

# KENTUCKY TRANSPORTATION CENTER ANNUAL REPORT 2009

## RESEARCH



EDUCATION

TRANSFER

TECHNOLOGY

# Advisory Board

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## **Technology Transfer**

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Sixteen research projects were completed during FY 2008/9.

All completed research project reports since 2000 can be found on the Center's Web site:

<http://www.ktc.uky.edu>

Technology transfer short course and workshop listings can be found at:

<http://www.kyt2.com>



## Director's Message

KTC's research reaches high and goes low. Stretching from the Combs-Hehl Bridges to the Cumberland Gap Tunnel, it provides a glimpse of the unique capabilities of the Center's research. This research is carried out by problem-solving transportation professionals using state-of-the-art science and technology, and benefits all Kentuckians by addressing the needs of a transportation infrastructure, which is necessary for economic development and redevelopment. Go ahead and turn to the centerfold to get the rest of the high-low research story.

We are well-known for having a technology transfer program that assists transportation professionals at all levels of government in the Commonwealth, as well as those in the private sector. While we are less known for our interdisciplinary education program, it has been in existence for over a decade. It brings in a small group of graduate students each year from several disciplines (including engineering, geography and public/business administration) and teaches them how to focus together on transportation problems and opportunities.

While we are in difficult recovery times, wondering whether the glass is half-empty or half-full, new challenges keep arising for our transportation system. How transportation projects are planned, developed, delivered and preserved requires new levels of efficiency and innovation in the face of insufficient resources. Research helps to meet that need head-on, with science-based problem solving meant to stretch the available human and financial resources both through incremental and innovative change. These changes get disseminated directly to the field through technology transfer training opportunities and are brought to the university classroom as part of our education initiative.

I am happy to announce that the Center is soon expecting a new director, who will lead us through the 2010 decade. Additionally, we will be honoring the past with an appointment of the center's first director emeritus. We are on a sound foundation and the Center has the opportunity to become a highly recognized regional and national source of science-based solutions while continuing to serve the transportation education, research, and technology transfer needs of our Commonwealth.

Don Hartman, MSP  
Interim Director

## EDUCATION: The Advanced Institute and the CTI Academy

**The Advanced Institute** is a quasi-certificate program that supports 5-10 graduate students each year working on issues surrounding transportation systems management. These graduate students must be full-time in a transportation related discipline. Over the 20-year life of the program 152 students have participated with the majority being in civil engineering; however, significant numbers have represented geography/geoscience and public/business administration. Participants have also included those majoring in landscape architecture and historic preservation.

The program requires participation in two specially designed graduate courses with a student project and attendance at a regional and/or national transportation conference. The unique courses are designed to enhance interdisciplinary experiences for students by bringing together people with different backgrounds and areas of specialty. In fall 2008 a course called "Concepts and Theories for Transportation and Land-Use Planning" was taught. The course was designed to provide a broad understanding of the interaction between transportation policy and the natural and built environment. The spring 2009 course was titled, "Issues and Applications in Transportation Planning and Community Development." These courses, with applied focuses and projects tailored to encourage inter-disciplinary interaction, help students come away with a clearer understanding of the subject matter, but also the ability to work better with other groups of specialists.

The primary funding for the institute is provided by the USDOT through the SECUTC (South-eastern Council of University Transportation Centers). In recent years this funding has been supplemented from the academy program described below.

**The CTI (Community Transportation Innovation) Academy** program has been established with periodic congressionally mandated funding through the USDOT/FHWA. The program includes education initiatives and research projects at both the University of Kentucky and the University of Louisville. Funding partially supports the student activities and teaching program of the Advanced Institute described above and also funding will continue to be directed toward professional development education and training initiatives. Support has also been provided for establishing and developing the Kentucky Transportation Cabinet's Preconstruction Project Managers Academy. A current project involves the preparation of a guide for highway designers that includes the concepts of context sensitive solution as well practical solutions. This handbook will be made available to highway designers throughout the U.S.

Many of the research projects supported with this program have application beyond the borders of Kentucky, however, most of the innovative concepts are being developed and refined working with transportation agencies and communities in state. Recent projects have involved developing and/or applying land use/transportation planning tools for: Woodford Co., KY; Franklin, KY; Simpson Co., KY; and Jeffersonville, IN.





# RESEARCH

## Construction Management

**TEAM:** The group is led by **Dr. Paul Goodrum, P.E.** and includes Dr. Tim Taylor, P.E. and several graduate students.

**PROBLEM:** Change orders affect many projects within the Kentucky Transportation Cabinet. While change orders are necessary to address unforeseen and unavoidable occurrences on a project, they are inherently inefficient. Review and approvals of change orders are an added cost to a project’s administration, and since this work is not competitively bid, the Cabinet may overpay for it. Also, change orders often involve field rework, which negatively impacts labor productivity and the motivation of construction crews. The Kentucky Transportation Center is investigating the leading causes of change orders on Cabinet projects and searching for better practices for pricing change orders on projects.

