	Bell Helicopter	$	50,000	$	50,000	$	100,000
R297	MS&T-Geo	$	27,708	$	13,921	$	41,629

R298	CDOT	$ 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/UM-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	$ 330,626.88	$ 129,809	$ 460,436
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	IRC	$ 140,000	$ 140,000	$ 280,000
R321	IRC	$ 120,000	$ 120,000	$ 240,000
R322	IRC	$ 110,000	$ 110,000	$ 220,000
R323	MS&T-EngMgt	$ 177,193	$ 177,193	$ 354,386
ETT324	MoDOT	$ 218,288	$ 218,288	$ 436,576
ETT325	Industry	$ 427,459	$ 195,200	$ 622,659
R326	NDOT - UNLV	$ 107,937	$ 107,937	$ 215,874
R327	Ameren	$ 10,661	$ 20,000	$ 30,661
R328	NDOR - UNL	$ 149,778	$ 210,612	$ 360,390
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	$ 263,485	$ 528,485
R333	MS&T - CE - GU	$ 123,476	$ 128,368	$ 251,844
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	$ 11,643	$ 16,052	$ 27,695
R340	MS&T - CompSci	$ 16,052	$ 16,052	$ 32,104
R341	MS&T - ECE	$ 26,055	$ 26,052	$ 52,107
R342	MS&T - CE	$ 12,738	$ 16,052	$ 28,790
R343	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R344	MS&T - CE	$ 11,082	$ 11,098	$ 22,180
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	$ 16,054	$ 16,052	$ 32,106
R349	MS&T - CE	$ 12,539	$ 12,539	$ 25,078
R350	MS&T - Geo	$ 9,469	$ 9,450	$ 18,919
R351	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R352	MS&T - CE	$ 16,052	$ 16,052	$ 32,104
R353	MS&T - CE	$ 16,032	$ 16,052	$ 32,084
R354	MS&T - CE	$ 19,753	$ 23,203	$ 42,956
ETT355	AMAE - MSC	$ 22,453	$ 22,417	$ 44,870
R356	UAF-CE	$ 56,205	$ 56,203	$ 112,408
R357	FYFE	$ 49,960	$ 49,660	$ 99,620
R358	UM - RB	$ 10,197	$ 10,197	$ 20,394
R359	UM - RB	$ 9,483	$ 9,483	$ 18,966
R360	MS&T - ECE	$ 25,924	$ 25,924	$ 51,848
R361	MS&T- CIES	$ -	$ 124,632	$ 124,632
ETT362	MS&T - CIES	$ -	$ 15,273	$ 15,273
R363	MoDOT	$ 220,713	$ 234,444	$ 455,157
R364	MS&T - Geo	$ 11,238	$ 11,237	$ 22,475
R365	MS&T-EngMgt	$ 30,788	$ 22,858	$ 53,646
R366	TxDOT - UT Austin	$ 105,523	$ 105,523	$ 211,046
R367	MS&T-Geo	$ 3,000	$ 3,000	$ 6,000
RE368	MS&T - CE/VPR	$ 105,000	$ 105,000	$ 210,000
R369	MoDOT	$ 3,958	$ 3,958	$ 7,916
Facilities & Admin. Indirect Costs			$ 2,255,694	$ 2,255,694
	TOTAL	**$ 19,628,721**	**$ 17,110,400**	**$ 36,739,121**

Legend:

AHDT=Arkansas State Highway and Transportation Department
AMAE - MSC = American Mechanical and Aerospace Engineers - MSC Software and Dassault Systems
CDOT=California Department of Transporation
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 Scholrships - Pre-College Programs
IRC - Icelandic Road Association
ISU=Iowa State University
KH=Knight Hawk
LGA=Leica Geosystems Advantage
MODOT = Missouri Department of Transporation
MODOT/WCM = Missouri Department of Transporation & Washington County Missouri
MS&T DCE = Missouri Uniersity of Science & Technology-Distance & Cont. Education
MS&T GS&E = Missouri Uniersity of Science & Technology-Geological Science & Engineering
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 Engineering
MS&T-EngMgt = Missouri University of Science and Technology-Engineering Management
MS&T -CE - UG = Missouri Uniersity of Science & Technology - Civil Engineering - Ghent University
MS&T ME = Missouri Uniersity of Science & Technology-Mining Engineering
MS&T MRC = Missouri Uniersity of Science & Technology-Materials Reserach Center
MS&T MAE = Missouri Uniersity of Science & Technology - Mechanical & Aerospace Engineering
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 - Univesity of Nevada, Las Vegas
NDOR- UNL = Nebraska Department of Roads - Univesity of Nebraska-Lincoln
NYSDOT=New York State Depart. of Transporation
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-Reserach 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

NUTC News / The Bridge Newsletters

news

MISSOURI S&T

CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY

Summer 2013: Vol. 8 | Issue 1

From the desk of the Director

Missouri S&T mascot Joe Miner, Summer 2013

As summer activities move into full swing on the Missouri S&T campus, so are the endeveours of the CTIS staff and researchers. One indicator of these activities is the network of research collaborators within the Center, which continues to grow. Over the past months, CTIS researchers have formed collabotarive projects with leading researchers at several universities, including 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. These joint projects have also led to several student exchanges.

The CTIS is currently working to finalize the details of the second annual Transportation Infrastructure Conference, which will be co-hosted with the Missouri Department of Transportation, and held in Jefferson City, MO on September 13, 2013. Please mark your calendars. The conference will highlight field implementation projects of innovative technologies in the transportation industry. Further details of this event will be announced soon.

In this issue:

FEATURED PROJECT:
Field implementation of recycled concrete aggregate – Mississippi River Bridge project

- Kamal H. Khayat, Professor, Dept. of Civil, Architectural and Environmental Engineering, Missouri S&T

Figure 1. General View of the Ramp Approach with the Reference Section Already in Place

Due to the increasing rate of demolition, it is essential to effectively reuse demolition waste in order to conserve the nonrenewable natural resources. Decreasing natural aggregate resources, as well as increasing problems with waste management, ecological hazards, landfill limitations, and increasing distances between the natural resources and consumption markets, support the idea of using recycled concrete as aggregate for new concrete production. As a result, the idea of incorporating recycled concrete aggregate (RCA) in concrete production, has emerged.

In February 2013, researcher from Missouri S&T started a study with the Missouri Department of Transportation (MoDOT) on the diesgn and monitoring of the performance of concrete made with RCA for use in pavement. The project involved field evaluation of three selected concrete mixtures made using RCA in pavement construction that would be part of the Mississippi River Bridge (MRB) construction project in downtown St. Louis. The field demonstration project involved the construction of a 22.5 ft wide ramp approach (outside lane and shoulder) from the Cass Ave. stub out to the EB Parkway Bridge over I-70. The first part of the section was used to cast the control pavement made with conventional concrete. The experimental RCA sections were cast afterwards up to the end of the length of the lane and shoulder in three different sections. Approximate volume of 600 cubic yards, including three experimental concrete mixtures and the reference one, were incorporated in this field evaluation.

- Continued on Page 4 -

FEATURED PROJECT:

MoDOT funds pavement preservation project

- David Richardson, Assoc. Professor, Dept. of Civil, Architectural and Environmental Engr., Missouri S&T

The Missouri Department of Transportation (MoDOT) has funded a project with the University of Missouri to enhance its pavement management system. The project is focusing on the development of a pavement maintenance process that will allow for a selection of appropriate maintenance treatments based on optimization of performance and cost at the project level. The total project funding is $1.5 million, including matching funds from the Center for Transportation Infrastructure and Safety (CTIS) and the University of Missouri at Columbia. Seven faculty and research staff members from the Rolla and Columbia campuses include project PI David Richardson and co-PI's Michael Lusher, Ronaldo Luna, Lesley Sneed, Neil Anderson, and Columbia campus co-PI's Brent Rosenblad and Andrew Boeckmann. Eight graduate and undergraduate students are participating as well.

Figure 1. Hamburg Rutting and Stripping Test Performed on Asphalt Mixture

The two year project is comprised of the following six Tasks.:
Task 1: mining of MoDOT historical data and production of data for further assessment;
Task 2: development of pavement performance models and pavement treatment models;
Task 3: assessment of available non-destructive pavement evaluation (NDE) techniques;
Task 4: field use of several promising non-destructive pavement evaluation techniques;
Task 5: evaluation of maintenance materials, and the development of pavement treatment triggers, and a selection process of candidate treatments; and
Task 6: creation of a re-calibration process for models and triggers.

RESULTS TO DATE INCLUDE:

- **Task 1:** Most of the various and fragmented repositories of MoDOT pavement performance data (pavement distress and smoothness), traffic data, and physical attributes (plans, etc.) have been identified, and researchers have learned how to retrieve, augment, and verify the accuracy of the information. Data continues to be accessed.

- Continued on Page 4 -

Field implementation of recycled concrete aggregate (continued from page 2)

Testing included fresh concrete properties (slump, air content, and unit weight), mechanical properties (compressive strength, splitting tensile strength, flexural strength, and modulus of elasticity) durability (freeze/thaw resistance, permeability, abrasion resistance and permeable void volume), as well as autogeneous and drying shrinkage. The structural health monitoring of optimized concrete mixtures made with 30% and 40% RCA replacements is assessed using vibrating wire strain gages (VWSG) embedded in the concrete pavement to monitor the long- term deformation.

Figure 2.
Casting pavement sections with RCA-made concrete

The expected result from this study will provide guidelines for evaluating, selecting, and specifying RCA concrete. These guidelines will provide MoDOT and design engineers with informtion to design, test, and implement RCA in transportation-related infrastructure.

MoDOT funds pavement preservation project (continued from page 3)

RESULTS TO DATE (continued):

- **Task 2:** Several pavement families have been devised which are based on pavement type (asphalt, concrete, or composite) and traffic level. Based on data produced from Task 1, various models are being developed for each family which will be used to learn how various types of pavements and treatments have performed in terms of smoothness and distress. This knowledge will lead to the ability to predict the life expectancy of various treatments.
- **Task 3:** A variety of NDE techniques and types of equipment have been evaluated. The results are being fed into Task 4.
- **Task 4:** Ten sites have been identified in MoDOT's highway system to be tested using the NDE techniques recommended by Task 3: penetrating radar, surface waves, electrical resistivity tomography, and falling weight deflectometer) along with several invasive methods (coring and dynamic cone penetrometer). Five of the site evaluations have been completed.
- **Task 5:** A variety of asphalt maintenance mixtures have been identified for longevity testing in Missouri S&T's Bituminous Laboratory, and several evaluations have been completed. Use of MEPDG (Mechanistic-Empirical Pavement Design Guide) software is also being evaluated for the possible prediction of pavement performance.
- **Task 6:** The work of this task will commence when the results of the other five tasks develops more fully.

FEATURED PROJECT:
Influence of mixing procedure on the robustness of self-consolidating concrete

- Dimitri Feys, Asst. Professor, Dept. of Civil, Architectural and Environmental Engineering, Missouri S&T

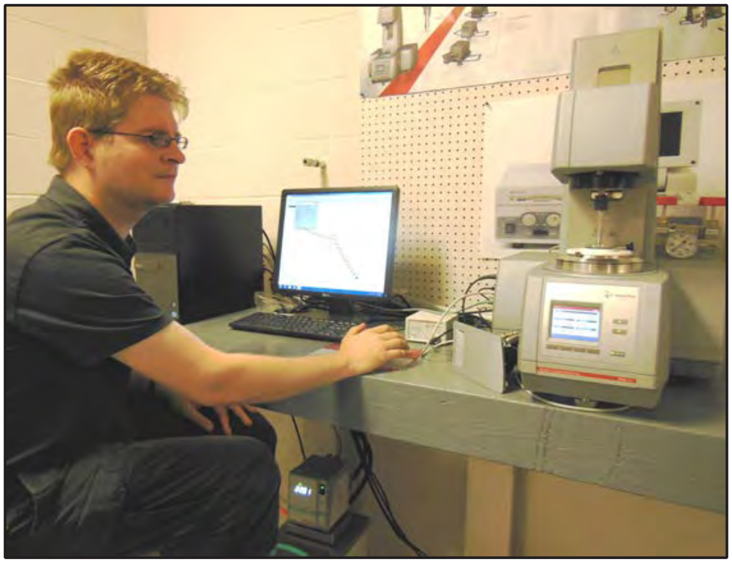


Figure 1. Dr. Dimitri Feys Testing Cement Paste using Anton-Paar MCR 302 Rheometer

Self-Consolidating Concrete (SCC) is a relatively new, very fluid concrete type. As a main advantage, this concrete does not require any external form of consolidation, allowing contractors to increase speed of construction and to reduce labor use. Despite the increased material unit cost, money can be saved on time of construction, re-allocation of labor, and reduction of the need to consolidate and finish the concrete. However, SCC has not yet experienced a major break-through in the construction industry, partly because its fresh properties are sensitive to small changes in the mix design and the mixing procedure (e.g. an unnoticed change in sand moisture content), especially compared to normal concrete. In collaboration with Ghent University in Belgium, the researchers at Missouri S&T are investigating ways to increase the robustness of SCC: i.e. to decrease the sensitivity of the properties to small changes in mix design and mixing procedure. While Ghent University investigates several moisture regulating additions (such as super-absorbent polymers), Missouri S&T researchers are investigating the influence of the mixing procedure on the properties of SCC. This involved the verification of the fresh properties of cement paste, mortar, and concrete by means of rheology. Rheology is the science of flow of materials, and cement-based materials are usually identified by two parameters: the yield stress, which is the stress needed to start the flow, and the plastic viscosity, which indicates the stress needed to accelerate the flow. The yield stress is related to the slump or slump flow of the concrete, while the plastic viscosity reflects its stickiness.
By changing different aspects of the mixing process, the magnitude of variations in rheological properties indicates the significance

- Continued Next Page -

Influence of mixing procedure on the robustness of self-consolidating concrete (continued)

of certain steps. The sequence of addition of the constituent materials, the mixing time, the mixing speed, the time of addition of the admixtures, etc. are varied to identify the most significant aspects of the mixing procedure. The magnitude of these variations is compared to the standard changes in mix design, which are the water and superplasticizer contents.

The research team aims to develop guidelines for mix design and mixing procedure to improve the robustness of SCC. In this way, the construction industry has more support to successfully develop and use SCC for infrastructure construction and repair. This collaboration with Ghent University can create new opportunities for international exchange with other European Universities in the growing field of transportation infrastructure.

The seventh international conference on case histories in geotechnical engineering was held in Chicago, Illinois from May 1 to 4, 2013 to commemorate the legacy of Professor Ralph B. Peck for introducing Observational Methods in Geotechnical Engineering. In a special session on this subject, six world renowned leaders who had worked with Professor Peck made technical and non-technical presentations. These included Gholamreza Mesri, Edward Cording, Elmo Di Biagio, Shamsher Prakash, Nancy Peck Young, and David Rogers.

A luncheon was held to recognize Dr. Shamsher Prakash for his achievements and to thank him for the direction he has provided for the Geotechnical Case Histories and Earthquake conference series over the past four decades. After serving the profession for more than 55 years, Dr. Prakash has decided to retire, and this conference was his last major professional activity on behalf of Missouri University of Science and Technology.

The conference was sponsored, in part, by the Center for Transportation Infrastructure and Safety.

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 with a new class, *Introduction to Materials: Concrete, Asphalt & General Materials*.

There are three main reasons a project fails prematurely: inadequate design, poor construction, and/or poor materials. This class focuses on materials and covers the basic properties of materials used in road and bridge projects. It also explains why it is important for an agency to care about materials. Agencies do not want to have to rebuild projects for many years. If an agency can add even five years to the life of a road, bridge or sidewalk, they may easily recoup the cost associated with the testing and inspection of materials. Time and money spent ensuring that quality materials are used will be returned with better performing and longer lasting products or in this case projects. Therefore, it is critical to determine the properties of materials correctly and what the proper frequency of testing is to ensure that what is being incorporated into a project meets the specification limits.

The following topics are covered:

- Acceptance methods for materials
- Concrete
- Asphalt
- General materials
- How to get testing done
- Having a quality plan
- Conflict resolution
- Specifying what you need

The first class is scheduled for August in Rolla. This will be a Level II class under the new structure in the Missouri LTAP "Show-Me" Road Scholar Program. Missouri LTAP is located at Missouri University of Science and Technology (Missouri S&T) and operates on funding provided by the Missouri Department of Transportation (MoDOT) and the Federal Highway Administration (FHWA). 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 the LTAP website at www.moltap.org.

FEATURED PROJECT:

Non-destructive evaluation of bridge decks

- Lesley H. Sneed, Asst. Professor, Dept. of Civil, Architectural & Environmental Engineering, Missouri S&T
- Neil L. Anderson, Professor of Geology, Dept. of Geological Sciences and Engineering, Missouri S&T

Figure 1.
Ground Penetrating Radar Unit Scanning Bridge Deck

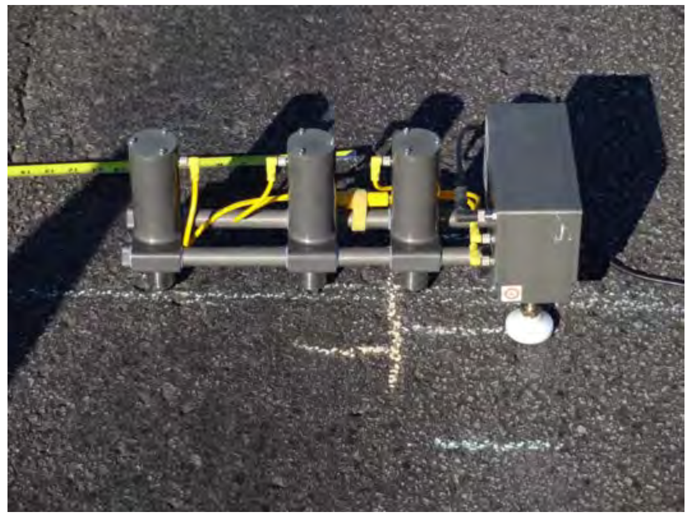


Figure 2.
Portable Seismic Property Analyzer

This project started in August 2012 through a joint effort between Dr. Lesley Sneed, Dr. Neil Anderson, and the Missouri Department of Transportation (MoDOT) with the objective of evaluating the application of non-destructive test methods to assess the structural condition of bridge decks. Missouri has over 10,400 bridges that are a part of the state highway system, which is the seventh largest total nationwide. Inspecting and maintaining these bridges requires a tremendous effort by MoDOT. This project is focused on evaluating the decks of 11 bridges in Missouri using Ground Penetrating Radar (GPR) and the Portable Seismic Property Analyzer (PSPA) to improve the overall quality and cost of bridge deck evaluation.

GPR is becoming more commonly used for the evaluation of many civil engineering endeavors. GPR transmits high-frequency electromagnetic (EM) waves into the structure of interest. The waves are then reflected back to the GPR unit after encountering an embedded object. For this project, the reinforcement in the bridge deck is used to reflect the EM waves back to the GPR antenna. Based on the amplitude and arrival time of the reflection, deterioration levels of the concrete can be predicted. Using a ground-coupled GPR (**Figure 1**), an entire bridge deck can be scanned in a few hours.

Another non-destructive tool used in this project is the PSPA, shown in **Figure 2**. The PSPA device induces high frequency seismic waves in the structure and then records the return of the waves using two accelerometers. The PSPA can be used to locate areas of delamination, or large voids in the concrete, as well as to determine the seismic modulus of the concrete. Data acquisition for each test location takes around one minute.

In order to determine the ability of the GPR and PSPA to predict deterioration, six to ten cores were taken from each bridge deck investigated. These cores have been carefully examined and documented for visible signs of deterioration. Chloride ion tests are

- Continued Next Page -

Non-destructive evaluation of bridge decks (continued)

also being performed on the cores to determine how the intrusion of deicing salts and the resulting concrete deterioration correlates to the GPR data. Additionally, four of the eleven bridges scanned are currently undergoing hydro demolition, where the deteriorated concrete is removed using high pressure water jets and then replaced with new concrete. With the help of Dr. Norbert Maerz at Missouri S&T, the bridges were scanned with LIDAR to determine the volume and location of deteriorated concrete removal. The LIDAR results are being compared to the GPR and PSPA results to determine the accuracy of the deterioration predictions (**Figure 3**).

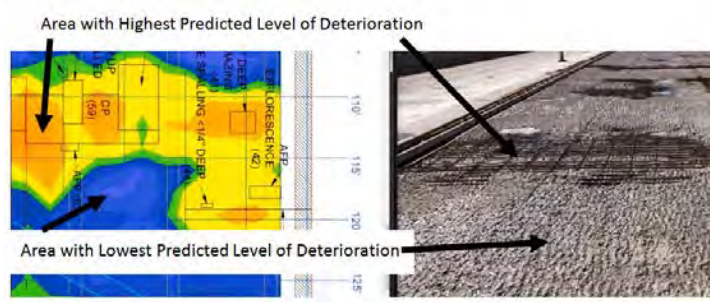
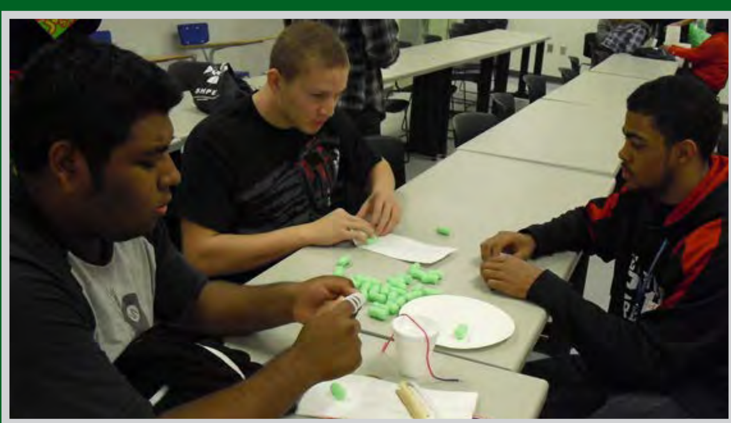


Figure 3.
Ground Penetrating Radar Deterioration Predictions (Left) versus Bridge Deck after Hydro Demolition (Right)

Upcoming Outreach Activities



The CTIS is proud to co-sponsor several outreach activities. These programs are designed to increase the number and diversity of students prepared to enter college and successfully pursue science, technology, engineering and math degrees. For more information about any of our upcoming Outreach Events, please contact our Student Diversity, Outreach and Women's Programs Office at 573-341-4212; sdowp@mst.edu

Upcoming Events	
Hit the Ground Running Summer Enrichment Program	July 7th - 26th 2013
Fall Si Se Puede	November 2013
National Society of Black Engineers Pre-College Initiative	February 2014

news
MISSOURI S&T
CENTER FOR TRANSPORTATION INFRASTRUCTURE AND SAFETY
Fall 2013: Vol. 8 | Issue 2

From the desk of the Director

CTIS Concrete Batching Plant

A new, state-of-the-art high sheer dual-mixer concrete batching plant is the latest addition to the research facilities available to CTIS faculty and students. The plant is currently being assembled and installed and is scheduled for completion by the end December. CTIS Director Dr. K. Khayat envisions this batching plant being permanently housed in the Butler-Carlton Hall Advanced Construction Materials Laboratory, a building expansion project that has been identified in the Civil, Architectural and Environmental Engineering Department VISION 2020 strategic plan.

CTIS is pleased to report that the second annual Transportation Infrastructure Engineering Conference, held in Jefferson City, MO at the Capitol Plaza Hotel on September 13, 2013, was another great success for the Center. The conference was chaired by CTIS Director, Dr. K. Khayat and co-chaired by Mr. William Stone, the Research Administrator of Missouri Department of Transportation. 135 people attended the event. The event will be held again the Fall of 2014 on the Missouri S&T campus.

In this issue:

FEATURED PROJECT:

Automated measurement and control of concrete properties in a ready mix truck

- Kamal H. Khayat, Professor of Civil, Architectural and Environmental Engineering, Missouri S&T
- Nicolas Ali Libre, Visiting Scholar, Center for Infrastructure Engineering Studies, Missouri S&T

Figure 1. Missouri S&T research team at Ozinga Ready-Mix Concrete in Chicago, IL

This study, initiated in July 2013, aimed at investigating the efficiency of an automated system, developed by VERIFI LLC, in managing fresh properties of concrete in the ready mix industry. VERIFI is an automated system that measures and records the properties of fresh concrete in real-time in a truck mixer. The system is also able to maintain the slump at target value by automatically adding water and/or a high range water-reducing (HRWR) admixture to maintain the targeted slump consistency of the concrete during concrete transport and delivery within the predefined allowable water-to-cementitious ratio (W/CM) limit. The project was undertaken in collaboration with Dr. Eric Kohler and Dr. Ezgi Yurdakul of the VERIFI LLC., Mr. William Stone of MoDOT, Mr. Paul Ozinga and Mr. Scott Kelly of Ozinga RMC, Inc. in Chicago.

In this research, 20 batches of concrete with six different mixture proportions were examined to evaluate the efficiency of the VERIFI system in maintaining slump consistency of concrete resulting from water addition or the incorporation of HRWR admixture. The investigated concrete mixtures are targeted for pavement, beam and column and municipal use and had slumps ranging between 2 and 10 in. and 28-day compressive strengths of 3500 to 8750 psi.

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Automated measurement and control of concrete properties in a ready mix truck (continued)

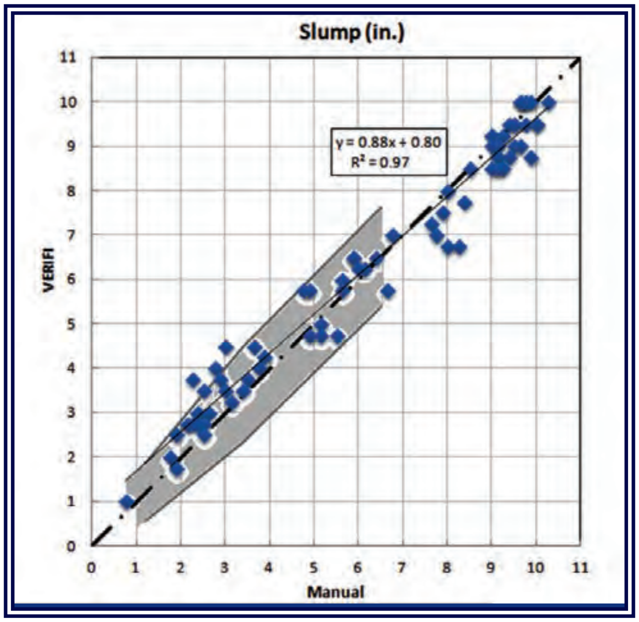


Figure 2. Manual slump measurement vs. Verifi measurement (acceptable precision in ASTM C143 are shown in gray)

For each batch, concrete was sampled at 30-minute intervals up to 90 minutes and tested for slump, temperature, air content, unit weight, water content using the microwave method, bleeding, and rheology. Cylindrical concrete specimens were cast and tested for compressive strength at 3 and 28 d (or 3 and 14 d for IDOT mixtures).

