UMR UTC NEWS
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# DIRECTOR'S message

A new year, a new start. First of all, many of us are getting ready for our January ritual consisting of a pilgrimage to the nation capital to attend the Transportation Research Board 85th Annual Meeting, together with about another 9,000 transportation professionals. This event is the largest gathering of its type and really provides an opportunity for taking the pulse of what is happening nationally and internationally in transportation. It is also an opportunity to visit with old and new friends, start new alliances and, whenever possible, celebrate past successes. Many institutions, universities, centers and the like host evening receptions mainly to remain in contact with alumni and attract potential recruits. Missouri has missed out on this and hopefully for the last year. Starting in 2007, we plan to join forces with the other UM campuses and the Missouri Transportation Institute (MTI) to establish a presence and claim our place in the sun.

The remaining portion of this message goes back to where we left off in the previous issue, in particular, to the topic of the UMR-UTC vision for the next five years that in the months to come will become a document to be submitted to the US DOT for approval. Our initial strategy indicates that the Center is to invest in three parallel directions. The analogy is that of a stool: we need three legs to maintain equilibrium. The first direction is to leverage (at the now historical rate of 2 to 1) institutional funds to recruit undergraduate and graduate students and faculty with education and research interests in transportation. It is in fact fundamental that we transversely increase our transportation critical mass to make this topical area a prominent part of the academic core of UMR.

The second direction is to create even a stronger than existing synergism with the Missouri Department of Transportation (MoDOT). The leverage of MoDOT research and technology transfer funding should occur not only in the traditional areas of interest to the Center (i.e., advanced materials and NDT technologies), but be extended to other areas where the Department has indicated the need for the attainment of "tangible results".

Finally, the third leg of the stool is to build on existing UMR research core competencies to participate in national government-industry-academia consortia aiming at addressing critical issues for the development and sustainability of the country. The hottest topic of the day appears to be hydrogen fuel.

In a nutshell, we are thinking of stimulating the growth of our institution workforce, of partnering with MoDOT for addressing state problems, and of becoming an indispensable contributor to the national transportation agenda.

If you now think like a regular citizen, I hope you feel that your tax dollars are wisely spent, but if you happen to be a researcher, an educator, or a student start thinking that you may soon pack your bags and come to Rolla!

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# ALKALINE-RESISTANT GLASS FIBERS FOR CONCRETE REINFORCEMENT

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This project is supported by the Department of Energy as a sub-contract through Mo-Sci Corp. (Rolla, MO). Calcium-iron-phosphate (CFP) glass fibers have been prepared and tested as alternatives for the zirconia-silicate alkaline resistant (AR) glasses presently used in glass fiber-reinforced cement (GFRC) composites. The CFP glasses withstand attack by high pH solutions, designed to simulate wet cement environments, as well as the commercial AR glasses. The fiber-forming temperatures of the CFP melts are near 1000-1100ºC, much lower temperatures than are needed to produce AR fibers.

| Glass code | Softening Temperature (°C) | CTE ($x10^{-6}/°C$) | Density ($g/cm^3$) | Young's Modulus (GPa) |
|---|---|---|---|---|
| SIP-54 | 560 | 8.9 | 2.79 | 60.5±0.5 |
| SIP-57 | 587 | 10.4 | 2.87 | 53.6±0.6 |
| SIP-58 | 598 | 10.7 | 2.94 | 57.6±0.5 |
| SIP-59 | 619 | 12.2 | 2.99 | 72.7±0.6 |
| SIP-60 | 636 | 9.7 | 3.00 | 69.5±0.3 |
| SIP-71 | 620 | 8.9 | 2.85 | 61.8±0.6 |
| SIP-72 | 620 | 9.0 | 2.85 | 61.7±0.5 |
| SIP-73 | 603 | 8.6 | 2.89 | 65.3±0.5 |

**Table 1:** Properties of alkaline resistant CFP glasses

Table1 summarizes some properties for representative CFP glasses, including the dilatometric softening temperature ($T_D$) and the coefficient of thermal expansion (CTE) measured, along with glass density and elastic modulus. The latter was measured on glass fibers using an acoustic pulse technique.

Figure 1 shows changes in the pH of Lawrence solution, an alkaline aqueous solution that models the composition of cement effluent, with time due to corrosion of several different CFP fibers. The most chemically stable fibers have the smallest effect on the solution pH.