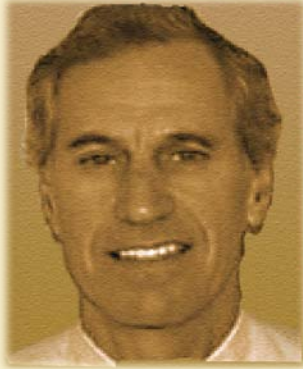
**SCIENCE/PROCESS:** The impact of change orders was investigated through a statistical analysis of 610 Cabinet projects completed between January 2005 and August 2008. This analysis found that Cabinet projects face the greatest change order price risk from contract omissions, contract item overruns, owner induced enhancements, and fuel & asphalt adjustments. There have been no uniform procedures for pricing change orders, which resulted in varying estimating processes among districts.

**RESULTS:** The team is producing two tools to aid in the implementation of the work. First, to reduce project risk a “change order risk” card will identify high risk areas such as contract omissions and contract overruns. This should increase the risk awareness during the early phases of a project to allow for improved project planning. Second, a change order pricing flow chart will provide a uniform formal procedure for pricing change orders. This will aid in the training of less experienced personnel in negotiating change orders.

**Quick Guide: Risk of PERCENT CHANGE by Reason Code and Road Type**

Reason Code	Description	Road Type				
		CR	I	KY	PW	US
1	Asphalt Lot Pay Adjustment	○	○	●	○	●
3	Fuel & Asphalt Adjustment	●	●	●	●	●
4	Contract Omission	○	○	●	○	●
5	Utility Issue	●	○	●	---	○
6	Contract Item Overrun	●	●	●	●	●
7	Geotechnical Issues	---	○	●	●	●
8	Owner Induced Enhancement	●	●	●	●	●
9	Environmental Issues	---	○	●	---	○

○ Low Risk of % change from original contract amount    --- Data Insufficient  
 ● Risk of % change from original contract amount  
 ● Extreme Risk of % change from original contract amount



## RESEARCH

### Traffic and Safety

**TEAM:** The group is led by **Jerry Pigman, P.E.** and includes research engineers: Ken Agent, P.E.; Eric Green, P.E. and Adam Kirk, P.E., AICP, PTOE along with analysts: David Cain and Neil Tollner and several student assistants. The team was supplemented by Civil Engineering professor/researcher Dr. Nick Stamatiadis, P.E.

**PROBLEMS:** The following problems and issues have been addressed during the past year:

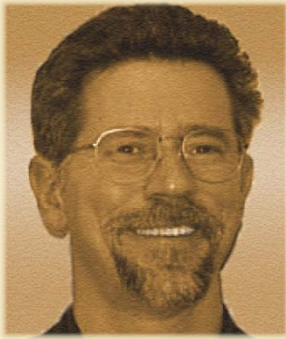
- Unreliable pavement marking performance (reflectivity and durability)
- Safety and effectiveness of raised pavement markers
- Improving processes to prioritize locations in need of guardrail
- Procedures for implementing the new work zone safety rules
- Improving intersection design practices

**SCIENCE/TECHNOLOGY & RESULTS:** Varying degrees of detail and technical complexity, as listed in the following approaches or methods have been applied:

- Measurements of pavement marking retro-reflectivity and assessment of durability were conducted by tracking installation contracts and making field observations of performance.
- Inspections and observations of raised pavement markers in conjunction with review of references and surveys indicated that their desirability was directly related to pavement condition. Overall crash analysis indicated that crash rates were less on roads with raised markers.
- Integration of a more streamlined crash analysis process for identifying locations in need of guardrail resulted in an improved process and increased compatibility with other databases.
- Data driven analysis of work zone crashes provided insight and direction for a recommended procedure to implement the Work Zone Safety and Mobility Rule.
- Analysis and evaluation of current intersection design practices addressed safety and capacity along with the desirability of minimizing the intersection footprint.



Retro-reflector being used to measure the reflectivity of double yellow center highway lines.



## RESEARCH

### Intelligent Transportation Systems

**TEAM:** This group is led by **Dr. Joe Crabtree, PE** and includes research engineers David Hunsucker, PE, Doug Kreis, PE, and Jenifer Walton, PE and research associate Mark Spellman. Several part-time engineers and research associates supplement the team along with Civil Engineering professor/researcher Dr. Mei Chen.

Intelligent Transportation Systems, or ITS, refers to the use of advanced detection, processing, and communications technologies to make transportation safer, more efficient, more secure, and less harmful to the environment. The ITS research section at the Kentucky Transportation Center has a multidisciplinary staff dedicated to a wide range of ITS projects. Our projects encompass a variety of ITS applications in areas such as Commercial Vehicle Operations, Incident Management, Homeland Security, Advanced Traveler Information Systems, Collection and Evasion of Taxes and Fees, ITS Architecture Development, and Evaluation of Integrated Traffic Management Systems.

