TxDOT Top Research Innovations and Findings 2001

Texas Department of Transportation

About the Top Research Innovations and Findings

Each fall, 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 saved lives, 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 pavements, structures, materials, geometric design, hydraulics, right-of-way, environmental considerations, transportation planning, traffic operations, and policy.

On the facing page is a listing of TxDOT's Top Research Innovations and Findings for this year. They are showcased individually on the pages that follow.

On the inside back cover is a listing of Top Research Innovations and Findings for 1999 and 2000.

TOP RESEARCH INNOVATIONS AND FINDINGS, 2001

MICRO-DEVAL TEST EQUIPMENT

Project 0-1771:
Comparative Analysis of the Micro-Deval and Magnesium Sulfate Soundness Tests

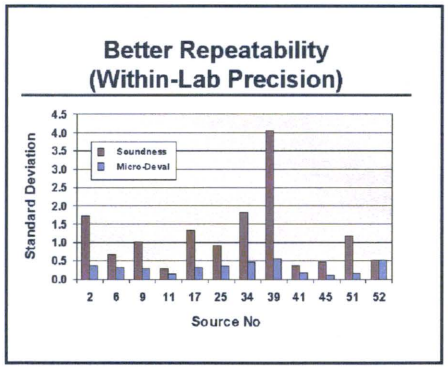
Project 5-1771:
Implementation of the Micro-Deval Equipment and Test

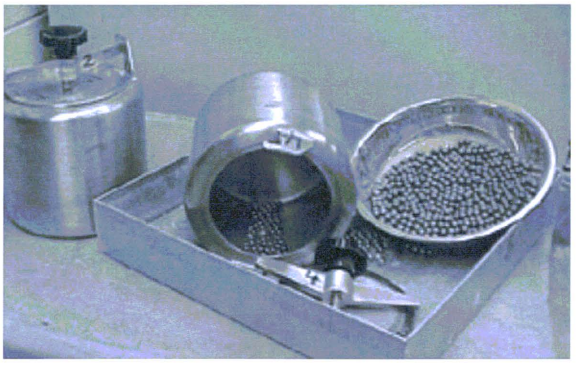
Research conducted at Texas Tech University Center for Multidisciplinary Research in Transportation (TechMRT)

The Micro-Deval (MD) test is an alternative test method to the five-cycle Magnesium Sulfate Soundness (MSS) Test for the evaluation of bituminous aggregates that is available for the evaluation of aggregate durability.

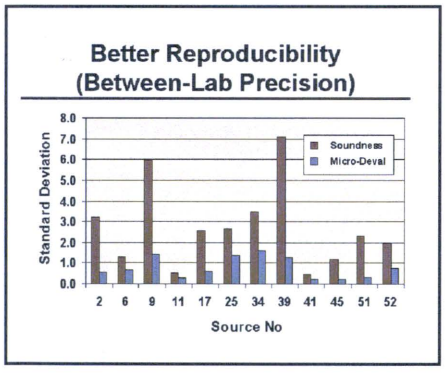
Process

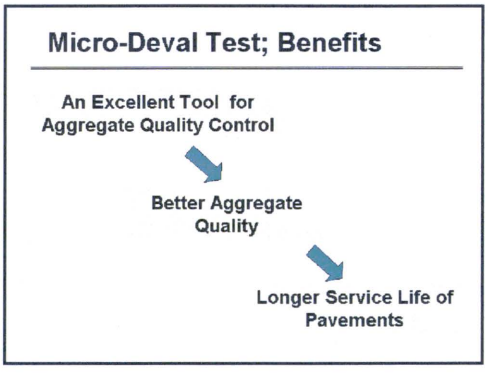
In this test method, a 1500 g sample of coarse aggregate is immersed in water for one hour and then placed in a steel drum with 2.0 liters of water and an abrasive charge consisting of 5000 g of 9.5 mm diameter steel balls. The jar, aggregate, water, and charge are then rotated at 100 rpm for two hours (12,000 revolutions). At the end of two hours the aggregate is oven dried and the percent passing 1.18 mm is determined and reported as the Micro-Deval loss (%).





