SPARKING INNOVATIVE TRANSPORTATION SOLUTIONS

Issue 15
Fall/Winter
2009

Ignition

News from TRB's IDEA Programs

HIGHWAY SYSTEMS
TRANSIT &
TRANSPORTATION
SAFETY

INSIDE:

- New tools for healthy structures
- Announcing a new IDEA program!

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THE IDEA PROGRAMS

Innovations Deserving Exploratory Analysis

IDEA programs provide start-up funding for promising but unproven innovations in surface transportation systems. The programs' goal is to foster ingenious solutions that are unlikely to be funded through traditional programs.

Managed by the Transportation Research Board, IDEA programs are supported by the member state departments of transportation of the American Association of State Highway and Transportation Officials (AASHTO), the Federal Transit Administration (FTA), the Federal Railroad Administration (FRA), and the Federal Motor Carrier Safety Administration (FMCSA).

The Transit IDEA program, which receives funding from FTA as part of the Transit Cooperative Research Program, is guided by a panel chaired by Fred Gilliam, President/CEO, Capital Metropolitan Transportation Authority in Austin, Texas. Harvey Berlin is the TRB program officer.

The NCHRP Highway IDEA program is supported by the member state departments of transportation of AASHTO through the National Cooperative Highway Research Program (NCHRP). It is guided by a panel chaired by Sandra Q. Larson, Director of Research, Iowa State Dot. Inam Jawed is the TRB program officer.

Safety IDEA is jointly funded by FMCSA and FRA. The committee is chaired by Bob Gallamore, a consultant. The program focuses on innovations to improve railroad, inter city bus, and truck safety. Harvey Berlin is the TRB program officer.

Visit the IDEA web site:
www.TRB.org/IDEA

On the Cover: Dr. Maria Feng compares her sensor with conventional components for monitoring structural vibration. Photo courtesy of Paul R. Kennedy.

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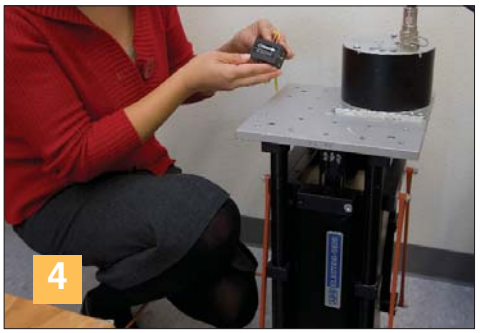
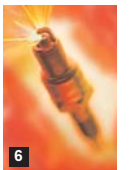
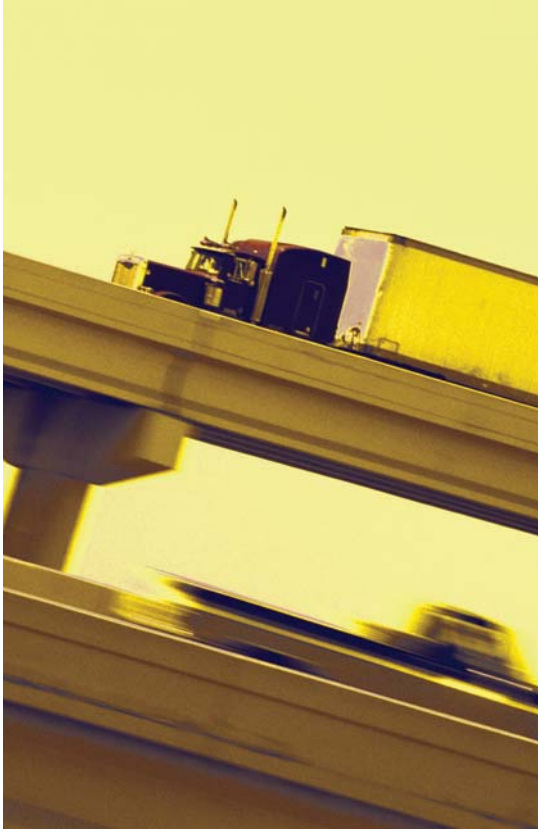






Staying Healthy

Long-time Penn State football coach Joe Paterno has advised generations of college football players to "Take care of the little things and the big things will take care of themselves." It's advice we've all heard and practice in various ways. Regular oil changes for the car, clean air filters for the furnace, checkups with the dentist; small actions taken to avert possible calamity. This issue of Ignition highlights a number of ways to detect small signs of trouble that could cause much bigger problems in our transportation system.