Highlighting:



**PROBLEM:** Despite the dangers associated with many hazardous materials carried on our nation's roadways each day, the United States Government cannot track the movement of the millions of high-risk hazmat shipments each year. How can this identified threat to our citizens, highways, and infrastructure from the movement of these materials be addressed so that the threat is minimized?

**PROJECT TEAM:** includes representatives Coldstream Digital, General Dynamics, ThoughtWorks, Microsoft Federal, ESRI, Advantage Factory, National Conference of State Legislatures and the Kentucky Transportation Center's project leader Doug Kreis, PE, MBA, PMP.

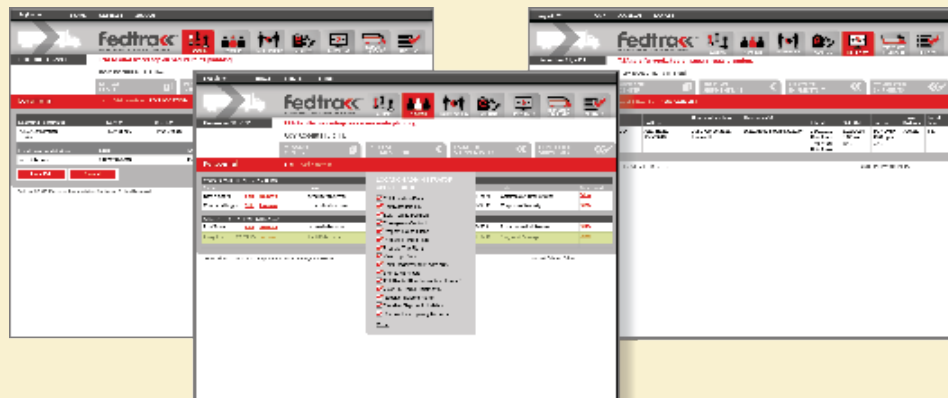
**SCIENCE/TECHNOLOGY:** KTC's project team is building Fedtrak, a web-based management and tracking system that will monitor the movement of trucks carrying high-risk hazardous materials on a real time basis. The system will draw data from truck-mounted smart-truck devices, including onboard computers, GPS receivers, and wireless modems. Data will flow into Fedtrak via cellular and satellite networks and will then be analyzed by Fedtrak to determine the riskiest shipments being transported at any given time.



Team members meet on the UK campus to establish Fedtrak system requirements.

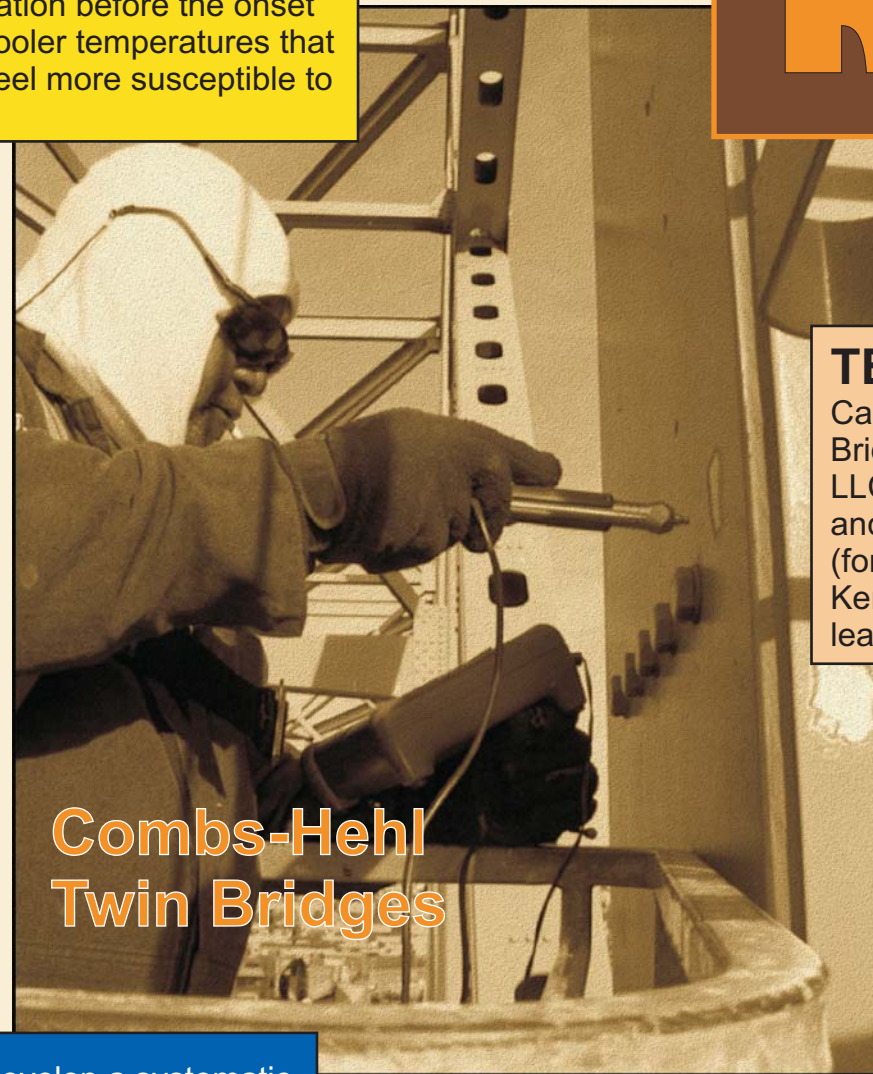


Fedtrak team members in work sessions (above) and simulated Fedtrak work station and vehicle tracking information screens (below).