Steel jar and charge used in Micro-Deval test





BENEFITS

- The Micro-Deval test requires only one day to complete, compared to six days needed to complete the Mg Sulfate Soundness (MSS) Test.
- It provides good repeatability. It has one-fourth of the variability compared to the Soundness Test.
- It is simple and similar to the Wet-Ball Mill Test. It is also less sensitive to test conditions and operator experience.
- It can be used as a job-control test to verify that an aggregate stockpile is consistent with the source rating.
- It can be used to supplement MSS test data and allows more frequent testing of aggregate sources with high variability and/or high production rates. It can be used as an additional requirement for special, high-performance mix designs.

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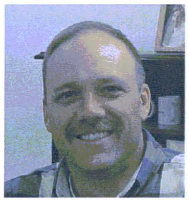

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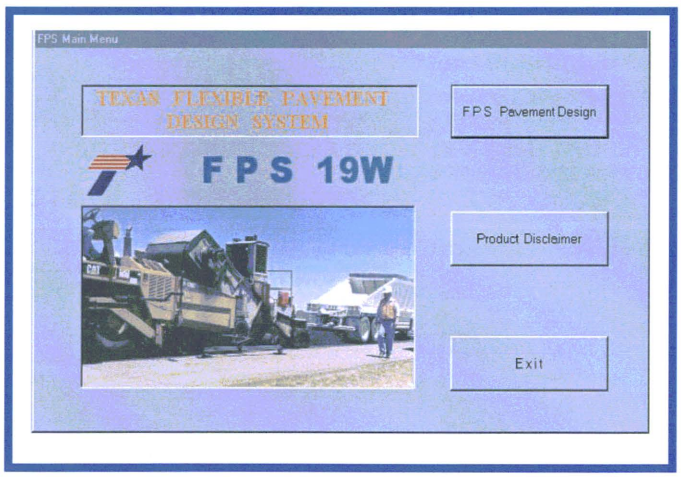
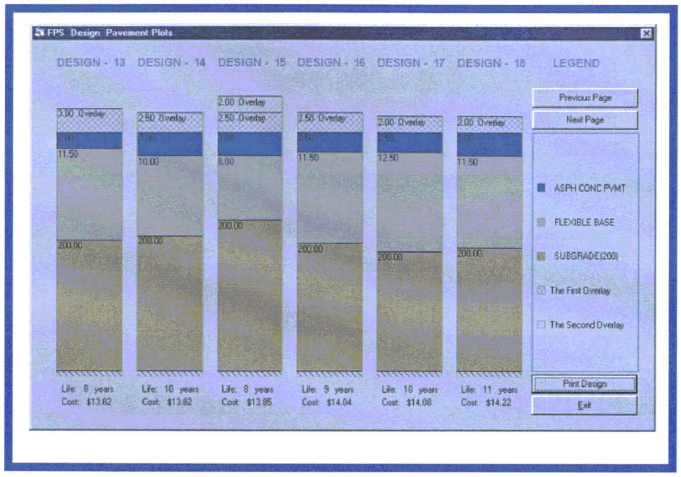
WINDOWS VERSION OF MODULUS / FPS19

Project 0-1869:
Improving Flexible Pavement Design Procedures

Research conducted at Texas Transportation Institute (TTI)

The new FPS19 for Windows program provides an improved flexible pavement design procedure and a tool for conducting structural investigations of pavements in the state.

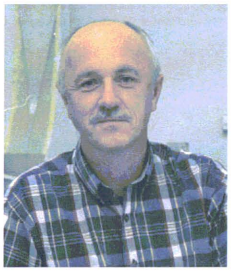




- *TxDOT's annual rehab budget is in excess of $300 million. This software program allows the adequate design of rehabilitation alternatives.*
- *Includes the use of new tools for performing structural evaluations with FWD and GPR.*
- *New Design Tools (FPS19W)*
- *TxDOT is one of the lead states in implementing new design approaches.*

BENEFITS

- Improved pavement modeling capabilities provide more reliable pavement designs.
- Automated design checking capabilities eliminate some common errors in pavement designs.
- Makes full use of the Windows environment, allowing easy navigation.
- Is easy to use with extensive on-line help.