The results of this research indicate that the VERIFI system is able to accurately measure concrete slump and temperature in the truck for the wide range of concrete mixtures. The accuracy of the VERIFI system in measuring slump and temperature of concrete in a truck mixer is shown to be 0.5-in. and 1.5 °F, respectively. This is within the acceptable variation limit stated in ASTM C143 and ASTM C1064. The VERIFI system is shown to be capable of adjusting slump automatically to maintain the target slump by adding water and/or water-reducing admixture.

The mean and standard deviation of the difference between the slump of concrete at delivery time and target slump are 0.66 in. and 0.42 in., respectively. Adding water in transit instead of in one single addition at the jobsite to maintain the slump within the specified range does not negatively affect concrete performance. The compressive strength of concrete was higher when water was added gradually during the transportation vs. single addition of water at the job site.

FEATURED PROJECT:

Functionally graded biomimetic energy absorption concept development for transportation systems

- Victor Birman, Engineering Education Center in St. Louis, Professor, Dept. of Mechanical Engineering, Missouri S&T

This research project employed the concept observed in biology extrapolating it to a development of energy and shock absorbent devices in transportation systems. In previous biological research, the PI and his colleagues noted a low-stiffness "band" in the attachment between tendon and bone and hypothesized that this band serves as an energy absorbing component in the attachment. This is in line with the observation that toughness of both engineering and biological materials increases with the decrease in their stiffness (so-called "banana curve"). In shock absorbers developed for transportation systems the concept utilizing a compliant energy-absorbent material may be combined with functional grading of the material, so that a higher stiffness, higher strength section provides the necessary strength, while a lower stiffness section serves to absorb the maximum amount of energy.

The structure developed in the present study consists of a cylindrical foam shell embedded within relatively rigid layers protecting the foam from environment and accidental loads. Static or dynamic loading is applied in the axial direction (**Figure 1**). The grading in the radial direction is such that the mass density and stiffness are power functions of the radial coordinate. Such situation can be found in variable-density open-cell or closed-cell foams. It is shown that a more efficient design is achieved with a denser and stiffer material adjacent to the inner surface and a less dense, more compliant material at radial locations approaching the outer surface.

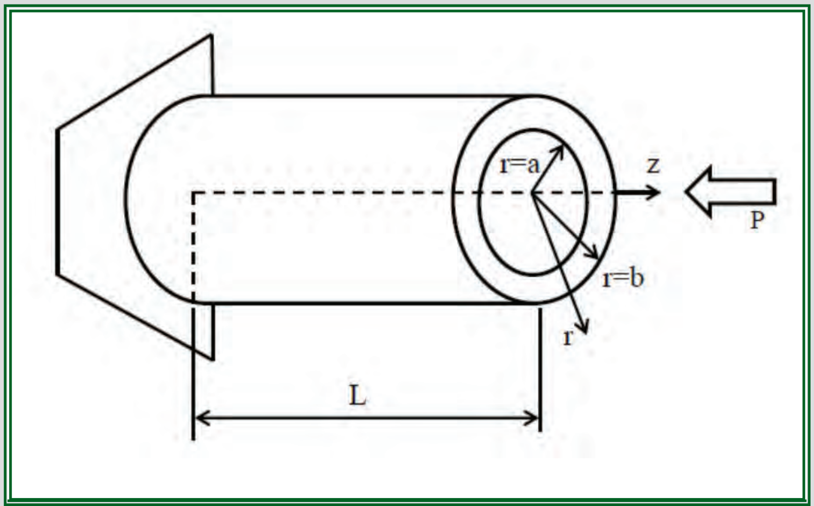


Figure 1. Foam cylinder loaded by axial force. The inner and outer boundaries are supported by stiffer layers providing environmental and accidental loading protection.

- Continued Next Page -

Functionally graded biomimetic energy absorption concept development for transportation systems (continued)

The exact solution developed in the study for stresses and energy absorption is rather unique both accounting for functional grading as well as satisfying the governing equations of anisotropic elasticity without any simplifying assumptions that are often adopted in problems involving the analysis of functionally graded structures. Moreover, the micromechanical aspect of the problem is exactly satisfied, i.e. the local constitutive equations for foam reflect the actual grading in the radial direction.

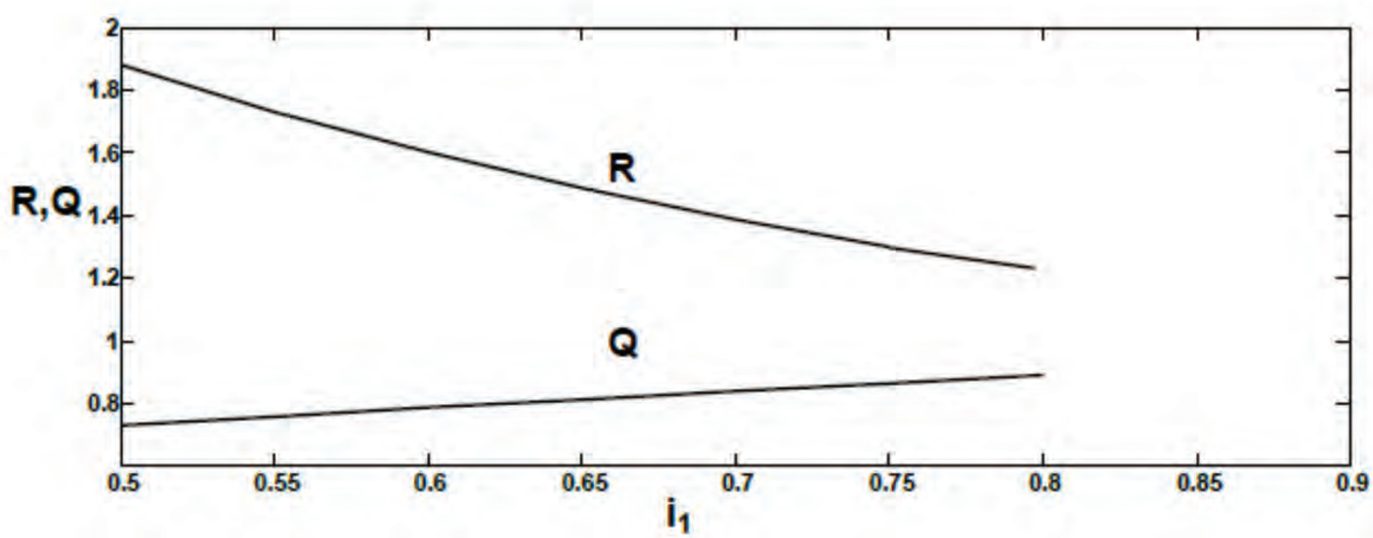


Figure 2. Example of the effect of the material density at the inner radius (nondimensional quantity along the horizontal axis) on the normalized energy absorption (Q) and normalized weight (R). A lower mass density results in higher energy absorption and lower weight of the device.

The solutions are developed for axial static loading as well as for the case where the load is a harmonic function of time. The optimization implies that the grading of foam should be such that the stresses at any location do not violate the strength requirements, while the energy absorption is maximized and the weight is minimized compared to a homogeneous cylinder with the a constant material density.

As a result of the numerical analysis it is demonstrated that a relatively higher energy absorption and weight savings over a homogeneous cylinder are achievable in a functionally graded cylinder (**Figure 2**). An overall reduction of the stiffness throughout the radial coordinate is beneficial to the energy absorption and it also result in a lighter cylinder. Parametric analysis for static and dynamic cases can be based on the explicit solution demonstrated in the study.

OUTREACH ACTIVITIES

"Hit the Ground Running" Summer Enrichment Program

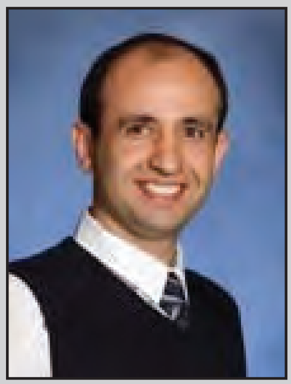
July 7–26, 2013

This program is for all Student Diversity Program (SDP) scholarship recipients. For three weeks, the SDP scholars take classes in mathematics, english and chemistry. The benefits are tremendous; not only do the students have an academic head start when the fall semester begins, but they also become a team. Rigorous study prepares them for a demanding engineering curriculum, and they experience life in a dorm away from friends and family. Along with academics, scholars learn about career opportunities that await them once they earn their degree. Special seminars are hosted by industry representatives and engineering department chairs that focus on career and educational opportunities for minority students. The proven track record of this program on the Missouri S&T campus has sparked a similar program for minority freshman engineering students. Students are surveyed at the end of the program with regards to how their degree could contribute to transportation sustainability and future developments.

2013 CTIS Student of the Year

Mahdi Arezoumandi

For the past 22 years, the U.S. Department of Transportation (USDOT) has honored an outstanding student from each University Transportation Center (UTC) at a special ceremony held during the Transportation Research Board (TRB) Annual Meeting. This year, the Center for Transportation Infrastructure and Safety has selected Mr. Mahdi Arezoumandi as its Outstanding Student of the Year. He will be recognized at the TRB Conference in January along with the other UTC Outstanding Students of the Year. The award ceremony will take place on Saturday, January 11, 2014 in Washington, D.C.



Mahdi Arezoumandi
2013 CTIS Student of the Year

Student Bio: Mahdi Arezoumandi is a PhD candidate and graduate research assistant in the Department Of Civil, Environmental And Architectural Engineering at Missouri University of Science and Technology, Rolla, MO. The topic area of his graduate research is Shear and Fracture Behavior of High Performance Concretes. During his graduate scholarly activities, Mahdi was advised by Dr. Jeffery Volz. He received his B.S. and M.S. from Amirkabir University, Tehran, Iran.

Mr. Arezoumandi is a friend of TRB AFF30 committee (Concrete Bridges), TRB AFN10 committee (Basic Research and Emerging Technologies Related to Concrete), and TRB AFN20 committee (Properties of Concrete). He is also a member of ACI committee 408 (Development and Splicing of Deformed Bars) and ACI committees 445 (Shear and Torsion). His research interests include structural behavior of high performance concrete. Mr. Arezoumandi received the Nevada medal for distinguished graduate student paper in bridge engineering (2013) in addition to post tensioning institute scholarship (2013) and Chi Epsilon scholarship (2012).

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

FEATURED PROJECT:

Highway rock fall measurements using LIDAR

- Norber Maerz, Associate Professor, Department of Geological Science and Engineering, Missouri S&T

Figure 1. Drilling and installing monitoring wells on the south site.

Rock falls on highways, while dangerous, are unpredictable. Most rock falls are of the raveling type and not conducive to stability calculations, and even the failure mechanisms are not well understood. LIDAR (LIght Detection And Ranging) has been shown to be able to measure the volumes of raveled rock as small as 1cm when repeatedly scanned over a period of time. Rock fall volumes can be correlated to external stimuli such as rainfall, seismic activity, and freeze thaw cycles to determine trigger for failure. Previous research has established a tentative relationship between rock fall and both rainfall and number of freeze/thaw cycles. The relationship is complex and implies that rainfall is most potent in the winter months. The main focus of the current research is to measure the groundwater pressure near the rock face. This is because failures are triggered not directly by rainfall, but when the groundwater pressures build up behind the rock face as a result of the infiltration of rainfall, and most likely the groundwater is retained by ice dams that restrict the drainage of groundwater. To that end two sites have been selected along highway 63 north, a north and a south sites. Both sites show indications of raveling failures, and evidence of groundwater release along the rock face. At each site multiple monitoring wells were installed (**Figure 1**). Pressure transducers will be installed in these wells. LIDAR measurements (**Figure 2**) will be used to quantify the rock fall while water pressure, rainfall, freeze-thaw cycling, and blasting records from the nearby quarry will be used to correlate to the rock fall quantities/episodes.

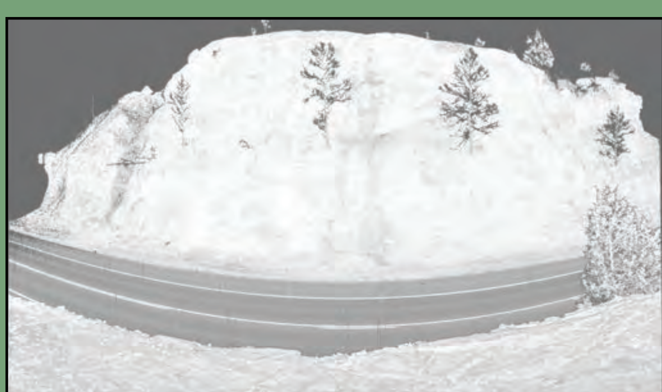


Figure 2.
LIDAR scan of the Highway 63 north site.

FEATURED PROJECT:
Missouri S&T formula electric racing

- Ryan S. Hutcheson, Asst. Teaching Professor, Mechanical and Aerospace Engineering, Missouri S&T

Figure 1. The Missouri S&T Formula Electric Racing Team.

Thanks to the support of CTIS and its other sponsors, Missouri S&T Formula Electric Racing is well on its way to competing in its first race. The team is currently building their entry for the 2014 Formula SAE Electric competition (http://students.sae.org/cds/formulaseries/electric/). This Society of Automotive Engineers sponsored student design competition will host 20 teams from universities across the world. The teams will compete in dynamic events with their electric racecars including a single lap autocross-style race, a figure 8 skidpad to test lateral acceleration, a standing acceleration event and most significantly a 20km endurance race. The team must also compete in static events including a design review with industry and racing professionals, a cost and manufacturing analysis and a business presentation.

The S&T team has completed mechanical and electrical design for their 2014 entry and is busy manufacturing their frame and chassis systems. Acquisition of all major components and materials has been completed. The team has received their 100 kW electric motor (which has to be limited to 85 kW per competition rules), motor controller and lithium polymer battery pack components. Battery pack construction will begin once classes resume in the spring 2014 semester.

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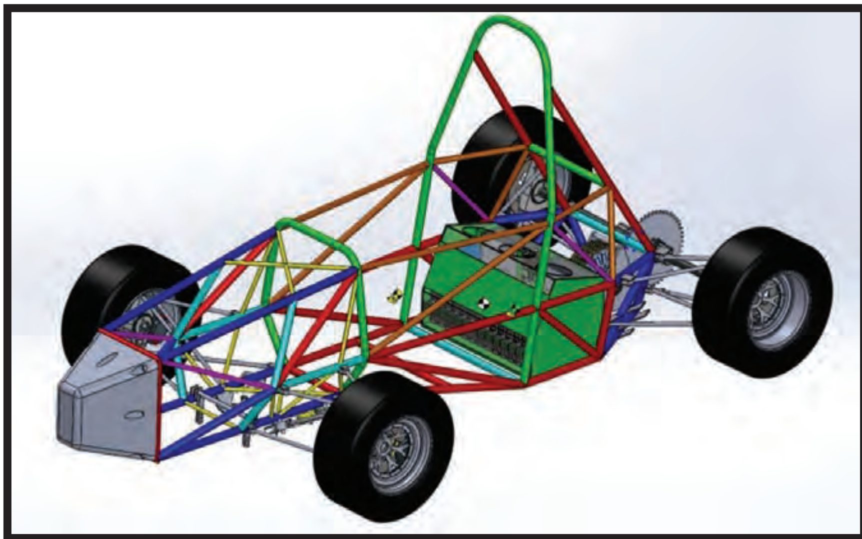

Figure 2. The 2014 Design Model.

The team expects to be driving the electric racecar during late March. Driver training, vehicle setup and endurance testing will continued up to the 2014 competition to be held June 18-21 in Lincoln Nebraska.

In addition to the design and construction of their 2014 car, the team has been busy promoting awareness of electric vehicle technology through a series of design seminars to undergraduate students and a summer camp for high school students. The 2013 Formula Electric Summer Camp hosted 30 students from high schools across the United States. The students were instructed in the basics of electric vehicle design and were required to design and construct a prototype frame for an electric racecar.

The team appreciates the support of all its sponsors, and looks forward to a successful 2014 competition. More information about the team can be found at their website: minerracing.com.

Figure 3. 2013 Formula Electric Summer Camp.

Local Transportation News:

Fall Advisory Committee Meeting

The Missouri Local Technical Assistance Program is located at Missouri University of Science and Technology and operates on funding provided by the Missouri Department of Transportation (MoDOT) and the Federal Highway Administration. Missouri S&T's National University Transportation Center also supported the efforts of Missouri LTAP by providing 1:1 match funds to aid in MO-LTAP's services and deliverables through December 2013.

The Missouri LTAP team met with its Advisory Committee for the second time in 2013 on November 22 at Missouri S&T Havener Center for its fall meeting. The committee is made up of selected county commissioners, MoDOT and FHWA representatives, and individuals from various public agencies throughout the state. Eleven committee members attended along with the LTAP staff. Those members included Larry Benz, Patrick Bonnot, Mike Geisel, Stuart Haynes, Sean McGonigle, Bonnie Prigge, Bill Stone, Marc Thornsberry, and Skip Wilson. MO-LTAP was represented by Heath Pickerill, Director, Kristi Barr, Program Specialist, Doreen Harkins, Administrative Asst., and Nicole Annis, Graduate Assistant.

See the complete list of committee members on the next page.

The Advisory Committee provides input and feedback on strategic planning and program goals throughout the year. The intent of the committee is to assure that all four focus areas of the Work Plan are discussed and evaluated in response to client needs. The focus areas include safety, workforce development, infrastructure management and organizational excellence. The committee also discusses potential areas for program growth and how to improve the overall cost-benefit of the program while offering input on strategic planning.

Heath Pickerill, LTAP Director, opened the meeting by welcoming everyone. Pickerill then gave a summary of 2013 center activities. A total of 162 classes were offered, which was an increase from 134 classes in 2012. A total of 6,469 people attended training throughout the year. New classes offered included Communicating Effectively in the Workplace (Advanced Communication Skills), Comprehensive Winter Planning, Construction Documents 101, and Fall Protection & Personal Protective Equipment. Utility Road Zone Training was also offered in partnership with MoDOT in the northwest district. A second training is planned for February 2014 in the northeast district. In addition, a chip seal showcase

Fall LTAP Advisory Committee Meeting

Local Transportation News:

Fall Advisory Committee Meeting (con't)

was offered in three locations, which included Lebanon, Jefferson City and Chillicothe. The partnering program with MoDOT included a one to two hour classroom discussion led by Mike DeGraff with Vance Brothers Asphalt and a one to two hour on-site demonstration. The showcases were free to local agencies. Finally, there were several new Road Scholar Program Level I graduates in 2013 bringing the total to 129. There are now 404 participants representing 46 agencies.

A few of the discussion highlights from the meeting included training plans for 2014, the National LTAP/TTAP Conference being held in St. Louis July 21-24, and some new training ideas. Some of the new classes planned for 2014 include Bucket Truck Operation & Safety, Confined Spaces, Introduction to Materials: Concrete, Asphalt & General Materials, Forklift Operation & Safety and Trenching & Shoring. MO-LTAP will also partner with MoDOT to offer a right-of-way training. A few of the suggested topics for future training included blood borne pathogens, lockout/tag out, and low cost improvements for rural roads.

The meeting concluded with closing comments from each committee member. Several members commented on the increase in training numbers for 2013. It was also suggested to increase the number of consulting firms, city and county clerks, other administrators and private agencies that are contacted as a way of promoting the upper levels

Advisory Committee Meeting

of the Road Scholar Program. A copy of the minutes can be found under the About Us >> Committees link on the website, www.moltap.org. The next meeting will be held in spring 2014. If anyone has an interest in serving on the Advisory Committee, please contact Heath Pickerill at pickerillh@mst.edu or 573-341-7637. For more information on Missouri LTAP please visit the MO-LTAP website.

Current LTAP Advisory Committee

Benz, Larry
Cole County Public Works & MACTO
Bonnot, Patrick
MIRMA
DeLong, Tony
University of Missouri Extension
Foster, Ken
FHWA Missouri Division
Gano, Johnathan
City of Springfield
Geisel, Mike
City of Chesterfield Public Works & Missouri Chapter APWA
McCord, Bonnie
Vernon County
McGonigle, Sean
Missouri Association of Counties
Miller, John P.
MoDOT
Prigge, Bonnie
Meramec Regional Planning Commission & MACOG representative
Ross, Dan
Missouri Municipal League
Haynes, Stuart – alternate –
Sager, Greg
Platte County Public Works
Scheipeter, Gary
City of Clayton & APWA representative
Stone, Bill
Construction and Materials, MoDOT
Thornsberry, Marc
FHWA Missouri Division
Voss, Kenny
MoDOT
Cremer, Jeff – alternate –
White, Randy
Pioneer Trails Regional Planning Commission & MACOG representative
Wilson, James
District 3, MoDOT

news

Missouri S&T

Center for Transportation Infrastructure and Safety

Winter 2014: Vol. 8 | Issue 3

From the desk of the Director

Stone sculptures on snowy S&T campus

As 2013 comes to a close and a new year of opportunity and growth begin, CTIS Director, Dr. K. Khayat is very pleased to report the next step in the future of transportation research endeavors at Missouri S&T. The University has been selected to lead a consortium of four universities sharing in a new Tier-1 University Transportation Center. Missouri S&T will share this two-year grant with Rutgers University, Southern University, University of Illinois at Urbana-Champaign and University of Miami. *"We are honored to be selected to lead this effort,"* says Dr. Khayat. *"This consortium has the opportunity to do great things. We have assembled a wonderful team of researchers, staff and students — this grant will give them the opportunity to shine."* This new UTC, named RE-CAST (Research on Concrete Applications for Sustainable Transportation), will focus on developing the next generation of cement-based construction materials. *"The ultimate goal of the proposed research program is to fast-track the acceptance of these technologies and develop national standards and guidelines for their use for the reconstruction of the nation's infrastructure for the 21st Century,"* says Khayat.

In this issue:

FEATURED PROJECT:

Examining system dynamics to study maritime transportation system

- Dr. Suzanna Long, Asst. Professor, Engineering Management and Systems Engineering, Missouri S&T
- Dr. Heather Nachtmann, Professor, Industrial Engineering, University of Arkansas
- Lizzette Perez-Lespier, PhD Candidate, Missouri S&T
- Furkan Oztanriseven, PhD Candidate, University of Arkansas

Figure 1. U.S. Maritime System

In the last decades, a number of factors have re-shaped the shipping industry, including the growth of international trade, the emergence of new markets, and the development of multimodal supply chains. This has made Maritime transportation, defined as ocean and coastal routes, inland waterways, railways, roads, and air-freight, a critical part of the global supply chains and global freight transportation systems. The volume of maritime freight is steadily growing and the freight distribution getting more complex with time because of its many origins, destinations and supply chains. Due to the complexity and interconnectivity of the MTS system, traditional models limit the ability to evaluate all factors of the system. The feasibility of a system dynamics approach is considered to determine its ability to simulate maritime transportation and its integration between the different modes of transportation. In the initial phase of this research, an integrative literature review of applications of system dynamics in the maritime transportation system was conducted. This literature review was used to define research questions in an emerging area and evaluate a proposed methodology against the state of the literature in terms of rigor, efficacy, and ability to generate valid results.

The results of this early research provide an overview of the applicability of system dynamics models in the maritime transportation system and suggest a path to develop a system dynamic framework model.

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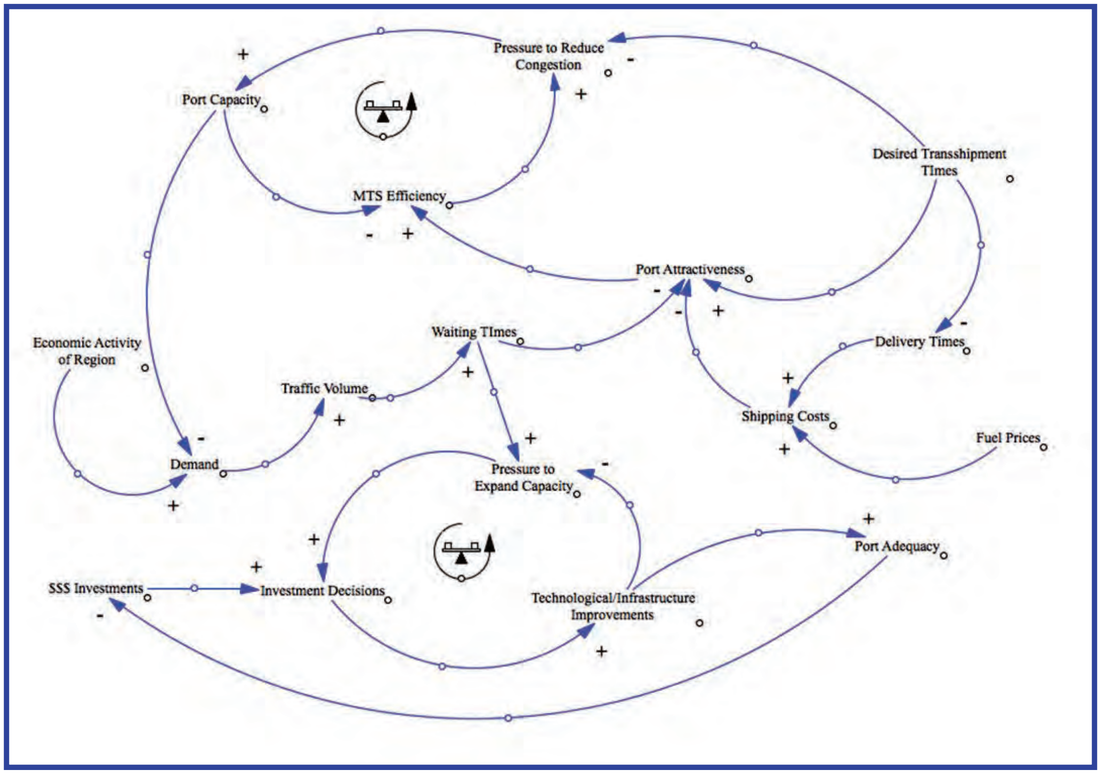

Figure 2. MTS Causal Loop Diagram

Further, results show that system dynamics has the ability of overcoming the drawbacks of time-series and statistical models currently in use. The system dynamics simulation takes causality into account, allows what-if scenario analysis, and can be adapted to fundamental changes in the system. Sensitivity analysis can be conducted within the model, which can help policy makers better analyze the outcomes of a policy change.

An initial framework model was built in order to understand the integration of system dynamics methodology into the maritime transportation field. The model shown in Figure 2 is a map of the MTS system. In the causal loop (map), variables are linked with arrows from cause to effect with a plus (+) or minus (-) sign at the end of the arrow to identify if the effect that each variable has on the other one is a positive or a negative one. This specific model forecasts the impact on system efficiency that investments in port infrastructure and maintenance of the maritime system will produce; these investments and maintenance are assumed to alleviate time delays, capacity and congestion disruptions and aid in the improvement of port attractiveness and port capacity. All variables are interconnected and have an impact on the system's overall efficiency. For example, depending on the input for 'desired transshipment times', even if the input is designed to produce the best possible (shorter), this will result in an opposite behavior in the 'pressure to reduce congestion'. Subsequently, the pressure congestion impacts the 'port capacity' positively and so forth. The loop continues with modifying decisions until the desired state of the system is achieved. At the end of the process, decision makers will benefit from understanding how these investments have an impact on the MTS's efficiency over time.

