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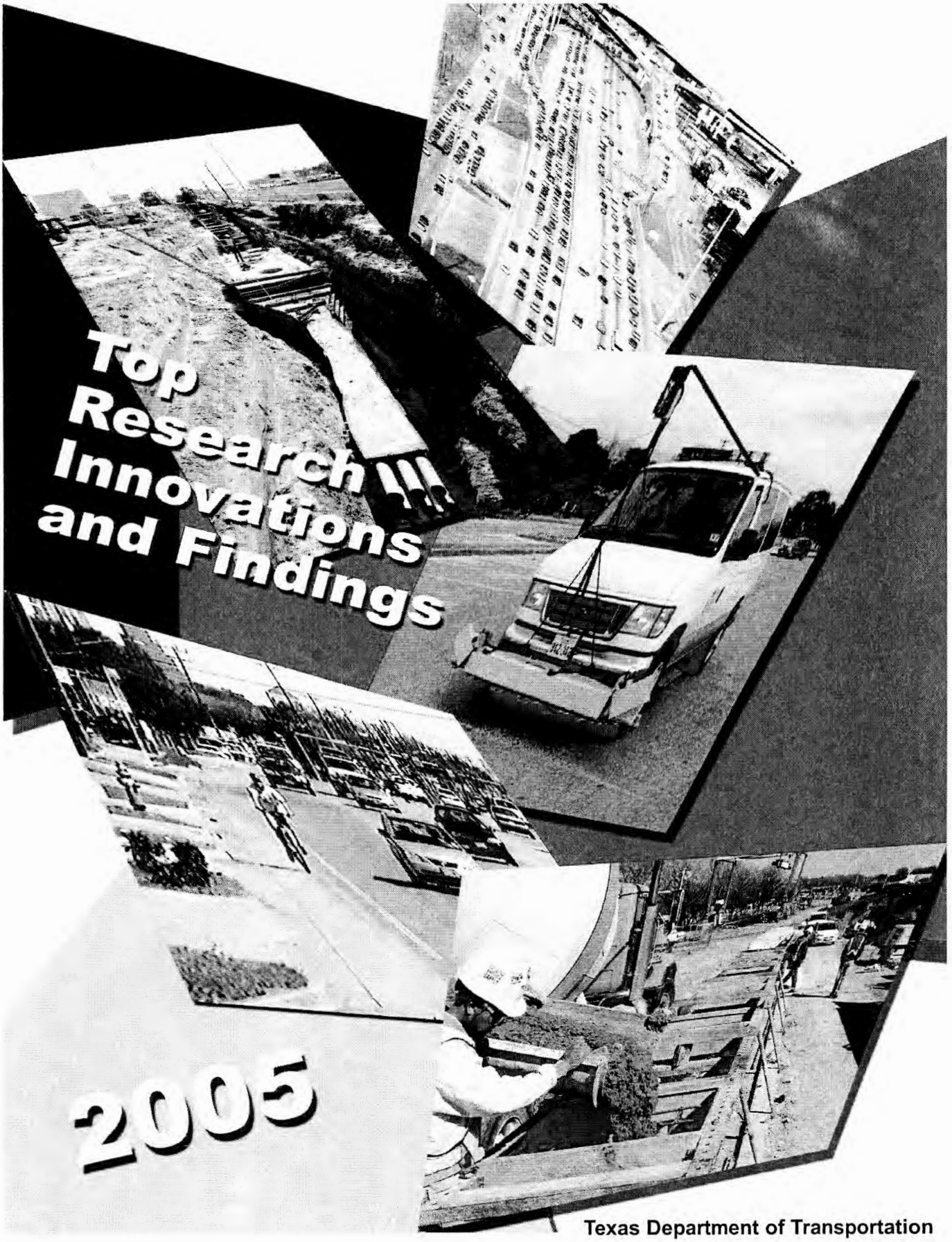


Texas Department of Transportation

About the Top Research Innovations and Findings

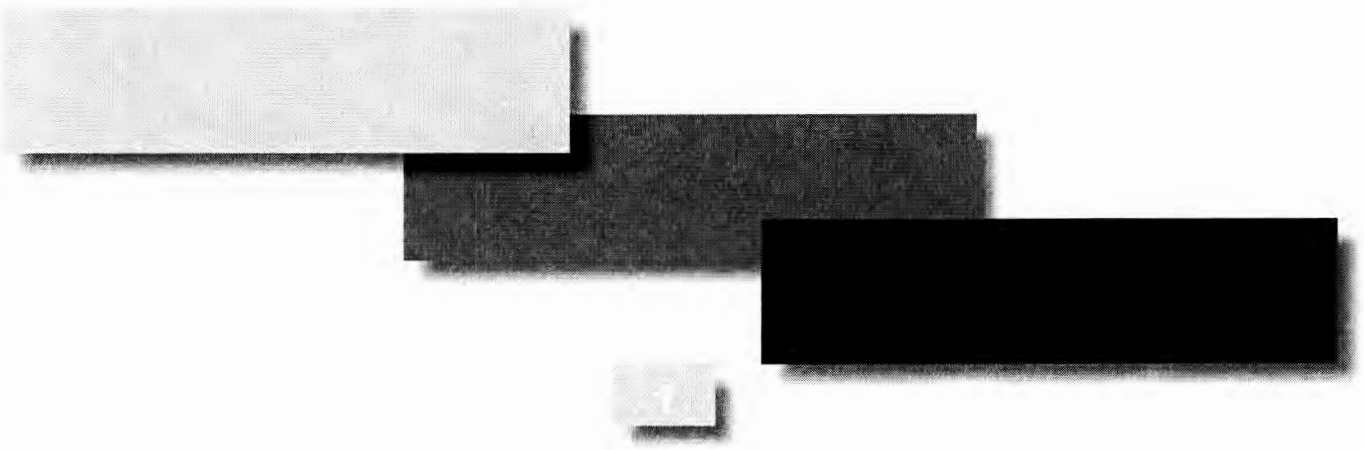
Each year, the Texas Department of Transportation (TxDOT) selects Top Research Innovations and Findings for the past year. They are selected based on anticipated or already realized dividends to the department and the state. These dividends may be in terms of lives saved, more efficient operations, improved services, and/or fiscal savings.

