University of Missouri-Rolla

UTC NEWS

Spring 2007 Volume 2, Issue 3

University Transportation Center

A Note from the Director – John J. Myers

In this newsletter I would like to take this opportunity to update everyone on the status of our National UTC. About 1 year ago, Chancellor John F Carney, III appointed an ad hoc task group to prepare a final draft of our National UTC vision, mission, and theme. It was developed to tackle new challenges while maintaining a solid foothold in its previous UTC thematic areas. The task group viewed these areas to be paramount to the future economical advancement and success of the State of Missouri. Abridged versions of these are highlighted below.

Center vision: To maintain and upgrade the transportation infrastructure of the 2nd millennium and to start the development for the one of the 3rd millennium.

Center mission: To conduct research and development and education and technology transfer activities related to the theme of the center.

Center theme: To address national needs in the areas of transportation with three focus areas: Advanced materials, Transition-state fuel vehicle infrastructure, and Non-destructive evaluation (NDE) technologies and methods.

In January of 2007, I was asked and agreed to serve as our National UTC Interim Center Director. This follows eight wonderful years of working with the former UTC Director, Dr. Antonio Nanni, as the Associate Director for Research Activities. In January, Dr. John Sheffield, Professor of Mechanical Engineering, agreed to serve as our Associate Director and lead efforts to develop our Transition-state fuel vehicle infrastructure theme area. The past four months have been extremely busy for our National UTC staff and personnel during this transitional period. Over this time, our National UTC Center Strategic Plan has been developed and submitted to the USDOT Research and Innovative Technology Administration (RITA) for approval. Final approval is anticipated in the near future. The official name of our National UTC was submitted to RITA as "The University of Missouri-Rolla Center for Transportation Infrastructure and Safety." However, with the University name change looming this January 1, 2008, we will soon likely be "Missouri University of Science and Technology Center for Transportation Infrastructure and Safety" or "Missouri S&T Center for Transportation Infrastructure and Safety" for short. Stay tuned…

During the past several months, the National UTC has also looked to form stronger ties with the Missouri Department of Transportation (MoDOT) and the Missouri Transportation Institute (MTI) based at UMR to address Missouri's on-going and future transportation challenges. Exciting new projects have been undertaken over the past several months as well. Some are highlighted in this newsletter. Finally, our UTC welcomes feedback on challenges you may have that we may be able to help you address through one means or another. To colleagues in the university setting, send us proposal requests on innovative ideas with matching opportunities on non-federal funds addressing our critical transportation issues, particularly in our thematic areas. Until the next newsletter…

Warm Regards, John

Inside…

Upcoming Events

10th North American Masonry Conference
June 3–6, 2007
St. Louis, MO
www.masonrysociety.org/namc

Sixth International Conference on Case Histories in Geotechnical Engineering*
August 11–16, 2008
Arlington, VA
www.6icchge2008.org

*See page 3 for important updates

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UMR

State-of-the-art Development of Distributed Coaxial Cable Sensors for Crack Detection with ETDR Measurements

A fundamentally new, topology-based cable sensor design concept has recently been proposed and developed by Dr. Genda Chen, David Pommerenke, James L. Drewniak, and David Van Aken. Cable sensors are basically communication coaxial cables with an innovative design of their outer conductor, spirally wrapped around dielectric or Teflon, as illustrated in Fig. 1.

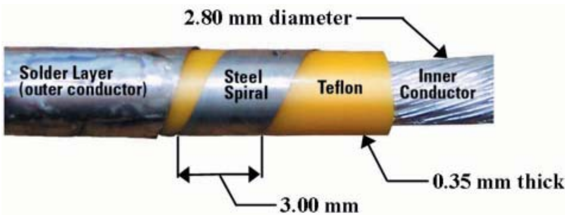

Figure 1. Cut-away sample of a coaxial cable sensor

Electric Time Domain Reflectometry (ETDR) is a remote sensing technology based on the propagation of electromagnetic waves in an electrical cable or a transmission line, which functions both as a signal carrier and a sensor. It uses a digital sampling oscilloscope with an ETDR sampling head. The sampling instrument launches a series of low-amplitude and fast-rising step pulses onto the transmission line and samples the reflected signal caused by an electrical property or topology change along the cable. The arrival time of the reflected signal represents the distance from the point of monitoring to the discontinuity, while the intensity of the signal represents the degree of the discontinuity. The topology change in a cable sensor is realized after the spirals as outer conductors of the cable are separated due to local strain effects as illustrated in Fig. 2, resulting in a detour of current flow path along the outer conductor.