# KENTUCKY TRANSPORTATION CENTER

**PROBLEM:** Identify the extent of possibly defective steel in the over 1,300 steel plates of the twin Northern Kentucky Bridges over the Ohio River that carry the traffic of I-275. A major concern was to conduct the evaluation before the onset of winter and its cooler temperatures that make defective steel more susceptible to brittle fracture.



Combs-Hehl  
Twin Bridges

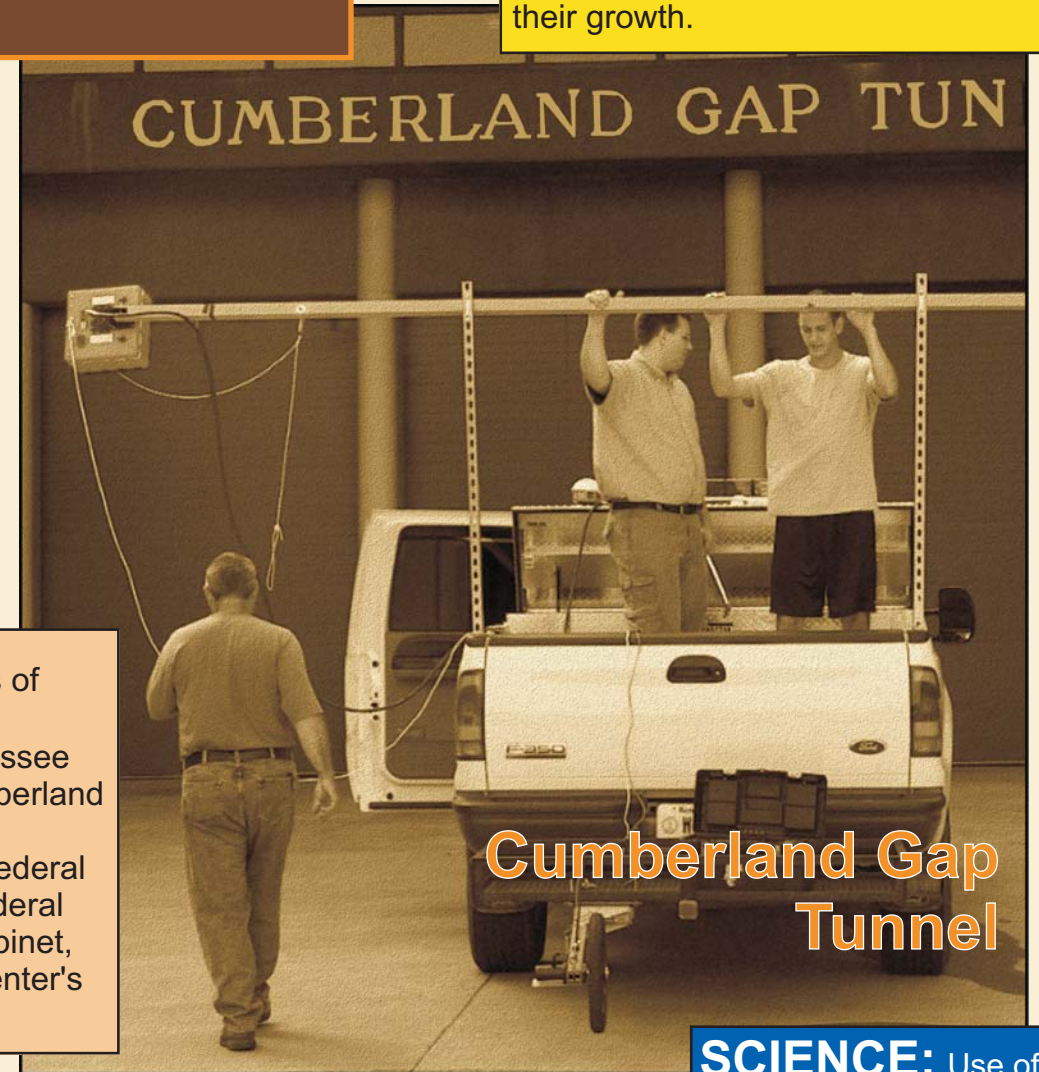
**SCIENCE:** Develop a systematic investigation protocol using non-destructive test instruments and find/employ experienced personnel to conduct tests on the bridge.

**RESULTS:** Seventeen steel plates were found to be defective. Consequently the Kentucky Department of Highways has let the necessary contracts to replace these out-of-specification gusset and splice plates.