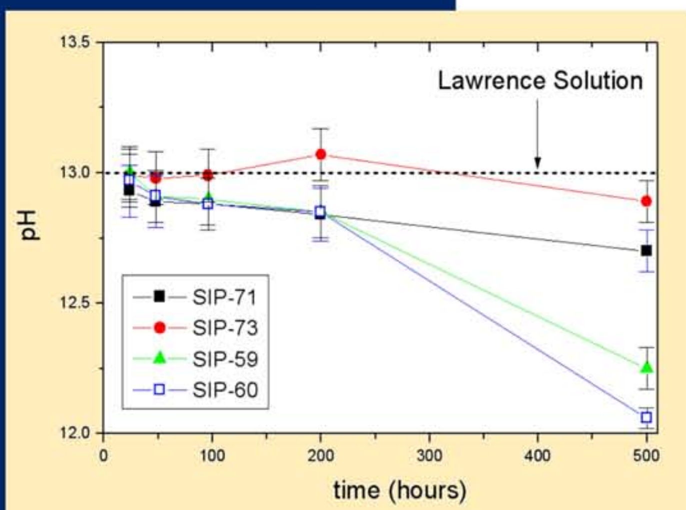


**Figure 1:** The effects of different CFP glass fibers on the pH of Lawrence solution at 80°C for up to 500 hrs.

Figure 2 shows a scanning electron micrograph of the fracture surface of a glass fiber reinforced concrete (GFRC) sample produced by mixing chopped fibers (about 30 microns in diameter) of SIP-59 glass with Portland cement. The fibers were prepared by Mo-Sci Corp. Note the effective 'fiber pull-out' from the cement matrix. 'Fiber pull-out' is a mechanism for increasing the flexural strength and fracture toughness of cement matrix composites.

For additional information, see the DOE website:

http://www.eere.energy.gov/industry/imf/pdfs/19651_iron_phospate_glass_fibers.pdf


**Figure 2:** SEM micrograph shown a single SIP-59 glass fibers when exposed to ordinary Portland cement.

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# CAMP INTRODUCES MINORITIES TO SCIENCE, TECHNOLOGY, ENGINEERING AND MATH AT UMR

**"Twenty-two high school seniors from Missouri and surrounding states are currently on the UMR campus to participate in hands-on science projects and engineering workshops"...**

As part of a nationwide outreach program to generate more interest in math and science among minority student populations, the University of Missouri-Rolla has hosted its ninth annual Minority Introduction to Technology and Engineering summer camp.

UMR also hosted a special "mini-camp" in advance of the regularly-scheduled session. Twenty-two high school seniors from Missouri and surrounding states were on the UMR campus to participate in hands-on science projects and engineering workshops. The students were also sitting in on lectures, touring the campus, participating in academic discussion groups, and interacting with faculty, staff and alumni.

"The student groups live in the university residence halls and participate in a number of activities that expose them to degree programs and facilities," says J.P. Fransaw, coordinator of the Minority Engineering and Science Program at UMR. "This is a very busy week for the students, but they are enjoying new experiences and hopefully processing new opportunities."

Those selected to participate in the camp expressed an interest in pursuing a higher education degree in a science, technology, engineering or mathematics field. High school transcripts were reviewed before students are selected for the camp.

"Each of the program's high school seniors is invited to start the UMR admissions and scholarship application procedures at the end of the camp," Fransaw says. "I expect most of these students will qualify for a UMR scholarship and are likely to attend classes as freshmen next fall."

The Minority Introduction to Technology and Engineering (MITE) summer camp is sponsored by UMR's Center for Pre-College Programs, UMR's Minority Engineering and Science Program (MEP), UMR's University Transportation Center and by Phelps County Bank in Rolla.

MITE Summer Institute Camp 2005 Group

## Minority Engineering & Science Program (MEP)/ Hit the Ground Running Program (HGR)

***Press Release***

MEP 2005 Freshman Class

This marks the thirty-second consecutive year for the Minority Engineering and Science Summer Enrichment Program at the University of Missouri Rolla (UMR). The program is sponsored by the Louis Stokes-Missouri Alliance for Minority Participation (LS-MoAMP), and the University Transportation Center (UTC) as a statewide outreach program focused on assisting students to adjust to the UMR community, the adoption of academic excellence strategies, leadership skills development, and the adoption of strategies that encourage student responsibility and ownership of realistic academic expectations among traditionally underrepresented student populations.

This year the MEP program partnered with the Hit the Ground Running Program to create an experience that would create one freshman experience. The sixty nine entering freshmen each lived in the Thomas Jefferson Residence Hall and took courses in College Algebra, Trigonometry, or Pre-Calculus, Chemistry, English Composition and a leadership development course. The program provided graduate teaching assistants and upper-class students to facilitate the transition from high school to college.

"This is an excellent opportunity to sharpen skills and develop good study habits, critical to becoming a success both at UMR and in the workforce" said JP Fransaw, Coordinator of the MEP Program at UMR, also a 1998 program participant. "This is a very busy summer for the students, but they seem to really enjoy the experience."

Most of the students in this year's program were from the St. Louis, Kansas City or Southwest Missouri areas; however, students also came from Kansas and as far away as Texas & California.

