SPARKING INNOVATIVE TRANSPORTATION SOLUTIONS

Issue 20
Summer/Fall
2013

Ignition

News from **TRB's IDEA** Programs

HIGHWAY SYSTEMS
TRANSIT
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INSIDE:

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News from TRB's IDEA Programs

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), and the Federal Railroad Administration (FRA).

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, Gilliam and Associates, Austin, Texas. Jon Williams is managing this program.

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 and Technology, Iowa State DOT. Inam Jawed is the TRB program officer.

The Safety IDEA program has been sponsored by the Federal Railroad Administration (FRA) and the Federal Motor Carrier Safety Administration (FMCSA). Since the program is currently funded only by the FRA, the Safety IDEA program is accepting new proposals only on innovative approaches to improve railroad safety or performance. The program committee is chaired by Bob Gallamore, a consultant and writer. Chuck Taylor is the TRB program officer.

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

On the Cover: A laser shot removes a portion of surface coating to generate a spectral emission that can be analyzed to identify its component elements.

Photo provided by Chesner Engineering

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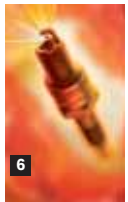

Who You Gonna Call?

When the term 'spectral fingerprints' came up in our feature article, I thought we should call Ghostbusters immediately. Where is Bill Murray when you need him, anyway?

It turns out that mineral aggregates used in pavements can be identified by unique spectral fingerprints found by measuring the wavelength and intensity of light from high-temperature plasma. Those fingerprints can help transportation agencies quickly verify that the aggregate is from approved sources and will perform as expected, which in the end improves pavement performance. It's not ectoplasm in a backpack, but it's still very cool science that you can read about on page 4.

Pavement performance can also be improved by an emerging technology that creates a friendly environment for joint sealants in the cracks between pavement slabs. Two new attachments to deal with moisture have been added to the crack-cleaning device developed in an earlier IDEA project. Deicing chemicals are notorious for causing crack sealant failure, so using the right amount is important. Automated spray technologies can automatically deliver the right amount of deicer to remote and urban bridges at just the right time; you can read how the IDEA programs helped bring this technology to the United States in the New Ideas section. Also in that section is news of further developments in a warning system to protect track workers that is of growing interest to transit operators.

The Business section reports some big news for one of the earliest IDEA successes as it receives investment from a major player in the global market. Success stories like this one are good reminders for innovators who need early help in testing their concepts to hone their proposals and contact the IDEA programs—who else are they going to call?

Linda Mason
Communications Officer
Transportation Research Board

Recently Released Reports from the NCHRP IDEA Program

NCHRP-IDEA 143: The Guayule Plant: A Renewable Domestic Source of Binder Materials for Flexible Pavement Mixtures (Missouri University of Science and Technology; P.Is: David N. Richardson and S. Michael Lusher)
http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP143_Final_Report.pdf

NCHRP-IDEA 145: Extraction of Layer Properties from Intelligent Compaction Data (Colorado School of Mines; P.I.: Michael A. Mooney)
http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP145_Final_Report.pdf

NCHRP-IDEA 151: Development of a Simple Test to Determine the Low Temperature Strength of Asphalt Mixtures and Binders (University of Minnesota; P.I.: Mihai O. Marasteanu)
http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP151_Final_Report.pdf

NCHRP-IDEA 153: Laser Measurement Accelerated Retrofit System (Fuchs Consulting, Inc., Leesburg, Virginia; P.I.: Paul Fuchs)
http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP153_Final_Report.pdf

NCHRP-IDEA 155: Corrosion-Resistant, Structurally Reinforced Thermal Spray Coatings for In-Situ Repair of Load Bearing Structures (State University of New York at Stony Brook; P.I.: Sanjay Sampath)
http://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP155_Final_Report.pdf

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

Spectral Fingerprints?

How Ghostly Images can ID Aggregates and Improve

The quality of pavements is heavily dependent on the quality of aggregates used to construct the pavement. Because of this, one of the primary responsibilities of most transportation agencies is to monitor aggregates through well-defined quality control/quality assurance (QC/QA) programs.

The NCHRP IDEA program is assisting in the development of new technology that uses lasers to scan aggregate materials to identify the engineering properties of the target aggregate. This technology has the potential to change the way that transportation agencies handle QC/QA monitoring in the laboratory and in field applications. It provides the means to characterize aggregate materials in near-real time. Successful deployment of such a technology could reduce the time and effort currently expended to test aggregates using current laboratory methods.