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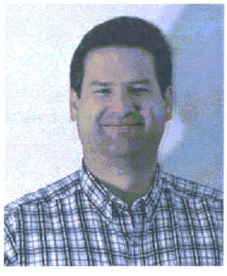

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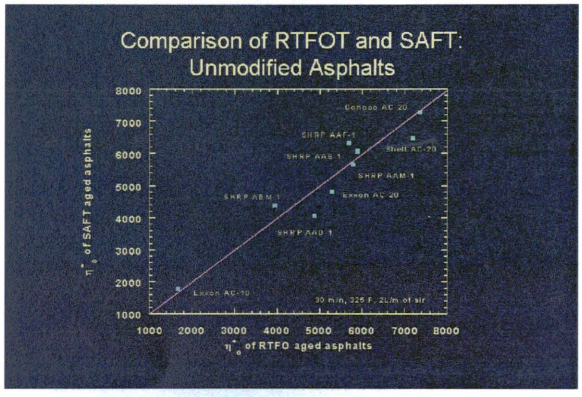
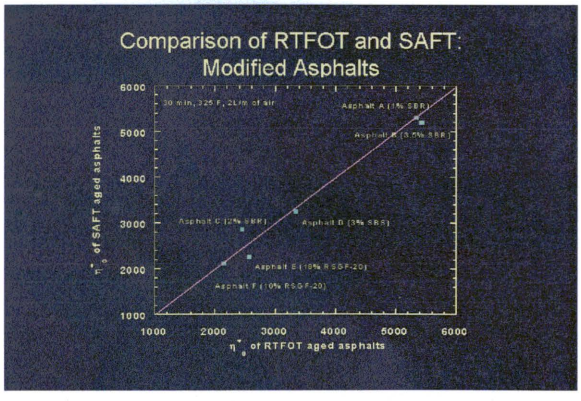
NEW ASPHALT AGING EQUIPMENT

Project 0-1742: Improved HMAC Plant Binder Aging Simulation

Research conducted at Texas Transportation Institute (TTI)





The **Stirred Air-Flow Test** (SAFT) is a new apparatus and procedure for obtaining short-term aging of asphalt materials that simulates aging that occurs in hot-mix plants.

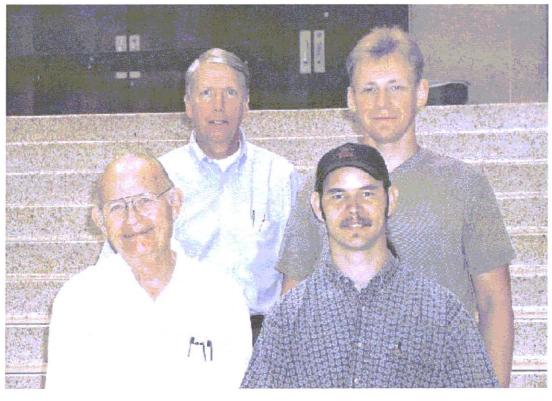
The standard tests for simulation of asphalt hot-mix aging are the **Rolling Thin-Film Oven Test** (RTFOT, ASTM D 2872) and the **Thin-Film Oven Test** (TFOT, ASTM D 1754). The RTFOT and TFOT have a number of deficiencies when used for viscous or modified asphalts, such as uneven aging, film formation, and difficulty with cleaning laboratory equipment. The purpose of this project was to develop a new procedure for simulating asphalt short-term aging that occurs at a hot-mix asphalt plant.

The resulting Stirred Air-Flow Test (SAFT) is designed based on fundamental studies of the process of air-blowing asphalt materials. Asphalt air blowing is used commercially to produce roofing and paving asphalts by oxidizing the bottom crude oil products with air, thereby altering the asphalt chemical composition and physical properties. The process conditions and binder composition have a direct impact on the properties of the resulting materials.

The new method is an improvement over the RTFOT test in that it eliminates the problems which are experienced with testing polymer modified binders, is easier and safer to use, and is less costly and more efficient.