Selecting top innovations and findings allows us to identify, thank, and congratulate the university researchers who were responsible for these noteworthy achievements. We also recognize our TxDOT project directors and advisors who provided support and direction to these researchers. Identifying top research products has the added value of providing momentum to the implementation of these findings.

Products from the research program include devices, machines, tools, materials, manuals, and software, while others are less tangible concepts, knowledge, or advice. These products affect virtually every area of TxDOT operations. Emphasis areas for research include construction, maintenance, pavements, structures, materials, geometric design, hydraulics, right-of-way, environmental considerations, transportation planning, and traffic operations.

On the facing page is a listing of TxDOT's Top Research Innovations and Findings for 2005. They are showcased individually on the pages that follow. On page 15 is a listing of Top Research Innovations and Findings for the past three years.

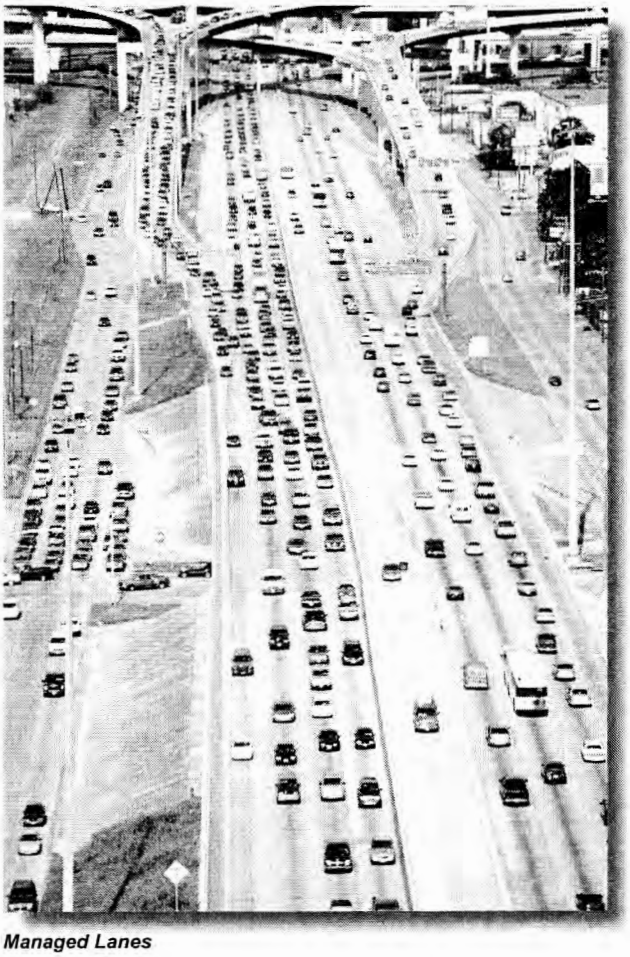
Top Research Innovations and Findings, 2005



Toolkit for Operating Freeways with Managed Lanes

Project - 0-4160:
Operating Freeways with Managed Lanes

The increasing population growth in Texas has placed enormous demands on the transportation infrastructure, particularly the freeway systems. There is a growing realization that the construction of sufficient freeway lane capacity to provide free-flow conditions during peak travel periods cannot be accomplished in developed urban areas due to cost, land consumption, neighborhood impacts, environmental concerns, and other factors. Like other transportation agencies nationwide, the Texas Department of Transportation (TxDOT) is searching for methods to better manage traffic flow and thus improve the efficiency of existing and proposed networks. A viable method for meeting mobility needs is the concept of "managed" lanes, which is growing in popularity among users and agencies alike. TxDOT anticipates that the managed lanes operational approach can offer peak-period free-flow travel to certain user groups by using strategies that manage demand in the lanes.



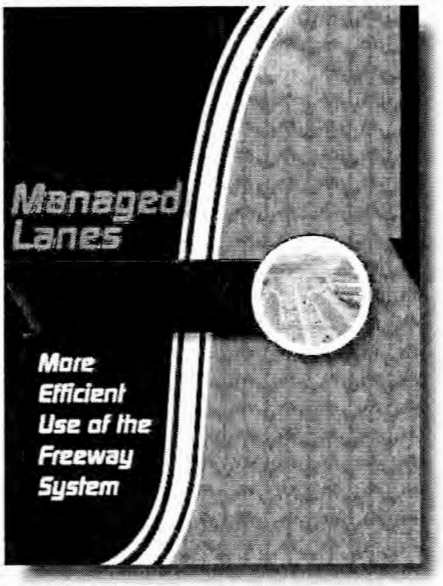
Managed Lanes

The goal of project 0-4160 was to research the complexities of designing a practical, flexible, safe, and efficient facility that may have multiple operating strategies throughout the course of a day, week, year, or beyond, to help ensure the successful implementation of managed lanes in Texas. The broad scope and long duration of this project allowed the research team to investigate the complex issues of managed lanes in a comprehensive manner. As tasks were completed, the researchers provided results to TxDOT to help ensure the timely implementation of findings into current projects. Furthermore the researchers shared those results with the transportation community through an internet site and electronic newsletter. Material is available on the internet at http://managed-lanes.tamu.edu. The products include technical papers, abstracts, journal and magazine articles, reports, bulletins, brochures, newsletters, technical memoranda, presentations, and a handbook and screening tool for managed lanes strategy selection.