Laboratory Analysis

In NCHRP IDEA Project 150, Warren Chesner of Chesner Engineering, P.C., and Nancy McMillan of New Mexico State University developed laboratory and modeling techniques using a laser ablation process, commonly referred to as laser-induced breakdown spectroscopy (LIBS), to evaluate the feasibility of using this process to characterize the engineering properties of aggregates. In the laser ablation process, a high-powered laser is focused on a tiny portion of a target sample, ablating it and inducing high-temperature plasma. A spectrometer is then used to collect and quantify the wavelength and the intensity of the light that is emitted from the plasma. The specific wavelengths and the respective intensities of the light emitted provide a detailed spectral fingerprint of the chemical makeup of the target aggregate. The researchers found that this spectral fingerprint could be used to examine and accurately predict several engineering properties. Aggregates from New York State were accurately characterized for acid-insoluble residue (AIR). D-cracking aggregates were readily detected in samples from Kansas and the presence of alkali-silica reactive chert was easily identified in samples from Texas. NCHRP IDEA Project 150 project concluded in 2012, and follow-on NCHRP IDEA Project 168 is now active.

Spectral Fingerprints

In plasma created during the laser ablation process, atoms (particularly the electrons) that comprise the target material absorb energy from the laser. This causes the electrons in these atoms to transition from their ground state to higher energy levels, before immediately reverting back to their ground-state energy level—releasing the absorbed energy in the form of light. The wavelength and intensity of the emitted light are unique to the elemental and molecular makeup of the target mineral aggregate. These unique characteristics comprise the spectral fingerprint.

Discriminant Analysis

A mathematical process known as discriminant analysis is used by the Chesner team to convert spectral fingerprint data into data that can be used by the engineer to characterize aggregate properties and determine the suitability of aggregates for specific uses. Discriminant analysis begins with the process of fingerprinting aggregates of interest. For example, let's say that the spectral fingerprints are available for four different aggregates: A, B, C, and D. Further assume that aggregate C is the only approved material for use in a particular application. When an aggregate supplier provides unknown materials for approval, discriminant analysis could be used to determine if the unknown aggregate is a match for type C or if it must be rejected. Or in another scenario, if aggregate D is known to be a deleterious material, discriminant analysis could be

Laboratory Laser System at New Mexico State University Used in NCHRP 150 Feasibility Testng |Warren Chesner.

The laser sample chamber (center) is encased in protective glass. The chamber door opens and aggregates can be placed on the small platform inside. The laser (top), which has several yellow warning stickers, is mounted above the sample chamber. When activated by the control box (left),the laser induces plasma from the aggregate. The light from this plasma is detected and sent to the spectrometer (far right) using fiber optical cables (blue). Data from the spectrometer is then sent to the computer (right) for processing.

used to determine if an unknown aggregate has a matching spectral fingerprint.

Discriminant analysis can also be used to quantify the magnitude of aggregate properties. One method used by the Chesner teams is a procedure known as compositional calibration, in which the known engineering properties of aggregates are correlated with a quantified spectral fingerprint. For example, let's say that our four aggregates have different AIR contents: A has 10%, B has 20%, C has 40%, and D has 80%. A calibration curve could be developed and used to predict the AIR composition of an unknown aggregate material. Furthermore, it is possible to conduct an analysis of most engineering properties of interest in aggregates, including durability, reactivity, gravimetry, skid properties, and the presence of deleterious materials.

Into Commercial Application

In NCHRP IDEA Project 168, Chesner is transitioning this technology from laboratory research to commercial field applications. This project is creating a moveable, patent-pending bulk aggregate monitoring system that is capable of determining the spectral fingerprints of bulk aggregate samples in real time.

In NCHRP IDEA Project 150, proof-of-concept testing work was undertaken using a shot-to-shot laboratory laser system, in which the laser is focused on one aggregate particle at a time and each spectral emission is captured in a spectrometer. However, most aggregate samples are heterogeneous, and multiple laser shots are needed to establish reliable data. In NCHRP IDEA Project 168, the research team is testing a continuous-flow laser system that provides the means to create extremely large data sets, which can address the heterogeneity of mineral aggregate particles. This patent-pending continuous monitoring system—known as the sampling laser and targeting (SLT) system—consists of a material flow system that moves the mineral aggregate past a laser, a laser targeting system to direct the laser at the target, and a laser-optics system to generate the laser and collect light emission information. The research team will also work with the American Association of State Highway and Transportation Officials (AASHTO) Subcommittee on Materials Testing to develop a standard of practice for the laser scanning of aggregates as part of Project 168.

Pooled Fund Study

Concurrent with NCHRP IDEA Project 168, the SLT system is being explored in Transportation Pooled Fund Program TPF-5(278), which is being led by Kansas Department of Transportation (DOT) with participation from New York State DOT, Ohio DOT, and Oklahoma DOT. This study is also working to transition the SLT from the lab to the field by further calibrating laser-spectral models for aggregate materials from the participating agencies and by demonstrating this technology in the field.