BENEFITS

- simple to use
- works well with polymer-modified and multigrade asphalts
- ease of cleanup
- condenser gives direct measure of volatiles
- reduced testing time (compared to Rolling Thin-Film Oven Test)
- low cost
- efficient use of laboratory space
- dual use capability (can be used for emulsion recovery also)



Front row: Dick Davison, Jerry Peterson (PD)
Back row: Charles Glover (RS), Nikolai Vassiliev

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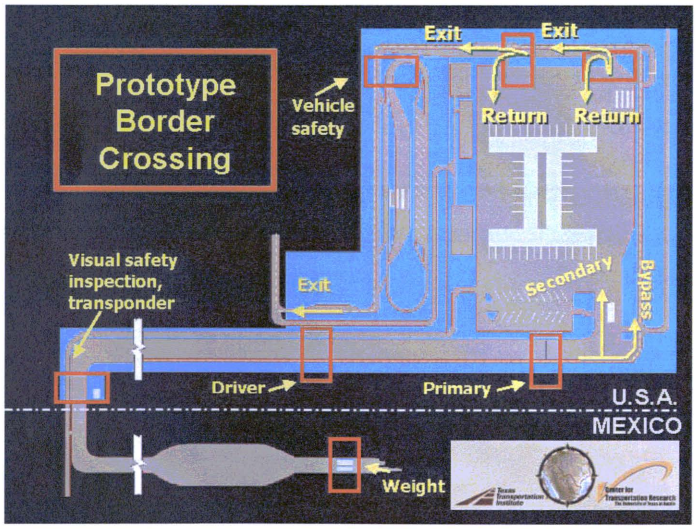
MODEL BORDER CROSSING DESIGN

Project 5-9014:
Criteria and Design for a Model Border Crossing

Conducted jointly at Center for Transportation Research (CTR) and Texas Transportation Institute (TTI)

With increasing NAFTA traffic, backups at the border have become a severe problem. This innovation is a design that improves the flow of commercial traffic.



Texas trade with Mexico is a giant opportunity. The One-Stop Model Border Crossing represents innovative technology, increased coordination, and plain old common sense. With it, crossing times of up to several hours can be cut to 12 minutes. Moreover, we can increase efficiency, decrease pollution, and deliver more goods to market. Most importantly, in communities all along the Texas-Mexico border, this model will make a big difference in the quality of all our lives.

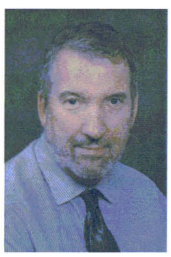
— Senator Eliot Shapleigh

- ***Model border crossing is feasible***
- ***Technology is available***
- ***Vehicle safety inspection is feasible***
- ***Applicable to entire southern border***
- ***Suitable to future border crossings***
- ***Institutional and bi-national arrangements needed***

BENEFITS

The expected benefits if the results are fully implemented:

- Of the 3 to 4 million trucks crossing the Texas-Mexico border each year, 70 percent can be pre-cleared and use an express lane.
- Each pre-cleared truck can save 30 to 45 minutes.
- The value of truck time is $25 to $35 per hour.
- Possible savings to economy range from $30 million to $60 million per year.
- Air pollution is reduced.
- International relations are improved.



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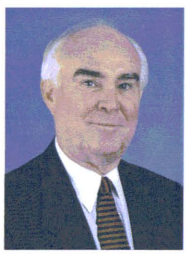

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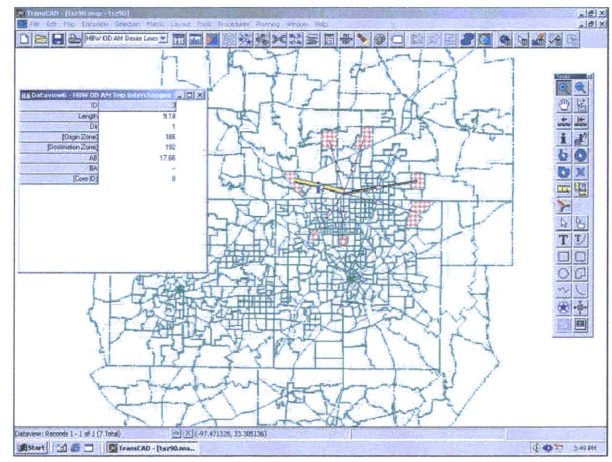
METHOD TO EVALUATE TCM EFFECTIVENESS IN OZONE NONATTAINMENT AREAS