Benefits

General benefits to TxDOT:

- The *Managed Lanes Handbook*, which compiles the research results into one easy-to-use resource and provides a clear and concise approach to planning, designing, operating, and enforcing managed lanes, and refers the user to other pertinent documents that provide additional information on various aspects of managed lanes.
- A user-friendly preliminary screening tool to assist TxDOT in identifying managed lane strategy options very early in the conceptual planning process.
- Ready and easy access to research results and products via the project website http://managed-lanes.tamu.edu.
- Two position papers on managed lanes intended to provide TxDOT's statewide perspective on managed lanes, tailored to the media and policy makers.
- Legislation needs on various managed lanes issues, including defining and allowing exclusive lanes and lane restrictions, which influenced the passage of new legislation in Texas.



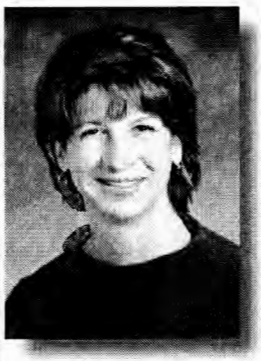
Managed Lanes Brochure

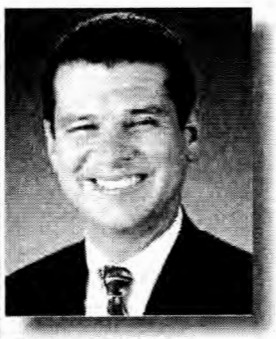
Specific benefits to TxDOT:

- Time savings to TxDOT in developing more than a dozen currently planned managed lanes projects by providing a screening tool and a single go-to document for project development guidance.
- Cost-savings to TxDOT by having outreach documents readily available for use in public meetings related to managed lanes projects.

In addition, there is an effort underway to move forward with an implementation project to develop a module-based workshop to provide TxDOT staff with training on the managed lanes handbook and to share the research results in an interactive forum.


Research Supervisor:
Beverly T. Kuhn, TTI


Assistant Research Supervisor:
Ginger Daniels Goodin, TTI


Project Director:
Carlos A. Lopez, TRF

Program Coordinator:
Gary K. Trietsch, HOU

Project Advisors:
Maribel P. Chavez, FTW
Mary M. Owen, TYL
James Randall, TPP
Amadeo Saenz, Jr., ADM
Richard Skopik, WAC

For more information please contact:
Wade Odell, RTI, 512-302-2363
Beverly T. Kuhn, TTI, 979-862-3558
Carlos A. Lopez, TRF, 512-416-3200

2005 Top Research Innovations And Findings

Project - 0-4958:
Development of an Artificial Lighting System to Enhance the Automated Pavement Distress Measurement System

Artificial Lighting for TxDOT's Automated Pavement Crack Rating System

Light bar installed on front bumpers

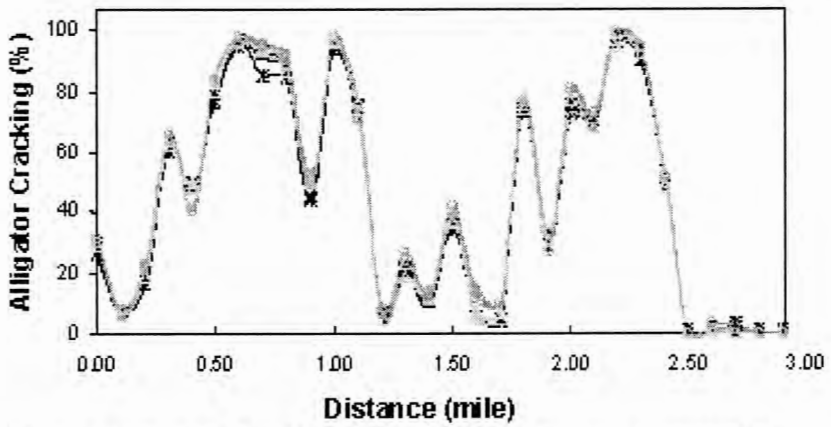
The artificial lighting system called a light bar is a specially designed lighting device for the automated pavement distress measurement system (VCrack) developed in a previous TxDOT project. The basic function of this device is to provide intense, uniform, and linear illumination for the VCrack's line-scan camera and help it provide high quality pavement images under any exterior lighting conditions. It consists of three major units: one six-foot long central unit and two one-foot long wing units. Each unit utilizes three rows of red LED's, a cylindrical lens and two mirrors, forming a one-inch wide beam at a distance of sixteen inches. The energy consumption of the light bar is <250 watts, eliminating the need for a special generator. Along with a matching band pass filter, the light bar enables the camera to avoid the variations of the ambient light. The lighting intensity is sufficient for nighttime surveys. The light bar has been merged with the existing rut bar that is installed on the front bumper, and its wing assemblies will break away should they collide with a foreign object. The light bar is eye-safe, durable, and easy to maintain.