> "*Through the work* that Warren and his team have done to date, they have been able to identify the bed from which a piece of aggregate was taken at a *100% success rate* using the aggregates spectral fingerprint and statistical modeling."

The results from the Pooled Fund Study have been very positive so far. "Kansas DOT was originally interested in the laser scanning technology to positively identify the beds in a quarry from which our limestone aggregates were originating," said Randy Billinger, Pooled Fund Manager and Research Geologist with Kansas DOT. "At present, we have no way to positively know if all the limestone aggregates being used on a project are actually coming from the preapproved beds in the quarries. Through the work that Warren and his team have done to date, they have been able to identify the bed from which a piece of aggregate was taken at a 100% success rate using the aggregates spectral fingerprint and statistical modeling." The compositional calibration abilities of the SLT system are also being tested. "Warren and his team are now able to take the aggregate spectral fingerprint and correlate it to the engineering property for which the aggregate will be used [through] compositional calibration. . . . At present, the team is consistently doing this successfully. So the laser can tell you precisely if the aggregate is of an approved source and if the aggregate will pass or fail the engineering property of interest."

Billinger went on to describe what he considers the three greatest benefits of the technology: "First, aggregates can be scanned and accurately identified as coming from approved sources instantaneously, no more guess work. Second, an aggregate spectral fingerprint can be used to predict numerous engineering properties of the aggregate, in real time, eliminating the need for multiple laboratory tests that currently can take months to complete. A third benefit would be the ability of each state DOT to create an aggregate database listing the results of each engineering property for that aggregate. These could culminate in a national aggregate database, which could easily be used to best match aggregate sources to engineering properties."

Contact: Warren Chesner, wchesner@chesnerengineering.com

Alert! Warning System Improves Transit Track Safety

In Transit IDEA Project 55, Peter Bartek of Protran Technology developed and tested the Real-Time Warning System, which included two devices to warn rail transit personnel of approaching trains—the Portable Train Detector and Warning Unit, and the Train Mounted Device. The project produced favorable results, which led to the implementation of this technology by a number of transit agencies.

Protran continued to develop the system, which now includes several real-time warnings—track worker advance warning, speed restriction, trespass warning, high-rail vehicle warning, pedestrian warning, and next-train alert. The newest systems also have programmable logic controllers, which provide the Operational Control Center (OCC) with the exact location of track workers in real time. Of the transit agencies that implemented Protran's technology, the Maryland Transit Administration (MTA) and the Los Angeles County Metropolitan Transportation Authority (Metro) upgraded to the full suite of warning systems.

Protran Portable ProTracker, Protran Personal Armband Device, Protran ProTracker

"One of the better features of the early warning system is that it is interactive," say Michael Davis and Al Panuska of MTA. "The system alerts both the operator and the employee on the track." They also like that the system is "very durable, light weight, and dependable, and has multiple applications. Another important aspect is the fact that the technology has evolved to encompass all types of warning/alert systems. The MTA now uses the same technology on our Light Rail system. On Metro we installed an alert system on an area of safety walk used by employees to walk from the main shop to the closest Metro station. We are currently investigating tying the Protran system into Metro's alarm system to alert the train operator of hazards in the Metro tunnel."

The system's greatest benefit to MTA is that it requires "safety checks and additional radio communication prior to an employee entering mainline track," add Davis and Panuska. "The device requires employees to check the personal devices in test units set up in maintenance facilities. Prior to entering mainline track, the employee is required to call OCC. OCC then asks if the employee has the Protran device, if it was checked and is functional. The system adds a layer of protection to contractors and all others working under work blocks on mainline tracks."

Contact: Peter Bartek, peter@protransafety.com

Improve Crack Filling and Joint Sealant in Pavements

When cleaning cracks or sealing joints in pavements, it is important to remove debris and other foreign materials—such as concrete dust, fine sand, and winter deicing chemicals—that can contaminate the sealing or filling material and reduce cohesion. Deicing materials, in particular, are notorious for causing crack sealant to fail prematurely.

To help construction crews clean cracks and joints before sealing, Yong Cho of the University of Nebraska, Lincoln, developed a low-cost mechanical tool in NCHRP IDEA Project 148 and refined it

Crack Cleaning Device (CCD) with Heat Lance Attachment in Field Test with Nebraska Department of Roads Crew

in NCHRP IDEA Project 159. In project 148, Cho created a prototype crack-cleaning device (CCD), which combines a pneumatically driven wire brush and an air blast nozzle into one device. This project included field tests at two highway crack-sealing sites in collaboration with the Nebraska Department of Roads and a demonstration for the City of Omaha street maintenance group in Nebraska.

Follow-on project 159 is developing two attachments for the CCD—an electric heat lance and a vacuum. The heat lance is intended to remove moisture, which can negatively affect sealant. The vacuum attachment is intended to contain dust and debris that is removed from cracks during the cleaning process. When released into the open air, these materials can negatively affect air quality, worker health, and motorist safety.