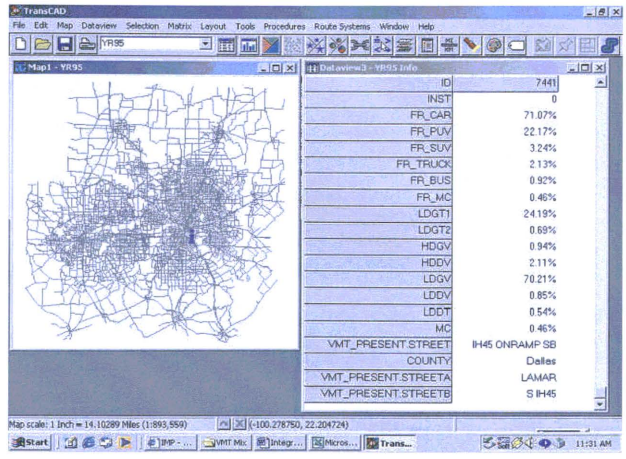
Project 0-1838:
Transportation Control Measure Effectiveness in Ozone Nonattainment Areas

Research conducted at Center for Transportation Research (CTR)

This project developed an integrated and coordinated regional transportation planning and emissions modeling procedure that represents a methodologically sound framework to assess the impact of Transportation Control Measures (TCMs) on mobility and emissions.



A graphical display of trip interchanges from an origin zone to several destination zones in the DFW metropolitan area



Display of the VMT Mix on an IH-45 SB ramp in Dallas, Texas

BENEFITS

- Provides TxDOT and MPOs the capability to directly assess and forecast the impact of TCMs using Travel Demand Models. This enhances the estimation of TCM-induced mobile-source emission reductions used to show conformance to emission budgets established in state implementation plans (SIPs) developed by environmental agencies.

- Accommodates the change in number of trips due to the implementation of TCMs. Existing Travel Demand Models are either unable to, or able to accommodate in a very limited fashion, the change in trip making due to TCMs.

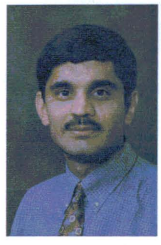
- Accounts for the temporal and spatial changes in trip destination due to TCMs that affect non-auto level-of-service. Existing Travel Demand Models are unable to account for these changes because they use auto travel time as the only impedance measure.

- Recognizes differential sensitivities of sociodemographic groups to transportation system performance. Accommodating such differential travel sensitivities of demographic groups is important for the accurate evaluation of TCMs as well as for environmental justice considerations in transport policy analysis.

- Provides accurate VMT mix ratio on network links based on link attributes and the geographic location of the link.

- Develops trip duration and soak-time distributions using vehicle trip data from household travel surveys and supplementary zonal demographic/land-use data. Since the emissions computations in the MOBILE model are very sensitive to these inputs, our refined models should provide more accurate emission forecasts than the existing models.

- Provides an integrated GIS environment to display and visualize traffic patterns in an urban area.



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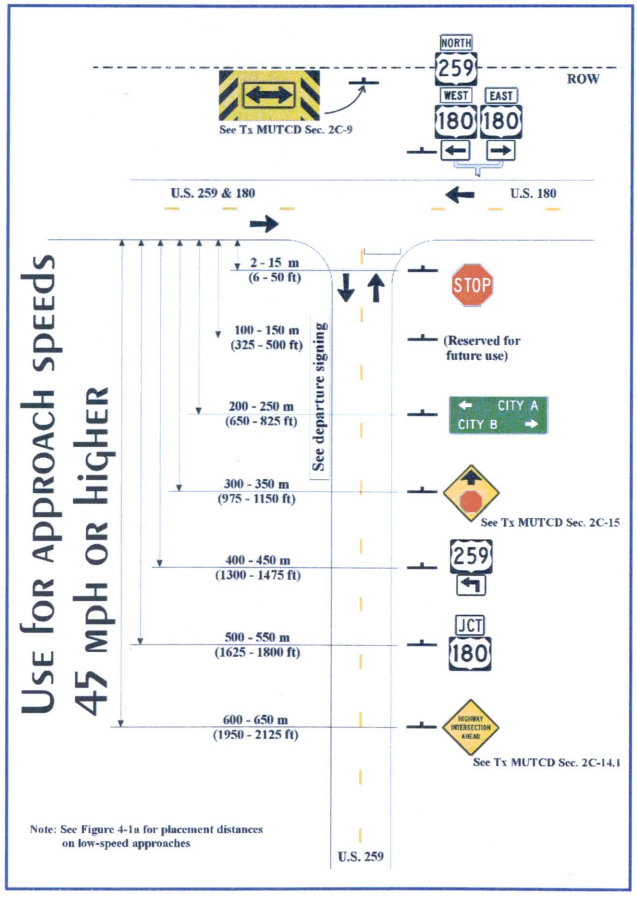
SIGN CREW FIELD BOOK