## RESEARCH

**TEAM:** Kentucky Transportation Cabinet (District 6 and Central Office Bridge Maintenance); Intech Contracting, LLC; IMR – Louisville; Huntington Testing and Technology – Louisville; Mistras (formerly Conam Testing); and the Kentucky Transportation Center's project leader Ted Hopwood, PE.

**TEAM:** Included representatives of Cumberland Gap Tunnel Authority, Kentucky Geological Society, Tennessee Department of Transportation, Cumberland National Park, Federal Highway Administration Kentucky Division, Federal Highway Administration Eastern Federal Lands, Kentucky Transportation Cabinet, and the Kentucky Transportation Center's project leader Brad Rister, PE.



Cumberland Gap  
Tunnel

**PROBLEM:** Determine the location and extent of voids developing beneath the tunnel's pavement, and continue tracking their growth.

**RESULTS:** The team was able to discover the location and extent of the voids beneath the pavement. In addition, the causal factors were identified. Analysis continues to determine the best solutions.

**SCIENCE:** Use of ground penetrating radar, pipeline video camera, water chemistry testing, and traditional surveying along with 3-D visual surveying.



# RESEARCH

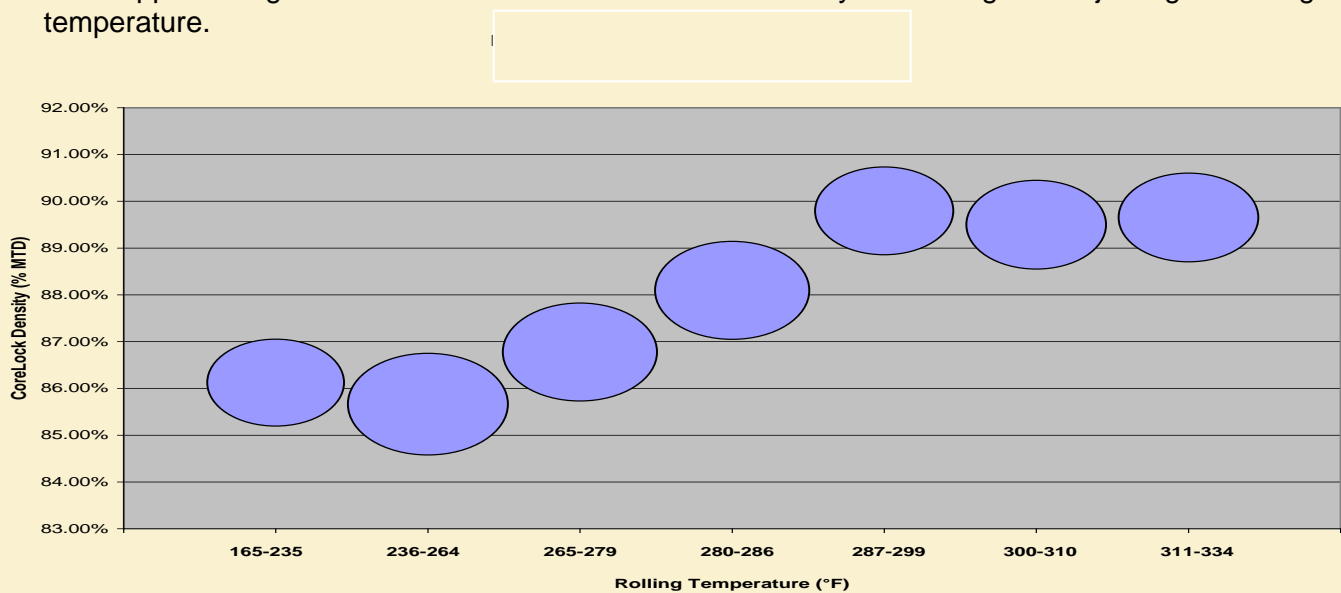
## Pavement, Materials and Geotech

**TEAM:** This group is led by **Clark Graves, P.E.** and includes research engineers: Brad Rister, P.E., Jonathon Fisher, P.E., Kean Ashurst, P.E., and Charlie Sun, P.E., along with technicians Tim Scully, Dan Eaton, Jamie Creech, Tim Jones, and Jared Fairchild. The team was supplemented by Civil Engineering research professors Dr. Sebastian Bryson, P.E. and Dr. Kamyar Mahboub, P.E.

**PROBLEM:** This team carries out forensic evaluations of problems or potential problems during construction, and periodically gauges pavement performance for distress or damages, searching for causes. They also focus on highway culverts, drainage pipes and a variety of geotechnical issues associated with highway design, construction and maintenance.

**SCIENCE/TECHNOLOGY:** This group uses advanced test instruments (nuclear density gages, real-time kinematic GPS, and falling weight deflectometers) and other equipment in unique ways. Devices such as the ground penetrating radar are used to examine roadway sub-surface conditions, and video cameras with lasers and image analysis software to help determine the condition of drainage pipes.