The CCD has the potential to improve the efficiency and quality of preventive maintenance, which could reduce the need for more costly major pavement rehabilitation. It also has the potential to improve the quality of sealants at new joints, which could extend pavement life.

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Clearing the Path for More Innovations

Sometimes an IDEA project takes the limelight. Other times it opens the door.

Fixed automated spray technology (FAST)| Boschung America, LLC

In the mid-1990s, a winter maintenance scan team in Europe learned about fixed automated spray technology, or FAST, which automatically applied deicing liquids to bridges. One of the researchers, Dr. Rand Decker, recognized the potential for this technology—the ability to quickly deice remote bridges during winter months. He submitted a proposal to the NCHRP IDEA Program, and in 1998, NCHRP IDEA Project 27, in cooperation with the Utah Department of Transportation, conducted the first demonstration of this technology in the United States. Considered a success, the results were disseminated in the IDEA final report and at the TRB Annual Meeting. They were also published in the Transportation Research Record: Journal of the Transportation Research Board.

Dr. Decker did not continue his involvement with the technology, but he did get people in the United States to notice it. Not long after the initial demonstration, European vendors started selling the technology in America. Domestic vendors appeared. FAST was slowly becoming a standard tool for winter maintenance, and by 2003, 23 states either had FAST systems or were planning to install them. Today the system, which is especially suited for remote bridges, is also being used on urban bridges, such as the I-35W Saint Anthony Falls Bridge in Minneapolis. A forthcoming NCHRP Synthesis Report, Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment, documents this proliferation. FAST systems use atmospheric and pavement sensors to apply the appropriate amount of chemicals at just the right time to prevent icing or snow packing and reduce the amount of chemicals needed.

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All Aboard for Railroad Safety

In 2012, the Safety IDEA Program, which is funded by the Federal Railroad Administration (FRA), shifted its focus solely to railroad safety and performance. On this new track, two projects are taking the lead.

The first project could lead to increased protection against railroad car collisions. In Safety IDEA Project 20, Afsaneh Rabiei of North Carolina State University is investigating the properties of composite metal foams (CMF), which are composed of hollow metallic spheres and a solid metallic matrix. Work in this project will include evaluating the dynamic properties of CMF during impact speeds of up to 220 miles per hour. An improved understanding of CMF could lead to lighter, safer, and more efficient railroad car safety structures.

The other project is exploring the ability of laser cladding to improve weld life expectancy. Laser cladding coatings have the potential to reduce surface and near-surface defects on welds, which would prevent plastic deformation along thermite welds, particularly at the heat-affected zone. In Safety IDEA Project 22, the University of Houston, in cooperation with Transportation Technology Center Inc. and the Laser Cladding Services Ltd., will test and evaluate the ability of laser cladding to reduce the detrimental effects along the heat-affected zone. The results could improve rail safety as well as the efficiency of railroad operations.

TRB is accepting Safety IDEA proposals for funding projects to develop and test innovative methods to improve railroad safety or performance. Safety IDEA proposals are due by September 16, 2013.

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Watching Driver Behavior Improve

One of the biggest successes from the ITS IDEA Program, DriveCam, caught Volvo's eye. In February 2013, Volvo Group Venture Capital (a subsidiary to the Volvo Group) made a strategic investment in DriveCam.

"Volvo Group and DriveCam have a common vision—to reduce traffic accidents worldwide," says Johan Carlsson, President of Volvo Group Venture Capital. "Volvo Group and DriveCam both believe that there is only one acceptable number of accidents in driving—zero," added DriveCam Chairman and CEO Brandon Nixon.

In 1998, DriveCam inventor Gary Rayner received $100,000 from the IDEA Programs to develop a data recorder for highway vehicles, which was intended to function similarly to the black box that is used in airplanes. The device is placed on the inside of a vehicle's windshield, and it records the video image of the scene in front of the vehicle, the audio inside the vehicle, and acceleration along three perpendicular axes. DriveCam uses these analytics to address the causes of poor driving behavior with real-time driver feedback and coaching, which has prevented collisions and reduced fuel costs.

For several decades, Volvo Group has studied and analyzed a large number of accidents involving trucks. This information has become part of the foundation for the design and development of the group's trucks. Their investigations have led to many safety-related improvements and DriveCam's help will lead to many more.

"…Volvo Group is also focused on the human element in reducing accidents, an area where DriveCam is a clear leader," says Carlsson. "This strategic investment enables the commercial vehicle industry to benefit from our collaborative development efforts, while it also supports the Volvo Group's vision to become the world leader in sustainable transport solutions."

More information about DriveCam and Volvo Group's investment can be found at www.drivecam.com.