Project 0-1373:
Evaluation of Rural Guide Signing

Research conducted at Texas Transportation Institute (TTI)



The Sign Crew Field Book (SCFB) was created by a team of TxDOT, TTI, and FHWA staff to improve the effectiveness and placement consistency of signs on conventional rural highways. The SCFB was developed initially for use by field crews to supplement and expand upon the guidelines contained in the Texas Manual on Uniform Traffic Control Devices (TMUTCD). The heavy use of figures and tables makes the SCFB more accessible and easier to understand than the TMUTCD.

The eight chapters of the Sign Crew Field Book provide information on the field placement of regulatory, warning, and guide signs; location and placement of object markers, delineators, and barrier reflectors; and location and installation of mailboxes. The field book does not supersede the MUTCD, but it provides additional guidance with respect to standards, recommended practices, or other requirements established by TxDOT documents.

Use of the field book has now expanded beyond the field crews into the design part of signing operations.

BENEFITS

- The Sign Crew Field Book allows crews to place signs more consistently throughout the state. Uniform signs help drivers find their destinations more safely and easily.
- The heavy use of figures and tables makes the SCFB more accessible and easier to understand than the TMUTCD.
- Sign crews can now provide drivers with more advance information at intersections. This has been accomplished by moving signs further from the intersection on the approach.
- A "no sign zone" is another concept implemented through the field book to help driver understanding.
- Since its initial publication, the Sign Crew Field Book has been one of the most popular documents distributed by the Traffic Operations Division. It has been widely distributed to TxDOT maintenance sections and can be found in almost every sign truck in the state. Area and district offices are also using the document when designing the sign portion of highway plans.

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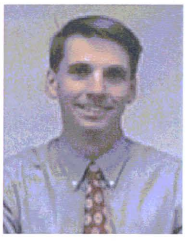

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ANALYSIS OF SMALL TARGET VISIBILITY METHOD

Project 0-1704:
Evaluation of Roadway Lighting Systems Designed by Small Target Visibility (STV) Methods

Research conducted at Texas Tech University Center for Multidisciplinary Research in Transportation (TechMRT)

This analysis found that the Small Target Visibility (STV) Method, a proposed national standard, does not warrant implementation. While quite unique among the Top Innovations and Findings for 2001 in being a negative finding, this finding has nonetheless provided TxDOT and the nation tremendous savings of resources that would have been poured into implementation efforts.

Small Target Visibility (STV) Method

STV is the first attempt to relate the physics of roadway lighting performance to the biology of the human eye (i.e., visibility). It uses the fact that visibility is a function of contrast, which is easily calculable in the static mode. The STV method is much more labor intensive than current TxDOT practice.

The static calculation of contrast does little to relate the design to its corresponding operating condition because of the variability in the following parameters:

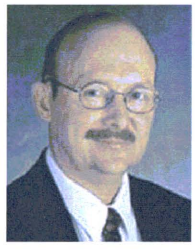
- **Human vision** – infinitely random and variable.
- **Reflective characteristics of pavement** – change with pavement's age.
- **Luminaire output characteristics** – vary over time due to aging and dirt accumulation.
- **Off-roadway lighting** – changes with development of the surrounding area.
- **Weather** – variations such as ice and rain invalidate design calculations by changing the pavement's reflective characteristics from diffuse to specular.