**EXAMPLE:** During the joint asphalt pavement density research with the Asphalt Institute, the team evaluated highway construction projects in Kentucky and Ohio. Research indicated that construction procedures, specifically paving temperature, have significant impact on in-place asphalt density. Laboratory work was completed to quantify the benefits of higher asphalt construction density on fatigue, rutting, and structural performance. For fatigue alone, the results indicate that even a 1% increase in density can achieve a 5% increase in pavement life. Increases in life approaching 25% can be realized in certain situations by monitoring and adjusting the rolling temperature.



Kentucky spends approximately \$70 million dollars annually on resurfacing to maintain roadway surfaces. The improvement in performance of 5 to 25 percent could yield a potential savings of \$ 3.5 -- 17.5 million .



## RESEARCH

### Structures and Coatings

**TEAM:** This unique team is led by **Dr. Issam Harik** and includes a variety of UK graduate and undergraduate students and visiting professors from around the world. The team is supplemented with Center research engineers and technicians as needed.

**PROBLEM:** The highway infrastructure, including its bridges, is aging in Kentucky as well as elsewhere in the U.S. Some of Kentucky's bridges are deteriorating and the cost of replacement is high. New approaches are needed to repair these structures while avoiding traffic delays and high cost.

**SCIENCE/TECHNOLOGY:** This research group has developed an innovative method to repair damaged bridges that uses various high performance carbon fiber materials. The fiber works like wall-paper and can be adhered directly to bridge girders. When applied according to the specific structural engineering requirements, the material has the strength of a steel plate 5 to 6 times as thick, while being very light-weight and manageable. Though the cost for such material is high, it is little compared to the cost of completely replacing a bridge. The team is known internationally for its use of this advanced material in this unique application.



Photos show development and testing of methods of applying carbon fiber in UK labs.

**RESULTS:** The carbon fiber material has been used to strengthen nine bridges in Kentucky. This spring two more bridges will be receiving a carbon fiber face-lift. One of the bridges, located in Louisville, will be the first highway or civil structure in the world to use a new three-directional type of the carbon fiber material. Another bridge close to Georgetown will be the second in the world to incorporate new high modulus carbon laminates. Typically the use of this method of repair can be accomplished with only 5-20% of the funding that would be required to replace the bridge. This application can usually be completed without taking the bridge out of service or requiring work zone traffic management and the results dramatically extend the life of the structure.



## RESEARCH

### Structures and Coatings

**TEAM:** The coatings group is led by **Ted Hopwood, PE** and includes research engineer Sudhir Palle, PE and technician Rick Younce.

**PROBLEM:** Chlorides are deposited on bridges from winter deicing applications. They cause corrosion and premature failures of protective steel coatings. Extremely small amounts of retained chlorides on steel appear to cause significant problems. Normal cleaning procedures used prior to bridge maintenance painting are sometimes ineffective in removing these chlorides. The amounts of retained chlorides that cause problems for new coating applications need to be determined. Some types of coatings may be more resistant to retained chlorides than other ones. This needs to be determined.

**SCIENCE/PROCESS:** Very low known concentrations of chlorides were placed upon steel test panels. The panels were painted with standard bridge coatings and were subsequently subjected to accelerated corrosion testing while their performance was monitored.

**RESULTS:** Some coatings were identified to be more tolerant of retained chlorides.

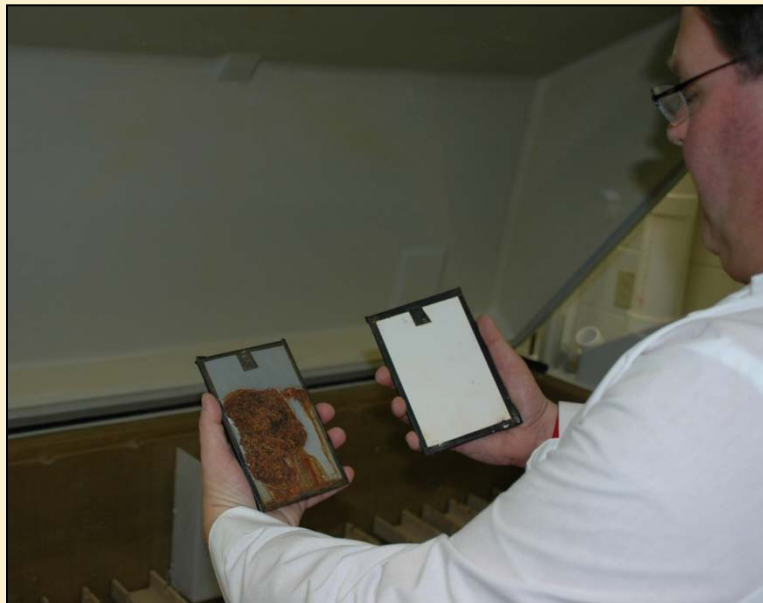


Photo shows technician comparing coating that failed due to chloride contamination with another that performed acceptably.