# THE DIVERSITY SHOWCASE 2005

## as part of a nationwide outreach program

As part of a nationwide outreach program to generate more interest in math and science among minority student populations, the University of Missouri-Rolla hosted the Diversity Showcase. The Diversity Showcase is composed of three components, they are:

- **Si Se Puede Program** *(English translation- Yes You Can)* **-** This program focuses on Kansas City High School Students. This program provides transportation, houses students at the Rolla Drury Hotel, and provides a number of activities designed to expose them to degree programs and facilities in the science, technology, engineering or mathematics fields. High school transcripts are reviewed before students are selected for the program.
- **Minority Transfer Showcase-** This program provides a preview for students attending the St. Louis Community Colleges (Florissant Valley, Forrest Park, or Meramec). Most students are participants of the Emerson Minority Engineering Program or the Missouri Alliance for Minority Participation (MoAMP).
- **St. Louis High School Minority Students-** This program provides transportation for families seeking more information about UMR and science, technology, engineering or mathematical fields.

All programs merged at the November 12 Open House. Over 150 minority students and their family members attended the various events. This is a joint effort between the Si Se Puede Team, Society of Hispanic Professional Engineers, the National Society of Black Engineers, UMR Admissions, Minority Engineering & Science Program, Women's Leadership Institute, and Women In Science and Engineering Program. This is the largest on campus annual recruiting event aimed at minority students. Diversity Showcase is always held on the November Open House Date.

"Each of the program's high school seniors is invited to start the UMR admissions and scholarship application procedures at the end of the camp," says J.P. Fransaw coordinator of the Minority Engineering and Science Program at UMR. "I expect most of these students will qualify for a UMR scholarship and are likely to attend classes as freshmen next fall."

The Diversity Showcase is sponsored by, UMR's University Transportation Center, the Cummins Cooperation, UMR Admissions, the UMR Society of Hispanic Professional Engineers and UMR's School of Engineering.

Si Se Puede Participants 2005

# AVK-TV Innovation Award 2005

On July 28th, Dr. Filippo Bastianini, an Adjunct Assistant Professor in Civil Engineering was notified by AVK-TV, the German Association of Composite Materials, announcing that UMR had been nominated for the 2005 award in the category of "university work" for the development of a "smart" Fiber-Reinforced Polymer (FRP) material with embedded Brillouin distributed fiber optic strain sensors.

**..."UMR had been nominated for the 2005 award in the category of 'university work' for the development of a 'smart' Fiber-Reinforced Polymer (FRP) material with embedded Brillouin distributed fiber optic strain sensors."**

As a finalist, UMR was also invited to expose this innovation at the annual AVK-TV conference and exhibition, held in Baden-Baden on October 26 - 29, with a small stand in the exhibit hall. The exhibit featured a poster, a collection of papers regarding the technology and also some samples to allow visitors to touch these "smart" materials.

The event, which seemed to draw interest mainly from the north European market of the composite materials, especially for the automotive industry, brought Dr. Bastianini in touch with industrial and research entities outside his traditional field of work. His hope is that the new contacts will produce new ideas and cooperation opportunities.

"I am happy that this success, even if small indeed, gave us the opportunity to make visible our work and the passion we have in doing it," remarked Dr. Bastianini.


AVK Poster

The developed technology allows embedding common and very inexpensive optical fibers into a fiber-reinforced polymer tape-like material. This material is much easier to handle than the bare optical fibers themselves and it can withstand shocks and bending without any damage. For this reason, the material can be easily dropped into any manufacturing process of fiberglass components or can be installed as a strengthening to repair and upgrade buildings and structures.

What makes it a "smart" material are the embedded optical fibers that, thanks to a technology called Brillouin Optical Time-Domain Reflectometry (BOTDR), can be used as distributed strain and temperature sensors. This basically means that by using this material and BOTDR it is possible to know the exact strain and temperature at any single point of the tape, that is simultaneously seeing "how much" and "where" the deformation and other heat related phenomena occur.

Dr. Filippo Bastianini

Preliminary tests were run to map the deformation of fiberglass pipes and to detect cracks in masonry. Then UMR and MoDOT provided the opportunity to perform tests on concrete bridges and on a large highway bridge. From these tests it was understood that the "smart" sensor is also much more sensitive and accurate that the bare fibers and proved that its use for Structural Health Monitoring (SHM) purposes is feasible in real applications and can bring unmatched advantages.

The potential field of application of the "smart" material appears to be extremely wide, ranging from quality control applications of industrial components such as tanks, pipes, chimneys, etc., to the industry of building and infrastructure, to FRP components used in aerospace, nautical and automotive industries, and even to consumer goods such as safety equipments and climbing ropes.