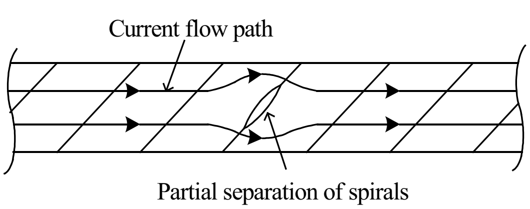

Figure 2. Mechanism of topology-based cable sensors

The new design concept enhanced the sensitivity of traditional cables by over 10 times and the spatial resolution of less than 50 mm. It enabled the sensors' application in structures as demonstrated by comparing the measured reflection coefficient waveforms under various crack widths (Fig. 3) with the crack pattern observed on the tested reinforced concrete (RC) beam (Fig. 3, inset).

Due to presence of the spiral outer conductor, when embedded near the surface of a RC member, a specially-designed cable sensor can permanently record the most severe damage, surface, and hidden cracks beneath Fiber Reinforced Polymer (FRP) sheets, distributed along the RC member provided the cracks intercept the sensor [2]. As illustrated in Fig. 4, this "memory feature" provides a high reliability of receiving damage data during a strong earthquake or hurricane by allowing critical damage detected either in real time or after the catastrophic event.

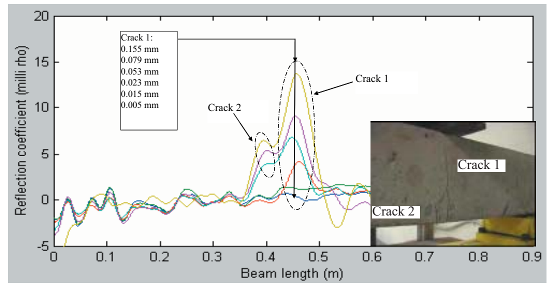

Figure 3. Sensitivity and spatial resolution of a cable sensor

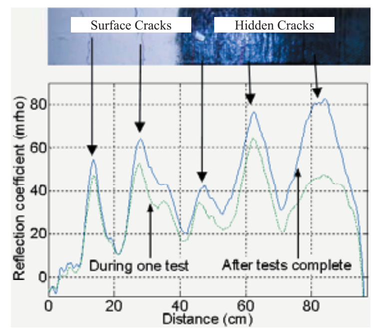

Figure 4. Reflection coefficient during and after testing

Crack sensors have been calibrated and correlated with the crack width using RC beams of a single crack and have proven sensitive to cracks of various sizes from visually undetectable to excessive. A crack sensor can give both the location and severity of damage simultaneously.

Two coaxial cable sensors were installed on a three-span bridge as shown in Fig. 4. The measurements from one sensor were presented in Fig. 5 for two load cases after the applied loads were removed. The test results were consistent and indicated no sign of cracks in this in-service structure. They also showed that in field conditions, the level of noise and/or environmental effects is around 3 mrho in reflection coefficient within an effective range of the sensors between 10 and 220 cm.

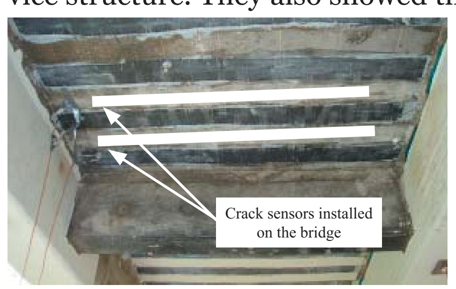

Figure 5. Highway bridge and sensor application

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Coaxial Cable Sensors (Cont.)

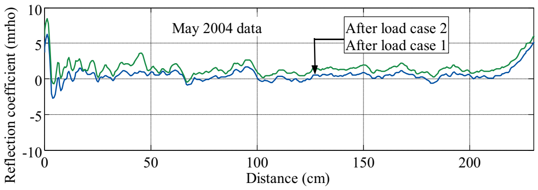


Figure 6. Measurements after different loads

In comparison with other sensors such as fiber optics, cable sensors have the following advantages:

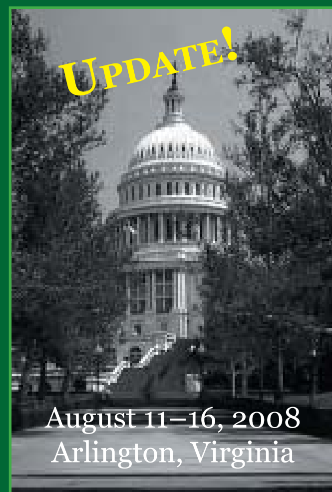
- Very rugged so that they can be used to measure a wide range of crack widths.
- Continuous in crack detection along each sensor.
- High in spatial resolution.
- Inexpensive in measurement instrument.
- Fast in crack detection under dynamic loads.