## RESEARCH

### Planning and Analysis

**TEAM:** The group is led by **Dr. Ted Grossardt** and includes GIS manager John Ripy, public administration researcher Dr. Len O'Connell and Ben Blandford an ABD graduate student. The team is supplemented by Dr. Keiron Bailey an assistant professor of geography at the University of Arizona.

**PROBLEMS/SCIENCE/TECHNOLOGY:** This team is one of the most consistently community involved groups in the Center works with the public to get them more involved with their communities' projects. The group answers planning, policy and research questions ranging from what to do with pieces of old roadways when new roads have been built, to planning ahead for developing projects, to ensuring that fewer problems are encountered, such as disturbing sites that hold artifacts or endangered habitats.

The group applies innovative technology, such as fuzzy set modeling and Geographic Information Systems (GIS) to create topographic preference maps and digital visualization to guide transportation planning and design professionals and inform citizens. The technology and processes developed by this group have been successfully applied to bridge design, transit station location/design and electric transmission line routing.

**EXAMPLE:** Currently the group is teaming with the Kentucky Research Consortium for Energy and the Environment and the College of Communications, both at UK, to assist in the development of a Future Vision for the Paducah Gaseous Diffusion Plant (PGDP), a nuclear fuel enrichment facility in western Kentucky. Researchers are providing the Structured Public Involvement (SPI) protocol for the project, which will allow citizens to see and discuss a wide array of possible future scenarios for the plant, and then provide their opinion about the suitability of each scenario using electronic keypads to register their anonymous opinions.

This protocol has been refined and applied to a wide range of transportation-related planning and design questions over the past 10 years by this group's researchers, and is now being recognized by the US Dept. of Energy for its potential application to other important public sector questions.



More about the PGDP Future Vision project at [www.uky.edu/krcree/project23.html](http://www.uky.edu/krcree/project23.html).

More about SPI at [spi.uky.edu](http://spi.uky.edu).



## TECHNOLOGY TRANSFER

**TEAM:** This group is led by **Patsy Anderson** and includes training manager Martha Horseman, training coordinators Lauren Cosentino, Dina Johnson, and Nicole Worthy, along with editor Mardi Miller and administrative assistant Valerie Pitts. Laura Whyne is the librarian and Victoria Brock is the library technician. The group is supplemented with part-time training coordinators and technical assistance field engineers.

The Technology Transfer Program shares transportation knowledge and puts research and new technologies into practice. These opportunities come through a safety circuit rider program, a transportation library, publications, Roads Scholar and Road Master Programs, and special interest training designed to solve specific problems. Classroom training continues to be the primary method for information transfer.

The Transportation Library holds a variety of technical assistance manuals and guides, and quarterly publications that are valuable resources, especially for roadway workers in remote rural areas. The library is part of the University Libraries Network and has access to worldwide databases. New in 2009 was the development and debut of the Online Video Lending Library, a convenient and free resource.

Environmental preservation issues have come to the forefront not only of national dialogues concerning global warming, recycling, and sustainability, but also within industries at the local and state level. Local and state governments, as well as agencies, are looking to apply new knowledge and practices to create a smarter workforce, build more sustainable infrastructures and above all manage resources and budgets while ensuring the safety of public works employees and the traveling public. The Technology Transfer Program created partnerships and training initiatives during 2009 to highlight certification and training relating to environmental preservation.

### **HIGHLIGHTED PROJECTS: Environmental Preservation Initiatives**

- **Pesticide Certification and Continuing Education Program**

Any person handling, applying or supervising the use of pesticides as part of that person's job must be certified and licensed by the Kentucky Department of Agriculture. Non-commercial pesticide applicators must complete 12 hours of training over a three-year period to remain certified. Our workshops offer four hours of continuing education training.

**Categories 3 & 6 Training and Testing** – Category 6 licensing and certification is required for persons handling, using or supervising the use of pesticides in the maintenance of public roads, electric power lines, pipelines, railway right-of-ways, or similar areas. This is the certification most often required for state and

local government highway workers. Category 3 certification is required for persons handling, using or supervising the use of pesticides or fertilizers for insect, weed, and/or disease control in residential and commercial landscapes and lawns.

**Continuing Education for Categories 3, 6 & 18** – This workshop is for those individuals who are currently licensed and who need continuing education credit in order to keep their applicator’s license.

- **Kentucky Erosion Prevention and Sediment Control (KEPSC)**

**KEPSC Introductory Course** – This course is designed to provide a basic understanding of the KPDES (Kentucky Pollution and Discharge Elimination System) Stormwater Permit requirements for construction sites, familiarity with the principles of erosion and sediment control, and general knowledge in the area.

**KEPSC Inspector Qualification Training and Testing Course** - This course is designed to assist developers, contractors and governmental agencies in complying with the KPDES General Permit for Construction. The course will provide students with the information necessary to properly inspect construction sites and document inspections required by the permit. Qualification will be established through testing at the completion of the course.