In Diagnosing Danger: New Tools for Healthy Structures, two IDEA projects by Principal Investigator Maria Feng are featured. Dr. Feng's innovative integration of technologies produced a way to monitor a structure's response to vibrations and to the soil around it, much the way doctors monitor our vital signs to check for dangerous symptoms. A second technology can detect small areas of deterioration that might be hiding under composite-wrapped bridge piers.

Detecting the presence of corrosion-causing chloride in concrete is another way to maintain healthy structures and the development of a new method for doing that is described in the New Ideas section. You can also read about an improved diagnostic system for air brakes, which is always a good thing to take care of. A new travel assistant device is described, too. This system can help people navigate public transit using a special mobile phone, increasing the options for independent travel. And the New Ideas section has a little bit of something we haven't seen much of lately—good news. A new IDEA program will begin in January 2010 and early information about it is provided in a sidebar.

The Business section updates a story about an ultraviolet filter system that provides healthier air on transit buses by eliminating the tiny bugs that make us sick. It seems that a growing number of agencies and businesses are taking the coach's advice—that's good news too.

Linda Mason
Communications Officer
Transportation Research
Board of the
National Academies

Your comments are welcome and may be sent to the editor at: **lmason@nas.edu**

Insight

Diagnosing Danger

New Tools for Healthy Structures

Just as doctors monitor their patients' vital signs to track trends that may signal dangerous changes, two new tools can provide similar health care for bridges and buildings. In the first of two projects in the NCHRP IDEA program, an innovative integration of technologies produced a sensor system that monitors a structure's response to vibrations and its interactions with the soil around it to provide vital indicators of structural integrity. A second project developed a diagnostic tool that detects damage concealed by fiber-reinforced polymer wrapping, a rehabilitation technique for aging highway bridges. The principal investigator for both of these projects was Maria Feng, a professor of civil and environmental engineering at University of California at Irvine and founding member of Newport Sensors, Inc.

The new tools represent significant advances in an area of increasing importance as the need to renew the transportation infrastructure becomes more urgent. Inspections conducted by state departments of transportation since the 2007 collapse of the I-35 west bridge over the Mississippi River in Minneapolis revealed that 21 percent of bridges in the United States classify as structurally deficient. The need for new and better methods of evaluating the condition of highway facilities grows as the transportation system ages and the driving population increases. Information derived from nondestructive methods of monitoring, testing, and evaluating structures can help prioritize maintenance and protect capital investments, limit traffic disruption, and indirectly improve safety.

> "...future includes sensors in all critical infrastructures to help avert disaster..."

Monitoring Vital Signs

Changes in vibration characteristics discovered through monitoring could indicate structural weakness and signal the need for action to avert further problems. The system developed in NCHRP IDEA project 124 has accurately and reliably measured both strong motion and microvibration caused by traffic, seismic, and other dynamic loads—in shake table tests and in actual conditions—by combining the benefits of lightweight fiber optics with the precision of moiré fringe phenomena.

Conventional sensors used to monitor dynamic response are typically electrical systems that were developed for mechanical or aerospace uses and are not well-suited to monitoring bridges. They require heavy and unwieldy cabling, can produce unreliable readings due to electromagnetic interference, and are easily damaged by weather. In performance tests conducted in three different laboratories and at two highway bridge locations in cooperation with Caltrans, the new sensor systems and their fiber optic cables were not vulnerable to these issues. The new sensors use no electricity, which provides immunity to electromagnetic interference and lightning strikes, and makes them safe to use in explosion-prone environments. Because the sensor head is mechanical rather than optical, it is environmentally robust and not sensitive to temperatures. The fiber optic cables are light weight, which makes the systems convenient to install and less costly than shielded electrical cable.