Potential applications of the developed crack sensors include:

- Monitoring the behavior of RC structures that are inaccessible, such as pile and shaft foundations as well as massive concrete structures (dams).
- Monitoring hidden cracks in RC columns retrofitted with steel, concrete, or FRP jacketing.
- Recording damage that has occurred during a recent disaster event. This application is particularly attractive for a rapid post-event assessment of the structural condition of critical buildings or bridges to facilitate emergency responses.

For more information, contact Dr. Genda Chen, Interim Director of the Center for Infrastructure Engineering Studies (CIES) by phone at (573) 341–4462 or by e-mail at gchen@umr.edu.

Financial support to complete this study was provided in part by the U.S. National Science Foundation and by the University Transportation Center at the University of Missouri-Rolla. Thanks are due to graduate students, Drs. Huimin Mu and Shishuang Sun, Ryan McDaniel, Michael Brower, and Liang Xue, for their significant contributions. The results, findings, and opinions expressed in this paper are those of the authors only and do not necessarily represent those of the sponsors.



The Sixth International Conference on Case Histories in Geotechnical Engineering
and Symposium in Honor of Professor James K. Mitchell

Abstracts submissions are still being accepted for papers on a newly developed theme, as shown below. Please send your abstract by July 15, 2007. Please visit the website, www.6icchge2008.org, for all other details and submission.

Theme 11

11a. Application of Case Histories in Education

How Case Histories Have Been Incorporated in Coursework
How to Conduct a Search for Case Histories and What Are the Major Sources
Examples of Specific Use/s
Importance of Teaching Case Histories
From Case Histories to Conceptual Models
Importance of Practical Experience of Professors
Use of Case Histories in the Teaching Process
Is it Possible to Involve Students in Case Histories (*i.e.*, in Engineering Practice)?

11b. Application of Case Histories to Practice

Use of Case Histories to Enhance Practical Geotechnical Engineering
Practice in Different Offices to Achieve This Objective with Examples
Importance of Lifelong Learning
Use of Case Histories in Lifelong Learning
Establishing an International Database for Case Histories

Further Information:

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Show Me the Road to Hydrogen

Missouri prepares for a rural hydrogen transportation test bed

The University of Missouri-Rolla (UMR), through a hydrogen internal combustion engine (H2ICE) vehicle evaluation participation agreement with the Ford Motor Company, will establish a commuter bus service and hydrogen refueling at a station in rural Missouri near Ft. Leonard Wood. Initiated by a request from the U.S. Army Maneuver Support Center (MANSCEN) at Ft. Leonard Wood (FLW), UMR helped establish the commuter service between FLW and the neighboring towns of Rolla and Lebanon each of which are located about 25 miles from the military base on Interstate-44 highway. The broad research, training, and education agenda for the rural hydrogen transportation test bed is to develop, demonstrate, evaluate, and promote safe hydrogen-based technologies in a real-world environment. This hydrogen initiative will build and operate a hydrogen fueling facility that includes on-site generation of hydrogen through electrolysis as well as selling a range of other traditional fuels.

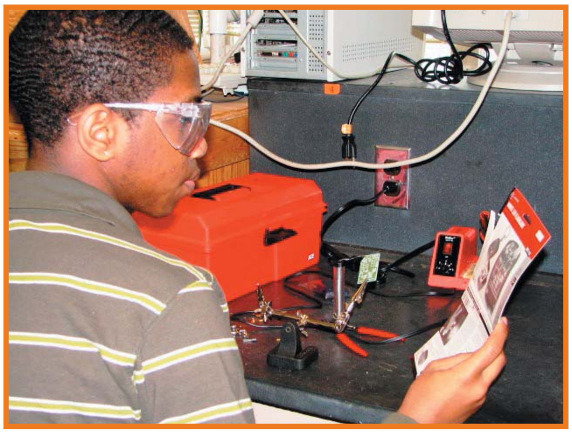
The public acceptance of hydrogen as an alternative fuel for transportation will depend heavily on its confidence in the safety of those vehicles as well as their supporting energy delivery and storage infrastructure. Ensuring the safety of the infrastructure for transporting, storing, and delivering hydrogen will be critical to the success of hydrogen as a fuel for transportation systems. The UMR's National University Transportation Center (UTC) with encouragement from US Department of Transportation (US DOT) Research and Innovative Technology Administration (RITA) is tackling the challenge of alternative fuels (including hydrogen) for the safe deployment of this new form of transportation. The strategic plans for the UMR-UTC seeks to address national needs in the area of transportation infrastructure and safety focusing on the following topical areas:

- Advanced Materials,
- Transition-state Fuel Vehicle Infrastructure, and
- Non-destructive Evaluation (NDE) Technologies and Methods.