Benefits

Benefits

The light bar provides a consistent lighting condition to the camera so the VCrack system can:

- Minimize the effects of change in cloudiness, vehicle driving direction, survey time, etc.
- Eliminate shadows of vehicles and roadside objects.
- Detect alligator cracks on dark pavements more reliably.
- Enable the vehicle to maintain more constant speeds.
- Reduce adjustments of camera scanning rates needed to accommodate changes in pavement condition.
- Perform nighttime surveys.



Alligator cracking data of an FM pavement in six repeated surveys conducted from morning to midnight

Ultimately, the light bar greatly improves the repeatability and accuracy of the measurement data. The chart above shows the alligator cracking data of an FM pavement in six repeated surveys conducted from morning to midnight. A project-level test proved that the use of the light bar can increase the correlations of the cracking data of multiple runs from under 0.8 to above 0.9. The light bar enables TxDOT to collect time-independent and weather-invariant cracking data.

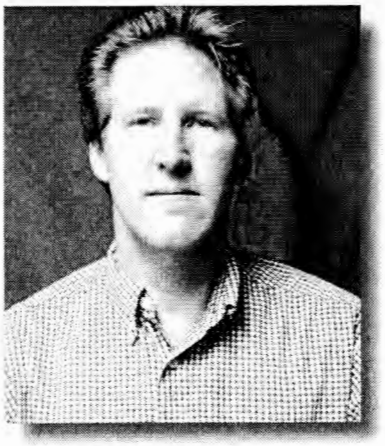
The economic benefit of this innovation can be calculated by assuming the new device will optimize routine and preventive maintenance, which totals $630 million per year. Assuming that TxDOT will save only 0.1% of routine and preventive maintenance cost, the savings will be about $600,000 a year.

Program Coordinator:
Mike Murphy, CST

Project Advisor:
Brian Michalk, CST

Researchers:
Yaxiong Huang, CTR
Yuequi Zhong, CTR

For more information please contact:
German Claros, RTI, 512-467-3881
Bugao Xu, CTR, 512-472-7226
Todd Copenhaver, CST, 512-465-3065



Project Director:
Todd Copenhaver, CST

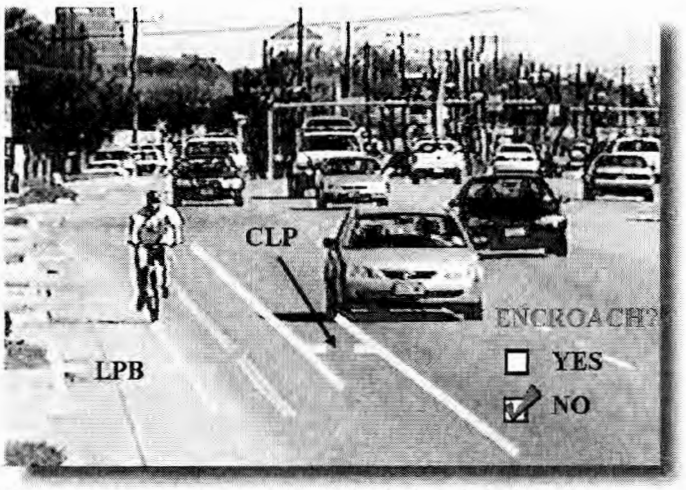
Research Supervisor:
Bugao Xu, CTR

2005 Top Research Innovations And Findings

Project - 0-5157:
Operational and Safety Impacts When Retrofitting Bicycle Lanes

Model for Predicting Operational and Safety Impacts When Retrofitting Bicycle Lanes

Many metropolitan areas consider adding bicycle facilities to their roadways without changing the curb-to-curb width – a process referred to as a "retrofit." AASHTO's *Guide for the Development of Bicycle Facilities* provides a range of design options potentially applicable to these retrofits, however, AASHTO does not provide evidence of the consequences for cyclists or motorists when choosing one option over another. Project 0-5157: Operational and Safety Impacts When Retrofitting Bicycle Lanes sought to remedy this deficiency with research, extensive field work and the creation of a quantitative Excel spreadsheet (created utilizing 8,000 observations of cyclists and motorists sharing Texas roadways).

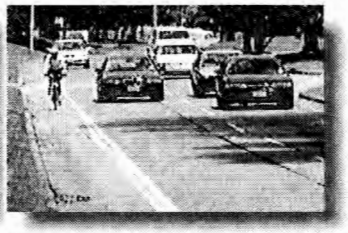


Observations taken from the field video included: the lateral position of the bicyclist (LPB) relative to the curb, the change in lateral position of the motorist (CLP) in the course of passing the cyclist, and whether or not the motorist encroached (ENCROACH?) into the adjacent motor vehicle lane.

The observations mentioned above came from 31 paid cyclists – men and women between the ages of 18 and 54 with varying levels of experience – riding at 24 test sites in Austin, Houston, and San Antonio. The University of Texas Center for Transportation Research (CTR) team worked extensively with the Texas Department of Transportation's project monitoring committee to select appropriate retrofit bikeways for testing. At each test site, two video cameras were placed, in opposing directions, to capture the actions and reactions of cyclist and motorists. To get "average" cyclists, CTR advertised in local newspapers (including school and university newsletters) and hired two cyclists for each day of testing. The cyclists rode in a loop for 30 minutes at each test site. The cameras were able to capture the behaviors of both motorists and cyclists in various scenarios. Observations included motorist's position within the roadway when there is not a cyclist present, and how motorist behavior changes when a cyclist is present. The behaviors of cyclists also changed when a motorist was present.