In order to "document" the event you will find in attachment the certificate given to the University of Missouri-Rolla, a picture taken when Dr. Bastianini received the certificate, and an image, reduced in size, of the poster that was displayed at the exhibition.

# WHY DID I-10 TWIN BRIDGES COLLAPSE DURING HURRICANE KATRINA?

## Bridge Structure and Damage

Fig. 2 Major damage to approach structures: drop-off spans and excessive lateral displacement

Built in 1963, I-10 twin bridges are two 5.4 mi long elevated structures across Lake Pontchartrain, connecting New Orleans and Slidell, Louisiana. Each structure consists of one main bridge over the navigation channel and two approaches that stand approximately 8.5 ft above the mean high water level. Each approach is comprised of 436 simply-supported, 65 ft by 40 ft, 285 ton precast-concrete spans. As shown in a typical span of the bridges, Fig. 1, each causeway span consists of a deck including guardrail barriers, six girders, and four intermediate and end diaphragms. Every two adjacent girders and two diaphragms form a structural box shaped cell with the opening facing downward toward the water. The span is supported through low steel bearing plates on a bent cap supported by three-column piers.

Storm surges generated by Hurricane Katrina rendered the bridge structures impassable. While the tall structure over the navigation channel stood intact, each approach causeway suffered significant damages or collapse as indicated in Fig. 1. According to the bridge maintenance engineer for the Louisiana Department of Transportation and Development (2005 Civil Engineering Magazine, Vol. 75, No. 11, pp. 13-14), 38 spans from the eastbound bridge and 20 spans from the westbound bridge were dislodged and fell either completely or partially into the water as illustrated in Fig. 2. One bent from the westbound bridge collapsed into the water. Many more spans from both bridges experienced excessive lateral displacements equal to one girder spacing and stopped at the exterior concrete pedestals as indicated in Fig. 1. Several spans were displaced into two girder spacing as shown in Fig. 2. In this case, the second girder passed over the exterior pedestals without experiencing significant damage.

## Plausible Reasons for Bridge Collapsing

The main culprit for the collapse of spans was the loss of their "effective gravity load" due to the air trapped underneath the bridge decks. After the air escaped and the space filled with water, the bridge decks landed again on the piers but at different transverse direction locations or dropped off their supports in the longitudinal (traffic) direction. To arrive at this finding, a hydrostatic analysis was conducted on a rectangular concrete box, similar to Fig. 1. For each span of the I-10 twin bridges, approximately 70% of the space of the concrete box was occupied by air. Under this condition, the "effective gravity load" and the friction resistance of the decks to the drag force of water became zero.▷

Fig. 1 Typical cross section and diaphragms underneath the bridge decks

# WHY DID I-10 TWIN BRIDGES COLLAPSE DURING HURRICANE KATRINA? continuation

## Supporting Evidences

The above "concrete box" theory is strongly supported by a number of evidences that were collected from several bridge structures in the Hurricane Katrina affected areas. As shown in Fig. 3, northwest and next to the I-10 twin bridges is a highway bridge carrying vehicular traffic on Highway US11. This bridge was open to traffic after a short period of traffic interruption. Similar to the I-10 bridges, the US11 bridge is also a simply-supported RC girder structure. However, the span length is short and the depth of all girders is significantly shallower than those girders in the I-10 bridges. In addition, all girders are arch shaped, making an even shallower section at midspan. The deck sections also had holes in the lateral diaphragms that allowed air to escape the box. Therefore, the possibility of having significant air masses trapped underneath the decks is much smaller in comparison with the I-10 bridges.

Fig. 3 US11 Bridge (middle of three bridges) and its superstructure

Further northwest is a railway bridge that did not suffer any structural damage except for a portion of washed-away tracks. The railroad bridge consists of solid slabs and their supporting piers. No air was trapped underneath the slabs to reduce the "effective gravity load" and the bridge superstructures were unlikely to have floated during the Hurricane.

The velocity of sustained winds and wind gust during the Hurricane and the velocity of the storm surge during and after the event are contributing factors but are unlikely the root cause for excessive displacements or collapse in the superstructures of the I-10 bridges. For example, the main bridge over the navigation channel did not experience any damage even though the bridge was subjected to higher wind forces than the approaches. In addition, all the indications of the excessive displacements imply that the superstructures of the I-10 bridges moved toward the east, which is inconsistent to the strongest winds from the east. However, the eye of Hurricane Katrina passed from south to north about 12 to 15 miles east of the I-10 bridges. Due to the counterclockwise rotation of the storm the strongest winds and highest storm surge are normally located to the east and north of the eye. As the storm continued north the still hurricane force winds would change to south and then east. The large expanse of Lake Pontchartrain to the west of the I-10 bridges would be susceptible to generating large waves due to the long fetch exposed to the easterly winds and at a time when the storm surge was still high. This would cause high water levels with large waves directed to the east.

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