One example of the research efforts focused on the safety is the modeling of composite hydrogen storage cylinders. Since pressurized hydrogen storage cylinders are a critical component of hydrogen transportation systems (vehicle fuel systems, bulk commodity transport, portable storage, and stationary storage). These cylinders also have pressure/thermal relief devices (P/TRDs) that are activated in case of an emergency. The ICHS 2007 paper "Analysis of Composite Hydrogen Storage Cylinders under Transient Thermal Loads" by William P. Chernicoff from US DOT RITA and Professor K. Chandrashekhara from UMR illustrates the ongoing development of comprehensive finite element analysis tool for the modeling, simulation, and design optimization of composite hydrogen storage cylinders for safe installation and operation. For example, by using of a neural network model, they can effectively predict the burst pressure of these composite hydrogen storage cylinders undergoing thermal loading. To date, they have applied their two-dimensional, shear deformable, composite shell model for static finite element analysis, thermomechanical analysis, dynamic analysis and failure analysis. Their ongoing tasks include the extension to three-dimensional analysis accounting for hydrogen with fluid - structure interactions; three-dimensional failure analysis/life prediction due to thermomechanical dynamic loading; impact analysis; nonlinear analysis with geometric nonlinearity (large deformation) and material nonlinearity (plasticity for aluminum liner and viscoplasticity for polymer liner); and the design optimization using neural network models.

For more information regarding this article, please contact John Sheffield at sheffld@umr.edu .

The UMR-National Society of Black Engineers (NSBE) Introduces Minorities to Science, Technology, Engineering, and Math at UMR



As part of a nationwide outreach program to generate more interest in math and science among minority student populations, the University of Missouri-Rolla chapter of NSBE hosted its annual Pre-College Initiative (PCI) February 22–25, 2007.

NSBE hosted 50 high school students from Missouri and surrounding states to participate in hands-on science projects and engineering workshops. The students were also able to sit in on lectures, tour the campus, participate in academic discussion groups, and interact with faculty, staff, and alumni.

“The student groups participated 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 weekend 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. Students were required to write an essay explaining their interest before being 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 in the fall.”

The summer camp is sponsored by UMR’s University Transportation Center, UMR’s Minority Engineering and Science Program (MEP), and by John Deere.

Wood Fibers and Fly Ash...BOOM!

Civil Engineering graduate student Matt Tinsley has recently been testing a new, eco-friendly material in UMR's Experimental Mine. The objective of his work is to develop a material with improved blast resistance and reduced fragmentation. In most cases, loss of human life is generally affected to a greater degree by harmful flying fragmentation than the actual blast event. His work shows promise to numerous infrastructure applications including bridge components, building facades, and barrier systems. To produce the material, a multi-layered, multi-density test panel of concrete is fabricated from various materials including wood fibers and fly ash, two materials that otherwise end up in our nation's landfills. This panel is added to a traditional reinforced concrete sub-layer. Then a layer of polyurea is added to the base or tension region of the panel. A sacrificial lower-density layer is added to mitigate a portion of the blast wave. To test this material, Matt (with the help of some UMR explosives engineering students) hangs RDX (an explosive nitroamine) above the material. They proceed to increase the amounts of RDX and decrease the distance between the material and the explosive until the system fails to characterize the blast resistance of the system undergoing progressive damage. Wood fibers and fly ash integrated with composite technologies comprise an exciting, new, environmentally useful solution for the field of Civil Engineering to help mitigate blast effects. This new material reuses waste products, while lessening the amount of debris scatter and/or fragmentation after a blast. The material essentially disintegrates when the blast hits it, and the super-stretchy polyurea layer expands to contain what's left. With conventional concrete, a blast would cause a high level of concrete chunks and fragments to fly everywhere.

Dr. John J. Myers, UTC's current Interim Director, has been serving as Matt's M.S. advisor. Matt graduated May 12, 2007, with his Master's degree in Civil Engineering and hopes to see his efforts implemented into infrastructure applications. For more information on this article, please contact Dr. John Myers by email at jmyers@umr.edu.

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