An additional benefit is that the sensors maintain their signal over long distances and so are suitable for monitoring long-span bridges and high-rise buildings. This characteristic enables a further application of the sensor system. Deep installation, as much as several thousand feet below the surface, allows the sensors to monitor the interaction between a structure and the soil around it. Detecting ground motion and structural response may make it possible to intervene before damage occurs. This application is undergoing long-term testing in a building on the campus at University of California at Irvine. The vibration data are streamed in real time to a lab and analyzed two or three times a day by a computer to determine if structural changes are occurring. Newport Sensors, Inc., submitted the winning proposal to install the optical fiber sensors on a 500-meter high-rise being constructed overseas, which will provide further opportunity to demonstrate long-term reliability.

Detecting Damage

In NCHRP IDEA project 109, Feng's research team developed and successfully tested a nondestructive way to detect damage to concrete bridge members that have been wrapped in fiber-reinforced polymer (FRP) composites. FRP wrapping has been demonstrated to be a cost-effective alternative to traditional construction materials for strengthening, retrofitting, and repairing highway bridges, but its implementation is constrained because there are no reliable tools for evaluating the long-term condition of the concrete beneath it.

In project 109, a smart antenna array concept was developed to detect air voids between the FRP and the concrete and between layers of FRP composites. The damage is detected by illuminating the structure with microwaves from the antenna array and comparing the scattered microwave signals with a reference signal obtained at a point on the same structure that has no damage. The array can

scan a focused microwave beam through an area of 8 square inches in about one second. The technique enables a high signal-to-noise ratio, deep inspection, and real-time damage assessment. The project resulted in a prototype hand-held antenna unit with a software package for operation control, signal processing, and display in real time. Since project completion in 2007, the cordless device, named the Gap Mouse, has been commercialized by Newport Sensors, Inc.

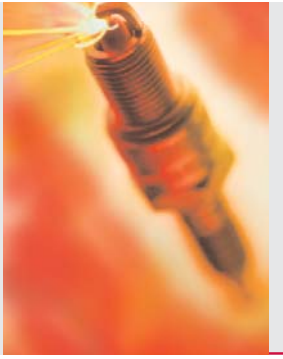
Pairing the Products

The two products are complementary and can be used in tandem to manage transportation assets. The fiber optic sensors can continuously monitor the dynamic characteristics of a bridge or other structure. That information can identify potential damage and its location in real time. The identified hot spot then can be inspected in detail with the Gap Mouse microwave imager to detect even small areas of debonding.

The Experience of a Lifetime

Dr. Feng's early work in robotics engineering was founded in tragedy, but it has given rise to great promise. A high school student in her homeland China when the 1976 Tangshan earthquake killed nearly a quarter of a million people, Feng believes that experience influenced her career choice. After earning a degree in mechanical engineering from the Nanjing Institute of Technology, she studied robotics at the University of Tokyo. "I learned a lot about vibration controls and sensors. I began wondering if I could apply the same concepts to the structure system," she says. Knowing how sensors can provide critically important information, Feng's vision of the future includes sensors in all critical infrastructures to help avert disaster and to help manage post-disaster scenarios. But before that sophisticated vision can become reality, much work remains. As Feng puts it, "With both the hardware and the software, we have a lot of research to do."