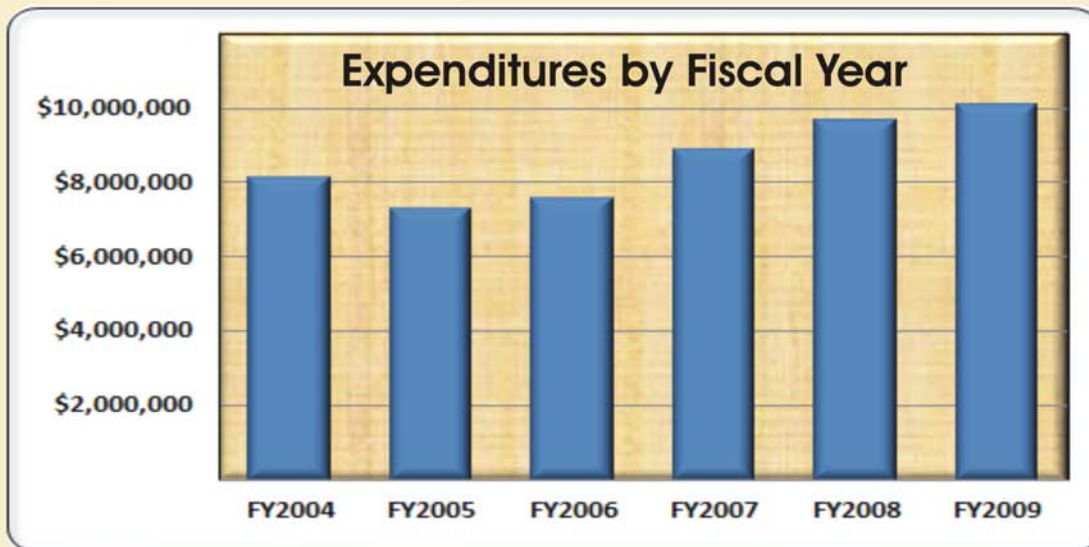
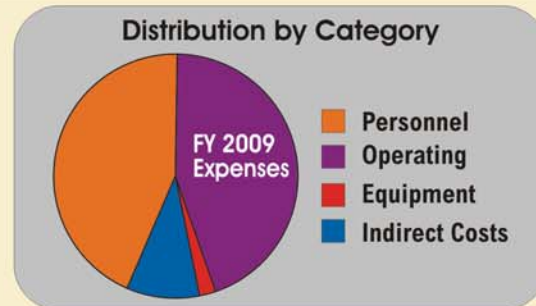
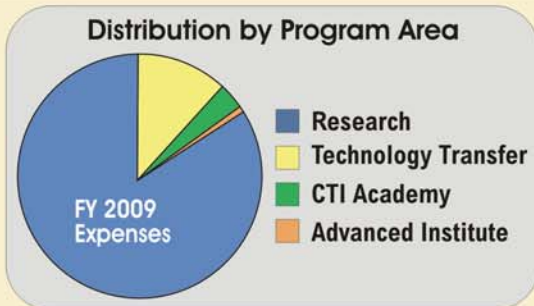
- **Preparation of Construction Site Storm Water Pollution Prevention Plans (SWPPPs)**

The Kentucky Division of Water requires the development and implementation of SWPPPs for all construction sites that disturb one acre of land or more US EPA and the division provides detailed guidance on what the plans should address in terms of site conditions and polluted runoff management practices. This newly developed course is designed to train individuals in the preparation of SWPPPs for construction sites.



# Financial Snapshot (FY 2009 Expenditures\*)

Program Area / Category	Research**	Technology Transfer	CTI Academy	Advanced Institute	Total
Personnel	3,528,484	608,267	177,251	67,634	\$4,381,636
Operating	3,820,781	563,745	108,260	0	\$4,492,786
Equipment	209,433	3,804	0	0	\$213,237
Indirect Costs	913,214	0	59,424	5,300	\$977,938
<b>Total</b>	<b>\$8,471,912</b>	<b>\$1,175,816</b>	<b>\$344,935</b>	<b>\$72,934</b>	<b>\$10,065,597</b>



\*Expenditure detail by subcategory of expense is available on request (1-800-432-0719)

\*\*The research/study program for FY09 consisted of over 100 projects conducted for the following agencies: the Kentucky Transportation Cabinet, Kentucky State Police, USDOT/FHWA, USDOT/FMCSA, NSF, TRB/NCHRP, NORPASS, and various other public jurisdictions. Some work was done in cooperation with other universities including: Northwestern University, University of Louisville, University of Tennessee, and Calspan-University of Buffalo Research Center and also in partnership with firms and organizations such as Michael Baker Inc., HMB Professional Engineers, Wilbur Smith and Associates, and the Asphalt Institute.

Note: The Advanced Institute and CTI Academy funding categories include the Education Program Area. The Advanced Institute funding is from SECUTC (Southeastern Council of University Transportation Centers) of which the University of Kentucky is a member. The funding received is for operating a Transportation Systems Management Graduate Certificate Program. The CTI (Community Transportation Innovation) Academy is both an education and research program that has been funded periodically by the USDOT/FHWA as a result of directed Congressional appropriation to the University of Kentucky (and the University of Louisville).

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