Preliminary system dynamics models may be combined with agent based modeling simulations in future research to better evaluate the change environment best suited for efficient movement of goods along the U.S. Maritime System.

FEATURED PROJECT:
Modelling the geomorphology of an active landslide

- Norber Maerz, Associate Professor, Department of Geological Science and Engineering, Missouri S&T

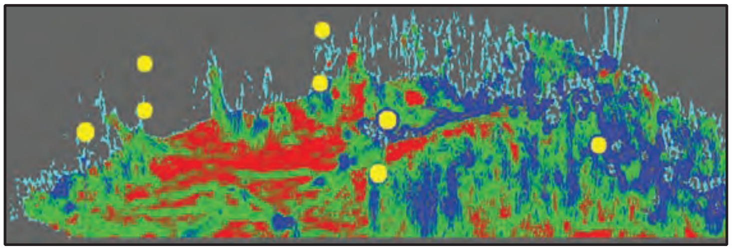

Figure 1. Development of a recursive sphere center finding algorithm on the LIDAR

Soft slope movement is a big problem near highways. Since the movement is not always predictable, having to inspect the slope visually is not necessarily the safest approach. If it can be done remotely with a laser scanner the observer will remain safe and may also be able to detect movement not readily noticeable, unlike tension cracks or scarp development.

The focus of this project is to determine millimeter/sub-millimeter movement within a slide body using high precision terrestrial LIDAR (LIght Detection And Ranging, a remote sensing technology that measures distance by illuminating a target with a laser and analyzing the reflected light) and artificial targets. The preliminary tests have used a smaller slope at a closer distance than the target slide in Branson, Missouri. The goal of the study is to model how a landslide deforms over time. Using different lengths of rebar (3, 4, and 5 feet) driven vertically into the slide area and two 4 inch Styrofoam balls placed onto each rebar in a network over the slide body, consecutive scans will be taken during the winter season. A total of 54 pieces of rebar with two balls each will be placed over the slide. An additional 6 pieces of rebar with one ball per piece will be used as control points and therefore placed outside of the movement area.

Using a sphere finding algorithm, the initial location of each ball will be recorded and referenced against all later scans. After several consecutive scans of the landslide area, a map will be generated

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Modelling the geomorphology of an active landslide (continued)

Figure 2. Test site in landslide in Branson MO. Rebar with 4" targets will be positioned on yellow markers (outside of the slide) for control, and at each intersection of the grid within the slide.

using displacement vectors to show how the slide body has deformed. Having two balls on each of the rebar and knowing the total length of the rebar a 3 dimensional model can be created, to not only measure downslope movements but also characterize the rotational movements.

To date, several test scans have been performed using varying distances and different LIDAR units. The raw data points have been analyzed in ArcScene to determine the magnitude of accuracy and scan point deviation.

Field Trip to Holcim, Inc.

Ste. Genevieve, MO

December 18, 2013

The CTIS organized a one day trip for faculty and students to visit the world's largest cement factory: Holcim, Inc., in Ste. Genevieve, MO. The plant produces 12,500 metric ton per day of cement and supplies this material to 22 states. It is one of the most environmentally-efficient cement plants in the Holcim Group. Ste. Genevieve, Missouri was chosen as the best site for this new plant for several reasons: a plentiful supply of good-quality limestone, a high-quality workforce, and good access to target markets via key transportation networks including waterway, rail and road which serves ten of the twenty largest cities in the United States.

FEATURED PROJECT:

Application of active microwave thermography to structural health monitoring

- Kristen M. Donnell, Asst. Professor, Dept. of Electrical and Computer Engineering, Missouri S&T
- Mohammad Tayeb Ghasr, Asst. Research Professor, Dept. of Electrical and Computer Engr., Missouri S&T
- Edward C. Kinzel, Asst. Professor, Dept. of Mechanical and Aerospace Engineering, Missouri S&T

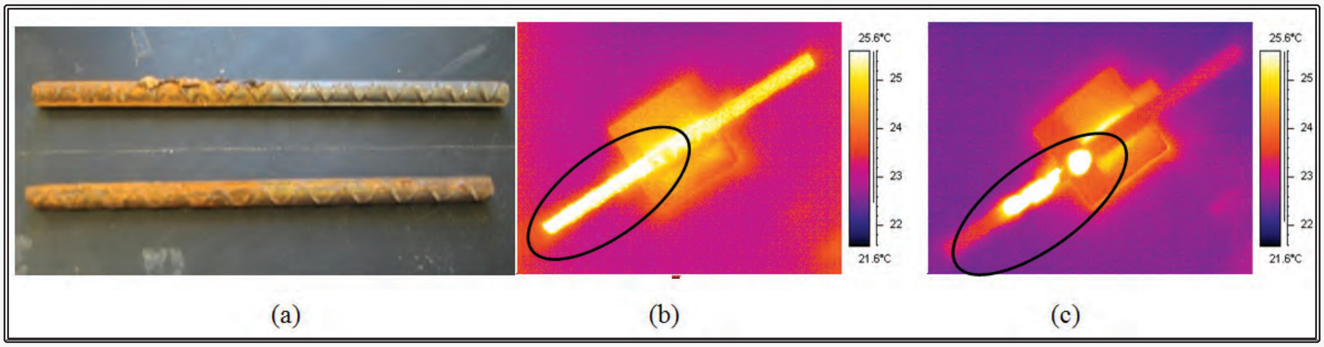

Figure 1. (a) Rebar with localized significant (top), and light corrosion (bottom). Thermal image of rebar with (b) light corrosion, and (c) localized corrosion.

Health monitoring of infrastructure is very important in the transportation and infrastructure industries. Many nondestructive testing (NDT) techniques have been applied for structural health monitoring including microwave NDT, ultrasound, thermography, etc. Due to the complex materials (composites, concrete, etc.) commonly used, it may be difficult to thoroughly inspect a structure using one method alone. Thus, hybrid NDT methods have been developed. Recently, the integration of microwave NDT and thermography, herein referred to as Active Microwave Thermography (AMT), has also been considered as a potential structural health monitoring tool. This hybrid method utilizes microwave energy to heat a structure of interest, and then the thermal surface profile is measured using a thermal camera.

Thus far, this project has focused on the application of AMT to detection of corrosion on reinforcing steel bars (rebars), and inspection of rehabilitated cement-based structures for delaminations under carbon-fiber-reinforced-polymer (CFRP) patches.

Detection of Corroded Rebar

To investigate the potential of AMT for detection of corroded rebar, two rebar samples were obtained; one with light corrosion along half of its length, the other with localized significant corrosion on a portion of its length. These rebar samples are shown above in **Figure 1a**. Each sample was exposed to microwave energy (frequency of 2.45 GHz) for 5 sec, and immediately following, imaged using a thermal camera, shown above in **Figure 1 b-c** (corroded area indicated in the black oval).

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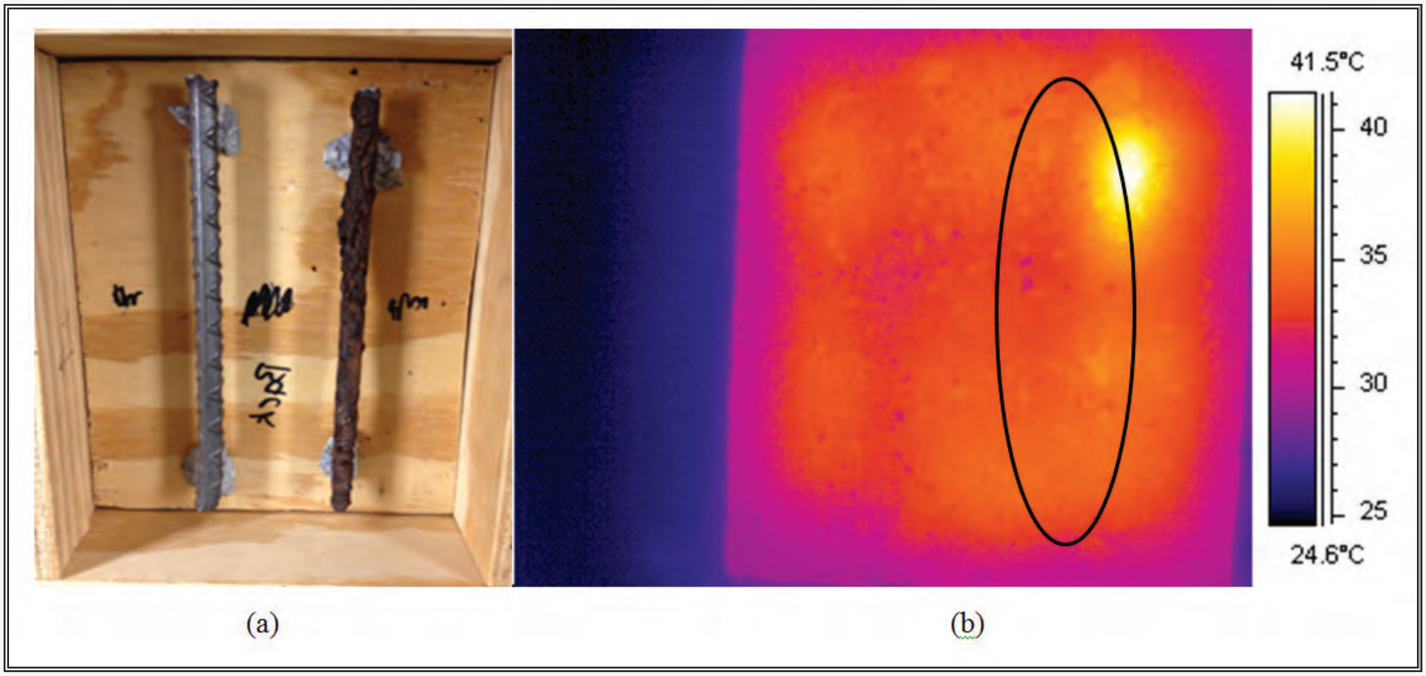

Figure 2. (a) photograph of clean (left) and corroded (right) rebar, and (b) thermal image of concrete block surface after microwave heating (location of corroded rebar indicated in the black oval).

As can be seen in **Figure 1b-c**, for both light and significant corrosion, the corrosion exhibited increased heating as opposed to the clean rebar. For the case of the lightly-corroded rebar, the temperature increase was nearly 600° mC (well above the sensitivity of the thermal camera used, 100° mC). In addition and as expected, more heat was generated in the localized significant corrosion (nearly 3000° mC), as compared to the light corrosion. While these results are quite encouraging, it is also important to more accurately replicate what may be found in practice. To this end, a concrete sample (dimensions of 17 × 15 × 5 cm^3) containing clean and corroded rebar embedded ~2.5 cm in the concrete was cast.

Measurements were performed using this sample as well. The sample mold and rebars are shown in **Figure 2a**. After allowing the sample to cure (~1 week) the sample was exposed to 15 sec of microwave energy. Then, using the same thermal camera as above, an image was captured of the sample, as shown in **Figure 2b**. Clearly (and as indicated by the black oval), the corroded rebar is detectable in the thermal image after microwave heating. The clean rebar is also evident in the image as well (left of the black oval), appearing as a lower-temperature line.

Delamination Detection

In order to study the potential of AMT for detection of delamination in rehabilitated structures, a coupled microwave-thermal simulation was conducted using CST Microwave Studio® and MPHYSICS Studio®. The simulation is completed in two parts; first, the electromagnetic response of the structure under test under planewave illumination is determined. Then, based on the electromagnetic response, the thermal response (i.e., heat generation and diffusion, etc.) of the structure is calculated. To begin, a small concrete sample with dimensions of 30×30×5 (cm^3), partially covered by a CFRP sheet, was considered. The CFRP sheet has dimensions of 20×20×0.2 (cm^3), and contains an offset delamination with cross sectional area of 4×4 (cm^2) and a depth of 2 (mm). The geometry of the structure is illustrated in **Figure 3** (see next page).

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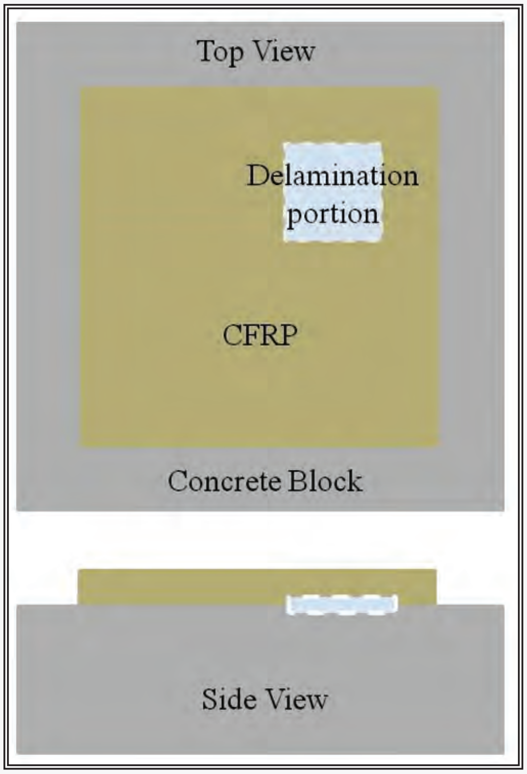

Figure 3. Top and side views of the SUT covered by CFRP.

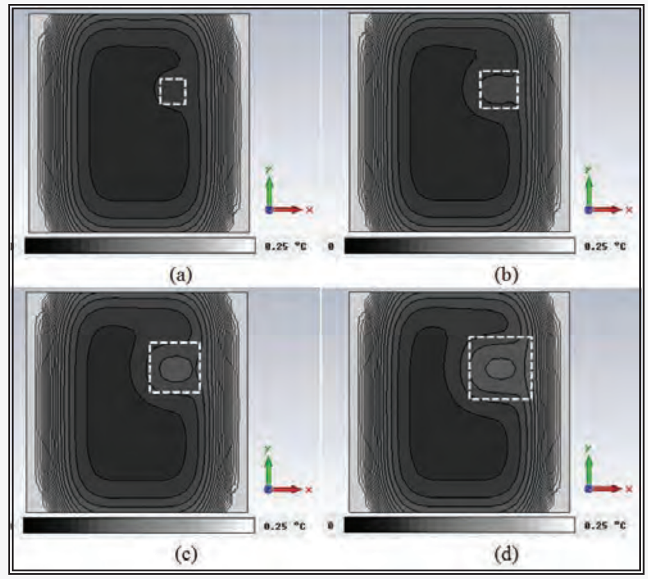

Figure 4. Surface temperature distribution for delamination dimensions of (a) 2, (b) 3, (c) 4, and (d) 5 cm (location of delamination is indicated by the white dashed line).

Under microwave illumination, currents will be induced in the CFRP and will operate as a heat source, adding to any dielectric heating that may occur (relative dielectric properties, εr, of the concrete are assumed to be εr = 10 – j4). The presence of a delamination will affect the thermal response of the structure resulting from the AMT-induced heat.

This simulation allowed the effect of delamination size on the temperature distribution to be studied. To this end, different cross-sectional areas of the delamination were considered, and the resulting change in temperature at the top surface of the CFRP analyzed. For these simulations, an incident power level of 50 (W) (frequency of 2.45 GHz) and microwave excitation time of 5 (sec) was assumed. The surface temperature profile for 4 different cross-sectional areas, 2×2 to 5×5 (cm^2), is shown below in **Figure 4**. A thermal measurement sensitivity of 10 mK is assumed for all cases.

As shown in **Figure 4**, the dimensions of the delamination clearly have an effect on the surface temperature distribution. For example, in **Figure 4a** (2×2 (cm^2) delamination), the temperature distribution is just beginning to provide an indication of the presence of the delamination. This indication becomes increasingly stronger as the delamination dimensions increase, as shown in **Figure 4c-d**.

Future Work

Thus far, the preliminary measurements and simulations indicate that AMT has significant potential as a new structural health monitoring tool. To continue the development of AMT, a small AMT system is currently under construction in the Applied Microwave Nondestructive Testing Laboratory (*amntl*) at Missouri S&T. Upon completion of the AMT system, the next step in the project will focus on preliminary delamination detection measurements.

FEATURED PROJECT:

Innovative concrete bridge to open in 2014 near Jefferson City, MO

- Mindy Limback, Assistant Director, Communications, Missouri S&T

Figure 1. Final bridge girder for Span 2 with instrumentation being placed.

Just east of Jefferson City, MO, sits a construction site that will soon be home to one of the nation's first bridges to incorporate an unusual concrete mix in its girders and support structure.

The three-span bridge, which is scheduled to be completed this fall on Highway 50, will also be outfitted with various sensors and instrumentation to collect data on how well the bridge performs over time.

It's another milestone for Dr. John J. Myers, a professor of civil, architectural and environmental engineering at Missouri University of Science and Technology working with the Missouri Department of Transportation and Missouri S&T's National University Transportation Center. Myers has spent the past decade studying and testing high-strength concrete and other innovative concrete systems for implementation.

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Figure 2. Bridge girder with instrumentation being set.

“In 2012, we completed a two-year study that examined overall behavior of self-consolidating concrete, or SCC, using locally available materials including natural river sands, dolomitic limestone aggregates and river gravels,” Myers says. The study examined the concrete and steel reinforcing material’s shear strength, transfer and development length, creep and shrinkage as well as key durability attributes.

Myers and his team found that using high-strength self-consolidating concrete, or HS-SCC, can either extend the span length of the HS-SCC girders, a structure’s main support member, or reduce the number of girder lines needed in a given span.

“That’s because this material can allow for additional prestressing tendons, which can increase the girder’s load-carrying capacity,” says Myers.

Myers says they also expected the material to have reduced maintenance costs and an extended service life compared to conventional concrete due to the HS-SCC’s improved durability behavior. Concrete typically has four key components: portland cement, water, fine aggregate like sand and course aggregate or rock. In HS-SCC, the course aggregate is finer and chemical admixtures are added to increase its flow rate. That allows it to flow into every corner of a form work, by its own weight, eliminating the need for vibration or other types of compacting effort that requires more labor at the precast plant or job-site.

- Continued Next Page -

Figure 3.
Missouri S&T graduate students Eli Hernandez and Alex Griffin attaching Data Acquisition System to bridge girder.

> *"It's a more efficient use of the material," Myers says. "With its increased strength, it can extend a span's length by 20 percent or more."*

The new bridge will combine three different types of concrete grades in the girders. The first 100-foot span will use traditional concrete. The second, 120-foot span, will use high-strength, self-consolidating concrete. The final span will use self-consolidating concrete. Using sensors embedded in the material, researchers will monitor to see any differences as they occur. The bridge also includes instrumentation that will allow the research team to collect important data during load testing and normal in-service conditions.

> *"The advantage of having one bridge demonstrating four to five types of concrete throughout the entire bridge is that you know the exposure conditions, salts, temperatures, weather conditions are all identical," Myers explains.*

In addition, one intermediate support will use concrete with a high-replacement level of fly ash, fine particles from coal are the by-product of a power plant's combustion process. During the manufacture of traditional cement, limestone and other materials are heated to extreme temperatures, releasing of CO^2 from both chemical reactions and the heating process. By replacing half of the cement with fly ash, the mix not only reduces the amount of fly ash that ends up in landfills but will cut CO^2 emissions as well. It also will make for a more cost-effective concrete mix, which will reduce construction costs.

The state's first bridge to use high-strength, self-consolidating concrete was constructed in 2009 in Rolla and led by Myers' research group. The bridge, designed for rapid construction, was one of two built to demonstrate the mechanical and material properties of high-strength concrete and high-strength, self-consolidating concrete. County Materials Corp. in Bonne Terre, Mo., was responsible for fabrication of the prestressed-precast girders. Iron Mountain Construction Services of Maryland Heights, Mo., was responsible for the overall construction of the bridge project.

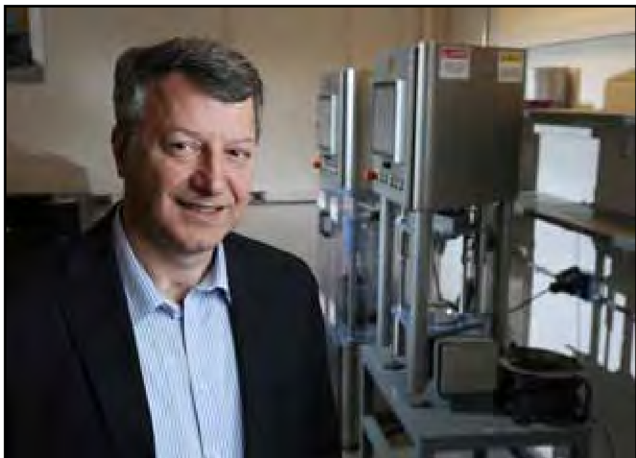
news

Missouri S&T

Center for Transportation Infrastructure and Safety

Spring 2014: Vol. 8 | Issue 4

From the desk of the Director



CTIS Director K. Khayat with state-of-the-art concrete rheometers

As the flowers and trees begin to blossom on the Missouri S&T campus, the CTIS faculty, staff and students are preparing for the completion of several research projects within the CTIS program, some of which are highlighted in this issue, as well as taking the next steps to spring into the next level of transportation infastructure research activities.
As a result of the efforts of a team of reasearchers led by CTIS Director, Kamal Khayat, **Advanced Materials for Sustainable Infrastructure** has been identified as a signature area of research in which Missouri S&T is positioned to become a top national leader. As part of the University's committment to this strategic initiative, new funding has been made available from campus and the University of Missouri System to support the hiring of additional faculty in this area, as well as in other areas of strategic importance.

In this issue:

PROJECT UPDATE:

Non-destructive evaluation of bridge decks - part 2

- Dr. Norbert H. Maerz, Program Head, Geological Engineering, Missouri S&T

Figure 1. LIDAR scanner set up to scan a Missouri bridge after hydro-demolition used to remove unsound concrete

In the Summer 2013 news issue (Vol. 8, Issue 1), Drs. Leslie Sneed and Neil Anderson presented a non-destructive method of determining the soundness of bridge decks using Ground Penetration Radar (GPR). GPR data when processed can provide a map of the soundness the bridge deck. GPR data was acquired on a number of bridge decks in Missouri. These bridge decks were subsequently subjected to hydro-demolition using high pressure water jets. This process preferentially removes the deteriorated concrete while leaving intact the good concrete. There should be a good spatial correlation between the areas where concrete has been removed by hydro-demolition and where the concrete is reported as highly deteriorated by the GPR survey.

To verify the accuracy of the GPR method, a Light Detection and Ranging (LIDAR) scanner was used to measure the depth and volume of material removed. (**Figure 1**). The scanner can very precisely measure the topography of surface of the road and consequently the depth of concrete removal (**Figure 2**). This is done by conducting before (hydro-demolition) and after LIDAR scans, and creating a difference map.

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Non-destructive evaluation of bridge decks - part 2 (continued)

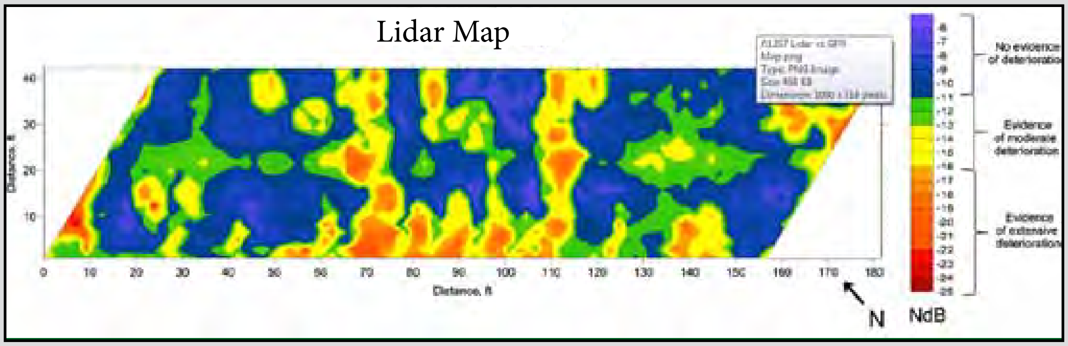

Figure 2.
LIDAR map of a span of the Union Pacific railroad bridge (A1298) on Highway 50 in Missouri. Blue areas show little or no concrete removal, while yellow and red show remove of 3-4" of concrete.

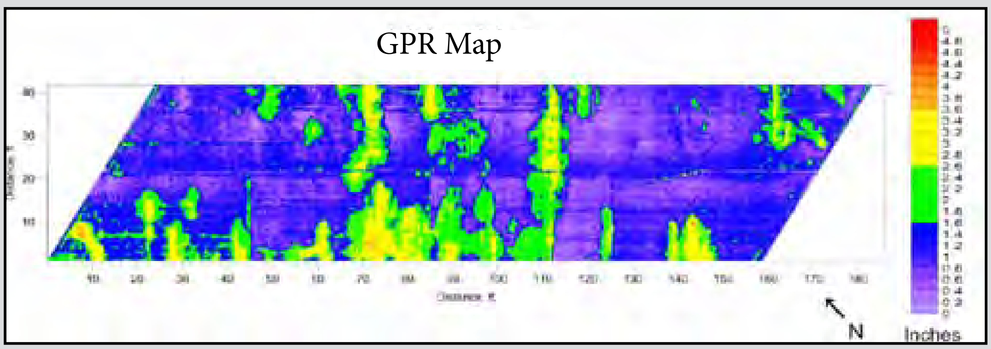

Figure 3.
GPR map of the same span of the Union Pacific railroad bridge (A1298) on Highway 50 in Missouri. Blue areas predict minor deterioration, while orange and red areas predict extreme deterioration. Courtesy of Dr. Neil Anderson

This "depth of removal" map can then be compared to a registered image of the GPR survey (**Figure 3**), which shows the areas in which we would expect good concrete and areas in which we would expect poor concrete.

Comparing Figures 2 and 3 shows a very good correlation between the GPR soundness data and the LIDAR map of the depth of material removed.

The average depth of rebar for both lanes was determined to be 1.76 inches below original surface.