Principal Investigator Maria Feng can be contacted at mfeng@newportsensors.com



A New Generation of Chloride Detection

Corrosion of reinforced concrete is a component of the estimated $8.3 billion annual direct cost of corrosion in highway bridges reported in a 2002 publication of the Federal Highway Administration.[1] Accurate and nondestructive ways to assess the potential for corrosion before it can cause structural damage have long been the subject of research. It has been shown that chlorides promote corrosion in rebars and lead to damage and structural failure. Chlorides can enter concrete through deicing salts, concrete setting accelerants, or seawater, either in the concrete mix water or as airborne droplets from ocean spray.

Researchers in NCHRP IDEA project 146 are developing a quick, precise, and nondestructive technique for detecting chlorides using a second-generation neutron detector. This revised configuration improves detection accuracy and allows for measuring the depth of chloride spread and the water-to-cement ratio in the concrete without destroying the test sample.

The research approach employs an electric collimator using the Compton telescope configuration to narrow the solid angle at which gamma rays are detected and to reduce background noise. A sodium iodide detector is also used to enhance the gamma rays from the chloride before it passes through a germanium detector.

The investigators are currently conducting Monte Carlo N-particle simulations, which are powerful radiation transport codes capable of simulating particle transport in matter. This modeling software effectively allows the investigators to model the physical behavior of the detector to a very high degree before they build it. Once the MCNP simulations are complete, the detector will be assembled and tested, then field tests will be conducted.

Principal investigator Dr. Mohamad Al-Sheikhly can be contacted at mohamad@umd.edu.

[1] Corrosion Costs and Preventive Strategies in the United States. Koch, Gerhardus H., M.P.H. Brongers, N.G. Thompson, et al. Federal Highway Administration FHWA-RD-156, 2002.

Improving Air Brake Diagnoses

Problems with brakes can lead to accidents and fatalities, and the 2006 Large Truck Crash Causation Study by the Commercial Vehicle Safety Alliance (CVSA) indicated that brakes were a factor in 29.4% of all crashes investigated. To identify brake problems early and avoid hazards, Safety IDEA project 12 investigators Dr. Swaroop Darbha and Dr. K.R. Rajagopal have developed an improved diagnostic system for S-cam foundation air brakes, which are a type of air brakes used in trucks and buses. In S-cam foundation brakes, compressed air flows into the brake chamber and moves the push rod, which applies the brakes. When the brake shoes wear or the brake drum expands at higher temperatures, the brake response time is slower, because the push rod stroke (the distance the push rod travels) is longer, requiring more air. When the push rod fully extends from the brake chamber, the contact between the drum and the brake pads may be lost and the brakes become ineffective. This is why the criteria that dictate when a vehicle should be declared out-of-service are based on the push rod stroke.

Diagnostic systems for air brakes exist that warn when the air pressure falls below a certain limit or when the push rod stroke exceeds a certain limit, but they do not fully measure the air pressure delivered to the brake chamber or the motion of the push rod. This project's investigators developed a diagnostic system for air brakes that

is able to detect the severity of leaks in the air brake system and to estimate the push rod stroke. Push rod stroke is calculated with a mathematical model that uses orifice equations for describing the mass flow rate of leaking air and incorporates the balance of mass equation. Measurements of the brake parts were used to corroborate the model.

The diagnostic system has the potential to be commercialized. The model has been developed in compliance with current Federal Motor Carrier Safety Administration and Federal Motor Vehicle Safety Standard norms for brake systems in trucks. A desktop computer currently performs the calculations, but a hand-held device is being constructed that can be used instead of the computer. The device also has the potential to be adapted for use on air brakes in trains.

Principal investigator Swaroop Dharba can be contacted at dswaroop@tamu.edu

HERE'S SOME GOOD NEWS

New IDEA Program Begins in January 2010

The time it takes to get from here to there by car is not always predictable. Maybe an incident in the roadway causes a back-up or a work zone slows the traffic. To reduce the frustration, costs, and risks caused by this kind of congestion, the second Strategic Highway Research Program (SHRP 2) is funding a new IDEA program.