CTR used these observations to build a model to predict the lateral positions of both cyclist and motorist when sharing a roadway. The model is user friendly and requires only basic, easily obtainable roadway and traffic data to produce results effectively. One clear conclusion from the research was that designated bicycle lanes with appropriate roadway striping and signage operate much better than wide outside lanes for both cyclists and motorists, when the same amount of space is available (see photographs on opposite page). Cyclists felt more comfortable riding in the designated bike lanes, with a larger buffer between their tires and the roadway's curb, while motorists driving beside a designated bike lane with a cyclist present swerved less into the adjacent motor lane resulting in a substantial reduction in the degree and number of times motorists encroached into the adjacent motor lane.

Benefits



Left to right: Typical cyclist and motorist lateral position on a wide outside lane (14ft wide outside lane) and typical cyclist and motorist lateral position on a roadway with a bicycle lane (10ft motor vehicle lane and 4ft bike lane)

The predictive model now exists as an easy-to-use Microsoft Excel spreadsheet that allows the user to input basic roadway and traffic variables and generate modeled expectations of a motorist and cyclist's lateral position, the quantitative amount a motorist will swerve when passing a cyclist and the probability the motorist will encroach into the adjacent motor vehicle lane. The most important measures used to create the Excel WorkBook/Model were developed from the analysis of widespread field observations. The Excel spreadsheet also uses the same inputs to produce a Bicycle Compatibility Index value – a measure developed for the Federal Highway Administration (FHWA) in 1998 to evaluate the desirability of travel along a roadway from the cyclist's perspective. A manual accompanying the Excel spreadsheet provides illustrated instructions for use, interpretation of results, an example application, and basic design considerations for both planned and retrofit roadway proposals. Together, these measures provide valuable information to designers, planners, and engineers considering on-street bicycle facilities.

(Pictured Left to Right)
Project Advisors:
Ken Zigrang, SAT
Charles Gaskin, HOU
Teri Kaplan, HOU
Paul Douglas, TPP
Jenny Peterman, AUS
Project Director:
Carol Nixon, HOU
Program Coordinator:
Maria Burke, DES
Project Advisor:
Paul Moon, PTN

(Pictured Left to right)
Research Supervisor:
Randy Machemehl, CTR
Research Assistant:
Ian Hallett, CTR
Researcher:
David Luskin, CTR

(Not Pictured)
Project Advisor: Mark Farris, DAL
Researcher: Khali Persad, CTR

Benefits

The New Excel WorkBook and Bikeway Guide will:

- Supplement AASHTO's Guide for the Development of Bicycle Facilities.
- Provide a user friendly design tool for evaluating both retrofit and planned on-street bikeways.
- Assist planners and engineers when considering on-street bikeway options in the design process.
- Provide a logical instrument for use in developing comprehensive bikeway plans.
- Aid in educating planners and engineers about on-street bikeways

For more information please contact:
Duncan Stewart, RTI, 512-465-7648
Randy Machemehl, CTR, 512-471-4541
Carol Nixon, HOU, 713-802-5301

Project - 0-4563:
Prediction Model for Concrete Behavior

ConcreteWorks

ConcreteWorks is a suite of Windows®-based concrete technology programs intended to be used by engineers, inspectors, contractors, pre-casters, suppliers and researchers. ConcreteWorks is being developed under research project 0-4563 "Prediction Model for Concrete Behavior". The purpose of the software is to improve the constructability and durability of concrete. The original project objective was to develop a tool for analyzing heat generation of mass concrete placements only. However, it quickly became apparent that the research team was capable of developing a much more versatile tool, that could be applied to virtually any volume of concrete to be placed, and that would be useful in predicting parameters beyond heat generation.

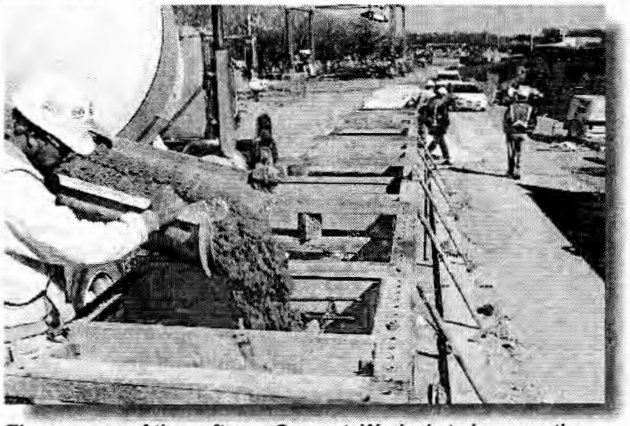
ConcreteWorks is a versatile, free, and user-friendly application written in Visual Basic that performs an array of tasks associated with proper design of concrete mixes. The current version includes the following capabilities:

- Mixture proportioning in accordance with ACI 211 (1991) procedures and National Highway Institute (NHI) Course 15123 (Hover, 2003).
- Prediction of maximum temperature and temperature gradient for a specific mix in a concrete element of user-defined geometry and exposure conditions.
- Determination of the susceptibility of a given mix to Alkali Silica Reactivity (ASR).
- Determination of the susceptibility of a given mix to Delayed Ettringite Formation (DEF).