Average percent of area ¾ inch or less in depth
30.2%
Average percent of area ¾ inch to top of rebar
47.5%
Average percent of area deeper than top of rebar
22.3%

PROJECT UPDATE:

Advanced moisture modeling of polymer composites

-K. Chandrashekhara, Curators' Professor, Dept. of Mechanical and Aerospace Engineering, Missouri S&T

-N. Roe, Z. Huo, V. Bheemreddy, Dept. of Mechanical and Aerospace Engineering, Missouri S&T

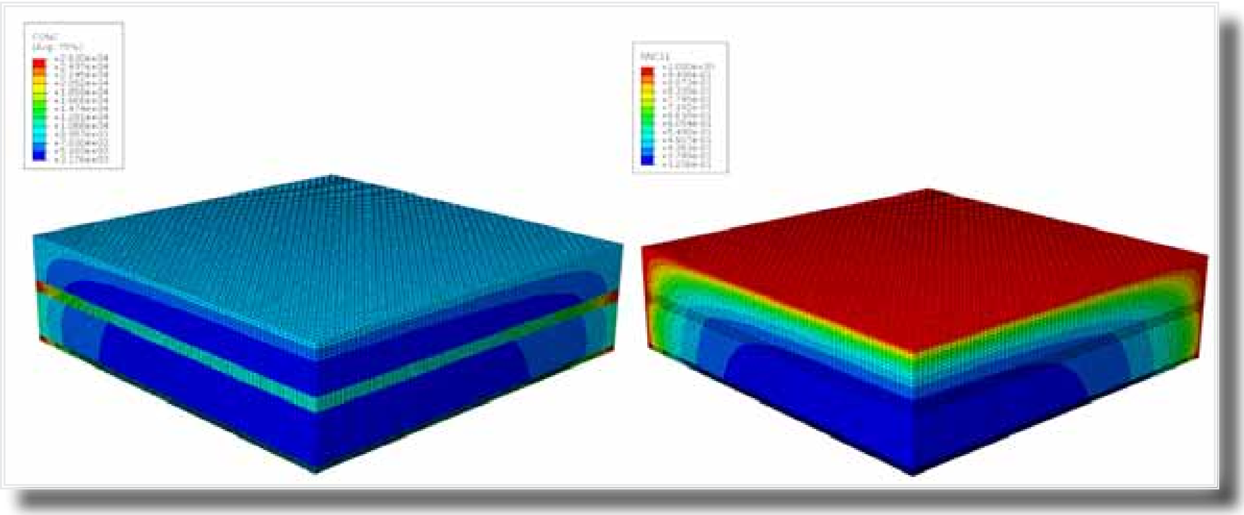

Figure 1. Model of four-layer symmetric hybrid composites with adhesive point cloud

Long term moisture exposure has been shown to affect the mechanical performance of polymeric composite structures. This reduction in mechanical performance must be considered during product design in order to ensure long term structure survival. In the current work, a three dimensional model is developed and implemented in commercial finite element code. The parametric study has been conducted for 3D shapes, moisture diffusion pathways, and varying moisture and temperature conditions.

The moisture diffusion characteristics in two-phase hybrid composites using moisture concentration-dependent diffusion method have been investigated. The two phases are unidirectional S-glass fiber-reinforced epoxy matrix and unidirectional graphite fiber-reinforced epoxy matrix. A user-defined subroutine was developed to implement this method into commercial finite element code.

Three-dimensional finite element models were developed to investigate the moisture diffusion in hybrid composites. A normalization approach was also integrated in the model to remove the moisture concentration discontinuity at the interface of different material components. The moisture diffusion in the three-layer hybrid composite exposed to 45 °C/84% relative humidity for 70 days was simulated and validated by comparing the simulation results with experimental findings.

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Advanced moisture modeling of polymer composites (continued)

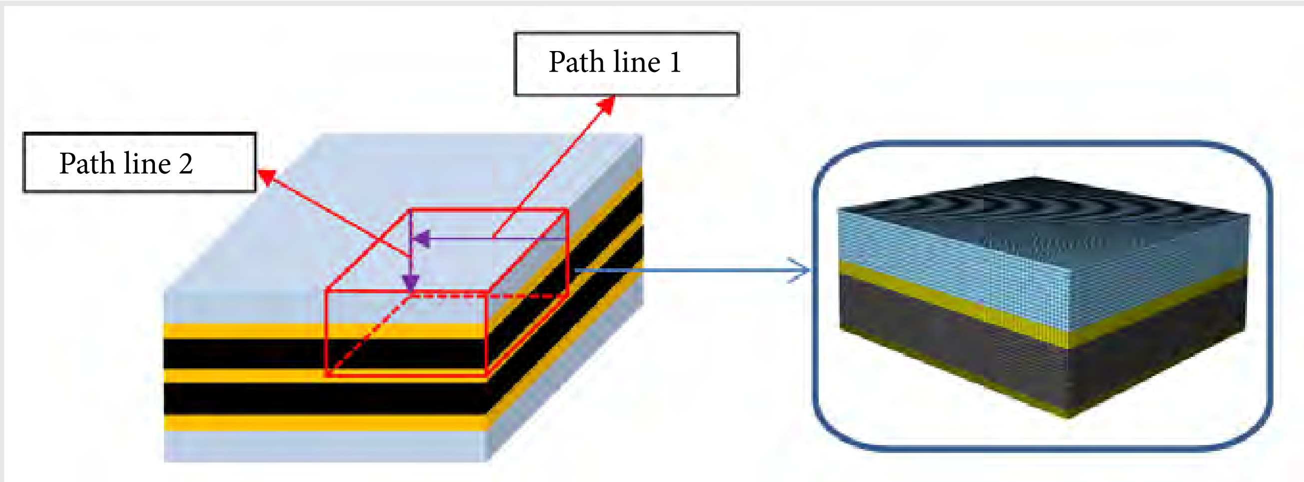

Figure 2. Moisture concentration and normalized concentration contour after 1.5 years' exposure (0.76 mm adhesive)

Results from 2D and 3D models were compared to the analytical and experimental findings. 3D analysis exhibited lower average moisture content in comparison with the prediction from the existing models, but the 3D modeling was more accurate than 2D modeling, especially in prediction of moisture diffusion into thick composite laminates. The results indicated that thinner adhesive layers (0.12 mm thick) didn't significantly affect the overall moisture uptake. Thicker adhesive layers (0.76 mm thick) noticeably accelerated the overall moisture uptake after 81 days' conditioning.

ADVANCED CONSTRUCTION MATERIALS LABORATORY (ACML) INAUGURATION

CTIS will celebrate the inauguration of the Advanced Construction Materials Laboratory (ACML) on **Friday, April 25**. The renovated laboratory will showcase over 35 recently purchased pieces of specialized equipment. This equipment will enable the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, with emphasis on concrete. A tour of the new concrete batching plant will take place the previous day, **April 24**.

PROJECT UPDATE:

Analysis of carbon emission regulations in supply chains with volatile demand

- Dincer Konur, Assistant Professor, Dept. of Engineering Mgt. and Systems Engr. Missouri S&T
- James Campbell, Professor, Logistics & Operations Mgt. Area, University of Missouri - St. Louis

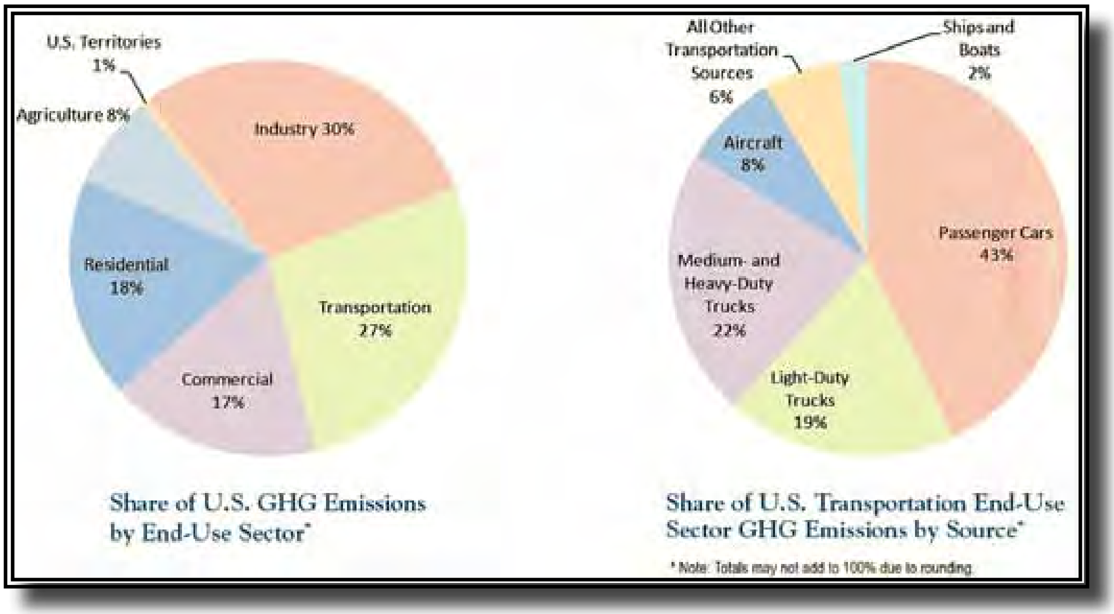

Figure 1. US 2011 GHG Emission Statistics (Source: EPA, 2011)

There is a growing consensus that carbon emissions are a leading contributor to global climate change, which has created increasing pressure around the world to enact legislation to curb these emissions. The US EPA reports that the transportation sector contributed 27% to GHG emissions in 2011 and freight transportation (freight trucks) are major transportation emission source after passenger transportation (see **Figure 1**).

Thus, a very large fraction of carbon emissions are due to supply chain activities including inventory holding, freight transportation, and logistics and warehousing activities. Inventory management is particularly important for a company as this determines not only the level of inventory carried and warehousing activities, but also the amount and the frequency of freight shipments and logistical operations. Hence, the inventory control policy of a company is inextricably linked with its carbon emissions.

The research team (Dr. Dincer Konur from Missouri S&T and Dr. James Campbell from UM-STL) aims at developing decision-making algorithms to help supply chain agents better manage inventory and transportation operations in light of economic and environmental pressures in the presence of demand volatility. To this end, the research team modeled a supply chain agent's stochastic inventory control and transportation planning problem under two well-known proposed carbon emission regulations: carbon-taxing and carbon-cap-and-trade. In this model, delivery speed is explicitly considered. Particularly, speeding the delivery may increase or decrease carbon emission generation rate of transportation while it may also increase or decrease vulnerability of the supply chain agent to the demand volatility. Currently, the research team is working on optimally solving this model. Later, the effects of transportation emissions and delivery speed on costs incurred and emissions generated will be analyzed.

PROJECT UPDATE:

Nano-engineered polyurethane resin-modified concrete

-K. Chandrashekhara, Curators' Professor, Dept. of Mechanical and Aerospace Engineering, Missouri S&T
-J. Volz, Assistant Adjunct Professor, Dept. of Civil, Architectural and Environmental Engr., Missouri S&T
-T. Schuman, Associate Professor, Dept. of Chemistry, Missouri S&T
-G.S. Dhaliwal, Dept. of Mechanical and Aerospace Engineering, Missouri S&T

Figure 1. Flexure test of PMC beam

Figure 2a.
Poly (vinyl alcohol co-ethylene) based concrete specimen

Figure 2b.
Polyurethane based concrete specimen

The goal of this study was to investigate the application of nano-engineered polyurethane (NEPU) emulsions for polymer modified concrete (PMC). NEPU emulsions are non-toxic, environment friendly, durable over a wide temperature range; provide better adhesion, high strength, less cracking, and compatible with all mortar types. 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 intends to 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.

To improve the strength of concrete, the research team investigated the effects of introducing polyurethane (PU) and poly (vinyl alcohol co-ethylene) to act as an intermediary between the aggregates and the cement matrix. The polymers used were pre-coated to the aggregate prior to the placement of the aggregate in the cement matrix. The proposed modified concrete specimens were subjected to compression and flexure tests. In this work, effects of different methods of making polymer modified concrete and effects of different amounts of polymer were also investigated.

The results showed that addition of poly (vinyl alcohol co-ethylene) had improved the bending strength of the concrete whereas PU had negative effect on the bending strength of the concrete. However, polyurethane and poly (vinyl alcohol co-ethylene) to the concrete had negative effect in improving the compressive strength.

PROJECT UPDATE:
Dilation behavior and strain rate effects of rubberized concrete confined with fiber reinforced polymers

- Mohamed ElGawady, Assoc. Professor, Dept. of Civil, Architectural and Envir. Engr., Missouri S&T
- Ayman Moustafa, Graduate Student, Dept. of Civil, Architectural and Envir. Engr., Missouri S&T

Figure 1. Test setup

This project investigates the dilation behavior and effects of strain rate on the behavior of rubberized concrete confined with glass fiber reinforced polymers (GFRP). Rubberized concrete includes scrap-tire rubber as a partial replacement of mineral aggregates which promotes the green construction. The rubber is an elastomeric material and its properties are highly dependent on the type of loading applied; whether it is static or dynamic. The effect of loading type is also inherent in the concrete itself and the properties of concrete are dependent on the strain rate.

Three concrete mixtures including 0%, 10%, and 20% of crumb rubber as a replacement of fine aggregates were designed. A total of 18 concrete cylinders confined with one and three layers of GFRP tubes of normal and rubberized concrete are tested under three different strain rates of 2.8E-5, 2.8E-3, and 2.8E-2 in./in./sec, corresponding to static loading, earthquake loading, and higher shock, respectively. The test setup is shown in **Figure 1**.

The effect of the loading rate on the confined compressive strength (f'_{cc}) in both normal and rubberized concrete is shown in **Figures 2 and 3** (see next page) for concrete confined with one layer and three layers of GFRP, respectively. **Figure 2** shows a linear increase in the strength of rubberized concrete confined with one layer of GFRP. For conventional concrete confined with one layer of GFRP, no increase in the strength was observed until a strain rate of 2.8E-3 in/in/s, beyond that, an increase of 13.9% was observed.

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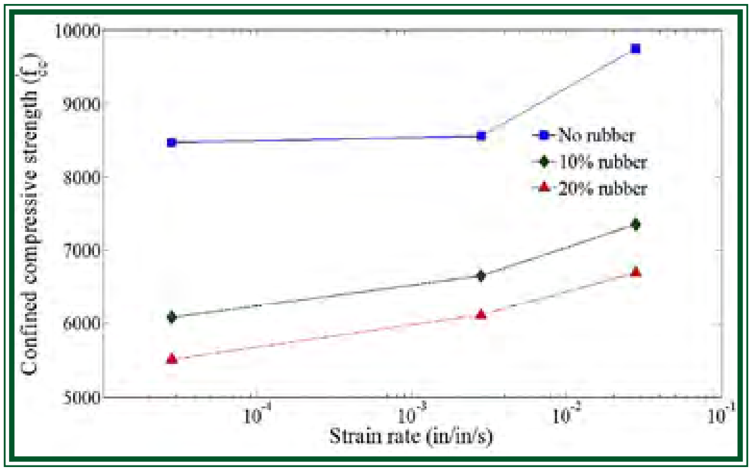

Figure 2. Effect of strain rate on normal and rubberized concrete confined with one layer of GFRP

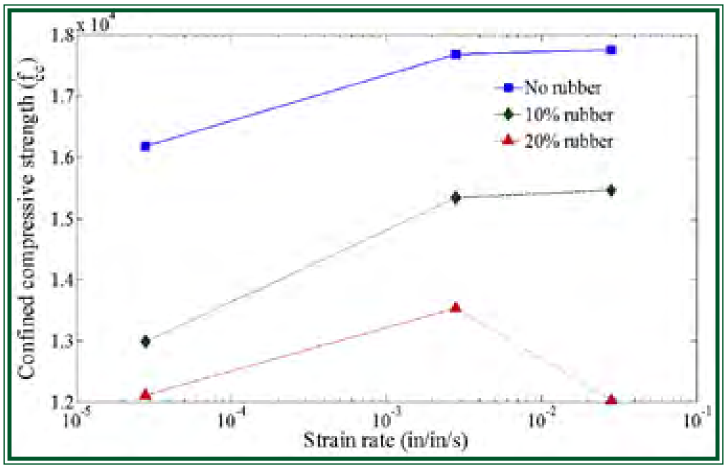

Figure 3. Effect of strain rate on normal and rubberized concrete confined with three layers of GFRP

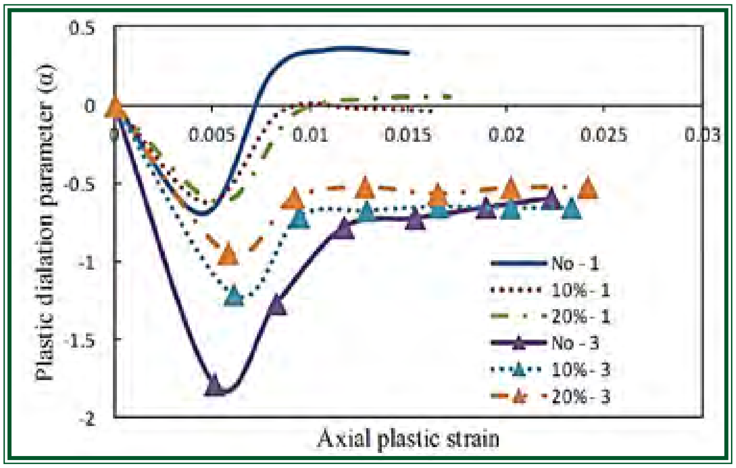

Figure 4. Dilation rate of normal and rubberized concrete

For the concrete confined with three layers of GFRP, shown in **Figure 3**, an increase is observed from the static rate of 2.8E-5 in/in/s to the dynamic rate of 2.8E-3 in/in/s and then it stabilizes, which indicates the GFRP is used to its full capacity in confinement and the concrete reached its maximum strength.

Another property of interest in the rubberized concrete is the dilation of concrete represented by the plastic dilation parameter (α), also called dilation rate. The dilation rate of confined concrete is important because it explains the behavior of concrete whether it is contracting or expanding leading to understanding of the effectiveness of confinement. **Figure 4** shows the change of the dilation rate with the axial plastic strain. For the normal concrete with one layer of GFRP, the concrete exerted contraction at the beginning of the loading and then it was dilated into expansion and stabilized, while for the rubberized concrete with one layer of GFRP, the concrete contracted and then was stabilized without expansion or with a very low value of expansion. For confinement with three layers of GFRP, the concrete continued to expand with higher dilation rates than the one layer and then was stabilized at contraction for both normal and rubberized concretes.

PROJECT UPDATE:

Optimization of rheological properties of self-consolidating concrete by means of numerical simulations, to avoid formwork filling problems in presence of reinforcement bars

- Dimitri Feys, Assistant Professor, Dept. of Civil, Architectural and Environmental Engr., Missouri S&T
- Joontaek Park, Assistant Professor, Dept. of Chemical and Biochemical Engineering, Missouri S&T

In this project, the flow of Self-Consolidating Concrete (SCC) in formworks was simulated using COMSOL Multiphysics® to study the effect of the reinforcement rebar configuration on the flow pattern as well as finding critical rheological properties for adequate formwork filling. Since SCC is a relatively new type of concrete which does not require any energy for consolidation, the flow pattern of SCC in the formwork can significantly influence the mechanical properties of concrete. Especially, the occurrence of dead zones during formwork filling can entrap air and can induce lower mechanical properties and durability of the final structural elements. Dead zones also increase the risk of casting joints or cold joints, reducing the bond strength between the concrete layers.

Instead of performing large-scale experiments with large quantities of concrete, the flow in formworks can also be predicted by means of numerical, single fluid simulations, in which the concrete is assumed to be a fluid without particles. However, numerical simulations that take into consideration the influence of reinforcement on local patterns in SCC flow have not been reported extensively. Preliminary simulations have shown that a vertical bar creates additional zones with very low and very high shear rates, compared to the flow in non-reinforced elements.

The SCC is modeled as a single phase yield-stress fluid in a rectilinear channel (length = 1 m, width = 0.4 m) with cylindrical objects. For the influence of the reinforcement configuration, four different rebar configurations were chosen in terms of concrete cover (distance between rebar and wall: dw) and the distance between the rebars in flow direction (dp) (see Table 1). Both the concrete cover and the distance between rebars are determined by structural requirements. As a result, only the concrete rheological properties can be varied to avoid the occurrence of dead zones. For each configuration, the rheological properties (plastic viscosity and yield stress) of the SCC were optimized to find the maximum yield stress to ensure dead zones are minimized and the formwork is filled adequately.

Cases	d_w (m)	d_p (m)	Description
Case A-1	0.025	0.1	Small d_w
Case A-2	0.05	0.1	Large d_w
Case B-1	0.0375	0.05	Small d_p
Case B-2	0.0375	0.25	Large d_p

Table 1. Rebar configuration and description of each case.

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Optimization of rheological properties of self-consolidating concrete by means of numerical simulations, to avoid formwork filling problems in presence of reinforcement bars (continued)

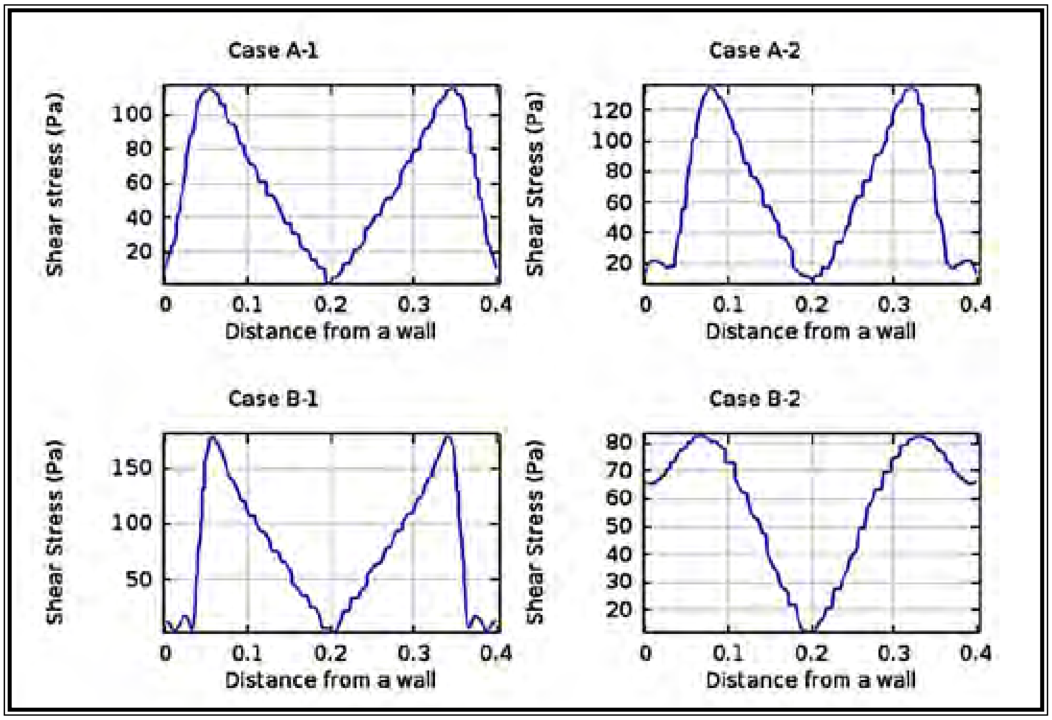

Figure 1. Simulated shear stress (τ*) profile as a function of the distance from a formwork wall.

The numerical simulations indicated that for the studied cases the spacing between the rebars (dp) was the most critical parameter for the occurrence of dead zones. The maximum yield stress of the concrete for which no dead zones occurred in case B-1 was significantly lower (3 Pa) compared to the other cases (9-12 Pa). Further analysis of the calculated results revealed that rebars with a small interspacing create some kind of virtual wall, and the shear stress between the rebars and the formwork (i.e. in the concrete cover) is rather low. In **Figure 1**, the shear stress profiles over the thickness of the formworks can be seen. The shear stress is logically zero in the center (at 0.2 m from the walls), while the maximum values are obtained at the position of the rebars. Especially in case B-1, where the rebars are close to each other, the shear stress is almost zero in the concrete cover. Dead zones are thus likely to occur in case B-1, unless self-levelling concrete is used. Dependent on the thixotropic build-up, the self-consolidation may be compromised leading to an increasing quantity of entrapped air. Furthermore, as the rebars create a virtual wall, a cold joint may occur between the concrete at rest in the cover and the concrete moving in the center of the wall, which may reduce the bond behavior between the two concrete layers and between the concrete and the rebars. This could lead to premature deterioration of the concrete cover of our infrastructure.

This project has also shown that numerical simulations can be a quick and easy tool to initially assess optimum concrete properties for specific applications. Performing numerical simulations can save a substantial amount of money, materials and labor to explore specific problems. By means of a short series of experiments, the conclusions of the numerical simulations can be verified and easily implemented in practice.

PROJECT UPDATE:

Shear wave velocity measurement of fresh concrete with bender element

- Bate Bate, Assistant Professor, Dept. of Civil, Architectural and Environmental Engr., Missouri S&T

- Jianfeng Zhu, Graduate Student, Dept. of Chemical and Biochemical Engineering, Missouri S&T

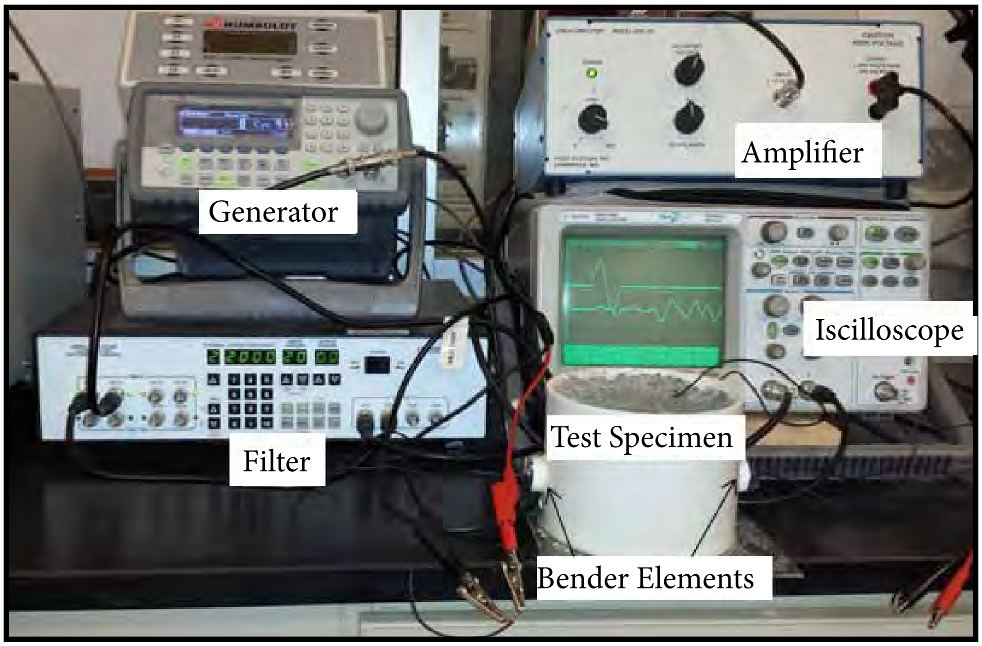

Figure 1. Test Setup

The evaluation of the curing process of a fresh concrete is critical to its construction process and monitoring. Traditionally stress sensor and compressive wave sensor were often used to measure concrete properties. Bender element (BE) test, a nondestructive test measuring shear wave velocity (Vs) was widely used in geotechnical engineering. BE test was used to monitor the curing process of fresh concrete in this study.

BE test was performed on a PVC pipe with diameter of 120mm and height of 100mm (**Figure 1**). The travel distance (tip-to-tip distance) was measured as 103.5mm. The ratio of cement: fine aggregate: coarse aggregate: water is 20%: 41%: 30.5%: 8.5% with c/w of 0.425. The density was 2180 kg/m3. Both sine shear wave (30 kHz) and square shear wave (20 Hz) were applied. The frequency cutoff was from 200Hz to 200kHz.