The Reliability IDEA program will fund early-stage investigations of innovative concepts that could help provide a reliable highway system. Goals of the new program will be described in the January 2010 IDEA Program Announcement. Look for it in January online at www.TRB.org/IDEA and at the TRB Annual Meeting January 10-14, 2010.

A TAD Bit of Help for Special Needs Transit Riders

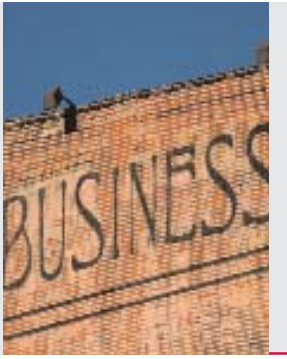
Transportation is essential for independent living, but individuals with mental or cognitive disabilities often have problems using transit systems. In the year 2000, there were nearly a million Americans over age 5 who were mentally disabled and not living in institutional settings, according to statistics provided by the U.S. Census Bureau. Many transit agencies offer paratransit options to individuals with special needs, but these options can be expensive and inconvenient for riders. To make independent use of public transit an option for people with special needs, the Center for Urban Transportation Research at the University of South Florida is developing special GPS-enabled mobile phone navigation software for public transportation in Transit IDEA Project 52.

The Travel Assistant Device (TAD) server connects to the transit system server, allowing it access to bus routes, bus stops, and real-time bus location. A caretaker can use the TAD website to plan trips (e.g., work to home) through a computer or a mobile phone. The website also allows the caretaker to manage trip itineraries and track the transit rider. The transit passenger uses a mobile phone to access the planned trip. The phone, equipped with global positioning software and the TAD mobile application, displays where bus stops are located and indicates which bus to take. The TAD also estimates when the bus will arrive, so the phone alerts the rider when the bus is near and when to signal the bus driver to make a stop.

Mark Shephard (right), a travel trainer with the Hillsborough Area Regional Transit Authority in Florida, explains the TAD system to a transit rider.

The server architecture and graphic interfaces continue to be refined by the investigators, who have teamed with the Florida Mental Health Institute to determine TAD's effectiveness as a prompting tool for the cognitively disabled. Field tests have been performed in cooperation with the Hillsborough Area Regional Transit system in Tampa, Florida. The investigators plan to expand TAD to other transit agencies and are examining funding sources and business models that could lead to commercialization.

Principal investigator Philip L. Winters can be contacted at winters@cutr.usf.edu



Clean Air Systems in Demand

Following the success of field tests conducted at the Houston Metropolitan Transit Authority, bus transit agencies, bus manufacturers, and rail transit agencies have expressed interest in the ultraviolet germicidal irradiation (UVGI) system developed in Transit IDEA project 53. The field tests proved the ability of the system to lower maintenance costs, and tests by Biological Consulting Services of North Florida proved the system reduces mold and fungi in the air conditioning system by 95-99% and reduces airborne harmful microorganisms such as flu viruses, including H1N1 influenza (swine flu), by 99%.

The researcher reports that the Fort Worth Transportation Authority purchased the system and installed it in its buses, as have the Jacksonville Transit Authority, the Hillsborough Area Regional Transit Authority (HART) in Tampa, and Palm Tran in West Palm Beach. The Key West Department of Transportation equipped six of its buses with the system and may retrofit additional buses with it. Dallas/Fort Worth International Airport has put the system into the specifications for about 76 buses that will be built in May of 2010. Central Florida Regional Transportation Authority (LYNX) is also looking into installing the technology and tests of the irradiation system are being conducted by the Chicago Transit Authority.

Bus manufacturers have expressed interest in UVGI technology. The system has been sold through New Flyer and Gillig, and other bus manufacturing companies are interested in the system. Two rail transit agencies are also considering implementing the technology in their rail rapid transit cars.

Information about the IDEA project, which was funded by the Transit IDEA program, is available from Harvey Berlin, Transit IDEA Program Manager, who can be contacted by e-mail at hberlin@nas.edu, and from Lee Huston at th@gte.net.

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