The research that went into developing ConcreteWorks is impressive. Semi-adiabatic calorimetry was used to develop the database of concrete hydration curves. Rigid cracking frame testing on highly specialized machines from Germany was conducted to characterize creep, thermal, and autogenous shrinkage of various mixtures. Field work for calibration purposes was carried out by instrumenting real-world concrete pours to compare actual versus predicted temperature profiles.

An updated version of ConcreteWorks with expanded capabilities is under development at this time. These expanded capabilities will include:

- Incorporation of standard TxDOT prestressed concrete beam shapes.
- Concrete pavement mixture design.
- Concrete cracking susceptibility.
- Time-to-corrosion predictions.
- Rapid Chloride Penetration Test (RCPT) value predictions.



The purpose of the software ConcreteWorks is to improve the constructability and durability of concrete

Benefits

An output screen from ConcreteWorks, graphically representing the temperature distribution within a rectangular column.

Benefits

The benefits which will be realized using ConcreteWorks are potentially huge. Durability of new concrete placed throughout the state will be improved through proper mixture proportioning and design, avoidance of ASR and DEF problems, and reduction in cracking due to thermal stresses.

Engineers will have one suite of programs to perform mixture design and analysis of structural concrete as well as concrete pavement. Engineers, contractors, fabricators and producers will have the ability to easily perform "what-if" scenarios for specific concrete elements, tweaking mix designs and placement operations for maximum economy while producing quality concrete in compliance with required specifications.

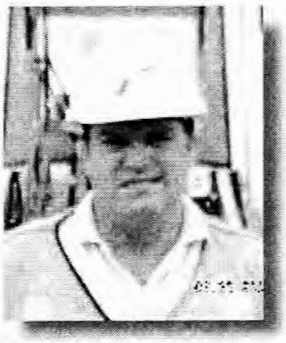
ConcreteWorks is currently being implemented on a trial basis in the Fort Worth District. The El Paso and Wichita Falls Districts are also expected to implement ConcreteWorks on a trial basis while the second-generation version with expanded capabilities is under development. Ultimately, ConcreteWorks will be available for free download to anyone from the TxDOT internet website.

ConcreteWorks is generating considerable interest across the country. References to it may already be found in the ACI publication *Concrete International*, and it is reported that CalTrans and the Kansas DOT are already using the program as well.

Project Advisors:
Doug Beer, WFS
Charles Gaskin, HOU
David Head, ELP
Lisa Lukefahr, CST
Brian Merrill, BRG
Jennifer Moore, CST

Researchers:
David Fowler, CTR
Loukas Kallivokas, CTR
David Whitney, CTR

For more information please contact:
Tom Yarbrough, RTI, 512-465-7685
Kevin Folliard, CTR, 512-232-3591
Ralph Browne, FTW, 817-399-4301



Project Director:
Ralph Browne, FTW

Program Coordinator:
J.C. Liu, HOU

(Pictured left to right)
Researcher: Maria Juenger, CTR
Research Supervisor: Kevin Folliard, CTR
Researchers: Kyle Riding, CTR
Jonathon Poole, CTR
Anton Schindler, Auburn University

2005 Top Research Innovations And Findings

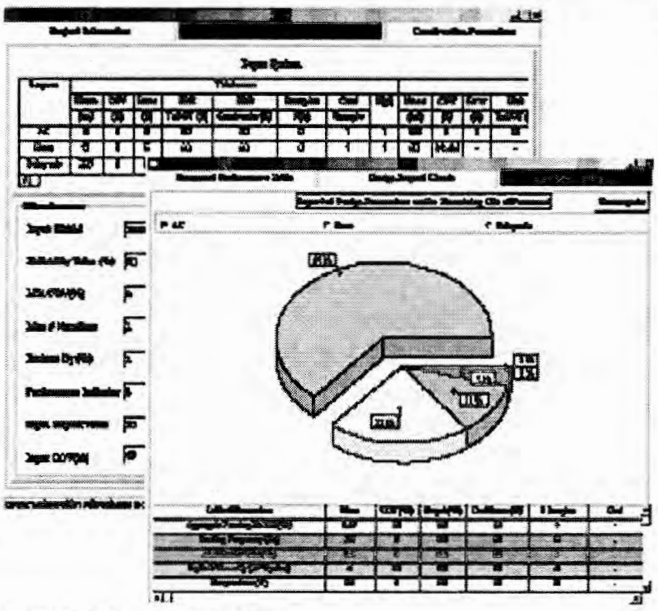
Project - 0-4046:
The Impacts of Construction Quality on the Life-Cycle Performance of Pavements Using Mechanistic Analysis

RECIPPE: A Software Tool for Maximizing Effectiveness of Inspection during Planning and Construction of Flexible Pavements

The goal in any highway construction project is to produce a durable pavement that will perform satisfactorily throughout its expected design life. Even though a well-calibrated design algorithm is necessary to accurately predict the life-cycle performance, the quality of construction also plays a significant role. In that context, quality of construction is defined as meeting a structural-related target variable with minimal variance.

Current quality assurance programs are geared towards ensuring the durability of the final product. However, the laboratory tests that are necessary to ensure this durability are experienced-based. Also, material selection and construction techniques are fine-tuned by trial and error methods. In other words, the concept of constructing pavements that perform satisfactorily throughout their design life is often discussed, but to date, it has only been implemented on a limited level and, for the most part, in a primitive fashion.