Test result shows the shear wave velocity increased dramatically along with time elapse. At the time of 72 hours, Vs was detected as high as 986 m/s (**Figure 2**). The measured Vs result in this study is lower than the typical values of those reported in the literature (**Table 1**). This is primarily due to the short curing period of 3 days.

Assuming Poisson's ratio was 0.2, compressive wave velocity (Vp) and Young's modulus (E) can be calculated by **Equations 1-3** (see next page)**.** Vp and E were also close to those in the literature.

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Shear wave velocity measurement of fresh concrete with bender element (continued)

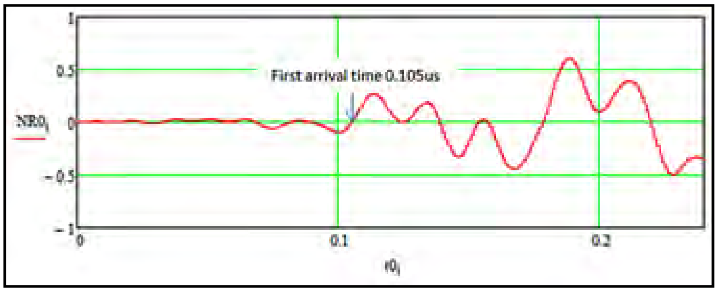

Figure 2. Received signal after 72 hours curing

$$G = \rho V_s^{\,2} \qquad (1)$$

$$\nu = \frac{1-2\left(\frac{V_s}{V_p}\right)^2}{2-2\left(\frac{V_s}{V_p}\right)^2} \qquad (2)$$

$$E = 2\rho V_s^{\,2}(1+\nu) \qquad (3)$$

Equations 1-3

It worth noting that Vs of cement paste (Zhu et al. 2011) was around 600 m/s, which is much lower than regular concrete. This low value was due to its simple composition of cement and water. It was also shown that both sine and square wave yielded similar results. Shear wave velocity from a square wave is no more than 2.7% higher than that from a sine wave.

Table 1. Comparison of test results

		Vs (m/s)	Vp (m/s)	ν	E (GPa)	ρ (kg/m3)	w/c
This study	at 3 days	986	1616 (if v=0.2)	0.2 (assumed)	5.1 (if v=0.2)	2180	0.425
Recep (2009)	at 28 days	2417±104	418±38	0.24	28.4	2190	0.45
Malhotra and Carino (2004)	hardened concrete	60% Vp	~4000	-	-	-	
Zhu et al. (2011)		600 (cement paste at 6 hours)	4010 (hardened concrete)	-	-	-	0.4
Finno and Chao (2005)	hardened concrete	2200-2800 (assumed)	-	0.14-0.28	-	~2350	-
An et al. (2009)	Different curing age	450-2700	-	-	-	-	0.38

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ElGawady elected to The Masonry Society

Dr. Mohamed ElGawady, associate professor of civil, architectural and environmental engineering at Missouri S&T, was recently elected to serve as a member of the The Masonry Society (TMS) board of directors.

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 degree with honors in civil engineering, as well as a master of science degree 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, a structural engineer, studies the seismic behavior of masonry and concrete structures. 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, segmental construction, rocking mechanics and the use of sustainable materials in seismic-prone regions.

TMS was founded in 1977 as an international group of professionals dedicated to the advancement and craft of masonry. The society has more than 650 members including: engineers, architects, builders, researchers, educators, building officials, material suppliers, manufacturers and others who want to contribute to and benefit from the global pool of knowledge on masonry.

The Masonry Society gathers and disseminates technical information through its committees, publications, codes and standards, slide sets, videotapes, computer software, newsletter, refereed journal, educational programs, professors’ workshop, scholarships, certification programs, disaster investigation team and conferences.

RE-CAST

Leading the effort to improve sustainability in our nation’s transportation infrastructure

Missouri S&T has been selected to lead a consortium of four universities sharing in a 2013 University Transportation Centers (UTC) Tier 1 grant. This program was authorized by Congress under the Moving Ahead for Progress in the 21st Century Act (MAP-21). The center’s research will focus on developing the next generation of cement-based construction materials.


Ben Gliha
Ph.D. Candidate
Civil Engineering

S&T will share a $1,414,100 per year, two-year grant with Rutgers University, Southern University, University of Illinois at Urbana-Champaign and University of Miami. The grant requires a minimum match from non-federal sources, so the overall program will be valued at least $2,121,150 per year by the time the grant concludes. The goal of the consortium is to meet a 1:1 match to ensure a funding level of approximately $5.5 million.

“We are honored to be selected to lead this effort,” says **Dr. Kamal H. Khayat**, director of Missouri S&T’s Center for Infrastructure Engineering Studies. “This consortium has the opportunity to do great things. We have assembled a wonderful team of researchers, staff and students — this grant will give them the opportunity to shine.”

A specialist in the development of advanced cement-based materials for structural applications and rehabilitation projects, Khayat is the Vernon and Maralee Jones Chair of Civil Engineering at Missouri S&T and is principal investigator for the grant. Co-PIs from Missouri S&T include **Dr. John J. Myers**, professor of civil, architectural and environmental engineering; **Dr. Dimitri Feys**, assistant professor of civil, architectural and environmental engineering; and Dr. Jeffery Volz, who recently relocated to Oklahoma University, but will continue to participate in the consortium.

This new UTC, named RE-CAST (Research on Concrete Applications for Sustainable Transportation), will carry out multi-scale and multi-disciplinary studies to investigate the use of innovative materials and structural systems to enhance the durability and sustainability of the transportation infrastructure.

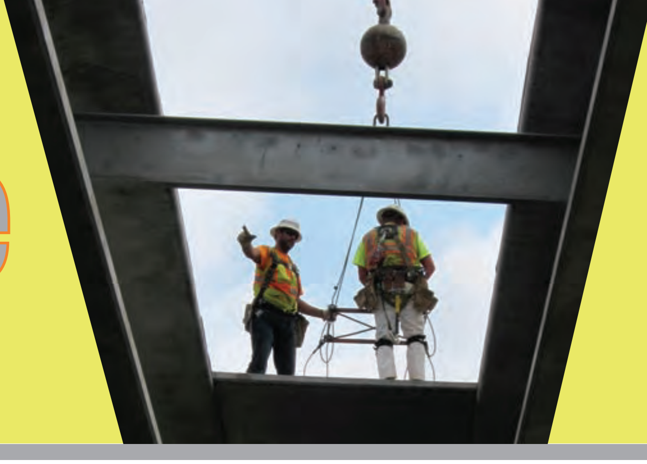
“The ultimate goal of the proposed research program is to fast-track the acceptance of these technologies and develop national standards and guidelines for their use for the reconstruction of the nation’s infrastructure for the 21st Century,” says Khayat, RE-CAST director.

The U.S. Department of Transportation’s Research and Innovative Technology Administration announced that 142 UTC applications were submitted for a share of the $63 million in grants. A total of 33 grants were awarded to research institutions across the United States.

U.S. Transportation Secretary Anthony Foxx said in a news release that UTCs are key to helping the country address today’s transportation needs, from environmental sustainability to safety. “The participating universities are a critical part of our national transportation strategy and to developing a professional workforce with the expertise and knowledge to tackle the challenges of the future,” he said.

Innovative concrete BRIDGE

By Mindy Limback



Just east of Jefferson City, Mo., sits a construction site that recently became home to one of the nation's first bridges to incorporate an unusual concrete mix in its girders and support structure. The three-span bridge, which was completed this fall on Highway 50, is outfitted with various sensors and instrumentation to collect data on how well the bridge performs over time.

Eli Hernandez, left, Ph.D. candidate in civil and Alex Griffin, right, M.S. student in civil, set up sensors to collect data on the new bridge outside of Jefferson City.

It's another milestone for **Dr. John J. Myers**, professor of civil, architectural and environmental engineering at Missouri S&T, working with the Missouri Department of Transportation and Missouri S&T's National University Transportation Center. Myers has spent the past decade studying and testing high-strength concrete and other innovative concrete systems for implementation.

"In 2012, we completed a two-year study that examined overall behavior of self-consolidating concrete, or SCC, using locally available materials including natural river sands, dolomitic limestone aggregates and river gravels," Myers says. The study examined the concrete and steel reinforcing material's shear strength, transfer and development length, creep and shrinkage as well as key durability attributes.

Myers and his team found that using high-strength self-consolidating concrete, or HS-SCC, can either extend the span length of the HS-SCC girders, a structure's main support member, or reduce the number of girder lines needed in a given span.

"That's because this material can allow for additional prestressing tendons, which can increase the girder's load-carrying capacity," says Myers.

Myers says they also expected the material to have reduced maintenance costs and an extended service life compared to conventional concrete due to the HS-SCC's improved durability behavior.

Concrete typically has four key components: portland cement, water, fine aggregate like sand and course aggregate or rock. In HS-SCC, the course aggregate is finer and chemical mixtures are added to increase its flow rate. That allows it to flow into every corner of a form work, by its own weight, eliminating the need for vibration or other types of compacting effort that requires more labor at the precast plant or job-site.

"It's a more efficient use of the material," Myers says. "With its increased strength, it can extend a span's length by 20 percent or more."

The new bridge will combine three different types of concrete grades in the girders. The first 100-foot span will use traditional concrete. The second, a 120-foot span, will use high-strength, self-consolidating concrete. The final span will use self-consolidating concrete. Using sensors embedded in the material, researchers will monitor to see any differences as they occur. The bridge also includes instrumentation that will allow the research team to collect important data during load testing and normal in-service conditions.

(continued on page 14)

Message
from the associate chair
Joel G. Burken, Ph.D., P.E., BCEE

The CArE Department is entering an exciting time with new, engaging opportunities on the horizon. We are still working toward our vision, which includes program changes, expanded learning opportunities, improvements in laboratory facilities, and new scholarships and fellowships for the undergraduate and graduate students who will CHANGE THE WORLD.

Within our faculty ranks, we are pleased to announce **Genda Chen** has been named the Robert W. Abbett Distinguished Chair in Civil Engineering, and we are currently searching for five new faculty members.

In addition, a cross-campus effort led by **Kamal Khayat** was selected as a campus strategic "signature area." This multidisciplinary investment in talent and facilities will propel the international reputation of sustainable infrastructure materials at Missouri S&T.

We also pay tribute to a prominent author that scripted part of our current legacy. **Paul Munger** leaves behind a 40-year career as a student and faculty member. We commemorate him as a mentor, teacher and friend who inspired us to advance our institution and the civil engineering profession.

Excellence has been a long-standing tradition by students from Rolla, and we are pleased to celebrate gifts such as the **Aaron and Zelda Greenberg** Scholarship — a $1.6 million endowment to support civil, architectural and environmental engineering students. These students have remarkable role models to emulate, such as the eight new members of the Academy of Civil Engineers that were inducted in April.

To ensure our students (i.e. future alumni) have premier instruction, we are thrilled to offer two new junior named faculty awards. The **Bryan A. and Jeanne Stirrat** Faculty Excellence Award and the **Francisco M. Benavides** Faculty Excellence Award. These awards denote and entice excellence among our professors. We greatly appreciate these gifts and the alumni who have helped us create and advance our exciting vision.

For nearly 150 years, S&T has fostered discovery and creativity that applies knowledge in bold new ways to turn ideas into realities. Many of our faculty members and students are highlighted on the pages that follow for their activities and research. Please take a few minutes to read these stories.

Great things are happening within the department and will continue well into the future. Please join us as we endeavor to CHANGE THE WORLD for the better.

ACML Lab Inauguration

During S&T Academy of Civil Engineers weekend, the Center for Infrastructure Engineering Studies (CIES) celebrated the inauguration of the Advanced Construction Materials Laboratory (ACML). The renovated laboratory showcased over 35 recently purchased pieces of specialized equipment, made possible by a grant from the U.S. Department of Transportation in the amount of $2.25M. This equipment will enable the development, manufacturing, and implementation of advanced and sustainable materials for transportation infrastructure, with emphasis on concrete.

Visit the department website at care.mst.edu or follow us on Facebook at MissouriSandTCArE

Update: Advanced Construction Materials Lab (ACML)

We are pleased to report that significant progress has been made in the development of our new Advanced Construction Materials Laboratory. Over the past months, **Dr. Kamal Khayat**, Vernon and Maralee Jones Chair of Civil Engineering, and **Dr. William Schonberg**, Department Chair, have worked closely with University Advancement and the Office of Development to plan fundraising efforts for this proposed expansion of Butler-Carlton Civil Engineering Hall. The ACML is a priority for the Department's Vision 2020 Campaign, which was kicked off this fall.

"We are seeking to raise private and corporate funds that will be matched at a 1:1 rate by the State of Missouri. It is a challenging process, however, it is important to reach the teaching and research capabilities that are needed to support our ambitious mission in becoming the Center of Excellence in the U.S. for civil engineering construction materials research," says Khayat.

New concrete batching plant

The proposed state-of-the-art facility will house 35 pieces of recently acquired equipment that uniquely positions S&T to conduct cutting-edge research in the field of civil engineering construction materials. This major infrastructure investment was made possible by a grant from U.S. Department of Transportation (amounting to nearly $2.5 M) that was awarded to the S&T Center of Infrastructure Engineering Studies. This equipment is currently spread over several locations on and off campus until the new laboratory expansion is available.

The largest piece of equipment, a dual-mixer concrete batching plant, is installed at a temporary location off campus. This equipment will enable researchers at S&T and their collaborators from the private and public sectors to actively contribute to the development and implementation of the next generation of cement-based construction materials essential to address the growing technical and environmental requirements of transportation infrastructure, as well as those in the building and energy sectors.

Israel works with EWB

As you well know, Missouri S&T's chapter of Engineers Without Borders (EWB) has a team devoted to a water infrastructure project in Nahualate, Guatemala. The goal of this project is to provide potable water to improve public health and overall quality of life in the community.

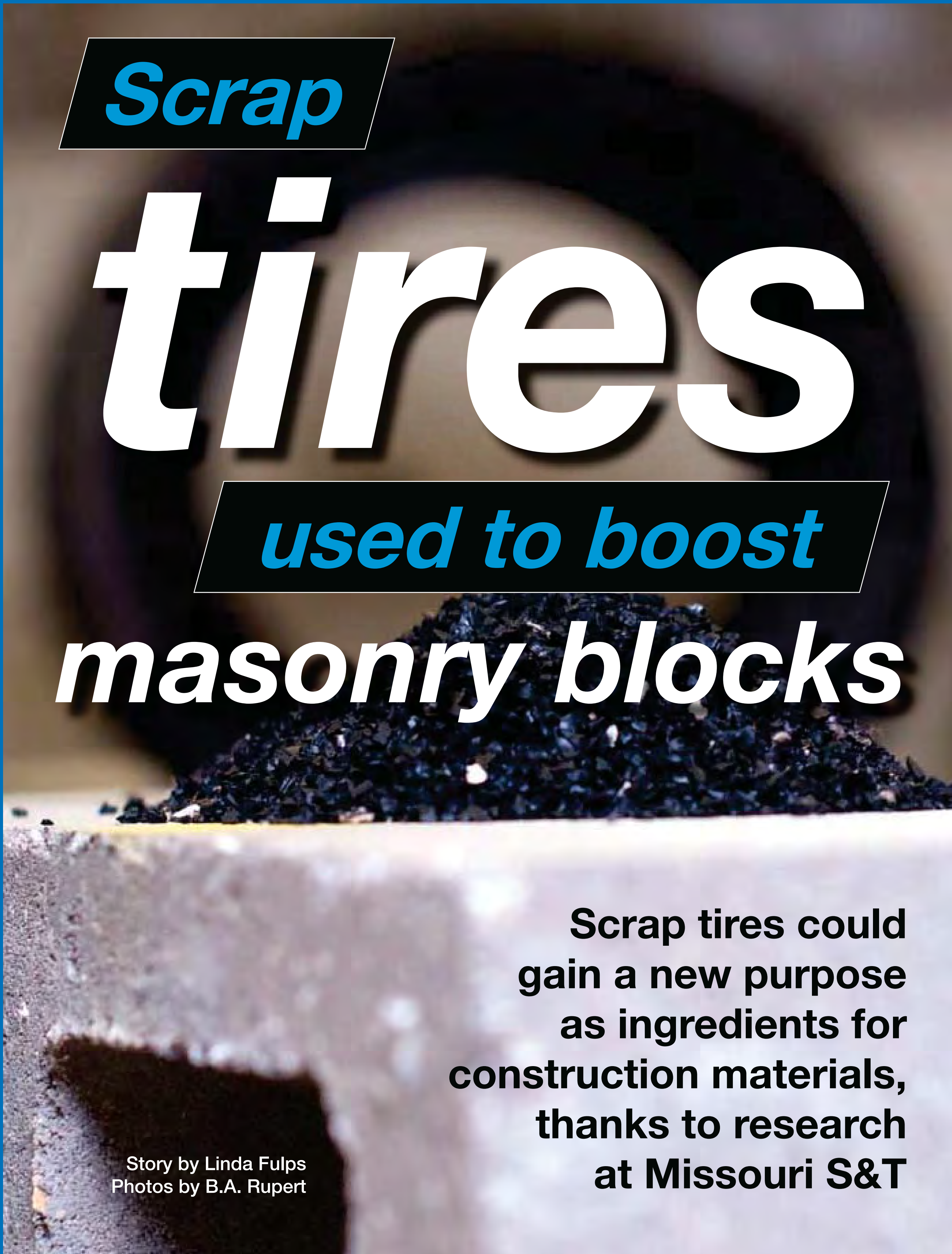
Prior to this trip, EWB surveyed the land, planned pipe layouts, drafted structures, drilled a well and met with multiple contractors. In late July the travel team, along with alumnus **Dan Israel**, CE'83, spent 10 days on a successful implementation trip. Israel's extensive experience in ground engineering and infrastructure was instrumental in the installation of the 4-inch main line to fill the tank. He provided sound advice and often got in the trenches to show the locals how it was done.

After assessment and design phases, EWB is happy to report the construction of the water distribution system is finally under way.

"I have really enjoyed working with S&T students on EWB projects. The students involved with this program are the most energized and caring young men and women I have ever worked with. It is great to see them taking an interest in helping the local communities. I am proud to be a part of their lives and to be able to work side by side with these amazing students."

— Dan Israel, P.E., CE'83, PD CE'06

(Top right, #42 blue hat)



Scrap tires used to boost masonry blocks

Scrap tires could gain a new purpose as ingredients for construction materials, thanks to research at Missouri S&T

Story by Linda Fulps
Photos by B.A. Rupert

Discarded tires are a big problem. Landfills are teeming with them and they can harbor disease-carrying mosquitos and rodents. Stockpiles of old tires also burn easily — creating fires that can quickly get out of control and may burn for months or even years.

But the longevity and resilience of scrap tires also makes them ideal for other uses. **Dr. Mohamed ElGawady**, a researcher at Missouri S&T, is currently testing new masonry blocks made with ground tires.

“Rubber has a lot of benefits in addition to its sustainability,” says ElGawady, associate professor specializing in structural engineering. “It’s very durable and provides good insulation. Among their many potential benefits, these new blocks could cut heating bills by 50 percent.”

ElGawady has been working with Midwest Block and Brick, a Jefferson City, Mo.-based company, to create the blocks, which are made from sand and scrap tires ground to fine particles.

These rubber-added blocks, called rubberized blocks, were constructed with a variety of ratios of sand and rubber particles before coming up with the right balance.

“The rubber makes the blocks a bit weaker, so after testing various percentages, we now only replace about 20 percent of the sand with rubber, so the blocks retain their strength,” ElGawady says.

He and his students use a compression machine to test and compare the strength of prisms built with the rubberized blocks to conventional concrete masonry blocks.

Both rubberized and conventional blocks are being tested in an environmental chamber at S&T.

In the chamber, the blocks undergo cycles of extreme temperatures and humidity levels, simulating different weather conditions. The rubberized blocks are also tested under cyclic compression loads simulating earthquake loads.

“Construction with these new blocks could improve a building’s resiliency during an earthquake by acting as shock absorbers,” says ElGawady.

Dr. Mohamed ElGawady, associate professor specializing in structural engineering (right), with graduate student Ahmed Gheni.

“Construction with these new blocks could improve a building’s resiliency during an earthquake by acting as shock absorbers.”

— Dr. Mohamed ElGawady

Advanced materials
is among first 'signature' areas named

By Andrew Careaga

Missouri S&T has made significant headway in carrying out its strategic plan by identifying two of four areas in which the campus aims to achieve best-in-class, or signature, status as a research university.

The two areas — advanced manufacturing and advanced materials for sustainable infrastructure — were chosen from among 15 proposals submitted by Missouri S&T faculty. The proposals and subsequent presentations were screened by a committee of faculty representatives from all academic areas on campus, then selected by S&T Chancellor **Cheryl B. Schrader** and Provost **Warren K. Wray**. The proposals were judged on how well they connected to long-term critical national issues, research and entrepreneurship potential, and alignment with Missouri S&T's strategic plan.

"From the beginning, we have known that to successfully implement our strategic plan, we would have to focus on signature areas of excellence," Schrader says. "Our plan isn't about being everything to everyone. It is about deciding where it makes the most sense to invest, enable and grow, and providing the best return on that investment to our customers. These two areas represent a bold step in the future vitality of this university and will offer research and educational solutions to benefit Missouri, the nation and the world."

(continued on page 11)

The signature area of advanced materials for sustainable infrastructure will focus on the rehabilitation of urban mass-transportation centers. It encompasses four S&T research centers and six academic departments and will be led by Dr. Kamal Khayat, the Vernon and Maralee Jones Professor of Civil Engineering and director of Missouri S&T's Center for Infrastructure Engineering Studies.

‘Signature’ areas (continued from page 6) ...

Attaining signature status in these areas means that Missouri S&T will build on their distinctive strengths in teaching and research to make the areas among the nation’s best, Schrader says. To better position S&T to achieve this status, last September Schrader announced new funding from campus and the University of Missouri System to support the hiring of additional faculty in signature areas, as well as in other areas of strategic importance. In all, S&T plans to add 100 new faculty positions by 2020, an increase of nearly 20 percent.

In the signature area of advanced manufacturing, S&T will emphasize instruction and research in the fields of additive manufacturing; energy manufacturing; micro- and nano-scale manufacturing; network-centric and cloud manufacturing; advanced materials for manufacturing; and intelligent, sensor-enabled manufacturing.

The area will be led by Dr. Ming Leu, the Keith and Pat Bailey Missouri Distinguished Professor of Integrated Product Manufacturing and involve a team of multidisciplinary researchers.

“This is a perfect fit for Missouri S&T because of the national importance of advanced manufacturing, the existing S&T strength in this area and our confidence in developing it to be among the best in the nation,” Leu says.

Photo by Sam O'Keefe

“Infrastructure is the foundation that connects the nation’s businesses, communities and people, driving our economy and improving our quality of life.”

— Dr. Kamal Khayat

The signature area of advanced materials for sustainable infrastructure will focus on the rehabilitation of urban mass-transportation centers, including highways, bridges, tunnels, rail, airports, and port and water navigation channels, as well as utility and nuclear infrastructure.

It encompasses four S&T research centers and six academic departments and will be led by **Dr. Kamal Khayat**, the Vernon and Maralee Jones Professor of Civil Engineering and director of Missouri S&T’s Center for Infrastructure Engineering Studies (CIES).

Those from the department of civil, architectural and environmental engineering working with Khayat include **Dr. William Schonberg**, chair of the department, **Dr. John Myers**, professor specializing in structural and architectural engineering and **Dr. Dimitri Feys**, assistant professor specializing in materials engineering.

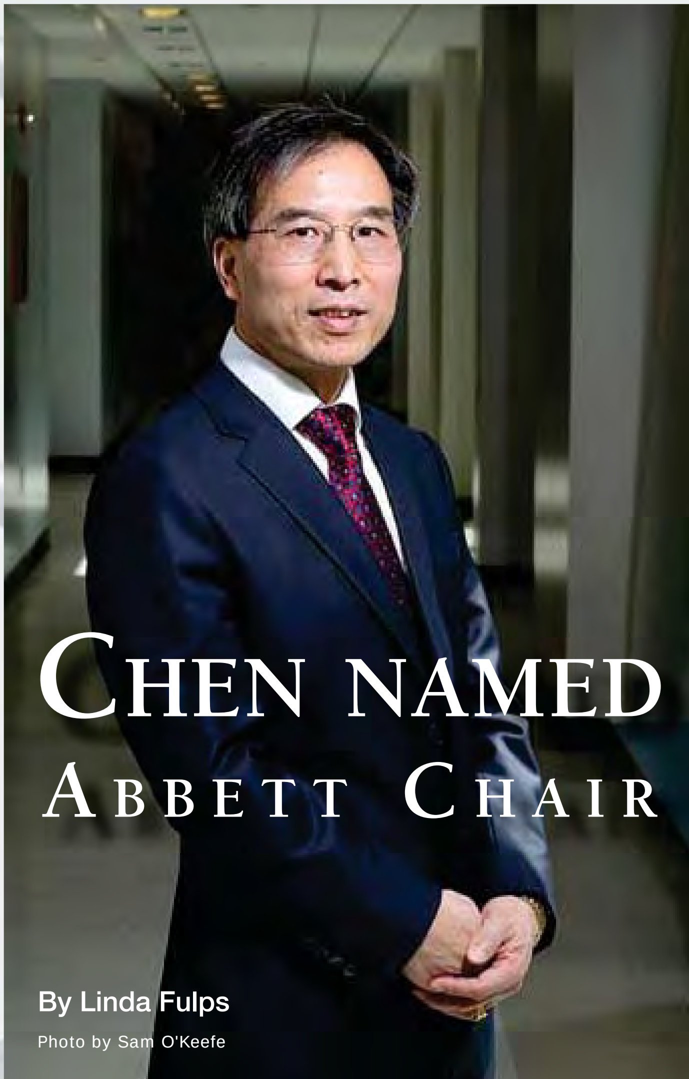
“Infrastructure is the foundation that connects the nation’s businesses, communities and people, driving our economy and improving our quality of life,” says Khayat. “Missouri S&T has existing strengths in this area and with further emphasis, we can become a best-in-class leader.”

U.S. News ranks S&T among top online graduate programs

Fourteen online master’s degree programs at Missouri S&T were ranked among the best in the country in three categories, according to *U.S. News & World Report*’s 2014 Best Online Programs Rankings. These rankings were released in January and are available online at www.usnews.com.

S&T’s online graduate engineering programs were tied for 17th place overall and ranked 13th among public universities. S&T offers online graduate degree programs in 11 disciplines, including civil and environmental engineering.

S&T began its first online degree program in 1998. Today S&T offers online graduate degree programs in 17 disciplines. More information about Missouri S&T’s online degree programs is available online at dce.mst.edu.



Chen named Abbett Chair

By Linda Fulps

Photo by Sam O'Keefe

Genda Chen has been named the Robert W. Abbett Distinguished Chair in Civil Engineering at Missouri S&T.