Using STV would increase current design effort by at least an order of magnitude by requiring the development of a complex computer simulation for each and every lighting installation.

At least 20 assumptions were identified that potentially introduce unrecognizable error in the final design. Errors in STV calculation are unacceptable (over 200 percent).

BENEFITS

- Tremendous waste in department resources is avoided.
- Has caused the Illuminating Engineering Society of North America (IESNA) to re-examine its standards.
- New methods used to evaluate lighting system performance will be the subject of future research projects.
- Allows TxDOT to keep using its current and more efficient method.



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STRUCTURAL CAPACITY DETERMINATION USING DAMAGE INDEX

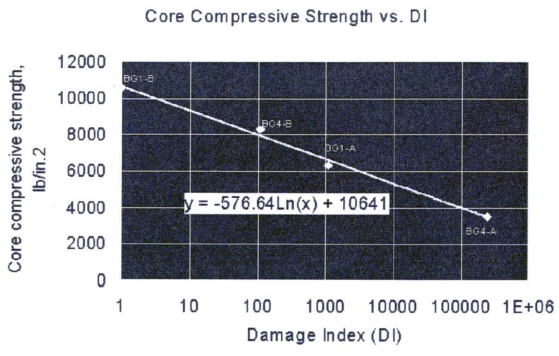
Project 0-1857:
Structural Assessment of In-Service Bridges with Premature Concrete Deterioration

Research conducted at Center for Transportation Research (CTR)

Typical premature concrete deterioration. Photo shows full-length horizontal cracks.

There are many structures in Texas exhibiting premature concrete deterioration (PCD). PCD is attributed to alkali-silica reactivity (ASR) and/or delayed ettringite formation (DEF). Prestressed concrete girders with PCD typically exhibit unsightly map cracking as well as cracks running longitudinally along the length of the girder. Visually, these cracks may be quite disturbing to the structural engineer and traveling public, calling into question the structural integrity of the girder and structure.

COMPRESSIVE STRENGTH VS. DAMAGE INDEX



The damage index (DI) was found to correlate remarkably well with compressive strength of concrete cores taken from girders exhibiting premature concrete deterioration, allowing determination of flexural and shear capacity of in-service damaged beams.

$$DI = \sum lw^2 \text{ (for a 12" x 12" defined area)}$$

where l = crack length
and w = crack width

BENEFITS

- The primary benefit is confidence of structural integrity of in-service structures.
- Determination of the damage index for a particular girder is relatively quick and simple. As girders exhibiting PCD are monitored over time, the damage index is determined and flexural and shear capacity are computed, assuring TxDOT engineers of the structural capacity of a given bridge.
- This tool has the potential to save TxDOT hundreds of thousands of dollars in girder replacement costs and costly load tests for in-service bridges exhibiting premature concrete deterioration.
- Motorist delay associated with girder replacement or live load testing is also eliminated through use of this innovative analysis tool.

Associated Research Project: Project 0-1857, *Structural Assessment of In-Service Bridges with Premature Concrete Deterioration*, Center for Transportation Research

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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. Besides strong department leadership, input concerning research needs and opportunities is received from 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 sometimes assisted by other department personnel serving in project advisor roles.

Department research is funded primarily from a federal source entitled 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.

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.

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**.

Implementation Program Projects

PAVEMENTS (RMC 1)

- Construction of SPS-8 for LTPP (5-9008)
- Development of Structural Field Testing of Flexible Pavement Layers
- Equipment and Training for GPR Implementation (5-1702 and 5-1702-01)
- Flexible Pavement Rehabilitation Training Courses (5-1712 and 5-1712-01)
- Hot Mix with Crumb Rubber Binder (5-9016)
- Implementation of the Micro-Deval Equipment and Test (5-1771)
- Monitoring Performance of Materials (5-1785)
- Noncontact Skid System (5-3969 and 5-3969-01)
- Pilot Implementation of a New Binder Aging Simulation Equipment (5-1742 and 5-1742-01)
- Post-Tension Prestressed Concrete Pavements (5-4035)
- Precast-Prestressed Panels for Pavement on High Volume Roads (5-1517 and 5-1517-01)
- Regional Workshops on Nonhazardous Recycled Materials (5-1509 and 5-1509-01)
- Stabilization of Soils Using In-Situ Vitrification (5-1860-01)
- Toner Modified Asphalt (5-3933 and 5-3933-01)
- Training for Seismic Refraction Instrument to Determine Bedrock Depth (5-2990 and 5-2990-01)
- Web-Based Training for Pavement Design and Analysis (5-1869-01)
- White-Topping Concrete Overlay (5-9010 and 5-9010-01)