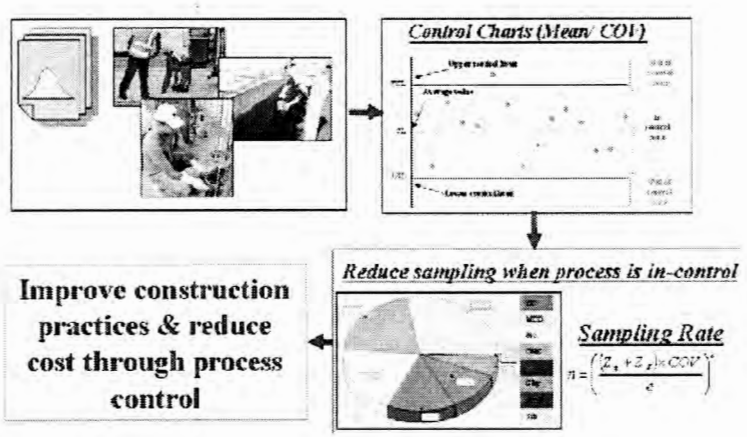
Under research project 0-4046, a software package called Rational Estimation of Construction Impact on Pavement Performance (RECIPPE) was developed to reconcile the results from pavement-performance models used in the state of practice, or those widely accepted by state agencies, with statistical process control techniques and uncertainty analysis methods, to determine project-specific parameters that should be used in construction quality management. The major advantage of RECIPPE is that the mechanistic procedure developed in the program is completely modular. This allows for new material and performance models to be input and/or calibrated as needed. The benefit of the software is to maximize effectiveness of inspection and testing resources during construction.



RECIPPE Software Interface

RECIPPE is separated into two phases: planning and construction. In the planning phase, the optimization process is carried out to identify the parameters that impact the life of pavement the most, and to concentrate the efforts of the inspectors during the quality control process on those parameters. In the construction phase, the identified significant parameters are used to determine a set of sampling frequencies for inspectors to use in control charts to insure quality during the construction process.

Benefits



Process to improve construction and maximize resources

The new layer-by-layer, mechanistic-based quality management procedures and tools packaged in RECIPPE are currently being implemented on a limited basis. The hope is that ultimately this software would be a catalyst to develop new quality management procedures that may potentially lead to development of performance-based specifications.

Benefits

RECIPPE has several benefits. During the planning stages, the software will highlight which layers in the pavement are contributing the most to the performance of the pavement. Furthermore, the program will demonstrate which aspect of processing and construction of a certain layer, from batching process to finish rolling, will most impact the quality of that layer. In that manner, the frequency of quality control can be optimized for any given construction activity, as opposed to arbitrarily following a pre-determined guide schedule as currently done.

During the construction process, the control charts embedded in the software can be used to reduce the sampling program for parameters that are consistently close to their target values, while increasing inspection efforts on activities that are out of the boundaries of the control chart.

The potential financial benefits of this project are great due to the fact that the construction budget at TxDOT is about 5 billion dollars a year. Improving quality could lead to substantial savings.

Research Supervisor:
Soheil Nazarian, UTEP

Project Director:
Stephen Smith, ODA

Program Coordinator:
David Head, ELP

Project Advisors:
Lisa Lukefahr, CST
Tomas Saenz, ELP

Researchers:
Imad Abdallah, UTEP
Carlos Ferregut, UTEP
Deren Yuan, UTEP

Graduate Research Assistant:
Brett Haggerty, CST

For more information please contact:
German Claros, RTI, 512-467-3881
Soheil Nazarian, UTEP, 915-747-6911
Stephen Smith, ODA, 432-498-4716

RUDI – Right of Way and Utility Adjustment Duration Information System

Project - 0-4617:
Identify Delays in the ROW and Utility Relocation Processes Affecting Construction and Develop Methods for Expediting the Processes

When planning and programming a transportation project for delivery to the traveling public, districts have historically relied on little more than the experience of their Right-of-Way (R/W) staff to establish the durations of right-of-way acquisition and utility adjustment processes, and subsequently, the timing of project letting. This lack of an established methodology exposes the department to risk relating to economics and negative public opinion.

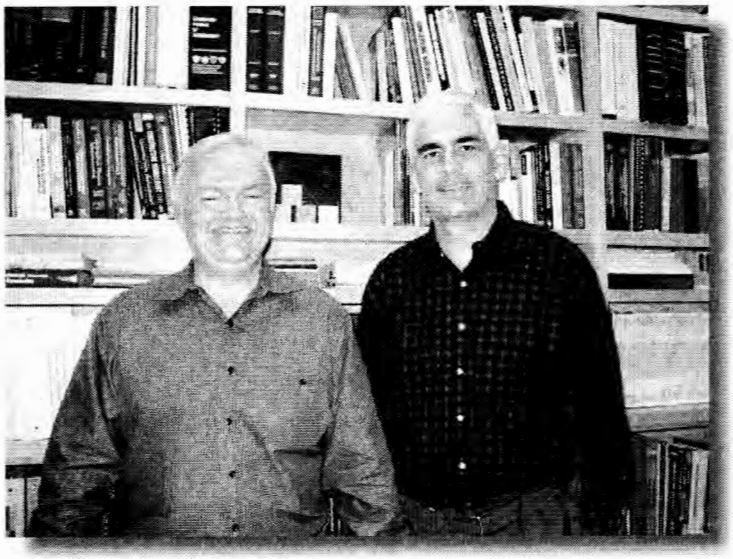
Research project 0-4617 has developed tools for improving TxDOT's ability to forecast the date of right-of-way and utility adjustment clearance. The "Right of Way and Utility Adjustment Duration Information" system (RUDI), combined with the "Stratified and Integrated R/W and Utility Adjustment Process Flow Map," provides a decision-making instrument for enhanced project development and delivery.