Dr. Genda Chen, professor of structural engineering at S&T, has been named the Robert W. Abbett Distinguished Chair in Civil Engineering. The appointment takes effect July 1.

The chair was established in 2005 through a gift from the estate of Robert W. Abbett, a 1927 civil engineering graduate of the university.

"We are very pleased that Dr. Chen will take on this new challenge," says Dr. Cheryl B. Schrader, chancellor of Missouri S&T. "He brings a wealth of experience and innovation to the infrastructure area."

A member of the Missouri S&T faculty since 1996, Chen is associate director of the Mid-America Transportation Center, a consortium of eight universities designated as the Region VII University Transportation Center by the U.S. Department of Transportation.

After earning a Ph.D. degree in 1992 from The State University of New York at Buffalo and completing postdoctoral training at the National Center for Earthquake Engineering Research, Chen joined Steinman Consulting Engineers, a New York City-based bridge consulting firm. In 1993, he was hired as a lead seismic analysis engineer on the seismic evaluation project for the Queensboro Bridge, a double-deck, double-cantilever bridge that spans the East River in New York, the first major project of its kind on the East Coast.

Chen has been widely published for his pioneering research on structural behavior monitoring, inorganic enamel coating of steel rebar for enhanced corrosion resistance and bond strength in concrete, and a damping-enhanced strengthening strategy for performance-based earthquake engineering.

He was the lead inventor on a patent granted in 2008 for strain-sensitive coax cable sensors for monitoring structures, in collaboration with Dr. James L. Drewniak, Curators' Professor of electrical and computer engineering at Missouri S&T, and Dr. David Pommerenke, professor of electrical and computer engineering at S&T. He was co-inventor on a patent granted in 2011 for corrosion-resistant glasses for steel enamels granted in collaboration with Dr. Richard K. Brow, Curators' Professor of materials science and engineering at S&T.

Chen received the National Science Foundation's Faculty Early Career Development (CAREER) Award in 1998; the Joseph H. Senne Jr. Academy of Civil Engineers Faculty Achievement Award in 2004; and Missouri S&T Faculty Research Awards in 2009, 2011 and 2013.

He is active in the American Concrete Institute, American Society of Civil Engineers, Earthquake Engineering Research Institute, International Society of Optics and Photonics, International Society for Structural Health Monitoring of Intelligent Infrastructure, Structural Engineering Institute and Transportation Research Board. He is associate editor of the ASCE *Journal of Structural Engineering* and was a recent guest editor of *Structural Engineering and*

(continued on page 8)

2013 CTIS Student of the Year: Mahdi Arezoumandi

For the past 22 years, the U.S. Department of Transportation has honored an outstanding student from each University Transportation Center (UTC) at a special ceremony held during the Transportation Research Board (TRB) Annual Meeting in Washington, D.C. This year, the Center for Transportation Infrastructure and Safety (CTIS) selected **Mahdi Arezoumandi**, pictured left, as its Outstanding Student of the Year.

Student Profile:
Arezoumandi graduated in December 2013 from Missouri S&T with a Ph.D. in civil engineering. His graduate research topic studied shear and fracture behavior of high performance concretes. He is a friend of TRB AFF30 Committee (Concrete Bridges), TRB AFN10 Committee (Basic Research and Emerging Technologies Related to Concrete) and TRB AFN20 Committee (Properties of Concrete). He is also a member of ACI committees 408 (Development and Splicing of Deformed Bars) and 445 (Shear and Torsion).

Arezoumandi received the Nevada Medal in 2013 for his distinguished graduate student paper in bridge engineering. In addition he received a Post Tensioning Institute Scholarship in 2013 and a Chi Epsilon Scholarship in 2012.

Selection Criteria:
Arezoumandi was selected as the Outstanding Missouri S&T UTC Student of the Year for his outstanding academic performance, as well as the technical merit and national importance of his research. Arezoumandi obtained his undergraduate and master degrees from Amirkabir University in Tehran, Iran. **Dr. Jeffery Volz**, a former faculty member, was his advisor.

Oerther elected treasurer of AAEES

By Peter Ehrhard

Starting in January 2014, **Dr. Daniel Oerther**, the John A. and Susan Mathes Professor of Environmental Engineering at S&T, will begin a three-year term as treasurer of the American Academy of Environmental Engineers and Scientists (AAEES).

The nearly 3,000 members of AAEES are licensed professional engineers who have received additional training and testing to become board certified. As leaders in the environmental engineering profession, AAEES is responsible for accreditation of degree programs at universities and advising federal, state and local governments.

Oerther's duties will include planning and fiscal management of an annual budget of approximately $1 million dollars and a staff of six full-time employees, all located in Washington, D.C.

Chen named Abbett Chair continued from page 7...

Mechanics: an International Journal. He has served in leadership roles in ASCE committees and as an executive member of the U.S. Panel on Structural Control and Monitoring. He was elected an ASCE Fellow in 2007 and SEI Fellow in 2013.

Chen was an invited member of the U.S. Department of Transportation's post-earthquake reconnaissance teams following the 2008 earthquake in China and the 2010 earthquake in Chile, as well as the DOT's post-earthquake study tour following the Great East Japan Earthquake in 2011. He also served on the U.S. Geological Society's post-hurricane reconnaissance team following the 2005 Atlantic hurricane.

APPENDIX: SUCCESS STORIES CLIPS

Awards

S&T students best in country at hydrogen design

July 26, 2013 by Peter Ehrhard

A team of students from Missouri University of Science and Technology scored the highest among U.S. teams in an international hydrogen design competition held this summer.

The Missouri S&T Hydrogen Design Team submitted its proposal to the 2012-2013 Hydrogen Student Design Contest. The teams were challenged to develop hydrogen fueling infrastructure plans for the Northeast and Mid-Atlantic States for the 2013-2025 timeframe.

A total of 24 teams competed, with teams entering from Japan, Great Britain, Bulgaria, India, and Italy, in addition to the United States. The S&T team earned fourth place, with a score of 72 percent.

S&T's entry in the competition outlined mass production of hydrogen using naturally occurring biogas from biomass found in landfills, then treating the biogas with high-temperature steam in a high-pressure processing device. The team identified possible production facilities and locations, provided a list of fueling station sites and looked at the economic impact of the plan. The team also evaluated transportation, storage and dispensing needs, while insuring that the supply of hydrogen could meet the demand of the proposal's 13-year period.

The team has experience with hydrogen fuel, as S&T is home to Missouri's only hydrogen production and fuel-dispensing station. The station produces 8.8 pounds of hydrogen per day as a high-pressure, three-stage dispensing facility.

"This year's competition involved a greater extent of project management than engineering," explains Yousif Hamad, a graduate student in mechanical engineering from Albdya, Libya. "Hydrogen has no carbon emissions, just water vapor, and the energy-to-weight ratio is better."

Dr. Fatih Dogan, professor of materials science and engineering at S&T, and Dr. Joan Schuman, assistant teaching professor of engineering management and systems engineering at S&T, are the co-advisors to the team. Hamad is the 2012-2013 team leader. The hydrogen design team will be recruiting for next year and students from all disciplines are encouraged to participate. For more information, contact Hamad at ymhm93@mail.mst.edu.

For more information on the Hydrogen Student Design Contest, visit www.hydrogencontest.org.

The following students were part of the 2012-2013 Hydrogen Design Team:

Abdulhakim Agll, a graduate student in geological engineering from Tripoli, Libya.

Sushrut Bapat, a graduate student in mechanical engineering from Mumbai, India.

Charles Bauer, a senior in engineering management from Kirkwood, Mo.

Andrew Clum, a graduate student in engineering management from Independence, Mo.

Yousif Hamad, a graduate student in mechanical engineering from Albdya, Libya.

Tarek Hamad, a graduate student in mechanical engineering from Albdya, Libya.

15 S&T faculty receive tenure, promotions

October 9, 2013 by Mary Helen Stoltz

Fifteen faculty members at Missouri University of Science and Technology received promotions or tenure effective Sept. 1. Those faculty members are:

- **Dr. Akim Adekpedjou**, promoted to associate professor of mathematics and statistics with tenure
- **Dr. Kwame Awuah-Offei**, promoted to associate professor of mining and nuclear engineering with tenure
- **Dr. Elizabeth Cudney**, promoted to associate professor of engineering management and systems engineering with tenure
- **Dr. Li-Li Eng**, promoted to associate professor of business and information technology with tenure
- **Dr. Mao Chen Ge**, associate professor of mining and nuclear engineering, awarded tenure
- **Dr. Abhijit Gosavi**, promoted to associate professor of engineering management and systems engineering with tenure
- **Dr. Katie Grantham**, promoted to associate professor of engineering management and systems engineering with tenure
- **Dr. Serhat Hosder**, promoted to associate professor of mechanical and aerospace engineering with tenure
- **Dr. Ulrich Jentschura**, promoted to associate professor of physics with tenure
- **Dr. Hyoung Koo Lee**, associate professor of mining and nuclear engineering, awarded tenure
- **Dr. F. Scott Miller**, promoted to teaching professor of materials science and engineering
- **Dr. Glenn Morrison**, promoted to professor of civil, architectural and environmental engineering
- **Dr. John Myers**, promoted to professor of civil, architectural and environmental engineering
- **Dr. Jeffery Thomas**, promoted to associate teaching professor of civil, architectural and environmental engineering
- **Dr. David Wright**, promoted to associate professor of English and technical communication with tenure.

22 faculty members to receive awards at Missouri S&T

February 21, 2014 by Mary Helen Stoltz

Twenty-two Missouri University of Science and Technology faculty members received the Faculty Achievement, Research, Service or Teaching Award for 2013. Each award winner receives a $1,000 stipend funded by industry and alumni contributions. The awards were presented at a ceremony held Feb. 18 on campus.

Receiving the 2013 Achievement Award are:

– Dr. Petra DeWitt, assistant teaching professor of history and political science

– Dr. Nishant Kumar, assistant teaching professor of mechanical and aerospace engineering

– Dr. W. Eric Showalter, associate teaching professor of civil, architectural and environmental engineering

– Dr. Theresa Swift, assistant teaching professor of electrical and computer engineering.

Receiving the 2013 Research Award are:

– Dr. Victor Birman, professor of mechanical and aerospace engineering at the Engineering Education Center in St. Louis

– Dr. Joel Burken, professor of civil, architectural and environmental engineering

– Dr. Genda Chen, professor of civil, architectural and environmental engineering

– Dr. Richard Dawes, assistant professor of chemistry

– Dr. Fatih Dogan, professor of materials science and engineering

– Dr. Ulrich Jentschura, associate professor of physics

– Dr. Sanjay Madria, professor of computer science

– Dr. David Pommerenke, professor of electrical and computer engineering.

Receiving the 2013 Service Award are:

– Dr. Michael Davis, associate professor of economics

– Dr. Shannon Fogg, associate professor of history and political science

– Dr. John Myers, professor of civil, architectural and environmental engineering

– Dr. Paul Worsey, professor of mining and nuclear engineering.

Receiving the 2013 Teaching Award are:

– Dr. Diana Ahmad, associate professor of history and political science

– Dr. Kelly Homan, associate professor of mechanical and aerospace engineering

– Dr. Irina Ivliyeva, associate professor of arts, languages and philosophy

– Dr. John C. McManus, professor of history and political science

– Dr. Kathryn Northcut, associate professor of English and technical communication

– Dr. Jeffrey Schramm, associate professor of history and political science.

S&T's Advanced Aero Vehicle Group earns fourth place

April 10, 2014 by Peter Ehrhard

Photo by Bob Phelan, Missouri S&T.

Missouri University of Science and Technology's Advanced Aero Vehicle Group earned fourth place in the advanced class at the annual Aero Design West Competition, held Friday, March 28, through Sunday, March 30, at the Fort Worth Thunderbirds Flying Field in Fort Worth, Texas.

Following a technical design presentation and aircraft inspection, the team was in eighth place prior to the flying portion of the competition. The team then flew its plane once on Saturday, March 29, and again on Sunday, March 30.

The team's flight objective was to use its 8.3-pound plane to carry a sandbag, designed to simulate a humanitarian aid package with food and medical supplies, and drop it on a fixed target on the ground. Scoring for this event was based on the sandbag's proximity to the target.

During flight, electronics on the S&T plane transmitted real-time altitude and first-person-view video. Students used this data to direct the pilot as he lined up to drop the sandbag, which was automatically calculated through onboard GPS.

Dr. Walter Eversman, Curators' Professor of mechanical and aerospace engineering at S&T, is the AAVG team advisor and Brandon Coleman, a senior in aerospace engineering from Raymore, Mo., is the team's president.

The students who participated in the event are:

Anthony Innes, a freshman in aerospace engineering from Lee's Summit, Mo.

Brandon Coleman, a senior in aerospace engineering from Raymore, Mo.

Bradley Parks, a sophomore in aerospace engineering from Fisk, Mo.

Brenda Wilson, a sophomore in aerospace engineering from Richland, Mo.

Drew McNeely, a senior in aerospace engineering from Houston, Texas.

Emily Dierkes, a senior in mechanical engineering from St. Louis.

John Schaefer, a senior in aerospace engineering from St. Louis.

Justin Nichols, a senior in aerospace engineering from Hawk Point, Mo.

Matthew Legner, a senior in aerospace engineering from Wildwood, Mo.

Melissa Heskett, a senior in mechanical engineering from St. Louis.

Paul Black, a freshman in aerospace engineering from St. Joseph, Mo.

Missouri S&T Chem-E-Car wins regional competition

April 21, 2014 by Peter Ehrhard

The 2014 ChemE Car design.

Missouri University of Science and Technology's Chem-E-Car Design Team earned first place at the American Institute of Chemical Engineers' 2014 Mid-America Regional Conference, held April 11-12 at the University of Iowa.

Missouri S&T competed against 13 other collegiate teams from eight universities at the conference. The team earned a spot at the national competition on Nov. 16, in Atlanta.

The Chem-E-Car competition challenged teams to design a build a chemically powered shoebox-sized car that uses a chemical reaction to travel a target distance while carrying a pre-established load. This year's competition required the cars to travel 62.99 feet while carrying 6.7 ounces of water.

The Missouri S&T car, named "The Hour Strikes XII," finished 1.5 feet from the target. It is powered by a homemade six-cell lead-acid battery. The braking system is controlled using photons from a chemiluminescent reaction, a mixture of luminol and bleach which acts as a stop and start mechanism, which triggers a relay that connects the battery and the motor. Team members had to calculate the average velocity of the car and then determine the volume of the chemical solution required to activate the braking system.

Kenneth Mucalo, a senior in chemical engineering from St. Louis, is the Chem-E-Car team leader. Dr. Daniel Forciniti, professor of chemical and biochemical engineering at S&T, is the Chem-E-Car team advisor.

The following students participated at the competition:

Kristian Branscum, a senior in chemical engineering from La Monte, Mo., as AIChE historian

Kenneth Mucalo, a senior in chemical engineering from St. Louis, as Chem-E-Car president

Folabomi Opakunle, a sophomore in chemical engineering from Blue Springs, Mo.

Chris Palmer, a senior in chemical engineering from St. Peters, Mo., as Chem-E-Car build officer

Shayan Sazdar, a sophomore in chemical engineering from Chesterfield, Mo., Chem-E-Car solution officer

Amy Snyder, a senior in chemical engineering from Rolla, Mo., Chem-E-Car safety officer.

The other members of the Chem-E-Car team include:

Nathan Breshears, a junior in chemical engineering from St. Peters, Mo.

Thomas Burke, a sophomore in chemical engineering from Kearney, Mo.

Brady Campbell, a junior in chemical engineering from Carl Junction, Mo.

Michael Clemons, a sophomore in chemical engineering from Ballwin, Mo.

Jonathan Colaric, a senior in chemical engineering from Lee’s Summit, Mo.

Robert Evans, a senior in electrical engineering from Neosho, Mo.

Micah Horsch, a freshman in chemical engineering from Springfield, Mo.

Aaron Latal, a sophomore in chemical engineering from St. Louis.

Michael McMahon, a sophomore in chemical engineering from Collinsville, Ill.

Carl Nelson, a senior in mechanical engineering from St. Louis.

Julie Nguyen, a senior in chemical engineering from St. Louis.

Colin Schulz, a sophomore in chemical engineering from Grafton, Wis.

Melissa Vidal, a senior in chemical engineering from Pozuelo de Alarcón, Spain

Lauren Weil, a senior in chemical engineering from Hecker, Ill.

Mathias Whitworth, a sophomore in chemical engineering from Mexico, Mo.

S&T's Steel Bridge Design Team wins regional competition

April 25, 2014 by Peter Ehrhard

Photo by Bob Phelan, Missouri S&T.

Missouri University of Science and Technology's Steel Bridge Design Team earned first place at the American Society of Civil Engineers' Mid-Continent Student Conference, held Thursday, April 24, through Saturday, April 26, at Oklahoma State University in Stillwater, Okla.

Missouri S&T competed against 13 other collegiate teams at the conference. The team earned a spot at the national competition that will be held May 23-24, at the University of Akron in Akron, Ohio.

The Steel Bridge competition challenged teams to construct a scale-model steel bridge as fast as possible. The bridges were then "load tested" to see if they could hold the required weight of 2,400 pounds. Missouri S&T's bridge weighs 320 pounds and is comprised of 22 pieces and more than 70 bolts. It is 17 feet long and is a 1:10 scale model bridge.

The teams were judged on bridge weight and rigidity, construction speed and the number of team members building the bridge. Missouri S&T's team earned first place in stiffness, efficiency and economy, and earned third in the display section. The team's scores were good enough for it to earn first place overall.

Dr. Timothy Philpot, associate professor of civil, architectural and environmental engineering at Missouri S&T, is the Steel Bridge Team faculty advisor, and Jermy Jamison, a senior in mechanical engineering from Grain Valley, Mo., is the 2014 team leader.

The following students are part of the 2014 Steel Bridge Team:

Photo by Bob Phelan, Missouri S&T.

Takota Anderson, a senior in mechanical engineering from Stark City, Mo.

Natalie Bouxsein, a senior in civil engineering from Sugar Hill, Ga.

Joel Cates, a junior in mechanical engineering from Pawnee, Ill.

Miranda Cory, a freshman in civil engineering from Atchison, Kan.

Matthew Duncan, a freshman in mechanical engineering from Moberly, Mo.

Shelby Gross, a junior in mechanical engineering from St. Charles, Mo.

Kayla Hindle, a junior in engineering from Wildwood, Mo.

Tyler Ishmael, a junior in mechanical engineering from Grain Valley, Mo.

Jermy Jamison, a senior in mechanical engineering from Grain Valley, Mo.

Sarah Jemison, a sophomore in architectural engineering from Nixa, Mo.

Nick Kaesik, a senior in architectural engineering from Freeburg, Mo.

Matthew Klegseth, a junior in civil engineering from Kansas City, Mo.

Sara Koestner, a junior in architectural engineering from Russellville, Mo.

Lynsey Lahey, a senior in civil engineering from Kirkwood, Mo.

Alex Marey, a freshman in computer science from Wildwood, Mo.

David Muller, a senior in architectural engineering from Ballwin, Mo.

Nathaniel Oberley, a sophomore in civil engineering from Virginia Beach, Va.

Holly Olson, a senior in mechanical engineering from Nanjemoy, Md.

Sarah Padgett, a senior in civil engineering from Topeka, Kan.

Kyle Roberts, a senior in architectural and civil engineering from Hannibal, Mo.

Alec Schlotzhauer, a sophomore in architectural engineering from Manhattan, Kan.

Austin Shull, a senior in architectural engineering from La Monte, Mo.

Samantha Smith, a senior in civil engineering from Washington, Ill.

Darrell Wallace, a senior in civil engineering from Lee’s Summit, Mo.

Missouri S&T's Human Powered Vehicle Team earns third place

May 1, 2014 by Peter Ehrhard

Missouri University of Science and Technology's Human Powered Vehicle Team earned third place at the American Society of Mechanical Engineers 2014 Human Powered Vehicle Challenge West Coast Competition, held April 25-27 in San Jose, Calif.

The competition challenged students to design, build and operate a human-powered vehicle for practical use. Missouri S&T's vehicle, named "Banshee," featured a carbon fiber fairing, the aerodynamic shell around the vehicle, on a recumbent trike, with two wheels in the front and one in the back. Touchscreen equipment was built into the handlebars to control the vehicle's lights, horn and turn signals.

Teams were scored on their engineering solutions through a written report and technical presentation about their vehicles. Missouri S&T earned third place in the innovation category during the design portion of the competition.

The actual racing was split into three sections. The first day of racing featured the men's and women's speed events, in which teams sprinted head-to-head over a short distance. On the second day of racing, teams competed in an endurance event, completing as many laps as possible during a span of several hours. Missouri S&T earned third in the women's speed and second in the men's speed events, earning the team third overall at the competition.

The team placed fifth at the Human Powered Vehicle Challenge East Coast Competition, held April 11-13 at the University of Central Florida in Orlando, Fla.

Dr. Daniel Stutts, an associate professor of mechanical and aerospace engineering at Missouri S&T, is the Human Powered Vehicle Team faculty advisor. For more information about the event, visit asme.org.

S&T Mars Rover Team is second in the world

June 3, 2014 by Mary Helen Stoltz

"Phoenix," Missouri S&T's Mars rover, took second place at the 2014 University Rover Challenge in Hanksville, Utah.

The Mars Rover Design Team at Missouri University of Science and Technology took second place in an international competition that challenges college students to design and build the next generation of Mars rovers.

Twenty-three teams from around the world competed in the University Rover Challenge, sponsored by the Mars Society, May 29-31 at the Mars Desert Research Station in Hanksville, Utah. The Hyperion Team from the Bialystok University of Technology in Poland took first place.

This is the second year Missouri S&T's Mars Rover Design Team competed in the University Rover Challenge. In 2013, the team placed last.

"The team expected to perform well during this year's competition, but did not expect to reach a second-place showing," says Dr. Melanie Mormile, professor of biological sciences at Missouri S&T and team advisor. "The team built an awesome rover."

Missouri S&T's Mars Rover, named Phoenix, is a student-designed and -built remote-controlled robotic rover with almost no off-the-shelf hardware or parts. The team developed custom circuitry for the rover, machined the aluminum and carbon-fiber support structure, had the frame cut using water-jet technology at Missouri S&T's Rock Mechanics and Explosives Research Center and 3-D printed the gears and drill bits used in the rover's arm.

Missouri S&T's team tied for first place in terrain traversing, in which the team must maneuver its rover across the rocky Utah terrain on a course designed to simulate the surface of Mars.

S&T took second place in both equipment servicing – a maintenance task designed to remotely repair broken parts; and in sample return – a task that requires the rover to collect and return soil samples from the course.

The team placed third in presentation. The students gave one presentation at the beginning of the competition to explain the design and cost of its rover, and another at the conclusion of the rover events to explain the reasoning behind the decisions the team made during the competition.

The team took fourth place in astronaut assist – a task designed to help collect lost tools.

"The team displayed amazing cooperation," Mormile says. "Everyone knew their functions and were also there to lend a hand as needed. It was a winning combination. The team is already aiming for first place next year."

Amde Amde and John Myers named TMS Fellow Members!
Come congratulate them at TMS's Annual Meeting

The Masonry Society's (TMS) Board of Directors and Awards Committee recently awarded Dr. Amde Amde of the University of Maryland and Dr. John Myers of Missouri University of Science and Technology with Fellow Membership in the Society. Fellow membership is one of the highest awards that can be bestowed on a TMS Member and is granted only rarely for exceptional service by individuals who have been Members of TMS for more than 10 years. TMS will formally recognize Amde and Myers at the 2014 TMS Annual Meeting in Scottsdale Arizona on October 11. They join a distinguished list of TMS Fellows as shown here.

New FTMS Dr. Amde Amde (left) of the University of Maryland and Dr. John Myers (right) of Missouri University of Science and Technology

APPENDIX: SUCCESS STORIES CLIPS

Missouri S&T in the News

External Media Sources

Most Recent Postings

Latest Dubai Press Releases >>

Spotlight on regional concrete construction growth at 'concrete in the middle east' conference in lebanon

- *One-day conference, organised by ACI Lebanon Chapter and ACTS, featured ACI Fresh Concrete Workability competition*
- *Latest concrete technologies, rapid evolution of Lebanon's construction sector and emergence of new trends such as unprecedented demand for high rise towers discussed*

Beirut, Lebanon; June 25, 2013: Advanced Construction Technology Services (ACTS), a consulting organisation in the field of construction materials and geotechnical engineering, collaborated with the Lebanese Concrete Society-ACI Lebanon Chapter for the conduct of 'Concrete in the Middle East' conference 2013 held recently in Movenpick Hotel, Beirut, Lebanon. This edition of the highly-awaited conference focused on the regional growth of concrete construction, with a particular emphasis on Lebanon's resilient construction sector which is seeing steady progress and the emergence of positive trends such as greater demand for high rise towers and stronger focus on quality.

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The conference also provided a platform for consultants, contractors, concrete and construction materials suppliers to discuss about the latest concrete technologies, including high-performance, high strength concrete; self-compacting concrete; cement technologies; in addition to technology related to durable construction and pumpability of concrete to high rise structures.

Another major highlight of the conference was a student competition under the name "ACI Mortar Workability Competition", which focused mainly on workability and rheological properties of concrete. Phillipe Hawi and Ashraf Ayad from the University of Balamand were adjudged as the first-placed team who won an all-expense-paid trip to the USA to attend the ACI convention.

"Following the overwhelming success of the 2011 edition of the 'Concrete in the Middle East' conference, we are excited to have teamed up once again with ACI Lebanon Chapter for this conference. The event held particular significance for the Lebanese construction sector, which has remained resilient despite several challenges and the unstable economic conditions in the region," said Khaled Awad, Chairman of ACTS and President of the Lebanese Concrete Society-ACI Lebanon Chapter

"We have witnessed a steady increase in the prices of land, especially in Beirut and other Lebanese cities with high population, which is in turn driving demand for high rise structures. This presents a new set of challenges in Lebanon, especially to the concrete industry as it must adapt and embrace advanced technologies. 'Concrete in The Middle East' Conference created the right setting for construction industry players, developers, engineers, contractors and concrete suppliers from different parts of the region to share best practices and insights to address emerging challenges and align the growth in the demand of concrete with best practices and modern technologies," Khaled Awad added.

The conference featured renowned local, regional and international speakers and experts who shared their knowledge and expertise in the various fields of concrete technology among them: Engr. Khaled Awad, Chairman and Founder of ACTS; Dr. Kamal Khayat, Director of the Center for Transportation Infrastructure and Safety and the Center for Infrastructure Engineering Studies in Missouri University of Science and Technology; Dr. György L. Balázs, professor at the Faculty of Civil Engineering in Budapest University of Technology and Economics Hungary; Dr. Hani Nassif, professor at Rugters the State University of New Jersey, Dr. Ibrahim Khatib, Associate and Manager of the Structural Department at Khatib & Alami and lecturer in the American University of Beirut; Eng. Rodolphe Mattar, Chairman of Bureau D'etudes Rodolphe Mattar; Eng. Elie Sfeir, QA/QC head of Section at erga Group, Dr. Michel Khouri Chairman of Civil Engineering Department at Lebanese University Branch 2, Dr. Joseph J. Assaad, R&D Manager at Holderchem Building Chemicals and part-time professor at Notre Dame University and Lebanese American University; Dr. Marwan Al Kazzaz, Head of Central Research, Development and technical support at SODAMCO-WEBER, a leading construction chemical supplier; and, Eng. Rachid Moubarak, head of Operations at Apave Liban and Deputy Regional manager.