TRANSPORTATION PLANNING (RMC 2)

- Automated Routing of Overweight Vehicles (5-1823)
- Criteria and Design for a Model Border Crossing (5-9014 and 5-9014-01)
- Impacts of Frontage Roads (5-1873)
- Port Evaluation Process (5-1833)
- Smart Card Technology for Collection of Transit Fares (5-1766)
- Use of Dredged Material from the Gulf Intracoastal Waterway (5-1733)

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Implementation Program Projects, continued

GEOMETRIC DESIGN, ENVIRONMENTAL, HYDRAULICS AND RIGHT-OF-WAY (RMC 3)

- Center for Water Resources (CRWR)—Flood Map Geographic Information System Application for Hydraulics Engineering (5-1738-02 and 5-1738-03)
- Experimental Noise Walls on IH-610 in Houston (5-2112)
- Methodology for Predicting Scour Depth versus Time at Bridge Piers (5-2937)

TRAFFIC OPERATIONS (RMC 4)

- Interactive Graphics Intersection Design System (IGIDS) (5-1291 and 5-1291-01)
- Procure Equipment for 0-4260 (5-4260)
- Transportation Research Implementation Consortium Operations and Management (5-1439 and 5-1439-01)
- Truck Monitoring and Driver Warning System (5-2915)
- Warning Lights for Lane Closures (5-3983)

STRUCTURES (RMC 5)

- Continuous Flight Auger Pile Bridge Foundations (5-3940 and 5-3940-01)
- Design Guidelines for Fiber-Reinforced Plastic (FRP) Structures (5-1773)
- Maturity Method Testing Procedures and Related Specifications (5-1714 and 5-1714-01)
- Mitigation of ASR/DEF—Evaluation of SP 421 (5-4085)
- Precast Bent Cap System with High Moment Demand Connection (5-1748-02 and 5-1748-03)
- Precast Bridge Construction System (5-9004 and 5-9004-01)
- Structural Design of FRP Ferry Boat Ramp for Port Aransas (5-1773-01)
- Use of Soundprint for Monitoring of Stay Cables (5-9001)

Top Research Innovations and Findings, 1999

- Connectivity of Intermodal Facilities
- Ground-Penetrating Radar Techniques
- Seal Coat Constructability Review
- Seismic Pavement Analysis Methods and Portable Seismic Pavement Analyzer
- Guidelines for Conducting a Traffic Signal Warrant Analysis
- Tapered Neoprene Bearing Pads for Prestressed Bridge Beams
- Use of 0.6-Inch Diameter Strand with High-Strength, High-Performance Concrete in Pretensioned Bridge Beams
- Precast Bent Caps for Bridge Substructures
- Wet Weather Accident Reduction Program
- Generic Crashworthy Work Zone Traffic Control Devices
- Guidance for Planning HOV Lanes
- GIS Application for Hydraulic Engineering
- Herbicide Delivery System for Controlling Mesquite in Right-of-Way

Top Research Innovations and Findings, 2000

- Strengthening of Existing Structures with Composites
- Automated Routing of Overweight Vehicles
- Truck Monitoring and Warning System for Freeway-to-Freeway Connections
- Use of Waste Toner in Asphalt
- Erosion Function Apparatus (EFA)
- Guidelines for Improved Driveway Location on Frontage Roads
- Pavement Surface Texture Measurement System
- Test for Radio Frequency Interference (RFI) in Vehicles
- Design and Construction of Continuous Flight Auger Cast Piles for Transportation Structures
- "Super Two" Geometric Design Guidelines

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