Benefits

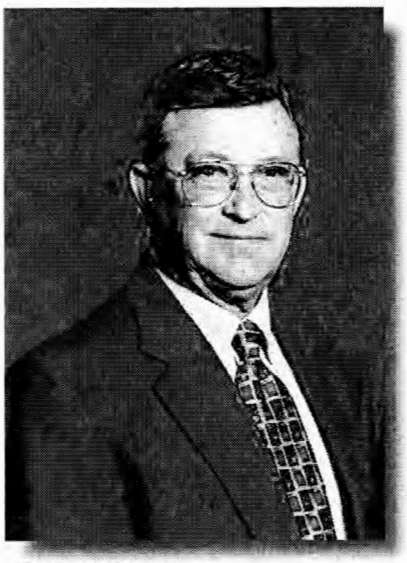
Benefits

Reducing the time from planning to construction of a project can ensure that the benefits of the project are available sooner to the traveling public. This will, in turn, greatly facilitate public commerce and reduce adverse traffic problems and their associated costs. The tools developed under research project 0-4617 significantly enhance TxDOT's capabilities for predicting the duration of these processes, and are of high value to TxDOT in better planning for project letting and ultimately accelerating overall project completion.

An implementation project is currently underway which will provide RUDI system training to personnel from several selected TxDOT districts. Once the initial round of training is complete, enhancements will be made as warranted and then statewide implementation will proceed.



(Pictured Left to Right)
Research Supervisor: Edward Gibson, CTR,
Researcher: James O'Connor, CTR



Project Director:
Larry Black, AMA

Reseachers:
Nabeel Khwaja, CTR
Khali Persad, CTR

Program Coordinator:
John Campbell, ROW

Project Advisors:
Terri Evans, ROW
Tommy Jones, ABL
Pat Moon, ROW
Dean Wilkerson, ISD

For more information please contact:
Tom Yarbrough, RTI, 512-465-7685
Edward Gibson, CTR, 512-471-4522
Larry Black, AMA, 806-356-3380

About the Research and Implementation Programs

TxDOT's Research Program was established by commission minute order on September 29, 1948. That directive provided a research program between the Agricultural and Mechanical College of Texas and the Texas Highway Department. The program has grown over the years to include numerous other Texas public universities. It has also grown in size, reputation, and value to the department. It is widely recognized as a model program among research and transportation professionals across the country.

A key to the success of this program is that it draws upon the expertise of department personnel from across the state. Five statewide research management committees, each assigned a specific technical or operational area of responsibility, create and give direction to annual programs of research designed to reach identified goals and provide specific benefits. Input concerning research needs and opportunities is received from TxDOT personnel and representatives of each participating university.

Individual research projects are also cooperative efforts between universities and the department. While university researchers perform the vast majority of the research work, every project has a department project director who provides support and assistance to the researcher. The project director also monitors work progress and reviews and approves research findings and reports. The project director is usually assisted by other department personnel serving in project advisor roles.

Department research is funded primarily from a federal source titled the State Planning and Research (SPR) program. These federal funds are dedicated to research and planning functions. The program requires one dollar in state contribution for every four dollars of federal funding used by the state (20% match).

The department formalized an Implementation Program in 1999. The purpose of this program is to assure that all research findings are carefully analyzed, that findings and innovations of value are identified, and that these research results are properly implemented into TxDOT's operations. More than 60 percent of findings are ultimately implemented, which is a considerable portion considering the exploratory nature and uncertainty of research. Annual return on investment from the research program is difficult to accurately determine, but it is many times the total cost of the program. In an evaluation of the top innovations from 1999-2001, it was demonstrated that the cost savings derived from 21 products exceeded the cost of the research program by approximately $268 million.

Overall management of both the research program and the implementation program is the responsibility of the Research and Technology Implementation Office. Questions related to either program may be directed to personnel of this office at 512-465-7403.

Top Research Innovations and Findings, 2004

- Lateral Bracing of Bridge Girders by Permanent Metal Deck Forms
- Texas Congestion Index
- Evaluation of Edge-line and Centerline Rumble Strips
- Urban Intersection Design Guidance
- Thermal Segregation Detection System
- Development of Low Frequency Radar to Measure the Thickness of Steel Reinforced Concrete Pavements
- New Overlay Testing System

Top Research Innovations and Findings, 2003

- Advanced Warning for End-of-Green System
- Guidelines for TxDOT - Regional Tollway Authority Coordination and Cooperation
- Smart Growth Texas Style Primer
- Thermochron and Hygrochron Button Innovations
- Long Term Durability for Post-Tensioned Substructures
- Climatic Adjustment of NRCS Curve Numbers
- Automatic Pavement Surface Distress Rating System for Asphaltic and Concrete Pavements
- Improving Edge Repair and Stabilization

Top Research Innovations and Findings, 2002

- New Detection System for Rural Signalized Intersections
- Scanning Laser Used for Transverse Profile Measurement
- Inventory and Data Management Methods for Utilities in Rights-of-Way
- Guidebook for Inland Ports
- Access Management Guidebook for Texas
- New Test Procedure to Measure Sulfate Content of Soils
- Safety Treatment Guidance for High Crash Locations on Rural Two-Lane Highways

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080

Telephone: 512-465-7403
Fax: 512-465-7486