Supporting the conference were ASTM International, fib (federation international du beton), OEA (order of Engineers and Architects), Araco, Sodamco, Cimenterie Nationale, MSC, Saint Gobain, Zerock, BCL, Holcim Holderchem, General Mix Concrete, Sika and Sibline Ciments.

Posted by : Tarabut PR, Hiba Al Hafidh / Lorena Fajardo
Viewed 11730 times
Posted on : Tuesday, June 25, 2013 3:37:00 PM UAE local time (GMT+4)

Highway 50 bridge to test technology

Monday, September 23, 2013 at 2:00 pm

JEFFERSON CITY (AP) — A new highway bridge east of Jefferson City will serve as an experiment in concrete technology.

Missouri University of Science and Technology has worked with state highway officials to develop several different mixtures of concrete that are being used on the Highway 50 bridge.

Engineering Professor John Myers said sensors are being embedded in the concrete to monitor performance.

One span of the bridge will use a traditional concrete mixture while another will use a self-consolidating mixture. A third span will use a high-strength, self-consolidating mixture that includes finer rock and chemicals designed to allow the cement to more easily flow into every corner of a form.

The bridge work is to be completed this fall.

Topics: Jefferson City, Structural Engineering, Concrete, Missouri University Of Science And Technology

Missouri bridge to test concrete technology

Posted: 09.23.2013 at 8:26 AM

Read more: Local, News, Highway Bridge, Jefferson City, Concrete Technology, Missouri University of Science and Technology, State Highway Officials, Mixtures of Concrete, U.S. 50 Bridge, Engineering Professor John Myers, Bridge Work

save send print

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/ File

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APR 14

PROJECT PROFILE: MISSOURI S & T EXPERIMENTAL BRIDGE

CATEGORIES // eNews, Bridge Girders & Prestress, Ready-Mix and Aggregates

Project Profile: Missouri S&T Experimental Bridge

A new bridge spanning the St Mary's River on Highway 50 just east of Jefferson City, MO may not look unusual, but it could save Missouri taxpayers thousands of dollars in bridge construction costs over the next few decades. It is being used to test innovative concrete mixes side by side under real world conditions in a series of research projects being conducted by the Missouri University of Science & Technology and Missouri DOT. One test, to which County Materials Corporation contributed its experience, will assess the relative performance of girders constructed from two different mixes of self-consolidating concrete (SCC) alongside a traditional concrete mix. This will be the first bridge in Missouri to contain SCC.

SCC is a type of concrete that, when poured, is considerably more flowable than traditional concrete mixes. This confers a number of advantages:

· SCC requires little to no use of mechanical vibrators to reduce entrapped air in the concrete during placement. It thus requires a smaller crew size, which leads to considerable savings in production costs.

· When used to fabricate precast or prestressed concrete structures, SCC flows more readily between and around the steel substructure. A more elaborate steel framework is possible, which can reduce girder size and result in a stronger, more durable product.

· Because SCC mixes contain less entrained air, fewer bubbles and "bug holes" appear in the finished product for a smoother, more aesthetically pleasing surface.

Most SCC mixes require an increase in the proportion of fines and a reduction of coarse aggregate compared to traditional concrete. This raises concerns that the materials' shear

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Most SCC mixes require an increase in the proportion of fines and a reduction of coarse aggregate compared to traditional concrete. This raises concerns that the materials' shear resistance may be adversely affected, and that stiffness may be compromised. Researchers hope that the results of testing on this bridge will prove the materials' merit and clear the way for the use of SCC on future transportation projects.

The three-span Highway 50 bridge contains three sets of girders fabricated by County Materials' Bonne Terre, MO plant. The girders for the first span are made from a standard SCC mix. The second set of girders is manufactured with a high-strength SCC. This mix contains a higher percentage of cement for a stronger, more durable product with a compressive strength of up to 14 KSI. The third span is constructed using a standard Missouri DOT approved concrete mix design and will function as the control in the experiment. The bridge decking was also supplied by County Materials.

Sensors embedded in the girders and bridge deck will allow researchers to monitor the materials' performance over time, and provide real-world data about their relative strength as well as detailed information on the bridge's internal stresses.

"There have been very few projects in the United States that have used a high-strength self-consolidating concrete. It's not so easy to translate laboratory tests into real-life estimates of service life. A project like this is really important because (the different types of concrete will) all be exposed to the same environmental conditions. Over time we'll directly get to see exactly how much more durable these other concrete materials are," says Dr. John Myers, the Missouri S&T professor who heads the research. Myers adds that using the high strength self-consolidating mix allowed the span length to increase by 20%, and is expected to reduce maintenance costs over the life of the structure. "Most of the current bridges (in Missouri) have a service life of 25-50 years. We're hoping to double that."

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Preliminary research began in the fall of 2013. Since the success of an SCC mix is very dependent on the particular materials used, numerous mixes using local aggregates were tested, and the minimum amount of coarse aggregate for the high strength SCC mix was determined before County Materials' Bonne Terre team formulated the final mixes used in the project. By March, 2013, County Materials had manufactured two large scale prototype girders. These underwent extensive laboratory testing before the mixes were approved for use in the bridge. The bridge is expected to be completed by late summer, 2014. Testing is expected to continue for years.

Missouri S&T graduate students and MoDOT personnel worked alongside County Materials staff at the Bonne Terre plant during fabrication of the girders and placement of the sensors. "It's been a very positive experience for us as the research team. (County Materials has) always been very accommodating at the plant. It's been a very positive relationship from the research perspective, integrating what we need to do with the folks in Bonne Terre," comments Dr. Myers. "They were all willing to help out and do anything we needed," agrees Shannon Inman, senior materials inspector of the materials division of MoDOT.

Both Myers and MoDOT were pleasantly surprised at the project's cost-effectiveness. Even at the experimental stage, the cost to build the structure was only slightly higher than standard construction. "We're very confident that as (the technology becomes more widespread), the cost will go down," says MoDOT research engineer Jen Harper, adding that "Missouri has been working hard to find more (ways) to save taxpayers money." If the results of the Highway 50 bridge experiment come out as expected, switching to self consolidating concrete could be one way to do just that.

To read up more and see a video on the project, please click on the link here.

S&T names first 'signature' areas

Missouri University of Science and Technology made significant headway in carrying out its strategic plan last week by identifying two of four areas in which the campus aims to achieve best-in-class, or signature, status as a research university.

By Staff Reports
Posted Jan. 20, 2014 @ 9:00 am
Updated Jan 20, 2014 at 9:52 AM

Missouri University of Science and Technology made significant headway in carrying out its strategic plan last week by identifying two of four areas in which the campus aims to achieve best-in-class, or signature, status as a research university.

The two areas – advanced manufacturing and advanced materials for sustainable infrastructure – were chosen from among 15 proposals submitted by Missouri S&T faculty.

The proposals and subsequent presentations were screened by a committee of faculty representatives from all academic areas on campus, then selected by S&T Chancellor Cheryl B. Schrader and Provost Warren K. Wray.

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The proposals were judged on how well they connected to long-term critical national issues, research and entrepreneurship potential, and alignment with Missouri S&T's strategic plan.

"From the beginning, we have known that to successfully implement our strategic plan, we would have to focus on signature areas of excellence," Schrader said.

"Our plan isn't about being everything to everyone. It is about deciding where it makes the most sense to invest, enable and grow, and providing the best return on that investment to our customers," the chancellor added. "These two areas represent a bold step in the future vitality of this university and will offer research and educational solutions to benefit Missouri, the nation and the world."

Attaining signature status in these areas means that Missouri S&T will build on their distinctive strengths in teaching and research to make the areas among the nation's best, Schrader said.

To better position S&T to achieve this status, last September Schrader announced new funding from campus and the University of Missouri system to support the hiring of additional faculty in signature areas, as well as in other areas of strategic importance.

In all, S&T plans to add 100 new faculty positions by 2020, an increase of nearly 20 percent.

In the signature area of advanced manufacturing, S&T will emphasize instruction and research in the emerging fields of additive manufacturing, energy manufacturing, micro- and nano-scale manufacturing, network-centric and cloud manufacturing, advanced materials for manufacturing, and intelligent sensor-enabled manufacturing.

The area will be led by a multidisciplinary team of researchers.

That team includes Dr. Ming Leu, the Keith and Pat Bailey Missouri Distinguished Professor of Integrated Product Manufacturing; Dr. Wayne Huebner, professor and chair of materials science and engineering; Dr. Jag Sarangapani, the William A. Rutledge-Emerson Electric Co. Distinguished Professor of Electrical and Computer Engineering; Dr. Suzanna Long, assistant professor of engineering management and systems engineering; Dr. Frank Liu, professor of computer science; Dr. Greg Hilmas, Curators' Professor of ceramic engineering; and Dr. Frank Liou, the Michael and Joyce Bytnar Professor of Product Innovation and Creativity.

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"This is a perfect fit for Missouri S&T because of the national importance of advanced manufacturing, the existing S&T strength in this area and our confidence in developing it to be among the best in the nation," Leu says.

UNIVERSITY STUDY SHOWS VERIFI BENEFITS FOR CONCRETE QUALITY

Posted on: February 18th, 2014 by Verifi

A new study released by the Missouri University of Science and Technology (MS&T) and sponsored by the Missouri DOT (MoDOT) shows that Verifi accurately measures concrete slump and temperature, correctly adjusts to target slump by adding water or admixture in transit, and ensures high concrete quality. (Read the full report **here**.)

The study, which was performed by Dr. Kamal Khayat and Dr. Nicolas Libre of MS&T, was sponsored by the Missouri Department of Transportation (MoDOT).

The report concludes:

> "The results of this research indicate that 1) VERIFI is able to accurately measure concrete slump and temperature in the truck, 2) VERIFI is able to adjust slump automatically to target by adding water and admixture, and 3) adding water in transit instead of at the jobsite or plant does not negatively affect concrete performance. Compared to current industry practices, VERIFI provides more accurate and complete documentation of concrete

FOR CONCRETE QUALITY

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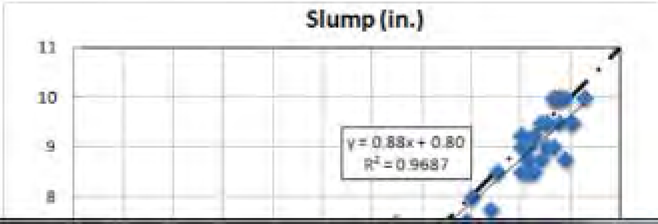
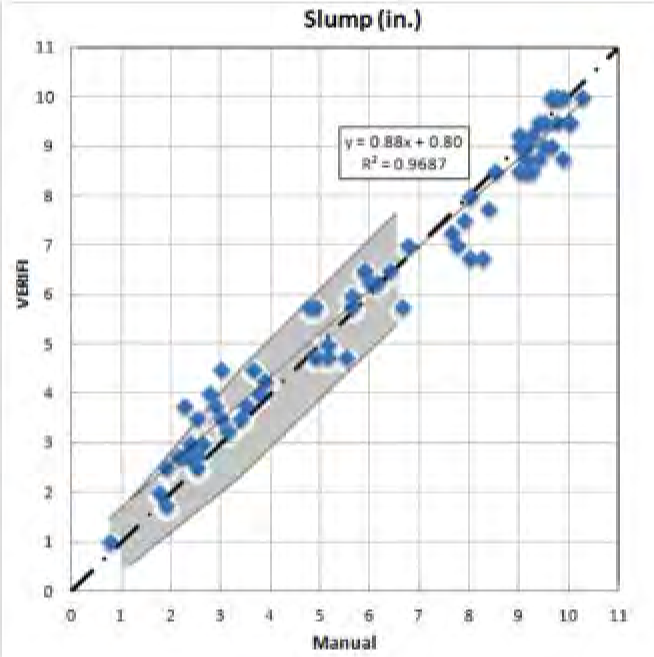
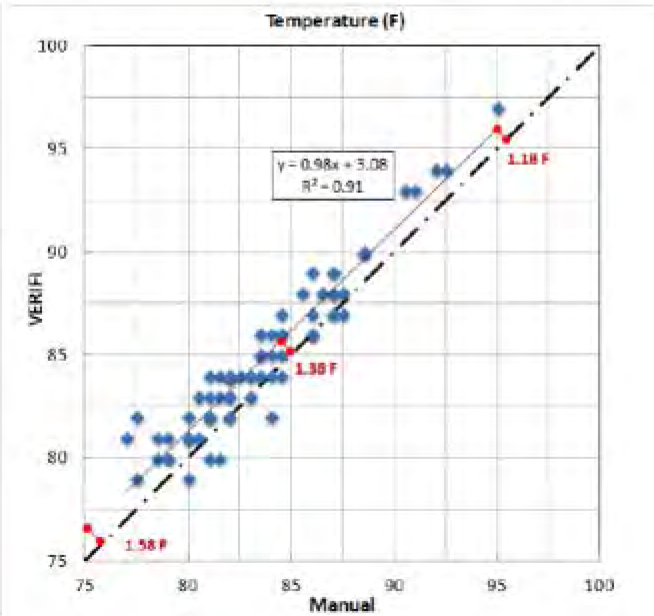
> "The results of this research indicate that 1) VERIFI is able to accurately measure concrete slump and temperature in the truck, 2) VERIFI is able to adjust slump automatically to target by adding water and admixture, and 3) adding water in transit instead of at the jobsite or plant does not negatively affect concrete performance. Compared to current industry practices, VERIFI provides more accurate and complete documentation of concrete properties, including all additions of water, so that engineers and inspectors can confirm whether concrete meets specification. Therefore, VERIFI can be allowed to add water during transit and data from VERIFI can be used for acceptance purposes."

The study evaluated 20 concrete batches, covering six mix designs and two trucks. The average absolute difference between the Verifi reading and the manual reading was 0.47 in. for concrete slump and 1.4°F for concrete temperature. These were well within ASTM limits.





MoDOT Report: Slump Accuracy



MoDOT Report: Temperature Accuracy

PHYS.ORG

Researchers study 'smart' rocks use for detecting bridge damage

July 2nd, 2014 in Technology / Engineering

Enlarge

An example of a passive smart rock containing a magnet suspended in liquid is in the foreground. Active smart rocks have embedded electronics. In the background is a concrete-encased smart rock that is about the size of a basketball and weighs about 50 lbs.

An example of a passive smart rock containing a magnet suspended in liquid is in the foreground. Active smart rocks have embedded electronics. In the background is a concrete-encased smart rock that is about the size of a basketball and weighs about 50 lbs.

(Phys.org) —It's hard to gauge how structurally sound a bridge is when its foundation is buried in a riverbed deep below the water's surface. New "smart" rocks that are being developed by researchers at Missouri University of Science and Technology will give engineers an accurate, easy and cost-effective tool to monitor a bridge's foundation, in real time.

The leading cause of bridge collapse in the U.S. is scour, an erosion process where water flow carries away river bed deposits and creates scour holes around the bridge pier or abutment. Floods intensify these scour effects and can quickly make the bridge unstable.

Smart rocks placed at the base of bridge foundations are designed to roll to the deepest point of a scour hole and act as field agents to relay scour depths.

"It's a simple, but very useful, concept," says Dr. Genda Chen, principle investigator and professor of civil, architectural and environmental engineering and the Robert W. Abbett Distinguished Chair in Civil Engineering at Missouri S&T. "The rock follows the trail of the scour hole's progression – as it goes deeper and deeper, the rock will also sink deeper and deeper. One reason we call it 'smart' is because the rock can represent the maximum depth of the hole."

Chen is collaborating on the project with Dr. David Pommerenke, professor of electrical and computer engineering, and Dr. Rosa Zheng, associate professor of electrical and computer engineering. The project is sponsored by the Research and Innovative Technology Administration of the U.S. Department of Transportation and the Missouri Department of Transportation.

The researchers are testing three smart rock technologies: passive, active and semi-active. Passive smart rocks have an embedded magnet that can be read by a remote magnetometer. Active smart rocks have embedded electronics, including a pressure sensor, gyroscope, timer, battery indicator and individual identification, which transmit data through wireless communication. Semi-active smart rocks include a free-to-rotate magnet that can be controlled with electronic circuitry.

"Engineers sometimes complain that these type of devices give them so much data, they don't know what to do with it all," says Chen. "These smart rocks can give engineers critical information they need, when they need it."

Chen says during normal operations, readings are usually taken every six months to a year. "But scour develops very rapidly during flood season," he says. "If the engineer feels like there might be a new development, they can take a reading at that moment, without being overwhelmed with continual data processing and storage."

The technology is also cost-effective, says Chen. "You can use this data to evaluate the foundation's stability without having to send a diver down there."

Engineers routinely place large rocks around the bridge foundation to protect the soil below from being eroded away by the current, a technique called riprap.

"No one really knows how effective riprap is during flood season," says Chen. "With the muddy water, you don't know what's going on. But if we mix a few smart rocks with the natural rocks around the foundation, the movement of the smart rocks will indicate the performance of the riprap system, and will also tell the engineer if there's a problem with scour."

A major concern for scour monitoring is how well the technology holds up during a flood event. "There is a lot of technology that works very well in the lab, but it cannot be applied in field conditions because of damage from strong currents," Chen says. The researchers are seeing good results with smart rocks deployed in 2012 at Missouri's Gasconade River Bridge and Roubidoux Creek Bridge. The rocks will last forever and the battery survives about five-to-10 years, depending on how often data is collected, Chen says.

The researchers hope to partner with state departments of transportation for further studies.

"We'd like to engage a few state DOTs to employ a number of smart rocks in their bridges so we can start taking data before and after the flood season to see whether rocks have moved or not," he says.

"About 60 percent of collapsed bridges in the U.S. are due to hydraulic reasons, of which scour plays a major part," says Chen.

Provided by Missouri University of Science and Technology

"Researchers study 'smart' rocks use for detecting bridge damage." July 2nd, 2014. http://phys.org/news/2014-07-smart-bridge.html

Homeland Security News Wire

Infrastructure protection

"Smart" rocks detect bridge damage

Published 3 July 2014

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It is hard to gauge how structurally sound a bridge is when its foundation is buried in a riverbed deep below the water's surface. New "smart" rocks which are being developed by researchers will give engineers an accurate, easy and cost-effective tool to monitor a bridge's foundation, in real time. The leading cause of bridge collapse in the United States is scour, an erosion process where water flow carries away river bed deposits and creates scour holes around the bridge pier or abutment. Smart rocks placed at the base of bridge foundations are designed to roll to the deepest point of a scour hole and act as field agents to relay scour depths.

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A Missouri S&T release reports that the leading cause of bridge collapse in the United States is scour, an erosion process where water flow carries away river bed deposits and creates scour holes around the bridge pier or abutment. Floods intensify these scour effects and can quickly make the bridge unstable.

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APPENDIX: SUCCESS STORIES CLIPS

Missouri S&T in the News

Internal Media Sources

S&T to lead partnership with industry in modular reactor consortium

July 29, 2013 by Mary Helen Stoltz

Ameren and Westinghouse Electric Co. are tapping into the expertise of Missouri University of Science and Technology (Missouri S&T) and the University of Missouri-Columbia (MU) to conduct research that will benefit the nuclear energy industry.

Graphical rendering of the Westinghouse SMR containment vessel. ©2013 Westinghouse Electric Company LLC. All Rights Reserved.

Missouri S&T, home to the state's first nuclear reactor, will lead the multi-university Small Modular Reactor (SMR) Research and Education Consortium with a satellite center at MU. Ameren and Westinghouse Electric Co. are founding members of the consortium.

"We're very pleased to lead this important collaboration," says Missouri S&T Chancellor Cheryl B. Schrader. "With research capabilities in nuclear, civil, electrical and chemical engineering, materials science and engineering, and manufacturing, Missouri S&T is well-positioned to provide a broad range of engineering and science expertise to this effort.

"We look forward to working with our colleagues in Columbia as well as with Westinghouse, Ameren and other partners to address one of our nation's most pressing energy challenges," Schrader says.

The consortium is also supported by a $250,000 grant from the Missouri Technology Corporation, a public-private partnership created by the Missouri General Assembly to promote entrepreneurship and foster the growth of new and emerging high-tech companies. Funds from the grant will be used to establish and grow the consortium, initially providing a 50 percent match for consortium membership fees.

"The consortium will support member-driven research," says Dr. Joseph Smith, the Wayne and Gayle Laufer Chair of Energy at Missouri S&T who also serves as executive director of the SMR Research and Education Consortium.

"An industrial advisory board representing each consortium member will determine the research projects and direction," Smith says. "We will be working on projects that are of interest to our members, and everyone will benefit from the research and education that results. The work of this consortium will have a significant impact on energy and energy security, and will help the U.S. maintain its leadership role in science and technology."

The consortium will identify and develop technology that supports small modular nuclear reactors to improve energy security and the environment. Smaller than traditional nuclear power plants, SMRs provide more flexibility for generating electricity.

The consortium will initially focus on seven areas:

- To establish and apply certified computer-aided engineering tools to evaluate the design and safe operation of SMRs
- To help regulatory agencies develop new SMR licensing, develop deployment strategies for SMRs and evaluate new applications that aren't possible with current nuclear reactors
- To support the development and testing of advanced construction materials like high-performance concrete and to help develop advanced manufacturing concepts
- To support development of advanced materials for SMR design that will reduce cost and increase safety, like silicon carbide and composites
- To collaborate with research laboratories, private industry and international groups to investigate advanced fuel cycles, advanced mining concepts, and waste collection, storage and disposal methods
- To develop new high-temperature remote sensors for advanced monitoring and control strategies required in SMR systems and to investigate and support use of hybrid energy systems combining nuclear energy with legacy and renewable energy sources
- To develop and provide distance-learning opportunities, both for credit and non-credit, related to SMR technology and to support public awareness through outreach to K-12 students, teachers and the public.

"The University of Missouri System, through its Rolla and Columbia campuses, is well-positioned to conduct cutting-edge research to advance the design, construction and operation of SMRs," says University of Missouri System President Tim Wolfe. "This impressive partnership between the UM System campuses and industry partners in this emerging energy field will help to provide educational and support research activities, creating and helping fill the pipeline of trained engineers and scientists that will be needed to support SMR renaissance for the nuclear industry."

"We anticipate that the development of the Small Modular Nuclear Reactor will be critical to meeting future energy needs worldwide in an environmentally responsible manner," says MU Chancellor Brady Deaton. "Our collaboration with Westinghouse and Ameren and others through this consortium with Missouri S&T will bring great prosperity and opportunity to Missouri as we collectively address these energy needs. MU hosts the most powerful research reactor on any university campus, and excellent programs in nuclear science, engineering, and in radiochemistry. We anticipate that our comprehensive strengths in these technical disciplines and in public policy will contribute profoundly to this new consortium."

Projects the consortium may consider in the future include a validation and verification study and a plan to study ways the heat generated by SMRs could be used in projects like water desalinization, production of petroleum products and hydrogen production.

Missouri S&T developed the state's first nuclear engineering program and one of the first in the nation, offering accredited undergraduate nuclear engineering degrees in 1960. Master's and Ph.D. degrees in nuclear engineering have been offered on the Rolla campus since 1959 and 1965, respectively. Today, S&T is one of only 22 universities in the nation to offer bachelor's degrees in nuclear engineering.

Missouri S&T's nuclear reactor began operations in 1961. Licensed to operate at 200 kilowatts thermal power, the reactor is used for research and teaching in many disciplines at Missouri S&T.

The MU Research Reactor, which is the highest-powered research reactor on a university campus in the United States, operates at 10 megawatts. The reactor has an extremely reliable history of continuous operation more than 150 hours per week providing neutrons for nuclear-based experiments ranging from neutron activation analysis to radioisotope production and radiation damage studies.

What others are saying about the SMR Research and Education Consortium:

"As Westinghouse has recognized, Missouri offers many advantages for the development and manufacture of SMRs, including our outstanding workforce, world-class research universities, central location and the excellent safety record of Ameren Missouri. This consortium bolsters those advantages, and showcases the cutting-edge work in nuclear energy taking place in our state." – Missouri Gov. Jay Nixon

"The development of Small Modular Reactors is very important to the energy future of the world. The technology is highly challenging, but this unique consortium between industry, the State of Missouri, Missouri S&T and MU is the ideal partnership to overcome the many technological barriers. The consortium possesses the world class researchers and resources to drive the technology and become world leaders." – **Dr. Mark Prelas, professor of nuclear engineeringat MU and a research associate with the MU Research Reactor and director of research at the Nuclear Science and Engineering Institute at MU**

"As a founding member of the consortium, we are able to advance state-of-the-art of nuclear power technology while supporting our local universities in research and educating the public. Our investment in the consortium will directly support efforts to advance the business of small modular reactors in our state, creating non-carbon energy, jobs and future economic development opportunities." – **Warner Baxter, president and CEO Ameren Missouri**

"Rapid deployment of the first Westinghouse SMR in Missouri offers the opportunity to create a new industry cluster to serve a global market. The research consortium provides a unique resource to our company and to the energy sector in the US. I extend my gratitude to Governor Jay Nixon for his leadership in supporting the state grant and we look forward to a productive investment in the consortium." – **Kate Jackson, chief technology officer at Westinghouse Electric Co.**

S&T researchers create model for managing urban restoration after a natural disaster

September 5, 2013 by Mindy Limback

Helping a community recover quickly after a major disaster is the goal of a new project by researchers at Missouri University of Science and Technology.

A view of the destruction from 24th Street, between Kentucky and Grand streets in Joplin, Mo.

Working with the U.S. Geological Survey and the University of Puerto Rico at Mayaguez, a team of Missouri S&T researchers is developing a model that can help city planners return their community to its pre-event state in the aftermath of a large-scale disaster. It's one of the first models to consider critical infrastructure elements, geospatial data, hazard damage and restoration rate in a comprehensive recovery approach.

"Most restoration plans deal with the short-term recovery, the search-and-rescue phase," explains Dr. Suzanna Long, professor of engineering management and systems engineering at S&T. "People are in the moment. They're facing an overwhelming task. A lot of decisions have to be made on instinct or expediency. We're saying they should trust those instincts, but it's our hope our model will add a layer of comfort in that decision process."

To construct the model, the research team began by gathering water, sewer line, transportation, communication and electricity data for Overland Park, Kan., a region that experiences tornadic activity at a rate that's 4.1 times the national average.

"We could have done it anywhere," she says. "But that area also is nationally connected, with both industrial and transportation logistics."

The team worked with Dr. Tom Shoberg, research geographer in the Center of Excellence for Geospatial Information Science at the USGS, to compile detailed imagery of roads, bridges, electric lines and poles, and cell phone towers in the area.

To get a solid understanding of a tornado's damage, the team called on the National Climate Data Center and the National Oceanic and Atmospheric Administration for insight into the average width, direction and path of an EF-5 tornado, along with the average size of the devastation and collateral damage zones.

The research is personal to Long, whose high school-aged daughter was born in Joplin, Mo., a community where Long also worked at Missouri Southern State University. When news broke that an EF-5 tornado had torn through Joplin in May 2011, Long was sitting on a plane in Dallas, Texas. She overhead the airline attendants say Joplin had been destroyed.

"It brought to mind things that had not worked well with Katrina, and I worried about that same type of misery impacting former friends and neighbors," Long says. "I thought, 'there has to be a better way.' During the emergency response, the feelings are about survival. During the recovery, those feelings quickly change to frustration with available resources."

The model also integrates information about collaboration among the local, state and federal agencies, the availability of raw materials, and number of skilled workers needed to get the community back on its feet.

"Some things will never be rebuilt, never come back," she says. "Some may never come back because the resources weren't available at the right time. We want the rebuild or not-to-rebuild decision to be based on considerations other than available resources. A better understanding of resource allocation logistics may help cities return to more quickly after the search-and-rescue phase has ended."

Also working alongside Long on the research, which is funded in part by USGS, are Dr. Steven Corns, assistant professor of engineering management and systems engineering at S&T, and Dr. Hector Carlo, associate professor of industrial engineering at the University of Puerto Rico at Mayaguez. Two S&T Ph.D. students, Varun Ramachandran and Liz Perez, are also working on the project.

For the next phase, the team plans to model the impact an 8 or 9 magnitude earthquake along the New Madrid fault of the St. Louis metropolitan area.

Innovative concrete bridge to open this fall near Jefferson City, Mo.

September 19, 2013 by Mindy Limback

Just east of Jefferson City, Mo., sits a construction site that will soon be home to one of the nation's first bridges to incorporate an unusual concrete mix in its girders and support structure. The three-span bridge, which is scheduled to be completed this fall on Highway 50, will also be outfitted with various sensors and instrumentation to collect data on how well the bridge performs over time.

It's another milestone for Dr. John J. Myers, a professor of civil, architectural and environmental engineering at Missouri University of Science and Technology working with the Missouri Department of Transportation and Missouri S&T's National University Transportation Center. Myers has spent the past decade studying and testing high-strength concrete and other innovative concrete systems for implementation.

"In 2012, we completed a two-year study that examined overall behavior of self-consolidating concrete, or SCC, using locally available materials including natural river sands, dolomitic limestone aggregates and river gravels," Myers says. The study examined the concrete and steel reinforcing material's shear strength, transfer and development length, creep and shrinkage as well as key durability attributes.

Myers and his team found that using high-strength self-consolidating concrete, or HS-SCC, can either extend the span length of the HS-SCC girders, a structure's main support member, or reduce the number of girder lines needed in a given span.

"That's because this material can allow for additional prestressing tendons, which can increase the girder's load-carrying capacity," says Myers.

Myers says they also expected the material to have reduced maintenance costs and an extended service life compared to conventional concrete due to the HS-SCC's improved durability behavior.

Concrete typically has four key components: portland cement, water, fine aggregate like sand and course aggregate or rock. In HS-SCC, the course aggregate is finer and chemical mixtures are added to increase its flow rate. That allows it to flow into every corner of a form work, by its own weight, eliminating the need for vibration or other types of compacting effort that requires more labor at the precast plant or job-site.

"It's a more efficient use of the material," Myers says. "With its increased strength, it can extend a span's length by 20 percent or more."

The new bridge will combine three different types of concrete grades in the girders. The first 100-foot span will use traditional concrete. The second, 120-foot span, will use high-strength, self-consolidating concrete. The final span will use self-consolidating concrete. Using sensors embedded in the material, researchers will monitor to see any differences as they occur. The bridge also includes instrumentation that will allow the research team to collect important data during load testing and normal in-service conditions.

"The advantage of having one bridge demonstrating four to five types of concrete throughout the entire bridge is that you know the exposure conditions, salts, temperatures, weather conditions are all identical," Myers explains.

In addition, one intermediate support will use concrete with a high-replacement level of fly ash, fine particles from coal are the by-product of a power plant's combustion process. During the manufacture of traditional cement, limestone and other materials are heated to extreme temperatures, releasing of CO_2 from both chemical reactions and the heating process. By replacing half of the cement with fly ash, the mix not only reduces the amount of fly ash that ends up in landfills but will cut CO_2 emissions as well. It also will make for a more cost-effective concrete mix, which will reduce construction costs.

The state's first bridge to use high-strength, self-consolidating concrete was constructed in 2009 in Rolla and led by Myers' research group. The bridge, designed for rapid construction, was one of two built to demonstrate the mechanical and material properties of high-strength concrete and high-strength, self-consolidating concrete.

Dr. Jeffery Volz, a former Missouri S&T assistant professor of civil, architectural and environmental engineering, is working with Myers on the research. County Materials Corp. in Bonne Terre, Mo., was responsible for fabrication of the prestressed-precast girders. Iron Mountain Construction Services of Maryland Heights, Mo., was responsible for the overall construction of the bridge project.

ElGawady elected to The Masonry Society

October 9, 2013 by Mary Helen Stoltz

Dr. Mohamed ElGawady, associate professor of civil, architectural and environmental engineering at Missouri University of Science and Technology, was recently elected to serve as a member of the The Masonry Society (TMS) board of directors.

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, a structural engineer, studies the seismic behavior of masonry and concrete structures. 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, segmental construction, rocking mechanics and the use of sustainable materials in seismic prone regions.

TMS was founded in 1977, as an international group of professionals dedicated to the advancement and craft of masonry. The society has more than 650 members including: engineers, architects, builders, researchers, educators, building officials, material suppliers, manufacturers, as well as others who want to contribute to and benefit from the global pool of knowledge on masonry.

The Masonry Society gathers and disseminates technical information through its committees, publications, codes and standards, slide sets, videotapes, computer software, newsletter, refereed journal, educational programs, professors' workshop, scholarships, certification programs, disaster investigation team and conferences.

S&T selected to lead effort to improve sustainability in nation's transportation

October 25, 2013 by Linda Fulps

Missouri University of Science and Technology has been selected to lead a consortium of four universities sharing in a 2013 University Transportation Centers (UTC) tier 1 grant. This program was authorized by Congress under the Moving Ahead for Progress in the 21st Century Act (MAP-21). The center's research will focus on developing the next generation of cement-based construction materials.

Dr. Kamal H. Khayat, director of new UTC

Missouri S&T will share a $1,414,100 per year, two-year grant with Rutgers University, Southern University, University of Illinois at Urbana-Champaign and University of Miami. The grant requires a minimum match from non-federal sources, so the overall program will be valued at least $2,121,150 per year by the time the grant concludes. The goal of the consortium is to meet a 1:1 match to ensure a funding level of approximately $5.5 million.

"We are honored to be selected to lead this effort," says Dr. Kamal H. Khayat, director of Missouri S&T's Center for Infrastructure Engineering Studies. "This consortium has the opportunity to do great things. We have assembled a wonderful team of researchers, staff and students — this grant will give them the opportunity to shine."

A specialist in the development of advanced cement-based materials for structural applications and rehabilitation projects, Khayat is the Vernon and Maralee Jones Chair of Civil Engineering at Missouri S&T and is principal investigator for the grant. Co-PIs from Missouri S&T include Dr. John J. Myers, professor of civil, architectural and environmental engineering; Dr. Dimitri Feys, assistant professor of civil, architectural and environmental engineering; and Dr. Jeffery Volz, who recently relocated to Oklahoma University, but will continue to participate in the consortium.

This new UTC, named RE-CAST (Research on Concrete Applications for Sustainable Transportation), will carry out multi-scale and multi-disciplinary studies to investigate the use of innovative materials and structural systems to enhance the durability and sustainability of the transportation infrastructure.

"The ultimate goal of the proposed research program is to fast-track the acceptance of these technologies and develop national standards and guidelines for their use for the reconstruction of the nation's infrastructure for the 21st Century," says Khayat, RE-CAST director.

The U.S. Department of Transportation's Research and Innovative Technology Administration announced that 142 UTC applications were submitted for a share of the $63 million in grants. A total of 33 grants were awarded to research institutions across the United States.

U.S. Transportation Secretary Anthony Foxx said in a news release that UTCs are key to helping the country address today's transportation needs, from environmental sustainability to safety. "The participating universities are a critical part of our national transportation strategy and to developing a professional workforce with the expertise and knowledge to tackle the challenges of the future," he said.

First two of four 'signature' areas named

January 17, 2014 by Andrew Careaga

Advanced Materials for Sustainable Infrastructure is one of Missouri S&T's signature areas for teaching and research.

Missouri University of Science and Technology made significant headway in carrying out its strategic plan this week by identifying two of four areas in which the campus aims to achieve best-in-class, or signature, status as a research university.

The two areas – Advanced Manufacturing and Advanced Materials for Sustainable Infrastructure – were chosen from among 15 proposals submitted by Missouri S&T faculty. The proposals and subsequent presentations were screened by a committee of faculty representatives from all academic areas on campus, then selected by S&T Chancellor Cheryl B. Schrader and Provost Warren K. Wray. The proposals were judged on how well they connected to long-term critical national issues, research and entrepreneurship potential, and alignment with Missouri S&T's strategic plan.

"From the beginning, we have known that to successfully implement our strategic plan, we would have to focus on signature areas of excellence," Schrader says. "Our plan isn't about being everything to everyone. It is about deciding where it makes the most sense to invest, enable and grow, and providing the best return on that investment to our customers. These two areas represent a bold step in the future vitality of this university and will offer research and educational solutions to benefit Missouri, the nation and the world."

Attaining signature status in these areas means that Missouri S&T will build on their distinctive strengths in teaching and research to make the areas among the nation's best, Schrader says. To better position S&T to achieve this status, last September Schrader announced new funding from campus and the University of Missouri System to support the hiring of additional faculty in signature areas, as well as in other areas of strategic importance. In all, S&T plans to add 100 new faculty positions by 2020, an increase of nearly 20 percent.

In the signature area of Advanced Manufacturing, S&T will emphasize instruction and research in the emerging fields of additive manufacturing; energy manufacturing; micro- and nano-scale manufacturing; network-centric and cloud manufacturing; advanced materials for manufacturing; and intelligent, sensor-enabled manufacturing.

The area will be led by a multidisciplinary team of researchers. That team includes Dr. Ming Leu, the Keith and Pat Bailey Missouri Distinguished Professor of Integrated Product Manufacturing; Dr. Wayne Huebner, professor and chair of materials science and engineering; Dr. Jag Sarangapani, the William A. Rutledge-Emerson Electric Co. Distinguished Professor of Electrical and Computer Engineering; Dr. Suzanna Long, assistant professor of engineering management and systems engineering; Dr. Frank Liu, professor of computer science; Dr. Greg Hilmas, Curators' Professor of ceramic engineering; and Dr. Frank Liou, the Michael and Joyce Bytnar

Professor of Product Innovation and Creativity.

“This is a perfect fit for Missouri S&T because of the national importance of advanced manufacturing, the existing S&T strength in this area and our confidence in developing it to be among the best in the nation,” Leu says.

The signature area of Advanced Materials for Sustainable Infrastructure will focus on the rehabilitation of urban mass-transportation centers, including highways, bridges, tunnels, rail, airports, and port and water navigation channels, as well as utility infrastructure. It encompasses four S&T research centers and six academic departments and will be led by Dr. Kamal Khayat, the Vernon and Maralee Jones Professor of Civil Engineering and director of Missouri S&T’s Center for Infrastructure Engineering Studies.

“Infrastructure is the foundation that connects the nation’s businesses, communities and people, driving our economy and improving our quality of life,” says Khayat. “Missouri S&T has existing strengths in this area and with further emphasis, we can become a best-in-class leader.”

The second round of selecting the two remaining signature areas is now under way and will conclude by summer.

Scrap tires used to boost masonry blocks

February 6, 2014 by Linda Fulps

Dr. Mohamed A. ElGawady, associate professor of civil, architectural and environmental engineering (right) with graduate student Ahmed Gheni.

Scrap tires could gain a new purpose as ingredients for construction materials, thanks to research at Missouri University of Science and Technology.

Discarded tires are a big problem. Landfills are teeming with them and they can harbor disease-carrying mosquitoes and rodents. Stockpiles of old tires also burn easily — creating fires that can quickly get out of control and may burn for months or even years.

But the longevity and resilience of scrap tires also makes them ideal for other uses.

Dr. Mohamed A. ElGawady, a researcher at Missouri S&T, is currently testing new masonry blocks made with ground tires.

"Rubber has a lot of benefits in addition to its sustainability," says ElGawady, associate professor of civil, architectural and environmental engineering. "It's very durable and provides good insulation. Among their many potential benefits, these new blocks could cut heating bills by 50 percent."

ElGawady has been working with Midwest Block and Brick, a Jefferson City, Mo.-based company, to create the blocks, which are made from sand and scrap tires ground to fine particles.

These rubber-added blocks, called rubberized blocks, were constructed with a variety of ratios of sand to rubber particles before coming up with the right balance.

"The rubber makes the blocks a bit weaker, so after testing various percentages, we now only replace about 20 percent of the sand with rubber, so the blocks retain their strength," ElGawady says.

He and his students use a compression machine to test and compare the strength of prisms built with the rubberized blocks to conventional concrete masonry blocks.

Both rubberized and conventional blocks are being tested in an environmental chamber at Missouri S&T. In the chamber, the blocks undergo cycles of extreme temperatures and humidity levels, simulating different weather conditions. The rubberized blocks are also tested under cyclic compression loads simulating earthquake loads.

"Construction with these new blocks could improve a building's resiliency during an earthquake by acting as shock absorbers," says ElGawady.

Genda Chen named Abbett Chair

March 19, 2014 by Linda Fulps


Dr. Genda Chen has been named the Robert W. Abbett Distinguished Chair in Civil Engineering at Missouri S&T.

Dr. Genda Chen, professor of civil, architectural and environmental engineering at Missouri University of Science and Technology, has been named the Robert W. Abbett Distinguished Chair in Civil Engineering. The appointment takes effect July 1.

The chair was established in 2005 through a gift from the estate of Robert W. Abbett, a 1927 civil engineering graduate of the university.

"We are very pleased that Dr. Chen will take on this new challenge," says Dr. Cheryl B. Schrader, chancellor of Missouri S&T. "He brings a wealth of experience and innovation to the infrastructure area."

A member of the Missouri S&T faculty since 1996, Chen is associate director of the Mid-America Transportation Center, a consortium of eight universities designated as the Region VII University Transportation Center by the U.S. Department of Transportation.

After earning a Ph.D. degree in 1992 from The State University of New York at Buffalo and completing postdoctoral training at the National Center for Earthquake Engineering Research, Chen joined Steinman Consulting Engineers, a New York City-based bridge consulting firm. In 1993, he was hired as a lead seismic analysis engineer on the seismic evaluation project for the Queensboro Bridge, a double-deck, double-cantilever bridge that spans the East River in New York, the first major project of its kind on the East Coast.

Chen has been widely published for his pioneering research on structural behavior monitoring, inorganic enamel coating of steel rebar for enhanced corrosion resistance and bond strength in concrete, and a damping-enhanced strengthening strategy for performance-based earthquake engineering.

He was the lead inventor on a patent granted in 2008 for strain sensitive coax cable sensors for monitoring structures, in collaboration with Dr. James L. Drewniak, Curators' Professor of electrical and computer engineering at Missouri S&T, and Dr. David Pommerenke, professor of electrical and computer engineering at S&T. He was co-inventor on a patent granted in 2011 for corrosion-resistant glasses for steel enamels granted in collaboration with Dr. Richard K. Brow, Curators' Professor of material science and engineering at S&T.

Chen received the National Science Foundation's Faculty Early Career Development (CAREER) Award in 1998; the Joseph H. Senne Jr. Academy of Civil Engineers Faculty Achievement Award in 2004; and Missouri S&T Faculty Research Awards in 2009, 2011 and 2013.

He is active in the American Concrete Institute, American Society of Civil Engineers, Earthquake Engineering Research Institute, International Society of Optics and Photonics, International

Society for Structural Health Monitoring of Intelligent Infrastructure, Structural Engineering Institute and Transportation Research Board. He is associate editor of the ASCE Journal of Structural Engineering and was a recent guest editor of Structural Engineering and Mechanics: an International Journal. He has served in leadership roles in ASCE committees and as an executive member of the U.S. Panel on Structural Control and Monitoring. He was elected an ASCE Fellow in 2007 and SEI Fellow in 2013.

Chen was an invited member of the U.S. Department of Transportation's post-earthquake reconnaissance teams following the 2008 earthquake in China and the 2010 earthquake in Chile, as well as the DOT's post-earthquake study tour following the Great East Japan Earthquake in 2011. He also served on the U.S. Geological Society's post-hurricane reconnaissance team following the 2005 Atlantic hurricane.

S&T's 2014 summer camps have it all

April 10, 2014 by Mary Helen Stoltz

Missouri S&T has a wide variety of summer camps for students in first grade through high school.

Missouri University of Science and Technology will host 17 camps this summer that offer students of all ages hands-on learning experiences. They can learn about explosives, make a microsatellite, hone their leadership skills and learn what it takes to have a career in science, technology, engineering or math.

Grade requirements indicated are for the grade students will enter in fall 2014:

Aerospace Camp — Students age 10-13 spend three days on the S&T campus to delve into the world of space flight and aeronautics. This camp will be held July 15-17.

Building Leaders for Tomorrow — This five-day program helps high school sophomores, juniors and seniors unlock the power of communication and hone their leadership skills. Camp will be held June 22-26.

Camp Invention — This day camp for students entering first through sixth grades offers hands-on activities to encourage a passion for learning. Two sessions are offered: July 7-11 and July 21-25.

CyberMiner Camp — High school juniors and seniors will unleash their cyber-self during five-day camp. Students will learn about software design, programming and other digital technologies. Camp will be held July 13-17.

EcoGirl (formerly Girls Go Green) — Girls entering their junior or senior year in high school are invited to participate in this five-day camp to explore careers in environmental fields, held July 14-18.

Explosives Camp — Rising high school juniors and seniors age 16 and older can attend this one-of-a-kind camp. Three sessions are offered: June 8-13, June 15-20 and June 22-27. Students must apply for admission to this camp.

Formula SAE Electric Car Camp — High school sophomores, juniors and seniors will design and model an Electric Formula SAE car at this five-day camp held, July 6-10.

It's A Girl Thing — Girls entering seventh or eighth grades are invited to attend this five-day camp to explore STEM careers through group projects and design competitions. Camp will be held June 2-6.

Jackling Introduction to Engineering — Rising high school juniors and seniors will find out what engineers do and their impact on the world at this five-day camp. Three sessions are available: June 8-12, June 22-26 and July 6-10.

Materials Camp — High school juniors and seniors will learn how engineers and scientists turn materials into useful products during this six-day camp held, July 20-25.

Minority Introduction to Technology and Engineering (MITE) — High school juniors and seniors find out what engineers actually do, their impact on the world and how math and science relate to engineering at this six-day camp designed specifically for underrepresented minorities. Students must apply for acceptance into this camp. Two sessions are available: June 1-6 and June 15-20.

Nuclear Engineering Camp — High school juniors and seniors spend six days exploring the power of the atom and learn about career opportunities in nuclear engineering. Camp will be held June 15-20.

Robotics Camp — Students age 12-15 will design their own robot and learn programming techniques at this three-day hands-on camp held, June 9-11.

Space-The Final Frontier — Rising high school sophomores, juniors and seniors will learn how engineering design and build satellites and launch a microsatellite 100,000 feet in the air during this camp, held July 20-24.

Sports Camps — S&T coaches and players will lead camps in a variety of sports. Visit minercamps.com for a complete schedule of these activities.

Summer Research Academy — Rising high school seniors or graduating seniors will work side-by-side with experts to conduct research in their favorite field. The academy is held from June 8-July 18. Students must apply for admission to the Summer Research Academy.

Summer Solutions for Girls — Girls entering their freshman or sophomore year will discover the possibilities of college life as well as careers in engineering and science at this five-day camp, held June 16-20.

Campers attending overnight sessions stay in Missouri S&T residence halls. Sessions fill quickly, so check for space availability, camp fees, enrollment deadlines and registration forms at summer.mst.edu.

For further information, visit summer.mst.edu or contact Missouri S&T's student diversity, outreach and women's programs at 573-341-4228 or by emailing precollege@mst.edu.

New electric-powered bus to shuttle S&T students

April 11, 2014 by Peter Ehrhard

Students at Missouri University of Science and Technology can ride in style on campus while learning about fuel efficiency thanks to a new electric shuttle bus. The bus will begin operation on campus on Monday, April 14.

Missouri S&T received a grant from the Federal Transit Administration to purchase the eBus shuttle to help protect the environment and promote energy independence.

Dr. Mehdi Ferdowsi, associate professor of electrical engineering at S&T, will lead research to examine the shuttle's integration into the campus in order to learn about vehicle battery performance under varying conditions. S&T researchers will also document public acceptance of alternatively fueled transit vehicles.

The Missouri S&T eBus is a fully electric-powered, plug-in shuttle with its own charging station on campus. The eBus is expected to average 80 miles per charge. It can accommodate 22 seated passengers and another 10 standing passengers. There will be no charge for S&T faculty, staff and students to use the shuttle during the spring 2014 semester.

"As a Climate Leadership Award winner, Missouri S&T continually demonstrates that we are leaders in new technology for environmental protection," says Angela Rolufs, director of the office of sustainable energy and environmental engagement at S&T. "The shuttle is a great opportunity for students to study and experience electric travel first hand."

The bus will complete a loop around the S&T campus twice an hour from 7:30 a.m. to 4 p.m. Monday through Friday. It will leave its terminal at E3 Commons and first stop at Miner Village. From there, the shuttle will make stops at Emerson Hall, Centennial Hall, the Havener Center and the Gale Bullman Multi-Purpose Building before returning to the E3 Commons.

Local bus company, USA Tours, will provide the eBus with drivers under a service contract with Missouri S&T. More information about the eBus can be found at ose3.mst.edu.

Researchers study 'smart' rocks use for detecting bridge damage

July 1, 2014 by Linda Fulps

It's hard to gauge how structurally sound a bridge is when its foundation is buried in a riverbed deep below the water's surface. New "smart" rocks that are being developed by researchers at Missouri University of Science and Technology will give engineers an accurate, easy and cost-effective tool to monitor a bridge's foundation, in real time.

The leading cause of bridge collapse in the U.S. is scour, an erosion process where water flow carries away river bed deposits and creates scour holes around the bridge pier or abutment. Floods intensify these scour effects and can quickly make the bridge unstable.

Smart rocks placed at the base of bridge foundations are designed to roll to the deepest point of a scour hole and act as field agents to relay scour depths.

"It's a simple, but very useful, concept," says Dr. Genda Chen, principle investigator and professor of civil, architectural and environmental engineering and the Robert W. Abbett Distinguished Chair in Civil Engineering at Missouri S&T. "The rock follows the trail of the scour hole's progression – as it goes deeper and deeper, the rock will also sink deeper and deeper. One reason we call it 'smart' is because the rock can represent the maximum depth of the hole."

Chen is collaborating on the project with Dr. David Pommerenke, professor of electrical and computer engineering, and Dr. Rosa Zheng, associate professor of electrical and computer engineering. The project is sponsored by the Research and Innovative Technology Administration of the U.S. Department of Transportation and the Missouri Department of Transportation.

An example of a passive smart rock containing a magnet suspended in liquid is in the foreground. Active smart rocks have embedded electronics. In the background is a concrete-encased smart rock that is about the size of a basketball and weighs about 50 lbs.

The researchers are testing three smart rock technologies: passive, active and semi-active. Passive smart rocks have an embedded magnet that can be read by a remote magnetometer. Active smart rocks have embedded electronics, including a pressure sensor, gyroscope, timer, battery indicator and individual identification, which transmit data through wireless communication. Semi-active smart rocks include a free-to-rotate magnet that can be controlled with electronic circuitry.

"Engineers sometimes complain that these type of devices give them so much data, they don't know what to do with it all," says Chen. "These smart rocks can give engineers critical information they need, when they need it."

Chen says during normal operations, readings are usually taken every six months to a year. "But scour develops very rapidly during flood season," he says. "If the engineer feels like there might be a new development, they can take a reading at that moment, without being overwhelmed with continual data processing and storage."

The technology is also cost-effective, says Chen. "You can use this data to evaluate the foundation's stability without having to send a diver down there."

Engineers routinely place large rocks around the bridge foundation to protect the soil below from being eroded away by the current, a technique called riprap.

"No one really knows how effective riprap is during flood season," says Chen. "With the muddy water, you don't know what's going on. But if we mix a few smart rocks with the natural rocks around the foundation, the movement of the smart rocks will indicate the performance of the riprap system, and will also tell the engineer if there's a problem with scour."

A major concern for scour monitoring is how well the technology holds up during a flood event. "There is a lot of technology that works very well in the lab, but it cannot be applied in field conditions because of damage from strong currents," Chen says. The researchers are seeing good results with smart rocks deployed in 2012 at Missouri's Gasconade River Bridge and Roubidoux Creek Bridge. The rocks will last forever and the battery survives about five-to-10 years, depending on how often data is collected, Chen says.

The researchers hope to partner with state departments of transportation for further studies.

"We'd like to engage a few state DOTs to employ a number of smart rocks in their bridges so we can start taking data before and after the flood season to see whether rocks have moved or not," he says.

"About 60 percent of collapsed bridges in the U.S. are due to hydraulic reasons, of which scour plays a major part," says Chen.

Students, faculty from around the world attend workshop

July 21, 2014 by Linda Fulps

An international group of participants recently attended a four-day workshop hosted by the RE-CAST (Research on Concrete Application for Sustainable Transportation) University Transportation Center. The workshop focused on the fundamentals of rheology and application on cement-based materials. Rheology involves flow behavior of material that cannot be measured with traditional workability methods.

Participants were offered an in-depth look into the science of rheology as well as hands-on laboratory experience with state-of-the-art testing equipment of cement-based materials. The workshop was coordinated by the Center for Infrastructure Engineering Studies (CIES). Instructors were faculty from the RE-CAST consortium (Dr. K. Khayat of Missouri S&T, Dr. David Lange of the University of Illinois at Urbana-Champaign and Dr. Dimitri Feys of Missouri S&T). Participants included undergraduate and graduate students, faculty and industry professionals. Forty people attended the workshop from the institutions listed below:

- Burns Concrete Inc. (Idaho)
- University of Nebraska
- Rutgers, the State University of New Jersey
- University of Illinois at Urbana-Champaign
- Missouri University of Science and Technology
- Durable Concrete (North Carolina)
- University of Oklahoma
- Southern University and A&M College (Baton Rouge, Louisiana)
- University of Miami (Florida)
- Universidad Autónoma de Nuevo León (Monterrey, Mexico)
- Université d'Artois (France)

For more information about RE-CAST, visit its website at recast.mst.edu.